US Army Corps of Engineers

Charleston Harbor Section 204

Beneficial Use of Dredged Material, Charleston, South Carolina

Detailed Project Report

March 2018

[This Page Intentionally Left Blank]

EXECUTIVE SUMMARY

This Section 204 Detailed Project Report presents the evaluation of beneficial uses for dredged material resulting from the planned deepening of the federal channel in Charleston Harbor. Through both previous coordination efforts and during the Charleston Harbor, South Carolina Project (Charleston Harbor Post 45 Project), stakeholders have requested that the USACE place dredged material along certain shorelines to reduce the effects of erosion such as on Fort Sumter, Crab Bank, and Shutes Folly Island. The recommended plan would address these concerns by restoring Crab Bank.

Normal Operations and Maintenance (O&M) annually removes about 1 million cubic yards of material in the lower reaches of the harbor. A shoaling analysis related to the upcoming deepening of the federal channel indicates an approximate 50% increase in the O&M material that will be dredged. In addition to the increase in O&M material, the deepening will produce a one-time opportunity to use new work material to the benefit of the harbor. While this study initially evaluated uses for both maintenance material and new work material from the lower reaches of the harbor, it was determined that the O&M material was not suitable for the alternatives that were ultimately formulated. These alternatives involved placing material at Crab Bank and Shutes Folly Island to enlarge both islands, extend their lives in the face of wave erosion and sea level rise, and expand nesting, foraging, and loafing habitat for avian species. The habitat suitability index (HSI) model for the brown pelican was used to derive environmental benefits and served as a proxy for other shorebirds that use Crab Bank.

Over thirty different measures were initially screened and eliminated. Twenty five alternatives were evaluated as part of this study. It was ultimately determined that the most cost effective beneficial use of the new material was to use it to enlarge Crab Bank and provide new avian habitat. The estimate of available material resulting from the deepening is approximately 825,000 cubic yards (cy), with approximately 660,000 cy ultimately being used. The restored Crab Bank will have an initial footprint of 79.4 acres at MLLW, with 27.8 acres, available for brown pelican nesting. At the end of the period of analysis, approximately 15.25 acres of Crab Bank will remain, with 1.36 acres of pelican nesting habitat remaining. All analysis was based on best available information at the time which was LiDar data from 2017. The design phase will utilize the most recent data available to develop the final footprint. The fully funded costs for the design and construction of the recommended plan are estimated to be approximately $3.98 million, with the federal share costing approximately $2.59 million.

Contents

List of Figures

List of Tables

Appendices

1.0 STUDY AUTHORITY AND BACKGROUND

This study evaluates the beneficial use of dredged material from both existing operations and maintenance (O&M) dredging as well as a one-time opportunity to use material resulting from the new work dredging associated with the authorized Charleston Harbor Post 45 Project. The authority for this study is under the Continuing Authorities Program (CAP) Section 204, Beneficial Uses of Dredged Material, Water Resource Development Act (WRDA) of 1992 (PL 102-580), as amended. Section 204 CAP authority authorizes the U.S. Army Corps of Engineers (USACE) to carry out projects, among other things, to protect, restore, and create aquatic and ecologically related habitats, including wetlands, in connection with dredging of authorized Federal navigation projects. The Federal share of the costs for any one project may not exceed $10,000,000.

Cost sharing for CAP Section 204 Beneficial Use of Dredged Material projects is unusual in that it compares the delta in costs between the proposed project and the cost of disposal of dredged material without the proposed project. The increased cost above the cost of the disposal option that would have been implemented without proposed project (referred to as the base plan) requires cost sharing. As stated in WRDA of 1992 (PL 102-580), as amended, the federal government funds the entirety of the feasibility phase for CAP Section 204 Beneficial Use of Dredged Material projects. If the approval of the proposal for implementation occurs, the non-Federal sponsor responsibilities, in accordance with the project partnership agreement (PPA)) include: (a) provide all lands, easements, rights of way, and dredged material disposal areas and perform all necessary relocations (LERRD) necessary for the project; (b) pay any cash contribution during construction necessary so that the total contribution of the non-federal interest including value of LERRD will be 35 percent of the cost of the project; (c) pay 100 percent of the operation, maintenance, replacement, repair, and rehabilitation (OMRR&R) cost of the beneficial use project. The non-federal sponsor shall receive credit for the value of in-kind contributions against the requirement for additional cash. Total project costs consist of the incremental amount above the costs for the existing dredging plan "base plan" (ER 1105-2-100 Appendix F, pg. F-37).

The South Carolina Ports Authority (SCPA) provided a letter on May 14, 2010, requesting the USACE's assistance with identification of beneficial uses of dredged material in the Charleston and Georgetown Harbor Federal navigation projects. In response, the Charleston District submitted a federal interest determination (FID) to the USACE-South Atlantic Division, which approved the FID on December 16, 2015 and established federal interest in further study of a Section 204 for Charleston Harbor, South Carolina.

In September 2016, USACE published a draft Supplemental Environmental Assessment (SEA), Beneficial Uses for Charleston Harbor Deepening Project (Post 45), which evaluated and selected potential beneficial use projects that could be implemented with the new work dredged material associated with construction of the Charleston Harbor Post 45 Project. All options exceeded the federal standard (least cost, environmentally acceptable). The incremental cost of a beneficial use that is above the least cost disposal option must be funded by a non-Federal sponsor or cost-shared according to the applicable authority. For that reason, the South Carolina Department of Natural Resources (SCDNR) submitted a letter of intent on 2 November 2016 expressing interest in exploring alternatives for dredged material disposal under CAP 204. The intent was that by pursuing CAP 204, the incremental costs would be shared between the federal government and a non-federal sponsor (SCDNR, others) instead of a non-federal sponsor contributing the entire increase in construction costs on their own. The SEA and Finding of No Significant Impact (FONSI) was finalized in January 2017. This Detailed Project Report provides the results of the Section 204 evaluation of the optimum beneficial use of dredged material project for Charleston Harbor at the present time.

2.0 STUDY PURPOSE, LOCATION, AND SCOPE

2.1 Study Purpose

This study analyzes beneficial use of dredged material obtained from both existing O&M practices in Charleston Harbor and new work dredged material associated with the construction of the Charleston Harbor Post 45 Navigation Project. The goal of the analysis is to use either O&M dredged material or new work dredged material beneficially rather than disposing in a traditional dredged material management area.

2.2 Study Area

Located just south of the geographical midpoint of South Carolina's coastline, Charleston Harbor is positioned on a natural tidal estuary formed around the confluence of the Cooper, Ashley, and Wando Rivers. The greater Charleston Metro area now encompasses West Ashley, Johns, James, and Morris, and Sullivan’s Islands, Mt. Pleasant, and North Charleston. Charleston Harbor includes about 14 square miles of open water. The Charleston Harbor entrance channel accesses the Atlantic Ocean to the southeast between Morris Island and Sullivan’s Island. Crab Bank Island and Shutes Folly Island, are two islands within the lower Charleston Harbor. Figures 1 and 2 show the locations of the federal channels and existing upland and offshore dredged material placement sites considered in this study. The figures also illustrate the relative locations of the inner harbor and entrance channel.

This project focuses on beneficially using materials dredged from the lower harbor, at locations proximate to the lower harbor. Thus, the study area includes the dredged material disposal areas, the lower reaches of the federal inner harbor channels, and any extension of these water bodies and shorelines that could benefit from dredged material placement alternatives.

2.3 Study Scope

As recommended by the FID approved by South Atlantic Division on 16 December 2015, this study investigates the beneficial use of dredged material from the federal channels of Charleston Harbor for marsh restoration and/or shoreline erosion protection. While the FID initially focused on O&M material, due to the SCDNR letter of interest the scope of the study was expanded to include both new work material from the deepening associated with the Post 45 Project and O&M material. This report considers an array of alternatives in addition to a no-action alternative. The Charleston District conducted this study in accordance with feasibility study guidelines contained in the Planning Guidance Notebook (ER 1105-2-100) and other applicable USACE regulations and guidance.

This detailed project report (DPR) study provides a level of detail appropriate for the scope and complexity of the Continuing Authorities Program study, and sufficient to proceed into detailed design and implementation. All NEPA coordination has been completed for the recommended plan and is incorporated by reference. The selected plan represents the best option for beneficial use of dredged material in Charleston Harbor at the present time and does not preclude future analysis of other alternatives.

3.0 PRIOR STUDIES, REPORTS, AND EXISTING PROJECTS

3.1 Prior Studies and Reports

Over the past 40 years, there have been a succession of feasibility related reports concerning deepening projects for the Charleston Harbor. Advances in engineering, economics, and other sciences have aided each successive investigation. An abbreviated list of the most important studies and reports relating directly this project are summarized below.

3.1.1 Feasibility Studies

Congress authorized deepening of the federal channels in Charleston Harbor from a depth of 40 feet mean lower low water (MLLW) to 45 feet MLLW based upon The Charleston Harbor Deepening/Widening, South Carolina, Report of the Chief of Engineers, 16 July 1996. This Report was based upon a 1996 Feasibility Study and EA. Construction was started in 1999 and completed in 2004. Most recently, Congress authorized deepening of the federal channels in Charleston Harbor from a depth of 45 feet MLLW to 52 feet MLLW based upon the Charleston Harbor Post 45 Report of the Chief of Engineers, signed September 8, 2015. This project has not yet been constructed.

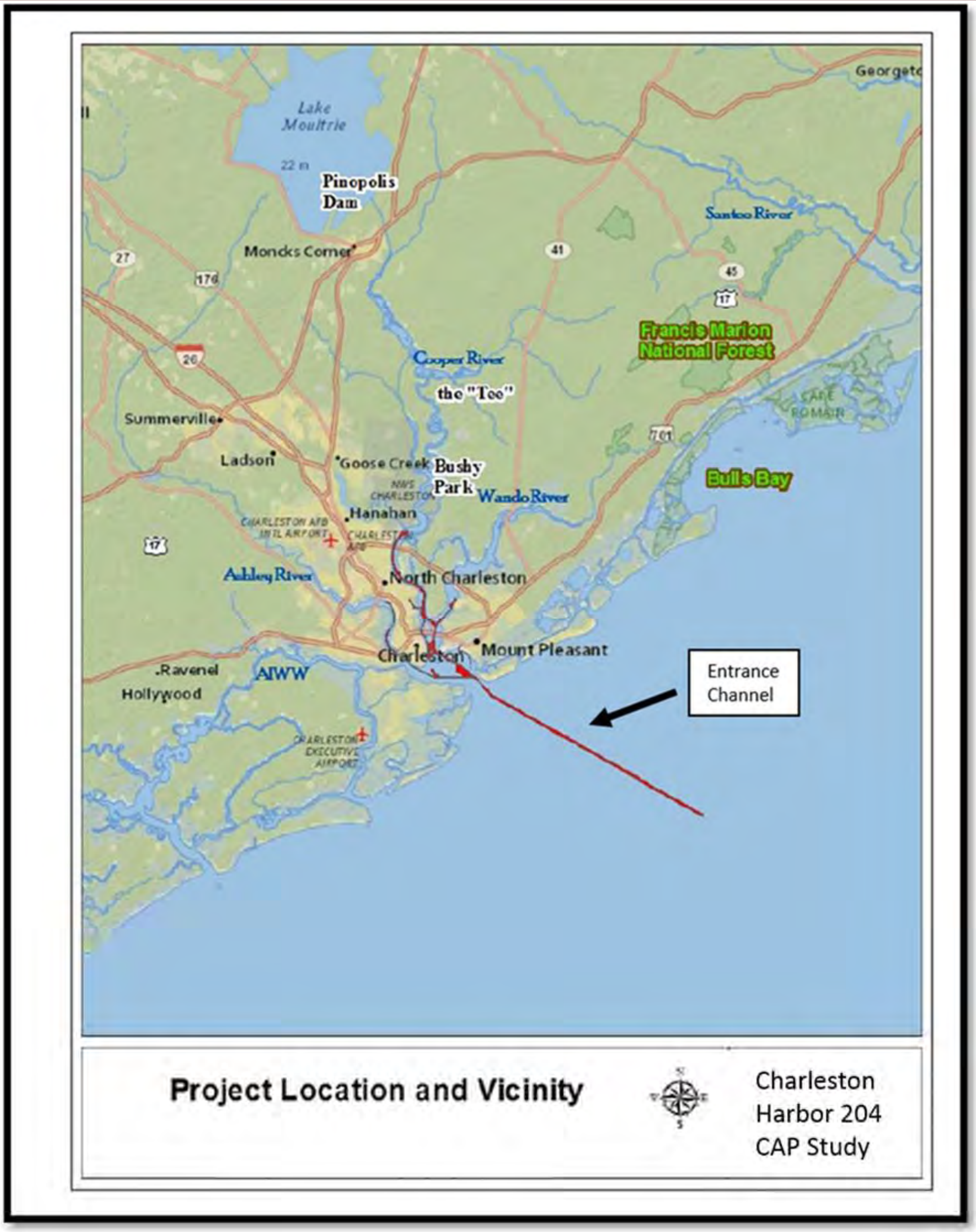


Figure 1. Charleston Harbor Project Location and Vicinity

Figure 2. Charleston Harbor Confined Disposal Sites and ODMDS in Relation to the Federal Channel

3.1.2 Dredging Reports

Charleston Ocean Dredged Material Disposal Site (ODMDS), Site Management And Monitoring Plan, November 2005. This plan was prepared and reviewed by the U.S. Environmental Protection Agency; the USACE; the U.S. Fish and Wildlife Service (USFWS); the South Carolina Department of Natural Resources;

and the SCPA. This modified site management and monitoring plan replaces the original and incorporates subsequent monitoring results and guidance outlined in the Water Resources Development Act of 1992.

An Environmental Monitoring Study of Hardbottom Reef Areas Near the Charleston Ocean Dredged Material Disposal Site, March 2006. This monitoring report documented the effectiveness of a USACE constructed "L" shaped berm comprised largely of cooper marl along the southern and western borders of the ODMDS. It was constructed to protect hardbottom reef habitats, and prevent long term loss of sessile (attached to substrate) biota and associated fin fishes caused by burial by fine grained sediments dispersed from the ODMDS.

Dredged Material Management Plan, Preliminary Assessment, Charleston Harbor, Charleston, South Carolina, June 2009. The report concluded that there was more than 20 years of capacity to contain the dredged material from Charleston Harbor maintenance dredging.

Final Environmental Assessment, Charleston Harbor Additional Advance Maintenance Dredging, Published September 2009. While the 1996 Feasibility Study and EA for deepening and widening the channels in Charleston Harbor anticipated dredging depths of 45 feet plus 2 feet of advanced maintenance and 2 feet of allowable overdepth (45+2+2), high shoaling rates necessitated that some reaches be dredged to depths of either 45 feet plus 4 feet of advanced maintenance and 2 feet of allowable overdepth (45+4+2) or 45 feet plus 6 feet of advance maintenance and 2 feet of allowable overdepth (45+6+2). The additional advance maintenance dredging allows the harbor to be maintained on a 12 to 18 - month cycle instead of a 6-month cycle.

Final Integrated Feasibility Report and Environmental Impact Statement, Charleston Harbor Post 45 Study, Published May 2015. This IFR/EIS examined the engineering, economic, environmental, and real estate issues related to the planned deepening of the Charleston Harbor navigation system. The Recommended Plan was the Locally Preferred Plan. This plan deepens the inner harbor channels leading to the Wando Welch container facility and the new Navy Base Terminal from the existing -45 feet MLLW to -52 feet MLLW, and the channel from the new Navy Base Terminal to the North Charleston container facility from -45 feet MLLW to -48 feet MLLW. The entrance channel would be deepened from -47 feet MLLW to -54 feet MLLW. While this plan was more costly than the NED plan it generates more net benefits. The findings and conclusions of this study is incorporated by reference into this report.

Final Environmental Assessment, Charleston Harbor Post 45, Expansion of Existing ODMDS, Published October 2016. The USACE Charleston District prepared this plan for the U.S. Environmental Protection Agency, which reviewed and approved EA in coordination with the USFWS; the SCDNR; and the SCPA.

Final Supplemental Environmental Assessment for Beneficial Uses for Charleston Harbor Deepening Project (Post 45). Published January 2017 (SEA). This SEA presents the environmental acceptability of potential alternatives for beneficial use of dredged material associated with this study. The information of this SEA is incorporated by reference into this report.

3.2 Existing Projects

3.2.1Historic Perspective

Charleston was founded on the west bank of the Ashley River in 1670. In 1680, the colony relocated to Oyster Point. This relocation gave the community a natural harbor that was more defensible from land

and sea assaults. After this move, the city grew in population and economic significance until the early 1800s. Between 1830 and 1850, Charleston Harbor declined in relative importance as New York Harbor expanded and new ports, such as New Orleans, developed. By 1840, Charleston realized that the harbor would need to be at least 17 feet deep to remain competitive. Over time, the harbor has been deepened as needed to adapt to the changing needs of its users. The below paragraphs summarize the channel improvements over time and Figure 3 provides a simplified timeline of the gradual deepening of Charleston Harbor.

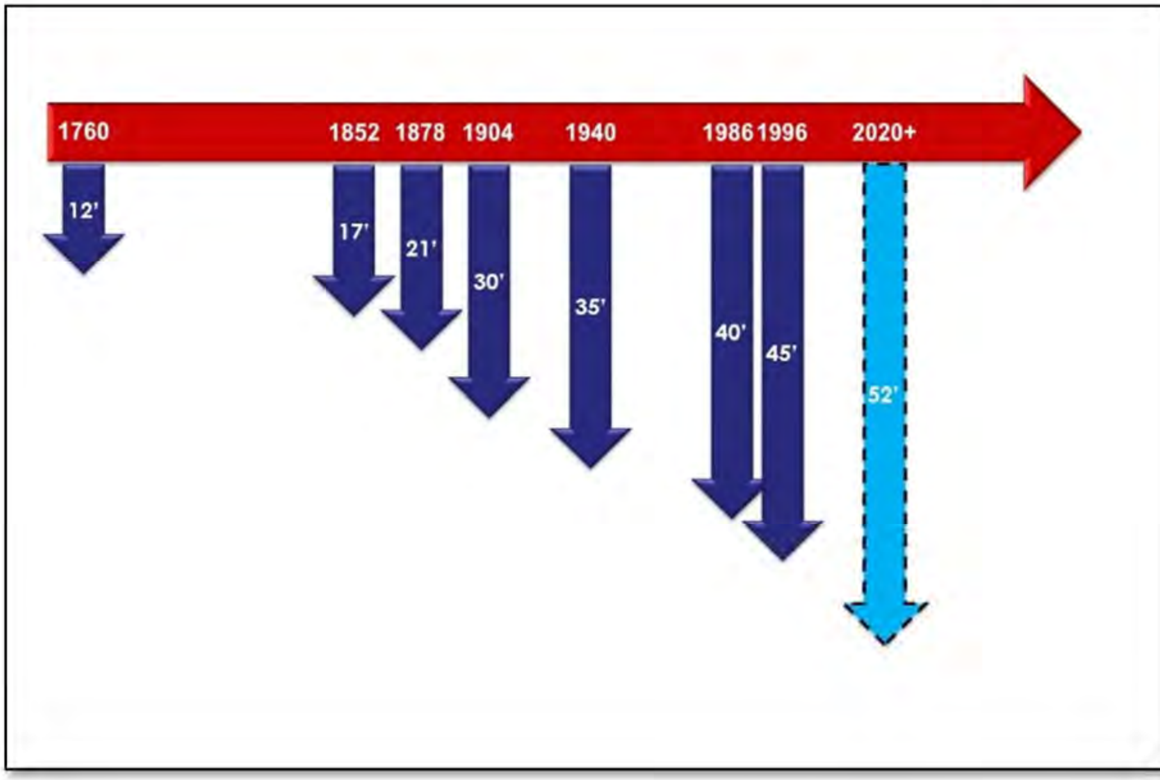


Figure 3. Charleston Harbor Authorized Depth Timeline

The Rivers and Harbors Act of 1852 authorized navigation improvements to Charleston Harbor. This work was interrupted by the Civil War and was not completed until after it ended. Later, the passage of the Rivers and Harbors Act of 1878 authorized the deepening of a channel to a depth of 21 feet MLLW and the construction of a pair of jetties to stabilize the new channel.

In 1898 through 1904, additional dredging was performed to increase channel depths to 26 and 30 feet MLLW, respectively. In 1940, a 35-foot MLLW project was authorized for the entrance channel, up Town Creek past the Union Pier and Columbus Street Terminals and up the main channel of the Cooper River to the North Charleston Terminal area. In 1986, the channels were authorized to 40 feet MLLW. In 1996, the major interior channels were authorized to 45 feet MLLW and the entrance channel was authorized to 47 feet MLLW. Finally, in 2016, Congress authorized the construction of the Post 45 Project, which authorized an Entrance Channel of 54 feet MLLW, lower harbor channels to the Wando Welch Terminal and Hugh Leatherman Terminal of 52 feet MLLW, and upper harbor channels to the Navy Base Terminal to 48 feet MLLW.

In addition to the historic dredging, the harbor has undergone some significant hydrodynamic changes. Prior to 1941, the three rivers that formed Charleston harbor, the Cooper, Wando, and Ashley were all tidally driven systems. Discharges in the Cooper averaged 150 cfs. In 1942, the Santee Cooper project diverted water from the Santee River system into the Cooper River. The resulting new discharge of the Cooper River now averaged 15,600 cfs. This condition remained until the rediversion of the majority of the flow back to the Santee River in the 1980s. Since the rediversion, flow into the Cooper averages 4500 cfs, still greater than what was originally entering the harbor. Prior to 1942, freshwater input and freshwater sedimentation was minimal. With the diversion, sedimentation in the harbor increased by a factor of 4. The rediversion in the 1980s was to reduce shoaling in the harbor. Due to the changes in freshwater contribution, sediment input in Charleston harbor is greater now than what can be considered as natural conditions. Analysis of sediment inputs into the Charleston Harbor, however, determined that approximately 66% of the sediment in the harbor was from oceanic sources.

3.2.2 Existing Federal Navigation Project

The Charleston Harbor Federal navigation project consists of channels, turning basins, an anchorage basin, contraction dikes, jetties, and dredged material disposal areas. The channels have been enlarged through the past 160 years, and the authorized depth supporting the major terminals is currently 45 feet MLLW (Figure 2).

The current project requires periodic maintenance dredging to maintain authorized depths. Historically, dredged material removed from Charleston Harbor has been placed within six upland disposal sites annually averaging 1,000,000 cubic yards in material received and the ODMDS, annually receiving and average of approximately 1,400,000 cubic yards (Figure 2). While it varies year to year, the average annual maintenance dredging needs of the federal channels is approximately 2,400,000 cubic yards. The entrance channel is typically dredged every two years by hopper dredge and the material is disposed of in the ODMDS since it is not beach compatible quality. The reaches around the ocean bar require minimal maintenance due to naturally deep water. The upper harbor upstream from Shipyard River is typically dredged every 18 to 21 months by a hydraulic pipeline dredge and the material is usually placed in the Clouter Creek upland disposal area. The lower harbor, downstream of Shipyard River to the entrance channel is dredged every 12 to 15 months. Maintenance dredging of the lower harbor is performed by clamshell dredging and the material is generally transported in a scow for disposal placement in the ODMDS.

Shoaling and subsequent operations and maintenance dredging in the lower harbor typically occurs within Hog Island Reach, Tidewater Reach, Lower Town Creek Reach, Town Creek Reach, Myers Bend Reach, Drum Island Reach, Lower Wando Reach, the Wando Turning Basin, and Upper Wando Reach. Within the upper harbor, shoaling and subsequent operations and maintenance dredging typically occurs within Shipyard River, Daniel Island Reach, Daniel Island Bend, Navy Yard Reach, Port Terminal Reach, Ordnance Reach, and Ordnance Reach Turning Basin.

The Post 45 Deepening Project would result in the following navigation improvements:

- Deepen the existing entrance channel from a project depth of -47 feet to -54 feet (MLLW) over the existing 800-foot bottom width, while reducing in the existing stepped 1,000-foot width to 944 feet from an existing depth of -42 feet to a depth of -49 feet.

- Extend the entrance channel approximately three miles seaward from the existing location to a depth contour including a -54-foot MLLW project depth plus overdepths.
- Deepen the inner harbor from an existing project depth of -45 feet to -52 feet MLLW to the Wando Welch container facility on the Wando River and the Hugh Leatherman Terminal on the Cooper River, and -48 feet MLLW for the reaches above that facility to the North Charleston container facility Expanded bottom widths range from 400 to 1,680 feet.
- Enlarge the existing turning basins to a 1615-foot diameter at the Wando Welch and new SCPA terminals to accommodate Post Panamax Generation 2 and 3 container ships and widen selected reaches (Figure 2).
- Enlarge the North Charleston Terminal turning basin to a 1525-foot diameter for Post Panamax Generation 2 container ships.
- Place dredged material and raise dikes at the existing upland confined disposal facilities at Clouter Creek, Yellow House Creek, and/or Daniel Island; and for material dredged from the lower harbor, place at the ocean dredged material disposal site (ODMDS) and expand. Place rock to create hardbottom habitat near the entrance channel as a least cost, beneficial use of dredged material.

Implementation of the Post 45 project would generate an estimated 40 million cy of dredged material. With respect to managing dredged material in the lower harbor, the least cost disposal option was determined to be excavation using a mechanical clamshell dredge with transportation and disposal at the Charleston ODMDS located approximately nine miles offshore of Charleston Harbor.

4.0 EXISTING AND FUTURE WITHOUT PROJECT CONDITIONS

The future without project (FWOP) condition will be described as the existing condition, projected into the future, assuming that this project is not constructed. The FWOP provides a baseline against which the future with project conditions can be compared.

4.0.1 Description of Future Without Project Condition

For the purposes of the below discussions, the FWOP is defined as USACE continuing current operations, including the authorized Post 45 deepening, and maintenance practices of disposing of sediments in existing management areas. Subsequent impacts resulting from current and planned activities are assumed to be part of the FWOP condition.

4.1 Physical Setting

4.1.1 Wind and Wave Climate

Existing Condition – Wind and Wave Climate

Wind and wave conditions are important considerations for navigation projects due to their potential impacts to both navigation and harbor shorelines. A wind rose generated from the National Oceanic and Atmospheric Administration (NOAA) data collection station in Charleston Harbor (see Appendix A-Engineering) indicates winds are predominantly from the southwest, but the strongest winds (fastest 10%) originate from the north - northeast (Figure 4).

As winds move over water, friction generates waves. The distance of open water (fetch) a wind blows over affects the size of waves produced (USACE, 2008). At a given wind speed and duration, a longer fetch will generate larger waves. At large fetch lengths in deep water, the wave height becomes dependent only on duration of the wind. The heights and energies of wind generated waves increase as long as the wind blows over them until they eventually reach shore. Conversely, vessel wakes dissipate as they move away from the transiting vessel. The average waves generated by winds and the average waves generated by vessels in Charleston Harbor are estimated to be of similar heights, on average, but occur with extremely different distributions and frequencies.

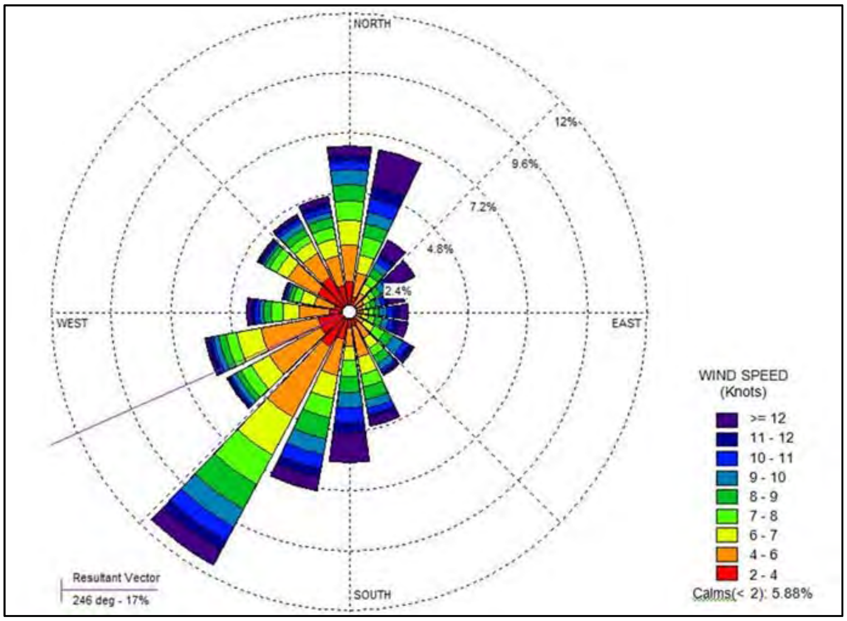


Figure 4. Charleston Harbor Wind Rose

Winds over Charleston Harbor and offshore are variable and can range up to 24 kt. with gusts up to 40 kt. Based on the two year sampling period, January 2010 - December 2011, the average wind was 6.8 kt. from 246 degrees. This average wind is capable of producing waves 0.18 feet high at Crab Bank Island, the area of concern with the longest fetch (~3.5 miles) from 246 degrees. Storms can also have significant impacts to shorelines and habitats over short periods of time. For example, the water level increased 6.9 ft. above mean higher high water (MHHW) in 1989 from Hurricane Hugo and 1.9 ft. above MHHW from Hurricane Floyd, remaining elevated for multiple days and exerting additional energy to sensitive regions above the high water line (Zervas et al., 2000).

In Charleston Harbor, the effect of waves on Crab Bank Island, Shutes Folly Island, Fort Sumter, Fort Moultrie, and the southern shore of Sullivan's Island are of particular interest. Crab Bank Island and Shutes Folly Island are important bird habitat areas and have been experiencing erosion/changing shorelines over several decades. Fort Sumter and Fort Moultrie are National Historic Monuments and Sullivan's Island has extensive homes and infrastructure.

Future Without - Project Condition – Wind and Wave Climate

The FWOP condition will result in no change to the wind and wave climate. Crab Bank Island, Shutes Folly Island, and other harbor shorelines will remain vulnerable within the Harbor due to their exposure to wind and wave activity.

4.1.2 Tides, Currents and Sea Level Rise

Existing Condition - Tides

The tidal range throughout the interior channels is relatively uniform. The tide range within Charleston Harbor averages about 6 ft. between low and high tides. Harbor shorelines, particularly Crab Bank Island and Shutes Folly Island, are vulnerable to overtopping during spring tides due to their relatively low elevations and 360 degree exposure to waves. No action by other agencies has occurred to date to enhance Crab Bank or Shutes Folly Island avian habitat and the islands are at risk to high tides, wave action, and historic sea level rise.

Future Without - Project Condition - Tides

Tidal range will generally remain the same as the existing condition, with changes related to mean sea level rise projections discussed below. Without the proposed project, the likelihood of prolonging the avian habitat of Crab Bank and Shutes Folly Island is nonexistent. Sea level rise, wave action, and erosion will reduce Crab Bank nesting habitat to half of its existing size within 10 years and it will essentially have no nesting habitat in 25 years, exclusive of any hurricanes or tropical storms. Except for Castle Pinckney, Shutes Folly Island will essentially have no avian habitat in 10 years, exclusive of any hurricanes or tropical storms. Detailed information regarding the loss of the study areas is provided in the Engineering Appendix (Appendix A).

Existing Condition - Currents

Ebb (falling tide) currents near the entrance to Charleston Harbor are generally about 1 kt. (about 1.69 feet/second) while ebb currents near Fort Sumter and Drum Island may reach 4 kt. (6.75 feet/second). Crosscurrents during ebb tide at the confluence of the Cooper and Wando rivers and high ebb currents at the confluence of the Shipyard River with the Cooper River can create navigation problems. Normally currents pose the greatest problems to vessels during turning basin maneuvering.

Future Without – Project Condition - Currents

Currents will generally remain the same as in the existing condition, but could experience some slight changes due to sea level changes. According to past Environmental Fluid Dynamic Code (EFDC) modeling results, the FWOP condition shows changes in current speeds in the estuary. These changes resulted in very small increases in current speeds in the lower harbor (maximum increases on the order of 0.1 to .02 ft./sec.) Some areas in the navigation channel show reduction in current speed as a result of the planned Charleston Harbor Post 45 channel deepening, with the largest reductions occurring proximate to the turning basin expansion areas. These increases are attributed to sea level rise that increases the tidal prism of the harbor and rivers causing increased flow during the ebbing and flooding tides.

Existing Condition – Relative Sea Level Change

Climate change has been observed during the 20th and 21st centuries. NOAA bench marks are located in the vicinity of U.S. Custom House, along East Bay Street, and along Broad Street. Based on monthly mean sea level data from 1921 to 2006, sea level in the study area has increased by approximately 1.03 feet over the last 100 years.

Future Without – Project Condition– Relative Sea Level Change

Recent climate research by the Intergovernmental Panel on Climate Change (IPCC) predicts continued or accelerated climate change for the 21st Century and possibly beyond, which would cause a continued or accelerated rise in global mean sea level. Using the USACE Institute of Water Resources (IWR) Sea Level Change calculator spreadsheet the trend at Charleston is estimated to be 3.15 mm/yr (.01033ft/yr) based on CO-OPS gage 8665530. Tidal data from 2012is used for the analysis of existing conditions. Estimating construction completion of the Charleston Harbor Post 45 in 2020, and a 50 year project life, – the rates of change relative to Charleston Harbor are as follows: "low" rate of change is 0.6 feet, the "intermediate" is 1.1 feet and the "high" is 2.8 feet. The two primary concerns related to this 204 study with respect to sea level rise include changing ecotypes in Charleston Harbor system due to rising water levels, and increasing vulnerability of human populations and infrastructure. Salt marshes adjacent to the project area would not be able to shift geographic position inland due to human development, thusly coastal marshes would become deep water habitat with no shallow wetland transition to developed land. Shorelines and erosional zones would shift inland, adversely affecting the quality of human life through flooding and shoreline instability without large scale exclusion projects.

4.2 Water Quality

Existing Condition – Water Quality

The central harbor area is an intertidal estuarine system, characterized by highly variable salinity and dissolved oxygen concentrations. Water quality In Charleston Harbor is classified by SCDHEC as SB, suitable for primary and secondary recreational contact and for the propagation of a balanced indigenous aquatic community of marine fauna and flora, and is considered water quality limited for the purposes of wasteload allocation (WLA) development. Available information on these systems shows that dissolved oxygen concentrations frequently fall below the criteria established for such waters with these excursions usually being observed during high temperature periods. Currently, no sections of the harbor itself is listed in the state 303(d) list as being impaired. A Section 401 Water Quality Certification was issued to the USACE for disposal of dredged material associated with the federal navigation project by the SCDHEC on March 16, 2016. This Certification covers the discharge of dredged material effluent from the existing disposal area outfalls. Special protocols are in place to manage the effluent, including turbidity increases, in an environmentally acceptable manner. Since the dredging and disposal methods have not changed and no new disposal locations have been added, the USACE considers the previous water quality certification to remain valid.

Future Without – Project Condition– Water Quality

Operations and maintenance dredging activities would continue to cause temporary increases in turbidity along and adjacent to the navigation channel when dredging is occurring. Additionally, discharge of effluent from the upland disposal areas will continue during dredging. South Carolina DHEC water quality regulations require that water quality standards not be violated during dredging operations. The Charleston District would continue to maintain the harbor under the existing 401 water quality certification until such a time as DHEC requests new data as a result of a changed condition or new information. The existing 401 certification contains various protective measures and monitoring programs that would continue to ensure compliance with state water quality criteria, however, the predicted change in sea level rise may bring unforeseen changes in water quality for the harbor.

4.3 Avian Habitat

Existing Condition –Avian Habitat

Various areas within Charleston Harbor are utilized by many species of shorebirds for nesting and feeding. Species commonly observed are the American oystercatcher (*Haematopus palliatus*), plovers (*Charadrius sp.*), willet (*Catoptrophorus semipalmatus*), sandpipers (*Scolopacidae*), lesser/greater yellow - legs (*Tringa flavipes/T. melanoleuca*), and gulls/terns (*Laridae*). Shorebirds typically feed by foraging for invertebrates in mud flats and sandy beaches. Foraging activity is usually focused around periods of low tide, where they feed in the intertidal zone. During high tides, shorebirds roost in flocks on the high beach, marsh, and sometimes on docks (Sanders and Murphy 2009). Sanders et al., (2004) stated that the American oystercatcher has been identified as an “extremely high priority” shorebird by the U.S. Shorebird Conservation Plan partly due a decline in suitable beach habitat.

Seabirds tend to nest on small coastal islands in mixed colonies. Seabirds that frequent the South Carolina coast are the sandwich tern (*Thalasseus sandvicensis*), least tern (Sterna albigrons), royal tern (*Thalasseus maximus*), common tern (*Sterna hirundo*), eastern brown pelican (*Pelecanus occidentalis*), Forster’s tern (*Sterna forsteri*), gull-billed tern (*Gelochelidon nilotica*), and black skimmer (*Rynchops nigra*). The least tern is listed as state threatened due to a loss of nesting habitat (Thompson et al 1997). All of the birds are subject to loss of suitable nesting habitat (Murphy et al., 2009). Seabirds usually nest on isolated coastal islands that are high enough to prevent overwashing, yet small enough to not support mammalian predators (Murphy et al 2009). They are picivorous and feed in nearshore and estuarine waters. During the nesting season, foraging occurs within 10 to 15 miles of their nesting sites including the nearshore and estuarine waters of Charleston Harbor.

Migratory birds in South Carolina represent three families: Scolopacidae (sandpipers), Charadriidae (plovers), and Recurvirostridae (avocets). Migrations can span across continents. Migratory shorebirds in South Carolina may be transient on northbound flights in the spring, southbound in the fall, or even wintering birds. Surveys of migrant shorebirds over the last three decades indicate that populations are on the decline (Manomet 2004).

Several features within Charleston Harbor are notable for their importance for local biota. In fact, several sites in or near the harbor are so important for nesting migratory birds, the state of South Carolina has closed them to human access for all or part of the year. The Crab Bank Seabird Sanctuary, which is closed from March 15 to October 15 for the protection of nesting birds and their young, is one of these sites. Typical bird species using these sites include black skimmers, brown pelicans, willet, Wilson’s plover, and various tern species (sandwich, least, royal, common, Forester’s, and gull-billed). The sites are preferred due to both the availability of grounds for nest creation as well as forage, i.e., small fish for supplying the chicks.

SCDNR provided a nesting update for both Crab Bank Island and Shutes Folly Island (email data from SCDNR Wildlife Biologist, 2016) (Table 1). While the data does not necessarily indicate any notable trends related to these two sites, they clearly show the importance of these islands to nesting habitat for seabird nesting. Figure 5 shows birds loafing on Crab Bank Island.

Table 1. Seabird Nesting Numbers for Crab Bank Island and Shutes Folly Island (2009 - 2015)

	2009		2010		2011		2012		2013		2014		2015	
	Crab Bank	Shutes Folly	Crab Bank	Shutes Folly	Crab Bank	Shutes Folly	Crab Bank	Shutes Folly	Crab Bank	Shutes Folly	Crab Bank	Shutes Folly	Crab Bank	Shutes Folly
BLACK SKIMMER	51	112	143	70	53	N/A	79	4	8	58	10	N/A	50	106
BROWN PELICAN	907	74	589	59	722	139	463	N/A	304	35	517	348	647	8
GULL-BILLED TERN	13	89	9	35	42	3	N/A	47	62	N/A	N/A	N/A	9	40
ROYAL TERN	1466	N/A	1032	N/A	2661	N/A	1581	N/A	1140	N/A	1337	N/A	1677	N/A
SANDWICH TERN	6	N/A	N/A	N/A	320	N/A	475	N/A	347	N/A	240	N/A	603	N/A

*NA means no birds of that species were observed at that location that year.

Figure 5. Birds Loafing on Crab Bank Island (Photo source: http://beidlerforest.blogspot.com/2008/09/)

In addition to providing necessary habitats for migratory bird species discussed above, many other species frequent Crab Bank Island and other areas/habitats within and near the project area. These birds roost and forage in surrounding coastal environments such as tidal flats, mud flats, and beaches during the winter months. Species likely to occur are listed in Table 2, along with their associated habitats.

Table 2. Avian Species with the Potential to Occur in the Project Area

Common Name	Scientific Name	Legal Status	SCDNR Priority Ranking	Sand/Beach	Mud - flat	Pond	Salt Marsh	Open Water
American avocet	*Recurvirostra*		High		X	X		
American bittern	*Botaurus*	State	Highest				X	
American coot	*Fulica*		Moderate			X		
*American	*Haematopus*	State	Highest		X	X	X	
Bald eagle	*Haliaeetus*	State	High			X		X

Common Name	Scientific Name	Legal Status	SCDNR Priority Ranking	Sand/Beach	Mud - flat	Pond	Salt Marsh	Open Water
Belted kingfisher	*Ceryle alcyon*		High			X		X
Black rail	*Laterallus*	State	Highest				X	
*Black skimmer	*Rynchops niger*	State	Highest	X		X		X
Black - backed gull	*Larus marinus*			X	X	X		X
Black - bellied plover	*Pluvialis*		High	X	X			
Black - crowned	*Nyticorax*		Highest			X	X	
Black - necked stilt	*Himantopus*		Highest	X	X	X		
*Brown pelican	*Pelecanus*		High				X	X
Clapper rail	*Rallus*		Highest				X	
Common moorhen	*Gallinula*		High			X		X
Common tern	*Sterna hirundo*		Highest	X		X	X	X
Double - crested	*Phalacrocorax*					X		X
Dunlin	*Calidris alpina*		High	X	X			
Foresters tern	*Sterna forsteri*		High	X		X	X	X
Glossy ibis	*Plegadis*		Moderate		X	X	X	
Great blue heron	*Ardea herodias*		Moderate			X	X	
Great egret	*Ardea alba*		High			X	X	
Greater yellowlegs	*Tringa*		High		X	X	X	
*Gull - billed tern	*Sterna nilotica*	State	Highest	X		X		X
King rail	*Rallus elegans*		Highest				X	
Laughing gull	*Larus atricilla*			X	X	X		X
Least tern	*Sterna*	State	Highest	X		X		X
Little blue heron	*Egretta caerulea*	State	Highest		X	X		
Long - billed	*Limnodromus*		Moderate		X	X		
Osprey	*Pandion*					X		X
Piping plover	*Charadrius*	Fed	Highest	X	X			
Red knot	*Calidris canutus*	Fed	Highest	X	X		X	
Ring - billed gull	*Larus*			X	X	X	X	X
*Royal tern	*Sterna maxima*		High	X		X		X
Ruddy turnstone	*Arenaria*			X	X			
Sanderling	*Calidris alba*		Highest	X	X			
*Sandwich tern	*Sterna*		Highest	X		X		X
Semipalmated plover	*Charadrius*		Moderate	X	X			
*Snowy egret	*Egretta thula*		Moderate		X	X		
Sora	*Porzana carolina*		High				X	
Spotted sandpiper	*Actitis macularia*			X	X			
*Tricolored heron	*Egretta tricolor*		High			X	X	
Virginia rail	*Rallus limicola*		High				X	
Whimbrel	*Numenius*		Highest	X	X		X	
*White ibis	*Eudocimus albus*		Highest		X	X		
Willet	*Tringa*		High	X	X			
Wilson's plover	*Charadrius*	State	Highest	X	X			
Wood stork	*Mycteria*	Fed	Highest			X		X
Yellow rail	*Coturnicops*		Highest				X	
Yellow - crowned	*Nyctanassa*		Highest			X		X

**Noted by SCDNR as a species that nests on islands*

Future Without – Project Condition – Avian Habitat

In the FWOP condition, operations and maintenance dredging would continue as well as the deepening of the channels in conjunction with the Post 45 project. Suitable bird nesting habitat would continue to be lost as long term erosion continues. Eventually, these nesting areas would be abandoned for other more suitable sites. Birds would still utilize the area for foraging habitat, however, competition for space would be greater leading to the potential for spread of disease and increased mortality.

4.4 Wetlands

Existing Condition -Wetlands

Wetlands play a vital role in the ecosystem due to their many functions including nutrient retention, wildlife habitat, flood attenuation, nursery habitat, etc. Wetlands within the project area are predominantly polyhaline emergent marshes. These marshes experience average salinities between 18 and 35 parts per thousand. Recent aerial photograph interpretation shows that Crab Bank Island has approximately 1.9 acres of saltmarsh vegetation. The amount of saltmarsh has been decreasing over the years as the size of the island has decreased. While wetlands on Shutes Folly Island are more stable and established than those at Crab Bank Island, there is still a concern with the loss of saltmarsh as sea level rises and erosion of the emergent island occurs. The vegetation is spotty across the approximately 1 mile length of Crab Bank Island. The largest area of marsh is located on the northern portion of the island and is approximately 0.8 acres in size. Emergent saltmarsh also occurs on the west side of Shutes Folly Island.

Surrounding most of the harbor is a fringing area of saltmarsh and mudflats. Saltmarsh vegetation consists of cordgrass species (*Spartina sp.*) and black needlerush (*Juncus roemerianus*). Higher elevation emergent marsh areas contain sea oxeye (*Borrichia frutescens*), salt grass (*Distichlis spicata*), and salt meadow hay (*Spartina patens*). Wetlands around Charleston Harbor provide habitat used by many species of fish and crustaceans for feeding, breeding, and nursery areas. The tidal marshes also contribute important organic materials to the waters.

Future Without – Project Condition – Wetlands

In the FWOP condition, the use of new work material for beneficial use will be limited to those options specified in the Final IFR/EIS, and operations and maintenance dredged material will still be placed in upland disposal sites and the ODMDS and not be employed for any beneficial use in the harbor. Factors such as upstream impoundments, bank stabilization along the shoreline, maintenance dredging, and natural processes contribute to the loss of sediment in the system and may contribute to coastal wetland shifts. Continual maintenance dredging will contribute to removing sediment from the system, some of which may have ultimately built up and created and sustained wetlands on its own absent man-made interference.

4.5 Threatened and Endangered Species

Existing Condition– Threatened and Endangered Species

The Endangered Species Act (ESA) of 1973 (16 USC § 1531–1534) establishes protection and conservation of threatened and endangered species and the ecosystems upon which they depend. USFWS and the NOAA Fisheries Service (NOAA Fisheries) administer the ESA and may designate critical habitat for each species it protects. Under the ESA, an endangered species is defined as a species in danger of extinction throughout all or a significant portion of its range. A threatened species is defined as a species likely to become an endangered species in the foreseeable future. Section 7 of the ESA requires all federal agencies to consult with USFWS or NOAA Fisheries, as applicable, before initiating any action that may affect a listed species. All principal aspects of the new work construction have been previously evaluated in the USACE Biological Assessment and National Marine Fisheries Services (NMFS) Biological Opinion (Appendices F1 and F2 of the IFR/EIS, USACE 2015). USACE has already coordinated with NMFS and USFWS on the beneficial use options for the new work construction of Post 45 project. The species in Table 3 are potentially present near the project area. For more information on these species, please see USACE 2015 and USACE 2017.

Table 3. Threatened (T) and Endangered (E) Species Potentially Present in the Project Vicinity

Common Name	Scientific Name	Status	Date Listed
Marine Mammals			
humpback whale	*Megaptera movaeangliae*	E	12/2/1970
North Atlantic right whale	*Eubalaena glacialis*	E	12/2/1970
West Indian Manatee	*Trichechus manatus*	E	10/21/1972
Turtles			
Kemp's ridley sea turtle	*Lepidochelys kempii*	E	12/2/1970
leatherback sea turtle	*Dermochelys coriacea*	E	6/2/1970
loggerhead sea turtle	*Caretta caretta*	T	7/28/1978
green sea turtle	*Chelonia mydas*	T	7/28/1978
Fish			
Atlantic sturgeon	*Acipenser oxyrhynchus*	E	4/6/2012
Shortnose sturgeon	*Acipenser brevirostrum*	E	3/11/1967
Birds			
American Wood Stork	*Mycteria Americana*	E (proposed for downlisting to "T")	2/28/1984
Piping Plover	*Charadrius melodic*	T	12/11/1985
Rufa Red Knot	*Calidris canutus rufa*	T	1/12/2015
E - Federally endangered	*T - Federally threatened*		

Future Without – Project Condition – Threatened and Endangered Species

Populations are expected to stay status quo during the 50 year study period with little change from their current threatened or endangered status. The FWOP will have only those impacts on T&E species that were identified and handled through formal consultation, as reflected in the Final IFR/EIS for Post 45.

4.6 Benthic Resources

Existing Condition – Benthic Resources

Dominant species in the harbor channels include mollusks, polychaetes, oligochaetes, nematodes, and amphipods (USACE 2006). Populations in the navigation channel are assumed to be not as stable and numerically abundant as the populations found in nearby wetlands and mudflats due to the frequent disturbance by ongoing maintenance.

In support of USACE efforts to understand the sediment composition and benthic composition of potential beneficial use placement areas (Crab Bank Island and Shutes Folly Island), SCDNR performed a transect analysis across the islands to characterize the existing conditions (Tweel and Sanger 2015b). Five transects were established across each island and samples were taken between the subtidal environment across the high point of the island and to the subtidal environment on the other side of the island. The following sections describe the results for each island.

Crab Bank Island – The habitat of Crab Bank Island was generally sandy intertidal and subtidal areas and contained relatively similar macroinvertebrate communities for the most abundant species. The macroinvertebrate community consisted of mostly of polychaetes (Figure 6), particularly *Leitoscolopolos fragilis* and *Streblospio benedicti*. The marsh habitats at the eastern portion of the northern transect contained the greatest overall abundance, mostly of polychaetes and oligochaetes. The middle transect contained the highest crustacean density on the island, and was largely driven by amphipods and isopods. The west side of the middle transect contained high silt/clay content and the bivalve *Petricolaria pholadiformis*. Lower elevation sites tended to contain fine sand or greater, and the higher sites contained a greater proportion of calcium carbonate than the lower sites.

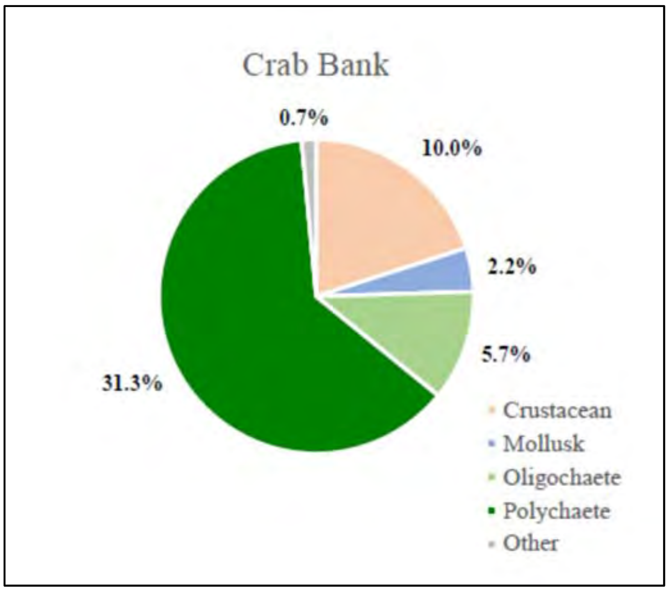


Figure 6. Macroinvertebrate Community of Crab Bank Island

Shutes Folly Island – The habitat of Shutes Folly Island had higher range of elevations and sediment types than on Crab Bank Island, which translated to a greater variety of habitats ranging from salt marsh and subtidal mud flats to supratidal oyster shell deposits. The overall abundance on Shutes Folly Island was much higher (3.6 times) than at Crab Bank Island, and was dominated by crustaceans and oligochaetes (Figure 7). The primary driver of this increased abundance was the high intertidal abundance of crustaceans and oligochaetes in the marsh habitat. The northern transect (Figure 10) was characterized by whole oyster shell. Also, the eastern high point of the island and down to the intertidal sites along each transect were dominated by whole oyster shell. These sites contained relatively low abundance of macrobenthos, but the dominant organism was the isopod Sphaeroma destructor. The western subtidal site was the only site to contain *Brachiodontes exustus* (scorched mussel) and *Crassostrea virginica* (eastern oyster). The middle and southern transects transition from subtidal flats at the eastern end to oyster shell rake and salt marsh and sand flats on the western end. The flats on the western end extend more gradually than on the eastern side of the island. The flats support several live oyster beds in the western embayment. Macrobenthos of the middle transect was dominated by salt marsh organisms such as tanaids, enchytraeids, and the polychaete *Capitella capitate*. The shelly habitats of the eastern side were comprised of isopods, oligochaetwes and the polychaete *Streblospio benedicti*. The southern transect was similar to the middle transect but had more abundance due to the high silt/clay content in the marsh on the eastern side of the island.

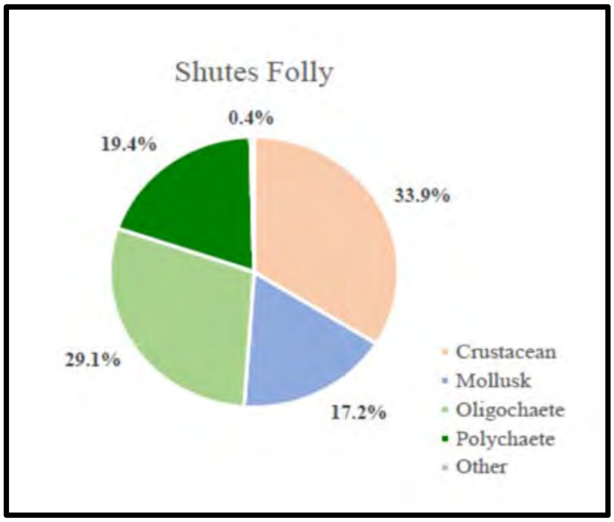


Figure 7. Macroinvertebrate Community of Shutes Folly Island

Future Without – Project Condition – Benthic Resources

In the FWOP condition, benthic community shifts could occur as habitat types are converted from one to another due to natural erosion and accretion processes. Benthic community structure would change in areas of Crab Bank Island, Shutes Folly Island and other areas where erosion is likely to continue in the future. As these areas transition to subbottom habitat and are less exposed to intertidal variation the macroinvertebrate community will change.

4.7 Essential Fish Habitat (EFH)

Existing Condition - EFH

EFH is defined by National Marine Fisheries Service (NMFS) (2004) and approved by the Secretary of Commerce acting through NMFS (50 CFR 600.10) as:

> "*…those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity (MSA § 3(10))*."

The 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson -Stevens Act) set forth a new mandate for the NMFS, regional fishery management councils (FMC), and other federal agencies to promote the protection, conservation, and enhancement of EFH. The EFH provisions of the Magnuson-Stevens Act support one of the nation's overall marine resource management goals to maintain sustainable fisheries.

An EFH Assessment was integrated into the 2017 SEA and was prepared in accordance with the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (MSA 16 U.S.C. 1855 (b)) including the Sustainable Fisheries Act (SFA [16 U.S.C. 1801]) amendment of 1996. The MSA was reauthorized in 2006. The SFA requires identifying habitats needed to create sustainable fisheries and comprehensive fishery management plans with habitat inclusions. The information below summarizes the information from the 2017 SEA. Charleston Harbor supports significant fish and wildlife resources including many marine and estuarine species. The estuary supports large populations of penaeid shrimp and blue crabs, both which are economically important species. Demersal fish species include Atlantic croaker, bay anchovy, Atlantic menhaden, spotted hake, weakfish, spot, blackcheek tonguefish, white catfish, and silver perch. Other fish of commercial or recreational value are commonly found in Charleston Harbor including flounder, red drum, spotted seatrout, bluefish, spot, and black drum. Six anadromous fish species; Atlantic sturgeon, shortnose sturgeon, American shad, blueback herring, hickory shad and striped bass, and one catadromous species, the American eel, use Charleston Harbor and its tributaries as migration routes and spawning areas. The following EFH occur within the beneficial use project areas: tidal wetlands, tidal creeks, oyster reefs, estuarine water column, and intertidal and subtidal mudflats. All of these types are thoroughly described in the EFH Appendix of the Post 45 IFR/EIS and are hereby incorporated by reference (USACE, 2015, Appendix H). Oyster reef habitat around Crab Bank Island and Shutes Folly Island is shown in Figure 8. Species that are managed by either the South Atlantic Fisheries Management Council (SAFMC) or the NMFS are shown in Table 4.

Future Without – Project Condition - EFH

Essential Fish Habitat would immediately remain unaffected in its current state except as identified in the Final IFR/EIS for Post 45. However, as previously discussed, as Crab Bank Island and Shutes Folly Island continue to erode and migrate, there could be less area that is intertidal and more area that is consistently submerged. This could reduce the amount of intertidal marsh in the area. The patchy wetlands on Crab Bank Island would continue to experience temporal changes in size and structure composition as the erosion continues.

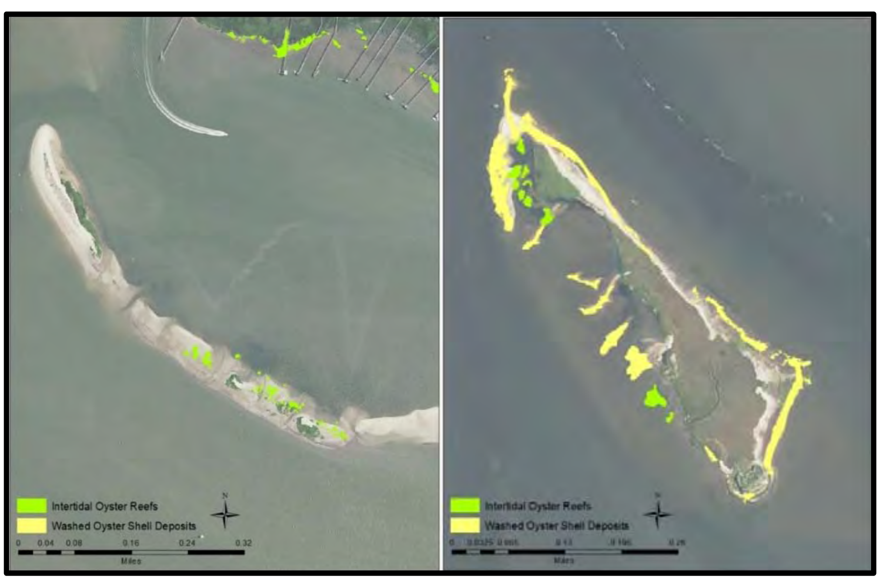


Figure 8. Oyster Reef Habitat at Crab Bank Island (left) and Shutes Folly Island (right)

Table 4. Fishery Management Plans and Managed Species that may occur in the Project Area

Common Name	Species
Shrimp	
brown shrimp	*Farfantepenaeus aztecus*
pink shrimp	*Farfantepenaeus aduorarum*
rock shrimp	*Sicyonia brevirostris*
royal red shrimp	*Pleoticus robustus*
white shrimp	*Litopenaeus setiferus*
Snapper Grouper Complex	
Jack crevalle	*Caranx hippos*
gag grouper	*Mycteroperca microlepis*
black sea bass	*Centropristis striata*
mutton snapper	*Lutjanus analis*
red snapper	*Lutjanus campechanus*
lane snapper	*Lutjanus synagris*
gray snapper	*Lutjanus griseus*
yellowtail snapper	*Ocyurus chrysurus*
spadefish	*Chaetodipterus faber*
white grunt	*Haemulon plumieri*
sheepshead	*Archosargus probatocephalus*
hogfish	*Lachnolaimus maximus*
Coastal Migratory Pelagics	
king mackerel	*Scomberomorus cavalla*
Spanish Mackerel	*Scomberomorus maculatus*
cobia	*Rachycentron canadum*
Mid-Atlantic FMP species which occur in South Atlantic	
bluefish	*Pomatomus saltatrix*
summer flounder	*Paralichthys dentatus*
Federally Implemented FMP	
lemon shark	*Negaprion brevirostris*
bull shark	*Carcharhinus leucas*
blacknose shark	*Carcharhinus acronotus*
finetooth shark	*Aprionodon isodon*
dusky shark	*Carcharhinus obscurus*
bonnethead shark	*Sphyrna tiburo*
Atlantic sharpnose shark	*Rhizoprionodron terraenovae*

4.8 Sediments

Existing Condition – Sediment Quality

Nearly all of the surficial soils in the Charleston area are from the Quaternary Epoch, and overlie Tertiary Epoch strata. The soils generally consist of interbedded sequences of clay, clayey to clean quartz sand, and fossiliferous sand which may be overlain by Holocene peat, silt, clean sand, or tidal marsh deposits (Weems and Lewis, 2002). A detailed description of sediment quality can be found within the IFR/EIS (USACE, 2015), Section 2.4.5. The following sections briefly describe the specific sediment composition within the reaches of the navigation channel proposed for beneficial use options and the areas where sediment will be placed beneficially.

New Work In-situ Channel Sediments

In order to determine the nature of the sediments within the navigation channel, and to build on the sediment sampling/testing work that was performed during the Feasibility Study, 49 additional vibracores were conducted in the lower harbor and entrance channel (see Appendices F and G of the 2017 SEA).

Each vibracore was divided vertically into multiple samples for physical analysis testing. While few of the individual vibracores contained 90% or greater sand over the entire length of the core, many of the cores contained high quantities of sand over the majority of the length of the core in some areas of the lower harbor and entrance channel. The testing revealed substantial quantities of sandy material in the Bennis Reach and Rebellion Reach areas of the lower harbor (see Figure 9). In an Interagency Coordination Team (ICT) meeting on 30 September 2015, USACE discussed that there is a very limited quantity of material in the channel that is 90% sand or greater. The ICT indicated that a threshold of 65% sand would be adequate for various beneficial use projects within Charleston Harbor. Using 65% sand or greater as a threshold for suitable beneficial use material, approximately 1,237,500 cy of material was identified that could be used beneficially.

Regarding the use of O&M material, the District refined the suitable material to the material within the lower harbor and Anchorage Basin. The base plan for dredging in the lower harbor and Anchorage Basin consists of dredging using a clamshell dredge and placement of the material at the ODMDS and dredging using a pipeline cutterhead dredge and placement at the Morris Island Placement Area, respectively. The Charleston District evaluated historic sediment shoaling data for O&M material to determine potential usable material. Based on this assessment, many channel reaches were screened out due to the material having a high silt/clay content. Channel reaches that contained the most suitable material include Hog Island Reach and the Anchorage Basin.

Crab Bank Island and Shutes Folly Island, In-situ Sediments

In support of USACE efforts to understand the sediment composition and benthic composition of Crab Bank Island and Shutes Folly Island, SCDNR performed a transect analysis across the islands to characterize the existing conditions (Tweel and Sanger 2015a, USACE 2017). Five transects were established across each island and samples were taken between the subtidal environment across the high point of the island and to the subtidal environment on the other side of the island.

Sediments and habitat types vary considerably along Crab Bank Island and Shutes Folly Island (Figures 10 and 11, respectively). The dominant grain size on both islands is fine sand. An additional 22% of Crab Bank Island samples were characterized by medium sand, while the same percent of Shutes Folly Island samples tends toward very fine sand. The middle parts of Crab Bank Island were dominated by more silts and clays, and are likely remnants from marsh that occupied this area in the recent past. The largest area of remaining marsh is along at the northeastern shoreline. The southern transect has some of the lowest elevations and sediments were characterized by sand and a larger proportion of $CaCO_3$ than elsewhere on the island. The mean phi size for Crab Bank Island was 2.3 (fine sand). Mean phi size for Shutes Folly Island was 2.7.

Figure 9. Location of Sandy Material in Bennis Reach and Rebellion Reach

Figure 10. Habitat Types along Crab Bank Island

Figure 11. Habitat Types along Shutes Folly Island

Future Without – Project Condition – Sediment Quality

In the FWOP condition, the harbor would continue to be maintained as per current dredged material management practices, including those specified in the Final IFR/EIS for Post 45. Sediments are periodically tested to ensure suitability for upland placement and for ocean placement under Section 103 of the Marine, Protection, Research and Sanctuaries Act. Dredged material from the harbor would be placed within upland and ocean disposal sites and would pose no increased risk to aquatic habitats.

4.9 Coastal Barrier Resources (CBRA)

Existing Condition - CBRA

The Coastal Barrier Resources Act (CBRA) was enacted by Congress in 1982. The CBRA was implemented to prevent development of coastal barriers that provide quality habitat for migratory birds and other wildlife and spawning, nursery, nesting, and feeding grounds for a variety of commercially and recreationally important species of finfish and shellfish. There are several CBRA Zones located near Charleston Harbor, most notably the Morris Island and the Bird Key Complexes. The Morris Island Complex covers Morris Island and portions of James Island. The Bird Key Complex covers the southwest portion of James Island and the northeastern tip of Kiawah Island. The Bird Key Complex Otherwise Protected Area (OPA) covers the southwest tip of Folly Beach.

Future Without – Project Condition

The Coastal Barrier Resources Act (CBRA) zones and otherwise protected areas (OPAs) will continue to be protected without a Section 204 project pending no changes in the current regulations.

4.10 Air Quality

Existing Condition – Air Quality

The U.S. EPA Region 4 and the South Carolina Department of Health and Environmental Control -Bureau of Air Quality (SCDHEC-BAQ) regulate air quality in South Carolina. The Clean Air Act (42 U.S.C. 7401–7671q), as amended, gives EPA the responsibility for establishing the primary and secondary National Ambient Air Quality Standards (NAAQS) (40 CFR Part 50) that set acceptable concentration levels for six criteria pollutants: fine particulate matter (PM10), very fine particulate matter (PM2.5), sulfur dioxide, carbon monoxide, nitrous oxides (NO_x), ozone (O_3), and lead. Short term standards (1, 8, and 24 hour periods) have been established for pollutants that contribute to acute health effects, while long term standards (annual averages) have been established for pollutants that contribute to chronic health effects. On the basis of the severity of the pollution problem, areas that do not attain the standards are categorized as marginal, moderate, serious, severe, or extreme. Each state has the authority to adopt standards stricter than those established under the federal program; however, South Carolina uses the federal standards (USEPA 2009).

EPA has defined Class I areas as those areas designated as pristine or wilderness areas and require more rigorous safeguard to prevent deterioration of the natural pristine air quality. The Cape Romain Wildlife Refuge is the only Class I area located within 200 km of the proposed project. Class III areas are planning areas set aside for industrial growth and EPA sets higher increments in these areas. There are no Class III designations approved for South Carolina and specifically in the project area. Class II areas are all other areas of the state that are not either Class I or III.

The air quality in Charleston and surrounding counties, South Carolina, are designated by SCDHEC-BAQ as an attainment area for all six criteria pollutants. Areas with concentrations of criteria pollutants that are below the levels established by the NAAQS are considered to be in attainment. The ambient air quality for Charleston County, South Carolina has been determined to be in compliance with the NAAQS.

Future Without – Project Condition – Air Quality

There would not be any change to air quality or emissions under the future without project condition scenario other than those identified in the Final IFR/EIS for Post 45.

4.11 Socio-Economics

Existing Condition – Socio-Economics

This section provides information on existing population demographics. An understanding of the socioeconomic conditions in the project area is important to ensure that all Americans are afforded the same degree of protection from environmental health hazards and an equal opportunity to maintain a healthy environment in which to live and work. In addition to NEPA requirements, several Executive Orders (EOs), including EO 12898, Environmental Justice (EJ), and EO 13045, Protection of Children, direct federal agencies to address the potential for proposed actions to disproportionately adversely impact sensitive, low income and minority populations. Environmental Justice includes the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income in the implementation, and enforcement of environmental laws, regulations, and policies. The following sections summarize population and demographic information for the Tri-County region comprised of Charleston, Berkeley, and Dorchester Counties, on a census tract and block group level, and then describe the outreach strategy used during this study.

In 2010, the U.S. Census Bureau estimated that the population of the Tri-County region was 664,607 people, with a density of roughly 257 persons per square mile. Population density varied significantly for the three counties from a low of 162 persons per square mile in Berkeley County, to a high of 382 persons per square mile in Charleston County (US Census Bureau 2010). A one mile buffer around the project footprint was established as the Environmental Justice area of interest.

Based on the Census America Community Survey (2012), the minority population for the Tri-County area is 36.6 percent. The minority population for the project's Environmental Justice area of interest (i.e. census tracts within a one mile buffer of the harbor) is 26.4 percent. As a whole, the area of interest does not meet the CEQ criteria as serving minority populations. However, some individual tracts have higher (up to 89.7 percent) minority populations than the area as a whole (Census America Community Survey 2012). Details of this analysis are provided in the Post 45 Final IFR/EIS.

Future Without – Project Condition – Socio-Economics

The FWOP condition of not performing any beneficial use of dredged material project will not create disproportionately high and adverse human health or environmental impacts on any minority or low income populations.

4.12 Cultural Resources

Existing Condition – Cultural Resources

Cultural resources are defined by the National Historic Preservation Act (NHPA) as prehistoric and historic sites, structures, districts, or any other physical evidence of human activity considered important to a culture, a subculture, or a community for scientific, traditional, religious, or any other reason. Several federal laws and regulations protect these resources, including the NHPA of 1966, the Archaeological and Historic Preservation Act of 1974, the American Indian Religious Freedom Act of 1978, the Archaeological Resources Protection Act of 1979, and the Native American Graves Protection and Repatriation Act of 1990. Documentation of historic/cultural resources is important for this project because Charleston Harbor provides an environment that is rich in prehistoric and historic human activity, and its geological setting is characterized by sediment types, especially heavy muds, that are well known for preserving shipwrecks and their contents.

Section 106 of the NHPA and its implementing regulations, 36 CFR Part 800, requires an assessment of the potential impact of an undertaking on historic properties that are within the proposed project's Area of Potential Effect (APE), which is defined as the geographic area(s) "within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties, if any such properties exist." The APE for the proposed beneficial use actions was determined to consist of the direct action area where construction will be occurring and material placed.

While there are 11 historic areas within Charleston, three properties are of particular concern with respect to this study. These are the Fort Sumter National Monument, the Fort Moultrie National Monument, and Castle Pinckney, located on Shutes Folly Island. These properties are all listed on the National Register of Historic Places (NRHP). All three sites are located along the shoreline of the harbor. At the mouth of the harbor, Fort Sumter is located on the west side and Fort Moultrie is located on the east shore opposite Fort Sumter. Castle Pinckney is located on the southern end of Shutes Folly Island. All shorelines are subject to the tides and sea level rise described in Section 4.1.3. As described in Section 4.1.1, the waves generated by winds and vessels vary depending upon wind direction and distance from the federal channel. These are being assessed under a Programmatic Agreement with the South Carolina State Historic Preservation Officer and the National Park Service for the Post 45 harbor deepening project.

Future Without – Project Condition – Cultural Resources

Without a beneficial use project, the extensive cultural and historic resources of the Charleston Harbor area would continue to be protected under several federal laws and regulations similar to the existing conditions descriptions. The absence of a beneficial use project will not result in the alteration of any historic properties. Erosion of Shutes Folly Island will continue to cause a concern for Castle Pinckney on the south end of the island. An existing revetment provides protection; however harbor islands are constantly in a state of flux and the erosion that has been occurring on the eastern flank will likely continue in the future. Fort Sumter will continue to be battered by waves due to its proximity to the mouth of the harbor.

4.13 Hazardous, Toxic, and Radioactive Wastes (HTRW)

Existing Condition-HTRW

Charleston Harbor is highly developed. There are four SCPA terminals handling containerized, roll on/roll off and breakbulk cargo: North Charleston Terminal which is located over five miles upriver, the Columbus Street and Union Pier Terminals which are in downtown Charleston, and the Wando Welch Terminal which is located on the Wando River. There are two petroleum terminals and one coal terminal in Shipyard Creek. Lastly, there are four petroleum terminals and one grain terminal near the North Charleston Terminal. The eastern edge of the Charleston peninsula is industrialized with the port terminals and various small businesses. Charleston relies heavily on tourism, however, so the majority of the peninsula proper, is not industrial, but is populated with hotels, dining establishments, and retail stores. Two industrial sites, Macalloy and W.R. Grace, have been closed and are being cleaned up as state and/or federal actions. A number of industries are located adjacent to or upstream of the North Charleston terminal. These include the Kapstone paper plant, Bayer Corporation, Amoco, and Nucor steel mill. All of the major storage facilities have confinement areas sufficient to contain any spills and no hazardous or toxic materials or waste have been identified within the project footprint.

Future Without – Project Condition-HTRW

There are no known sources of HTRW that affect the dredging areas. Post 45 construction and continued operations and maintenance dredging would occur within the current navigational channel and dredging of sediments within the channel would continue to be operated in accordance with the most recent 401 water quality certification, dredged material management plan, and 404(b)(1) assessment.

4.14 Floodplains

Existing Condition-Floodplains

Executive Order 11988, Floodplain Management states that federal agencies shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out agency responsibilities. Palustrine freshwater forested wetlands exist at the landward extent of the head of tide and above the saltwater-freshwater interface, which theoretically occurs at the 0.5 ppt salinity boundary. Field et al., (1991) conservatively estimated that there are 40,000 hectares of tidal freshwater forested wetlands in South Carolina. EPA defines these systems as river swamps, and states that, “They are found along rivers and streams of the southeast and south central United States, generally in broad floodplains. These ecosystems are commonly found wherever streams or rivers at least occasionally cause flooding beyond their channel confines.”

Future Without – Project Condition-Floodplains

The FWOP condition would have no impact on the floodplain beyond any identified in the Final IFR/EIS for Post 45.

4.15 Aesthetics and Recreation

Existing Condition–Aesthetics and Recreation

Aesthetic resources are perhaps more difficult to define than aesthetics itself. EPA (1973) stated the following:

> *"A. G. Alexander Baumgarten (1714-62) is credited with coining the word AESTHETIC, in his work Aesthetica (dated 1750), to denote "that branch of science which deals with beauty" (Klien, 1966). Like beauty, then, the word has no clear and agreed-on definition that is operative-it remains a term that designates a vague concept…"*

In the context of large infrastructure projects, aesthetics generally involves personal and subjective evaluations of the acceptability of visual scenes. The subject is often approached in terms of a "viewshed", which is the scene of the proposed project and consequences as viewed from various locations. Since the project involves a large landscape, this section will be addressed from a regional Charleston aspect.

Charleston is a historic seaport. A scenic setting is provided by the harbor and river and the numerous vessels common to these waters, including commercial and recreational boats as well as vessels calling on the Port. The estuarine environment provides opportunities for boating and fishing, as well as an escape from the faster pace of land-based activities. Several boat ramps and marinas are located in Charleston Harbor. Currently, two ecotour companies operate on Shem Creek primarily to rent kayaks and paddleboards or guide trips to Crab Bank Island. Kayak tour companies in SC and other states offer special trips to Crab Bank Island to view nesting birds from the water. Fishing guides take clients by Crab Bank Island to see the birds and photo tours bring clients to Crab Bank Island for numerous photographic opportunities. These activities result in revenue for businesses on Shem Creek. Crab Bank Island also provides educational opportunities. School groups, tourists, fishermen, etc. kayak or boat around the island and can learn about seabird natural history. The island has a video camera, called the "pelicam", that provides a wide audience insight into pelican nesting behavior. This live video can be viewed online and is displayed in the Charleston Aquarium.

Future Without – Project Condition – Aesthetics and Recreation

Impacts to aesthetics and recreation would be anticipated under this scenario. Presently, multiple companies offer ecotours to Crab Bank Island for recreation and for bird watching. Consequently, these companies and others are dependent on Crab Bank's continued existence. As the island continues to erode, opportunities for recreation will decrease. If Crab Bank disappears, the associated recreational activities disappear also. The Coastal Conservation League and the Nature Conservancy have recently installed a bird video camera on Crab Bank Island called the "pelicam". This camera and the contents it shows could be compromised over time under the no action alternative scenario if erosion and migration of the island continues to occur. Shutes Folly and Morris Islands also receive recreational activity. Many people fish in the surrounding areas and potential fishing habitat would be lost if these features disappear.

5.0 PLAN FORMULATION AND ALTERNATIVE EVALUATION

This section discusses problems, opportunities, objectives, and constraints. Based on these problems, opportunities, objectives, and constraints the project delivery team, the sponsors, resource agencies, and interested parties developed a series of restoration alternatives.

5.1 Problems, Opportunities, Objectives and Constraints

For planning purposes, a problem is an undesirable condition that exists or will exist in the future. An opportunity is a chance to create a future, more desirable condition. Problems and opportunities can be viewed as local and regional resource conditions that could be modified in response to public or natural resource concerns. Objectives are generated to describe how the problems could be addressed and to capitalize on the opportunities. Constraints are resource, legal, or policy considerations that limit the range or types of actions that could be implemented.

5.1.1 Problems

As discussed in the existing conditions section, resources within Charleston Harbor are particularly subject to hydrodynamic stresses (waves, tides, and seal level rise) and could have these stresses mitigated through the strategic placement of dredged material. Crab Bank Island, Shutes Folly Island, Fort Sumter, and Fort Moultrie, are all resources of particular significance. Crab Bank Island and Shutes Folly Island are important areas for avian nesting and foraging; Castle Pinckney, Forts Sumter and Moultrie are all listed on the National Register of Historic Places. Currents, storm surge (inundation), wave attack, and sea level change are contributing to changing conditions within Charleston Harbor, leading to the following problems:

- Spatial losses of Crab Bank Island and Shutes Folly Island are reducing avian nesting and foraging areas within the Charleston Harbor,
- Erosion due to system hydrodynamic and human activities is decreasing the size of supratidal beaches and intertidal habitat within the harbor, and
- Historically significant structures within Charleston Harbor are being threatened by erosion from wind generated waves and rising sea level.

Erosion trends for Crab Bank Island show that the size of this feature has reduced from approximately 23 acres in 2000 to an approximate current size of 0.68 acres. For Shutes Folly Island, the projected erosional trend shows that the island outside the Castle Pinkney protected area will disappear within 50 years.

The Fort Sumter National Monument was established in 1948 and listed on the NRHP in 1966. The remnants of this masonry fort, associated with the Civil War defense of Charleston, stand on the south side of the mouth of Charleston Harbor. The outer wall of Fort Sumter was constructed on a foundation consisting of about 6 feet of fitted stone placed over a five to six foot thick mole foundation composed of dumped granite. The most recent placements of stone were in 1969, 1971, and 1972, when material was placed on the Fort's left and right sides, in berms near the dock on the left flank, the Fort's point, and along part of the right flank, up to about elevation 8.5 ft. above mean low water, respectively. Individual stones used in the revetment weighed between 500 and 1500 pounds.

The south and east faces of the fort are particularly exposed to wave action. In a letter to the USACE dated 29 September, 2011, the NPS indicated that there is now a gap in the existing stone breakwater that allows waves to crash directly against the brick masonry, especially at high tide.

Castle Pinckney stands on Shutes Folly Island near the center of Charleston Harbor. This brick fortification was built in 1808-1811 and was listed on the NRHP in 1970. In 2009, a 294 ft. long revetment constructed at an elevation at 7 feet above mean low water was built at a distance of 30 ft. from Castle Pinckney. This project was constructed under Section 14 of the Continuing Authorities Program, with the South Carolina Ports Authority as the non-federal sponsor. The project is currently managed by the Castle Pinckney Historical Preservation Society. This project’s structure protects the eastern, southern, and western sections of the Castle. Shutes Folly Island is now eroding at the northeast end, outside the Section 14 project limits.

5.1.2 Opportunities

The anticipated average annual maintenance dredging needs from the federal channels within Charleston Harbor is approximately 2,400,000 cubic yards. Approximately 1,400,000 cubic yards of this material is intended to be disposed in the EPA designated Charleston ocean dredged material disposal site (ODMDS), and approximately 1,000,000 cubic yards of this material goes to the Clouter Creek Disposal Area.

These annual volumes are expected to increase as a result of channel modifications related to the Charleston Harbor Post 45 Project. In addition to the material that will be dredged through routine maintenance of the harbor, the deepening of the federal channel will necessitate the accommodation of additional dredged material, which is “new work” material. This one-time event will result in an estimated 1.24 million cubic yards of sandy material available for beneficial use.

Based on an evaluation of the existing conditions within the project area the following opportunities have been identified:

- Improve and expand bird habitat within Charleston Harbor,
- Reduce hydrodynamic stresses to existing structures in Charleston,
- Contribute to the goals of the USACE Regional Sediment Management by putting material back into the system,
- Offset losses of supratidal and intertidal habitats in Charleston, and
- Reduce habitat loss and impacts to historic structures to maintain the quality of coastal recreation and ecotourism.

5.1.3 Planning Objectives

Objectives guide the formulation process and assist in evaluating an alternative’s effectiveness. Planning objectives are an offspring of the identified problems and opportunities and represent a desired positive outcome. The following project specific planning objectives and metrics were developed.

- Maintain or increase the spatial area of habitat for all avian life cycles within Charleston Harbor over a 50 year period of analysis, from 2021 to 2070,

- Metric – Acreage of brown pelican habitat as determined by the 1985 Habitat Suitability Index (HSI) model developed by the USFWS.

- Protect existing historic structures within Charleston Harbor from hydrodynamic stressors over a 50 year period of analysis, from 2021 to 2070,
  - Metric – Extend current level of protection on existing structures. For Fort Sumter, this level of protection is at 8.5 feet above mean low water. Castle Pinckney's level of protection is at 7 feet above mean low water.

5.1.4 Planning Constraints

Constraints limit the range of measures that could be implemented to meet the study objectives and may be related to items of resource, legal, or policy origins. The following planning constraints and considerations were developed and will be used in both the formulation, screening, and evaluation of measures and alternatives:

- Avoid plans that require the segregation of materials,
- Avoid plans that depend on continued placement of material,
- Avoid measures or plans that cause or contribute to the increased risk of introducing rodents, snake or other predator populations on bird nesting islands,
- Minimize placement of unsuitable material,
- Avoid the placement of material outside the confines of lower Charleston Harbor,
- Avoid activities that interfere with current navigation operations and practices,
- Avoid non cost effective measures and alternatives, and,
- Consider potential for future human uses of beneficial use areas.

5.2 Measures Considered

5.2.1 Measure Development

A management measure is a feature or activity that can be implemented to address either single or multiple planning objectives. Management measures are either structural or non-structural. ER 1105-2-100–E-15 (d) states that "all dredged material management studies include an assessment of potential beneficial uses for environmental purposes including fish and wildlife habitat creation, ecosystem restoration and enhancement and/or hurricane and storm damage reduction." During the feasibility phase of the Post 45 Charleston Harbor deepening, it was acknowledged that there would be opportunities to explore the possibility of using both O&M material and new work material to address issues within Charleston Harbor. The Post 45 Interagency Coordination Team (ICT) met on April 29, 2013 and discussed potential management measures for using the dredged material. This meeting and the follow up coordination with the ICT addressed using dredged material in Charleston Harbor regardless of material origin, and resulted in a host of general ideas being discussed. Subsequent to the ICT meeting, the PDT developed multiple measures addressing multiple issues around Charleston Harbor.

Between the ICT and the PDT, 31 potential management measures were initially developed. Many of the initial measures developed were either beyond project scope or would not be allowed under CAP 204 authority. In general, the measures focused around the following general concepts:

Enhancing Crab Bank Island

Enhancing Shutes Folly Island

Using rock to create habitat in the entrance channel and near the ODMDS

Creating an offshore bird island

Creating fish attractors

Creating marshes at various locations around Charleston Harbor

Protecting historic structures such as the Morris Island and Fort Sumter

A full list of the measures can be found in Appendix B.

5.2.2 Measure Screening

The initial measures were screened against the planning constraints listed in section 5.1.4. The measures that passed the screening are shown in Table 5 below. Screened out measures and justifications can be found in Appendix B.

Table 5. Measures Screened In

Measure	Description
Measure 1a. Crab Bank Island Enhancement	Place dredged material along the high point of the island and western side towards the navigation channel.
Measure 1b. Crab Bank Island Enhancement	Place material along the south end of the island. The south end is more eroded and at a lower elevation than the northern portion of the island.
Measure 1c. Crab Bank Island Enhancement	Place material on the Mt. Pleasant side of the island to create/expand marsh habitat.
Measure 1d. Crab Bank Island Enhancement	Place material on northwest side of the island to create a shallow sub-bottom habitat.
Measure 1e. Crab Bank Island Enhancement	Use rip rap in combination with dredged material on the western side towards the navigation channel.
Measure 1f. Crab Bank Island Enhancement	Combine plantings with the dredged material placements listed in Measures 1a through 1d for island and habitat creation.
Measure 1g. Crab Bank Island Enhancement	Combine rip rap and plantings with dredged material placements listed in Measures 1a through 1d for island and habitat creation.

Measure	Description
Measure 2a. Shutes Folly Island Enhancement	Create/expand marsh on west side of island.
Measure 2b. Shutes Folly Island Enhancement	Enlarge the eastern frontal sand bank of island that is currently covered in whole dead oyster shell.
Measure 2c. Shutes Folly Island Enhancement	Use rip rap in combination with dredged material on the western side of the island for stabilization.
Measure 2d. Shutes Folly Island Enhancement	Combine plantings with dredged material placements listed in Measures 2a and 2b for habitat creation.
Measure 2e. Shutes Folly Island Enhancement	Combine rip rap and plantings with dredged material placements listed in Measures 2a and 2b for habitat creation.

There are several commonalities among the measures that were successfully screened. All of the remaining measures focus on enlarging or restoring either Crab Bank Island or Shutes Folly Island. While many of the measures screened out would provide ecological benefits, they were not appropriate for this study due to the factors listed in Appendix B or were not implementable under the CAP 204 authority. Another result of the initial screening is that all of the measures that addressed the objective of protecting historic structures within Charleston Harbor were screened out for various reasons. Therefore that objective will not be met as part of this study.

The initial screening also resulted in the elimination of using O & M material for environmental restoration purposes. Many of the initial measures assessed using O & M material, but were eliminated. (see Appendix B). In addition, using the O & M material would not allow the project to meet the objective of maintaining or increasing the spatial area of habitat for all avian life cycles. As Table 6 below shows, the sediment composition of the O & M material in the lower harbor contained little or no sand (ANAMAR, 2010) , which is preferable for avian nesting and loafing activities.

Table 6. Grain Size Analysis of O & M Material

Sample:		CHEC09-COMP	TWCH09-COMP	TCLR09-COMP	HI09-COMP	DI09-COMP	WLR09-COMP	WUR09-COMP	WTB09-COMP
Sample Location		Entrance Channel	Tidewater & Custom House Reach	Town Creek Lower Reach	Hog Island Reach	Drum Island Reach	Wando River Lower Reach	Wando River Upper Reach	Wando River Turning Basin
Sediment Description		CLAY, some silt, little fine sand, gray	SILT, some clay, some fine quartz sand, gray	SILT, some clay, some fine quartz sand, gray	SAND, fine quartz, some clay, little silt, gray	CLAY, some silt, some fine quartz sand, gray	SAND, fine quartz, some clay, little silt, gray	SAND, fine quartz, little clay, few silt, gray	CLAY, some silt, some fine sand, dark gray
Gravel	%	0	0	0	0	0	0	0	0
Coarse Sand	%	0.2	0.2	0.3	0.1	0.8	0	0.2	0

Medium Sand	%	0.3	0.5	0.7	0.3	2.5	6.3	3.9	1.3
Fine Sand	%	14.3	21.3	31.1	64.9	45.8	61.8	79	25
Silt	%	37.7	46.1	35.8	12	22.8	11.6	7.3	28.6
Clay	%	47.5	31.9	32.1	22.7	28.1	20.3	9.6	45.1

In contrast, vibracores collected as part of the 2017 SEA showed that the planned dredge material had a much higher sand content and is more compatible with the projects stated objectives. Because of the higher sand content, only new work material will be used in formulation alternatives.

5.2.3 Formulation of Alternative Plans

All of the measures listed in Table 5 were carried forward and evaluated as stand-alone alternatives. Other measures combined to form alternatives. Some combinations also included planting and armoring features, along with varying volumes of dredged material placement. The strategies to formulate the alternatives were based on location and materials and were designed to:

- Formulate alternatives for areas that have a public interest,
- Formulate alternatives that increase fish/wildlife habitat within Charleston Harbor, and
- Formulate alternatives so that the dredged material used is compatible with in situ material.

For each of these strategies larger areas were targeted for restoration as it resulted in more cost efficient transport and placement of material and provided greater environmental benefits. In general, the resultant alternatives can be catalogued in three groups:

No Action Alternative – The National Environmental Policy Act (NEPA) requires the USACE to consider the option of "no action" as one of the alternatives. No action assumes that no project would be implemented by the federal government to achieve planning objectives. No action, or the "without project condition", forms the basis from which all other alternative plans are measured. Under the no action plan, the USACE would not consider any beneficial uses of dredged material as alternatives to placement of the dredged material at the normal O&M or base plan locations of upland confined disposal sites or the ODMDS as shown in Figure 2.

Crab Bank Island Shoreline Protection / Bird Island Enhancement

These alternatives involve placing new work material along the harbor side of Crab Bank Island, and are analyzed with respect to the amount of material used and fill configuration. Several Crab Bank Island alternatives incorporate plantings and/or rip rap as features to provide additional stabilization. The Crab Bank Island alternatives were evaluated as both stand-alone alternatives and combined with Shutes Folly Island for additional alternatives.

With respect to configuration, several footprints on Crab Bank Island were configured that used the same volume of material but had different footprints. The footprints differed with respect to shape and height within the historical footprint in an attempt to optimize avian habitat. The alternative plans formulated for this study are in Table 8 below.

Shutes Folly Island Protection

These alternatives involve using new work material along the harbor side of Shutes Folly Island and are analyzed with respect to the amount of material used and incorporates plantings and/or rip rap as features to provide additional stabilization. In addition several reaches of Shutes Folly Island are too steep to successfully place dredged material on and the area that can be enlarged is limited in size and cannot accept even half of the anticipated material that will be available.

5.2.4 Evaluation of Alternative Plans

Alternatives were evaluated using to the four criteria described in the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G):

- **Completeness** – the extent to which the alternative or alternative plans provide and account for all the necessary investments or other actions to ensure the realization of the planning objectives,
- **Effectiveness** – the extent to which the alternative or alternative plans contribute to achieve the planning objectives,
- **Efficiency** – the extent to which an alternative or alternative plan is the most cost effective means of achieving the objectives, and,
- **Acceptability** – the extent to which the alternative or alternative plans are acceptable in terms of applicable laws, regulations and public policies.

Evaluating against this criteria should result in plans that should, to the greatest extent possible, meet the planning objective of maintaining or increasing the amount of avian habitat in lower Charleston Harbor. An evaluation of the alternatives using the P&G criteria can be found in the Plan Formulation Appendix (Appendix B).

5.2.4.1 Alternatives Using Rip-Rap

Several of the alternatives listed use rip rap in combination with dredged material. While these alternatives would provide better stability and enhance project life, the costs of using the rip rap exceed the cost limit of Section 204 of the Continuing Authorities program. Project rip rap costs for various arrangements for both Crab Bank Island and Shutes Folly Island are shown in Table 7 below and detailed costs can be found in Appendix A.

Table 7. Cost Ranges of using Rip Rap for Crab Bank Island and Shutes Folly Island

Features	Armoring Cost Ranges
Crab Bank Island Rip Rap Features	$12,227,530 - $ 15,018,530 - $ 17,251,799
Shutes Folly Island Rip Rap Features	$ 8,307,217 - $ 11,643,397 - $ 12,297,496

The above costs are only for the purchase and installation of the rip rap. The cost ranges are based on the potential size of the project based on available dredged material. This is above the costs of using any dredged material. Therefore any alternative that uses rip rap more than triples the cost and would have permanently eliminated a significant amount of intertidal habitat at Crab Bank. Such that the cost would have exceeded the 204 CAP limit due to mitigation requirements.

5.2.4.2 Evaluation Criteria Results for Alternative Plans

A summary of the evaluation criteria results can be found in Table 8 below. Alternatives 1a, 1f, 2b, and 2d met the criteria evaluation and are carried forward. The remaining alternatives involve using new work dredged material to enlarge Crab Bank Island or Shutes Folly Island.

Table 8. Outcomes of Evaluation Criteria

Alternative	Completeness	Effectiveness	Efficiency	Acceptability	Carried Forward
Alternative 1a. Crab Bank Island Enhancement	Yes	Yes	TBD	Yes	**Yes**
Alternative 1b. Crab Bank Island South End Enhancement	No	No	TBD	Yes	No
Alternative 1c. Crab Bank Island Salt Marsh Enhancement	No	No	TBD	Yes	No
Alternative 1d. Crab Bank Island Sub-bottom Habitat Enhancement	No	No	TBD	Yes	No
Alternative 1e. Crab Bank Island Enhancement with Rip Rap	Yes	Yes	TBD	Yes	No
Alternative 1f. Crab Bank Island Enhancement with Plantings	Yes	Yes	TBD	Yes	**Yes**
Alternative 1g. Crab Bank Island Enhancement with Rip Rap and Planting	Yes	Yes	TBD	Yes	No
Alternative 2a. Shutes Folly Island Enhancement- Enhance Marsh Habitat	Yes	Yes	TBD	No	No
Alternative 2b. Shutes Folly Island Enhancement	Yes	Yes	TBD	Yes	**Yes**
Alternative 2c. Shutes Folly Island Enhancement with Rip Rap	Yes	Yes	TBD	Yes	No
Alternative 2d. Shutes Folly Island Enhancement with Plantings	Yes	Yes	TBD	Yes	**Yes**
Alternative 2e. Shutes Folly Island Enhancement with Rip Rap and Planting	Yes	Yes	TBD	Yes	No

5.2.5 Optimizing the Alternatives

The maximum volume of available material is potentially 1,250,000 cubic yards assuming all of the allowable advanced maintenance. 825,000 cubic yards of material is available volume based on a 52 foot construction channel plus two feet of advance maintenance and none of the additional allowable overdepth. The remainder of the material results from potential additional overdepth dredging of two feet, for a total potential depth of 56 feet. The island sizes are based on the volume of dredged material (assuming a 20% loss of dredged material) to provide a low, medium, and high volume for each location (Figures 12-15 for Crab Bank Island and Figures 16-18 for Shutes Folly Island).

Figure 12. Crab Bank Island Footprint at 660,000 cy of Dredged Material (Crab Bank Island Medium)

Figure 13. Crab Bank Island Footprint at 660,000 cy of Dredged Material (Crab Bank Island Medium A) **(This footprint is more compressed than either Crab Bank Island Medium or Crab Bank Island Medium B.)**

Figure 14. Crab Bank Island Footprint at 660,000 cy of Dredged Material (Crab Bank Island Medium B) **(This footprint is similar to Crab Bank Island Medium, but has been shifted down, not covering the northern tip of the island)**

Figure 15. Crab Bank Island Footprint at 990,000 cy of Dredged Material (Crab Bank Island High)

Figure 16. Shutes Folly Island Footprint at 100,000 cy of Dredged Material (Shutes Folly Island Low)

Figure 17. Shutes Folly Island Footprint at 196,000 cy of Dredged Material (Shutes Folly Island Medium)

Figure 18. Shutes Folly Island Footprint at 296,000 cyof Dredged Material (Shutes Folly Island High)

Full sized pictures of each alternative footprints can be found in the Appendix. A refined array of the various scales of the alternatives were determined. This array provides for three island sizes for both Crab Bank Island and Shutes Folly Island, based on the amount of material available, and examines the use of plantings.

In addition to the volumes and footprints shown above, Appendix A also includes discussions regarding the placement of 330,000 cy of material on Crab Bank Island. This option was eliminated from analysis because using this amount of material would not result in a lasting solution, when defined as island size being the same as or greater than the present island size after the 50-year project life. Additionally, it should be noted that the combination of Shutes Folly Island High and Crab Bank High footprint are not feasible due to the limited amount of quality material available, as discussed in Appendix A, and therefore not included in the final array.

5.3 Ecological Outputs and Habitat Suitability Index

Environmental Benefits Assessment (EBA) is used to measure the increase in both the quality and quantity of a targeted ecosystem due to various proposed restoration measures and alternatives at a site. For the Charleston Harbor 204 study, quality was measured in terms of a habitat suitability index (HSI). The HSI is multiplied by the number of acres being restored in order to generate a “habitat unit (HU)” as output. The greater the number of Habitat Units the greater the ecological benefit.

HSI models are approved for use by the USACE Ecosystem Planning Center of Expertise. The US Fish and Wildlife Service Blue Book series of models was developed to provide habitat information for evaluating impacts on fish and wildlife habitat from water or land use changes (Schamberger et al., 1982). The models reference numerous literature sources in order to consolidate scientific information on species habitat relationships. All models are based on a numerical index of habitat suitability on a 0.0 to 1.0 scale, with 1.0 being the best habitat (Schamberger et al., 1982). Their purpose is to serve as a basis for improved decision making and increased understanding of habitat relationships (Schamberger et al., 1982).

The project delivery team evaluated the various HSI's available to use and the following HSI's were most applicable to quantifying benefits to avian species for this project: least tern, Forster's tern, laughing gull, and eastern brown pelican. Of these the most applicable is the eastern brown pelican. The eastern brown pelican HSI captures the majority of environmental benefits from the proposed project. Of the models that were considered for use in this study none captured benefits as well as the eastern brown pelican HSI. The benefits not captured are small and are generally the same across alternatives. Modeling of intertidal habit was not conducted as part of this study. The quality of the intertidal habit is expected to be virtually identical before and shortly after construction.

The brown pelican, while plentiful now, was previously on the endangered species list. While it was removed from the endangered species list in 2009, it is still protected in SC. It has a SC priority species ranking of high in the South Carolina State Wildlife Action Plan (http://dnr.sc.gov/swap/main/chapter2-priorityspecies.pdf). The island is so important to the brown pelican that the Coastal Conservation League, a local non-profit, dedicated to protecting natural habitats, installed a video camera to view the brown pelican and other bird nesting on the island (http://coastalconservationleague.org/pelicam/).

5.3.1 Habitat Suitability Index (HSI) Model.

The eastern brown pelican HSI model is intended for use in the habitat evaluation procedures (HEP) developed by the USFWS for impact assessment and habitat management (Hingtgen, et. al. 1985). The brown pelican HSI has 4 variables. The model can be used to evaluate estuarine island habitat, natural islands, and dredge material islands within the breeding range, which includes the Charleston Harbor area. The HSI is designed to model nesting and loafing cover for the animal and the habitat variables that support this life requisite. Habitat suitability is determined based on the four variables for nesting/loafing habitat (Figure 19). The complete model can be found in Appendix D.

5.3.1.1 Determining Island Size (Variable 1)

The first variable of the brown pelican HSI model accounts for the area of the island that is above 2ft. MHW (i.e., 4.27 ft. NAVD 88) contour, which is considered the area suitable for brown pelican nesting habitat. HSI scores were calculated for each alternative based on the acreage above 2.4 ft. MHW at construction. The HSI model dictates what elevations at MHW constitute nesting habitat, and this number was used for island size.

Expected erosion of the island over the 50-year life of the project was also calculated and HSI scores were determined for each alternative at the end of project life. The natural erosion rate of the island was determined by comparing the change in island size from 2000 through 2016 (see Appendix A for details.)

5.3.1.2 Determining Distance from Mainland (Variable 2)

This variable was determined by approximating the straight line distance from the closest point of the islands to the mainland approximate high ground. The distances are the same for all Crab Bank Island alternatives as well as all Shutes Folly Island alternatives. For Shutes Folly Island, all alternatives would be approximately 0.9 km away from the mainland of downtown Charleston. For Crab Bank Island, all alternatives would be approximately 0.5 km away from the high ground at Patriot's Point. Because of this all alternatives received an HSI score of 1.0 for this variable.

5.3.1.3 Determining Distance from Nearest Human Activity Center (Variable 3)

This variable was determined by approximating the straight line distance from the closest point of the islands to the nearest center of human activity. Charleston Harbor is an active sea port and is heavily used by recreational and commercial vessels. However, since Crab Bank Island and Shutes Folly Island are currently protected from human activity during bird nesting season, the distances were determined to be to a more definite center of activity versus the adjacent Charleston Harbor waterbody. The distances are the same for all Crab Bank Island alternatives as well as all Shutes Folly Island alternatives. For Shutes Folly Island, all alternatives would be approximately 0.9 km away from the mainland of downtown Charleston where heavy urban activity occurs. For Crab Bank Island, all alternatives would be approximately 0.5 km away from the mouth of Shem Creek, which is a popular location for recreational boaters, commercial shrimp vessels, and commercial activities such as restaurants and businesses. The distances from the nearest human activity will not change regardless of the alternative. Because of this, the HSI score for this variable is consistent for all the alternatives. Within the HSI documentation it is indicated that the distance from mainland is the point of concern. "Eastern brown pelican nesting colonies occur on coastal islands small enough to be free from human habitation and recreation and far enough from the mainland to be inaccessible to potential mammalian predators (Schreiber 1979;Williams 1979)". The distance from the mainland is key as it serves to limit access to nest by predators such as rats and raccoons. Additionally, SCDNR restricts all visitation to Crab Bank during the bird nesting season to ensure nesting birds are not disturbed. Crab Bank can be accessed by the public outside the nesting season.

5.3.1.4 Relative Cover of Nesting Vegetation (Variable 4)

In South Carolina, brown pelicans are ground nesters. The HSI model defines this variable for South Carolina as the amount surface area at least 2 ft. in surface elevation. This translates to an elevation of 7.4 ft. MLLW. Since island size is calculated as acreage above 7.4 ft. MLLW, and that island size is consistently reflected in the erosion rates, the PDT used 100% of the island above 7.4 ft. MLLW all the time. This acreage equates to the acreage of nesting vegetation not the total nesting acreage.

5.3.2 Computation of Habitat Suitability Index

The alternatives being evaluated all involve enlarging Crab Bank Island and Shutes Folly Island and then letting those features erode naturally. Erosion rates, acreage of pelican habitat, and subsequent HSI values were calculated for each year over the life of the project. HSIs at construction and at the end of the project life are shown in Table 10 below.

All of the alternatives being evaluated will enlarge the existing features and will result in the features remaining at the end of the project's life.

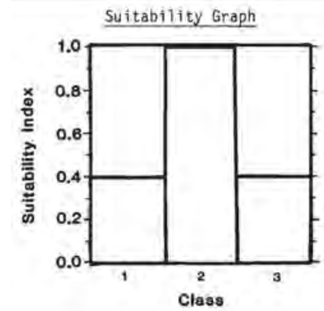
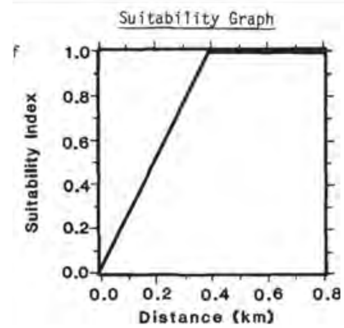
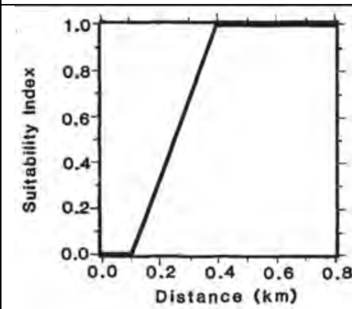
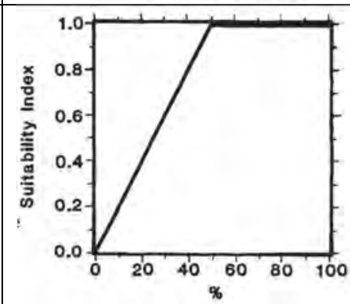
HSI Variables for Suitability for brown pelican nesting/loafing		
Variable	Data Source/Measurement	HSI Graph
V1 Island size	Measure the acreage of the island 2 feet above Mean High Water	
V2 Distance from mainland	Measure straight-line distance from mainland shore to island shore at low tide.	
V3 Distance from nearest human activity center	Measure straight-line distance from closest area of any center of human activity to the colony island.	
V4 Percent of Vegetation Coverage	Calculate percent of vegetation relative to surface area.	

Figure 19. HSI Variables for Suitability for Brown Pelican Nesting/Loafing

5.3.3 "Base Plan" Cost

Under the Section 204 Authority, costs of beneficial use of sediment projects are limited solely to project costs that are in excess of the "base plan" or the least cost environmentally acceptable disposal costs without the project. As a result, the costs used for evaluation and comparison purposes are the incremental first costs of the potential ecosystem restoration construction over the first cost associated with disposing of the sediments as described in the base plan.

Under the base plan for dredging of new work materials from Bennis and Rebellion Reaches during the construction of the Post 45 Project, materials would be excavated with a clamshell dredge. The clamshell would place materials within a scow, which would then be transported offshore to the ODMDS where it would be bottom dumped. The base plan cost was calculated as the amount of material to be dredged for each refined alternative multiplied by the unit cost for placement at the ODMDS (Table 9). Details on the methods used to determine base plan costs can be found in Appendix A.

5.3.4 Cost Analysis of Alternatives

After determining the base cost plan for each alternative, the project delivery team determined the costs associated with using that material to construct each of the alternatives. As previously described, these costs factored in the placed amount of material and the amount of material that would need to be dredged to achieve that placement yardage, with an assumed 20% loss of material. The construction methods are discussed in detail in the SEA. The cost factored in the mobilization cost and demobilization cost for additional equipment. These cost estimates do not account for contingency or inflation as shown in the fully funded costs of the recommended plan of Appendix A. These costs estimates utilized for the cost analysis is reflected in Table 9.

As previously stated, the costs used for evaluation and comparison purposes are the incremental first

costs of the potential ecosystem restoration plans construction over the cost associated with disposing of the sediments as described in the Base Plan. Table 9 demonstrates the incremental cost difference for each alternative.

Table 9. Construction Cost (incremental cost difference) for each Alternative.

Alternative	Total Cost of Alternative	Total Base Plan Cost	Delta Cost
Crab Bank Island High	$8,949,600	$5,568,750	$3,380,850
Crab Bank Island Medium (all Medium footprints)	$6,600,000	$3,712,500	$2,887,500
Crab Bank Island Medium A- Shutes Folly Island High	$9,470,240	$5,400,000	$4,070,240
Crab Bank Island Medium A - Shutes Folly Island Medium	$8,722,240	$4,815,000	$3,907,240
Crab Bank Island Medium A - Shutes Folly Island Low	$7,786,300	$4,275,000	$3,588,000

5.3.5 Cost Effectiveness and Incremental Cost Analysis (CEICA)

Benefit-cost analysis is generally considered the "best case scenario" for water resources plan evaluation. In benefit-cost analysis, the monetary cost of a plan is subtracted from the monetary value of the benefits to be provided by that plan to compute net benefits. When there is a range of alternative plans, the plan that provides the most net benefits is typically the recommended plan. When project benefits aren't measured in dollars, cost effectiveness and incremental cost analyses offer the next-best approach for plan evaluation. While the cost effectiveness and incremental cost analyses of alternative plans may not identify a unique or "optimal" solution, they lead to better-informed choices. Cost effectiveness analysis and incremental cost analysis weigh the costs of restoration and mitigation plans against nonmonetary measures of output. Such evaluation is at the heart of the analyses and is the basis for their application in environmental planning.

Cost effectiveness analysis can assist in the formulation of cost effective alternative plans, and can also be used to screen out plans that are not cost effective from further consideration. Incremental cost analysis reveals changes in costs as levels of environmental outputs increase. In the absence of a common measurement unit for comparing the non-monetary benefits with the monetary costs, cost effectiveness and incremental cost analyses are valuable tools to assist in decision making. The Shutes Folly Island alternatives were not evaluated on a stand-alone basis because the island is not as threatened as Crab Bank Island.

Proper use of cost effectiveness and incremental cost analyses can help decision makers allocate limited resources more efficiently and avoid the selection of economically irrational plans. The analysis results are displayed in Table 10 and Figure 20 below were used in the comparison of alternatives and indicate if the next incremental step is justified by the expense. Crab Bank Island Medium A and Crab Bank Island Medium A with Plantings were determined to be the "best buy" alternatives. While all Crab Bank Island Medium alternatives use the same volume of material, the differing configurations result in differing topography and island height. The Medium A alternative is more compact than the other two Medium alternatives resulting in greater overall height with more "high spots" for nesting.

Table 10. Average Annual Costs, Outputs, and Cost Effectiveness Summary

Alternative Name	Cost	Average Annual Output	Volume of Material Placed (cy)	Initial Pelican Habitat (Acres)	Pelican Habitat (all types) After 50 Years (Acres)	H S I At Construction	H S I at 50 Years	Average Annual Cost (50yrs@ 2.75 %)	Cost Effective?
No Action Plan	$0	0	0	0.93	0	0.795271	0	$0	**Best Buy**
Crab Bank Island High	$3,380,850	0.863514	990,000	47.40	1.06	0.795271	0.795271	$133,142	No
Crab Bank Island Medium	$2,887,500	0.823317	660,000	28.40	0.64	0.795271	0.795271	$114,764	No
Crab Bank Island Medium A	$2,887,500	0.871542	660,000	27.80	0.64	0.795271	0.795271	$114,764	**Best Buy**

Alternative Name	Cost	Average Annual Output	Volume of Material Placed (cy)	Initial Pelican Habitat (Acres)	Pelican Habitat (all types) After 50 Years (Acres)	H S I At Construction	H S I at 50 Years	Average Annual Cost (50yrs@ 2.75 %)	Cost Effective?
Crab Bank Island Medium B	$2,887,500	0.867528	660,000	31.4	0.70	0.795271	0.795271	$114,764	No
Crab Bank Island High w Planting	$3,760,650	0.795271	990,000	47.40	23.54	0.795271	0.795271	$147,290	No
Crab Bank Island Med w Planting	$3,215,500	0.872746	660,000	28.40	14.10	0.795271	1	$126,982	No
Crab Bank Island Med A w Planting	$3,215,500	0.899643	660,000	27.80	13.81	0.795271	1	$126,982	**Best Buy**
Crab Bank Island Med B w Planting	$3,215,500	0.867528	660,000	31.40	15.59	0.795271	1	$126,982	No
Shutes Folly Island High	$1,492,840	.784619	296,000	16.65	0	1	0	$62,811	No
Shutes Folly Island Medium	$1,284,840	.772576	196,000	11.80	0	1	0	$55,063	No
Shutes Folly Island Low	$944,000	.662957	1,000,000	6.75	0	1	0	$42,366	No
Shutes Folly Island High w Planting	$1,727,740	1	296,000	16.65	8.27	1	1	$74,561	No
Shutes Folly Island Med w Planting	$1,505,140	1	196,000	11.80	5.86	1	1	$63,269	No
Shutes Folly Island Low w Planting	$1,116,800	.795271	100,000	6.75	3.35	.795271	.795271	$7,435	No

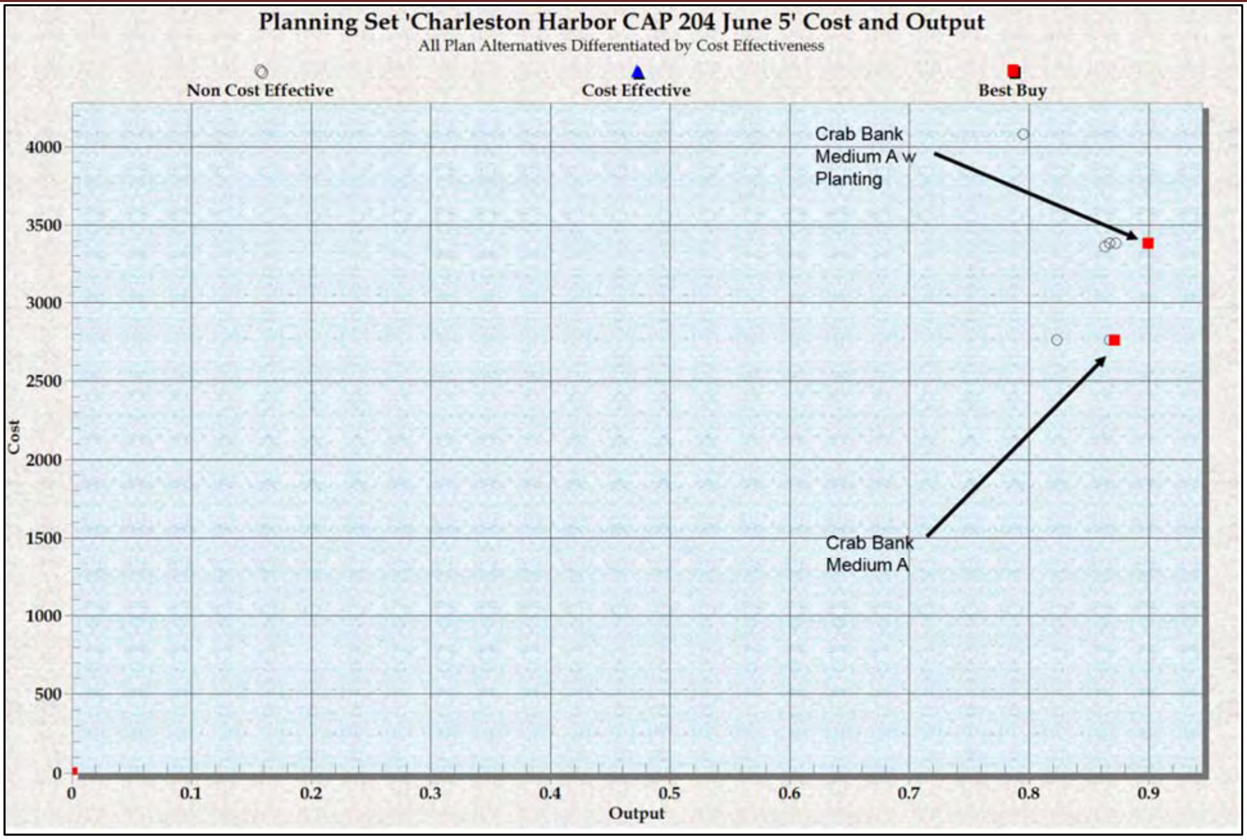


Figure 20. Relationship between Average Annual Cost (Cost) and Average Annual Habitat Units (Outputs) for each Alternative

5.4 Comparison of Alternative Plans

5.4.1 Analysis of Best Buys

Based on the cost effectiveness and incremental cost analyses, the “best buy” alternatives, the no action plan, Crab Bank Island Medium A and Crab Bank Island Medium A with Plantings were carried forward for a more detailed comparison.

The no action plan can be eliminated as this does not meet any of the project objectives within the period of analysis. Implementing the no action alternative will result in the loss of Crab Bank Island as avian habitat. Recent report of shore bird eggs from Crab Bank Island washing up onto Sullivan’s Island (See May 25, 2017 news article in Appendix E) are evidence of how quickly Crab Bank Island is disappearing and how this will impact local avian populations.

Crab Bank Island Medium A will use material resulting from the deepening of the Bennis and Rebellion reaches to their new authorized depth to reestablish Crab Bank Island. The plan will result in approximately 52.8 acres being added onto the existing island, resulting in a new island that will be approximately 79.4 acres in size. This plan will result in Crab Bank Island having 27.8 acres of new brown pelican nesting habitat. At the end of the project’s life, it is estimated that Crab Bank Island will be approximately 15.25 acres in size with 0.64 acres of brown pelican nesting habitat remaining. The material being placed on the island is assumed to have 15H: 1V slopes. The top of the new material will not be smoothed, but will be intentionally arranged to undulate, leaving both peaks and troughs to accommodate multiple avian species' needs and life cycles. Accounting for volume loss during transport and deposition, approximately 660,000 cy of material will be placed. The new island will be configured as shown in Figure 21 below.

Crab Bank Island Medium A with Planting will use the material resulting from the deepening of the Bennis and Rebellion reaches to their new authorized depth to reestablish Crab Bank Island. The plan will result in approximately 52.8 acres being added onto the existing island, resulting in a new island that will be approximately 79.4 acres in size. This plan will result in Crab Bank Island having 27.8 acres of new brown pelican nesting habitat. At the end of the project's life, it is estimated Crab Bank Island will be approximately 13.8 acres in size with 0.70 acres of brown pelican nesting habitat remaining. The material being placed on the island is assumed to have 15H: 1V slopes. The top of the new material will not be smoothed, but will be intentionally arranged to undulate, leaving both peaks and troughs to accommodate multiple avian species' needs and life cycles. Accounting for volume loss during transport and deposition, approximately 660,000 cy of material will be placed. The new island will be configured as shown in Figure 21 below.

Figure 21. Footprint of Recommended Plan, Crab Bank Island Medium A.

Crab Bank Island Medium A with planting optimizes the Crab Bank Island Medium by supplementing the placement of dredged material with marsh plants to stabilize the material. Conceptually, this entails planting vegetation on top of the dredged material at the upper range of the intertidal zone (Figure 22). Plantings would be a combination of *Spartina alterniflora and Juncus roemerainus.* While it was recognized that any plantings would need to be protected, no definite protection method was initially identified.

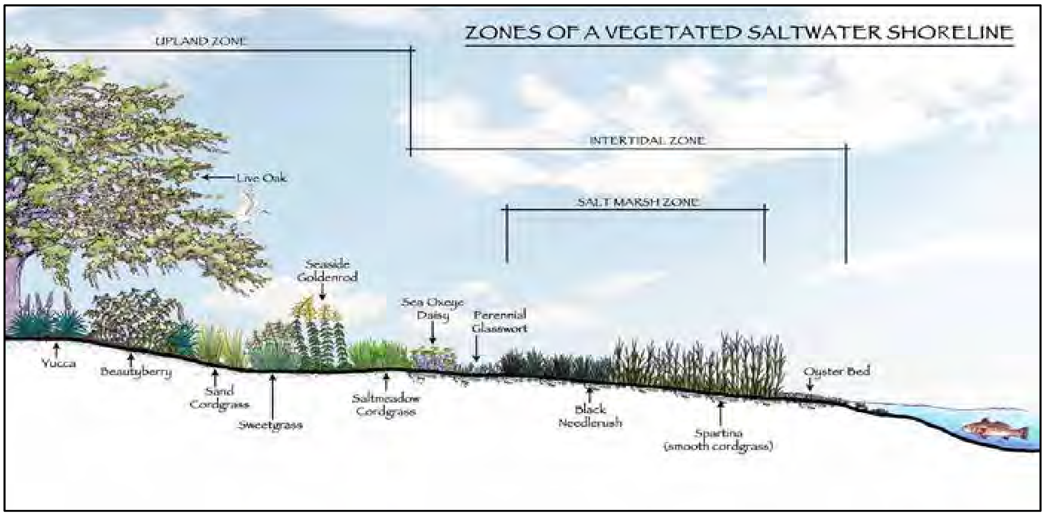


Figure 22. Conceptualized Planting Zone for Crab Bank Island

Priest (2017) developed evaluation criteria to determine the appropriateness of constructing living shorelines (Table 11). This approach provides guidance in analyzing alternative approaches to successful planting methods. Based on this criteria, Crab Bank Island is a medium energy environment, and a sill system would be necessary to successfully establish plants. Shoreline plantings alone are not technically feasible as this alternative would only be acceptable in low energy environments. Therefore, some form of toe protection is necessary. Common toe protection includes (Priest 2017):

Coir logs – Coir logs are usually made of coconut fibers. These features provide support only long enough for the plants to be established. As such, this feature is considered a temporary measure and may not last more than one or two years. In addition, coir logs are not suitable for medium energy environments such as Crab Bank Island.

Bagged oyster shells – Bagged oyster shells have been used for sill construction in low energy systems. Oyster shell, however, is a limited resource in South Carolina, there is not enough available to construct a sill, even if the wave climate was favorable.

Rock Sills – Rock sills are usually used in medium energy environments, and are typically granite or some such similar rock. Material must be placed versus being simply dumped, and should have some underlying filter fabric underneath. Rock size and sill height is a function of physical oceanographic factors of the environment in question. Rock size must be sized to withstand wave energy. The larger the fetch, the larger the rock is needed.

Table 11. Living Shoreline Site Evaluation Criteria

Parameter	Criteria Value			Score	Comments
	1	2	3		
Storm surge	2′	2′–4′	>4′	3	The storm surge of a Category I storm at Sullivan’s Island is 7.6 ft.
Fetch	<0.5 mi	0.5–1 mi	1–5 mi	3	The longest fetch at Crab Bank Island is approximately 3.5 miles.
Bank height	<3′	3′–6′	>6′	2	In 2016, the maximum elevation on Crab Bank Island was 3.6 ft. above msl.
Bank condition	Stable	Transitional	Eroding	3	Crab Bank Island is eroding.
Nearshore depths	<1′	1′–2′	>3′	3	Depths vary. The 4 ft. contour (MLLW) approaches the impacted shoreline.
Sediment type	Mud	Mud/sand	Sand	2	Sediment to be used is 65% sand.
Tide range	1′–2′	2′–4′	>4′	3	Tidal Range for Charleston Harbor is approximately 5.5 ft.
Erosion rate	1′	2′	>3′	3	Rate greater than 3 ft/yr.
Shoreline orientation	South	East or west	North	2	Crab Bank Island’s impacted shoreline faces west.
Shoreline configuration	Cove	Linear	Point	2	Crab Bank Island is basically linear.
Infrastructure proximity	>100′	50′–100′	<50′	1	No infrastructure proximate.
Width of waterway	>300′	300′–100′	<100′	1	Waterway is over 2 mi in width.
Buffer condition	Lawn	Natural grasses	Forest	NA	No buffer on Crab Bank Island.
Total score				**28**	
13–18		Low energy, trim trees and plant marsh			
19–32		Medium energy, sill system			
33–39		High energy, breakwater system			

Wave analysis produced as part of the Post 45 study reports that the fetch at Crab Bank Island is 3.5 miles when subject to the prevailing winds. As such, larger rip rap is necessary for sill construction. Sill construction on Crab Bank Island would require an estimated 112,301 tons of stone, at an additional cost of $ 7 million. While evaluating the alternatives through the Cost Effective/Incremental Cost Analysis. CE/ICA analysis, it was not yet determined that rock sills were necessary to provide protection to any Harbor side, intertidal plantings. The addition of rock more than triples the cost and would have permanently eliminated a significant amount of intertidal habitat at Crab Bank. Such that the cost would have exceeded the 204 CAP limit due to mitigation requirements.

6.0 Recommend Plan

6.1 Plan Description

The tentatively selected plan is Crab Bank Island Medium A (Figure 21). The plan involves using new work dredged material from Bennis and Rebellion Reaches of the navigation channel to enlarge Crab Bank Island in Charleston Harbor. A clamshell dredge or a cutterhead pipeline dredge will be used to excavate the material from the available reaches, transported via pipeline, and discharged on a designated placement area on Carb Bank Island. It is anticipated that approximately 825,000 cy of in-situ dredged material will be available for this project with approximately 660,000 cubic yards being ultimately used to enlarge Crab Bank Island.

Mechanized equipment will be used for construction. Placement will be in a non-uniform pattern to allow for greater topographic complexity and therefore greater habitat diversity. Island height will range between 6.5’ (roughly 1’ above mean high tide) and 10’ MLLW. The footprint of the island is shown in Alternative Medium A, which has been identified as a “best buy” alternative. The resulting island will be 79.4 acres in size, with 27.8 acres of usable brown pelican nesting habitat. At the end of the 50 year project life, it is anticipated that Crab Bank Island will be approximately 15.25 acres in size, with 0.64 acres of brown pelican nesting habitat remaining. Costs are approximately $ 3.98 million, with the federal amount to be approximately $ 2.59 million.

6.2 Summary of Significance

6.2.1 Institutional Significance

Significance based on institutional recognition means that the importance of an environmental resource is acknowledged by Federal, State, regional, local, or Tribal governmental or private entities. Sources of institutional recognition include laws, executive orders, rules and regulations, treaties, policy statements, ordinances, planning documents, resolutions, and other policy statements of entities with jurisdiction in the study area.

In 2006, Crab Bank Island was designated by SCDNR as a Seabird Sanctuary. Presently there are only six designated sanctuaries in the state. The island is managed as part of SCDNR’s Heritage Trust Lands. Public access to the island is limited, with no access allowed during nesting season, March 15 through October 15.

South Carolina Department of Health and Environmental Control-Bureau of Ocean and Coastal Resource Management (SCDHEC-OCRM) has designated Crab Bank Island a Geographic Area of Particular Concern

(GAPC) under the state's Coastal Zone Management Program. This shows that the State considers Crab Bank Island to be of unique importance.

6.2.2 Public Significance

Public significance is based on public recognition and means that some segment of the general public recognized the importance of an environmental resource, as evidenced by people engaged in activities that reflect an interest or concern for that particular resource. Such activities may involve contributions in funds or efforts to protect, promote, or otherwise benefit the resource.

Natural resources are the basis for most recreational activities in South Carolina. South Carolina's natural resources are essential for economic development and contribute nearly $30 billion and 230,000 jobs to the state's economy. In 2008, natural resources-based industries in South Carolina supported $29.1 billion in total economic impact, including 235,431 jobs and $7.8 billion in labor income (University of South Carolina, 2009). Table 12 below shows that bird watching is the most significant recreational activity with respect to trips.

Table 12. Total Participation in Recreational Activities by South Carolinians Age 12 and Older

Activity	Number of Trips
Bird wildlife	46,093,331
Watching wildlife	46,093,331
Beach swimming/ sunbathing	24,547,789
Motor boating	19,850,155
Freshwater fishing	16,247,458

With respect to coastal activities in general, non-historic tourism produces approximately $3.5 billion in revenue and supports 81,000 jobs. Table 13 shows both total economic output and value added impacts to the state.

Table 13. Economic Impacts of Coastal Tourism in South Carolina (USC 2009)

2008	Direct	Indirect **	Induced**	Total
Value Added*	$2,175,917,712	$525,611,037	$800,411,667	$3,501,940,417
Labor Income	$1,357,208,542	$295,208,228	$411,000,802	$2,063,417,573
Employment	60,399	8,119	12,466	80,984
Output	$4,684,866,174	$1,002,277,617	$1,358,850,668	$7,045,994,459

Crab Bank Island itself is also designated by the Audubon Society as a Globally Important Bird Area. To meet the Audubon's designation as a Globally Important Bird Area, certain standardized criteria must be met. Crab Bank Island meets the following criteria:

- **Sites for endangered or threatened species, or species of concern in South Carolina** – Crab Bank Island is a documented nesting habitat for several species of concern including the brown pelican, black skimmer, and royal tern.

- **Sites where birds regularly concentrate in significant numbers when breeding, in winter, or during migration –** It has been documented that Crab Bank Island contains significant numbers of both nesting birds and birds that use it for foraging and loafing.
- **Sites important for long-term avian research or monitoring –** Crab Bank Island is considered an important bird research area and SCDNR conducts annual nesting surveys for Crab Bank Island to monitor populations and island usage.

In 2014, the Crab Bank Island "Pelicam" was installed on the island. The Pelicam consists of two solar powered cameras that transmits live video of the island. This effort publically funded. Sponsors include the Coastal Conservation League, the Charleston Harbor Pilots, Coastal Expeditions, and others.

Crab Bank Island has also been publicly highlighted as a significant and threatened resource, as evidenced in the following Post and Courier news articles:

- "Crab Bank live: shorebirds get webcam" (Unattributed), May 7, 2014,
- "Save Crab Bank before its too late" by Nathan Dias, October 22, 2016,
- "Coastal storms wash away South Carolina shorebird eggs around Charleston Harbor" by Bo Peterson, May 25, 2017, and
- "May's storms wiped out almost all the pelican nests on Charleston's Crab Bank" by Bo Peterson, June 5, 2017.

Copies of all of the referenced articles are found in Appendix E.

6.2.3 Technical Significance

Significance based on technical recognition means that the resource qualifies as significant based on its technical merits, which are based on scientific knowledge or judgment of critical resource characteristics. Technical significance should be described in terms of one or more of the following criteria: scarcity, representativeness, status and trends, connectivity, and limiting habitat.

Scarcity – Overall consensus from the USFWS, SCDNR, and the Audubon Society is that shorebird populations have been in decline over the last three decades. Red knot and brown pelican populations have declined in South Carolina by 50% since 1990. Loss of habitat, due to coastal development, is the primary reason for this decline. (Manomet, 2012). Crab Bank Island is only one of 6 designated sanctuaries in South Carolina and is recognized as an important component in maintaining shorebird populations. Based on this and previously expressed facts, this is a feature of technical significance.

Representativeness – The SCDNR counts of nesting pairs in Table 1 show that Crab Bank Island is used by a variety of birds for nesting. Brown pelicans have been nesting on the island since 1979. Crab Bank Island is considered ideal nesting and foraging habitat, and SCDNR attributes the island, along with the other seabird sanctuaries, critical for the long term fate of shorebirds. (SCDNR, 2015)

Status and Trends – Shorebird nesting areas have significantly decreased as coastal populations increase. As such, isolated, protected lands such as Crab Bank Island are becoming more important for species propagation and survival. Crab Bank Island and similar features will only increase in importance as pressures from both population growth and sea level rise increased in the future.

Not only has shorebird nesting habitat decreased, but the island itself has been disappearing over time. This report has documented the reduction of the island from approximately 23 acres in 2000 to an approximate current size of 0.68 acres. Long term projects indicate that almost all of the island will disappear within the next 50 years.

Connectivity – Crab Bank Island is part of the Audubon's Atlantic Coast flyway. Migratory shorebirds transit through South Carolina during both spring and fall migrations. Many birds overwinter in Charleston Harbor. In addition to nesting habitat, Crab Bank Island provides migratory species an undisturbed location for foraging, resting, and loafing.

Limiting Habitat – There are few areas such as Crab Bank Island that are suitable for shorebird nesting and other avian life cycle habitat. Sites on mainlands are under threat from development, predators, and unanticipated threats such as physical disturbance from people and/or domestic animals. Physically isolated and legally protected features such as Crab Bank Island are few in number, making them essential for the continued propagation of shorebirds.

Biodiversity – Crab Bank Island supports colonies of nesting shorebirds because of its isolated nature and lack of mammalian predators. While not all species are continually present, species that have used Crab Bank Island include the brown pelican, least tern, royal tern, black skimmer, gull-billed tern, sandwich tern, common tern, laughing gull, Wilson's plover, American oystercatcher, willet, great egret, snowy egret, tricolored heron and ibis. In addition to providing nesting habitat, the sanctuary provides winter loafing and feeding areas for numerous species.

In addition to avian species, the intertidal and subtidal areas contain polycheates, oligochetes, amphipods and isopods. Crabs, snails, and mussels live in the *Spartina* patches and the oyster reefs on the southern end of the island are entire separate ecosystems that host much more than shellfish.

6.3 Real Estate Requirements

The State of South Carolina claims ownership of Crab Bank Island (Figure 1). Crab Bank Island, a narrow strip of land, is located in Charleston Harbor between Shem Creek and Fort Sumter. The approximate 22 acre islet was documented on maps as a sandbar. By the 1950s the Crab Bank Island became an island due to the placement of dredged material. The island's shape and size frequently shift due to erosion caused by storms and passing wakes. The island is currently used as a nesting site for seabirds.

The SCDNR has expressed interest in sponsorship and provided a letter of intent for a feasibility level study for Crab Bank Island. SCDNR is a capable sponsor and has set aside funding for the design portion of the implementation phase. For the construction of the project, they are requesting to receive funds through their state appropriations, but also working with local stakeholder groups that have expressed interested in contributing funds (through SC DNR) for construction of the project. SCDNR is making an effort to partner with other interested stakeholders to secure the funds needed for the non-federal cost share. SCDNR, the potential sponsor, is a state agency and the authorization for entry and construction will be provided by the State of South Carolina (Appendix F).

The recommended plan would result in construction of an island with a final footprint above mean high water. All construction equipment will be barged to the site. Should the need for a staging area be identified after project approval, the sponsor will be required to provide a temporary work area easement.

6.4 Operation, Maintenance, and Replacement Considerations

Since the recommended plan involves using a one-time only source of dredged material to enlarge Crab Bank Island and letting it erode naturally, operations, maintenance, and replacement considerations are not applicable to this study.

6.5 Monitoring and Adaptive Management Plan

A monitoring and adaptive management plan is not required for this CAP 204 Study. Regardless, outside the requirements of the project, the local sponsor has indicated that they will treat for invasive plants and monitor the success of the project.

6.6 Detailed Cost Estimate for Recommended Plan

Table 14 provides a detailed cost estimate.

Table 14. Detailed Cost Estimate

Civil Works Work Break Down Structure		Estimated Costs				PROJECT FIRST COSTS (Constant Dollar Basis)					TOTAL PROJECT COST (FULLY FUNDED)			
						Program Year (Budget EC)				2018				
						Effective Price Level Date				1-oct-17 Spent Thru: 1 Oct- 16				
WBS Number	Civil Works Feature and Sub Feature	COST ($K)	CNTG ($K)	CNTG (5)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($)	REMAINING COSTS (K)	TOTAL FIRST COSTS ($K)	ESC (5)	COST ($K)	CONT G ($K)	FULL ($K)
06	Fish & Wildlife Facilities	$ 2,855	$ 628	22%	$ 3,482	1.9%	$ 2,908	$ 640	$ 3,547	$ 3,547	5.1%	$3,057	$ 673	$ 3,729
Construction Estimate Totals		$ 2,855	$ 628	22%	$ 3,482	1.9%	$ 2,908	$ 640	$ 3,547	$ 3,547	5.1%	$3,057	$ 673	$ 3,729
01	Lands and Damages													
30	Planning, Engineering, and Design	$ 150	$ 33	22%	$183	3.1%	$ 155	$ 34	$ 189		2.4 %	$ 158	$ 35	$ 193
31	Construction Management	$ 44	$ 10	22%	$ 54	3.1%	$ 45	$ 10	$ 55		10.4%	$ 50	$ 11	$ 61
Project Total Costs		$ 3,049	$ 671	22%	$ 3,719		$3,108	$684	$ 3,791		6.9 %	$ 2,855	$ 625	$ 3,984
										ESTIMATED TOTAL PROJECT COSTS				**$ 3,984**
										ESTIMATED FEDERAL COST (65%)				$ 2,589
										ESTIMATED NON-FEDERAL COSTS (35%)				$ 1,394

6.7 Cost Sharing

Under the Section 204 authority, the non-federal sponsor is responsible for 35% of the Total Project Costs, approximately $ 1.39 million.

7.0 SUMMARY OF ENVIRONMENTAL IMPACTS

This section evaluates the environmental impacts of the recommended plan. All impacts have been fully coordinated through the SEA and coordination documentation (USACE 2017). Section 8.0 of the SEA addresses the environmental impacts associated with various beneficial use options considered, including the placement of material on Crab Bank. It should be restated that since there is no recommended plan for the beneficial use of dredged material based on current O&M dredging, this section will not discuss any impacts associated with those measures.

7.1 Physical Environment

7.1.1 Climate

The recommended plan will have no effect on climate.

7.1.2 Tides, Currents, and Sea Level Rise

Under the recommended plan, Crab Bank Island will be increased in size. However, each of the alternatives is merely expanding the island footprint back to a similar historic footprint. Since no significant new features are being created, it is not anticipated that constructing the recommended plan would have any distinctive hydrodynamic changes, nor will they impact natural circulation or sedimentation patterns from what has occurred in the past. Placement of material to enlarge and elevate the islands could temporarily offset the impacts of sea level rise. Appendix A presents a detailed evaluation of sea level rise. Essentially, increased rates of sea level further express the importance of this beneficial use project.

7.2 Water Quality

Significant impacts to water quality are not anticipated from implementation of the recommended beneficial use plan. The dredging of material and resultant temporary turbidity plumes have previously been evaluated in the Final IFR/EIS. The sediment testing and elutriate analyses performed during the feasibility phase did not reveal that these reaches contained significant concentrations of any toxic or harmful substances. However, temporary and minor decreases in water quality are anticipated. Increased turbidity will be associated with construction at the immediate site. The duration of the turbidity plume in the water column depends upon water temperature, salinity, currents, and sediment grain size (ICES 1992). The distance of sediment transport is dependent upon current strength, storm resuspension, water salinity and temperature, and sediment grain size (ICES 1992). For the recommended plan the material from the channel is approximately 65% sand or greater. The remainder of the material is comprised of silts and clays.

Safeguards such as containment dikes would be used to minimize excess turbidity and suspended solids entering any adjacent water body. If necessary, additional temporary erosion and sedimentation control features will be conducted. At all times, protective measures shall be taken to prevent chemicals, fuels, oils, and greases from entering area waters. Chemical analysis of sediments from the navigation channel has revealed no significant concentration of toxic or harmful substances that could adversely affect water quality of the area (USACE 2015). Hence, water quality impacts from project construction would only be temporary and minor and the State's Classification Standards should not be contravened. Waters of the State of South Carolina would not be significantly affected and water clarity would return to ambient conditions shortly after completion of construction. No significant impacts are expected to result from the construction, dredging, and disposal operations. As required by the Clean Water Act, a Section 404(b)(1) evaluation for the effects of conducting the proposed action has been prepared and is included as

Appendix H within USACE 2017. A water quality certification (WQC) for the proposed action was granted by the SCDHEC on March 16, 2015. This WQC is still considered valid.

7.3 Avian Habitat

Various shorebirds and seabirds utilize areas in the general vicinity of the beneficial use option. The immediate project area at Crab Bank contains minimal area of suitable nesting habitat for shorebirds. However, this habitat has been documented by SCDNR as supporting significant shorebird nesting habitat for the State. In order to determine benefits to avian habitat, the brown pelican HSI model was used as a proxy. Based upon the methods of the model, USACE determined that the proposed activities will increase the size of Crab Bank by 52.8 acres, resulting in a total island size of 79.4 acres, including 27.80 acres of brown pelican nesting habitat. Increasing the size of the island would lessen competition for nesting, foraging and loafing habitat and decrease the chance of disease. Over the life of the project, sea level rise and waves and currents will cause erosion to the island; however, it is anticipated that the recommended plan will have long-term positive impacts on bird usage in the area, even if some temporary displacement occurs during the construction.

7.4 Wetlands

Under the recommended plan, material from the navigation channel would be placed on Crab Bank Island. Roughly 1.9 acres of wetlands exist on Crab Bank Island. This number changes from year to year based upon movement and erosion of the island. Wetland protection is only anticipated for the marsh complex on the northwest portion of the island. This marsh is the only significant area of existing marsh habitat. The approximately 0.8 acre fragment of marsh on the northern end would be protected with temporary sediment containment measures during construction. The remainder of the patchy wetlands will be impacted by the placement of material during construction. As previously stated, these wetlands are patchy and sporadic in nature and are expected to quickly be reestablished, through natural process, after construction. A significant amount of these wetlands, meeting or exceeding what currently exist, are expected to return naturally after construction. Avoidance of these pocket wetlands would create additional expenses and inefficiencies when constructing the project. The total estimated acreage of small wetland impacts is approximately 1.1 acres. Enlarging the channel-facing beachfront of the island would allow for the potential natural recruitment of saltmarsh by protecting the back side of the island from overwash on high tides. Temporary sediment containment will be provided during the construction to prevent material from filling in the marsh.

The Crab Bank Island option afford the opportunity for natural expansion of marsh habitat due to the increased volume of material placed on the island. This option would not vegetate any areas; rather, natural vegetation would be allowed to occur.

7.5 Threatened and Endangered Species

All dredging related impacts were previously addressed in the USACE 2014 Biological Assessment and the NMFS 2015 Biological Opinion (Final IFR/EIS, USACE 2015, Appendices F1 and F2). The 2017 SEA addressed the placement impacts of beneficial use alternatives at Crab Bank Island, Shutes Folly, and Morris Island. This section will summarize the potential impacts from the construction of the recommended plan.

The impact producing factors associated with dredged material disposal include:

- Burial of habitat
- Increased turbidity and sedimentation
- Disturbance of sessile biota and finfish assemblages
- Modification of bathymetry and topography
- Potential change in benthic community structure

This section discuss the USACE decision-making for an effects determination for the relevant threatened and endangered species. Table 15 summarizes the potential effects on these listed species from the placement of material.

Table 15. Summary of Effect Determination

Listed Species	Effect Determination	Summary
West Indian Manatee	May affect, not likely to adversely affect	Temporary habitat disturbance
North Atlantic Right Whale	No effect; No effect on Critical Habitat	Rarely present in action area
Humpback Whale	No effect	Rarely present in action area
Piping Plover	No effect; No effect on Critical Habitat	Not present at Crab and Shutes; Temporary beach disturbance at Morris Island
Rufa Red Knot	No effect	Not present at Crab and Shutes; Temporary beach disturbance at Morris Island
Wood Stork	No effect	Not likely to utilize habitat
Atlantic Sturgeon	No effect	Disturbance of foraging habitat
Shortnose Sturgeon	No effect	Disturbance of foraging habitat
Loggerhead Sea Turtle	No effect; No effect on Critical Habitat	Unlikely to utilize the action area
Kemp's Ridley Sea Turtle	No effect	Unlikely to utilize the action area
Leatherback Sea Turtle	No effect	Unlikely to utilize the action area
Green Sea Turtle	No effect	Unlikely to utilize the action area

7.6 Benthic Resources

The placement of the dredged material within the ecosystem would temporarily displace benthos; however, the area should repopulate rapidly. Impacts to benthos would occur through direct burial of the benthic habitat on all constructed portions of the islands. The disposal can adversely affect infauna, including both macro and micro benthic organisms by burying them or forcing motile organisms to migrate from the area. The area of burial is expected to be approximately 40 acres for Crab Bank Island. These impacts will be temporary in nature as repopulation will commence immediately after construction is completed. Recovery would be similar to beach projects and is expected within 6 months to one year.

Species composition should be similar to that which existed prior to construction. These impacts are acceptable due to the long-term benefits of island enhancement outweighing the temporary burial impacts, and the fact that the proposed option is merely restoring the islands to a historic position.

Benthic impacts can also occur due to burial of benthic organisms in the area of the turbidity plume where sedimentation can occur. The effects of sedimentation on the benthos include smothering and decreased gas exchange, toxicity from exposure to anaerobic sediments, reduced light intensity, and physical abrasion (Wilber et al., 2005). Mobile species may be forced to leave; however, surrounding habitat is similar in nature and impacts will be minor and temporary. Benthic infauna can exhibit some ability for vertical migration activity following sediment placement (Bolam, 2011), although the degree of migration depends upon species and sediment type. Since sedimentation from the recommended plan would be dispersed across a broad area and no substantial depositional areas are anticipated, benthic impacts are anticipated to be minor.

7.7 Essential Fish Habitat (EFH) and Fisheries

Impacts to EFH for all projects consist of the reduction of shallow sub-bottom habitat, the loss of minimal amounts of saltwater wetlands, and the loss of a minimal amount of oyster reef habitat. Approximately 1.9 acres of wetlands exist on Crab Bank Island, and approximately 1.1 acres of those wetlands would be impacted by burial during the construction of the proposed beneficial use project. This acreage area changes from year to year based upon movement and erosion of the island. As previously stated, these wetlands are patchy and sporadic in nature and are expected to quickly be reestablished, through natural processes, after construction.

Shallow sub-bottom habitat, including some oyster reef, will be buried during the construction of the proposed option. The loss or burial of sub-bottom habitat is usually to be avoided, however, any adverse effects occurring would be minimal as the planned fill area is located within historical boundaries of Crab Bank which experiences a large amount of natural habitat migration. Edge habitat surrounding the islands will increase due to a larger circumference of all islands which should allow for the natural re-establishment of the impacted EFH with time.

As stated in the No Action Alternative section, without the proposed option, wetland losses and migration could continue to occur. Without a project, Crab Bank Island will disappear. This option would increase Crab Bank Island to a previous condition and prolong the life of the island. Because the benefits of this project to the shorebirds are substantial compared to the loss of shallow water habitat and small patchy wetlands and these wetlands are expected to quickly re-establish, through natural process, after construction, no mitigation is being proposed. This option is being pursued as beneficial use alternatives to traditional disposal in the ODMDS.

Temporary increase in turbidity will be associated with the placement of material associated with the recommended plan. However, these impacts will not be significantly greater than those already anticipated to occur as a result of the dredging itself. The location of the plumes will, however, be different than the dredging operations within the channel. Turbidity affects different life stages of fishes. Colby and Hoss (2004) found that sediment concentrations affect estuarine fish foraging success differently for different species. The severity of turbidity effects tends to be greatest for early life stages and for adults of some highly sensitive species (Newcombe and Jenson 1996, Wilber and Clarke 2001). In fact, many fish thrive in turbid estuarine environments (Blaber and Blaber 1980 and Cyrus and Blaber 1992). This may be due to reduced risk of predation due to reduced visibility and potentially greater availability of prey due to recently removed substrate containing benthic organisms. Due to the relatively small scale of this option, the additional, temporary turbidity impacts are anticipated to be minimal. No managed species will be adversely affected by the proposed construction of this beneficial use option and no long term adverse effects to any managed species are anticipated. USACE has proposed a no dredging window from April 1 through September 30 to avoid potential impacts to spawning fish by avoiding dredging at two separate SCDNR fish spawning ‘hotspots’. The first is at the mouth of the harbor at a location called the “Grillage” and the second site is 1000’ on either side of the Ravenel Bridge.

7.8 Sediments

Based upon the results of the SCDNR transect analysis, Crab Bank Island has variable sand content across its extent. This variability leads to the acceptability of 65% sand placement on the island. Overtime, natural processes will winnow out the material causing sandier material to be deposited on the top of the island and finer sediments to deposit further into the intertidal and subtidal environment as shown in the SCDNR transects. No long term effects to sediment content are anticipated from this project.

7.9 Coastal Barrier Resources

The recommended plan will not occur within or impact any designated CBRA unit.

7.10 Air Quality

The recommended plan would result in some minor, short term air quality impacts. Emissions are expected to occur and would result from the operation of the dredge, construction equipment, and any other support equipment, which may be on or adjacent to the job site. The final IFR/EIS evaluated the emissions from the Post 45 Project. The only additional emissions would come from the temporary use of shore-based equipment such as bulldozers and front end loaders. An additional pump out station may also be used depending on the dredging method. Constructing the recommended plan would have negligible additional air quality impacts as the additional equipment used for construction would be offset by the reduction in travel distance for dredge material disposal. The project area is currently in attainment with National Ambient Air Quality Standards parameters. The proposed action would not affect the attainment status of the project area or region.

7.11 Socio - Economics

The recommended plan is not designed to create a benefit for any group or individual, but rather benefits on a nationwide basis. The proposed beneficial use of dredged material option occur relatively far from any areas of significant populations. There are no indications that the proposed activities would be contrary to the goals of E.O. 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, or would create disproportionately high and adverse human health or environmental impacts on minority or low income populations of the surrounding community.

7.12 Cultural Resources

The recommended plan will have no impact on any historic structures on Crab Bank Island. A preconstruction side scan sonar and magnetometer survey will be performed on the main channel side of Crab Bank Island. The survey will cover the extent of the construction footprint. Results will be shared with SHPO and SCIAA. If during the course of work, cultural resources are uncovered, work will cease immediately and the Charleston District will coordinate with SHPO and SCIAA before additional work is performed.

7.13 Hazardous, Toxic, and Radioactive Wastes

No HTRW concerns are anticipated for the recommended plan. The dredged material will be the same as described in the final IFR/EIS (USACE, 2015) and associated appendices. All material is suitable for placement either upland or at the ODMDS and no HTRW concerns were noted during the Post 45 feasibility study or the SEA review period.

7.14 Floodplains

Floodplains receive protection under Executive Order 11988. The EO states that federal agencies shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains in carrying out agency responsibilities. The proposed project would have no adverse impacts to floodplain management.

7.15 Aesthetics and Recreation

Aesthetics would be reduced in the project area during construction, due to the physical presence of the heavy equipment used in the construction process. However, these impacts would be temporary and insignificant. Once the construction is complete, the aesthetic values provided by the restored habitats would have many beneficial impacts. Presently, Crab Bank Island is barely visible on spring high tides. Since the island has been migrating and eroding over the years, this trend would continue without the project. The recommend plan at Crab Bank Island would make it a more prominent feature in the lower harbor. Crab Bank Island is a major tourist attraction and fishing area. Multiple companies offer waterborne tours of Crab Bank Island originating from Shem Creek. A more prominent island will be a benefit to these companies and will provide more opportunity outside of bird nesting season for people to utilize the island. Shellfish harvesting will not be impacted because it is restricted within Charleston Harbor.

7.16 Cumulative Impacts

The National Environmental Policy Act (NEPA), as implemented by Council on Environmental Quality (CEQ) regulations (40 CFR §§ 1500 - 1508) requires federal agencies, including the USACE, to consider cumulative impacts in rendering a decision on a federal action under its jurisdiction. According to 40 CFR § 1508.7, a *cumulative impact* is the impact on the environment that results from the incremental impact of the recommended plan when added to other past, present, and reasonably foreseeable future actions regardless of the entity that undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

Reviewing historical nautical charts reveals that Crab Bank was originally a large sand bar and was officially noted as an island in the 1965 nautical chart. Crab Bank was created with dredge material in the 1950's and 1960's (based on rough USACE dredging records and historical nautical charts). While the island fluctuates in size constantly, it has largely been migrating towards the north and west over the last 25 years. The island presently has little area that is above mean high water.

Crab Bank is becoming increasingly more important for sea and shorebirds because of marked declines in nesting birds at other sites over the last few years (Nathan Dias, personal communication, 2/9/2012). Crab Bank has been designated as an "Important Bird Area" in South Carolina and is established as "Crab Bank Seabird Sanctuary". The South Carolina Department of Natural Resources (SCDNR) indicates that, "Crab Bank supports colonies of nesting waterbirds because of its isolated nature and lack of mammalian predators. Crab Bank is recognized as one of five active nesting sites in South Carolina and as being "vital to the survival of at least fifteen species of birds" (http://coastalconservationleague.org/pelicam/).

As a result of the implementation of the recommended plan, Crab Bank will be enlarged from its current footprint and continue to provide quality bird habitat. As a result of construction there will be a minor temporary cumulative impact on water quality, benthic habitat, and EFH; however, all these impacts are temporary and minor. No long term impacts negative environmental impacts are anticipated. Regulations require the dredged material to be disposed of such that all suspended and dissolved portions after dilution meet all applicable water quality criteria [40 CFR 227.13(c)(2)(i)] and do not cause any adverse biological effects [40 CFR 227.27(b)]. The goal of these requirements is to eliminate any adverse effects associated with individual contaminants or any synergistic effects of multiple contaminants present in the dredged material. Consequently, the proposed action is not expected to contribute significantly to the cumulative negative impacts of regional activities on water quality.

This alternative will not induce or support development. The alternative could result in more research efforts to monitor bird activity on the island and could result in increased recreational visitation. No future work on Crab Bank, by the Corps or others, is expected to occur on Crab Bank as a result of construction of the recommend plan.

The negative impacts of the recommended plan for Crab Bank, when considered along with present and future actions, are cumulatively insignificant because all impacts from the recommended plan are minor, temporary, construction related impacts and known present and future actions in the area are expected to be nonexistent. The overall lack of negative impacts associated with the recommended plan demonstrates both the benign nature and limited impacts of this project. No significant negative impacts would occur from implementation of the recommended plan. Restoration of positive environmental would occur with construction of the recommended plan. Any negative impacts associated with the recommended plan, when added to other past, present, and reasonably foreseeable future actions, are collectively insignificant.

.

8.0 ENVIRONMENTAL COMPLIANCE

8.1 National Environmental Policy Act

NEPA requires that all federal agencies assess the environmental effects of their proposed actions prior to making a decision. The requirements of NEPA have previously been considered and fully documented with the SEA and FONSI for beneficial use of dredged material associated with Post 45 new work dredging. The SEA elaborated on multiple options that could be constructed if and when a cost sharing sponsor was identified; these options were initially identified in the beneficial use of dredged material section of the Final IFR/EIS for Post 45. Since the recommended plan within this Detailed Project Report is based upon and within the scope of the options presented within the Final IFR/EIS for Post 45 and evaluated in the SEA and FONSI , no additional NEPA compliance is warranted.

8.2 Clean Water Act

On March 16,2016, the USACE obtained a water quality certification from the State of South Carolina pursuant to the Clean Water Act (CWA) for the discharge of dredged or fill material into navigable waters applicable to the deepening of the Federal Navigation Channel in Charleston Harbor and the Ashley, Cooper, and Wando Rivers. The recommended plan is covered by this certification.

8.3 Wetlands

CWA Section 404 and implementing USACE regulations at 33 C.F.R. 336.0(a) and 33 C.F.R. 320.4(b) require the USACE to avoid, minimize, and mitigate impacts to wetlands. The recommended plan is consistent with the findings of the 404(b)(1) evaluation completed for the SEA (USACE 2017).

8.4 Coastal Zone Management Act (CZMA)

In accordance with the CZMA, it was been determined that the proposed deepening of the federal navigation channel would be carried out in a manner that is fully consistent with the enforceable policies of the SC CMP. With conditions, the SCDHEC – concurred with the USACE consistency determination for the Final IFR/EIS on 8 December 2014. One of the conditions was that, “The final plans for beneficial uses of the dredged spoil material shall be provided to the Department for final approval.” This document serves to satisfy that requirement. After review of the draft SEA, SCDHEC had no additional comments on the project (email dated 28 November 2016). As such, the project is in full compliance with the CZMA.

8.5 Clean Air Act (CAA)

The recommended plan is in compliance with the CAA. All air emissions resulting from the proposed action would be temporary and minor. No long term changes would occur to air quality in the region as a result of any of the considered options. The study area is in an attainment area for all air quality criteria and the proposed option will not cause the study area to go out of attainment. During the review of the SEA, the SCDHEC–Bureau of Air Quality offered strategies to benefit air quality during construction, including utilizing alternatively fueled equipment, utilizing emission controls applicable to equipment, reducing idling time on equipment, minimizing fugitive dust emissions through good operating practices.

8.6 US Fish and Wildlife Coordination Act

This project is in compliance with this Act. The project has been coordinated with the USFWS and other state and federal natural resource agencies. Input from the USFWS, including any conservation recommendations under Section 2(b) of this Act, will be considered and incorporated into the project plans as they are developed.

8.7 Endangered Species Act

The ESA protects threatened and endangered species by prohibiting federal actions that would jeopardize the continued existence of such species or that would result in the destruction or adverse modification of any critical habitat of such species. ESA Section 7 (Interagency Cooperation) requires that consultation regarding conservation of such species be conducted with USFWS and/or NMFS prior to project implementation. Integrated within the 2017 Final SEA, which is in turn based upon the Final IFR/EIS for Post 45, the USACE has evaluated potential impacts of the recommended plan on threatened and endangered species and associated critical habitat. Based on informal consultation with NMFS a determination of no effect has been reached. As a result of this determination NMFS did not provide conservation recommendations.

8.8 Magnuson - Stevens Fishery Conservation and Management Act (MSA)

This Act requires federal action agencies to consult with the NMFS if a proposed action may affect EFH. NMFS did not offer any conservation recommendations during the review of the 2017 SEA and integrated EFH Assessment.

8.9 Anadromous Fish Conservation Act

The recommended plan is in compliance with this Act. USACE considered habitat impacts specifically to sturgeon species. Mitigation would not be required for the minor adverse effects on these species due to temporary turbidity increases affecting water quality. No long term impacts are anticipated.

8.10 Marine Mammal Protection Act (MMPA)

The MMPA prohibits the take of marine mammals including the West Indian manatee, North Atlantic right whale, and humpback whale. Protective measures for marine mammals would be implemented. It was determined in the SEA that the project would have no effect to marine mammals. The 2017 SEA was coordinated with USFWS and NMFS. The project is in compliance with this Act and no incidental harassment would occur with the implementation of USFWS standard manatee conditions. NMFS did not provide conservation recommendations.

8.11 National Historic Preservation Act (NHPA)

The USACE evaluated the potential for adverse impacts to archaeological or historic resources within an Area of Potential Effects (APE). USACE has determined that the recommended plan would have no effect on historic properties, and the SHPO concurred with this determination on December 13, 2016.

8.12 Executive Order 11990, Protection of Wetlands

This EO directs all federal agencies to minimize the destruction, loss, or degradation of wetlands; and preserve and enhance the natural beneficial values of wetlands in the conduct of the agency's responsibilities. Direct wetland impacts resulting from the disturbance and burial of small patchy wetlands on Crab Bank Island would occur as a result of this option. USACE has planned to avoid the most significant area of marsh in the northwestern area of Crab Bank Island. As previously stated, these wetlands are patchy and sporadic in nature and are expected to quickly be reestablished, through natural process, after construction as such, no mitigation is proposed. It is anticipated that the proposed option at Crab Bank Island could allow for the natural recruitment of saltmarsh species on the northern (Mt. Pleasant) side of the island. No other wetland impacts are anticipated

8.13 Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations

In accordance with this EO, the USACE has determined that no group of people would bear a disproportionately high share of adverse environmental consequences resulting from constructing the recommended plan.

8.14 Executive Order 13045, Protection of Children from Environmental Health Risks and Safety Risks

This EO ensures that all federal actions address the unique vulnerabilities of children. In accordance with this EO, the USACE has determined that no children would bear a disproportionately high share of adverse environmental consequences resulting from the proposed work.

8.15 Migratory Bird Treaty Act; Executive Order 13186, Responsibilities of Federal Agencies to Protect Migratory Birds

This Act makes it illegal for anyone to take, possess, import, export, transport, sell, purchase, barter, or offer for sale, purchase, or barter, any migratory bird, or the parts, nests, or eggs of such a bird except under the terms of a valid permit issued pursuant to federal regulations. The USACE does not anticipate that migratory birds would be either directly or indirectly adversely affected by the proposed action. The recommended plan could create expanded habitat to support seabird and migratory bird nesting as well as other habitat usage. USACE has proposed to avoid construction during the nesting season between March 15 and October 15 in the northwestern portion of Crab Bank Island where seabird nesting is currently concentrated.

9.0 SUMMARY COORDINATION, PUBLIC VIEWS, AND COMMENTS

9.1 Scoping Comments and Responses

From past coordination efforts during the Charleston Harbor Post 45 navigation study the general public and agencies have concerns with existing erosion problems facing many areas in Charleston Harbor and how the proposed deepening or new construction project may affect those problems. Some stakeholders have also requested that the USACE place dredged material along certain shorelines to reduce the effects of erosion such as Fort Sumter, Crab Bank Island, and Shutes Folly Island.

9.2 Stakeholder Meetings

The District coordinated in person and through email with environmental resource agencies, the National Park Service representatives at Fort Sumter National Historic Monument, Shutes Folly Island property owners, and the South Caroline State Ports Authority.

10.0 PLAN IMPLEMENTATION

10.1Non - Federal Responsibilities

SCDNR has expressed support for the project, has the financial capability to execute a project partnership agreement, and has agreed to accept the role of non-federal sponsor in event of the approval of a final feasibility report. SCDNR has statutory authority under South Carolina law to make binding commitments to carry out the non-federal responsibilities related to USACE projects, including making cash contributions to projects. SCDNR has stated they are capable to meet O&M requirements. As natural process will be allowed to shape Crab Bank after construction, no monitoring except continuing the currently ongoing bird counts is required. There is no requirement to replace lost sand or mange vegetation. In order to implement the Recommended Plan, the non-federal sponsor would be responsible for the following:

1. Provide all lands, easements, rights-of-way, relocations, and disposal areas (LERRDs),
2. Provided cash contributions during the period of implementation equaling 35% of the project's first cost, minus the value of the non-federal real estate contribution,
3. Fund the annual O&M necessary to keep project in its design function, and
4. Satisfy all provision of the project partnership agreement (PPA) regarding non-federal sponsor responsibilities in project implementation.

10.2 Federal Responsibilities

In order to implement the recommended plan, the USACE will provide the federal share of the project cost, to equal the project first cost minus the total non-federal Share, not including the Annual Operation and Maintenance expenses. The federal share of the project cost is currently estimated to be $ 2,589,000 not including feasibility phase costs. Total federal expenditures on any one project under Section 204 authority may not exceed a total of $ 10 million. The USACE would provide the following:

1. Review and certification of Real Estate provisions,
2. Design and construction,
3. Contracting for project construction, and
4. Supervision and administration of project construction.

10.3 In-Kind Contributions

In-Kind Contribution is defined as work contributed by the non-federal Sponsor toward implementation of a project, in lieu of payment of a portion of the sponsor's cash contributions toward implementation of the project. A non-federal sponsor may receive credit toward its required cost share for the value of in-kind contributions it provides if those in-kind contributions are determined to be integral to the project. In-kind contributions are not anticipated towards non-Federal sponsor share of the implementation of the project.

10.4 Project Partnership Agreement (PPA)

Upon approval of a final feasibility report, a project partnership agreement (PPA) would be created. A PPA is a legally binding agreement between the federal government (USACE) and a non-federal sponsor (SCDNR) for the construction of the Charleston Harbor 204 Beneficial Use of Dredged Material for Crab Bank Island Restoration Project. The PPA would describe the project and responsibilities of the USACE and the SCDNR in the sharing of the costs and project execution.

11.0 RECOMMENDATIONS

I have determined that the recommended plan, Crab Bank Island Medium A, would provide the greatest ecosystem restoration benefits in the most cost effective manner within the cost constraints of the Section 204 Authority. The project would result in an island of approximately 79.4 acres in size, with 27.8 acres of usable brown pelican nesting habitat and have minimum adverse impacts. Therefore, I have selected this plan as the recommended plan for implementation upon approval of the final feasibility report and execution of a PPA.

JEFFREY S. PALAZZINI
LTC, EN
Commanding

12.0 REFERENCES

Anamar Environmental Consulting, Inc. 2010. Final Report: Evaluation of Charleston Lower Harbor and Entrance Channel Dredged Material Proposed for Ocean Disposal (Sediment Characterization Report) Charleston, South Carolina. Prepared for U.S. Army Corps of Engineers, Charleston District. September 2010.

Anamar Environmental Consulting, Inc. 2015. *Final Report: Lower Harbor Sediment Sampling and Analysis, Charleston Harbor Federal Navigation Channel, Charleston, Berkeley County, South Carolina*. Prepared for U.S. Army Corps of Engineers, Charleston District. June 2015.

American Vibracore Services. 2016. *Subsurface Investigation and Geotechnical Laboratory Testing Results, Charleston Harbor Post 45 Preconstruction Engineering and Design, Beneficial Use of Dredged Material, Charleston County, South Carolina*. Prepared for U.S. Army Corps of Engineers. July 2016.

Bailey, William. Construction of an offshore bird nesting island at Savannah Harbor. Proceedings of the Georgia Water Resources Conference, held April 25-27, 2005, at the University of Georgia. Kathryn J. Hatcher, editor, Institute Ecology, The University of Georgia, Athens, Georgia.

Blaber, S.J.M. and T.G. Blaber. 1980. Factors affecting the distribution of juvenile estuarine and inshore fish. Journal of Fish Biology. 17: 143-162.

Bolam, S.G. 2011. Burial survival of benthic macrofauna following deposition of simulated dredged material. Environmental Monitoring Assessment. 181: 13-27.

Colby, D., and D. Hoss. 2004. Larval fish feeding responses to variable suspended sediment and prey concentrations. USACE, Engineering Research Development Center. DOER Technical Notes Collection. ERDC TN-DOER-E16.

Costa, H, 2004. Savannah Morning News, article dated Jun 27, 2004.

Cyrus, D.P. and S.J.M. Blaber. 1992. Turbidity and salinity in a tropical northern Australian estuary and their influence on fish distribution. Estuarine Coastal and Shelf Science. 35: 545-563.

Dias, Nathan, Executive Director Cape Romain Bird Observatory McClellanville, SC.

Department of the Navy). 2007. Final Integrated Natural Resources Management Plan for the Naval Station Mayport. Mayport, Florida.

Field D.W., A. Reyer, P. Genovese, B. Shearer. 1991. Coastal wetlands of the United States – an accounting of a valuable national resource. Strategic Assessment Branch, Ocean Assessments Division, Office of Oceanography and Marine Assessment, National Ocean Service, National Oceanic and Atmospheric Administration, Rockville, MD.

Fritts, T.H., A.B. Irvine, R.D. Jennings, L.A. Collum, W. Hoffman, and M.A. McGhee. 1983. Turtles, Birds, and Mammals in the Northern Gulf of Mexico and nearby Atlantic Waters. FWS/OBS - 82/64. U.S. Fish and Wildlife Service, Washington D.C.

FWC (Florida Fish and Wildlife Conservation Commission). 2002. Sea Turtle Conservation Guidelines. FWC, FWRI, St. Petersburg, FL.

Hands, E. B. and M. C. Allison. 1991. Mound migration in deeper water and methods of categorizing active and stable depths. In Proceedings of Coastal Sediments '91. American Society of Civil Engineers, pp 1985-1999.

Hingtgen, T.M., Mulholland, R., and Zale, A.V. 1985. Habitat suitability index models: eastern brown pelican. U.S. Fish and Wildlife Service, Biological Report 82(10.90). 20pp.

ICES (International Council for the Exploration of the Sea). 1992. Report of the ICES working group on the effects of extraction of marine sediments on fisheries. Copenhagen (Denmark): ICES Cooperative Research Report #182.

IUCN (International Union for the Conservation of Nature). 2008. Red List of Threatened Species [website]. Accessed 01/02/11 online at: http://www.iucnredlist.org/.

Lazell, J.D., Jr. 1980. New England waters: critical habitat for marine turtles. Copeia 1980:290–295.

Manomet Center for Conservation Sciences. 2004. International Shorebird Surveys. http://shorebirdworld.org/template.php?g=13&c=11, September 10, 2004.

McLellan, T. N. and N. C. Kraus. 1991. Design guidance for nearshore berm construction. In Proceedings of Coastal Sediments '91.

MMS (Minerals Management Service). 2009. Charleston ODMDS Sand Borrow Project Final Environmental Assessment. Prepared by Moffatt & Nichol Engineers. October 2009 for Minerals Management Service Branch of Environmental Assessment. Published by the U.S. Department of the Interior Minerals Management Service Environmental Division.

Murphy, Thomas M., Sally R. Murphy, and DuBose Griffin. 2009. Colonial Nesting Seabird Guild. http://www.dnr.sc.gov/cwcs/pdf/Colonialnestingseabirds.pdf. Accessed on October 6.

NOAA (National Oceanic and Atmospheric Administration). 2009. Final Amendment 1 to the Consolidated Atlantic Highly Migratory Species Fishery Management Plan. Essential Fish Habitat, Including a Final Environmental Impact Statement. Department of Commerce, NOAA, NMFS, Highly Migratory Species Management Division, Office of Sustainable Fisheries, Silver Spring, MD.

NAVFAC (Naval Facilities Engineering Command, Southeast). 2008. Final Environmental Impact Statement for the Proposed Homeporting of Additional Surface Ships at Naval Station Mayport, Florida. NAVFAC, Mayport, FL.

NMFS (National Marine Fisheries Service). 2004. Essential Fish Habitat Consultation Guidance. Version NMFS, Office of Habitat Management, Silver Spring, MD.

NMFS (National Marine Fisheries Service). 2005. Marine Mammal Protection Act [website]. Accessed 01/02/11 online at http://www.nmfs.noaa.gov/pr/laws/mmpa/.

NMFS (National Marine Fisheries Service). 2006a. ESA Section 7 letter from R. Crabtree to N. Ball. October 31, 2006.

NMFS (National Marine Fisheries Service). 2006b. Draft Recovery Plan for the Fin Whale (Balaenoptera physalus). Office of Protected Resources.

Newcombe, C.P. and J.O. Jenson. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management. 16(4): 693-727.

O'Connor, J.K., Morgan, B., Nichol, S., and Black, C. 2010. New Port Construction Leads to Salt Water Wetland Creation. Proceeding so Ports 2010. 12th Triannual International Conference, Building on the Past, Respecting the Future. Jacksonville, FL.

Priest, Walter I. 2017. Practical Living Shorelines. Living Shorelines – The Science and Management of Nature Based Coastal Protection. Bilkovic, D. M., Mitchell, M.M. La Peyere, M. K., and Toft, J. T. Eds. CRC Press. 2017.

Rebel, T.P. 1974. Sea Turtles and the Turtle Industry of the West Indies, Florida, and the Gulf of Mexico. University of Miami Press, Coral Gables, FL.

Sanders, F.J., T.M. Murphy and M.D. Spinks. 2004. Winter abundance of the American Oystercatcher in South Carolina. *Waterbirds* 27: 83–88.

Sanders, F.J., T.M. Murphy. 2009. Migratory Shorebird Guild. http://www.dnr.sc.gov/cwcs/pdf/Migratoryshorebirdguild.pdf.%20Accessed%20on%20October%206.

Schamberger, M., Farmer, A.H., and Terrell, J.W. 1982. Habitat suitability index models: introduction. U.S. Fish and Wildlife Service, FWS/OBS-82/10. 2p.

The South Carolina Department of Natural Resources. 2015. 2015 A Successful Seabird Nesting Season. DNR News, October 26, 2015. http://www.dnr.sc.gov/news/yr2015/oct22/oct22_bird.html.

Thompson, Bruce C., Jerome A. Jackson, Joannna Burger, Laura A. Hill, Eileen M. Kirsch and Jonathan L. Atwood. 1997. Least Tern (Sternula antillarum), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/290.

Tweel, Andrew and Denise Sanger. 2015a. Charleston Harbor Dredging Project Environmental Assessment: Crab Bank and Shutes Folly, Surficial Sediment Characterization. Final Report. Submitted to US Army Corps of Engineers, by SC Department of Natural Resources, Marine Resources Division. May 2015.

Tweel, Andrew and Denise Sanger. 2015b. Charleston Harbor Dredging Project Environmental Assessment: Crab Bank and Shutes Folly, Benthic Macrofaunal Abundance and Distribution. Final Report. Submitted to US Army Corps of Engineers, by SC Department of Natural Resources, Marine Resources Division. May 2015.

University of South Carolina More School of Business. 2009. Underappreciated Assets: The Economic Impact of South Carolina's Natural Resources. 24 pp.

USACE (U.S. Army Corps of Engineers). 2006. Final Environmental Impact Statement, Proposed Marine Container Terminal at the Charleston Naval Complex, North Charleston, South Carolina. USACE Charleston District, Charleston, SC. http://www.porteis.com/project/documents.htm.

USACE (U.S. Army Corps of Engineers).2008. Coastal Engineering Manual. Engineer Manual (EM) 1110-2-1100.

USACE (US. Army Corps of Engineers.) 2013. South Carolina Hurricane Evacuation Study Technical Data Report. Charleston District, Charleston, SC.

USACE. 2015. Charleston Harbor Post 45. Final Integrated Feasibility Report and Environmental Impact Statement. June 2015. Online at: http://www.sac.usace.army.mil/Missions/Civil - Works/Charleston - Harbor - Post - 45/.

USACE. 2017. Beneficial Uses for Charleston Harbor Deepening Project (Post 45): Final Supplemental Environmental Assessment. January 2017. Online at: http://www.sac.usace.army.mil/Portals/43/docs/civilworks/post45/finalbeneficialuseea/BeneUse%20Supplemental%20EA%20%20FINAL.pdf?ver=2017-01-13-134631-220. Appendices of this report accessible via: http://www.sac.usace.army.mil/Missions/Civil-Works/Charleston-Harbor-Post-45/.

U.S. Census Bureau. 2012. Census American Community Survey 2012. http://www.census.gov/acs/www/.

U.S. Environmental Protection Agency (EPA). 1973. Aesthetics in Environmental Planning. Document EPA-600/5-73-009. USEPA Office of Research and Development. Washington, DC. 159 pp.

Van Dolah, R.F., J.B. Boynton, K.S. Schulte, and J.C. Felber. 2011. A comprehensive spatial mapping effort of South Carolina's Coastal Resources and Activities. Final Report. Submitted to: South Carolina Energy Office, Columbia, SC.

Waring, G.T., E. Josephson, C.P. Fairfield - Walsh and K. Maze - Foley, eds. 2009. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments - 2008. NOAA Tech Memo. NMFS NE 210. 440 pp.

Weems, R.E., and Lewis, W.C. 2002. Structural and tectonic setting of the Charleston, South Carolina region: Evidence from the Tertiary stratigraphic record. Geological Society of America Bulletin. January 2002, V. 114, no. 1, p. 24-42.

Wilber, D.H., Clarke D.G. 2001. Biological effects of suspended sediments: a review of suspended sediment impacts on fish and shellefish with relation to dreding activities in estuaries. North American Journal of Fisheries Management. 21 (4): 855-75.

Wilber, D.H., W. Brostoff, D. Clarke, and G. Ray. 2005. Sedimentation: potential biological effects of dredging operations in estuarine and marine environments. DOER Technical Notes Collection. USACE, Engineering Research Development Center. ERDC TN-DOER-E20. 14p. http://el.erdc.usace.army.mil/dots/doer/pdf/doere20.pdf.

Zervas, C., Duncan, S., Deitemyer, D., Hubbard, J., Culp, J. Landon, T., Connolly, M., Wright, D., Bourgerie, R. 2000. Effects of Hurricane Floyd on Water Levesl Data Report. NOAA Technical Report, NOS CO-OPS 027.

Appendix A
Engineering Appendix

Charleston Harbor Cap 204 Detailed Project Report

Contents

I Purpose

The purpose of this Engineering appendix is to provide documentation of the supporting analyses in evaluating remaining alternatives of the beneficial use of the Post 45 Harbor Deepening new work construction dredge material covered under the Charleston Harbor Continuing Authorities Program (CAP) Section 204 Study. After evaluating over 15 alternatives the potential uses identified in the FINAL Integrated Feasibility Study and Environmental Impact Statement (IFR/EIS) and Supplemental Environmental Assessment were placement on Crab Bank and Shutes Folly Island for the purpose of bird nesting habitat. Discussions with experts concluded that material with a composition of at least 65% sand was acceptable for bird habitat. Determination of the future island acreages usable for bird nesting habitat require an estimate of future erosion.

Originally, the team had not decided on what criteria would be selected to determine the habitat. Foraging habitat could be considered the area above mean lower low water (MLLW). Nesting habitat for some of the species using the island could be mean higher high water (MHHW) since it would not be overtopped by tides. Finally, the Brown Pelican was selected as the species to evaluate using the Habitat Suitability Indices (HSI) that was available. The elevation criteria for the Brown Pelican is 2 feet above mean high water, which is equal to 7.4 MLLW or 4.27 NAVD88.

II Methodology Crab Bank and Shutes Folly Island Shoreline Change Analysis.

II.1 Introduction

Crab Bank and Shutes Folly Island are important bird habitat areas and have been experiencing erosion/changing shorelines over several decades.

As part of the Post 45 project it was proposed to employ beneficial use of dredged material from the harbor to enhance the bird habitat on the islands. As part of previous shoreline change analyses conducted by Charleston District (SAC) and by the Engineering Research and Development Center (ERDC), habitat acreage and erosion rate for Crab Bank and Shutes Folly Island were determined. However, due to inconsistencies in the methodology and interpretation as well as the dynamic nature of the island, the results between the two studies were not consistent.

The two previous methods involved using aerial imagery to detect the edge of the island and thus estimate an area for the island. While this method is sufficient to determine area and area change, it is subject to interpretation of the shoreline boundary. It also fails to detect changes in volume over time. It was proposed that for the purposes of this study that SAC utilize Digital Elevation Maps (DEMs) derived from Aerial Light Detection and Ranging (LIDAR) data to determine the shape and size of Crab Bank and Shutes Folly Island . Using elevation allows determination of the size and shape of the island using a contour based on a defined vertical datum. Using a contour eliminates error generated by visual interpretation of the shoreline because it is based on a measured elevation.

II.2 Data

The first challenge for this study was finding data over a sufficient time period. SAC has contracted LIDAR flights through Joint Airborne Lidar Bathymetry Technical Center of Expertise (JALBTX) for the last several years within Charleston Harbor, but only 2016 captured all of Crab Bank. NOAA's Digital Coast repository (https://coast.noaa.gov/dataviewer/#/) is an excellent source of data and the District was able to obtain data collected by the State of South Carolina going back to 2000. In the end, the analysis used four datasets from the years 2000, 2007, 2009, and 2016. All data used a Horizontal datum of South Carolina State Plane (2011) International Feet, and the North American Vertical Datum 1988 (NAVD88).

The accuracy of the datasets is as follows, excerpted from source's metadata :

A. 2000 Summer East Coast NOAA/USGS/NASA Airborne LiDAR Assessment of Coastal Erosion (ALACE) Project for the US Coastline

Full metadata report can be found here:
https://coast.noaa.gov/dataservices/Metadata/TransformMetadata?u=https://coast.noaa.gov/data/Documents/Metadata/Lidar/harvest/atm2000_summer_east_coast_m10_metadata.xml&f=html

Horizontal_Positional_Accuracy_Report:

The ATM LIDAR elevation points are known to be horizontally accurate to +/- 0.8 meters at an aircraft altitude of 700 meters.

Vertical_Positional_Accuracy_Report:

The ATM LIDAR elevation measurements have been found to be within +/- 15 centimeters of each other in successive and overlapping passes of the same area. In comparisons of LIDAR data for a small geographic region with various ground surveys the differences are between +/- 15 to 20 centimeters. The accuracy of the majority of the data is estimated to be consistent with the above stated results. At this time, there has been no large scale verification of the data.

B. 2007 South Carolina LiDAR: Charleston (partial), Jasper, and Colleton Counties

Full metadata report can be found here:
https://coast.noaa.gov/dataservices/Metadata/TransformMetadata?u=https://coast.noaa.gov/data/Documents/Metadata/Lidar/harvest/sc2007_jas_coll_chas_m56_metadata.xml&f=html

Horizontal_Positional_Accuracy_Report:

CHARLESTON COUNTY: Horizontal accuracy is 1 m based on collections specifications.

Vertical_Positional_Accuracy_Report:

CHARLESTON COUNTY: Based on a control-to-LiDAR comparison, LiDAR data delivered for this project returned an RMSE of 0.092 m and an Accuracy of 0.18 m at the 95% confidence level in open terrain, based on 26 points. Combined Vertical Accuracy (CVA) is 0.183 m at the 95% confidence level, based on 75 points.

C. 2009 SCDNR Charleston County Lidar

Full metadata report can be found here:
https://coast.noaa.gov/dataservices/Metadata/TransformMetadata?u=https://coast.noaa.gov/data/Documents/Metadata/Lidar/harvest/sc2009_scdnr_charleston_m3653_metadata.xml&f=html

Horizontal_Positional_Accuracy_Report:

Lidar source compiled to meet 1 meter horizontal accuracy.

Quantitative_Horizontal_Positional_Accuracy_Assessment:

Horizontal_Positional_Accuracy_Value: 1.0
Horizontal_Positional_Accuracy_Explanation:
Dewberry does not perform independent horizontal accuracy testing on the LiDAR. LiDAR vendors perform calibrations on the LiDAR sensor and compare data to adjoining flight lines to ensure LiDAR meets the 1 meter horizontal accuracy standard at the 95% confidence level.

Vertical_Positional_Accuracy_Report:

The vertical accuracy of the original LiDAR was tested by Dewberry in 2012 (or whenever we performed the original QAQC). Vertical Accuracy was not re-tested post updates performed in 2014.
The vertical accuracy of the of the full LiDAR project was tested by Dewberry with independent survey checkpoints. The survey checkpoints were evenly distributed throughout the project area and are located in areas of bare earth and open terrain, high grass, pavement, brush and low trees, and forest. The vertical accuracy is tested by comparing survey checkpoints to a triangulated irregular network (TIN) that is created from the LiDAR ground points. Checkpoints are always compared to interpolated surfaces created from the LiDAR point cloud because it is unlikely that a survey checkpoint will be located at the location of a discrete LiDAR point. Checkpoints in open terrain were used to compute the Fundamental Vertical Accuracy (FVA). Project specifications required a FVA of 0.80 ft (24.5 cm) based on a RMSEz (0.41 ft/12.5 cm) x 1.9600. All checkpoints were used to compute the Consolidated Vertical Accuracy (CVA). Project specifications required a CVA of 1.19 ft (36.3 cm) based on the 95th percentile.

Quantitative_Vertical_Positional_Accuracy_Assessment:

Vertical_Positional_Accuracy_Value: 0.185
Vertical_Positional_Accuracy_Explanation:
Calculated FVA to 0.61 ft (18.5 cm). Based on the vertical accuracy testing conducted by Dewberry, using NSSDA and FEMA methodology, vertical accuracy at the 95% confidence level (called Accuracyz) is computed by the formula RMSEz x 1.9600 (Charleston County had a RMSEz of 9.25 cm+). The dataset for the Charleston County, SC LiDAR project satisfies the criteria: Lidar dataset tested 0.49 ft vertical accuracy at 95% confidence level in open terrain, based on RMSEz (0.33 ft) x 1.9600.

D. 2016 Charleston Harbor Survey JALBTX

Horizontal_Positional_Accuracy_Report:

Compiled to meet 0.909 feet horizontal accuracy at 95 percent confidence level.

Vertical_Positional_Accuracy_Report:

Bare-Earth DEM Non-Vegetated Vertical Accuracy (NVA) Tested 0.197 Ft Intl Non-Vegetated vertical accuracy at a 95 percent confidence level, derived according to NSSDA, in open terrain using (RMSEz) x 1.96000 as defined by the National Standards for Spatial Data Accuracy (NSSDA); assessed and reported using National Digital Elevation Program (NDEP)/ASPRS Guidelines and tested against the DEM.

II.3 Tools

All data processing and analysis was performed using ArcGIS for Desktop 10.4.1.

- The Primary toolboxes used were Data Management, Spatial Analyst, and 3D Analyst.
- Tools used:
  - Contour (Spatial Analyst)
  - Feature to Polygon (Data Management)
  - Calculate Field (Data Management)
  - Polygon to Raster (Data Management)
  - Cut Fill (3D Analyst)

II.4 Data Processing

Contour quality:

Esri's contour tool quality statement: Excerpted from Esri's online help documentation:

http://desktop.arcgis.com/en/arcmap/10.3/tools/3d-analyst-toolbox/how-contouring-works.htm

The contour tools produce engineering-quality contours, representing an exact interpretation of the raster surface. Overall contour accuracy depends on how well the data used to create the input raster represents the actual surface.

The size of the raster cells used affects the appearance of the output contours. A large cell size may result in coarse, blocky contours.

Occasionally, engineering-quality contours may cross, appear to intersect, or form an unclosed branching line. Crossing contours can occur in saddle regions that lie exactly on a contour interval. In other cases, the contours may pass so close to one another that they appear to intersect. Branching contours can occur in cases of intersecting ridges that fall exactly on a contour interval. These are all valid engineering-quality interpretations of the surface that cartographers typically modify for aesthetic purposes.

All elevations referenced in this section are in NAVD88 unless otherwise stated.

Baseline Data Processing (using Crab Bank as an example)

1. Contours were generated with a 1 foot interval for each of the four years. The Islands were fairly well defined by the contours but depending on the tide at the time the data were collected the lowest contour varied from -3 foot elevation to a -1 foot NAVD88 elevation.
2. After evaluating the data, the -1 foot NAVD88 (or approx. 2.14 MLLW) elevation was the lowest contour that each dataset had in common and was used as the baseline elevation for Crab Bank for all four years.
3. Contours generated did a good job of laying out the general shape of the Island, however, some manual cleanup was still required in order to create closed polyline features off which a raster surface could be defined. Using the data editor, gaps in the contours were manually closed. (Figure 1)

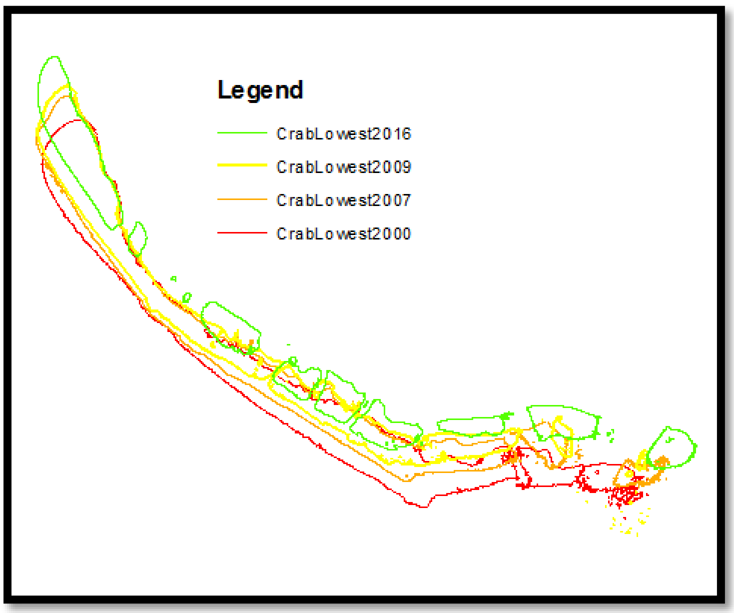


Figure 1 – Negative 1 foot contours for Crab Bank 2000 - 2016

4. Once all gaps were removed polylines representing the -1 elevation were converted to polygons using the feature to polygon tool.
5. Polygons were then converted into Raster surfaces with a value of -1 using the Polygon to Raster tool. (Figure 2)

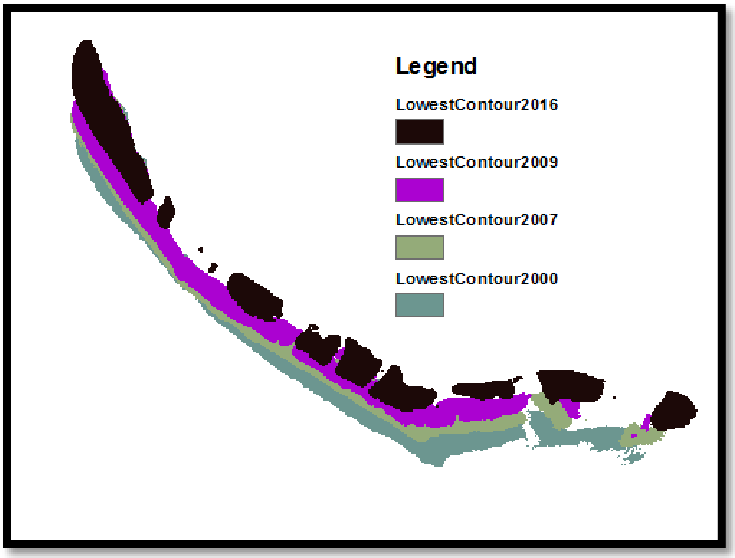


Figure 2 – Negative 1 foot Surfaces for Crab Bank 2000 - 2016

Further Processing

After discussion amongst the team, further need was determined to evaluate the changes in Crab Bank in four roughly equal-area sections to determine if the erosion/accretion rate varied depending on location. Using the data editor four roughly equal-area polygons (Zones 1 through 4) were created to evaluate changes in the island over time. (Figure 3)

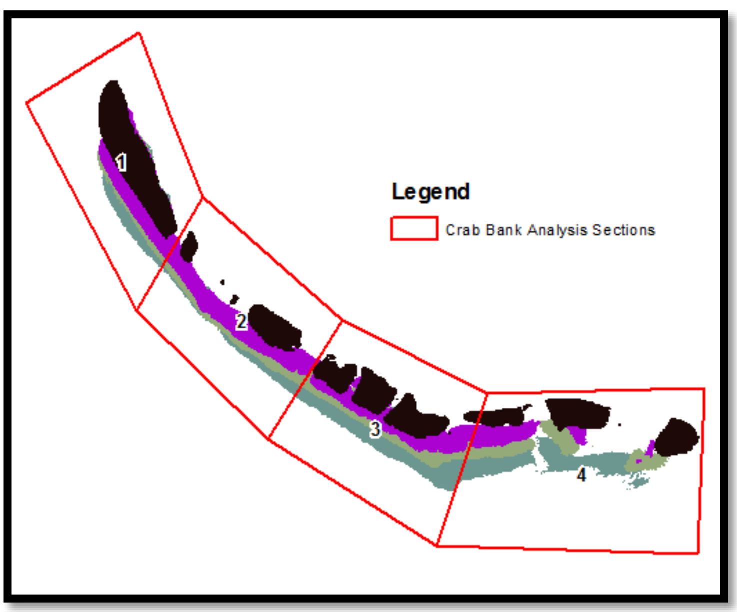


Figure 3 – Analysis Sections for Crab Bank at elevation -1 NAVD88

1. In order to determine the area and volume of each section, the Cut-Fill tool was used between the -1 elevation surface for each year and section thus providing the total area and volume of Island above this base elevation.

2. Area and Volume values were transcribed into a spreadsheet where rates of change between the datasets were calculated using simple subtraction. (Figure 4)

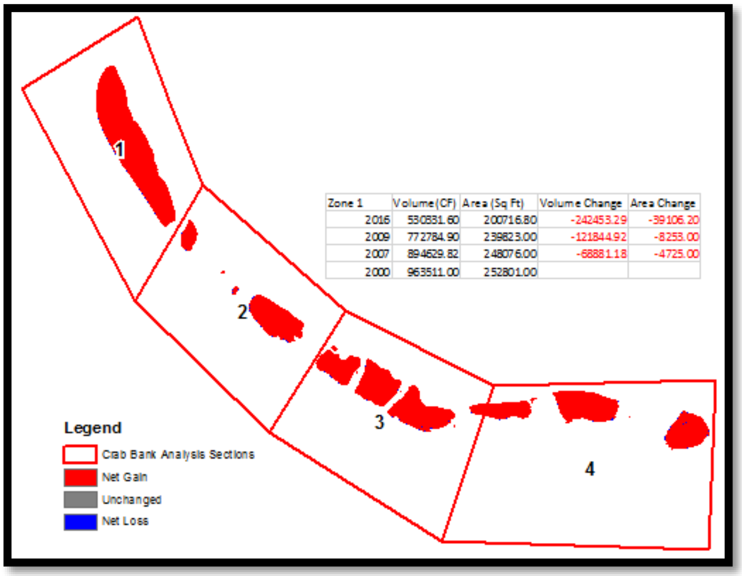


Figure 4 – Sample of Cut-Fill Analysis

Note* All of the above processing steps, except the manual operations, can be modeled for easy repetition in the future.

Based on the accuracy of the data, there is a 95% confidence level that the analysis is within 1 square meter (approximately 11 square feet or 0.0002 acres) for area and within .18 cubic meters (approximately 35 cubic feet) for volume based on the lowest accuracy assessment of the data sets used.

While assessment of the -1 elevation contour provides an idea of the changes of the island at low tide, the bird nesting habitat is the area above Mean Higher High Water (MHHW) that is not overtopped by tidal and wave action. Therefore the same procedure was performed for the 2.6 NAVD88 contour (5.76 MLLW).

Elevations of tidal datums referred to Mean Lower Low Water (MLLW),				
			meters	feet
HIGHEST OBSERVED WATER LEVEL (09/21/1989)			3.817	12.52
MEAN HIGHER HIGH WATER	MHHW		1.757	5.76
MEAN HIGH WATER	MHW		1.648	5.41
North American Vertical Datum	NAVD88		0.957	3.14
MEAN SEA LEVEL	MSL		0.891	2.92
MEAN TIDE LEVEL	MTL		0.853	2.80
MEAN LOW WATER	MLW		0.057	0.19
MEAN LOWER LOW WATER	MLLW		0	0.00
LOWEST OBSERVED WATER LEVEL (03/13/1993)			-1.245	-4.08
Based on North American Vertical Datum (NAVD88)				

III Erosional Trends Based on Shoreline Change Analysis

III.1 Crab Bank: In order to determine an erosional trend to assess habitat units lost over time, volume and area changes of the entire island at the -1 NAVD88 elevation were evaluated. When the subareas were evaluated, it was noted that the Zone 1 rate of change was much less than the other zones and that the volume to area ratio was greater than the other zones. .

As seen in Table 1, the overall reduction in habitat above -1 NAVD88 (or 2.14 MLLW) indicated an initial loss of 18% over the first seven years, 17% over the next two years, then tapering off to 11% over the next 7 years. Zone 1 experienced a lesser change in area initially then increased the last 7 years. Zone 2 saw a significantly increased loss the last 7 years over the first 7 years. Zone 3 had a greater loss in the first 9 years then tapered off. Zone 4 had an initial loss of about 26%, a significant loss in two years, but then indicated a slight increase in area by the year 2016 but with a loss in volume (note the 2009 dataset was incomplete for the end of the island).

Table 1 Crab Bank Assessment of the -1 NAVD88 contour

Total Area		Volume (CF)	Area (Sq Ft)	Area acres	Volume Change	Volume % change	Area Change	Area % change	vol/area
2016	16	795663	602631	13.83	-486459	-38%	-76986	-11%	1.32
2009	9	1282122	679617	15.60	-548088	-30%	-142281	-17%	1.89
2007	7	1830210	821898	18.87	-827730	-31%	-182664	-18%	2.23
2000	0	2657940	1004562	23.06					2.65
Zone 1		**Volume (CF)**	**Area (Sq Ft)**	**Area acres**	**Volume Change**	**Volume % change**	**Area Change**	**Area % change**	**vol/area**
2016	16	530332	200717	4.61	-242453	-31%	-39106.20	-16%	2.64
2009	9	772785	239823	5.51	-121845	-14%	-8253.00	-3%	3.22
2007	7	894630	248076	5.70	-68881	-7%	-4725.00	-2%	3.61
2000	0	963511	252801	5.80					3.81
Zone 2		**Volume (CF)**	**Area (Sq Ft)**	**Area acres**	**Volume Change**	**Volume % change**	**Area Change**	**Area % change**	**vol/area**
2016	16	31291	81431	1.87	-188094	-86%	-84411.96	-51%	0.38
2009	9	219385	165843	3.81	-254829	-54%	-27702.00	-14%	1.32
2007	7	474214	193545	4.44	-170439	-26%	-25155.00	-12%	2.45
2000	0	644652	218700	5.02					2.95
Zone 3		**Volume (CF)**	**Area (Sq Ft)**	**Area acres**	**Volume Change**	**Volume % change**	**Area Change**	**Area % change**	**vol/area**
2016	16	193315	169761	3.90	-57764	-23%	-25457.72	-13%	1.14
2009	9	251079	195219	4.48	-130966	-34%	-38160.00	-16%	1.29
2007	7	382045	233379	5.36	-525428	-58%	-99855.00	-30%	1.64
2000	0	907472	333234	7.65					2.72
Zone 4		**Volume (CF)**	**Area (Sq Ft)**	**Area acres**	**Volume Change**	**Volume % change**	**Area Change**	**Area % change**	**vol/area**
2016	16	40726	150723	3.46	-38597	-49%	3824.56	3%	0.27
2009	9	38874	78732	1.81	-40449	-51%	-68166.00	-46%	0.49
2007	7	79322	146898	3.37	-62982	-44%	-52929.00	-26%	0.54
2000	0	142304	199827	4.59					0.71

Note: The Zone 4 2009 Area dataset was incomplete and therefore disregarded in the assessment.

A regression analysis based on the total area reduction was used to estimate the erosional trend. (Figure 5)

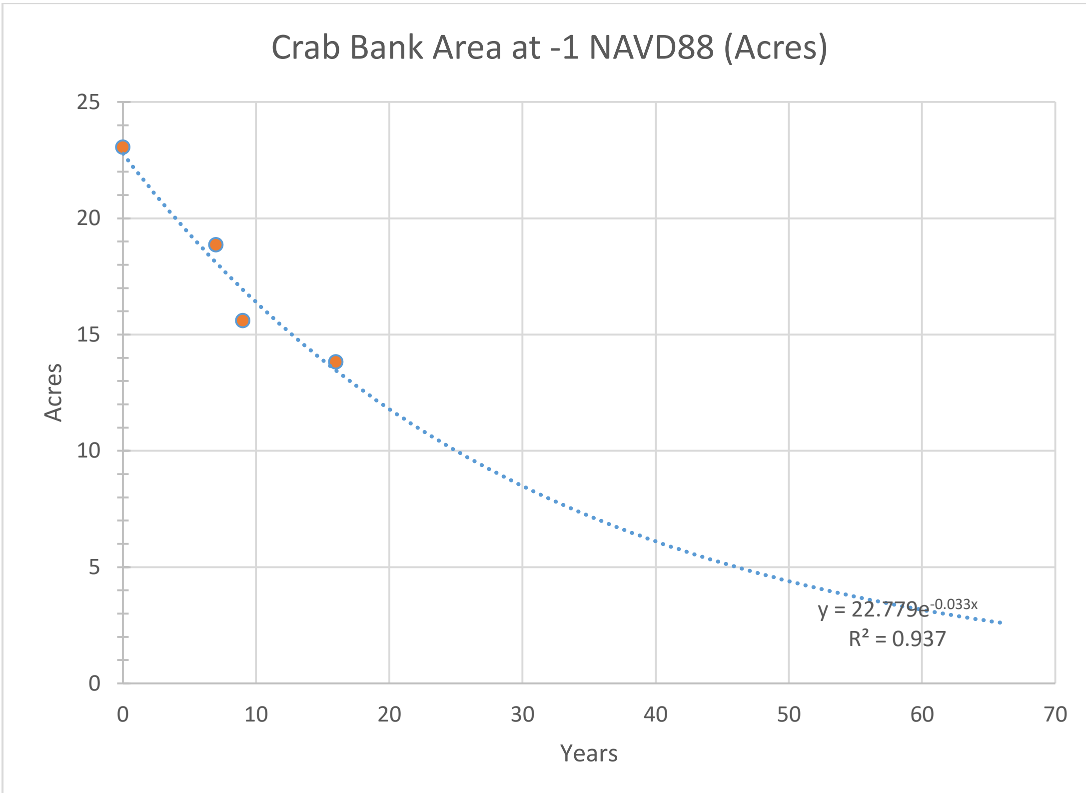


Figure 5 Crab Bank Erosion Trend of total area at -1 NAVD88

The focus, however, is on bird habitat and therefore the area above MHHW. The same analysis was done for the area above MHHW or 2.6 NAVD88. (Figure 6) Significant portions of the island in Zone 4 were overwashed frequently and lost within the first 7 years since 2000. Zone 2 lost 96% within the first nine years and all within 16 years, shown in Table 2 below. Zone 3 lost 81% in the first 7 years and 89% in the first nine years.

The petals selected for the wind rose for Charleston Harbor (Figure 7) reflect the three key directions: the largest number of winds, the highest speed winds and those with longest fetch (distance to travel). The largest number of winds in Charleston Harbor come from the southwest, while the most high-speed winds (fastest 10% of winds) come from the north-northeast direction (Wando River). Winds entering the harbor from open ocean (south-east) have the potential to travel the furthest distance before reaching a shoreline. (See Appendix A of Charleston Harbor Final Integrated Feasibility Study and Environmental Impact Statement (IFR/EIS) for more discussion on wind generated waves). The combination of low elevation of this portion of the island and high wave action effected the increased erosion rate of Zones 2, 3 and 4.

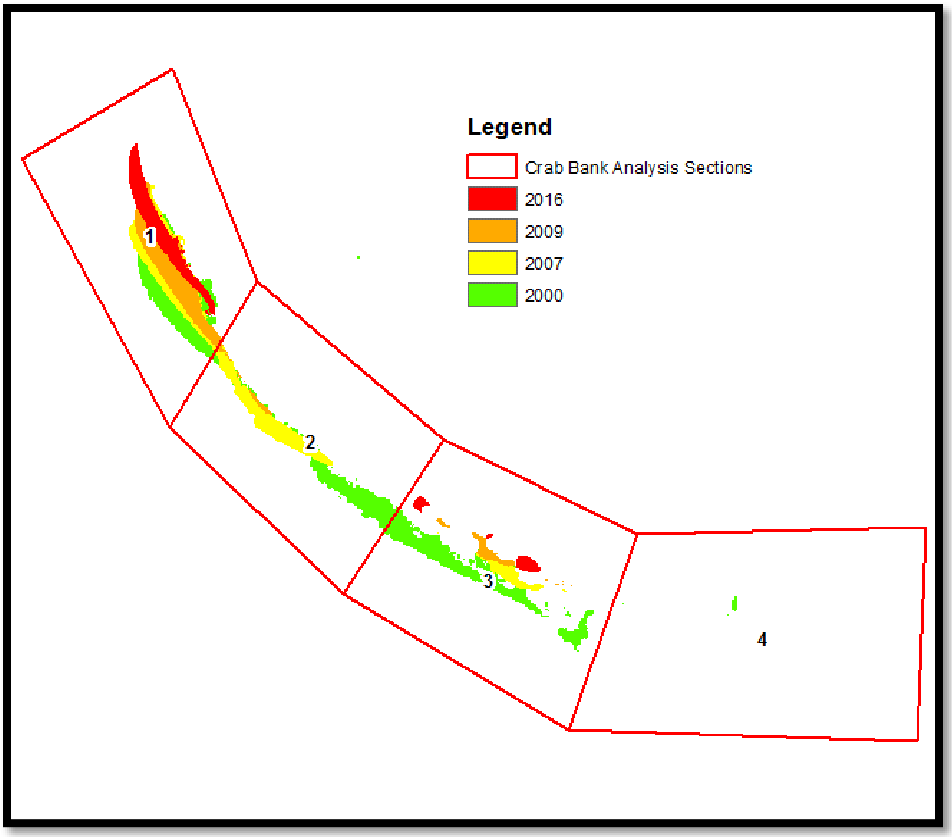


Figure 6 Crab Bank Assessment at 2.6 NAVD88

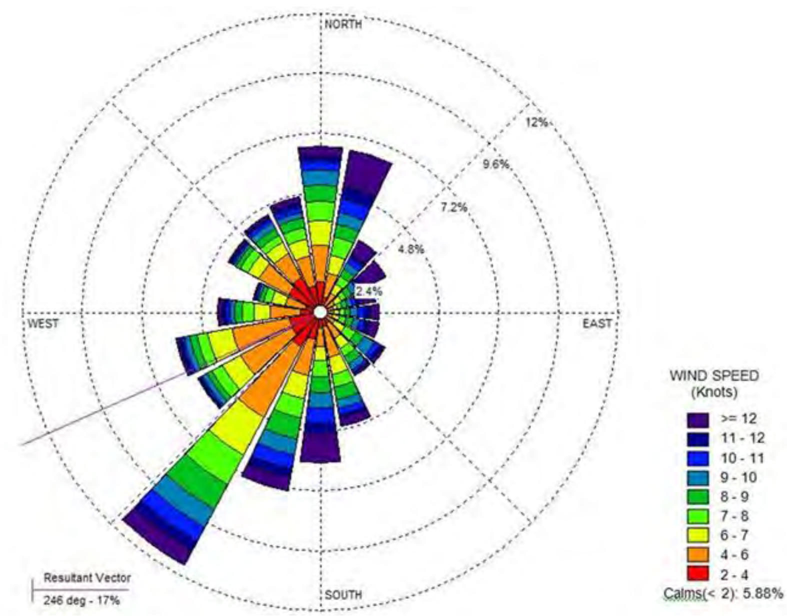


Figure 7 Wind Rose Charleston Harbor (source FINAL IFR/EIS)

Table 2 Crab Bank Assessment of the 2.6 NAVD88 contour (MHHW)

Total Area		Volume(CF)	Area (Sq Ft)	Area acres	Volume Change	Volume % change	Area Change	Area % change	vol/area
2016	**16**	101227	65016	1.49	-87862	-46%	-41526	-39%	1.56
2009	**9**	189090	106542	2.45	-159556	-46%	-84024	-44%	1.77
2007	**7**	348645	190566	4.37	-828962	-70%	-732186	-79%	1.83
2000	**0**	1177607	922752	21.18					1.28
Zone 1		**Volume(CF)**	**Area (Sq Ft)**	**Area acres**	**Volume Change**	**Volume % change**	**Area Change**	**Area % change**	**vol/area**
2016	**16**	93968	55012	1.26	-86671	-48%	-37688	-41%	1.71
2009	**9**	180640	92700	2.13	-75846	-30%	-28044	-23%	1.95
2007	**7**	256485	120744	2.77	11511	5%	-32508	-21%	2.12
2000	**0**	244974	153252	3.52					1.60
Zone 2		**Volume(CF)**	**Area (Sq Ft)**	**Area acres**	**Volume Change**	**Volume % change**	**Area Change**	**Area % change**	**vol/area**
2016	**16**	0	0	0.00	-1304	-100%	-3861	-100%	0.00
2009	**9**	1304	3861	0.09	-73844	-98%	-48501	-93%	0.34
2007	**7**	75149	52362	1.20	-16187	-18%	-37062	-41%	1.44
2000	**0**	91336	89424	2.05					1.02
Zone 3		**Volume(CF)**	**Area (Sq Ft)**	**Area acres**	**Volume Change**	**Volume % change**	**Area Change**	**Area % change**	**vol/area**
2016	**16**	7259	10004	0.23	113	2%	23	0%	0.73
2009	**9**	7146	9981	0.23	-9866	-58%	-7479	-43%	0.72
2007	**7**	17011	17460	0.40	-60771	-78%	-76176	-81%	0.97
2000	**0**	77782	93636	2.15					0.83
Zone 4		**Volume(CF)**	**Area (Sq Ft)**	**Area acres**	**Volume Change**	**Volume % change**	**Area Change**	**Area % change**	**vol/area**
2016	**16**	0	0	0.00	0	0%	0	0%	0.00
2009	**9**	0	0	0.00	0	0%	0	0%	0.00
2007	**7**	0	0	0.00	-925	-100%	-2025	-100%	0.00
2000	**0**	925	2025	0.05					0.46

The majority of the island in Zones 2, 3 and 4 are below MHHW (see table 2) and are subject to tidal action and overwash. Therefore, the erosion rate is higher in these areas and bias the erosion rate of the entire island. The proposed construction of the island will result in a larger percentage of the island above MHHW for the purpose of creating habitat, therefore, the erosion rate of the entire island is not expected to be duplicated. It can be estimated that the erosional trend of the high ground would more duplicate Zone 1 erosion. (Figure 8)

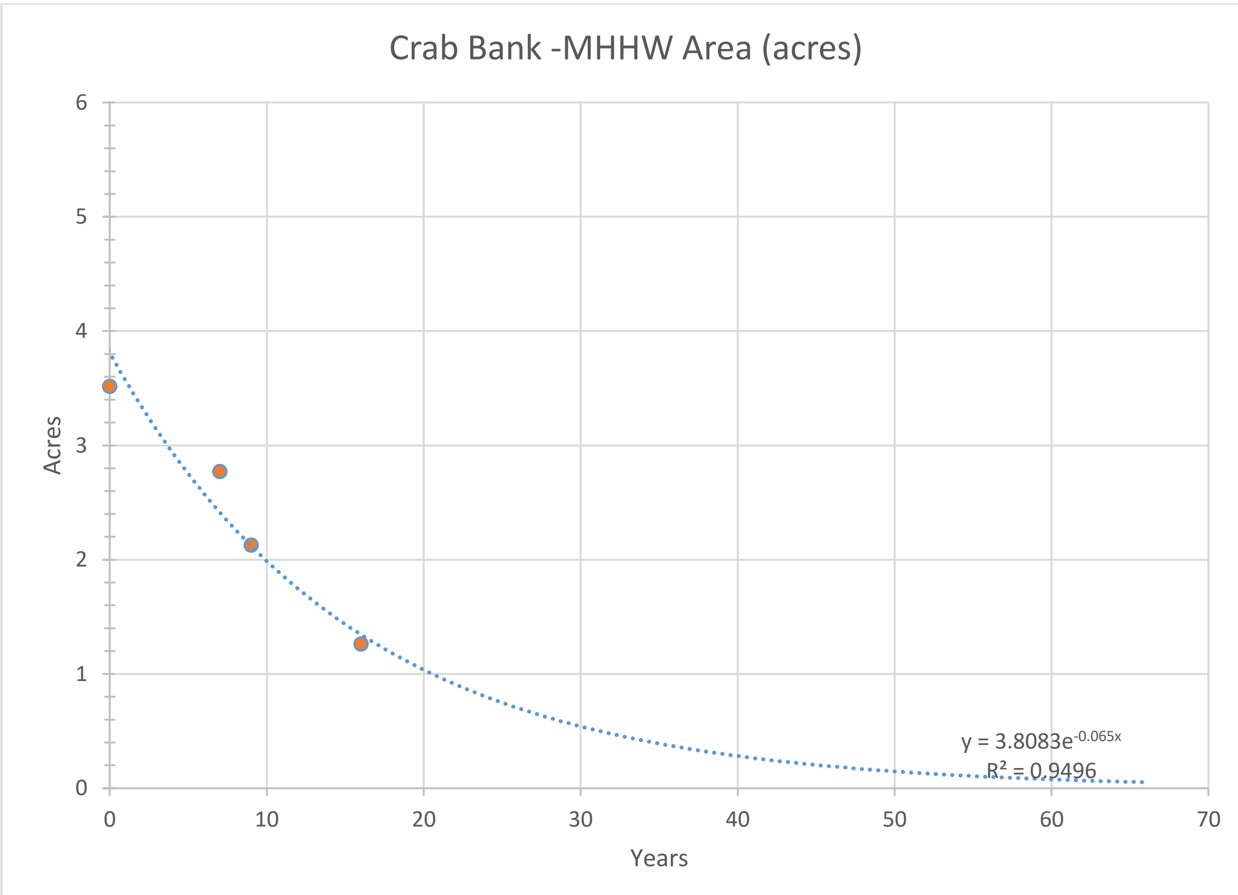


Figure 8 Crab Bank Erosion Trend of MHHW for Zone 1

The Brown Pelican is the species being evaluated with a Habitat Suitability Index (HSI) model to determine ecologic benefits. The criteria for nesting is 2 feet above MHW, which is 7.41 MLLW or 4.27 NAVD88. Table 3 shows the changes in area at elevation 7.41 MLLW that were used to develop the erosional trend. Again Zone 1 was used to determine the erosion trend of the proposed alternatives (Figure 9).

Table 3 Crab Bank Assessment of the 7.41 MLLW (which is 2 feet above MHW)

Total Area		Area (Sq Ft)	Area Change		Acres
2016	16	29628.94	-35010.67		0.68
2009	9	64639.61	-43353.16		1.48
2007	7	107992.77	-4724.75		2.48
2000	0	112717.52			2.59
Zone 1		**Area (Sq Ft)**	**Area Change**	**Max Elev**	**Acres**
2016	16	28719.33	-35833.62	6.66	0.66
2009	9	64552.95	-21701.64	7.15	1.48
2007	7	86254.59	-9204.40	6.82	1.98
2000	0	95458.99		9.63	2.19
Zone 2		**Area (Sq Ft)**	**Area Change**	**Max Elev**	**Acres**
2016	16	0.00	0.00	0.28	0.00
2009	9	0.00	-18241.72	3.86	0.00
2007	7	18241.72	9015.14	6.96	0.42
2000	0	9226.58		5.67	0.21
Zone 3		**Area (Sq Ft)**	**Area Change**	**Max Elev**	**Acres**
2016	16	909.61	822.95	4.69	0.02
2009	9	86.66	-3409.80	4.63	0.00
2007	7	3496.46	-4535.49	4.95	0.08
2000	0	8031.95		5.42	0.18
Zone 4		**Area (Sq Ft)**	**Area Change**	**Max Elev**	**Acres**
2016	16	0.00	0.00	0.03	0.00
2009	9	0.00	0.00	0.85	0.00
2007	7	0.00	0.00	2.04	0.00
2000	0	0.00		4.03	0.00

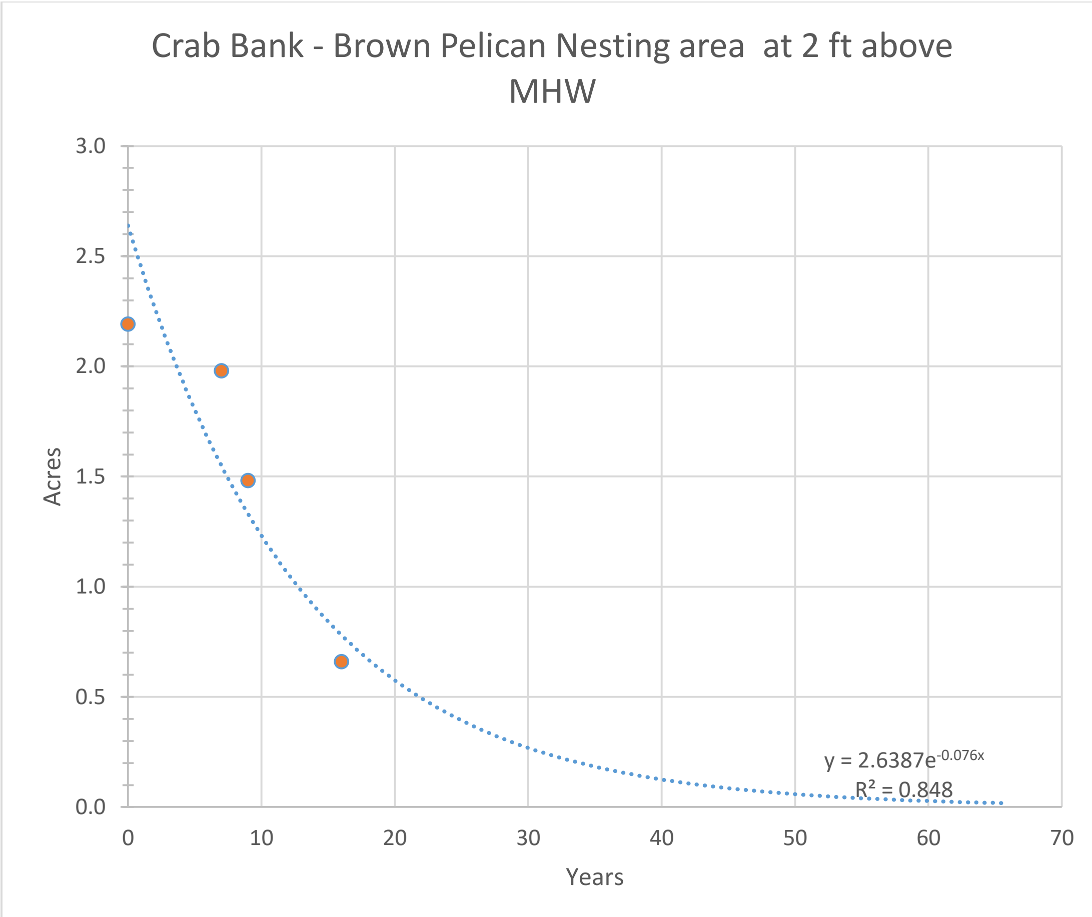


Figure 9 Crab Bank Erosion Trend for 2 feet above MHW or 7.41 MLLW

III.2 Shutes Folly Island

Shutes Folly Island does not have the same variability along the island, in that there are no large portions of the island that are submerged at mid and high tide levels (Figure 10). Therefore, the island was assessed as a whole for the area along the channel where placement would occur. The erosional trend for the total area at elevation 0 NAVD88 was determined (Figure 11), as well as the area at MHHW (Figure 12) and 2 feet above MHW or 7.41 MLLW (Figure 13).

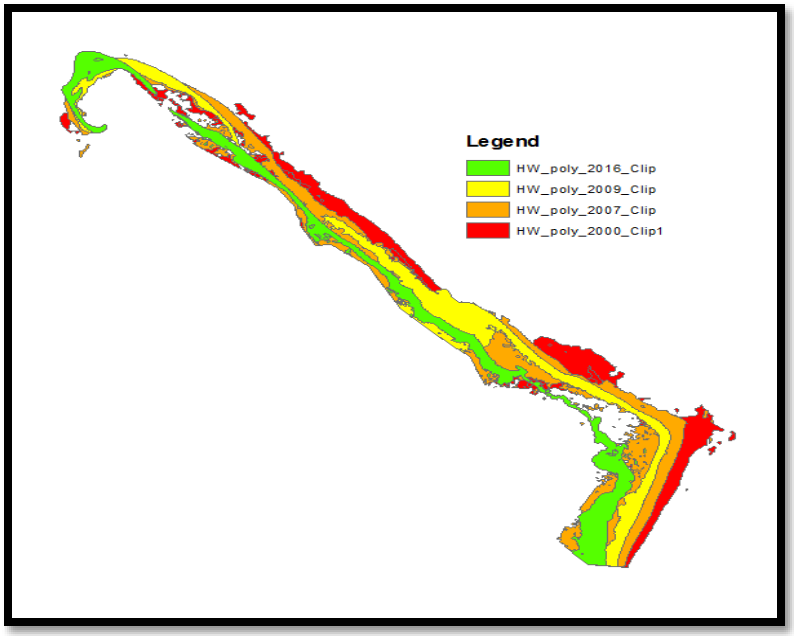


Figure 10 Shutes Folly Island Shoreline Change at elevation MHHW (2.6 NAVD88)

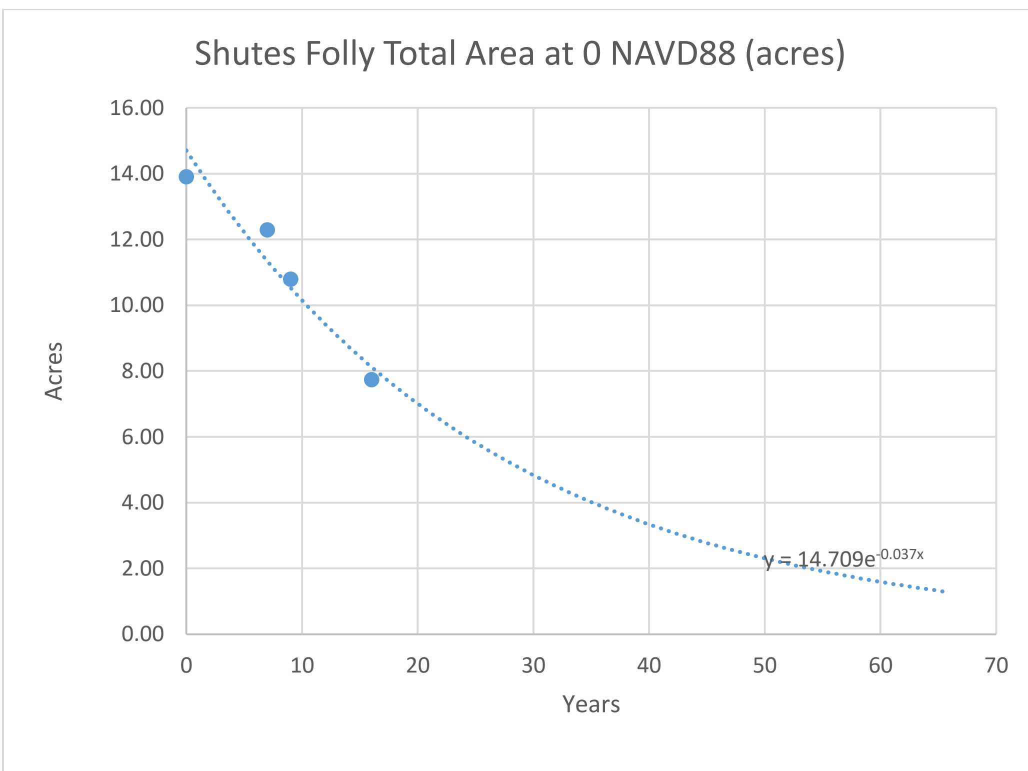


Figure 11 Shutes Folly Island Erosion Trend Total Area

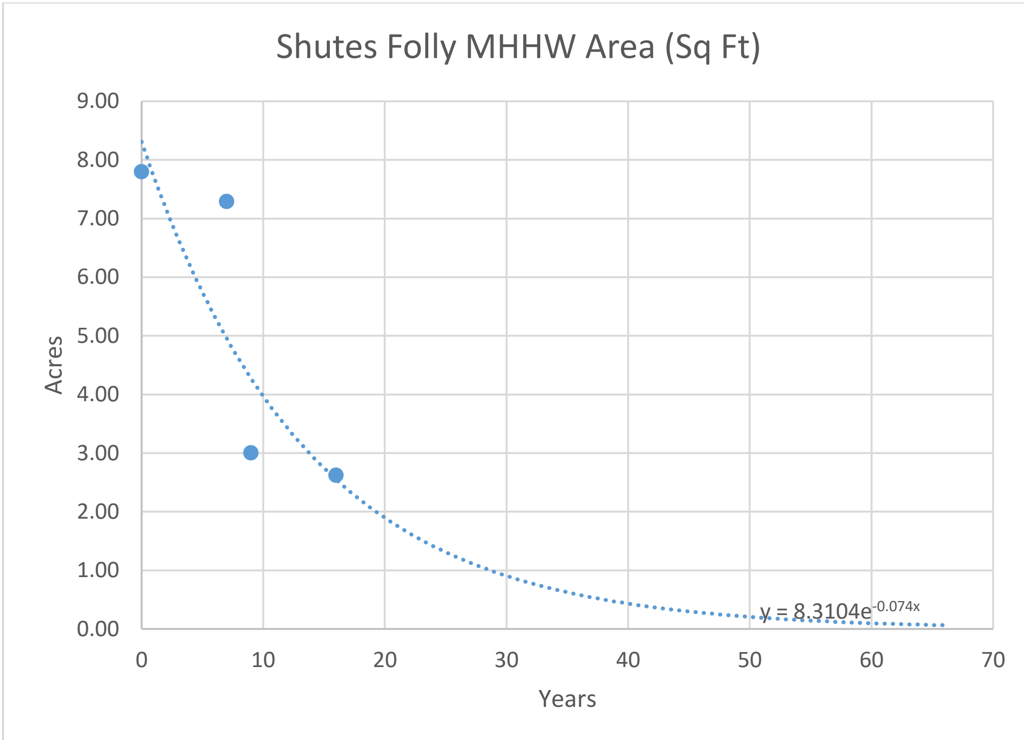


Figure 12 Shutes Folly Island Erosion Trend MHHW

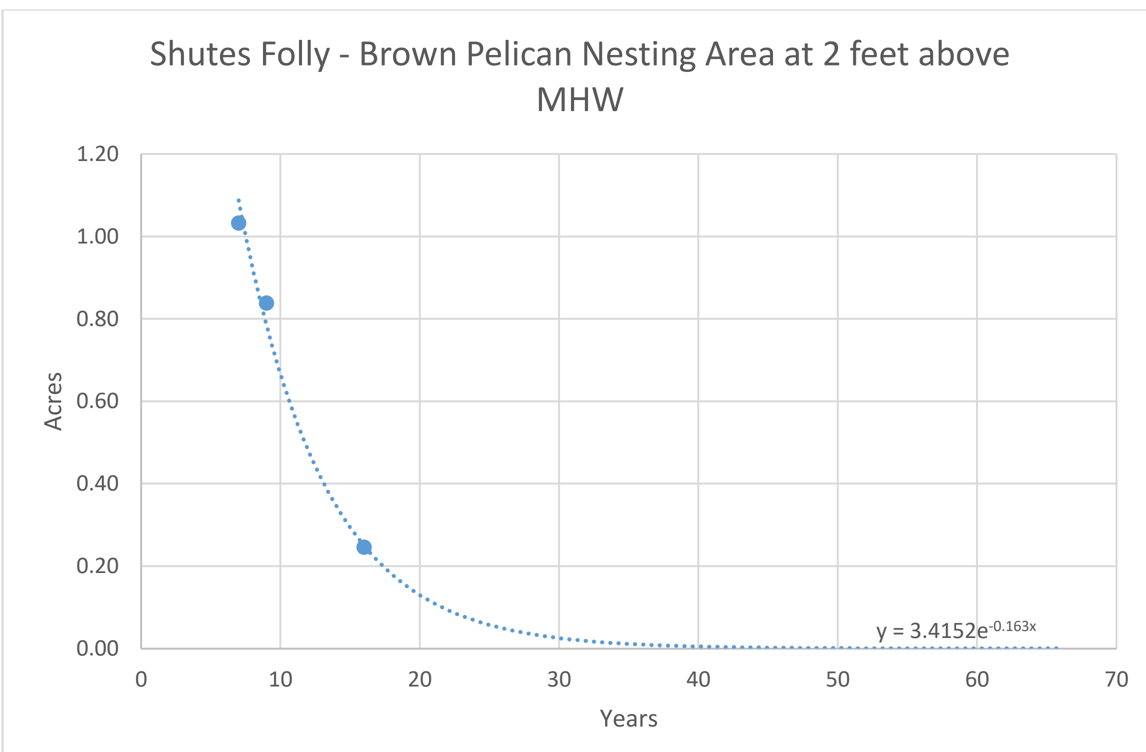


Figure 13 Shutes Folly Island Erosion Trend 2 feet above MHW

IV Existing Sediment Composition

A SCDNR report documents the analysis that was done to characterize the surficial sediment across Crab Bank and Shutes Folly Island. (see Appendix A of the Supplemental Environmental Assessment). The analysis concluded Crab Bank is considerably sandier than Shutes Folly Island. On average, sediments collected from Crab Bank are comprised of 91% sand, as compared to 71% for Shutes Folly Island. Large portions of Shutes Folly Island are whole oyster shell, which is notably absent from Crab Bank. Between the two islands, the average composition is 81% sand (55% excluding $CaCO_3$), but there is a wide variety of sediment types present, especially on Shutes Folly Island.

V Sea Level Change

USACE Engineering Regulation ER 1110-2-8162 "Incorporating Sea Level Change into Civil Works Programs" was developed with the assistance of coastal scientists from the NOAA National Ocean Service and the US Geological Survey. Please refer to the ER for explanation of how and why sea level is to be applied to USACE projects. Planning studies and engineering designs are to evaluate the entire range of possible future rates of sea-level change (SLC), represented by three scenarios of "low", "intermediate' and "high" sea-level change. (Figure 12). The use of sea level change scenarios as opposed to individual scenario probabilities underscores the uncertainty in how local relative sealevels will actually play out into the future. At any location, changes in local relative sea level (LRSL) reflect the integrated effects of global mean sea level (GMSL) change plus local or regional changes of geologic, oceanographic, or atmospheric origin.

- "**Low**" rate of sea-level change is equal to the historic rate of SLC.
- "**Intermediate**" rate of sea-level (ISL) change is based on the modified NRC curve I and Using the current estimate of 1.7 mm/year for GMSL change, the following equations

$$E(t) = 0.0017t + bt^2$$

in which t represents years, starting in 1986, b is a constant, and E(t) is the eustatic sea level change, in meters, as a function of t.

Manipulating the above equation to account for the fact that it was developed for eustatic sea level change starting in 1992, while projects will actually be constructed at some date after 1992, results in equation

$$E(t_2) - E(t_1) = 0.0017(t_2 - t_1) + b(t_2^2 - t_1^2)$$

where t_1 is the time between the project's construction date and 1992 and t_2 is the time between a future date at which one wants an estimate for sea level change and 1992 (or $t_2 = t_1$ + number of years after construction)

- "**High**" rate of sea-level change (HSL) is based on the modified NRC curve III and the above equations.

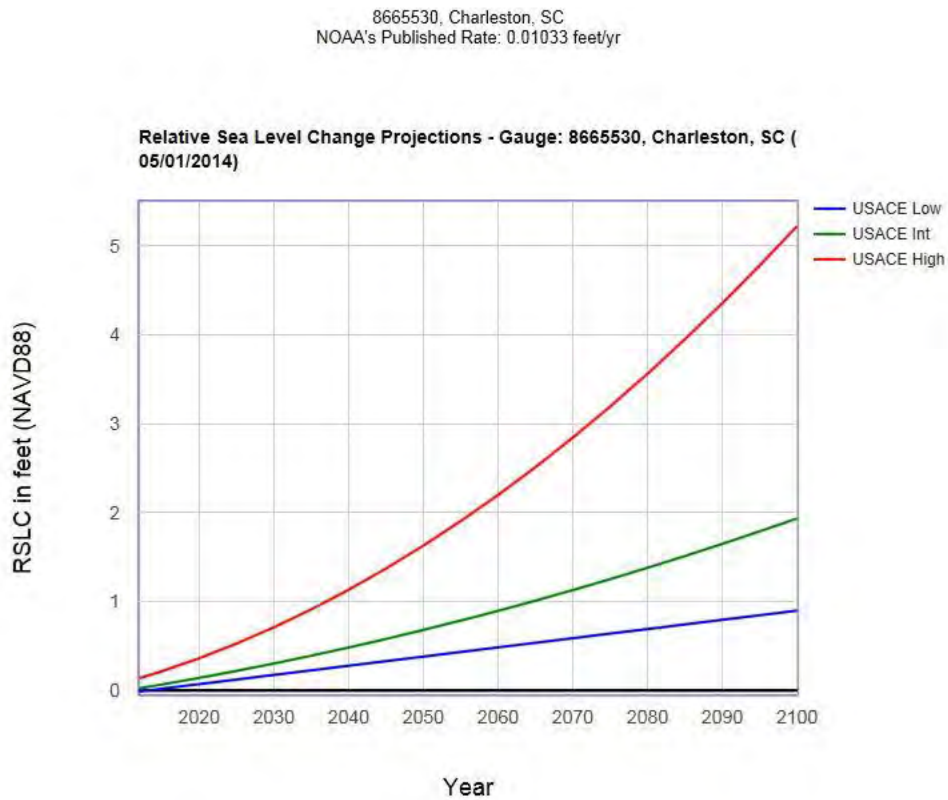


Figure 14 Relative Sea Level Changes for Charleston Harbor

Using the USACE Institute of Water Resources (IWR) Sea Level Change calculator spreadsheet the trend at Charleston is estimated to be 3.15 mm/yr (.01033ft/yr) based on CO-OPS gage 8665530. 2012 tidal data is used for the analysis of existing conditions. Estimating construction completion of 2020, and a 50 year project life, – the rates of change relative to Charleston Harbor are as follows: "low" rate of change is 0.6 feet, the "intermediate" is 1.1 feet and the "high" is 2.8 feet (Table 4 and Figure 14).

All alternatives are equally affected by the rate of sea level change. Therefore, the study alternative analysis is done within a single scenario, typically the "most-likely" or historic (low) rate and identify the preferred alternative under that scenario.

Since the erosion trend is based on a historical trend of elevation change that includes the historical sea level change. It is assumed that the erosion rate used to predict future acreages incorporates the low (historic rate of sea level change).

Table 4 Sea Level Change Rates

8665530, Charleston, SC			
NOAA's Published Rate: 0.01033 feet/yr			
All values are expressed in feet relative to NAVD88			
Year	USACE Low	USACE Int	USACE High
2020	0.1	0.1	0.4
2025	0.1	0.2	0.5
2030	0.2	0.3	0.7
2035	0.2	0.4	0.9
2040	0.3	0.5	1.1
2045	0.3	0.6	1.4
2050	0.4	0.7	1.6
2055	0.4	0.8	1.9
2060	0.5	0.9	2.2
2065	0.5	1	2.5
2070	0.6	1.1	2.8
2075	0.6	1.3	3.2

As seen in table 4, the historic rate of sea level rise results in a 0.6 feet increase in fifty years. The same rise in elevation occurs in 25 years under the intermediate rate of sea level rise and in less than 10 years (approximately 7 years) under the high rate of sea level rise. Thus the same results of nesting habitat would be reached in 25 years under the intermediate rate of sea level rise and in less than 10 years under the high rate of sea level rise.

VI Alternative Analysis

Field sampling, analysis, and analytical results for sediment samples collected from selected sites in the lower harbor of the Charleston Harbor Federal Navigation Channel were used to determine available material for the purpose of beneficial use. Field sampling took place from October 13 through October 16, 2014. Vibracore samples were collected in the lower harbor to determine physical and chemical properties of the material and suitability for beneficial use. (see Appendix F of the Supplemental Environmental Assessment for full documentation).

The District also conducted vibracore sampling and wash probe operations for this project. The field work was conducted in the Lower Reaches and Entrance Channel of Charleston Harbor, Charleston, South Carolina from May 13th through May 15th, 2016. A total of 29 vibracores were collected. A total of 30 wash probes were completed in the outer 7-miles of the Charleston Harbor entrance channel including the 3-mile extension. The cores were analyzed per USACE project guidelines, and a report of the findings is listed herein. (see Appendix G of the Supplemental Environmental Assessment for full documentation).

District personnel then assessed the data and determined there was no substantial source of material that matched the existing material found by SCDNR on the islands. Discussion with environmental agencies indicated that 65% sand was acceptable for bird nesting habitat; this was documented in the Supplemental EA. The District determined an area of new work material that contains 65% or greater sands is found in Bennis and Rebellion Reaches. (Figure 15).

Figure 15 Rebellion and Bennis Reach Acceptable Material

VI.1 Measures

The maximum volume of available insitu material based on 54-foot constructed depth (authorized depth of 52-feet plus 2-feet required overdepth (OD)) plus all of allowable OD is potentially 1,237,500 Cubic Yards (CY). 825,000 CY of material is the minimum available insitu volume based on a 54-foot constructed and none of the allowable OD. Assuming a 20% loss in placement activities, the following measures in Table 5 were evaluated. As noted in options 4 through 9, only a Crab Bank medium size footprint or a Crab Bank low size footprint can be done in conjunction with any placement on Shutes Folly Island due to the limited amount of material available.

Table 5 Measures

Options	Placement location 1	Volume of Placed Material (CY)	Placement Location 2	Volume of Placed Material (CY)	Total Volume of Placed Material (CY)	Total Volume of Insitu Material (CY)
1	Crab Bank (high)	990,000	na	0	990,000	1237500
2	Crab Bank (medium)	660,000	na	0	660,000	825000
3	Crab Bank (low)	330,000	na	0	330,000	412500
4	Crab Bank (medium)	660,000	Shutes Folly (high)	296,000	956,000	1195000
5	Crab Bank (medium)	660,000	Shutes Folly (medium)	196,000	856,000	1070000
6	Crab Bank (medium)	660,000	Shutes Folly (low)	100,000	760,000	950000
7	Crab Bank (low)	330,000	Shutes Folly (high)	296,000	626,000	782500
8	Crab Bank (low)	330,000	Shutes Folly (medium)	196,000	526,000	657500
9	Crab Bank (low)	330,000	Shutes Folly (low)	100,000	430,000	537500

VI.2 Footprints of Measures

Table 6 shows the acreages for options at Crab Bank. The Crab 990 is the maximum footprint within the boundaries covered in the Final IFR/EIS and uses the maximum volume of material. Crab 660 is a smaller island based on the similar shape but lesser quantity. Crab 660A and Crab 660B uses the same quantity as Crab 660 but a different footprint utilizing higher bathymetry to optimize nesting habitat. The shallow areas are on either end of the historic island with the center portion having a steeper slope that requires more material. Crab 330 is a smaller island on the northern end. Crab330A provided a slightly larger acreage. The acreages are provided for the full footprint, a footprint a 0 MLLW to reflect foraging area, at footprint and 5.76 MLLW (or MHHW) to reflect other bird nesting habitat and 7.41 MLLW which reflects the Brown Pelican nesting habitat. Table 7 shows the acreages for the three options at Shutes Folly Island. These are the only footprints that can be constructed at Shutes Folly Island due to the steep slope along the channel side of the island. Figures 16-18 show the footprints of Crab Bank and Figures 19-21 show the footprints of Shutes Folly Island.

Table 6 Crab Bank Areas of Habitat based on volume of material placed and existing area.

	Units of CY	Units of Acres (if applicable, includes existing acreage)			
Scenario	**Placement Fill volume**	**Footprint of placement**	**Footprint at 0' MLLW**	**Footprint at 5.76' MLLW**	**Footprint top at 7.41' MLLW**
Existing	N/A	N/A	39.5	1.49	0.68
Crab 330	330,000	31.3	60.3	16.6	12.2
Crab 330A	330,000	33.8	61.3	17.8	12.9
Crab 660	660,000	59.4	79.1	35.2	28.4
Crab 660A	660,000	52.8	79.4	33.2	27.8
Crab 660B	660,000	56.8	79.1	37.3	31.4
Crab 990	990,000	80.1	100.1	54.4	47.4

Figure 16 Crab Bank 330k CY

Figure 16 A Crab Bank 330K CY Alternative A

Figure 17 Crab Bank 660k CY

Figure 17 A Crab Bank 660K CY Alternative A

Figure 17B Crab Bank 660K CY Alternative B

Figure 18 Crab Bank 990K CY

Table 7 Shutes Folly Island Areas of Habitat based on volume of material placed and existing area minus the protected Castle Pinckney area.

	Units of CY	Units of Acres (if applicable, includes existing acreage)			
Scenario	**Fill volume**	**Footprint toe of fill**	**Footprint at 0' MLLW**	**Footprint at 5.76' MLLW**	**Footprint top at 7.41 MLLW**
Existing	N/A	N/A	45.5	15.5	0.25
Shutes 100	100,000	16.4	59.7	24.5	6.75
Shutes 196	196,000	26.5	67.2	30.3	11.81
Shutes-296	296,000	33.6	73.2	35.4	16.65

Figure 19 Shutes Folly Island 100k CY


Figure 20 Shutes Folly Island 196k CY

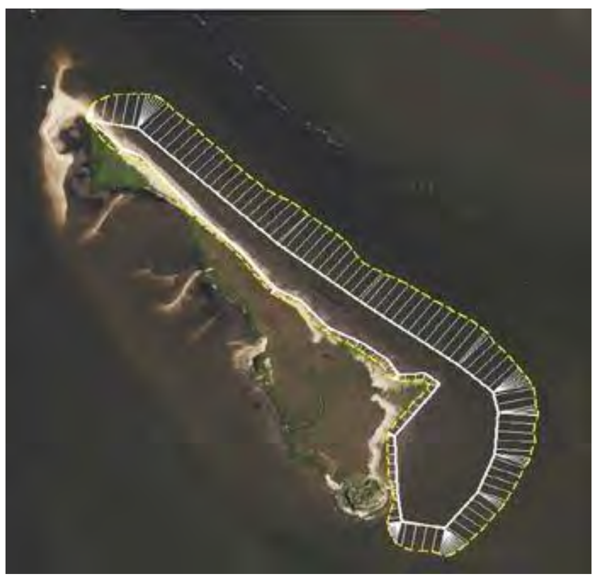


Figure 21 Shutes Folly Island 296k CY

VI.3 Future Acreage

The erosional trend that was based on the low rate of sea level rise and does not reflect potential morphology changes that could affect erosion /accretion rates associated with sea level rate, was then applied to the three options (high, medium and low) for each island to determine how the habitat would reduce over time. (Note since the Shoreline Change could not determine changes at 0 MLLW because LIDAR data was not available, the trend at -1 NAVD88 was used for Crab Bank (Table 8) and the trend a 0 NAVD88 was used at Shutes Folly Island to estimate the erosion trend of the 0 MLLW area (Table 11)). Table 9 indicates the loss of habitat above MHHW that would occur at Crab Bank. Table 10 Crab Bank loss of habitat acreage at 2 feet above MHW for the Brown Pelican nesting habitat. Table 12 indicates the loss of habitat above MHHW for Shutes Folly Island, excluding the Castle Pinckney protected area and Table 13 indicates the loss of Brown Pelican nesting habitat that would occur at Shutes Folly Island, excluding the Castle Pinckney protected area.

Table 8 Crab Bank Habitat acreage at 0 MLLW

Year	0 MLLW Crab330	0 MLLW Crab 330A	0 MLLW Crab 660	0 MLLW Crab 660A	0 MLLW Crab 660B	0 MLLW Crab 990
0	60.3	61.3	79.1	79.4	79.1	100.1
5	51.13	51.98	67.07	67.32	67.07	84.87
10	43.35	44.07	56.87	57.08	56.87	71.96
15	36.76	37.37	48.22	48.40	48.22	61.02
20	31.17	31.68	40.88	41.04	40.88	51.74
25	26.43	26.86	34.66	34.80	34.66	43.87
30	22.41	22.78	29.39	29.50	29.39	37.19
35	19.00	19.31	24.92	25.02	24.92	31.54
40	16.11	16.38	21.13	21.21	21.13	26.74
45	13.66	13.88	17.92	17.98	17.92	22.67
50	11.58	11.77	15.19	15.25	15.19	19.22

Table 9 Crab Bank Habitat acreage at MHHW

Year	5.760 MLLW Crab 330	5.76 MLLW Crab 330A	5.760 MLLW Crab 660	5.76 MLLW Crab 660A	5.76 MLLW Crab 660B	5.76 MLLW Crab 990
0	16.6	17.8	35.2	33.2	37.3	54.4
5	11.99	12.86	25.43	23.99	26.95	39.31
10	8.67	9.29	18.38	17.33	19.47	28.40
15	6.26	6.71	13.28	12.52	14.07	20.52
20	4.52	4.85	9.59	9.05	10.17	14.83
25	3.27	3.51	6.93	6.54	7.34	10.71
30	2.36	2.53	5.01	4.72	5.31	7.74
35	1.71	1.83	3.62	3.41	3.83	5.59
40	1.23	1.32	2.61	2.47	2.77	4.04
45	0.89	0.96	1.89	1.78	2.00	2.92
50	0.64	0.69	1.36	1.29	1.45	2.11

Table 10 Crab Bank Habitat acreage at 2 feet above MHW

Year	7.41 MLLW No action	7.41 MLLW Crab 330	7.41 MLLW Crab 330A	7.41 MLLW Crab 660	7.41 MLLW Crab660A	7.41 MLLW Crab660B	7.41 MLLW Crab 990
0	0.68	12.2	12.9	28.4	27.8	31.4	47.4
5	0.47	8.34	8.82	19.42	19.42	21.47	32.42
10	0.32	5.71	6.03	13.28	13.28	14.68	22.17
15	0.22	3.90	4.13	9.08	9.08	10.04	15.16
20	0.15	2.67	2.82	6.21	6.21	6.87	10.37
25	0.10	1.82	1.93	4.25	4.25	4.70	7.09
30	0.07	1.25	1.32	2.90	2.90	3.21	4.85
35	0.05	0.85	0.90	1.99	1.99	2.20	3.32
40	0.03	0.58	0.62	1.36	1.36	1.50	2.27
45	0.02	0.40	0.42	0.93	0.93	1.03	1.55
50	0.02	0.27	0.29	0.64	0.64	0.70	1.06

Table 11 Shutes Folly Island Habitat acreage at 0 MLLW

Year	0 MLLW No Action	0 MLLW Shutes 100	0 MLLW Shutes 196	0 MLLW Shutes 296
0	45.5	59.7	67.2	73.2
5	37.82	49.54	55.85	60.84
10	31.43	41.11	46.42	50.56
15	26.12	34.12	38.58	42.02
20	21.71	28.31	32.06	34.92
25	18.04	23.50	26.65	29.03
30	14.99	19.50	22.15	24.12
35	12.46	16.18	18.41	20.05
40	10.36	13.43	15.30	16.66
45	8.61	11.14	12.71	13.85
50	7.15	9.25	10.57	11.51

Table 12 Shutes Folly Island Habitat acreage at MHHW

Year	MHHW No Action	MHHW Shutes 100	MHHW Shutes 196	MHHW Shutes 296
0	15.5	24.5	30.3	35.4
5	10.71	16.92	20.93	24.45
10	7.40	11.69	14.46	16.89
15	5.11	8.07	9.99	11.67
20	3.53	5.58	6.90	8.06
25	2.44	3.85	4.76	5.57
30	1.68	2.66	3.29	3.84
35	1.16	1.84	2.27	2.66
40	0.80	1.27	1.57	1.83
45	0.55	0.88	1.08	1.27
50	0.38	0.61	0.75	0.88

Table 13 Shutes Folly Island Habitat acreage at 2 feet above MHW

Year	7.41 MLLW No Action	7.41 MLLW Shutes 100	7.41 MLLW Shutes 196	7.41 MLLW Shutes 296
0	0.25	6.75	11.8	16.65
5	0.11	2.99	5.22	7.37
10	0.05	1.32	2.31	3.26
15	0.02	0.59	1.02	1.44
20	0.01	0.26	0.45	0.64
25	0.00	0.11	0.20	0.28
30	0.00	0.05	0.09	0.13
35	0.00	0.02	0.04	0.06
40	0.00	0.01	0.02	0.02
45	0.00	0.00	0.01	0.01
50	0.00	0.00	0.00	0.00

Table 14 indicates the initial and end of project life predicted nesting habitat for the combined alternatives at 2 feet above MHW based on estimated erosion rates.

Table 14 Nesting Habitat (2 feet above MHW) Alternative Life Cycle

Alternative	Placement Location 1	Placed Material (CY)	Placement Location 2	Placed Material (CY)	Initial Habitat (acres)	50 Years Habitat (acres)
Crab 990	Crab Bank (high)	990,000	N/A	0	47.4	1.06
Crab 660	Crab Bank (medium)	660,000	N/A	0	28.4	0.64
Crab 660A	Crab Bank (medium)	660,000	N/A	0	27.8	0.64
Crab 660B	Crab Bank (medium)	660,000	N/A	0	31.4	0.70
Crab 330	Crab Bank (low)	330,000	N/A	0	12.2	0.27
Crab 330A	Crab Bank (low)	330,000	N/A	0	12.9	0.29
Crab 660B & Shutes 296	Crab Bank (medium)	660,000	Shutes Folly (high)	296,000	48.1	0.7
Crab 660B & Shutes 196	Crab Bank (medium)	660,000	Shutes Folly (medium)	196,000	43.2	0.7
Crab 660B & Shutes 100	Crab Bank (medium)	660,000	Shutes Folly (low)	100,000	38.2	0.7
Crab 330A & Shutes 296	Crab Bank (low)	330,000	Shutes Folly (high)	296,000	29.55	0.29
Crab 330A & Shutes 196	Crab Bank (low)	330,000	Shutes Folly (medium)	196,000	24.7	0.29
Crab 330A & Shutes 100	Crab Bank (low)	330,000	Shutes Folly (low)	100,000	19.65	0.29
No Action	Crab Bank No Action	0		0	0.68	0.02
No Action		0	Shutes Folly No Action	0	0.25	0.0

VII Protective Stabilization Measures

The District assessed measures to stabilize the shoreline to prolong the life of the habitat.

VII.1 Riprap

Riprap along the entire harbor facing shoreface resulted in additional costs that exceed the limits of CAP funding.

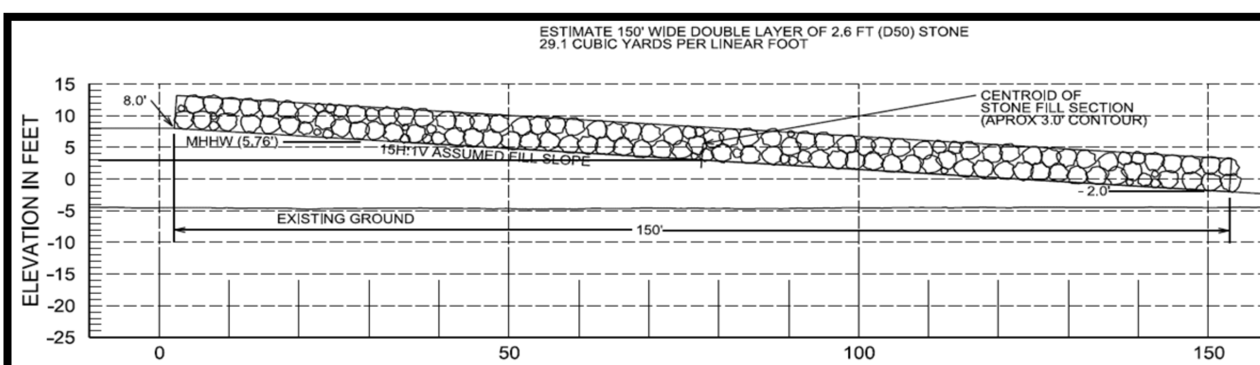


Figure 22 cross- section of riprap placement along harbor face shoreline

Table 15 Riprap Quantities and additional cost of stone placement

Riprap Placement	CB 330	CB 660	CB 990		SF 100	SF 196	SF 296
Length of placement FT: Length of 3.0' contour line along the channel facing side	4,500	5500	6500		2500	3400	3700
Placement density CY/FT	29.1	29.1	29.1		29.1	29.1	29.1
Total Volume Stone CY	130,950	160,050	189,150		72,750	98,940	107,670
Assume uniform armor stone, granite (165 pcf)	165	165	165		165	165	165
Assume 37% porosity (Hudson equation)							
Quantity of stone TONS	183,800	224,600	265,400		102,100	138,800	151,100

Cost estimates for riprap were around $10M to $15M additional to the placement of dredge material, which exceeds the authority. So it was not considered in determination of the recommended plan.

VII.2 Vegetation

Placement of vegetation on the upper harbor facing shoreface was considered. It would also require some form of temporary barrier to allow the vegetation to establish. Haybales were assumed for cost estimating.

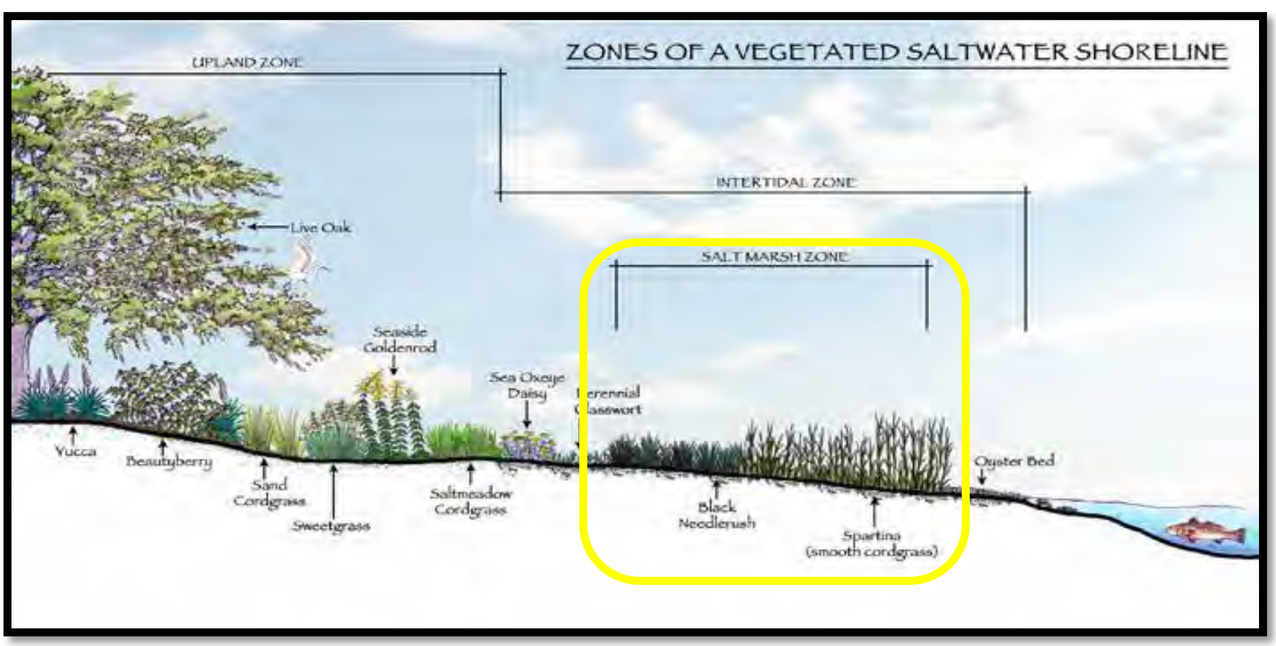


Figure 23 Cross-section of vegetated shoreline (only area with yellow to be planted)

Assume mean tide to MHHW is zone of planting. Assumes 10 rows 2 feet spacing.

Table 16 Plants

			#Plants per row	total	#Plants per row	Total
Crab Bank	**Linear feet**	**Acreage**	**Cordgrass**	**Cordgrass**	**Needlerush**	**Needlerush**
330	4500	4.4	2250	22500	2250	22500
660	5500	5.3	2750	27500	2750	27500
990	6500	6.3	3250	32500	3250	32500
Shutes Folly						
100	2500	2.4	1250	12500	1250	12500
196	3400	3.3	1700	17000	1700	17000
296	3700	3.6	1850	18500	1850	18500

Using a nearby shoreline near Patriot's Point the historic erosion rates considering a vegetated shoreline was computed in the same manner as the erosion rate for Crab Bank and Shutes Folly Island (Figure 24).

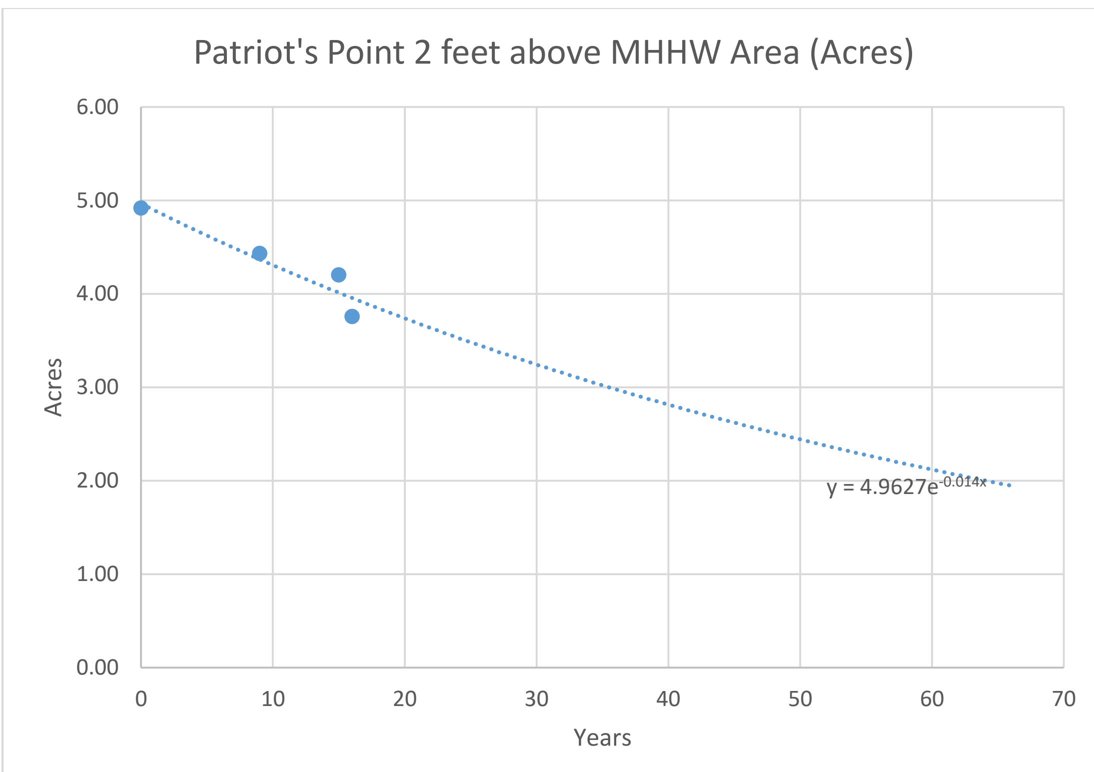


Figure 24 Erosion Rate at Patriot's Point

The erosion rate was then applied to Crab Bank and resulted in the following acreages in Table 17:

Table 17 Erosion rate of a Vegetated Shoreline

Year	7.41 MLLW Crab 330	7.41 MLLW Crab 330A	7.41 MLLW Crab 660	7.41 MLLW Crab660A	7.41 MLLW Crab660B	7.41 MLLW Crab 990
0	12.2	12.9	28.4	27.8	31.4	47.4
5	11.38	12.03	26.48	25.92	29.28	44.20
10	10.61	11.21	24.69	24.17	27.30	41.21
15	9.89	10.46	23.02	22.53	25.45	38.42
20	9.22	9.75	21.46	21.01	23.73	35.82
25	8.60	9.09	20.01	19.59	22.13	33.40
30	8.02	8.48	18.66	18.27	20.63	31.14
35	7.47	7.90	17.40	17.03	19.24	29.04
40	6.97	7.37	16.22	15.88	17.94	27.08
45	6.50	6.87	15.13	14.81	16.72	25.24
50	6.06	6.41	14.10	13.81	15.59	23.54

There is concern about whether the vegetation would actually take root and establish the needed erosion prevention in a high dynamic area. The area at Patriot's Point is not an island and is stabilized on the landward side. It is not subject to any overwash during storms. Historically vegetation on Crab Bank predominantly exists on the back side of the island (the Mt Pleasant side). Vegetation appearing along the front or channel side is ephemeral, appearing and disappearing with time. It is likely that it would require multiple replanting and still there is no guarantee that it would stabilize and provide the needed protection.

VII.3 Combination riprap and vegetation

A combination of riprap along the lower shoreline from 3 MLLW to -2 MLLW combined with vegetation on the upper slope from 5.4 MLLW to 3 MLLW, resulted in lower costs than stone alone and would result in a different erosion rate. Costs exceeds the authority limit. Therefore it was not pursued in selecting a recommended plan.

VIII Cost Analysis

VIII.1 Cost Methodology

VIII.1.1 General

The cost estimate for the various alternatives have been prepared to an equivalent price level of 15 July 2017 using CEDEP Version 2.1 and MCACES revision 2 version 4.3. The preparation of the cost estimate is in accordance with guidelines and policies included in

Appendix B
Plan Formulation

Charleston Harbor Cap 204 Detailed Project Report

US Army Corps of Engineers

Charleston Harbor Section 204

Beneficial Use of Dredged Material, Charleston, South Carolina

Plan Formulation Appendix

March 2018

Contents

List of Figures

List of Tables

1.0 PLAN FORMULATION AND ALTERNATIVE EVALUATION

This section discusses problems, opportunities, objectives, and constraints. Based on these problems, opportunities, objectives, and constraints the project delivery team, the sponsors, resource agencies, and interested parties developed a series of restoration alternatives.

1.1 Problems, Opportunities, Objectives and Constraints

For planning purposes, a problem is an undesirable condition that exists or will exist in the future. An opportunity is a chance to create a future, more desirable condition. Problems and opportunities can be viewed as local and regional resource conditions that could be modified in response to public or natural resource concerns. Objectives are generated to describe how the problems could be addressed and to capitalize on the opportunities. Constraints are resource, legal, or policy considerations that limit the range or types of actions that could be implemented.

1.1.1 Problems

As discussed in the existing conditions section, resources within Charleston Harbor are particularly subject to hydrodynamic stresses (waves, tides, and sea level rise) and could have these stresses mitigated through the strategic placement of dredged material. Crab Bank Island, Shutes Folly Island, Fort Sumter, and Fort Moultrie, are all resources of particular significance. Crab Bank and Shutes Folly islands are important areas for avian nesting and foraging; Castle Pinckney, Forts Sumter and Moultrie are all listed on the National Register of Historic Places. Currents, storm surge (inundation), wave attack, and sea level change are contributing to changing conditions within Charleston Harbor, leading to the following problems:

- Spatial losses of Crab Bank Island and Shutes Folly Island are reducing avian nesting and foraging areas within the Charleston Harbor,
- Erosion due to system hydrodynamic and human activities is decreasing the size of supratidal beaches and intertidal habitat within the harbor, and
- Historically significant structures within Charleston Harbor are being threatened by erosion from wind generated waves and rising sea level.

Erosion trends for Crab Bank Island show that the size of this feature has reduced from approximately 23 acres in 2000 to an approximate current size of 0.68 acres. For Shutes Folly Island, the projected erosional trend shows that the island outside the Castle Pinkney protected area will disappear within 50 years.

The Fort Sumter National Monument was established in 1948 and listed on the NRHP in 1966. The remnants of this masonry fort, associated with the Civil War defense of Charleston, stand on the south side of the mouth of Charleston Harbor. The outer wall of Fort Sumter was constructed on a foundation consisting of about 6 feet of fitted stone placed over a five to six foot thick mole foundation composed of dumped granite. The most recent placements of stone were in 1969, 1971, and 1972, when material was placed on the Fort's left and right sides, in berms near the dock on the left flank, the Fort's point, and along part of the right flank, up to about elevation 8.5 ft. above mean low water, respectively. Individual stone used in the revetment weighed between 500 and 1500 pounds.

The south and east faces of the fort are particularly exposed to wave action. In a letter to the USACE dated 29 September, 2011, the NPS indicated that there is now a gap in the existing stone breakwater that allows waves to crash directly against the brick masonry, especially at high tide.

Castle Pinckney stands on Shutes Folly Island near the center of Charleston Harbor. This brick fortification was built in 1808-1811 and was listed on the NRHP in 1970. In 2009, a 294 ft. long revetment constructed at an elevation at 7 feet above mean low water was built at a distance of 30 ft. from Castle Pinckney. This project was constructed under Section 14 of the Continuing Authorities Program, with the state port authority as the non-federal sponsor. The project is currently managed by the Castle Pinckney Historical Preservation Society. This project's structure protects the eastern, southern, and western sections of the Castle. Shutes Folly Island is now eroding at the northeast end, outside the Section 14 project limits.

1.1.2 Opportunities

The anticipated average annual maintenance dredging needs from the federal channels within Charleston Harbor is approximately 2,200,000 cubic yards (cy). Approximately 1,400,000 cubic yards of this material is intended to be disposed in the EPA designated Charleston ocean dredged material disposal site (ODMDS), and approximately 1,000,000 cubic yards of this material goes to the Clouter Creek Disposal Area.

These annual volumes may increase as a result of channel modifications related to the Charleston Harbor Post 45 Project. In addition to the material that will be dredged through routine maintenance of the harbor, the deepening of the federal channel will necessitate the accommodation of additional dredged material, which is "new work" material. This one-time event will result in an estimated 1.2375 million cubic yards available for use.

Based on an evaluation of the existing conditions within the project area the following opportunities have been identified:

- Improve and expand bird habitat within Charleston Harbor,
- Reduce hydrodynamic stresses to existing structures in Charleston,
- Contribute to the goals of the USACE Regional Sediment Management by putting material back into the system,
- Offset losses of supratidal and intertidal habitats in Charleston, and
- Reduce habitat loss and impacts to historic structures to maintain the quality of coastal recreation and ecotourism.

1.1.3 Planning Objectives

Objectives guide the formulation process and assist in evaluating an alternative's effectiveness. Planning objectives are an offspring of the identified problems and opportunities and represent a desired positive outcome. The following project specific planning objectives and metrics were developed.

- Maintain or increase the spatial area of habitat for all avian life cycles within Charleston Harbor over a 50 year period of analysis, from 2021 to 2070,

    - Metric – Acreage of brown pelican habitat as determined by the 1985 Habitat Suitability Index (HSI) model developed by the USFWS.

- Protect existing historic structures within Charleston Harbor from hydrodynamic stressors over a 50 year period of analysis, from 2021 to 2070,

    - Metric – Extend current level of protection on existing structures. For Fort Sumter, this level of protection is at 8.5 feet above mean low water. Castle Pinckney's level of protection is at 7 feet above mean low water.

1.1.4 Planning Constraints

Constraints limit the range of measures that could be implemented to meet the study objectives and may be related to items of resource, legal, or policy origins. The following planning constraints and considerations were developed and will be used in both the formulation, screening, and evaluation of measures and alternatives:

- Avoid plans that require the segregation of materials,
- Avoid plans that depend on continued placement of material,
- Avoid measures or plans that cause or contribute to the increased risk of introducing rodents, snake or other predator populations on bird nesting islands,
- Minimize placement of unsuitable material,
- Avoid the placement of material outside the confines of lower Charleston Harbor,
- Avoid activities that interfere with current navigation operations and practices,
- Avoid non cost effective measures and alternatives, and,
- Consider potential for future human uses of beneficial use areas.

1.2 Measures Considered

1.2.1 Measure Development

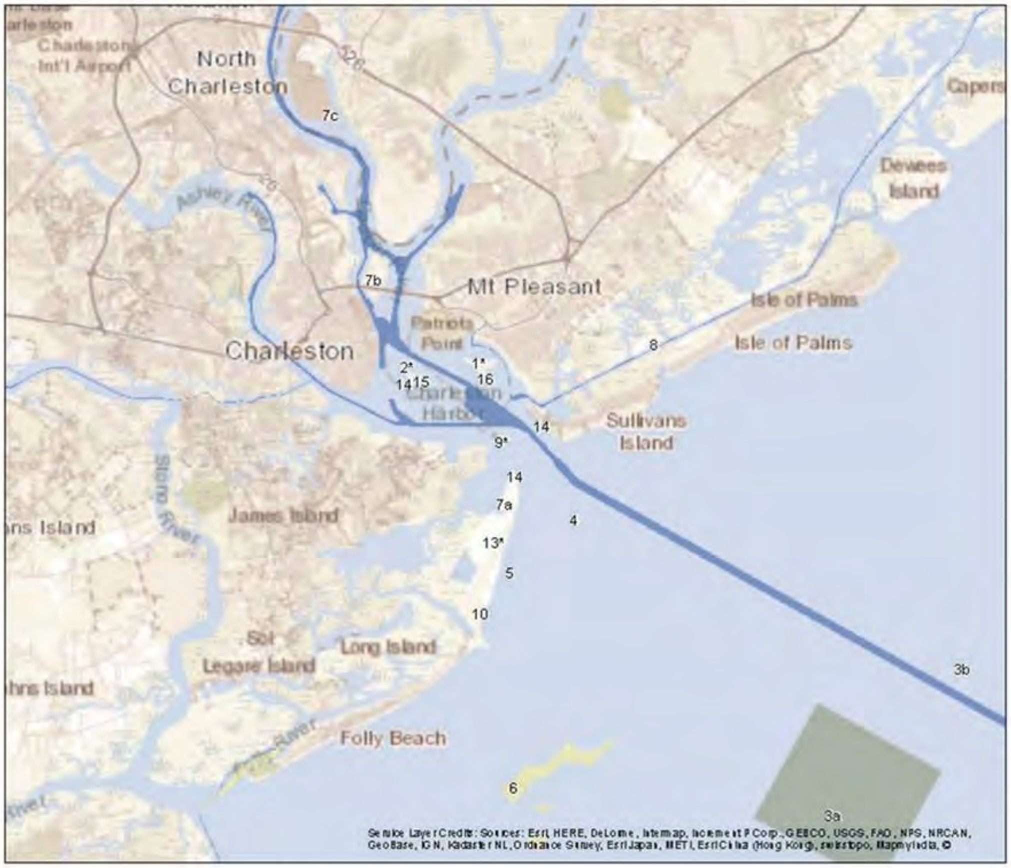
A management measure is a feature or activity that can be implemented to address either single or multiple planning objectives. Management measures are either structural or non-structural. ER 1105-2-100–E-15 (d) states that "all dredged material management studies include an assessment of potential beneficial uses for environmental purposes including fish and wildlife habitat creation, ecosystem restoration and enhancement and/or hurricane and storm damage reduction." During the feasibility phase of the Post 45 Charleston Harbor deepening, it was acknowledged that there would be opportunities to explore the possibility of using both O&M material and new work material to address issues within Charleston Harbor. The Post 45 Interagency Coordination Team (ICT) met on April 29, 2013 and discussed potential management measures for using the dredged material. This meeting and the follow up coordination with the ICT addressed using dredged material in Charleston Harbor regardless of material origin, and resulted in a host of general ideas being discussed. Subsequent to the ICT meeting, the PDT developed multiple measures addressing multiple issues around Charleston Harbor. The measures developed are listed below and shown in Figure 1.

- **Measure 1a.** Crab Bank Island Enhancement – Place dredged material along the high point of the island and western side towards the navigation channel,
- **Measure 1b.** Crab Bank Island Enhancement – Place material along the south end of the island. The south end is more eroded and at a lower elevation than the northern portion of the island,
- **Measure 1c.** Crab Bank Island Enhancement – Place O & M material on the Mt. Pleasant side of the island to create/expand marsh habitat,
- **Measure 1d.** Crab Bank Island Enhancement – Place material on northwest side of the island to create more shallow sub-bottom habitat,
- **Measure 1e.** Crab Bank Island Enhancement – Use rip rap in combination with dredged material on the western side towards the navigation channel,
- **Measure 1f.** Crab Bank Island Enhancement – Combine plantings with dredged material placement for island and habitat creation,
- **Measure 1g.** Crab Bank Island Enhancement – Combine rip rap and plantings with dredged material for island and habitat creation.
- **Measure 2a.** Shutes Folly Island Enhancement – Create/expand marsh on west side of island,
- **Measure 2b.** Shutes Folly Island Enhancement – Enlarge the eastern frontal sand bank of island that is currently covered in whole dead oyster shell,
- **Measure 2c.** Shutes Folly Island Enhancement – Use rip rap in combination with dredged material on the western side of the island for stabilization,
- **Measure 2d.** Shutes Folly Island Enhancement – Combine plantings with dredged material for habitat creation,
- **Measure 2e.** Shutes Folly Island Enhancement – Combine rip rap and plantings with dredged material for habitat creation,
- **Measure 3a.** Use rock material to build up a berm around the perimeter of the ocean dredged material disposal site,
- **Measure 3b.** Use rock material to create artificial reefs near the entrance channel,
- **Measure 4.** Create an offshore bird nesting island,
- **Measure 5.** Offshore fish attractant and wave attenuation berm,
- **Measure 6.** Place sandy material into the used portions of the Folly Beach sand borrow areas,
- **Measure 7a.** Marsh creation using O & M on landward side of Morris Island,

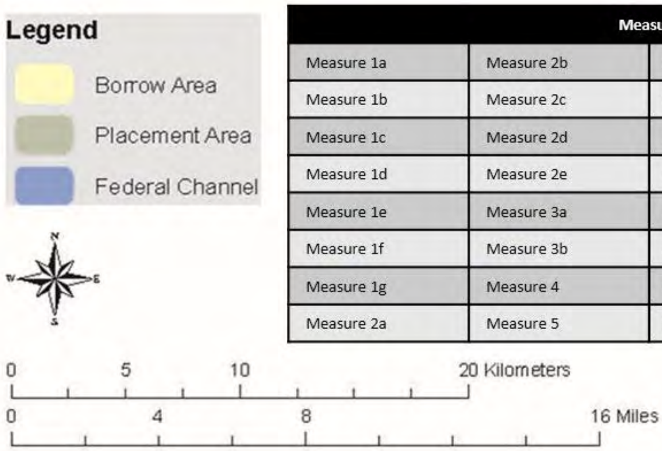
- **Measure 7b.** Marsh creation using O & M at Drum Island fringing marshes,
- **Measure 7c.** Marsh creation using O & M along fringing marshes of Clouter Creek and Daniel Island disposal areas,
- **Measure 8.** Use material to build up an eroding dike along the Intracoastal Waterway behind Breech Inlet,
- **Measure 9a.** Fort Sumter shoreline protection – Use dredged rock to create revetment or breakwater,
- **Measure 9b.** Fort Sumter shoreline protection – Create a protective marsh around Fort Sumter,
- **Measure 9c.** Fort Sumter shoreline protection – fill geotextile tubes in front of Ft. Sumter and backfill with fine material using O&M material,
- **Measure 10.** Place material around Morris Island Lighthouse,
- **Measure 11.** Commercial sale of dredged material,
- **Measure 12.** Create oyster reefs with dredged rock and place along select locations within the harbor,
- **Measure 13a.** Place material in the nearshore area of Morris Island,
- **Measure 13b.** Place material on the beachfront of Morris Island,
- **Measure 14.** Use dredged rock from entrance channel for shoreline protection in high erosion areas,
- **Measure 15.** Use rip-rap to stabilize reaches of Shutes Folly Island, and
- **Measure 16.** Import quarried rock to use for armoring structures in lower Charleston Harbor.

1.2.2 Measure Screening

The initial measures were screened against the planning constraints listed above. The measures initially screened out are shown in Table 1.



Measure			
Measure 1a	Measure 2b	Measure 6	Measure 10
Measure 1b	Measure 2c	Measure 7a	Measure 11
Measure 1c	Measure 2d	Measure 7b	Measure 12
Measure 1d	Measure 2e	Measure 7c	Measure 13a
Measure 1e	Measure 3a	Measure 8	Measure 13b
Measure 1f	Measure 3b	Measure 9a	Measure 14
Measure 1g	Measure 4	Measure 9b	Measure 15
Measure 2a	Measure 5	Measure 9c	Measure 16



* multiple alternatives represented in a small area, see chart.

Figure 1. Location of Initial Measures

Table 1. Measures Eliminated during Initial Screening

Measures Not Carried Forward	Justification
Measure 3a. Use rock material to build up a berm around the perimeter of the ocean dredged material disposal site.	This measure is being completed as part of the least cost disposal plan for the Post 45 Project.
Measure 3b. Use rock material to create artificial reefs near the entrance channel.	This measure is already being completed as part of the least cost disposal plan for the Post 45 Project.
Measure 4. Create an offshore bird nesting island.	Not proximate to the channel reaches of the Lower Charleston Harbor containing suitable material. Not technically feasible.
Measure 5. Offshore fish attractant and wave attenuation berm.	Not proximate to the channel reaches of the Lower Charleston Harbor containing suitable material. Not technically feasible.
Measure 6. Place sandy material into the used portions of the Folly Beach sand borrow areas.	Folly Beach Project Borrow Areas are approximately 3 miles off the northern end of Folly Beach, past the ocean dredged material disposal site. In addition, the dredged material is not compatible for use on the Folly Beach Storm Damage Reduction Project.
Measure 7a. Marsh creation on landward side of Morris Island.	Not close enough to Lower Charleston Harbor to be cost effective compared to other measures.
Measure 7b. Marsh creation at Drum Island fringing marshes.	Not proximate to the channel reaches of the Lower Charleston Harbor containing suitable material. Not environmentally acceptable.
Measure 7c. Marsh creation along fringing marshes of Clouter Creek and Daniel Island disposal areas.	Not proximate to the channel reaches of the Lower Charleston Harbor containing suitable material. Not environmentally acceptable.
Measure 8. Use material to build up an eroding dike along the Intracoastal Waterway behind Breech Inlet.	Not proximate to Lower Charleston Harbor. Not technically feasible.

Measures Not Carried Forward	Justification
Measure 9a. Use rock material to create a revetment or breakwater around Ft. Sumter.	Dredged material is not suitable for use as erosion protection and will not meet USACE engineering standards. In addition, Fort Sumter is Federally owned. As such, this work would not be authorized under this Authority.
Measure 9b. Fort Sumter Shoreline Protection Create a protective marsh around Fort Sumter.	Through coordination with the National Park Service, USACE learned that this measure would allow unauthorized access to Fort Sumter and increase the risk of damage or vandalism. In addition, Fort Sumter is Federally owned. As such, this work would not be authorized under this Authority.
Measure 9c. Fort Sumter Shoreline Protection. Fill geotextile tube(s) in front of Ft. Sumter, and backfill with fine material.	Geotubes would shift and present stability problems. The risk of geotubes leaking or breaking presents an unacceptable hazard. In addition, Fort Sumter is Federally owned. As such, this work would not be authorized under this Authority.
Measure 10. Place material around Morris Island Lighthouse.	Not proximate to Lower Charleston Harbor. Not technically feasible.
Measure 11. Commercial sale of dredged material.	Not authorized under this authority and not viable.
Measure 12. Create oyster reefs with dredged rock and place along select locations within the harbor.	Dredged material source is not proximate to Lower Charleston Harbor and is not cost effective.
Measure 13a. Place material in the nearshore area of Morris Island.	Not proximate to Lower Charleston Harbor.
Measure 13b. Place material on the beachfront of Morris Island.	Not proximate to Lower Charleston Harbor.
Measure 14. Use dredged rock from entrance channel for shoreline protection in high erosion areas.	Dredged material is already proposed for beneficial uses associated with the Post 45 Project. In addition, dredged rock is not suitable for use as erosion protection and will not meet USACE engineering standards.

Measures Not Carried Forward	Justification
Measure 15. Use rip-rap to stabilize reaches of Shutes Folly Island around Castle Pinckney.	Rip rap would have be brought in and this does not use dredged material. In addition, Shutes Folly Island already has a Section 14 Stabilization Project built and would require a new Section 14 Study.
Measure 16. Import quarried rock to use for armoring structures in lower Charleston Harbor.	Rock would have to be brought in and this does not use dredged material. Previous Corps studies of quarried limestone shows that it loses density in water and is not recommended for coastal structures.

While many of the measures screened out would provide ecological benefits, they were not appropriate for this study due to the factors listed above or were not implementable under CAP 204 authority. In addition, all of the measures that addressed the objective of protecting historic structures within Charleston Harbor were also screened out for reasons listed above. Therefore that objective will not be met as part of this study.

1.2.3 Formulation of Alternative Plans

The remaining measures were evaluated as stand-alone alternatives and/or combined in various ways to be evaluated. Combinations also included planting and armoring features, along with varying volumes of dredged material placement. The strategies to formulate the alternatives were based on location and materials and were designed to:

- Formulate alternatives for areas that have a public interest,
- Formulate alternatives that increase fish/wildlife habitat within Charleston Harbor, and
- Formulate alternatives so that the dredged material used is compatible with in situ material.

For each of these strategies larger areas were targeted for restoration as it resulted in more cost efficient transport and placement of material and provided greater environmental benefits. The resulting alternatives are shown below.

1. 2.4 Alternative Plans

The alternative plans formulated for this study are:

- **Alternative 1a. Crab Bank Island Enhancement** – Place dredged material along the high point of the island and western side towards the navigation channel.
- **Alternative 1b. Crab Bank Island Enhancement** – Place material along the south end of the island because it is more eroded and at a lower elevation than the northern portion of the island.

- **Alternative 1c. Crab Bank Island Enhancement** – Place material on the Mt. Pleasant side (northeast side) of the island to create/expand marsh habitat.
- **Alternative 1d. Crab Bank Island Enhancement** – Place material on northwest side of the island to create a shallower sub-bottom habitat.
- **Alternative 1e. Crab Bank Island Enhancement** – Use rip rap in combination with dredged material on the western side towards the navigation channel.
- **Alternative 1f. Crab Bank Island Enhancement** – Combine replanting with dredged material placement for island and habitat creation.
- **Alternative 1g. Crab Bank Island Enhancement** – Combine rip rap and plantings with dredged material for island and habitat creation.
- **Alternative 2a. Shutes Folly Island Enhancement** – Create/expand marsh on west side of island.
- **Alternative 2b. Shutes Folly Island Enhancement –** Enlarge the eastern frontal sand bank of island that is currently covered in oyster shell.
- **Alternative 2c. Shutes Folly Island Enhancement** – Use rip rap in combination with dredged material on the western side of the island for stabilization.
- **Alternative 2d. Shutes Folly Island Enhancement** – Combine replanting with dredged material for habitat creation.
- **Alternative 2e. Shutes Folly Island Enhancement** – Combine rip rap and plantings with dredged material for habitat creation.
- **No Action Alternative.** This alternative evaluates the conditions if the project is not implemented.

In general, the alternatives can be catalogued in three groups:

No Action Alternative – The National Environmental Policy Act (NEPA) requires the USACE to consider the option of "no action" as one of the alternatives. No action assumes that no project would be implemented by the federal government to achieve planning objectives. No action, or the "without project condition", forms the basis from which all other alternative plans are measured. Under the no action plan, the USACE would not consider any beneficial uses of dredged material as alternatives to placement of the dredged material at the normal O&M or base plan locations of upland confined disposal sites or the ODMDS as shown in Figure 2.

Crab Bank Island Shoreline Protection / Bird Island Enhancement

These alternatives involve placing new work material along the harbor side of Crab Bank Island, and are analyzed with respect to the amount of material used and fill configuration. Several Crab Bank Island alternatives incorporate plantings and/or rip rap as features to provide additional stabilization. The Crab Bank Island alternatives were evaluated as both stand-alone alternatives and combined with Shutes Folly Island for additional alternatives.

With respect to configuration, several footprints on Crab Bank Island were configured that used the same volume of material. The footprints differed with respect to shape and height in an attempt to optimize avian habitat.

Shutes Folly Island Protection

These alternatives involve using new work material along the harbor side of Shutes Folly Island and are analyzed with respect to the amount of material used and incorporates plantings and/or rip rap as features to provide additional stabilization. The Shutes Folly Island alternatives were not evaluated on a stand-alone basis because the island is not as threatened as Crab Bank Island. In addition several reaches of Shutes Folly Island are too steep to successfully place dredged material on and the area that can be enlarged is limited in size and cannot accept even half of the anticipated material that will be available.

1.2.5 Evaluation of Alternative Plans

Alternatives were evaluated using to the four criteria described in the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G):

- Completeness is the extent to which the alternative or alternative plans provide and account for all the necessary investments or other actions to ensure the realization of the planning objectives,
- Effectiveness is the extent to which the alternative or alternative plans contribute to achieve the planning objectives,
- Efficiency is the extent to which an alternative or alternative plan is the most cost effective means of achieving the objectives, and,
- Acceptability is the extent to which the alternative or alternative plans are acceptable in terms of applicable laws, regulations and public policies.

Evaluating against this criteria should result in plans that should, to the greatest extent possible, meet the planning objective of maintaining or increasing the amount of avian habitat in lower Charleston Harbor.

An evaluation of the alternatives using the P&G criteria is shown below.

Alternative 1a. Crab Bank Island Enhancement – Dredged material would be used to enlarge Crab Bank Island by placing material on the west side of the island running from north to south. This would help support the avian species that utilize the island for nesting, roosting, foraging, and provide winter loafing and feeding areas for numerous species. Although the island is in constant flux, it has largely been migrating north over the last 15 years, and has constantly decreased in size since initially constructed. Public comments received during the Post 45 Feasibility Study indicate that preserving or enhancing this island is a desirable activity.

- Completeness – This alternative meets the completeness criteria as it requires no investments or actions by others to achieve the planning objectives.
- Effectiveness – This alternative meets the planning objectives by increasing avian habitat, and by constructing between 16 and 54 acres of high ground.

- Efficiency – If carried forward, this alternative will be evaluated in the cost effectiveness and incremental cost analyses section of the report.
- Acceptability – As determined during past coordination for the Charleston Harbor Post 45 navigation study the general public and agencies have concerns with existing erosion problems facing many areas in Charleston Harbor and how the proposed deepening or new construction project may affect those problems. Some stakeholders have also requested that the USACE place dredged material along certain shorelines to reduce the effects of erosion such as Fort Sumter, Crab Bank Island, and Shutes Folly Island. This alternative is acceptable in terms of applicable laws, regulations and public policies, and has strong public support.

Alternative 1b. Crab Bank Island South End Enhancement – This alternative involved the placement of material along the south end of the island. This end is more eroded and at a lower elevation when compared to the northern portion of the island. This alternative would essentially create two separate islands.

- Completeness – This alternative meets the completeness criteria as it requires no investments or actions by others to achieve the planning objectives.
- Effectiveness – This alternative does not meet the effectiveness criteria as it would not protect the contiguousness of Crab Bank Island. This alternative would essentially create two separate islands. This is not as desirable a condition due to the potential to create an inlet between the high points of the island (the northwest section and the newly created portion along the south end). Inlets are not stable and prone to migrate, which would increase the risks of accelerating the erosion of Crab Bank Island.
- Efficiency – If carried forward, this alternative will be evaluated in the cost effectiveness and incremental cost analyses section of the report below.
- Acceptability – As determined during past coordination for the Charleston Harbor Post 45 navigation study the general public and agencies have concerns with existing erosion problems facing many areas in Charleston Harbor and how the proposed deepening or new construction project may affect those problems. Some stakeholders have also requested that the USACE place dredged material along certain shorelines to reduce the effects of erosion such as Fort Sumter, Crab Bank Island, and Shutes Folly Island. This alternative is acceptable in terms of applicable laws, regulations and public policies, and has strong public support.

Alternative 1c. Crab Bank Island Salt Marsh Enhancement – This alternative involved the placement of material on the Mt. Pleasant side (northeast side) of the island to create and expand marsh habitat.

- Completeness – This alternative meets the completeness criteria as it requires no investments or actions by others to achieve the planning objectives. This area is not stable, as evidenced by the sparse marsh that currently grows there. Placing material northeast (Mount Pleasant) side of the island without some form of protection would be a wasteful expenditure of resources. This alternative does not meet the completeness criteria.

- Effectiveness – This alternative does not meet the effectiveness criteria as it will not meet the planning objectives of either restoring habitat or protecting structures. Material placed in accordance with this alternative would migrate.
- Efficiency – If carried forward, this alternative will be evaluated in the cost effectiveness and incremental cost analyses section of the report below.
- Acceptability – As determined during past coordination for the Charleston Harbor Post 45 navigation study the general public and agencies have concerns with existing erosion problems facing many areas in Charleston Harbor and how the proposed deepening or new construction project may affect those problems. Some stakeholders have also requested that the USACE place dredged material along certain shorelines to reduce the effects of erosion such as Fort Sumter, Crab Bank Island, and Shutes Folly Island. This alternative is acceptable in terms of applicable laws, regulations and public policies, and has strong public support.

Alternative 1d. Crab Bank Island Sub – **Bottom Habitat Enhancement** – This alternative involved a site specific project on Crab Bank Island whereby material would be placed on the northwest side of the island to create shallower sub-bottom habitat.

- Completeness – This alternative meets the completeness criteria as it requires no investments or actions by others to achieve the planning objectives.
- Effectiveness – This alternative does not meet the effectiveness criteria as will not meet the Planning Objectives. This alternative does not create avian habitat for multiple uses and will not fully protect structures.
- Efficiency – If carried forward, this alternative will be evaluated in the cost effectiveness and incremental cost analyses section of the report below.
- Acceptability – As determined during past coordination for the Charleston Harbor Post 45 navigation study the general public and agencies have concerns with existing erosion problems facing many areas in Charleston Harbor and how the proposed deepening or new construction project may affect those problems. Some stakeholders have also requested that the USACE place dredged material along certain shorelines to reduce the effects of erosion such as Fort Sumter, Crab Bank Island, and Shutes Folly Island. This alternative is acceptable in terms of applicable laws, regulations and public policies, and has strong public support.

Alternative 1e. Crab Bank Island Enhancement with Rip Rap – This alternative would use rip rap in combination with dredged material on the western side towards the navigation channel.

- Completeness – This alternative meets the completeness criteria as it requires no investments or actions by others to achieve the planning objectives. The rip rap would provide additional stability to any constructed project.
- Effectiveness – This alternative would meet the planning objective of creating avian habitat. The rip rap would provide additional stability to any constructed project.

- Efficiency – If carried forward, this alternative will be evaluated in the cost effectiveness and incremental cost analyses section of the report below.
- Acceptability – As determined during past coordination for the Charleston Harbor Post 45 navigation study the general public and agencies have concerns with existing erosion problems facing many areas in Charleston Harbor and how the proposed deepening or new construction project may affect those problems. Some stakeholders have also requested that the USACE place dredged material along certain shorelines to reduce the effects of erosion such as Fort Sumter, Crab Bank Island, and Shutes Folly Island. This alternative is acceptable in terms of applicable laws, regulations and public policies, and has strong public support.

Alternative 1f. Crab Bank Island Enhancement with Plantings – This alternative would combine plantings with dredged material placement for island and habitat creation.

- Completeness – This alternative meets the completeness criteria as it requires no investments or actions by others to achieve the planning objectives.
- Effectiveness – This alternative meets the planning objectives by increasing avian habitat. This alternative would also result in between 16 and 54 acres of high ground being constructed with the plants providing additional stability.
- Efficiency – If carried forward, this will be evaluated in the cost effectiveness and incremental cost analyses section of the report.
- Acceptability – As determined during past coordination for the Charleston Harbor Post 45 navigation study the general public and agencies have concerns with existing erosion problems facing many areas in Charleston Harbor and how the proposed deepening or new construction project may affect those problems. Some stakeholders have also requested that the USACE place dredged material along certain shorelines to reduce the effects of erosion such as Fort Sumter, Crab Bank Island, and Shutes Folly Island. This alternative is acceptable in terms of applicable laws, regulations and public policies, and has strong public support..

Alternative 1g. Crab Bank Island Enhancement with Rip Rap and Planting – This alternative combines rip rap and plantings with dredged material for island and habitat creation.

- Completeness – This alternative meets the completeness criteria as it requires no investments or actions by others to achieve the planning objectives..
- Effectiveness – This alternative meets the planning objectives by increasing avian habitat. This alternative would result in between 16 and 54 acres of high ground being constructed with the plants providing additional stability
- Efficiency – If carried forward, this will be evaluated in the cost effectiveness and incremental cost analyses section of the report.
- Acceptability – As determined during past coordination for the Charleston Harbor Post 45 navigation study the general public and agencies have concerns with existing erosion problems facing many areas in Charleston Harbor and how the proposed deepening or new

construction project may affect those problems. Some stakeholders have also requested that the USACE place dredged material along certain shorelines to reduce the effects of erosion such as Fort Sumter, Crab Bank Island, and Shutes Folly Island. This alternative is acceptable in terms of applicable laws, regulations and public policies, and has strong public support..

Alternative 2a. Shutes Folly Island Enhancement – **Enhance Marsh Habitat** – This alternative consisted of using a cutterhead dredge for dredged material placement to build up shallow sub bottom habitat to achieve an elevation consistent with the existing marsh in the area.

- Completeness – This alternative meets the completeness criteria as it requires no investments or actions by others to achieve the planning objectives.
- Effectiveness – This alternative meets the effectiveness criteria it meets both planning objectives. This alternative wwould result in between 15 and 28 acres of new habitat being constructed and would protect Shutes Folly Island and thus, Castle Pinckney.
- Efficiency – If carried forward, this alternative will be evaluated in the cost effectiveness and incremental cost analyses section of the report below.
- Acceptability – This alternative is not acceptable as it may impact Essential Fish Habitat.

Alternative 2b. Shutes Folly Island Enhancement – Dredged material would be used to enlarge Shutes Folly Island to a previous condition by placing material on the northeast side of the island.

- Completeness – This alternative meets the completeness criteria as it requires no investments or actions by others to achieve the planning objectives. Effectiveness – This alternative meets both Planning Objectives by increasing avian habitat and protecting a significant structure, Castle Pinckney.
- Efficiency – If carried forward, this alternative will be evaluated in the Cost Effectiveness and Incremental Cost Analyses section of the report below this alternative would result in between 61 and 74 acres of high ground being constructed, which would enhance opportunities for avian nesting, roosting, and foraging on Shutes Folly Island. As Castle Pinckney sits atop of the island, this alternative would also protect a historic significant structure.
- Acceptability – As determined during past coordination for the Charleston Harbor Post 45 navigation study the general public and agencies have concerns with existing erosion problems facing many areas in Charleston Harbor and how the proposed deepening or new construction project may affect those problems. Some stakeholders have also requested that the USACE place dredged material along certain shorelines to reduce the effects of erosion such as Fort Sumter, Crab Bank Island, and Shutes Folly Island. This alternative is acceptable in terms of applicable laws, regulations and public policies, and has strong public support.

Alternative 2c. Shutes Folly Island Enhancement with Rip Rap – This alternative will use rip rap in combination with dredged material to build up shallow sub bottom habitat to achieve an elevation consistent with the existing high ground in the area.

- Completeness – This alternative meets the completeness criteria as it requires no investments or actions by others to achieve the planning objectives.
- Effectiveness – This alternative meets the effectiveness criteria as it meets both planning objectives. This alternative would result in between 15 and 28 acres of new habitat being constructed and would protect Shutes Folly Island and thus, Castle Pinckney. The addition of the rip rap would enhance stability of any new construction.
- Efficiency – If carried forward, this alternative will be evaluated in the cost effectiveness and incremental cost analyses section of the report below.
- Acceptability – As determined during past coordination for the Charleston Harbor Post 45 navigation study the general public and agencies have concerns with existing erosion problems facing many areas in Charleston Harbor and how the proposed deepening or new construction project may affect those problems. Some stakeholders have also requested that the USACE place dredged material along certain shorelines to reduce the effects of erosion such as Fort Sumter, Crab Bank Island, and Shutes Folly Island. This alternative is acceptable in terms of applicable laws, regulations and public policies, and has strong public support.

Alternative 2d. Shutes Folly Island Enhancement with Plantings – Combine replanting with dredged material for habitat creation.

- Completeness – This alternative meets the completeness criteria as it requires no investments or actions by others to achieve the planning objectives.
- Effectiveness – This alternative meets the effectiveness criteria it meets both planning objectives. This alternative would result in between 15 and 28 acres of new habitat being constructed and would protect Shutes Folly Island and thus, Castle Pinckney. The addition of the plantings would enhance stability of any new construction.
- Efficiency – If carried forward, this alternative will be evaluated in the cost effectiveness and incremental cost analyses section of the report below.
- Acceptability – As determined during past coordination for the Charleston Harbor Post 45 navigation study the general public and agencies have concerns with existing erosion problems facing many areas in Charleston Harbor and how the proposed deepening or new construction project may affect those problems. Some stakeholders have also requested that the USACE place dredged material along certain shorelines to reduce the effects of erosion such as Fort Sumter, Crab Bank Island, and Shutes Folly Island. This alternative is acceptable in terms of applicable laws, regulations and public policies, and has strong public support.

Alternative 2e. Shutes Folly Island Enhancement with Rip Rap and Planting – This alternative would combine rip rap and plantings with dredged material for habitat creation.

- Completeness – This alternative meets the completeness criteria as it requires no investments or actions by others to achieve the planning objectives.

- Effectiveness – This alternative meets the effectiveness criteria it meets both planning objectives. This alternative would result in between 15 and 28 acres of new habitat being constructed and would protect Shutes Folly Island and thus, Castle Pinckney. The addition of the rip rap and plantings would enhance stability of any new construction.
- Efficiency – If carried forward, this alternative will be evaluated in the cost effectiveness and incremental cost analyses section of the report below.
- Acceptability – As determined during past coordination for the Charleston Harbor Post 45 navigation study the general public and agencies have concerns with existing erosion problems facing many areas in Charleston Harbor and how the proposed deepening or new construction project may affect those problems. Some stakeholders have also requested that the USACE place dredged material along certain shorelines to reduce the effects of erosion such as Fort Sumter, Crab Bank Island, and Shutes Folly Island. This alternative is acceptable in terms of applicable laws, regulations and public policies, and has strong public support.
- Acceptability – This would keep the proposed work confined in the historic footprint as identified in the associated EA. Therefore, there are no legal or policy issues related to this alternative so it is acceptable.

1.2.5.1 Using Rip- Rap

While using rip rap in combination with dredged material would provide better stability and enhance project life, the costs of using the rip rap exceed the cost limit of Section 204 of the Continuing Authorities program. Project rip rap costs for various arrangements for both Crab Bank Island and Shutes Folly Island are shown in Table 2 below and detailed costs can be found in Appendix A.

Table 2. Cost Ranges of using Rip Rap for Crab Bank Island and Shutes Folly Islands

Features	Armoring Cost Ranges
Crab Bank Island Rip Rap Features	$12,227,530 - $ 15,018,530 - $ 17,251,799
Shutes Folly Island Rip Rap Features	$ 8,307,217 - $ 11,643,397 - $ 12,297,496

The above costs are only for the purchase and installation of the rip rap. The cost ranges are based on the potential size of the project based on available dredged material. This is above the costs of using any dredged material. Therefore any alternative that uses rip rap more than triples the cost and would have permanently eliminated a significant amount of intertidal habitat at Crab Bank. Such that the cost would have exceeded the 204 CAP limit due to mitigation requirements.

1.2.5.2 Evaluation Criteria Results for Alternative Plans

A summary of the evaluation criteria results can be found in Table 3 below. Alternatives 1a, 1f, 2b, and 2d met the criteria evaluation and are carried forward. The remaining alternatives involve using new work dredged material to enlarge Crab Bank Island or Shutes Folly Island.

Table 3. Outcomes of Evaluation Criteria

Alternative	Completeness	Effectiveness	Efficiency	Acceptability	Constraints	Carried Forward
Alternative 1a. Crab Bank Island Enhancement	Yes	Yes	TBD	Yes	No	**Yes**
Alternative 1b. Crab Bank Island South End Enhancement	No	No	TBD	Yes	No	No
Alternative 1c. Crab Bank Island Salt Marsh Enhancement	No	No	TBD	Yes	Yes	No
Alternative 1d. Crab Bank Island Sub-bottom Habitat Enhancement	No	No	TBD	Yes	Yes	No
Alternative 1e. Crab Bank Island Enhancement with Rip Rap	Yes	Yes	TBD	Yes	Yes	No
Alternative 1f. Crab Bank Island Enhancement with Plantings	Yes	Yes	TBD	Yes	No	**Yes**
Alternative 1g. Crab Bank Island Enhancement with Rip Rap and Planting	Yes	Yes	TBD	Yes	Yes	No
Alternative 2a. Shutes Folly Island Enhancement- Enhance Marsh Habitat	Yes	Yes	TBD	No	Yes	No
Alternative 2b. Shutes Folly Island Enhancement	Yes	Yes	TBD	Yes	No	**Yes**
Alternative 2c. Shutes Folly Island Enhancement with Rip Rap	Yes	Yes	TBD	Yes	Yes	No
Alternative 2d. Shutes Folly Island Enhancement with Plantings	Yes	Yes	TBD	Yes	No	**Yes**
Alternative 2e. Shutes Folly Island Enhancement with Rip Rap and Planting	Yes	Yes	TBD	Yes	Yes	No

Alternatives 1a, 1f, 2b, and 2d met the criteria evaluated and avoided the constraints and are carried forward. All of the remaining alternatives involve using new work dredged material to enlarge Crab Bank or Shutes Folly islands.

1.2.6 Optimizing the Alternatives

In order to determine the project that maximizes the national ecosystem restoration (NER) benefits, the project team developed an array of options for each action alternative based upon volume of new work dredged material and associated island size.

The maximum volume of available material is potentially 1,250,000 cy assuming all of the allowable advanced maintenance. 825,000 CY of material is available volume based on a 52 foot construction channel plus two feet of advance maintenance and none of the additional allowable overdepth. The remainder of the material results from potential additional overdepth dredging of two feet, for a total potential depth of 56 feet. The island sizes are based on the volume of dredged material (assuming a 20% loss of dredged material) to provide a low, medium, and high volume for each location (Figures 2-7 for Crab Bank Island and Figures 8-10 for Shutes Folly Island).

Figure 2. Crab Bank Island Footprint at 330,000 cy of Dredged Material (Crab Bank Low)

Figure 3. Crab Bank Island Footprint at 330,000 cy of Dredged Material (Crab Bank Low A)

(The footprint has been shifted to cover the lower part of the island.)

Figure 4. Crab Bank Island Footprint at 660,000 cy of Dredged Material (Crab Bank Medium)

Figure 5. Crab Bank Island Footprint at 660,000 cy of Dredged Material (Crab Bank Medium A)

(This footprint is more compressed than either Crab Bank Medium or Crab Bank Medium B.)

Figure 6. Crab Bank Island Footprint at 660,000 cy of Dredged Material (Crab Bank Medium B)

(This footprint is similar to Crab Bank Medium, but has been shifted down, not covering the northern tip of the Island.)

Figure 7. Crab Bank Island Footprint at 990,000 cy of Dredged Material (Crab Bank High)

Figure 8. Shutes Folly Island Footprint at 100,000 cy of Dredged Material (Shutes Folly Island Low)

Figure 9. Shutes Folly Island Footprint at 196,000 cy of Dredged Material (Shutes Folly Island Medium)

Figure 10. Shutes Folly Island Footprint at 296,000 cy of Dredged Material (Shutes Folly Island High)

A refined array of the various scales of the alternatives were determined (Table 4). This array carries forward Alternative 1a, 1f, 2b, and 2d from Table 3 with the optimization of island sizes. The results includes all combinations of three island sizes for Crab Bank and Shutes Folly Island and the use of plantings for both islands with one exception. The combination of Crab Bank High and Shutes Folly High is not possible due to the limited amount of acceptable material available for placement, as further described in Appendix A, Section VI.1 Measures

Table 4. Array of Alternative Volumes

Placement Location 1	Volume of Placed Material (cy) Location 1	Placement Location 2	Volume of Placed Material (cy) Location 2	Total Volume of Placed Material (cy)	Total Volume of In-situ Material (cy)
Crab Bank High	990,000	Na	0	990,000	1,237,500
Crab Bank Island Medium	660,000	Na	0	660,000	825,000
Crab Bank Island Medium A	660,000	Na	0	660,000	825,000
Crab Bank Island Medium B	660,000	Na	0	660,000	825,000
Crab Bank Island Medium B	660,000	Shutes Folly Island High	296,000	956,000	1,195,000
Crab Bank Island Medium B	660,000	Shutes Folly Island Medium	196,000	856,000	1,070,000
Crab Bank Island Medium B	660,000	Shutes Folly Island Low	100,000	760,000	950,000
Crab Bank Island Low	330,000	Na	0	330,000	412,000
Crab Bank Island Low A	330,000	Na	0	330,000	412,000
Crab Bank Island Low A	330,000	Shutes Folly Island High	296,000	626,000	782,500
Crab Bank Island Low A	330,000	Shutes Folly Island Medium	196,000	526,000	657,500
Crab Bank Island Low A	330,000	Shutes Folly Island Low	100,000	430,000	537,500
Crab Bank Island High w Plantings	990,000	Na	0	990,000	1,237,500
Crab Bank Island Medium w Plantings	660,000	Na	0	660,000	825,000
Crab Bank Island Medium A w Plantings	660,000	Na	0	660,000	825,000

Placement Location 1	Volume of Placed Material (cy) Location 1	Placement Location 2	Volume of Placed Material (cy) Location 2	Total Volume of Placed Material (cy)	Total Volume of In-situ Material (cy)
Crab Bank Island Medium B w Plantings	660,000	Na	0	660,000	825,000
Crab Bank Island Medium B w Plantings	660,000	Shutes Folly Island High w Plantings	296,000	956,000	1,195,000
Crab Bank Island Medium B w Plantings	660,000	Shutes Folly Island Medium w Plantings	196,000	856,000	1,070,000
Crab Bank Island Medium B w Plantings	660,000	Shutes Folly Island Low w Plantings	100,000	760,000	950,000
Crab Bank Island Low w Plantings	330,000	Na	0	330,000	412,000
Crab Bank Island Low A w Plantings	330,000	Na	0	330,000	412,000
Crab Bank Island Low A w Plantings	330,000	Shutes Folly Island High w Plantings	296,000	626,000	782,500
Crab Bank Island Low A w Plantings	330,000	Shutes Folly Island Medium w Plantings	196,000	526,000	657,500
Crab Bank Island Low A w Plantings	330,000	Shutes Folly Island Low w Plantings	100,000	430,000	537,500

Appendix A includes discussions regarding the placement of 330,000 cy^3 of material on Crab Bank Island. These options were eliminated from analysis because using this amount of material would not result in a lasting solution, when defined as island size being the same as or greater than the present island size after the 50-year project life.

1.3 Ecological Outputs and Habitat Suitability Index

Environmental Benefits Assessment (EBA) is used to measure the increase in both the quality and quantity of a targeted ecosystem due to various proposed restoration measures and alternatives at a site. For the Charleston Harbor 204 study, quality was measured in terms of a habitat suitability index (HSI). The HSI is multiplied by the number of acres being restored in order to generate a "habitat unit (HU)" as output. The greater the number of Habitat Units the greater the ecological benefit.

HSI models are approved for use by the USACE Ecosystem Planning Center of Expertise. The US Fish and Wildlife Service Blue Book series of models were developed to provide habitat information for evaluating impacts on fish and wildlife habitat from water or land use changes (Schamberger et al., 1982). The models reference numerous literature sources in order to consolidate scientific information on species habitat relationships. All models are based on a numerical index of habitat suitability on a 0.0 to 1.0 scale, with 1.0 being the best habitat (Schamberger et al., 1982). Their purpose is to serve as a basis for improved decision making and increased understanding of habitat relationships (Schamberger et al., 1982).

The project delivery team evaluated the various HSI's available to use and the following HSI's were most applicable to quantifying benefits to avian species for this project: least tern, Forster's tern, laughing gull, and eastern brown pelican. Of these the most applicable is the eastern brown pelican. The eastern brown pelican HSI captures the majority of environmental benefits from the proposed project. Of the models that were considered for use in this study none captured benefits as well as the eastern brown pelican HSI. The benefits not captured are small and are generally shared between alternatives. Modeling of intertidal habit was not conducted as part of this study. No significant impact to the analysis of benefits is expect as a result of not quantitatively measuring this minor benefit. The existing intertidal habitat would be negatively impacted by construction of any of the alternatives but would quickly recover, as this habitat type is highly dynamic. The quick recovery of intertidal areas is well documented for beach renourishment projects in the area and Crab Bank intertidal habitat is very similar to intertidal areas impacted by beach renourishment. As such, the only improvement to intertidal habitat would occur due to an increase in the linear distance of habitat created as the result of an action. The quality of the intertidal habit is expected to be virtually identical before and shortly after construction.

The brown pelican, while plentiful now, was previously on the endangered species list. While it was removed from the endangered species list in 2009, it is still protected in SC. It has a SC priority species ranking of high in the South Carolina State Wildlife Action Plan (http://dnr.sc.gov/swap/main/chapter2-priorityspecies.pdf). The island is so important to the brown pelican that the Coastal Conservation League, a local non-profit, dedicated to protecting natural habitats, installed a video camera to view the brown pelican and other bird nesting on the island (http://coastalconservationleague.org/pelicam/).

1.3.1 Habitat Suitability Index (HSI) Model.

The eastern brown pelican HSI model is intended for use in the habitat evaluation procedures (HEP) developed by the USFWS for impact assessment and habitat management (Hingtgen, et. al. 1985). The brown pelican HSI has 4 variables. The model can be used to evaluate estuarine island habitat, natural islands, and dredge material islands within the breeding range, which includes the Charleston Harbor area. The HSI is designed to model nesting and loafing cover for the animal and the habitat variables that support this life requisite (Figure 11).

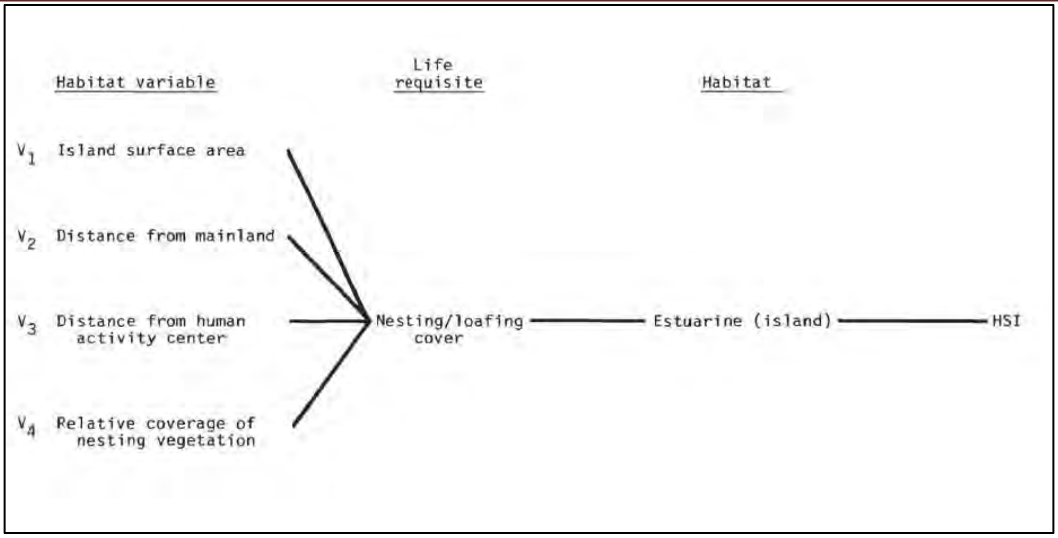


Figure 11. Relationships of Habitat Variables, Life Requisite, and Habitat Type in the HSI Model for the Eastern Brown Pelican.

Habitat suitability is determined based on the four variables for nesting/loafing habitat (Table 5).

1.3.2 Determining Island Size (Variable 1)

The first variable of the brown pelican HSI model accounts for the area of the island that is above 2ft. MHW (i.e., 4.27 ft. NAVD 88) contour, which is considered the area suitable for brown pelican nesting habitat. HSI scores were calculated for each alternative based on the acreage above 2.4 ft. MHW at construction. The HSI model dictates what elevations at MHW constitute nesting habitat, and this number was used for island size.

Expected erosion of the island over the 50-year life of the project was also calculated and HSI scores were determined for each alternative at the end of project life. The natural erosion rate of the island was determined by comparing the change in island size from 2000 through 2016 (see Appendix A for details.)

1.3.1.3 Determining Distance from Mainland (Variable 2)

This variable was determined by approximating the straight line distance from the closest point of the islands to the mainland approximate high ground. The distances are the same for all Crab Bank alternatives as well as all Shutes Folly Island alternatives. For Shutes Folly Island, all alternatives would be approximately 0.9 km away from the mainland of downtown Charleston. For Crab Bank Island, all alternatives would be approximately 0.5 km away from the high ground at Patriot's Point. Because of this all alternatives received an HSI score of 1.0 for this variable.

1.3.1.4 Determining Distance from Nearest Human Activity Center (Variable 3)

This variable was determined by approximating the straight line distance from the closest point of the islands to the nearest center of human activity. Charleston Harbor is an active sea port and is heavily used by recreational and commercial vessels. However, since Crab Bank Island and Shutes Folly Island are currently protected from human activity during bird nesting season, the distances were determined to be to a more definite center of activity versus the adjacent Charleston Harbor waterbody. The distances are the same for all Crab Bank Island alternatives as well as all Shutes Folly Island alternatives. For Shutes Folly Island, all alternatives would be approximately 0.9 km away from the mainland of downtown Charleston where heavy urban activity occurs. For Crab Bank Island, all alternatives would be approximately 0.5 km away from the mouth of Shem Creek, which is a popular location for recreational boaters, commercial shrimp vessels, and commercial activities such as restaurants and businesses. Because of this, the HSI score for this variable is consistent for all the alternatives. Within the HSI documentation it is indicated that the distance from mainland is the point of concern. “Eastern brown pelican nesting colonies occur on coastal islands small enough to be free from human habitation and recreation and far enough from the mainland to be inaccessible to potential mammalian predators (Schreiber 1979;Williams 1979). The distance from the mainland is key as it serves to limit access to nest by predators such as rats and raccoons. Additionally, SCDNR restricts all visitation to Crab Bank during the bird nesting season to ensure nesting birds are not disturbed. Crab Bank can be accessed by the public outside the nesting season

1.3.1.5 Relative Cover of Nesting Vegetation (Variable 4)

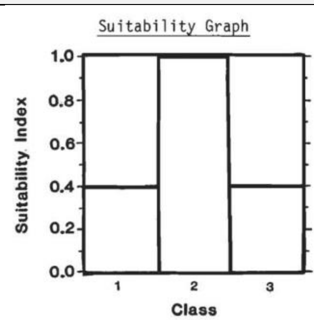
In South Carolina, brown pelicans are ground nesters. The HSI model defines this variable for South Carolina as the amount surface area at least 2 ft. in surface elevation. This translates to an elevation of 7.4 ft. MLLW. Since island size is calculated as acreage above 7.4 ft. MLLW, and that island size is consistently reflected in the erosion rates, the PDT used 100% of the island above 7.4 ft. MLLW all the time. This acreage equates to the acreage of nesting vegetation not the total nesting acreage.

1.3.2 Computation of Habitat Suitability Index

The alternatives being evaluated all involve enlarging Crab Bank Island and Shutes Folly Island and then letting those features erode naturally. Erosion rates, acreage of pelican habitat, and subsequent HSI values were calculated for each year over the life of the project. HSIs at construction and at the end of the project life are shown in Table 6 below.

All of the alternatives being evaluated will enlarge the existing features and will result in the features remaining at the end of the project’s life.

Table 5. HSI Variables for Suitability for Brown Pelican Nesting/Loafing

HSI Variables for Suitability for brown pelican nesting/loafing		
Variable	Data Source/Measurement	HSI Graph
V1 Island size	Measure the acreage of the island 2 feet above Mean High Water	

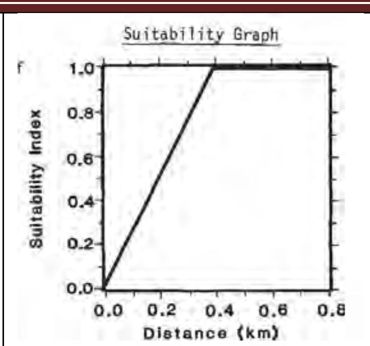
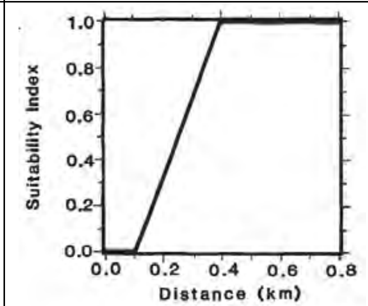
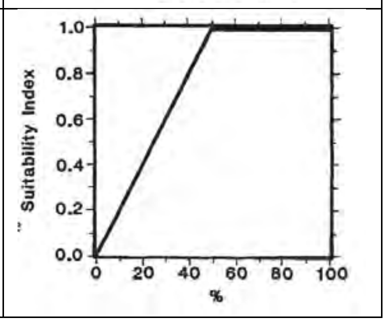
V2 Distance from mainland	Measure straight-line distance from mainland shore to island shore at low tide.	
V3 Distance from nearest human activity center	Measure straight-line distance from closest area of any center of human activity to the colony island.	
V4 Percent of Vegetation Coverage	Calculate percent of vegetation relative to surface area.	

Table 6. Size and HSIs at Construction and End of Project Life

Alternative Name	Volume of Material Placed (cy)	Brown Pelican Habitat at Construction (acres)	Brown Pelican Habitat after 50 Years (acres)	H S I at Construction	H S I at 50 Years
No Action Plan	0	0.93	0	0.795271	0
Crab Bank Island High	990,000	47.40	1.06	0.795271	0.795271
Crab Bank Island Medium	660,000	28.40	0.64	0.795271	0.795271
Crab Bank Island Medium A	660,000	27.80	0.64	0.795271	0.795271
Crab Bank Island Medium B	660,000	31.50	0.70	0.795271	0.795271
Crab Bank Island High w Planting	990,000	47.40	23.54	0.795271	0.795271
Crab Bank Island Med w Planting	660,000	28.40	14.10	0.795271	1
Crab Bank Island Med A w Planting	660,000	27.80	13.81	0.795271	1
Crab Bank Island Med B w Planting Island	660,000	31.40	15.59	0.795271	1
Shutes Folly Island High	296,000	16.65	0	1	0
Shutes Folly Medium	196,000	11.80	0	1	0
Shutes Folly Island Low	100,000	6.75	0	1	0
Shutes Folly Island High w Plantings	296,000	16.65	8.27	1	1
Shutes Folly Island Medium w Plantings	196,000	11.80	5.86	1	1
Shutes Folly Island Low w Plantings	100,000	6.75	3.35	.795271	.795271
Crab Bank Island Medium A-Shutes Folly Island High	1470.84	48.15	0.70	0.86606514	0.795271

Alternative Name	Volume of Material Placed (cy)	Brown Pelican Habitat at Construction (acres)	Brown Pelican Habitat after 50 Years (acres)	H S I at Construction	H S I at 50 Years
Crab Bank Island Medium A - Shutes Folly Island Medium	1,263	43.30	0.70	0.851063199	0.795271
Crab Bank Island Medium A - Shutes Folly Island Low	922	38.25	.07	0.831399647	0.795271
Crab Bank Island Medium A- w Planting Shutes Folly Island High w Planting	1,692	48.15	22.08	0.795271	0.795271
Crab Bank Island Medium A - w Planting Shutes Folly Island Medium w Planting	1,470	43.30	19.67	0.795271	0.795271
Crab Bank Island Medium A - w Planting Shutes Folly Island Low w Planting	1,085	38.250	17.16	0.795271	0.795271

1.3.3 "Base Plan" Cost

Under the Section 204 Authority, costs of beneficial use of sediment projects are limited solely to project costs that are in excess of the "base plan" or the least cost environmentally acceptable dredging costs without the project. As a result, the costs used for evaluation and comparison purposes are the incremental first costs of the potential ecosystem restoration construction over the first cost associated with disposing of the sediments as described in the base plan.

Under the base plan for dredging of new work materials from Bennis and Rebellion Reaches during the construction of the Post 45 Project, materials would be excavated with a clamshell dredge. The clamshell would place materials within a scow, which would then be transported offshore to the ODMDS where it would be bottom dumped. The base plan cost was calculated as the amount of material to be dredged for each refined alternative multiplied by the unit cost for placement at the ODMDS. Details on the methods used to determine base plan costs can be found in Appendix A.

1.3.4 Cost Analysis of Alternatives

After determining the base cost plan for each alternative, the project delivery team determined the costs associated with using that material to construct each of the alternatives. As previously described, these costs factored in the placed amount of material and the amount of material that would need to be dredged to achieve that placement yardage, with an assumed 20% loss of material. The construction methods are discussed in detail in the SEA. The cost factored in the mobilization cost and demobilization cost for additional equipment. These costs are reflected in Table 7.

Table 7. Cost of Constructing each Alternative.

Alternative	Crab Bank Placement		Shutes Folly Placement		Mob/ demob	Total Cost w/o contingency or escalation
	CY Placed	Unit Cost	CY Placed	Unit Cost		
Crab Bank Island High	990,000	$8.74	0		$297,000	$8,949,600
Crab Bank Island Medium	660,000	$9.55	0		$297,000	$6,600,000
Crab Bank Island Medium-Shutes Folly Island High	660,000	$9.55	296,000	$9.44	$373,000	$9,470,240
Crab Bank Island Medium A Shutes Folly Island Medium	660,000	$9.55	196,000	$10.44	$373,000	$8722,240
Crab Bank Island Medium A Shutes Folly Island Low	660,000	$9.55	100,000	$11.87	$373,000	$7,863,000

As previously stated, the costs used for evaluation and comparison purposes are the incremental firsts costs of the potential ecosystem restoration plans construction over the cost associated with disposing of the sediments as described in the Base Plan. Table 8 demonstrates the incremental cost difference for each alternative and is noted in the last column as the "Fully Funded" cost of construction. The project implementation costs will also include design and management costs added to the "Fully Funded" costs.

Table 8. Fully Funded Construction Cost (incremental cost difference) for each Alternative.

Alternative	Alternative Numbers	Total Cost of Alternative	Total Base Plan Cost	Delta Cost	Contingency	Escalation	Fully Funded	Average Annual Cost
Crab Bank Island High	1,13	$8,949,6000	$5,568,750	$3,380,850	$743,787	$164,985	$4,289,622	$338,785.33
Crab Bank Island Medium	2,3,4,5,6,7, 14,15,16	$6,600,000	$3,712,500	$2,887,500	$635,250	$140,910	$3,663,660	$245,615.19
Crab Bank Island Medium A- Shutes Folly Island High	17,22	$9,470,240	$5,400,000	$4,070,240	$895,453	$198,628	$5,164,321	$ 355,370.16
Crab Bank Island Medium A - Shutes Folly Island Medium	18,23	$8,722,240	$4,815,000	$3,907,240	$859,593	$190,673	$4,957,506	$ 326,985.00
Crab Bank Island Medium A - Shutes Folly Island Low	19,24	$7,7863,000	$4,275,000	$3,588,000	$789,360	$175,094	$4,552,454	$294,378.48

1.3.5 Cost Effectiveness and Incremental Cost Analysis (CEICA)

Benefit-cost analysis is generally considered the "best case scenario" for water resources plan evaluation. In benefit-cost analysis, the monetary cost of a plan is subtracted from the monetary value of the benefits to be provided by that plan to compute net benefits. When there is a range of alternative plans, the plan that provides the most net benefits is typically the recommended plan. When project benefits aren't measured in dollars, cost effectiveness and incremental cost analyses offer the next-best approach for plan evaluation. While the cost effectiveness and incremental cost analyses of alternative plans may not identify a unique or "optimal" solution, they lead to better-informed choices. Cost effectiveness analysis and incremental cost analysis weigh the costs of restoration and mitigation plans against nonmonetary measures of output. Such evaluation is at the heart of the analyses and is the basis for their application in environmental planning.

Cost effectiveness analysis can assist in the formulation of cost effective alternative plans, and can also be used to screen out plans that are not cost effective from further consideration. Incremental cost analysis reveals changes in costs as levels of environmental outputs increase. In the absence of a common measurement unit for comparing the non-monetary benefits with the monetary costs, cost effectiveness and incremental cost analyses are valuable tools to assist in decision making.

Proper use of cost effectiveness and incremental cost analyses can help decision makers allocate limited resources more efficiently and avoid the selection of economically irrational plans. The analysis results are displayed in Table 9 and Figure 12 below were used in the comparison of alternatives and indicate if the next incremental step is justified by the expense. The IWR Planning Suite dependency tool allowed for the combination of the Shutes Folly Island alternatives with Crab Bank Island Medium alternative for this comparison.

Table 9. Average Annual Costs, Outputs, and Cost Effectiveness Summary

Alternative Name	Cost	Average Annual Output	Volume of Material Placed (cy)	Initial Pelican Habitat (Acres)	Pelican Habitat (all types) After 50 Years (Acres)	H S I At Construction	H S I at 50 Years	Average Annual Cost (50yrs@ 2.75 %)	Cost Effective?
No Action Plan	0	0	0	0.93	0	0.795271	0	0	**Best Buy**
Crab Bank Island High	3,380,850	0.863514	990,000	47.40	1.06	0.795271	0.795271	133,142	No
Crab Bank Island Medium	2,887,500	0.823317	660,000	28.40	0.64	0.795271	0.795271	114,764	No
Crab Bank Island Medium A	2,887,500	0.871542	660,000	27.80	0.64	0.795271	0.795271	114,764	**Best Buy**
Crab Bank Island Medium B	2,887,500	0.867528	660,000	31.50	0.7	0.795271	0.795271	114,764	No
Crab Bank Island High w Planting	3,760,650	0.795271	990,000	47.40	23.54	0.795271	0.795271	147,290	No
Crab Bank Island Med w Planting	3,215,500	0.872746	660,000	28.40	14.1	0.795271	1	126,982	No

Alternative Name	Cost	Average Annual Output	Volume of Material Placed (cy)	Initial Pelican Habitat (Acres)	Pelican Habitat (all types) After 50 Years (Acres)	H S I At Construction	H S I at 50 Years	Average Annual Cost (50yrs@ 2.75 %)	Cost Effective?
Crab Bank Island Med A w Planting	3,215,500	0.899643	660,000	27.80	13.81	0.795271	1	126,982	**Best Buy**
Crab Bank Island Med B w Planting	3,215,500	0.867528	660,000	31.40	15.59	0.795271	1	126,982	No
Shutes Folly Island High	1,492,840	.784619	296,000	16.65	0	1	0	62,811	No
Shutes Folly Island Medium	1,284,840	.772576	196,000	11.80	0	1	0	55,063	No
Shutes Folly Island Low	944,000	.662957	1,000,000	6.75	0	1	0	42,366	No
Shutes Folly Island High w Planting	1,727,740	1	296,000	16.65	8.27	1	1	74,561	No
Shutes Folly Island Med w Planting	1,505,140	1	196,000	11.80	5.86	1	1	63,269	No
Shutes Folly Island Low w Planting	1,116,800	.795271	100,000	6.75	3.35	.795271	.795271	7,435	No

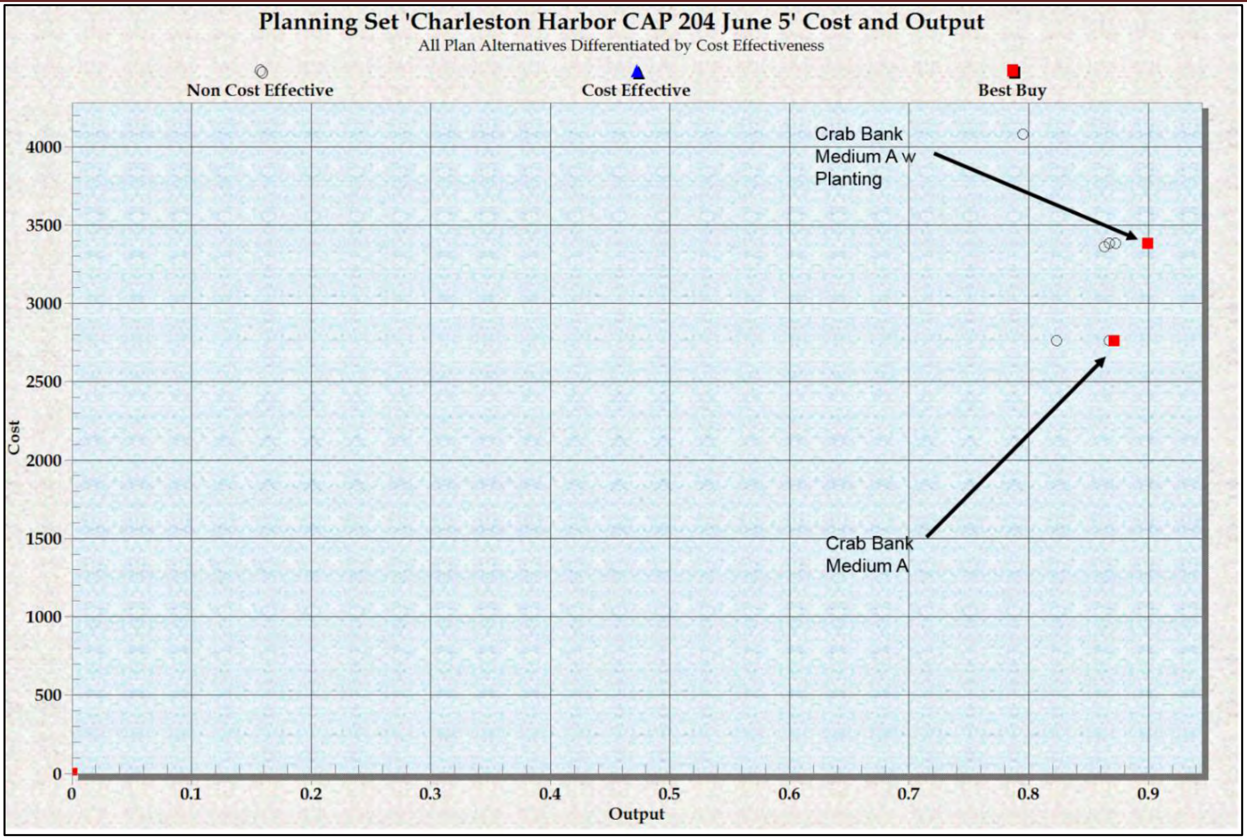


Figure 12. Relationship between Average Annual Cost (Cost) and Average Annual Habitat Units (Outputs) for each Alternative

Crab Bank Island Medium A and Crab Bank Island Medium A with Plantings were determined to be the "best buy" alternatives. While all Crab Bank Island Medium alternatives use the same volume of material, the differing configurations result in differing topography and island height. The Medium A alternative is more compact than the other two Medium alternatives resulting in greater overall height with more "high spots" for nesting.

1.4 Comparison of Alternative Plans

1.4.1 Analysis of Best Buys

Based on the cost effectiveness and incremental cost analyses, the "best buy" alternatives, the no action plan, Crab Bank Medium A and Crab Bank Medium A with Plantings were carried forward for a more detailed comparison.

The no action plan can be eliminated as this does not meet any of the project objectives within the period of analysis. Implementing the no action alternative will result in the loss of Crab Bank Island as avian habitat. Recent report of shore bird eggs from Crab Bank Island washing up onto Sullivan's Island (See May 25, 2017 news article in Appendix E) are evidence of how quickly Crab Bank is disappearing how this will impact local avian populations.

Crab Bank Island Medium A will use material resulting from the deepening of the Bennis and Rebellion reaches to their new authorized depth to reestablish Crab Bank Island. The plan will result in approximately 52.8 acres being added onto the existing island, resulting in a new island that will be approximately 79.4 acres in size. This plan will result in Crab Bank Island having 27.8 acres of new brown pelican nesting habitat. At the end of the project's life, Crab Bank Island will be approximately 15.25 acres in size with 0.64 acres of brown pelican nesting habitat remaining. The material being placed on the island will have 15H: 1V slopes. The top of the new material will not be smoothed, but will be intentionally arranged to undulate, leaving both peaks and troughs to accommodate multiple avian species' needs and life cycles. Accounting for volume loss during transport and deposition, approximately 660,000 cy of material will be placed. The new island will be configured as shown in Figure 25 below.

Crab Bank Island Medium A with Planting will use the material resulting from the deepening of the Bennis and Rebellion reaches to their new authorized depth to reestablish Crab Bank Island. The plan will result in approximately 52.8 acres being added onto the existing island, resulting in a new island that will be approximately 79.4 acres in size. This plan will result in Crab Bank Island having 31.5 acres of new brown pelican nesting habitat. At the end of the project's life, Crab Bank Island will be approximately 13.8 acres in size with 0.70 acres of brown pelican nesting habitat remaining. The material being placed on the island will have 15H: 1V slopes. The top of the new material will not be smoothed, but will be intentionally arranged to undulate, leaving both peaks and troughs to accommodate multiple avian species' needs and life cycles. Accounting for volume loss during transport and deposition, approximately 660,000 cy of material will be placed. The new island will be configured as shown in Figure 13 below.

Figure 13. Footprint of Recommended Plan, Crab Bank Island Medium A.

Crab Bank Island Medium A with planting optimizes the Crab Bank Island Medium by supplementing the placement of dredged material with marsh plants to stabilize the material. Conceptually, this entails planting vegetation on top of the dredged material at the upper range of the intertidal zone (Figure 14). Plantings would be a combination of *Spartina alterniflora and Juncus roemerainus.* While it was recognized that any plantings would need to be protected, no definite protection method was initially identified.

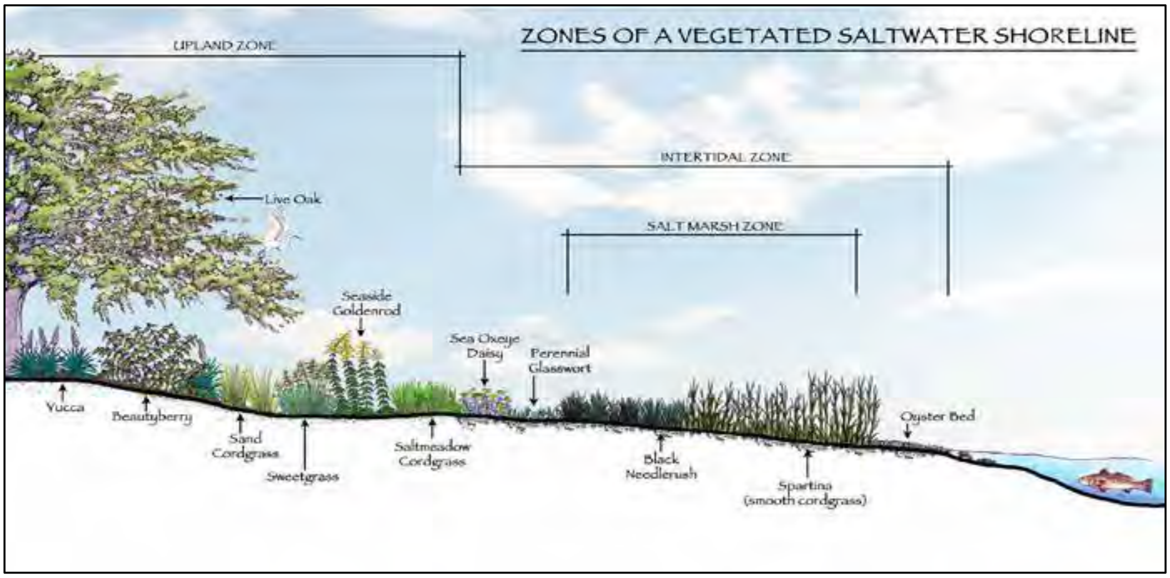


Figure 14. Conceptualized Planting Zone for Crab Bank Island

Priest (2017) developed evaluation criteria to determine the appropriateness of constructing living shorelines (Table 10). This approach provides guidance in analyzing alternative approaches to successful planting methods. Based on this criteria, Crab Bank Island is a medium energy environment, and a sill system would be necessary to successfully establish plants. Shoreline plantings alone are not technically feasible as this alternative would only be acceptable in low energy environments. Therefore, some form of toe protection is necessary. Common toe protection includes (Priest 2017):

Coir logs – Coir logs are usually made of coconut fibers. These features only provide support only long enough for the plants to be established. As such, this feature is considered temporary measures and may not last more than one or two years. In addition, coir logs are not suitable for medium energy environments such as Crab Bank Island.

Bagged oyster shells – Bagged oyster shells have been used for sill construction in low energy systems. Oyster shell, however, is a limited resource in South Carolina, there is not enough available to construct a sill, even if the wave climate was favorable.

Rock Sills – Rock sills are usually used in medium energy environments, and are typically granite or some such similar rock. Material must be placed versus being simply dumped, and should have some underlying filter fabric underneath. Rock size and sill height is a function of physical oceanographic factors of the environment in question. Rock size must be sized to withstand wave energy. The larger the fetch, the larger the rock is needed.

Table 10. Living Shoreline Site Evaluation Criteria

Parameter	Criteria Value			Score	Comments
	1	2	3		
Storm surge	2′	2′–4′	>4′	3	The storm surge of a Category I storm at Sullivan's Island is 7.6 ft.
Fetch	<0.5 mi	0.5–1 mi	1–5 mi	3	The longest fetch at Crab Bank is Island approximately 3.5 miles.
Bank height	<3′	3′–6′	>6′	2	In 2016, the maximum elevation on Crab Bank was 3.6 ft. above msl.
Bank condition	Stable	Transitional	Eroding	3	Crab Bank Island is eroding.
Nearshore depths	<1′	1′–2′	>3′	3	Depths vary. The 4 ft. contour approaches the impacted shoreline.
Sediment type	Mud	Mud/sand	Sand	2	Sediment to be used is 65% sand.
Tide range	1′–2′	2′–4′	>4′	3	Tidal Range for Charleston Harbor is approximately 5.5 ft.
Erosion rate	1′	2′	>3′	3	Rate greater than 3 ft.
Shoreline orientation	South	East or west	North	2	Crab Bank Island's impacted shoreline faces west.
Shoreline configuration	Cove	Linear	Point	2	Crab Bank Island is basically linear.
Infrastructure proximity	>100′	50′–100′	<50′	1	No infrastructure proximate.
Width of waterway	>300′	300′–100′	<100′	1	Waterway is over 2 mi in width.
Buffer condition	Lawn	Natural grasses	Forest	NA	No buffer on Crab Bank Island.
Total score				**28**	
13–18		Low energy, trim trees and plant marsh			
19–32		Medium energy, sill system			
33–39		High energy, breakwater system			

Wave analysis produced as part of the Post 45 study reports that the fetch at Crab Bank Island is 3.5 miles when subject to the prevailing winds. As such, larger rip rap is necessary for sill construction. Sill construction on Crab Bank Island would require an estimated 112,301 tons of stone, at an additional cost of $ 7 million. While evaluating the alternatives through the CE/CEA analysis, it was not yet determined that rock sills were necessary to provide protection to any Harbor side, intertidal plantings. The addition of rock more than triples the cost and would have permanently eliminated a significant amount of intertidal habitat at Crab Bank. Such that the cost would have exceeded the 204 CAP limit due to mitigation requirements.

2.0 Recommend Plan

2.1 Plan Description

The tentatively selected plan is Crab Bank Island Medium A (Figure 13). The plan involves using new work dredged material from Bennis and Rebellion Reaches of the navigation channel to enlarge Crab Bank Island in Charleston Harbor. A clamshell dredge or a cutterhead pipeline dredge will be used to excavate the material from the available reaches, transported via pipeline, and discharged on a designated placement area on Carb Bank Island. It is anticipated that approximately 825,000 cy of in-situ dredged material will be available for this project with approximately 660,000 cubic yards being ultimately used to enlarge Crab Bank Island.

Mechanized equipment will be used for construction. Placement will be in a non-uniform pattern to allow for greater topographic complexity and therefore greater habitat diversity. Island height will range between 6.5' (roughly 1' above mean high tide) and 10' MLLW. The footprint of the island is shown in Alternative Medium A, which has been identified as a "best buy" alternative. The resulting island will be 79.4 acres in size, with 27.8 acres of usable brown pelican nesting habitat. At the end of the project's life, it is anticipated that Crab Bank Island will be approximately 15.25 acres in size, with 0.64 acres of brown pelican nesting habitat remaining. Costs are approximately $ 3.98 million, with the federal amount to be approximately $ 2.59 million.

2.2 Summary of Significance

2.2.1 Institutional Significance

Significance based on institutional recognition means that the importance of an environmental resource is acknowledged in the laws, adopted plans, and other policy statements of public agencies, tribes, or private groups. Sources of institutional recognition include public laws, executive orders, rules and regulation, treaties, and other policy statements of the federal government: plans, laws, resolutions, and other policy statements of regional and local public entities with jurisdiction in the study area.

In 2006, Crab Bank Island was designated by SCDNR as a Seabird Sanctuary. Presently there are only six designated sanctuaries in the state. The island is managed as part of SCDNR's Heritage Trust Lands. Public access to the island is limited, with no access allowed during nesting season, March 15 through October

South Carolina Department of Health and Environmental Control-Bureau of Ocean and Coastal Resource Management (SCDHEC-OCRM) has designated Crab Bank Island a Geographic Area of Particular Concern (GAPC) under the state's Coastal Zone Management Program. This shows that the state considers Crab Bank Island to be of unique importance.

2.2.2 Public Significance

Public significance is based on public recognition and means that some segment of the general public recognized the importance of an environmental resource, as evidenced by people engaged in activities that reflect an interest or concern for that particular resource. Such activities may involve contributions in funds or efforts to protect, promote, or otherwise benefit the resource.

Natural resources are the basis for most recreational activities in South Carolina. South Carolina's natural resources are essential for economic development and contribute nearly $30 billion and 230,000 jobs to the state's economy. In 2008, natural resources-based industries in South Carolina supported $29.1 billion in total economic impact, including 235,431 jobs and $7.8 billion in labor income (University of South Carolina, 2009). Table 11 below shows that bird watching is the most significant recreational activity with respect to trips.

Table 11. Total Participation in Recreational Activities by South Carolinians Age 12 and Older

Activity	Number of Trips
Bird wildlife	46,093,331
Watching wildlife	46,093,331
Beach swimming/ sunbathing	24,547,789
Motor boating	19,850,155
Freshwater fishing	16,247,458

With respect to coastal activities in general, non-historic tourism produces approximately $3.5 billion in revenue and supports 81,000 jobs. Table 12 shows both total economic output and value added impacts to the state.

Table 12. Economic Impacts of Coastal Tourism in South Carolina (USC 2009)

2008	Direct	Indirect **	Induced**	Total
Value Added*	$2,175,917,712	$525,611,037	$800,411,667	$3,501,940,417
Labor Income	$1,357,208,542	$295,208,228	$411,000,802	$2,063,417,573
Employment	60,399	8,119	12,466	80,984
Output	$4,684,866,174	$1,002,277,617	$1,358,850,668	$7,045,994,459

Crab Bank Island itself is also designated by the Audubon Society as a Globally Important Bird Area. To meet the Audubon's designation as a Globally Important Bird Area, certain standardized criteria must be met. Crab Bank meets the following criteria:

- **Sites for endangered or threatened species, or species of concern in South Carolina** – Crab Bank Island is a documented nesting habitat for several species of concern including the brown pelican, black skimmer, and royal tern.
- **Sites where birds regularly concentrate in significant numbers when breeding, in winter, or during migration –** It has been documented that Crab Bank Island contains significant numbers of both nesting birds and birds that use it for foraging and loafing.
- **Sites important for long-term avian research or monitoring –** Crab Bank Island is considered an important bird research area and SCDNR conducts annual nesting surveys for Crab Bank Island to monitor populations and island usage.

In 2014, the Crab Bank Island "Pelicam" was installed on the island. The Pelicam consists of two solar powered cameras that transmits live video of the island. This effort publically funded. Sponsors include the South Carolina Coastal Conservation League, the Charleston Harbor Pilots, Coastal Expeditions, and others.

Crab Bank Island has also been publicly highlighted as a significant and threatened resource, as evidenced in the following Post and Courier news articles:

- "Crab Bank live: shorebirds get webcam" (Unattributed), May 7, 2014,
- "Save Crab Bank before its too late" by Nathan Dias, October 22, 2016,
- "Coastal storms wash away South Carolina shorebird eggs around Charleston Harbor" by Bo Peterson, May 25, 2017, and
- "May's storms wiped out almost all the pelican nests on Charleston's Crab Bank" by Bo Peterson, June 5, 2017.

Copies of all of the referenced articles are found in Appendix E.

2.2.3 Technical Significance

Significance based on technical recognition means that the resource qualifies as significant based on its technical merits, which are based on scientific knowledge or judgment of critical resource characteristics. Technical significance should be described in terms of one or more of the following criteria: scarcity, representativeness, status, and trends, connectivity, and limiting habitat.

Scarcity – Overall consensus from the USFWS, SCDNR, and the Audubon Society is that shorebird populations have been in decline over the last three decades. Red knot and brown pelican populations have declined in South Carolina by 50% since 1990. Loss of habitat, due to coastal development, is the primary reason for this decline (Manomet, 2012). Crab Bank Island is only one of 6 designated sanctuaries in South Carolina and is recognized as an important component in maintaining shorebird populations. Based on this and previously expressed facts, this is a feature of technical significance.

Representativeness – The SCDNR counts of nesting pairs in Table 1 show that Crab Bank Island is used by a variety of birds for nesting. Brown pelicans have been nesting on the island since 1979. Crab Bank Island is considered ideal nesting and foraging habitat, and SCDNR attributes the island, along with the other seabird sanctuaries, critical for the long term fate of shorebirds. (SCDNR, 2015)

Status and Trends – Shorebird nesting areas have significantly decreased as coastal populations increase. As such, isolated, protected lands such as Crab Bank Island are becoming more important for species propagation and survival. Crab Bank Island and similar features will only increase in importance as pressures from both population growth and sea level rise increased in the future.

Not only has shorebird nesting habitat decreased, but the island itself has been disappearing over time. This report has documented the reduction of the island from approximately 23 acres in 2000 to an approximate current size of 0.68 acres. Long term projects indicate that almost all of the island will disappear within the next 50 years.

Connectivity – Crab Bank Island is part of the Audubon's Atlantic Coast flyway. Migratory shorebirds transit through South Carolina during both spring and fall migrations. Many birds overwinter in Charleston Harbor. In addition to nesting habitat, Crab Bank Island provides migratory species an undisturbed location for foraging, resting, and loafing.

Limiting Habitat – There are few areas such as Crab Bank Island that are suitable for shorebird nesting and other avian life cycle habitat. Sites on mainlands are under threat from development, predators, and unanticipated threats such as physical disturbance from people and/or domestic animals. Physically isolated and legally protected features such as Crab Bank Island are few in number, making them essential for the continued propagation of shorebirds.

Biodiversity – Crab Bank Island supports colonies of nesting shorebirds because of its isolated nature and lack of mammalian predators. While not all species are continually present, species that have used Crab Bank Island include the brown pelican, least tern, royal tern, black skimmer, gull-billed tern, sandwich tern, common tern, laughing gull, Wilson's plover, American oystercatcher, willet, great egret, snowy egret, tricolored heron and ibis. In addition to providing nesting habitat, the sanctuary provides winter loafing and feeding areas for numerous species.

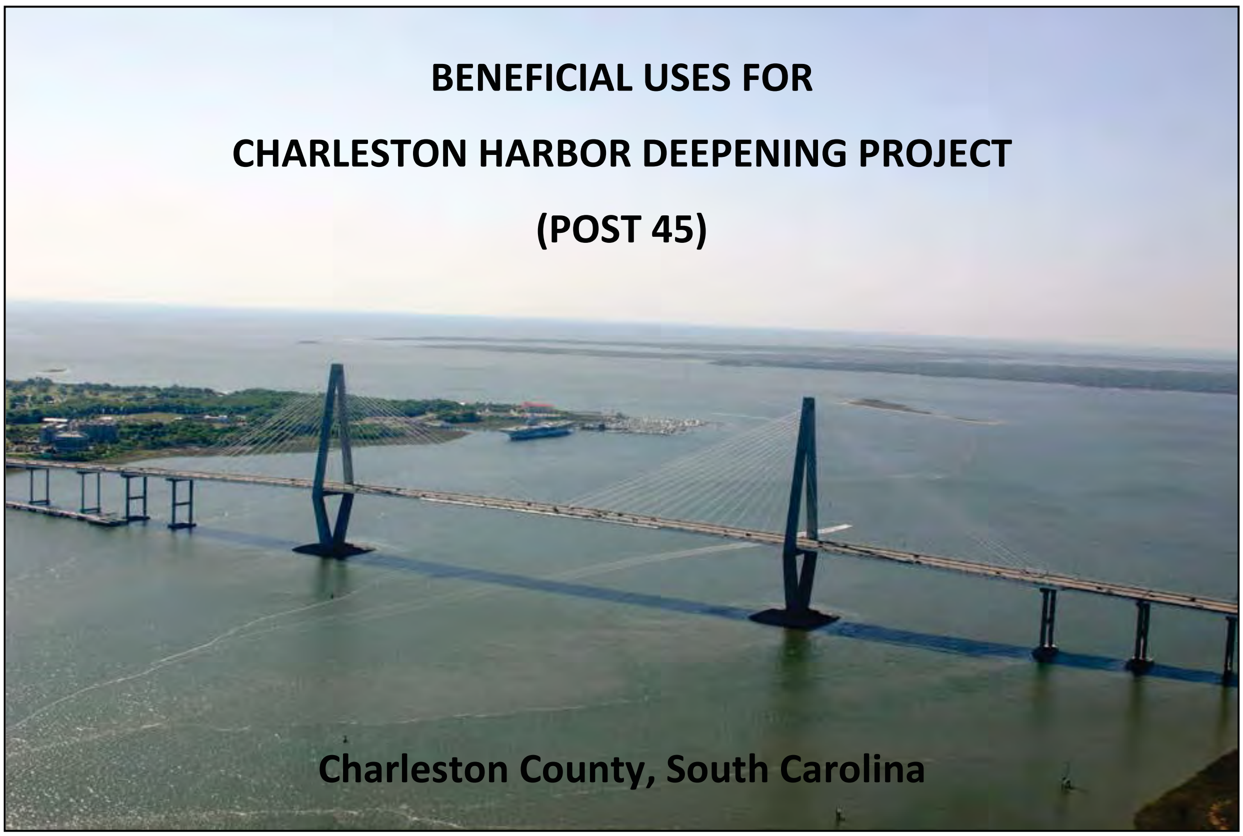
In addition to avian species, the intertidal and subtidal areas contain polycheates, oligochetes, amphipods and isopods. Crabs, snails, and mussels live in the spartina patches and the oyster reefs on the southern end of the island are entire separate ecosystems that host much more than shellfish.

Appendix C
2017 Environmental Assessment

Charleston Harbor Cap 204 Detailed Project Report

US Army Corps Of Engineers®
Charleston District

FINAL SUPPLEMENTAL ENVIRONMENTAL ASSESSMENT



January 2017

Prepared by

U.S. Army Corps of Engineers, Charleston District

Contents

Appendices

List of Tables

List of Figures

1.0 Project Background

The Federal Government has placed considerable emphasis on using dredged material in a beneficial manner. Statutes such as the Water Resources Development Acts of 1992, 1996, 2000, and 2007 demonstrate that beneficial use has been a Congressional priority. The United States Army Corps of Engineers (USACE) has emphasized the use of dredged material for beneficial use through such regulations as 33 CFR Part 335, ER 1105-2-100, and ER 1130-2-520 and by Policy Guidance Letter No. 56. ER 1105-2-100 on page E-69 requires that "all dredged material management studies include an assessment of potential beneficial uses for environmental purposes including fish and wildlife habitat creation, ecosystem restoration and enhancement and/or hurricane and storm damage reduction."

Opportunities exist for beneficial use of dredged material associated with the dredging of new work material during the construction of the Charleston Harbor Post 45 Navigation Project. In accordance with ER 1105-2-100, the USACE is considering beneficial use of dredged material as a part of the project. USACE regulations (ER 1105-2-100) state that, "where environmentally beneficial use of dredged material is the least cost, environmentally acceptable method of disposal, it is cost shared as a navigation cost." The incremental costs of a beneficial use that is above the least cost disposal option would need to be funded by a non-Federal sponsor or cost-shared according to the applicable authority. The beneficial use concepts and alternatives discussed below may or may not be constructed, particularly if the costs are greater than the least cost disposal option and a non-Federal sponsor is not identified to pay for the incremental increase in cost.

The USACE has two continuing authorities that address beneficial uses of dredged material. Section 204 of the Water Resources Development Act (WRDA) of 1992 established programmatic authority which allows the USACE to carry out ecosystem restoration projects in connection with dredging for construction, operation, or maintenance of authorized navigation projects. Section 207 of WRDA 1996 allows the USACE to select a disposal method that is not the least cost if it is determined that the incremental costs are reasonable in relation to the environmental benefits (Section 207 amended Section 204 of WRDA 1992 – both are codified at 33 USC 2326). Under each of these authorities, the incremental cost above the least cost disposal base plan will be shared with a non-Federal sponsor. The USACE, Charleston District, intends to maximize the beneficial use of dredged material where: 1) suitable, environmentally-acceptable options exist, 2) it is the least cost disposal option, and/or 3) a cost-sharing sponsor can be identified.

This Environmental Assessment (EA) is a supplement to the Final Integrated Feasibility Report and Environmental Impact Statement for the Charleston Harbor Post 45 Study ("IFR/EIS," USACE, 2015). In the Final IFR/EIS, Dredging and Dredged Material Management was addressed in Section 4.2, and Beneficial Use of Dredged Material in Section 4.2.6. The IFR/EIS stated that "[d]uring the PED phase, options for beneficial uses that are cost-effective and meet regulatory and environmental protection requirements would be pursued," (Section 4.2.6), and that "[f]inal designs, decisions to implement, and environmental considerations/clearances would take place during the PED phase" (Section 4.2.6.8). A Record of Decision was signed on 12 January 2016.

2.0 Proposed Post 45 Project

In July 2015, the USACE Charleston District released the IFR/EIS for the Charleston Harbor Post 45 Study. The Recommended Plan (RP) is a Locally Preferred Plan (LPP) that proposed the following navigation improvements:

- Deepen the existing entrance channel from a project depth of -47 feet to -54 feet mean lower low water (MLLW) over the existing 800-foot bottom width, while reducing the existing stepped 1,000- foot width to 944 feet from an existing depth of -42 feet to a depth of -49 feet.
- Extend the entrance channel approximately three miles seaward from the existing location to a depth contour including a -54-foot MLLW project depth plus overdepths.
- Deepen the inner harbor from an existing project depth of -45 feet to -52 feet MLLW to the Wando Welch container facility on the Wando River and the Hugh Leatherman Terminal on the Cooper River, and -48 feet MLLW for the reaches above that facility to the North Charleston container facility (over expanded bottom widths from 400 to 1,800 feet).
- Enlarge the existing turning basins to an 1800-foot diameter at the Wando Welch and new South Carolina State Ports Authority (SCSPA) terminals to accommodate Post Panamax Generation 2 and 3 container ships and widen selected reaches (Figure 1).
- Enlarge the North Charleston Terminal turning basin to a 1650-foot diameter for Post Panamax Generation 2 container ships.
- Place dredged material and raise dikes at the existing upland confined disposal facilities at Clouter Creek, Yellow House Creek, and/or Daniel Island; and for material dredged from the lower harbor, place at the Ocean Dredged Material Disposal Site (ODMDS) and expand. Place rock to create hardbottom habitat near the entrance channel as a least cost, beneficial use of dredged material.

A plan view of the inner channel project footprint can be seen in Figure 1.

Figure 1 Proposed deepening and widening in the upper and lower harbor

The pre-construction, engineering, and design (PED) phase started in December 2015 upon signing of a Design Agreement between the USACE and the SC Ports Authority. Consistent with the Final IFR/EIS, this Supplemental EA provides the PED phase evaluation of beneficial uses of dredged material for the new work material dredged from the channel. The "Alternatives Evaluated in Detail" in Section 6.2, below, were all identified in the IFR/EIS as options that would receive additional analysis or development during the PED phase. This EA also includes the process and results of fine-tuning the construction methodologies and locations of artificial reefs (previously evaluated during the Feasibility Phase in the Final IFR/EIS) near the entrance channel, and of identifying any existing SCDNR approved reefs that could be supplemented with rock material from the channel. Potential environmental impacts of the proposed rock placement for beneficial use were previously evaluated in detail in the Post 45 Final IFR/EIS (which is incorporated by reference). Section 7.0 of this EA sets forth the Proposed Action which, to the extent it is adopted, would be pursued as part of the RP.

The Final IFR/EIS also committed to perform ship simulation and evaluate the minimization of channel widening measures during the PED phase. A report documenting the results of the ship simulation analysis and recommended widening reductions will be released separately. This EA does not address ship simulation or widening reductions (no additional environmental review is anticipated because the maximum widening footprint is already evaluated in the Final IFR/EIS and Record of Decision).

3.0 Purpose and Need for the Proposed Action

The purpose of the proposed action is to: (1) reasonably maximize the environmental opportunities to provide beneficial uses of new work dredged material from the Post 45 deepening project, (2) determine the technical, economic, and environmental feasibility of protecting and restoring valuable natural and cultural resources in the Charleston Harbor area, and (3) to identify which alternatives would require a sponsor to share the cost of project implementation. Although adequate disposal site capacity exists for construction of the Post 45 project, the USACE is committed to evaluating beneficial uses to support the USACE Regional Sediment Management (RSM) practices and the USACE Engineering with Nature (EWN) principles. Beneficial use projects also aid in maintaining capacity in existing disposal areas and thereby reducing future maintenance costs associated with disposal area operations and maintenance.

Certain areas within the harbor are subject to wave and wake activity, as well as strong currents from tidal action. These areas include but are not limited to Crab Bank, Shutes Folly, and Ft. Sumter. Crab Bank has been designated as an "Important Bird Area" in South Carolina and is established as "Crab Bank Seabird Sanctuary." Another resource of concern in the harbor is Shutes Folly. Shutes Folly provides nesting habitat for colonial seabirds due to its isolated nature, small size, and lack of predators. It is one of only nine active nesting sites in the entire state. Castle Pinckney, an important historic site, sits on the southern tip of Shutes Folly. Fort Sumter National Monument, established in 1948 and listed on the National Register of Historic Places in 1966, sits at the mouth of the harbor on the southern side of the navigation channel. Beneficial use options were explored to augment these resources and delay the inevitable shoreline changes and erosion that have been occurring over the years.

In support of the proposed action, this Supplemental EA elaborates on the suite of potential beneficial use actions originally identified in the Final IFR/EIS that may be eligible to be implemented. In order to be eligible for implementation, an option must be environmentally-acceptable and either (1) able to be included in the least cost disposal method, or (2) a cost share sponsor has been identified to cover all or a portion of the additional costs above the least cost dredging and disposal alternative. The report will discuss: (1) the purpose and need for the proposed action (2) the existing conditions specific to various resources within the harbor, (3) the anticipated environmental impacts of the proposed actions, and (4) the relationship and compliance with applicable laws and regulations.

4.0 Scope and Incorporation by Reference

This Supplemental EA was prepared in accordance with applicable portions of Engineer Regulation (ER) 200-2-2, *Procedures for Implementing the National Environmental Policy Act (NEPA)* and the Council on Environmental Quality (CEQ) *Regulations for Implementing the Procedural Provisions of the National Environmental Policy Act* (40 Code of Federal Regulations (CFR) Pts. 1500-1508). As previously noted, the NEPA document to be supplemented is the Charleston Harbor Post 45 Final FR/EIS, which is incorporated by reference. This Supplemental EA will further describe the beneficial use of dredged material actions proposed for new work construction associated with the Charleston Harbor Post 45 Navigation Project and determine the magnitude of their associated environmental impacts. If the impacts are considered insignificant, and the beneficial use actions and impacts of the Proposed Plan do not represent either a substantial change to the RP relevant to environmental concerns or present significant new circumstances or information relevant to environmental concerns, a Finding of No Significant Impact (FONSI) would be issued. The conditions, project description, and environmental effects described in the Final IFR/EIS are still valid, and this Supplemental EA is designed to operate in accordance with the tiering regulations under 40 CFR 1502.20 and 1508.28. This document also serves to demonstrate compliance with other applicable laws and regulations.

5.0 Existing Conditions

This section will describe the relevant existing environmental conditions within the affected environment prior to outlining the various alternatives that were considered and evaluated for this project. A majority of the existing conditions discussion for the affected resources can be found in the Post 45 Final IFR/EIS and are incorporated by reference (e.g., tides, currents, relative sea-level change, surface water quality, groundwater, wetlands, hardbottom habitat, essential fish habitat, protected species, marine mammals, fisheries, birds, invasive species, air quality, hazardous materials, noise, coastal barrier resources). The below sections will describe in more detail the conditions associated with the various beneficial use options in a more site-specific manner, where possible.

5.1 Crab Bank Description

Oblique view of Crab Bank from NW looking SE
Picture by SCDNR

South Carolina has several areas that are considered seabird sanctuaries/islands. These include, Tomkins Island, Deveaux Bank, Bird Key, Shutes Folly, Crab Bank, and Marsh Island, etc. Crab Bank is located in Charleston Harbor, just south of the mouth of Shem Creek near Mount Pleasant (Figure 1). Reviewing historical nautical charts reveals that the island was originally a large sand bar and was officially noted as an island in the 1965 nautical chart. Crab Bank was created with dredge material in the 1950's and 1960's (based on rough USACE dredging records and historical nautical charts). While the island fluctuates in size constantly, it has largely been migrating towards the north and west over the last 25 years. The island presently has little area that is above mean high water as evidenced visually (see above inset picture) and by recent topography data (Figure 2).

Crab Bank is becoming increasingly more important for sea and shorebirds because of marked declines in nesting birds at other sites over the last few years (Nathan Dias, personal communication, 2/9/2012). Crab Bank has been designated as an "Important Bird Area" in South Carolina and is established as "Crab Bank Seabird Sanctuary". The South Carolina Department of Natural Resources (SCDNR) indicates that, "Crab Bank supports colonies of nesting waterbirds because of its isolated nature and lack of mammalian predators. Although all species may not nest on the island each year, examples of species that have used the island include: brown pelican, least tern, royal tern, black skimmer, gull-billed tern, sandwich tern, common tern, laughing gull, Wilson's plover, American oystercatcher, willet, great egret, snowy egret, tricolored heron and ibis. Besides providing nesting habitat, the sanctuary provides winter loafing and feeding areas for numerous species. (https://www.dnr.sc.gov/mlands/managedland?p_id=215, accessed in 2015). The public significance of Crab Bank was demonstrated during the NEPA scoping period for Post 45 when approximately 20 of the comments received requested that material be used to expand/enhance the island. Additionally, Crab Bank is recognized as one of five active nesting sites in South Carolina and as being "vital to the survival of at least fifteen species of birds" (http://coastalconservationleague.org/pelicam/).

Figure 2 Crab Bank existing topography and bathymetry (MLLW)

5.2 Shutes Folly / Castle Pinckney Description

Oblique view of Shutes Folly from NW looking SE
Picture by SCDNR

Shutes Folly provides nesting habitat for colonial seabirds due to its isolated nature, small size, and lack of predators. It is one of only nine active nesting sites in the entire state. Skimmers and oyster catchers have been observed utilizing the shell hash that faces the eastern side of Shutes Folly. The island has been noted by Charleston Harbor Wildlife as being "often considered for restoration." They state that, "in 1997, wildlife biologists pressed for the island as a sight for dredge spoil to boost the small seabird colony there…" http://charlestonharborwildlife.com/iwa/cp-sf/). The island has little high ground above mean high water (MHW) (see inset picture above) (Figure 3). The majority of Shutes Folly is privately owned.

Castle Pinckney, an historic site, sits atop the southern tip of the island about 1,950 ft from the Navigation Channel (Figure 1). It is one of the oldest fortifications of its kind still in existence and was built to provide defense of the coast. It is one of a series of forts consisting of Fort Sumter, Fort Moultrie, The Battery, Fort Johnson, and others which made up the defenses of Charleston during the War Between the States. In 1794, Congress approved the establishment of a system of port and harbor fortifications from Maine to Georgia. Charleston was one of the ports selected for fortification. Castle Pinckney was constructed of logs and sand on the south shore of Shutes Folly Island in Charleston Harbor. It was rebuilt in brick in 1809. During the latter half of 1861, Castle Pinckney served as a prison for Yankee soldiers captured during the First Battle of Manassas. Over the years since then, the Castle has changed ownership numerous times and is currently owned by the Castle Pinckney Historical Society. The fort is included as one of three ownership parcels that make up the island of Shutes Folly. The other two parcels are owned by a private land owner.

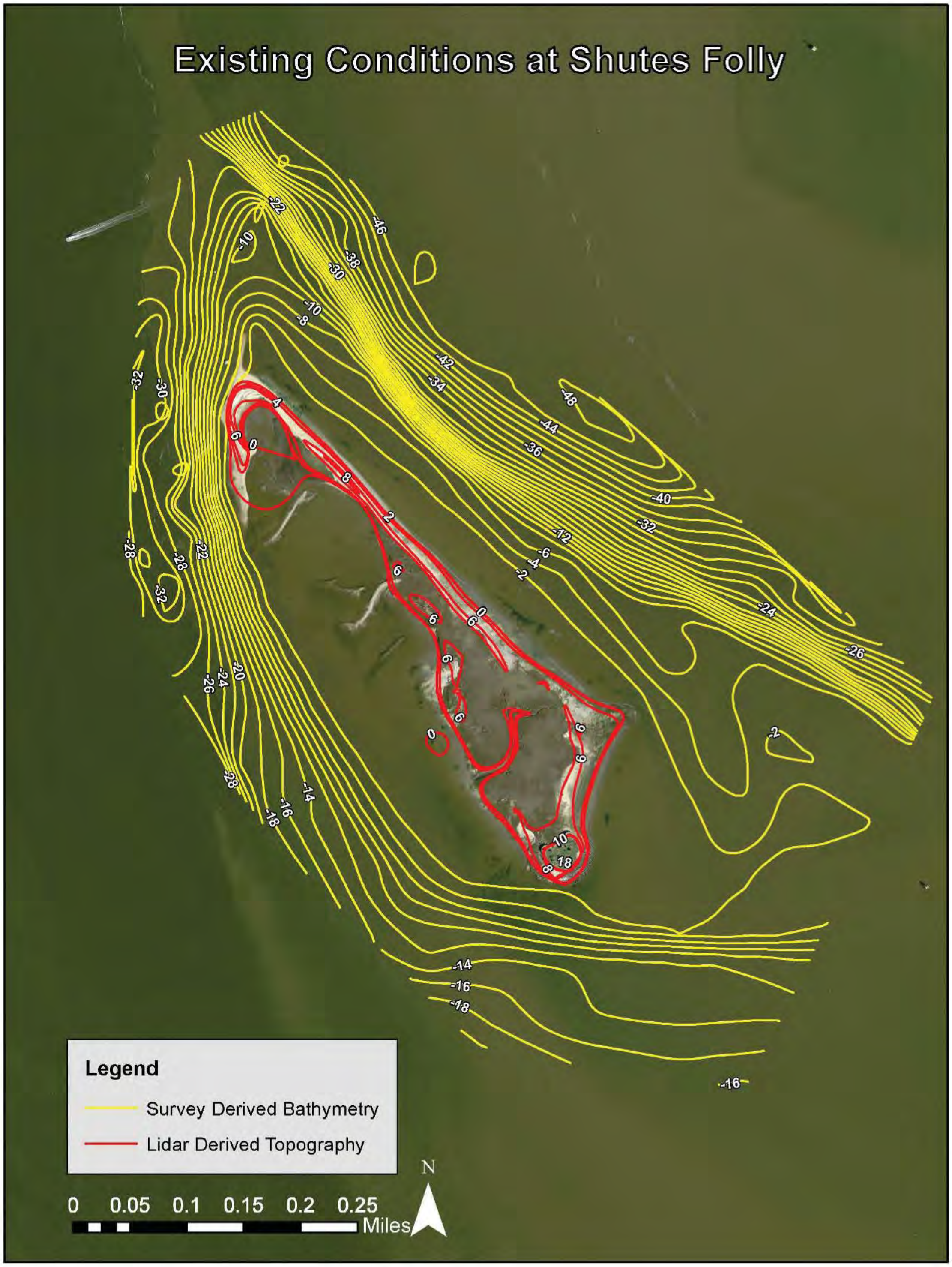


Figure 3. Shutes Folly existing topography and bathymetry (MLLW)

5.3 Ft. Sumter Description

The Fort Sumter National Monument was established in 1948 and listed on the National Register of Historic Places (NRHP) in 1966. The remnants of this masonry fort, associated with the Civil War defense of Charleston, stand on the south side of the mouth of Charleston Harbor, and are located approximately 2,925 ft from the Navigation Channel. The south and east faces of the fort are particularly exposed to wave action. In a letter to the USACE dated 29 September, 2011, the NPS indicated that the gap in the existing stone breakwater allows waves to crash directly against the brick masonry especially at high tide. The USACE analysis presented in Appendix A of the Post 45 IFR/EIS concludes that the island has been accreting along the east and south faces in the recent past (USACE, 2015).

5.4 Morris Island Description

Morris Island is an approximately 840 acre uninhabited island just south of the mouth of Charleston Harbor (Figure 4). On June 16, 2016, USACE staff performed a reconnaissance effort to visually inspect the terminus of the south jetty of Charleston Harbor due to reports that there was flanking (i.e., water going around the landward end) occurring at the terminus of the southern jetty at Morris Island. Flanking around the jetty would create a bypass channel, erode the island, potentially undermine the emerged jetty on the land and adversely affect the function of the jetties. With sea level rise, the risk of flanking becomes even greater as more opportunities exist for high tides to flank the jetty.

View of the slumping occurring at the south jetty on Morris Island

Along with the noted flanking, there was escarpment of the dune along the toe in some places and the inland tip (near harbor – known as Cumming’s Point) had dying cypress trees. It appeared that at high tide there was not much dry beach habitat and that astronomical tides and/or storms had been causing many of the cedar trees to die back. As the jetty emerged onto the land there was obvious subsidence and movement of the stone (see picture). The subsidence was evidenced by the high and low spots along the emerged jetty, with large gaps along the top. The harbor side beach was a few inches higher than the ocean side of the beach and in spots maybe up to a foot. Ebb tide sediment collected across the island is a possible reason for this. It is speculated that due to the size and weight of the stone, displacement of stone likely occurred during extreme storm events such as Hurricane Hugo.

Figure 4. Morris Island existing topography and bathymetry (MLLW)

5.5 Physical Characteristics (Wind, Waves, Tides, Currents)

Wind and wave conditions are important considerations for this project due to their potential erosive forces that can impact harbor shorelines. The wind and wave conditions within Charleston Harbor are thoroughly documented within the Post 45 IFR/EIS (sections 2.4.1, 2.4.2, and 2.4.3, and Appendix A – Engineering, USACE 2015). Winds are predominantly out of the southwest, but the strongest (fastest 10%) are mainly from the north-northeast. The tidal range throughout the harbor is relatively uniform with the astronomically-generated high and low tides ranging from about 5 to 6 feet above MLLW throughout a given year. On a high spring tide, the majority of Crab Bank and Shutes Folly are submerged and have minimal areas seldom covered by water (supratidal land). Currents within the study area are generally about 1 knot while ebb currents near Fort Sumter may reach up to 4 knots. Strong currents have been observed adjacent to the eastern side of Shutes Folly.

During the Feasibility Phase, USACE performed an analysis of shoreline changes that have occurred over the last approximately 20 years (IFR/EIS, USACE, 2015, Appendix A). Table 1 documents the results of the analysis over the study period. Throughout the study period Crab Bank condensed in size and migrated towards the northeast or towards the Mt Pleasant side of Charleston Harbor (Figure 5). The island has lost approximately 13 acres of dry land since 1994. Shutes Folly has been slowly eroding on all sides and has lost approximately 10 acres of land since 1994. The small tidal sand island on the northern point appears to be migrating towards the main northern shoreline of the island. The rip-rap armoring on the face of Castle Pinckney appears to be stable and preventing any further erosion (Figure 6). . The channel and ocean-facing sides of Fort Sumter are armored with rip-rap and throughout the study interval appears to remain stable. The tidal marsh/sand flat area to the leeward side of the island appears to be slowly accreting material in a very dynamic way (Figure 7), and has actually accreted about 1 acre of dry land since 1994.

Table 1. Historic shoreline change on resources within Charleston Harbor (1994-2011)

AREA YEAR	Crab Bank (SQ FT)	Crab Bank (AC)	Castle Pinckney (SQ FT)	Castle Pinckney (AC)	Fort Sumter (SQ FT)	Fort Sumter (AC)	Drum Island (SQ FT)	Drum Island (AC)	Main Harbor (water area) (SQ FT)	Main Harbor (water area) (AC)
1994	781266	17.94	1301690	29.88	203388	4.67	12266700	281.60	670011010	15,381.34
1999	565391	12.98	1062780	24.40	212680	4.88	12060800	276.88	681643010	15,648.37
2006	358917	8.24	1017670	23.36	220457	5.06	11934300	273.97	672035970	15,427.82
2011	218185	5.01	850508	19.52	241195	5.54	11717700	269.00	708561980	16,266.34
	LOSS/GAIN									
1994-1999	-215,875	-4.96	-238,910	-5.48	9,292	0.21	-205,900	-4.73	-11,632,000	-267.03
1999-2006	-206,474	-4.74	-45,110	-1.04	7,777	0.18	-126,500	-2.90	9,607,040	220.55
2006-2011	-140,732	-3.23	-167,162	-3.84	20,738	0.48	-216,600	-4.97	-36,526,010	-838.52
1994-2011	-563,081	-12.93	-451,182	-10.36	37,807	0.87	-549,000	-12.60	-38,550,970	-885.01

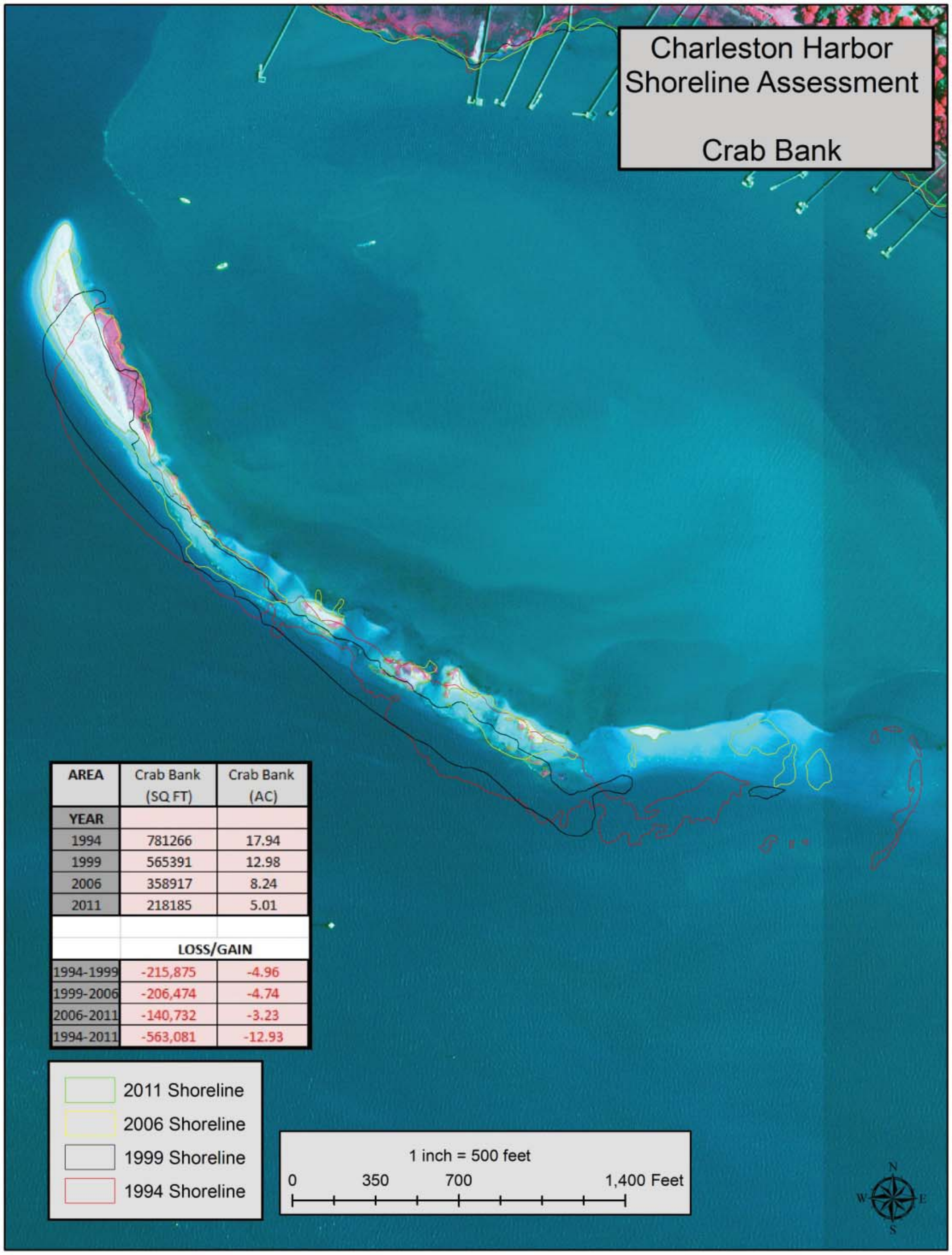


Figure 5. Crab Bank shoreline changes (1994-2011)

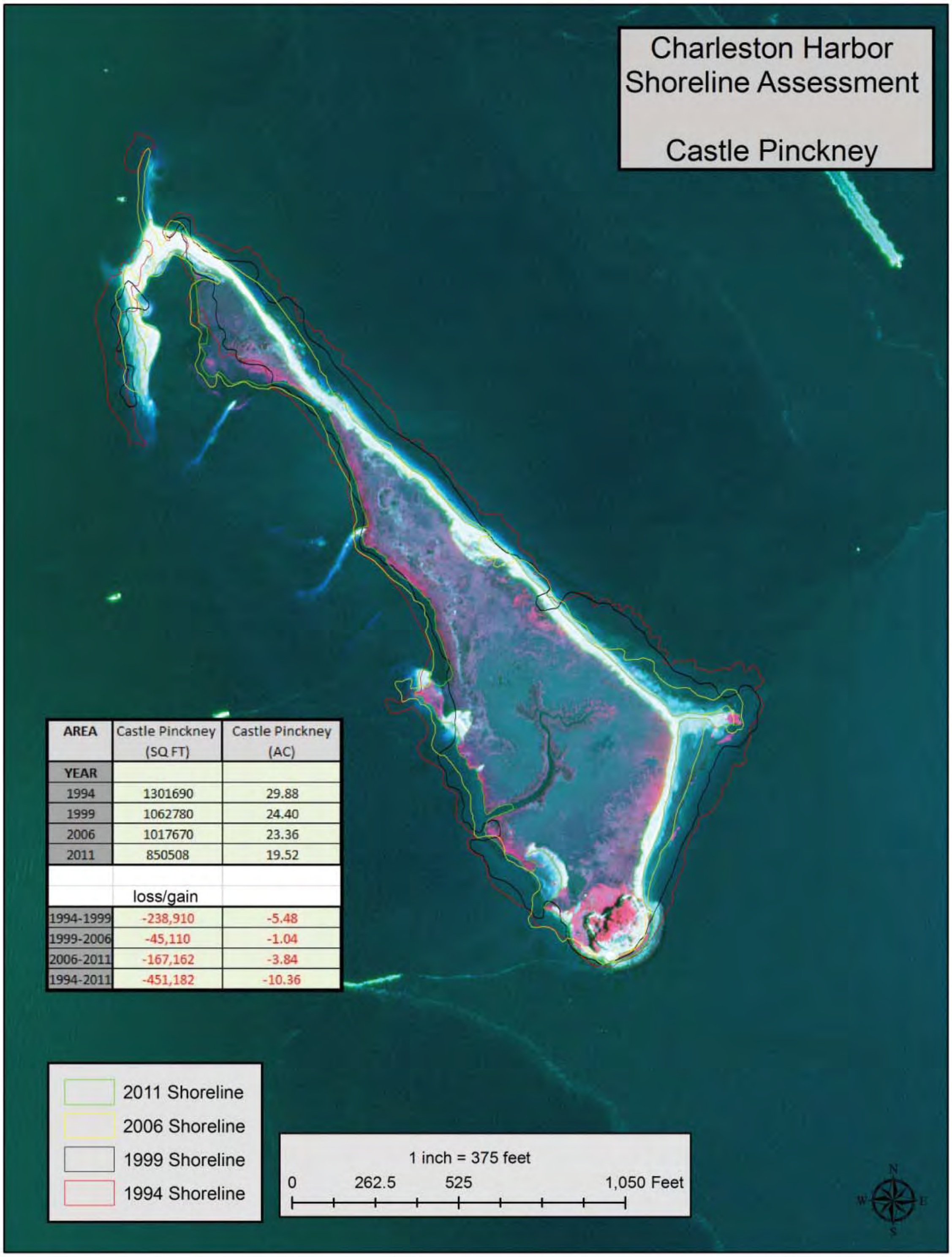
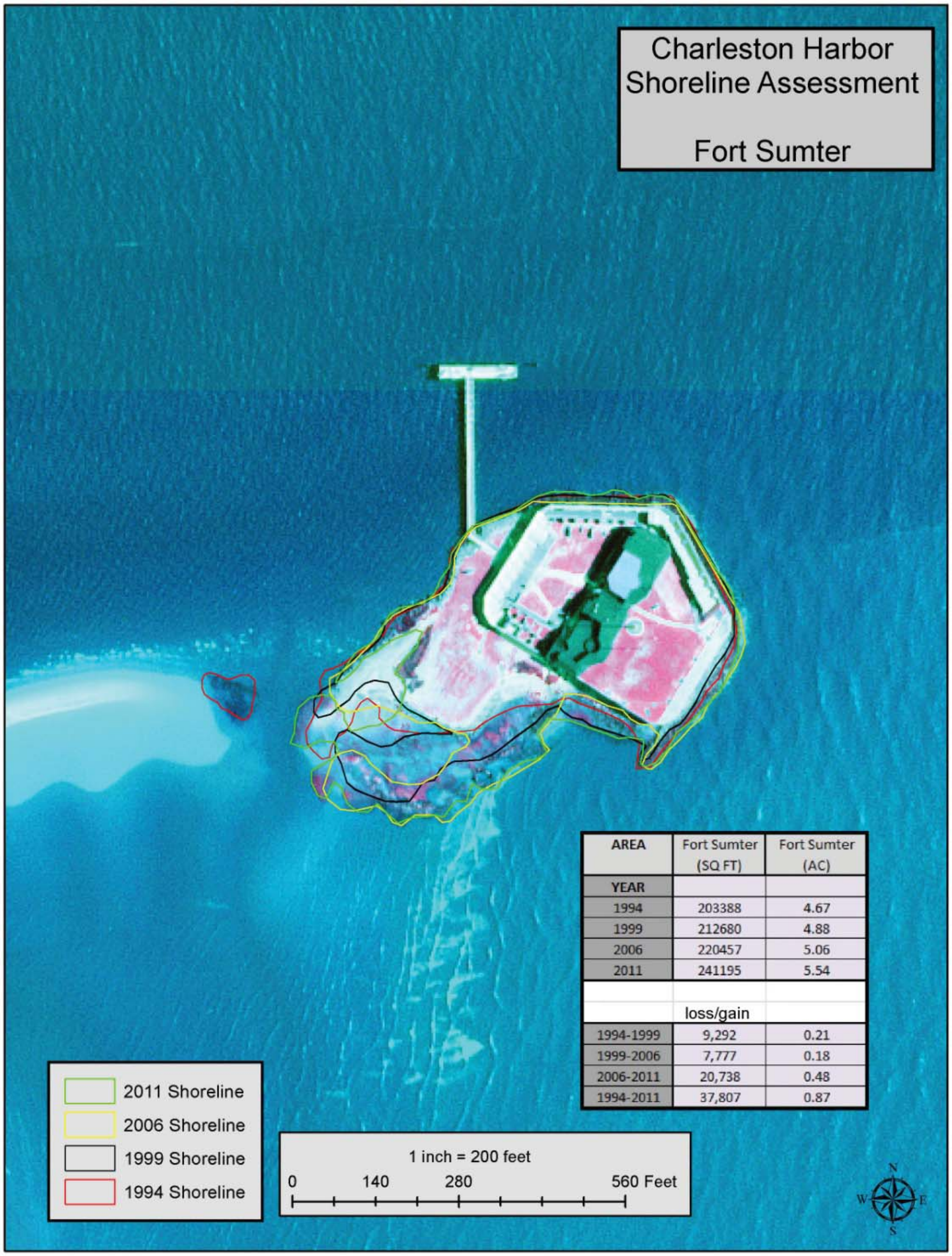


Figure 6. Shutes Folly shoreline changes (1994-2011)



AREA	Fort Sumter (SQ FT)	Fort Sumter (AC)
YEAR		
1994	203388	4.67
1999	212680	4.88
2006	220457	5.06
2011	241195	5.54
	loss/gain	
1994-1999	9,292	0.21
1999-2006	7,777	0.18
2006-2011	20,738	0.48
1994-2011	37,807	0.87

Figure 7. Ft. Sumter shoreline changes (1994-2011)

5.6 Water Quality

Water quality In Charleston Harbor is classified as SB by the South Carolina Department of Health and Environmental Control (SCDHEC 2002). The SB rating applies to tidal salt water suitable for survival and propagation of aquatic life; primary and secondary contact recreation; crabbing and fishing for market purposes and/or human consumption.

Salinity concentration in the river affects the estuarine habitat in many ways. Along with tidal inundation, salinity generally determines the marsh vegetation species; it directly affects the fish, crustacean and clam populations; and it influences the dissolved oxygen (DO) concentrations. Salinity in the river is also of concern from a water usage perspective. Bushy Park is a freshwater reservoir located in the upper reaches of the Cooper River and used by local industry for water supply. Salinity intrusion to the estuary can cause periodic increases in chloride concentration above acceptable limits at the reservoir. These events typically occur during periods of drought, very high tides, sustained wind conditions or storm events. To counter salinity intrusion events, there are several monitoring stations in the harbor and the freshwater discharge from Lake Moultrie can be managed by increasing flow during these events to lower salinity concentrations in the Cooper River (USACE 2006). Based upon hydrodynamic modeling of the Charleston Harbor system associated with the Post 45 project, 10th percentile (lowest) DO between March and October in the lower harbor is around 5 mg/L with a mean around 6 mg/L (USACE, 2015 – Appendix H). As part of the Magnuson-Stevens Act consultation, the National Marine Fisheries Service (NMFS) requested more water quality data to gain a better understanding of the DO conditions throughout the harbor during the critical months of July, August, and September (when DO is typically the lowest). These data are presented in tables within Appendix H of the Post 45 Essential Fish Habitat (EFH) Assessment and are incorporated by reference. In the bottom layer of the hydrodynamic model, DO conditions in the lower harbor ranged from 4.8 to 5.1 mg/L (cells H1-H5). Due to these values for modeled DO as well as the temporary timeframe of construction, it is not anticipated that DO will be a concern during the construction of these beneficial use projects.

5.7 Sediments

Nearly all of the surficial soils in the Charleston area are Quaternary in age, and they unconformably overlie the Tertiary strata. The soils generally consist of interbedded sequences of clay, clayey to clean quartz sand, and fossiliferous sand which may be overlain by Holocene peat, silt, clean sand, or tidal marsh deposits (Weems and Lemon, 1993). A detailed description of sediment quality can be found within the IFR/EIS (USACE, 2015), Section 2.4.5. The following sections briefly describe the specific sediment composition within the reaches of the navigation channel proposed for beneficial use options and the areas where sediment will be placed beneficially.

In-Channel and Harbor Sediments

Throughout the harbor, grain size varies from silt to sandy material and can be represented by the percent sand in a sample. The South Carolina Department of Natural Resources (SCDNR) has tested surficial sediment composition and chemistry within Charleston Harbor for the last few decades through the South Carolina Estuarine and Coastal Assessment Program (SCECAP). Figure 8 depicts the average percent sand within Charleston Harbor sediments as interpolated from SCDNR SCECAP data and sediment testing data collected for this project. As shown in this figure, the percent sand found throughout the majority of the harbor is commonly below 90%, and is important to note because 90% sand is a commonly used threshold for determining beach compatible material.

The work by SCDNR covered all areas of the harbor, not just the Federal Navigation Channel. In order to determine the nature of the sediments within the navigation channel, and to build on the sediment sampling/testing work that was performed during the Feasibility Study, 49 additional vibracores were conducted in the lower harbor and entrance channel (see Anamar 2015 [Appendix F] and American Vibracore Services 2016 [Appendix G]). Each vibracore was divided vertically into multiple samples for physical analysis testing. While few of the individual vibracores contained 90% or greater sand over the entire length of the core, many of the cores contained high quantities of sand over the majority of the length of the core in some areas of the lower harbor and entrance channel. The testing revealed substantial quantities of sandy material in the Bennis Reach and Rebellion Reach areas of the lower harbor (see Figure 9). In an ICT meeting on 30 September 2015, USACE discussed that there is a very limited quantity of material in the channel that is 90% sand or greater. The ICT indicated that a threshold of 65% sand would be adequate for various beneficial use projects within Charleston Harbor. Using 65% sand or greater as a threshold for suitable beneficial use material, approximately 1,200,000 yd^3 of material was identified that could be used beneficially. Using the same 65% sand threshold, the testing also revealed approximately 500,000 yd^3 of material in the entrance channel that could be used beneficially (see Figure 10).

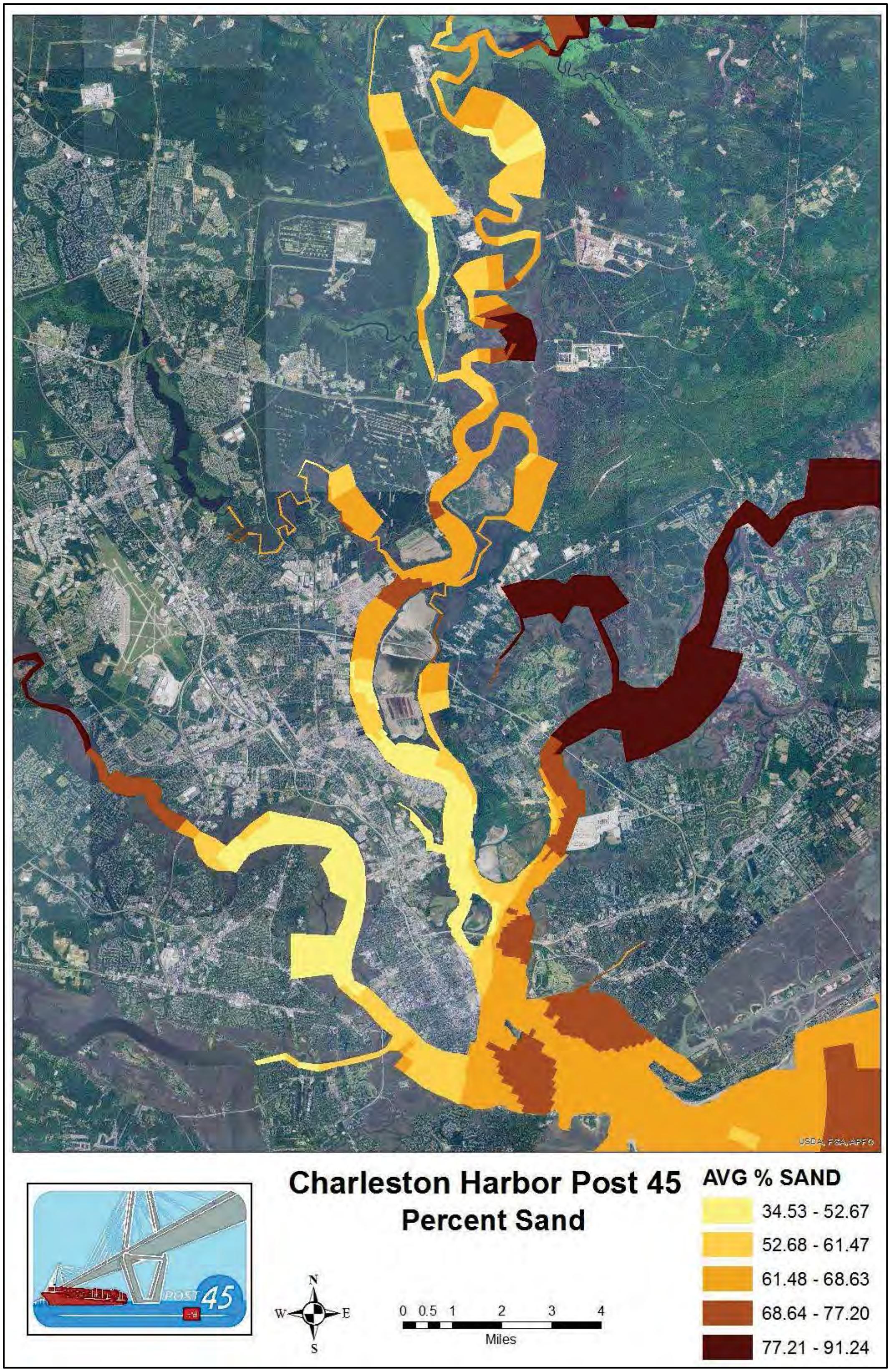


Figure 8. Charleston Harbor sediment composition

Figure 9. Location of sandy material in Bennis Reach and Rebellion Reach

Figure 10. Location of sandy material in Entrance Channel

Crab Bank, Shutes Folly, and Fort Sumter In-situ Sediments –

In support of USACE efforts to understand the sediment composition and benthic composition of Crab Bank and Shutes Folly, SCDNR performed a transect analysis across the islands to characterize the existing conditions (Tweel and Sanger 2015a, Appendix A). Five transects were established across each island and samples were taken between the sub-tidal environment across the high point of the island and to the subtidal environment on the other side of the island (Figure 11).

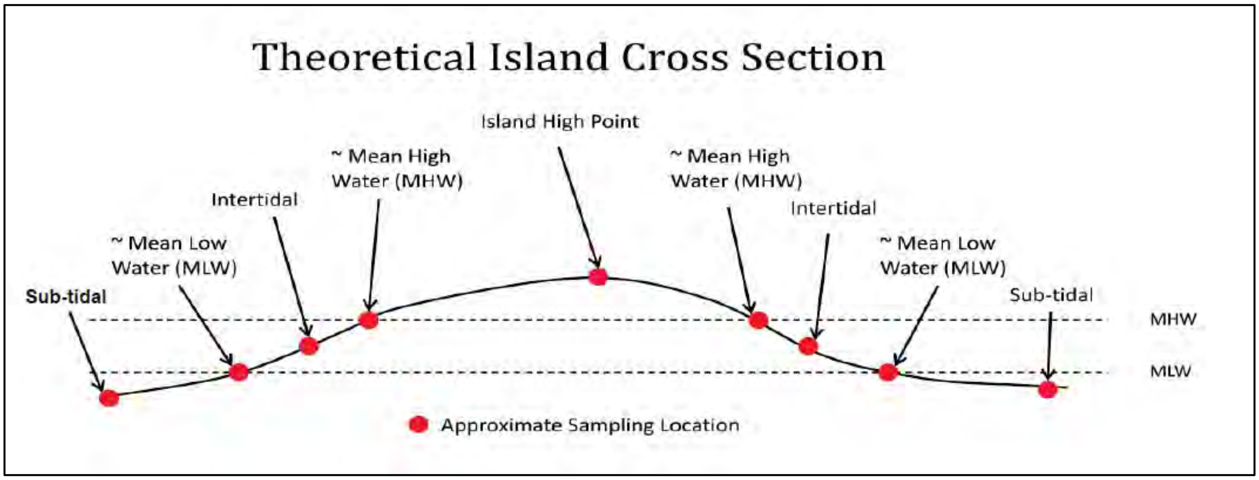


Figure 11. Sampling locations across Crab Bank and Shutes Folly transects

Sediments and habitat types vary considerably along Crab Bank and Shutes Folly (Figures 12 and 13, respectively). The dominant grain size on both islands is fine sand (61% of samples). An additional 22% of Crab Bank samples were characterized by medium sand, while the same percent of Shutes Folly samples tends toward very fine sand. Transects C and D along Crab Bank was dominated by more silts and clays, and are likely remnants from marsh that occupied this area in the recent past. The largest area of remaining marsh is along Transect A at the northeastern shoreline. The southern transect has some of the lowest elevations and sediments were characterized by sand and a larger proportion of $CaCO_3$ than elsewhere on the island. The mean phi size for Crab Bank was 2.3 (fine sand). Mean phi size for Shutes Folly was 2.7.

USACE evaluated sediments along the west and south side of Ft. Sumter in a similar manner (Figure 14). Samples were taken to an environmental lab for analysis. Results of this analysis indicate that the material accreting on the south and west faces of Morris Island is greater than 90% sand.

Figure 12. Habitat types along Crab Bank

Figure 13. Habitat types along Shutes Folly

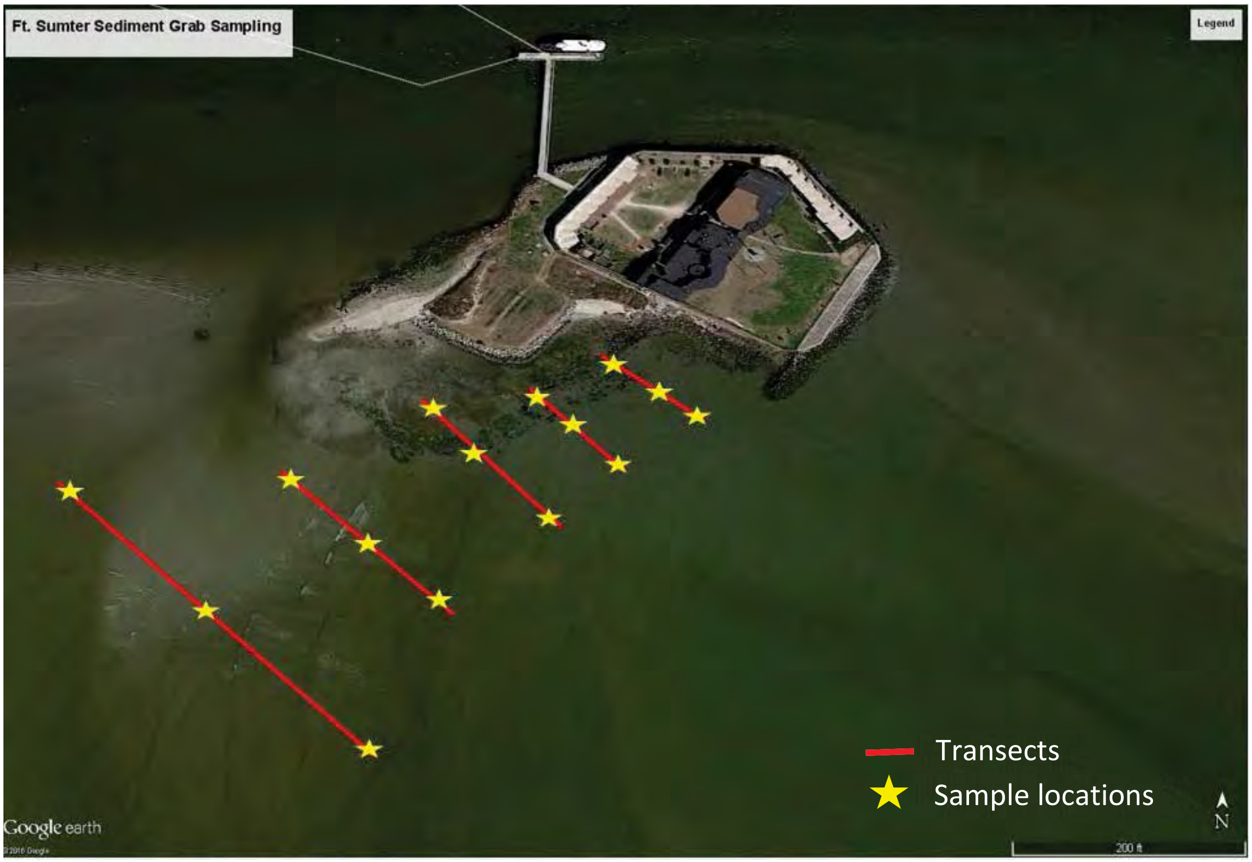


Figure 144. Sampling location for sediment composition analysis

5.8 Wetlands

Wetlands play a vital role in the ecosystem due to their many functions including nutrient retention, wildlife habitat, flood attenuation, nursery habitat, etc. Wetlands within the project area are predominantly polyhaline emergent marshes. These marshes experience average salinities between 18 and 35 parts per thousand. A review of the most recent data available using Environmental Systems Research Institute (ESRI) data reveals that Crab Bank has approximately 1.9 acres of saltmarsh vegetation (Source: ESRI, Digital Globe, GeoEye, Earthstar Geographics, World Imagery Basemap). The amount of saltmarsh has been decreasing over the years as the size of the island has decreased. While wetlands on Shutes Folly are more stable and established than those at Crab Bank, there is still a concern with the loss of saltmarsh as sea level rises and erosion of the emergent island occurs. The vegetation is spotty across the approximately 1 mile length of Crab Bank. The largest area of marsh is located on the northern portion of the island and is approximately 0.8 acres in size. Emergent saltmarsh also occurs on the west side of Shutes Folly.

Surrounding most of the harbor is a fringing area of saltmarsh and mudflats. Saltmarsh vegetation consists of cordgrass species (*Spartina sp.*) and black needlerush (*Juncus roemerianus*). Higher elevation emergent marsh areas contain sea oxeye (*Borrichia frutescens*), salt grass (*Distichlis spicata*), and salt meadow hay (*Spartina patens*). Wetlands around the Charleston Harbor provide high quality habitat used by many species of fish and crustaceans for feeding, breeding, and nursery areas. The tidal marshes also contribute important organic materials to the waters. Protecting and preserving wetlands is important to the USACE.

5.9 Benthic organisms

Dominant species in the harbor channels include mollusks, polychaetes, oligochaetes, nematodes, and amphipods (USACE 2006). Populations in the navigation channel are assumed to be not as stable and numerically abundant as nearby wetlands and mudflats due to the frequent disturbance by ongoing maintenance.

In support of USACE efforts to understand the sediment composition and benthic composition of Crab Bank and Shutes Folly, SCDNR performed a transect analysis across the islands to characterize the existing conditions (Tweel and Sanger 2015b). Five transects were established across each island and samples were taken between the sub-tidal environment across the high point of the island and to the subtidal environment on the other side of the island (Figure 11). The following sections describe the results for each island.

Crab Bank – The habitat of Crab Bank was generally sandy intertidal and subtidal areas and contained relatively similar macroinvertebrate communities for the most abundant species. A few of the transects contained marsh sites at the northern end of Crab Bank and the middle transect. The macroinvertebrate community consisted of mostly of polychaetes (Figure 15), particularly *Leitoscolopolos fragilis* and *Streblospio benedicti*. The marsh habitats at the eastern portion of the northern transect contained the greatest overall abundance, mostly of polychaetes and oligochaetes. The middle transect (transect C) contained the highest crustacean density on the island, and was largely driven by amphipods and isopods. The west side of the middle transect contained high silt/clay content and the bivalve *Petricolaria pholadiformis*. Lower elevation sites tended to contain fine sand or greater, and the higher sites contained a greater proportion of calcium carbonate than the lower sites.

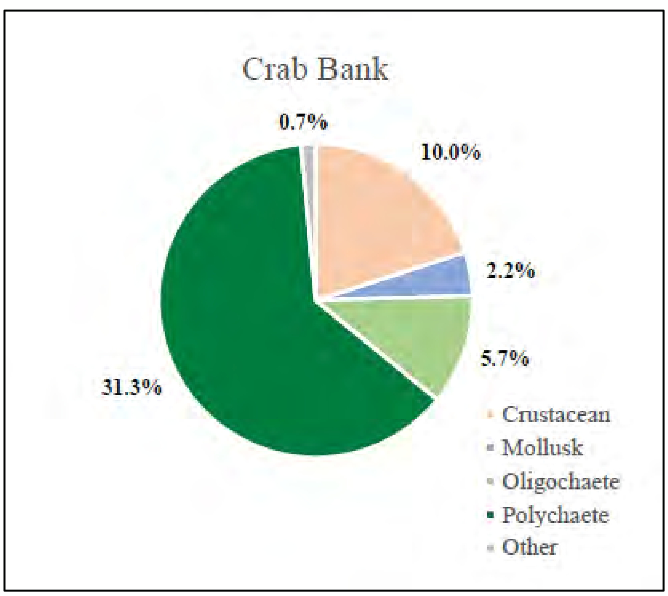


Figure 155. Macroinvertebrate community of Crab Bank

Shutes Folly – The habitat of Shutes Folly had higher range of elevations and sediment types than on Crab Bank, which translated to a greater variety of habitats ranging from salt marsh and subtidal mud flats to supratidal oyster shell deposits. The overall abundance on Shutes Folly was much higher (3.6 times) than at Crab Bank, and was dominated by crustaceans and oligochaetes (Figure 16). The primary driver of this increased abundance was the high intertidal abundance of crustaceans and oligochaetes in the marsh habitat. The northern transect (transect A) was characterized by whole oyster shell. Also, the eastern high point of the island and down to the intertidal sites along each transect were dominated by whole oyster shell. These sites contained relatively low abundance of macrobenthos, but the dominant organism was the isopod Sphaeroma destructor. The western subtidal site was the only site to contain *Brachiodontes exustus* (scorched mussel) and *Crassostrea virginica* (eastern oyster). The middle and southern transects (transects C and E) transition from subtidal flats at the eastern end to oyster shell rake and salt marsh and sand flats on the western end. The flats on the western end extend more gradually than on the eastern side of the island. The western side has two shore-perpendicular bars of washed oyster shell between transects C and E. The flats support several live oyster beds in the western embayment. Macrobenthos of the middle transect was dominated by salt marsh organisms such as tanaids, enchytraeids, and the polychaete *Capitella capitate*. The shelly habitats of the eastern side were comprised of isopods, oligochaetwes and the polychaete *Streblospio benedicti*. The southern transect (transect E) was similar to the middle transect but had more abundance due to the high silt/clay content in the marsh on the eastern side of the island.

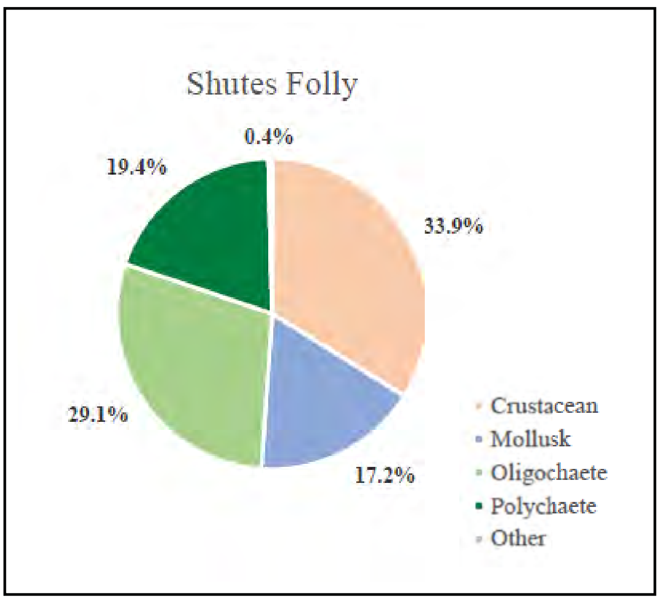


Figure 16. Macroinvertebrate community of Shutes Folly

5.10 Essential Fish Habitat

The EFH Assessment integrated into this Supplemental EA was prepared in accordance with the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (MSA 16 U.S.C. 1855 (b)) including the Sustainable Fisheries Act (SFA [16 U.S.C. 1801]) amendment of 1996. The MSA was reauthorized in 2006. The SFA requires identifying habitats needed to create sustainable fisheries and comprehensive fishery management plans with habitat inclusions. EFH is defined by National Marine Fisheries Service (NMFS) (2004) and approved by the Secretary of Commerce acting through NMFS (50 CFR 600.10) as:

> "*…those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity (MSA § 3(10))*."

The 1996 amendments to the Magnuson-Stevens Fishery Conservation and Management Act (Magnuson-Stevens Act) set forth a new mandate for the NMFS, regional fishery management councils (FMC), and other federal agencies to promote the protection, conservation, and enhancement of Essential Fish Habitat (EFH). The EFH provisions of the Magnuson-Stevens Act support one of the nation's overall marine resource management goals to maintain sustainable fisheries. The Magnuson-Stevens Act's final rule, to manage fishery resources and their habitats, was released on January 17, 2002. The National Marine Fisheries Service (NMFS) and affiliates, the South Atlantic Fishery Management Council (SAFMC) and the Mid-Atlantic Fishery Management Council (MAFMC), oversee the managed species and their habitats potentially found within the proposed project's footprint [National Oceanic and Atmospheric Administration (NOAA) 2009b, NOAA 2009c]. In addition, the Atlantic States Marine Fisheries Commission (ASMFC) serves as a roundtable for cooperative discussion between 15 Atlantic States, coordinating the protection and administration of the states' shared near shore fishery resources (ASMFC 2009).

The combination of fishery and habitat management with emphasis on healthy and diverse estuarine and marine ecosystems meets the EFH mandates of the Magnuson-Stevens Act. If a construction, permitting, funding, or other proposed action potentially affects EFH(s), then applicable federal permitting agencies must consult with the NMFS. The EFH consultation ensures the potential action considers the effects on important habitats and supports the management of sustainable marine fisheries (NOAA, South Atlantic Region 2008).

Charleston Harbor supports significant fish and wildlife resources including many marine and estuarine species. The estuary supports large populations of penaeid shrimp and blue crabs which are economically important species. Demersal (living near the bottom of the sea) fish species include Atlantic croaker; bay anchovy; Atlantic menhaden; spotted hake; weakfish; spot; blackcheek tonguefish; white catfish; and silver perch. Other fish of commercial or recreational value are commonly found in Charleston Harbor; including flounder; red drum; spotted seatrout; bluefish; spot; and black drum. Six anadromous fish species; Atlantic sturgeon; shortnose sturgeon; American shad; blueback herring; hickory shad; and striped bass; and one catadromous species; American eel; use Charleston Harbor and its tributaries as migration routes and spawning areas. The following Essential Fish Habitats occur within the beneficial use project areas: tidal wetlands, tidal creeks, oyster reefs, estuarine water column, and intertidal and subtidal mudflats (shallow sub-bottom habitat). All of these types are thoroughly described in the EFH Appendix of the Post 45 IFR/EIS and are hereby incorporated by reference (USACE, 2015, Appendix H). Oyster reef habitat around Crab Bank and Shutes Folly is shown in Figure 17.

Figure 167. Oyster reef habitat at Crab Bank and Shutes Folly

Species that may occur in the project area habitats are noted in Table 2, if managed by either the South Atlantic Fisheries Management Council (SAFMC) or the NMFS or if either entity has developed fishery management plans for that species. Detailed descriptions of the managed species can be found within Appendix H of the IFR/EIS (USACE 2015), and are incorporated by reference.

Shrimp. In the southeastern United States, the shrimp industry is based on the white shrimp (*Litopenaeus setiferus*), brown shrimp (*Farfantepenaeus aztecus*), pink shrimp (*Farfantepenaeus duorarum*), and the deeper water rock shrimp (*Sicyonia brevirostri*). The royal red shrimp (*Pleoticus robustus*) also occurs in deeper water and sustains a limited harvest. For the above species, Habitat Areas of Particular Concern (HAPC) within the project area include estuarine and marine water columns within the inlet, which includes the potential beneficial use project areas. These areas are the connecting water bodies between inshore estuarine nursery areas, offshore marine habitats used for spawning and growth to maturity. EFH for rock shrimp and royal red shrimp occurs in deeper offshore waters.

Table 2. Fishery management plans and managed species that may occur in the project area

Common Name	Species
Shrimp	
brown shrimp	*Farfantepenaeus aztecus*
pink shrimp	*Farfantepenaeus aduorarum*
rock shrimp	*Sicyonia brevirostris*
royal red shrimp	*Pleoticus robustus*
white shrimp	*Litopenaeus setiferus*
Snapper Grouper Complex	
Jack crevalle	*Caranx hippos*
gag grouper	*Mycteroperca microlepis*
black sea bass	*Centropristis striata*
mutton snapper	*Lutjanus analis*
red snapper	*Lutjanus campechanus*
lane snapper	*Lutjanus synagris*
gray snapper	*Lutjanus griseus*
yellowtail snapper	*Ocyurus chrysurus*
spadefish	*Chaetodipterus faber*
white grunt	*Haemulon plumieri*
sheepshead	*Archosargus probatocephalus*
hogfish	*Lachnolaimus maximus*
Coastal Migratory Pelagics	
king mackerel	*Scomberomorus cavalla*
Spanish Mackerel	*Scomberomorus maculatus*
cobia	*Rachycentron canadum*
Mid-Atlantic FMP species which occur in South Atlantic	
bluefish	*Pomatomus saltatrix*
summer flounder	*Paralichthys dentatus*
Federally Implemented FMP	
lemon shark	*Negaprion brevirostris*
bull shark	*Carcharhinus leucas*
blacknose shark	*Carcharhinus acronotus*
finetooth shark	*Aprionodon isodon*
dusky shark	*Carcharhinus obscurus*
bonnethead shark	*Sphyrna tiburo*
Atlantic sharpnose shark	*Rhizoprionodron terraenovae*

For the Post 45 EFH Assessment, the white shrimp was used as a representative species. White shrimp are especially important in South Carolina. The species is subject to both recreational and commercial fisheries. The local agency responsible for management of white shrimp stocks within South Carolina waters is the SCDNR. Detailed species information can be found in the IFR/EIS, USACE 2015, Appendix H. Figure 18 shows where white shrimp have been captured in the Charleston Harbor estuary during SCECAP and other inshore fisheries sampling efforts. Only approximately two-dozen sites produced samples with white shrimp, and none of those were near Crab Bank, Shutes Folly, nor Morris Island. However, based on discussions with local fishing groups, the Crab Bank area is used for recreational shrimp baiting. For white shrimp species summary, see the SCDNR website (https://www.dnr.sc.gov/marine/species/white shrimp.html).

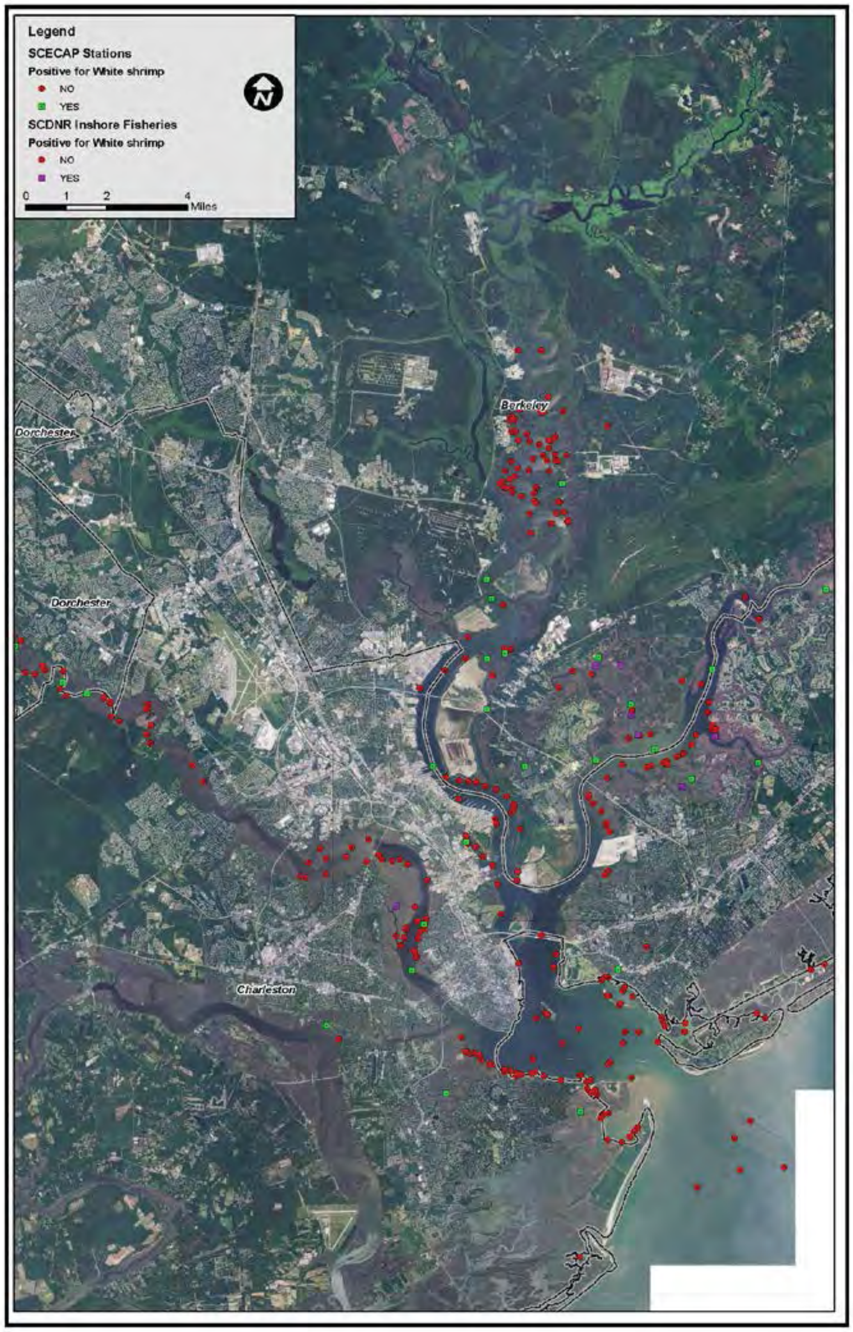


Figure 178. White Shrimp captures during SCECAP trawls.

Snapper Grouper Complex. This complex of 10 families of fishes containing 73 species is managed by the South Atlantic Fishery Management Council (SAFMC). There is variation in specific life history patterns and habitat use among the snapper grouper complex species. For specific life stages of estuarine dependent and nearshore snapper grouper species, EFH includes areas inshore of the 100 - foot-deep ocean contour, such as the salt and brackish marshes, tidal creeks, soft sediments found in Charleston

Harbor, and unconsolidated bottom occurring in the navigation channel. EFH-HAPC for species of the complex is found throughout the project area in the Charleston Harbor.

Within the Post 45 IFR/EIS and EFH Assessment, the gray snapper was used as a representative species. Gray snapper (*Lutjanus griseus*) is a popular gamefish, and one of many species that makes use of both inshore/estuary habitats as well as deeper, offshore habitats. In South Carolina waters, they are generally affiliated with reefs, oyster bars, rocky areas, and estuaries, particularly among seagrass beds if present as well as over soft and sand-bottom areas (Bester 2014). Spawning (broadcast, with demersal eggs) occurs April through November and peaks during summer in estuaries. When individuals reach approximately 8 cm, they move toward shallow rocky areas and coastal reefs (Bester 2014). As the fish approach 20 cm, they may have a preference for habitats with salinities between 9 and 23 ppt (Serrano et al. 2010). Figure 19 shows SCDNR inshore fisheries catch data for gray snapper; apparently approximately 8 to 10 miles upstream of Daniel Island in the Cooper River, there are important gray snapper nurseries.

***Coastal Migratory Pelagics*.** King and Spanish mackerel and cobia are coastal migratory pelagic species managed by the SAFMC. EFH for these species include the inlet and, in a more general sense, any high salinity bays which may occur in the project vicinity. Many coastal pelagic prey species are estuarine-dependent in that they spend all or a portion of their lives in estuaries. Accordingly, the coastal pelagic species, by virtue of their food source, are to some degree also dependent upon estuaries and can be expected to be adversely affected if the productive capabilities of estuaries are greatly degraded.

Within the Post 45 EFH Assessment (IFR/EIS, USACE 2015, Appendix H), the king mackerel was used as a representative species due to a marked decrease in landings since 1998. SCDNR (2013a) explained recreational and commercial fishing trends for the past 35 years (Figure 20):

- Recreational catch. "The recreational catch, while variable year-to-year, has been on a declining trend since the mid 1980s. The relatively low recent 10 year average (compared to the entire time series) reflects the low total catch in the last ten years. The most recent 10 year average total catch (2002-2012) was one-third the average catch for the entire time series.
- Commercial landings. "Commercial landings for king mackerel reflect a similar trend to the recreational landings with peak landings occurring in the 1980s and early 1990s. There has been a steady decline in commercial landings since 1990 with the latest 10 year average (2002-2012) landings at 23,400 lbs versus 115,873 lbs for the previous ten years (1991-2001)."

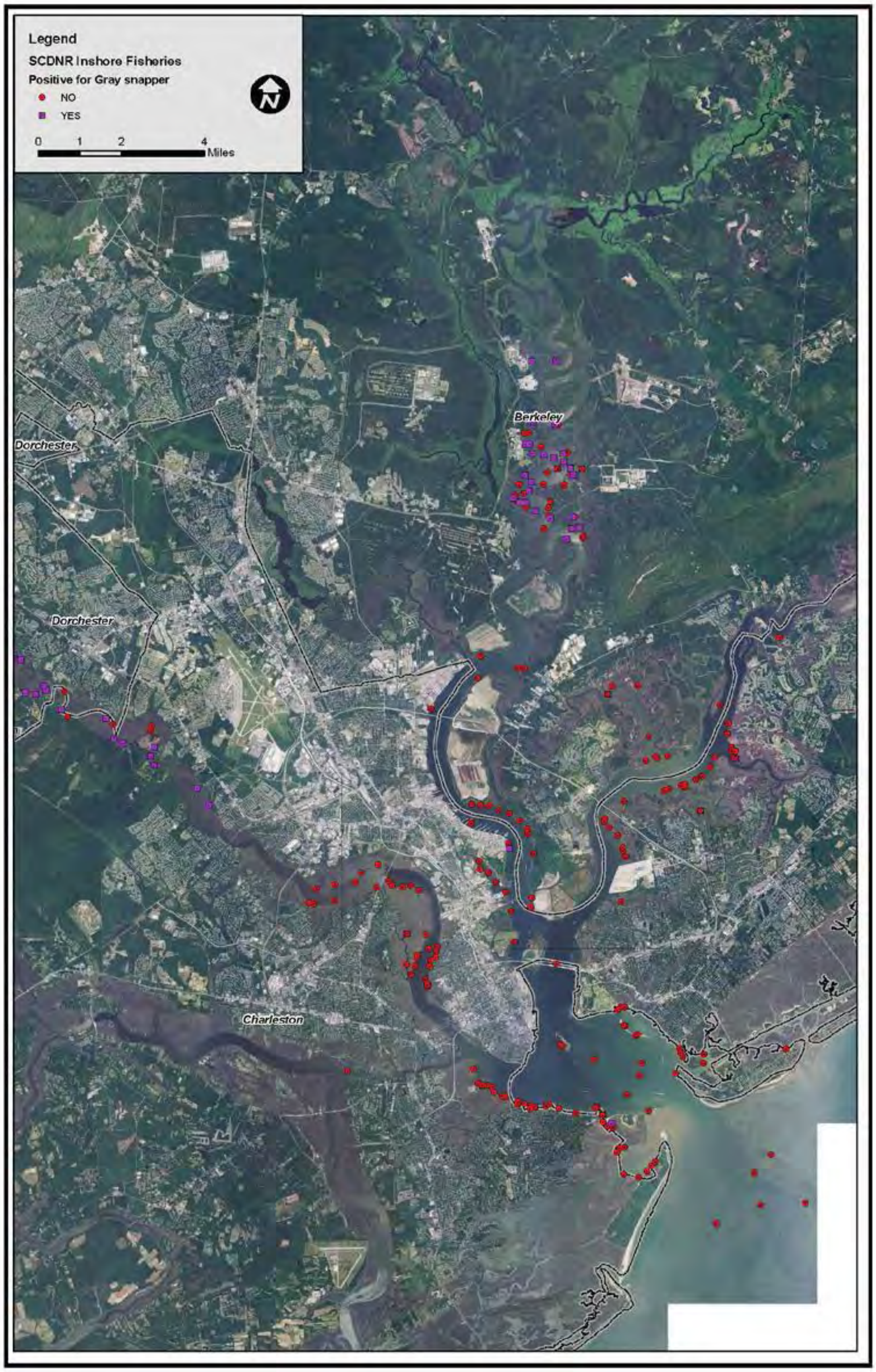


Figure 18. Gray snapper captures during SCECAP trawls

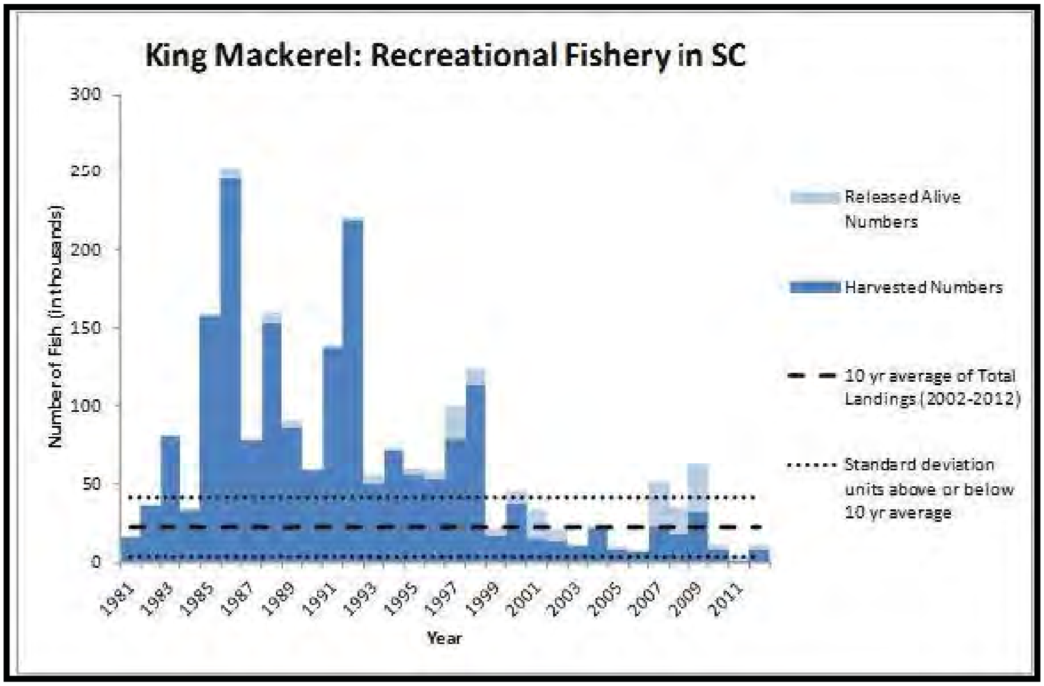


Figure: SCDNR (2013a)

Figure 19. King mackerel recreational fishery catch in South Carolina (1981-2013)

Mid-Atlantic Species in South Atlantic Region. Bluefish and summer flounder are two species listed in the Mid-Atlantic Fisheries Management Plan that occur in the South Atlantic. Bluefish juveniles and adults are listed as using estuaries from North Carolina to Florida and are common in Charleston Harbor including the vicinity of the navigation channel.

Highly Migratory Species. The sharks listed in Table 2 are included in the Highly Migratory Species (federal) Fishery Management Plan, and are relatively common in Charleston Harbor. EFH for the shark species include the inlet and estuarine and shallow coastal waters which all include navigation channels.

5.11 Threatened and Endangered Species

The ESA of 1973 (16 USC § 1531–1534) establishes protection and conservation of threatened and endangered species and the ecosystems upon which they depend. USFWS and the NOAA Fisheries Service (NOAA Fisheries) administer the Endangered Species Act (ESA) and may designate critical habitat for each species it protects. Under the ESA, an endangered species is defined as a species in danger of extinction throughout all or a significant portion of its range. A threatened species is defined as a species likely to become an endangered species in the foreseeable future. Section 7 of the ESA requires all federal agencies to consult with USFWS or NOAA Fisheries, as applicable, before initiating any action that may affect a listed species. All principal aspects of the new work construction have been previously evaluated in the USACE Biological Assessment and NMFS Biological Opinion on the subject project (Appendices F1 and F2 of the IFR/EIS, USACE 2015). The purpose of this action is to only further evaluate the effects of the proposed beneficial use alternatives, including on listed species or critical habitat.

Table 3. Threatened (T) and Endangered (E) Species Potentially Present in the Project Vicinity

Common Name	Scientific Name	Status	Date Listed
Marine Mammals			
humpback whale	*Megaptera movaeangliae*	E	12/2/1970
North Atlantic right whale	*Eubalaena glacialis*	E	12/2/1970
West Indian Manatee	*Trichechus manatus*	E	10/21/1972
Turtles			
Kemp's ridley sea turtle	*Lepidochelys kempii*	E	12/2/1970
leatherback sea turtle	*Dermochelys coriacea*	E	6/2/1970
loggerhead sea turtle	*Caretta caretta*	T	7/28/1978
green sea turtle	*Chelonia mydas*	T	7/28/1978
Fish			
Atlantic sturgeon	*Acipenser oxyrhynchus*	E	4/6/2012
Shortnose sturgeon	*Acipenser brevirostrum*	E	3/11/1967
Birds			
American Wood Stork	*Mycteria Americana*	E (proposed for downlisting to "T")	2/28/1984
Piping Plover	*Charadrius melodic*	T	12/11/1985
Rufa Red Knot	*Calidris canutus rufa*	T	1/12/2015
E - Federally endangered	*T - Federally threatened*		

The following sections briefly summarize important life history traits and distribution of species listed in Table 3 within the project area.

5.11.1 Sea Turtles

Four of the six species of sea turtles in U.S. waters may be found in the Charleston Harbor and nearby areas and are federally protected under the ESA. These species include the green, loggerhead, leatherback, and Kemp's Ridley sea turtles. Of these, the loggerhead is the most common in South Carolina waters.

5.11.1.1 Green Turtle

Green sea turtles are globally distributed within tropical and subtropical waters. Along the Atlantic and Gulf coasts of the United States, they can be found from Texas to Massachusetts and around the U.S. Virgin Islands and Puerto Rico. This species uses beaches for nesting and coastal areas and open ocean convergence zones for feeding. Green turtles' preferred habitats are seagrass beds and worm-rock reefs, which are located primarily in shallow-water environments along the Atlantic coast. South of North Carolina, green sea turtles are expected to occur year-round in waters between the shoreline and the 50-meter isobath. Green sea turtles are known to nest in substantial numbers in the southeastern United States. Nesting takes place from April through September, with an incubation period of approximately 2 months (FWC 2002, DoN 2007b). In 2016, three stranded green turtles were recorded in the Charleston Harbor Vicinity (www.seaturtle.org/strand, accessed August 12, 2016). Green sea turtles are expected to occur within the vicinity of the proposed action area throughout the year. No critical habitat has been designated for this species in the project area. Additional information on the green sea turtle can be found within the Biological Assessment and NMFS Biological Opinion for the Charleston Harbor Post 45 Study (USACE 2015, Appendix F1 and F2).

5.11.1.2 Loggerhead Turtle

In the project area, the loggerhead is listed as the Northwest Atlantic Ocean Distinct Population Segment (DPS) and is the most common sea turtle in South Carolina. Loggerhead sea turtles are circumglobal, inhabiting continental shelves, bays, estuaries, and lagoons in temperate, subtropical, and tropical waters. The species has been observed as far as 500 miles offshore. They are the most abundant sea turtle found in U.S. coastal waters. About 90% of the total nesting in the United States occurs on the south Atlantic coast of Florida (Fritts et al. 1983). Loggerhead densities seem to be highest during summer months (Fritts et al. 1983), and they forage on benthic invertebrates, fish, and aquatic vegetation.

South Carolina's coastal waters are a migration path for loggerheads at all times of the year, and South Carolina's beaches are within the species' nesting range in the United States (North Carolina to Mexico). Loggerheads consistently occur off Charleston Harbor during spring, summer, and fall and sporadically occur in the Charleston Harbor estuarine system (USACE 2006). They have been thoroughly monitored in the southeastern region, both in terms of monitoring nesting density and sampling for juvenile loggerhead turtles in shallow coastal waters. SCDNR has been monitoring sea turtle nests since the 1970s. The relative abundance of sea turtle nests on the various beaches surveyed along the South Carolina coastline have been summarized in the GIS layer files to represent turtle nest densities/km of beach (Figure 21). Loggerhead sea turtles regularly strand along the coast of South Carolina. In 2016, 31 stranded loggerhead turtles were recorded in the Charleston Harbor vicinity (between Isle of Palms and Folly Beach) (www.seaturtle.org/strand, accessed August 12, 2016). Loggerheads are expected to occur within the vicinity of the proposed beneficial use areas throughout the year.

Critical habitat has been designated in the action area for the Northwest Atlantic Ocean loggerhead sea turtle Distinct Population Segment. The critical habitat in the action area includes nearshore reproductive habitat in areas just south of the Charleston Harbor Entrance Channel (LOGG-N-07) (Figure 22). Additional information on the loggerhead sea turtle can be found within the Biological Assessment for the Charleston Harbor Post 45 Study (USACE 2015, Appendix F1).

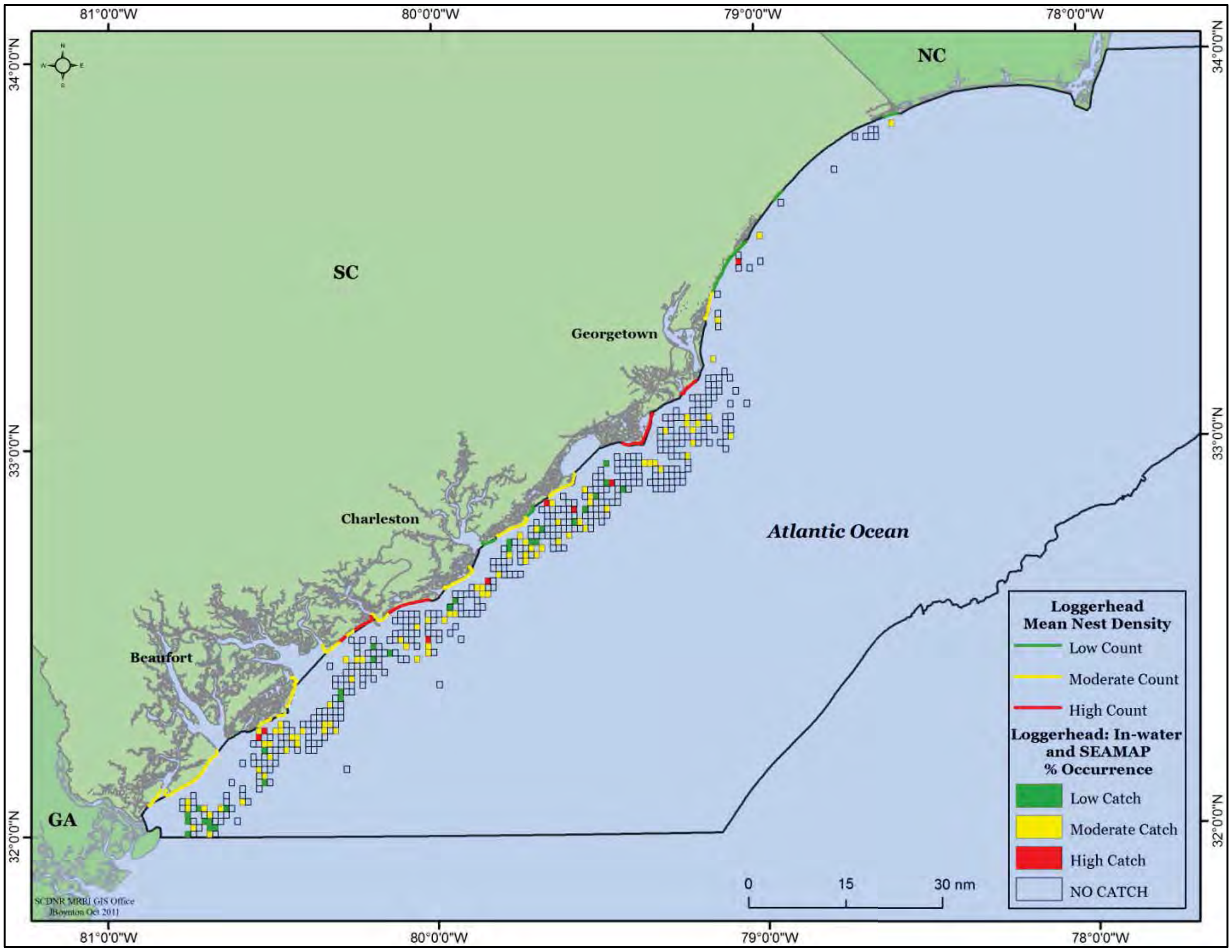


Figure 201. Data summary of the relative abundance (#nests/km) and distribution of loggerhead sea turtle nests along the South Carolina coastline, and juvenile loggerhead sea turtles caught by trawl in the in-water sea turtle surveys and SEAMAP trawl surveys

Source: Van Dolah et al. 2011

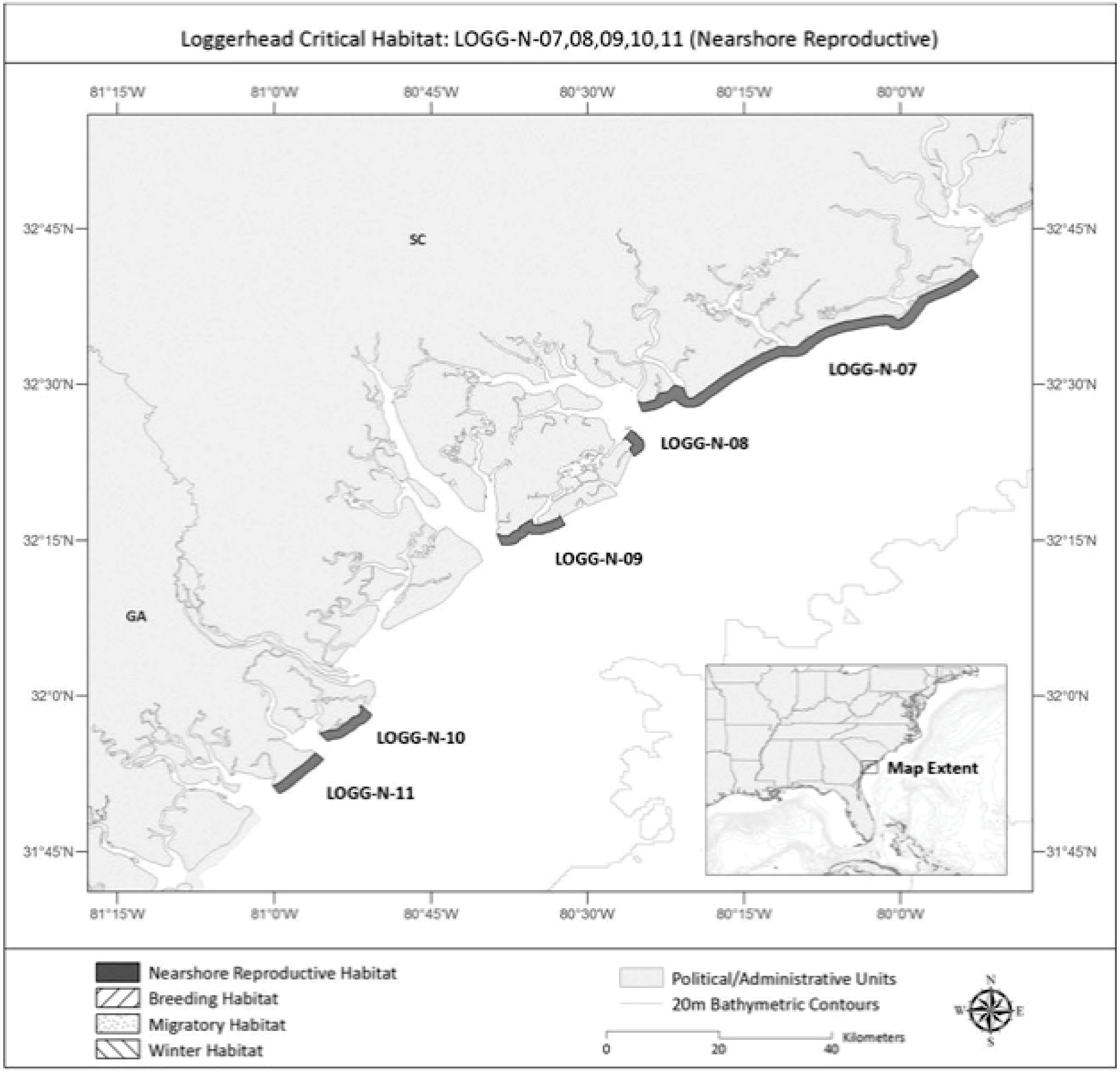


Figure 212. Critical Habitat in the Action Area for the Northwest Atlantic Ocean Loggerhead Sea Turtle Distinct Population Segment

Source: http://www.nmfs.noaa.gov/pr/species/turtles/criticalhabitat_loggerhead.htm#maps

5.11.1.3 Leatherback Turtle

The leatherback sea turtle is the most widely distributed sea turtle species and is probably the most oceanic of all sea turtles, preferring deep waters (Rebel 1974). Leatherback sea turtles migrate widely and have been reported as far north as Nova Scotia (Lazell 1980). Although generally a deep-diving pelagic species that feeds on jellyfish, they do move seasonally into coastal waters to feed on large jellyfish that are associated with rivers and frontal boundaries. Major rookeries are rare for this species, and dispersed nesting is common. Nesting occurs from March through July, with an incubation period of 55 to 75 days (DoN 2007).

Leatherbacks are present off the coast of South Carolina. In 2016, five stranded leatherback turtles were recorded in the Charleston Harbor vicinity (between Isle of Palms and Folly Beach) (www.seaturtle.org/strand, accessed August 12, 2016). While there is potential for leatherbacks to be present off the coast of South Carolina during migration, they are not expected to be common within the proposed beneficial use areas. No critical habitat has been designated for this species in the project area. Additional information on the leatherback sea turtle can be found within the Biological Assessment for the Charleston Harbor Post 45 Study (USACE 2015, Appendix F1).

5.11.1.4 Kemp's Ridley Turtle

The Kemp's Ridley sea turtle is probably the most endangered of the sea turtles. They are shallow-water benthic feeders and primarily inhabit the Gulf coasts of Mexico and the United States, but are occasionally found as far north as Nova Scotia and Newfoundland in the North Atlantic. This species is found in submerged habitats where there is muddy or sandy substrate where they feed on crabs, fish and mollusks.

Kemp's Ridley sea turtles are not common off the coast of South Carolina; however, immature individuals are encountered in the nearshore and coastal water of South Carolina (USFWS 1998). Juvenile Kemp's Ridleys use South Carolina waters as developmental foraging grounds (www.dnr.sc.gov/seaturtle/lk.htm). Subsequently, sub-adult turtles return to neritic zones of the Gulf of Mexico or northwestern Atlantic Ocean to feed and develop until they reach adulthood (www.nmfs.noaa.gov/pr/species/turtles/kempsridley.htm). In 2016, 11 stranded Kemp's Ridleys were recorded in the Charleston Harbor vicinity (between Isle of Palms and Folly Beach) (www.seaturtle.org/strand, accessed August 12, 2016). Accordingly, Kemp's Ridley sea turtles could be present in the proposed beneficial use areas. No critical habitat has been designated for this species in the project area. Additional information on the Kemp's Ridley sea turtle can be found within the Biological Assessment for the Charleston Harbor Post 45 Study (USACE 2015, Appendix F1).

5.11.2 Marine Mammals

All marine mammals are protected under the Marine Mammal Protection Act of 1972 (MMPA) and are under the jurisdiction of NMFS or USFWS. With certain exceptions, the MMPA prohibits the taking of marine mammals in U.S. waters by U.S. citizens on the high seas and the importation of marine mammals and marine mammal products into the United States. (NMFS 2005). Therefore, all marine mammals encountered in the offshore region of Charleston must be given due consideration. The emergence of terms, legislation, and monitoring organizations created after the MMPA, such as the ESA of 1973, the USFWS Endangered Species Program, and the International Union for the Conservation of Nature (IUCN), require that certain species be given greater protection and consideration (IUCN 2008). These populations are more sensitive to and are negatively impacted by factors such as habitat loss, pollution, harvesting, and vessel traffic. Therefore, regulation that protects these species from extinction is fundamental.

5.11.2.1 North Atlantic Right Whale

The historic range of the North Atlantic right whale was from temperate areas to subarctic locations in the North Atlantic Ocean (NAVFAC 2008). Some individuals have been sighted migrating over extremely deep waters, but most sightings occur in coastal and continental shelf waters. Individuals have been reported as far south as the Gulf of Mexico, although these occurrences are rare. Currently, their distribution is highly influenced by season and specific activities. Calving occurs between November and April in southeastern U.S. waters. In February 2015, NOAA Fisheries proposed to expand the designated critical habitat for endangered North Atlantic right whales in the northwestern Atlantic Ocean, including areas that will support calving and nursing. The rule would expand the critical habitat to roughly 29,945 nmi^2, and includes northeast feeding areas in the Gulf of Maine/Georges Bank region and calving grounds from southern North Carolina to northern Florida (Figure 23).

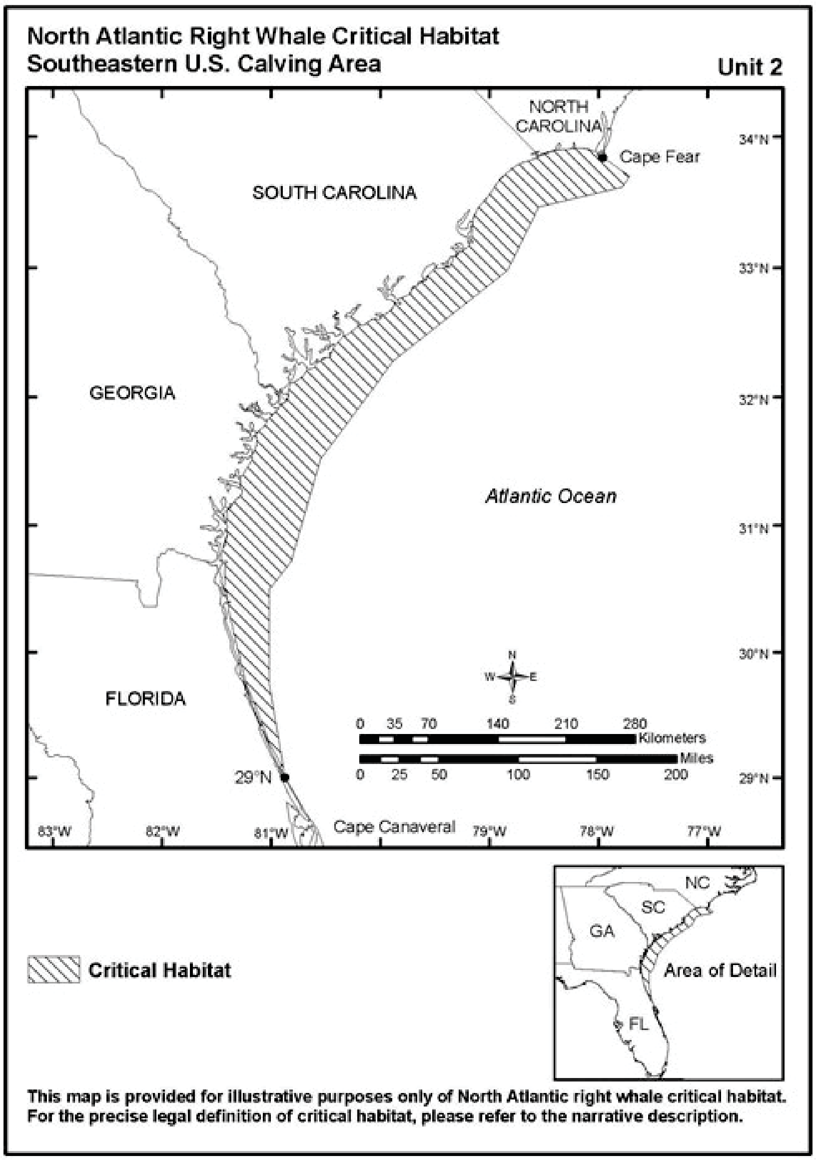


Figure 22. Southeastern Calving Critical Habitat for North Atlantic Right Whales

Feeding primarily occurs from spring until fall in coastal waters of the northeastern United States and Canada where their prey (zooplankton) is abundant. When North Atlantic right whales are not occupied with reproductive or paternal duties, their distribution is strongly linked to the distribution of their prey, which is comprised of various zooplankton species, particularly those with high lipid content. Migration for feeding is a critical activity, as both the quality and quantity of their food source are important. Although general distributional patterns do exist, information for many individuals throughout the winter is not well documented (NMFS 2004, 2006a). Figure 24 provides a summary of the whale sightings along the South Carolina coastline from November and April from 2002-2010.

Coastal South Carolina is within the range of designated critical habitat, and right whales would be expected to occur off the coast of South Carolina during their seasonal migrations. Charleston is within the Mid-Atlantic Region, for the purposes of right whale management, an area that extends approximately from Block Island Sound, Rhode Island, to Port of Savannah, Georgia, between known right whale high-use areas in the northeast and winter calving areas in the southeast (MMS 2009). The Mid-Atlantic Region is a migratory corridor for pregnant females moving from northeast to southeast in fall (September to November) and for mother/calf pairs departing winter calving area in the southeast headed for the northeastern United States (March through May), and is likely used by calving females from December to March. The mother-calf pairs stay close to shore, with 94% of sightings within 30 nmi (56 km) of shore and 80% of sightings in depths less than 90 feet (27 m) (MMS 2009). Please see Appendix F1 in USACE 2015 for more information.

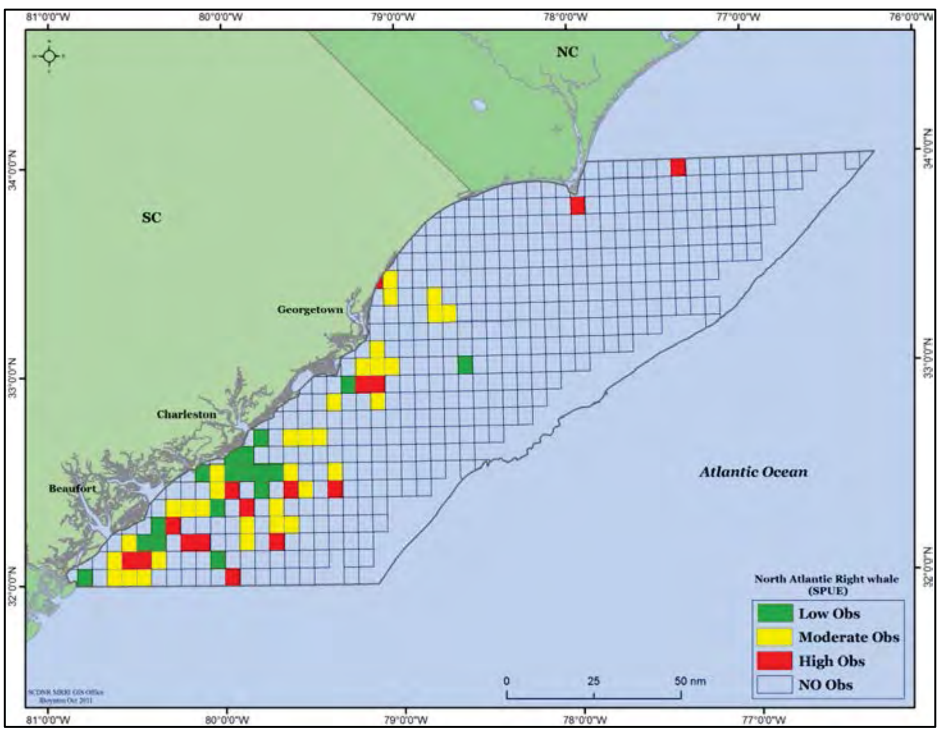


Figure 23. Example of the Relative Abundance and Distribution of North American Right Whale Sightings along the Coast of South Carolina

Source: Van Dolah et al. 2011

5.11.2.2 Humpback Whale

Humpback whales are found in all of the world's oceans and were listed as endangered in 1973. In general, summers are spent at high-latitude feeding grounds from southern New England to Norway, and migration during the winter is to the West Indies, over shallow banks and along continental coasts, where calving occurs. Most humpback whale sightings are in nearshore and continental shelf waters; however, humpback whales frequently travel across deep water during migration. Calving peaks from January through March, but some animals have been documented arriving as early as December, and a few not leaving until June. Strandings occur each year, for which over 50% of the animals exhibit scarring or fresh wounds due to fishing gear entanglement or boat collisions (DoN 2002). Humpback whales migrate south to calving grounds during the fall and make return migrations to the northern feeding grounds in spring. Please see Appendix F1 in USACE 2015 for more information.

5.11.2.3 West Indian Manatee

The West Indian manatee can be found along coasts and inland waters of the southeastern United States, eastern Mexico, the Greater Antilles (Hispaniola, Cuba, Puerto Rico, Jamaica), and Central America down to as far as northern Brazil. Manatees inhabit both salt and fresh water of sufficient depth (5 feet to usually less than 20 feet) throughout their range (USACE 2006). Manatees may be encountered in shallow, slow-moving water bodies such as canals, rivers, estuarine habitats, and saltwater bays, although on occasion they have been observed as much as 3.7 miles (6 km) off the Florida Gulf coast. Manatees require warm water, migrating to warmer waters whenever the temperature falls below 20°C. They are herbivorous, subsisting on seagrasses, large algae, and freshwater plants. Manatees reproduce slowly, reaching sexual maturity at 5 to 9 years of age and bearing a single young (rarely twins) every 2 to 5 years.

Threats to the manatee include natural mortality due to cold and red tide poisoning and human-induced mortality from loss of habitat, watercraft collisions, pollution, litter, and water control structures. According to Waring et al. (2009), roughly a third of documented manatee mortality is due to human-related causes, the vast majority from collisions with watercraft.

Manatees are known to visit the Charleston Harbor area in the summer months (April through November) as they migrate up and down the coast (USACE 2006). Given their migratory habits, manatees can be assumed to occur in the Charleston Harbor and surrounding waters. Please see Appendix F1 in USACE 2015 for more information.

5.11.3 Fish

5.11.3.1 Atlantic Sturgeon

The historic range of the Atlantic sturgeon is from St. Croix, Maine, to the St. Johns River, Florida. They spend most of their lives in marine waters and migrate up rivers in February and March to spawn. A large U.S. commercial fishery (100,000 to 250,000 lbs/year) existed for the Atlantic sturgeon from the 1950s through the mid-1990s; the origin of the fishery dates back to colonial times (NOAA NMFS 2009). The Atlantic sturgeon is managed under a fishery management plan (FMP) implemented by the Atlantic States Marine Fisheries Commission (ASMFC). They implemented a coast-wide moratorium on the harvest of wild Atlantic sturgeon in late 1997/early 1998. This moratorium is to remain in effect until there are at least 20 protected-year classes in each spawning stock (anticipated to take up to 40 or more years). NMFS followed this with a similar moratorium for federal waters.

Threats from dredging, water quality, and commercial by-catch likely contribute to the population decline of this species. The status of Atlantic sturgeon was initially reviewed in 1998 after USFWS and NMFS received a petition to list the species under the ESA; it was determined at that time that listing was not warranted. In 2003, a workshop sponsored by NMFS and USFWS was held to review the status of the Atlantic sturgeon. The workshop concluded that some populations seemed to be recovering while others continued to be depressed (NOAA NMFS 2009). As a result, NMFS initiated a second status review of the Atlantic sturgeon in 2005 to re-evaluate whether this species required protection under the ESA. That status review was completed in 2007, and the Status Review Team recommended that Atlantic sturgeon in the United States be divided into the following five DPSs: Gulf of Maine; New York Bight; Chesapeake Bay; Carolina; and South Atlantic. After reviewing the available information on the two DPSs located within the NMFS Southeast Region (Carolina and South Atlantic), NMFS determined that listing these two DPSs as endangered is warranted. The Final Listing Rule for South Atlantic and Carolina DPSs of Atlantic sturgeon in the southeast region was published in the *Federal Register* on February 6, 2012 (77 FR 5914).

Based upon telemetry monitoring of the Atlantic sturgeon by SCDNR, this species is noted to occur within Charleston Harbor and the vicinity of the proposed beneficial use projects. Critical Habitat for the Atlantic Sturgeon was proposed in June 2016 (Federal Register Vol. 81, No. 107). The proposed Critical Habitat near the project vicinity is Carolina Unit 7, Santee-Cooper Unit (Figure 25). This Critical Habitat starts at the NMFS identified river mile 0, which is around the Customs House and just upstream of the project area. Please see Appendix F1 in USACE 2015 for more information.

5.11.3.2 Shortnose Sturgeon

The shortnose sturgeon is the smallest of the three sturgeon species that occur in eastern North America. It is an anadromous fish that spawns in coastal rivers along the east coast of North America from the St. John River in Canada to the St. Johns River in Florida (http://www.nmfs.noaa.gov/pr/species/fish/shortnosesturgeon.htm, accessed September 9, 2014). In the southern portion of the range, they are found in the St. Johns River in Florida; the Altamaha, Ogeechee, and Savannah rivers in Georgia; and in South Carolina, the river systems that empty into Winyah Bay and the Santee/Cooper River complex that forms Lake Marion. It prefers the nearshore marine, estuarine, and riverine habitats of large river systems. Shortnose sturgeon, unlike other anadromous species in the region such as shad or salmon, do not appear to make long-distance offshore migrations. They are benthic feeders. Juveniles are believed to feed on benthic insects and crustaceans, and adults primarily feed on mollusks and large crustaceans.

Shortnose sturgeon have been documented by SCDNR to occur in the areas proposed for beneficial use projects. Recent hydroacoustic studies have also noted that inter-basin movement via the ocean by shortnose sturgeon is more common than previously believed (B. Post SCDNR pers. comm.). Please see Appendix F1 in the IFR/EIS (USACE 2015) for more information.

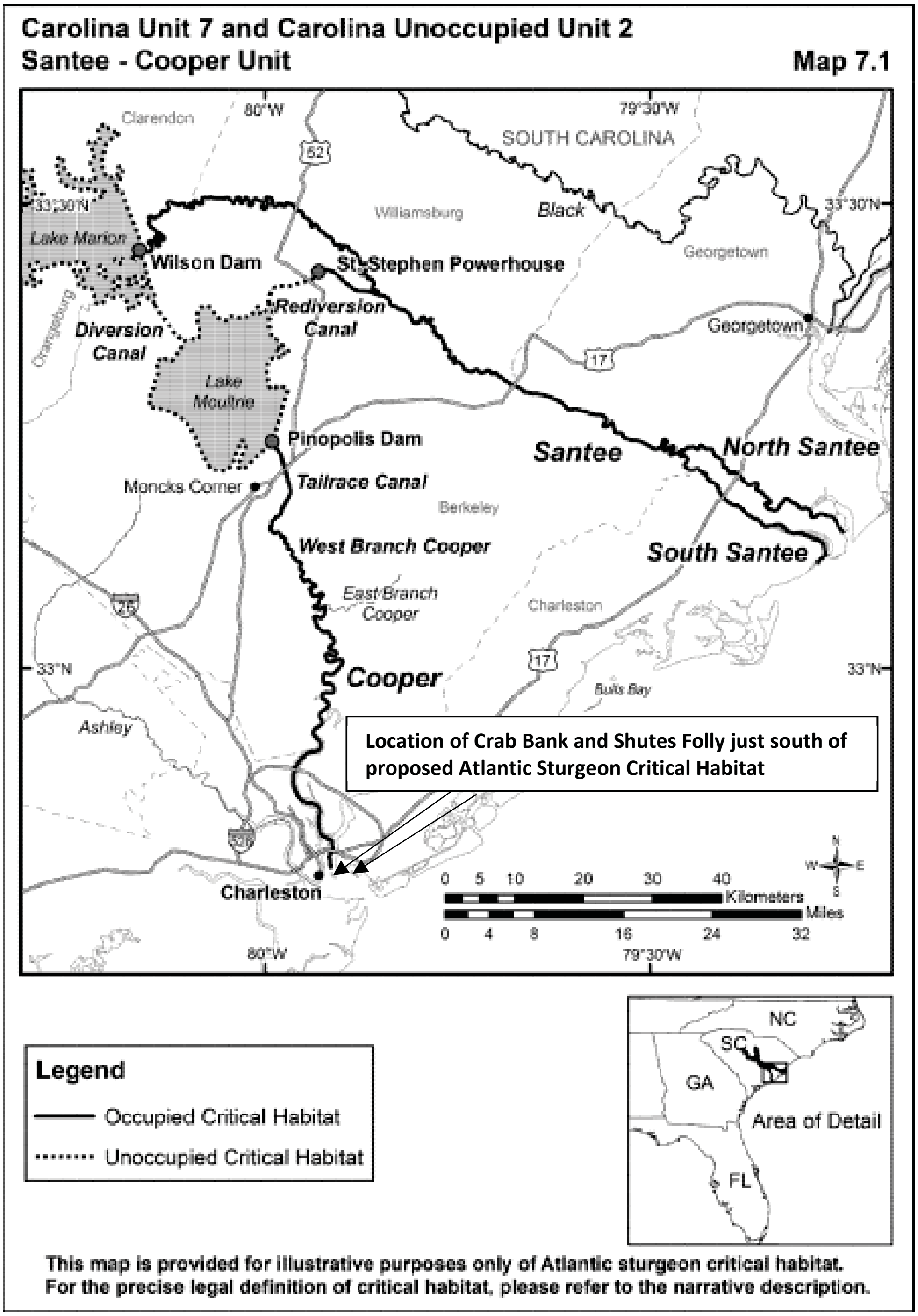


Figure 24. Atlantic Sturgeon proposed Critical Habitat near the project area

5.11.3 Birds

5.11.3.1 American Wood Stork

Wood storks are large, long-legged wading birds, about 50 inches tall, with a wingspan of 60 to 65 inches. The plumage is white except for black primaries and secondaries and a short black tail. The head and neck are largely unfeathered and dark gray in color. The bill is black, thick at the base, and slightly decurved. Immature birds are dingy gray and have a yellowish bill (http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=B06O). Wood storks in Georgia and South Carolina initiate nesting on a seasonal basis regardless of environmental conditions. They lay eggs from March to late May, with fledging occurring in July and August (Federal Register/Vol. 75, No. 182/ September 21, 2010). Wood storks typically utilize freshwater and estuarine wetlands, and primarily nest in cypress or mangrove swamps. They feed in freshwater marshes, narrow tidal creeks, or flooded tidal pool. Habitat loss, pollution and loss of prey base are the major threats to wood stork populations. This reduction is attributed to loss of wetland habitat as well as to changes in water hydroperiods from draining wetlands and changing water regimes by constructing levees, canals, and floodgates to alter water flow in south Florida. Wood storks have a unique feeding technique and require higher prey concentrations than other wading birds. The 2006 nesting totals indicate that the Wood stork population has reached its highest level since it was listed as endangered in 1984 and since the early 1960s with over 11,000 nesting pairs documented in FL, GA, SC and NC during the 2006 breeding season. Since listing, the number of nesting pairs is increasing, the number of nesting colonies is increasing, and the nesting range is growing. Even though threats that affect wood storks appear to be continuing at the same levels, the conclusion is that the overall population status is improving. Please see Appendix F1 in USACE 2015 for more information.

5.11.3.2 Piping Plover

There are three recognized populations of piping plovers in North America; Atlantic Coast, Northern Great Plains, and the Great Lakes population. The Atlantic Coast population winters from North Carolina to Florida with some nesting occurring in North Carolina. The Atlantic Coast piping plover population breeds on coastal beaches from Newfoundland to North Carolina (and occasionally in South Carolina) and winters along the Atlantic Coast (from North Carolina south), the Gulf Coast, and in the Caribbean where they spend a majority of their time foraging (www.fws.gov/northeast). Piping plovers have been observed in the following counties in South Carolina: Beaufort, Charleston, Colleton, Georgetown, Horry and Jasper (http://ecos.fws.gov). Piping plovers typically nest in sand depressions on un-vegetated portions of the beach above the high tide line on sand flats at the ends of sand spits and barrier islands, gently sloping foredunes, blowout areas behind primary dunes, sparsely vegetated dunes, and washover areas cut into or between dunes. They head to their breeding grounds in late March or early April and nesting usually begins in late April; however, nests have been found as late as July (Potter, et al., 1980). Feeding areas include intertidal portions of ocean beaches, washover areas, mud flats, sand flats, wrack lines, and shorelines of coastal ponds, lagoons, or salt marshes (USFWS, 1996). Prey consist of worms, fly larvae, beetles, crustaceans, mollusks, and other invertebrates (Bent, 1928).

Loss and degradation of habitat due to development and shoreline stabilization have been major contributors to the decline of piping plovers in southeast. The current commercial, residential, and recreational development has decreased the amount of coastal habitat available for piping plovers to nest, roost, and feed. Furthermore, beach erosion and the abundance of predators, including wild and domestic animals as well as feral cats, have further diminished the potential for successful nesting of this species. There are 15 areas in South Carolina with designated Critical Habitat for the Piping plover. These extend along beaches from Little River Inlet to Beaufort County near Hilton Head Island. South Carolina has 187 sandy miles of beach shoreline available, 56 miles of which are nourished within critical habitats, resulting in 30% of affected sandy shoreline in critical habitat units (USFWS, 2009). A total of 5618 acres are designated Critical Habitat in South Carolina; However, there are no critical habitat areas in the proposed project area (http://www.fws.gov/plover/#maps).

5.11.3.3 Rufa Red Knot

Red knots are migratory shorebirds. Their migration is one of the most impressive, with many individuals annually flying over 9,000 miles from the Arctic breeding grounds to the tip of South America. The red knot is about 9 inches tall, with a wingspan of 20 to 22 inches. During the breeding season, red knots exhibit black, brown and chestnut colored plumage above and a pinkish-cinnamon breast and face. In winter, the plumage changes to pale gray above and white below with a white eyebrow. Its legs are a greenish/blackish in color, with a black, slightly tapered but otherwise straight bill (http://www.dnr.sc.gov/marine/mrri/acechar/specgal/knotred.htm).

Red knots winter in the coastal United States from Cape Cod to Mexico and South America and spend the summer on islands in the High Arctic. Red knots breed in the Arctic planes and islands above the Arctic Circle in the summer. Southern migration begins in the fall towards South America. Knots migrate in large numbers and will often fly over 1,500 miles before stopping over at winter feeding grounds. Wintering grounds are coastal beaches and mud flats along both the Pacific and Atlantic coasts from California and Massachusetts south to South America. In SC, they winter all along the coast, primarily on sandy beaches and mud flats. During the wintering stopovers knots feed on marine worms, small mollusks and most importantly in the southeast United States horseshoe crab eggs. Habitat loss, pollution, toxins, disease, hunting and loss of prey base are the major threats to red knot populations. No critical habitat has been published for the red knot but is likely to be by the beginning of 2015. It is not expected that critical habitat would be within the proposed project area.

5.12 Avian Habitat

Various areas within Charleston Harbor are utilized by many species of shorebirds for nesting and feeding. Species commonly observed are the American oystercatcher (*Haematopus palliatus*), plovers (*Charadrius sp.*), willet (*Catoptrophorus semipalmatus*), sandpipers (*Scolopacidae*), lesser/greater yellow-legs (*Tringa flavipes/T. melanoleuca*), and gulls/terns (*Laridae*). Shorebirds typically feed by foraging for invertebrates in mud flats and sandy beaches. Plovers are medium sized birds with short, thick bills. They run to feed on vulnerable invertebrates. Avocets are larger shorebirds with long recurved bills that feed by using both tactile and visual methods. Foraging activity is usually focused around periods of low tide, where they feed in the intertidal zone. During high tides, shorebirds roost in flocks on the high beach, marsh, and sometimes on docks (Sanders and Murphy 2009). Sanders et al., (2004) stated that the American

Oystercatcher has been identified as an “extremely high priority” shorebird by the US Shorebird Conservation Plan partly due a decline in suitable beach habitat.

Seabirds tend to nest on small coastal islands in mixed colonies. The three common families of seabirds are Pelecaniae (pelicans), Pynchopidae (skimmers), and Laridae (gulls and terns). Seabirds that frequent the South Carolina coast are the sandwich tern (*Thalasseus sandvicensis*), least tern (Sterna albigrons), royal tern (*Thalasseus maximus*), common tern (*Sterna hirundo*), eastern brown pelican (*Pelecanus occidentalis*), Forster’s tern (*Sterna forsteri*), gull-billed tern (*Gelochelidon nilotica*), and black skimmer (*Rynchops nigra*). The least tern is listed as state threatened due to a loss of nesting habitat (Thompson et al 1997). All of the birds are subject to loss of suitable nesting habitat (Murphy et al., 2009). Seabirds usually nest on isolated coastal islands that are high enough to prevent overwashing, yet small enough to not support mammalian predators (Murphy et al 2009). They are picivorous and feed in nearshore and estuarine waters. During the nesting season, foraging occurs within 10 to 15 miles of their nesting sites including the nearshore and estuarine waters of Charleston Harbor.

Migratory birds in South Carolina represent three families: Scolopacidae (sandpipers), Charadriidae (plovers), and Recurvirostridae (avocets). Migrations can span across continents. Migratory shorebirds in South Carolina may be transient on northbound flights in the spring, southbound in the fall, or even wintering birds. Surveys of migrant shorebirds over the last three decades indicate that populations are on the decline (Manomet 2004).

Several features within Charleston Harbor are notable for their importance for local biota. In fact, several sites in or near the harbor are so important for nesting migratory birds, the state of South Carolina has closed them to human access for all or part of the year. One of these sites is the Crab Bank Seabird Sanctuary, which is closed from March 15 to October 15 for the protection of nesting birds and their young. Typical bird species using these sites include black skimmers, brown pelicans, willet, Wilson’s plover, and various tern species (sandwich, least, royal, common, Forester’s, and gull-billed). The sites are preferred due to both the availability of grounds for nest creation as well as forage, i.e., small fish for supplying the chicks.

SCDNR provided a nesting update for both Crab Bank and Shutes Folly (email data from Felicia Sanders, 2016) (Table 4). While these data don’t necessarily indicate any notable trends related to these two sites, they clearly show the importance of these islands to nesting habitat for seabird nesting.

Table 4. Seabird nesting numbers for Crab Bank and Shutes Folly (2009-2015)

	2009		2010		2011		2012		2013		2014		2015	
	Crab Bank	Shutes Folly	Crab Bank	Shutes Folly	Crab Bank	Shutes Folly	Crab Bank	Shutes Folly	Crab Bank	Shutes Folly	Crab Bank	Shutes Folly	Crab Bank	Shutes Folly
BLACK SKIMMER	51	112	143	70	53	N/A	79	4	8	58	10	N/A	50	106
BROWN PELICAN	907	74	589	59	722	139	463	N/A	304	35	517	348	647	8
GULL-BILLED TERN	13	89	9	35	42	3	N/A	47	62	N/A	N/A	N/A	9	40
ROYAL TERN	1466	N/A	1032	N/A	2661	N/A	1581	N/A	1140	N/A	1337	N/A	1677	N/A
SANDWICH TERN	6	N/A	N/A	N/A	320	N/A	475	N/A	347	N/A	240	N/A	603	N/A

Although the seabird sanctuaries are known to provide necessary habitats for migratory bird species discussed above, many other species frequent the sanctuaries and other areas/habitats within and near the project area. Such birds roost and forage in surrounding coastal environments such as tidal flats, mud flats, and beaches during the winter months. Species likely to occur are listed in Table 5, along with their associated habitats.

Table 5. Avian species with the potential to occur in the project area

Common Name	Scientific Name	Legal Status	SCDNR Priority Ranking	Sand/ Beach	Mud -flat	Pond	Salt Marsh	Open Water
American avocet	*Recurvirostra americana*		High		X	X		
American bittern	*Botaurus lentiginosus*	State Concern	Highest				X	
American coot	*Fulica americana*		Moderat			X		
*American oystercatcher	*Haematopus palliatus*	State Concern	Highest		X	X	X	
Bald eagle	*Haliaeetus leucoephalus*	State	High			X		X
Belted kingfisher	*Ceryle alcyon*		High			X		X
Black rail	*Laterallus jamaicensis*	State Concern	Highest				X	
*Black skimmer	*Rynchops niger*	State Concern	Highest	X		X		X
Black-backed gull	*Larus marinus*			X	X	X		X
Black-bellied plover	*Pluvialis squatarola*		High	X	X			
Black-crowned night heron	*Nyticorax nycticorax*		Highest			X	X	
Black-necked stilt	*Himantopus mexicanus*		Highest	X	X	X		
*Brown pelican	*Pelecanus occidentalis*		High				X	X
Clapper rail	*Rallus longirostris*		Highest				X	
Common moorhen	*Gallinula chloropus*		High			X		X
Common tern	*Sterna hirundo*		Highest	X		X	X	X
Double-crested cormorant	*Phalacrocorax auritus*					X		X
Dunlin	*Calidris alpina*		High	X	X			
Foresters tern	*Sterna forsteri*		High	X		X	X	X
Glossy ibis	*Plegadis falcinellus*		Moderat		X	X	X	
Great blue heron	*Ardea herodias*		Moderat			X	X	
Great egret	*Ardea alba*		High			X	X	
Greater yellowlegs	*Tringa melamoleuca*		High		X	X	X	
*Gull-billed tern	*Sterna nilotica*	State Concern	Highest	X		X		X
King rail	*Rallus elegans*		Highest				X	
Laughing gull	*Larus atricilla*			X	X	X		X
Least tern	*Sterna antillarum*	State Threatened	Highest	X		X		X
Little blue heron	*Egretta caerulea*	State Concern	Highest		X	X		
Long-billed dowitcher	*Limnodromus scolopaceus*		Moderat		X	X		
Osprey	*Pandion haliateus*					X		X
Piping plover	*Charadrius melodus*	Fed Threatened	Highest	X	X			
Red knot	*Calidris canutus*	Fed Threatened	Highest	X	X		X	
Ring-billed gull	*Larus delawarensis*			X	X	X	X	X
*Royal tern	*Sterna maxima*		High	X		X		X
Ruddy turnstone	*Arenaria interpres*			X	X			
Sanderling	*Calidris alba*		Highest	X	X			
*Sandwich tern	*Sterna sandvicensis*		Highest	X		X		X
Semipalmated plover	*Charadrius semipalmatus*		Moderat	X	X			
*Snowy egret	*Egretta thula*		Moderat		X	X		
Sora	*Porzana carolina*		High				X	
Spotted sandpiper	*Actitis macularia*			X	X			
*Tricolored heron	*Egretta tricolor*		High				X	
Virginia rail	*Rallus limicola*		High				X	
Whimbrel	*Numenius phaeopus*		Highest	X	X		X	
*White ibis	*Eudocimus albus*		Highest		X	X		
Willet	*Tringa semipalmata*		High	X	X			
Wilson's plover	*Charadrius wilsonia*	State Threatened	Highest	X	X			
Wood stork	*Mycteria americana*	Fed Threatened	Highest			X		X
Yellow rail	*Coturnicops*		Highest				X	
Yellow-crowned night heron	*Nyctanassa violacea*		Highest			X		X

**Noted by SCDNR as a species that nests on the islands*

Some of the notable areas providing various habitat functions are detailed below. Many of these sites are not only used by bird species, but also by other vertebrate species that are associated with birds (in many cases preying on eggs, chicks, and fledglings).

5.13 Coastal Barrier Resources

The primary land-based regulatory boundary that can influence activities in the nearshore coastal zone is the Coastal Barrier Resources System (CBRS) established by the Coastal Barrier Resources Act of 1982 (CBRA). The CBRS is comprised of undeveloped coastal barriers along the Atlantic, Gulf, and Great Lakes coasts. The law encourages the conservation of hurricane-prone, biologically rich coastal barriers by restricting federal expenditures that encourage development, such as federal flood insurance through the National Flood Insurance Program. Activities that could adversely affect the biological resources or stability of CBRS sites are a concern to USFWS.

Within the vicinity of the proposed beneficial use projects there is the Morris Island Complex (M006) (Figure 26).

5.14 Cultural and Historic Resources

Cultural resources are defined by the National Historic Preservation Act (NHPA) as prehistoric and historic sites, structures, districts, or any other physical evidence of human activity considered important to a culture, a subculture, or a community for scientific, traditional, religious, or any other reason. Several federal laws and regulations protect these resources, including the NHPA of 1966, the Archaeological and Historic Preservation Act of 1974, the American Indian Religious Freedom Act of 1978, the Archaeological Resources Protection Act of 1979, and the Native American Graves Protection and Repatriation Act of 1990. Documentation of historic/cultural resources is important for this project because Charleston Harbor provides an environment that is rich in prehistoric and historic human activity, and its geological setting is characterized by sediment types, especially heavy silts and clays, that are well known for preserving shipwrecks and their contents.

Section 106 of the NHPA and its implementing regulations, 36 CFR Part 800, requires an assessment of the potential impact of an undertaking on historic properties that are within the proposed project's Area of Potential Effect (APE), which is defined as the geographic area(s) "within which an undertaking may directly or indirectly cause alterations in the character or use of historic properties, if any such properties exist." The APE for the proposed beneficial use actions was determined to consist of the direct action area where construction will be occurring and material placed.

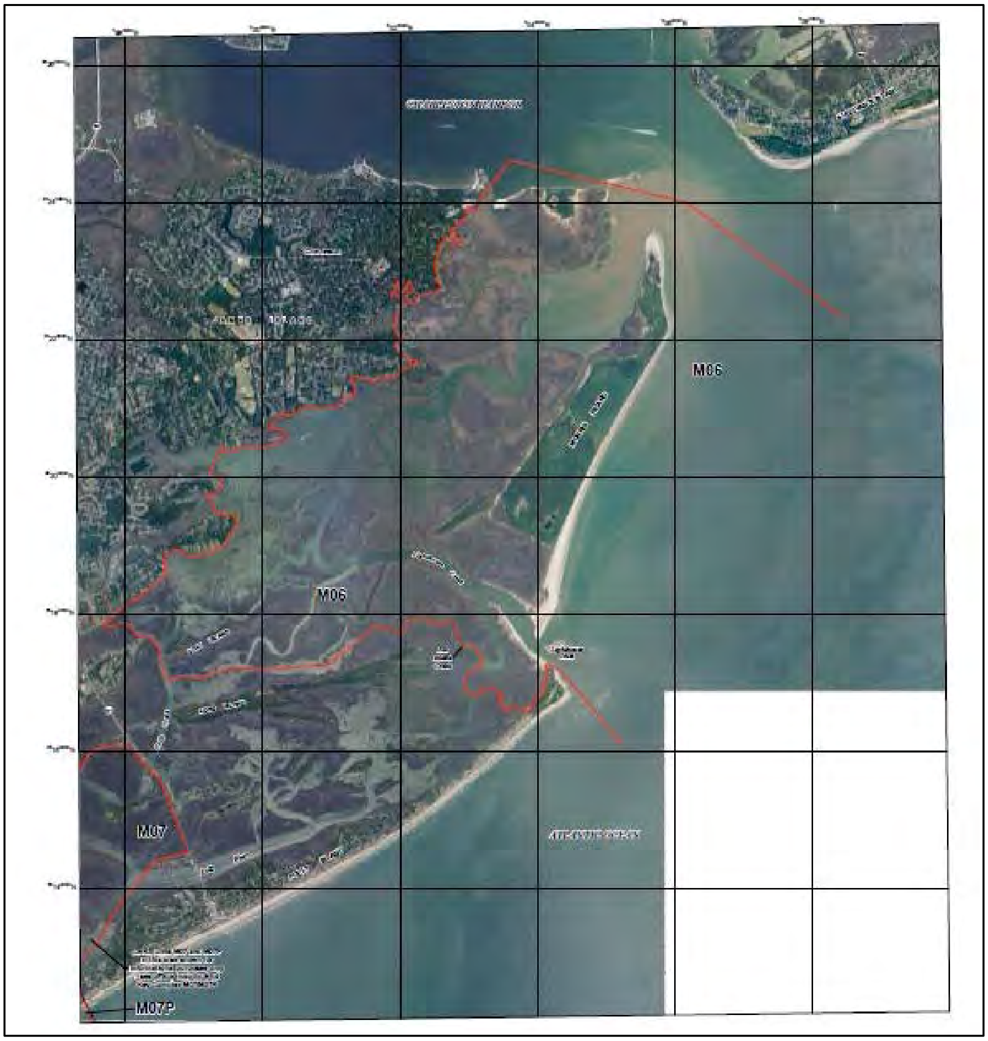


Figure 25. Morris Island Complex (M06) of the Coastal Barrier Resources System

All information regarding cultural and historic resources contained within the IFR/EIS (USACE 2015) is incorporated by reference. Coordination with the South Carolina Department of Archives and History (SCDAH) and South Carolina Institute for Archaeology and Anthropology (SCIAA) regarding Section 106 has occurred. There are no known historic resources located on Crab Bank or around the potential placement areas for Shutes Folly (Arch Site and personal communication with Jim Spirek, SCIAA). Morris Island is the site of Battery Wagner which was a fortification built at the mouth of Charleston Harbor.

5.15 Aesthetics and Recreation

Charleston is a historic seaport, and has been associated with vessels of increasing size for hundreds of years. A scenic setting is provided by the harbor and river and the numerous vessels common to these waters, including commercial and recreational boats as well as vessels calling on the Port. The estuarine environment provides opportunities for boating and fishing, as well as an escape from the faster pace of land-based activities. Several boat ramps and marinas are located in Charleston Harbor.

Crab Bank is a tourist attraction for wildlife viewing trips originating from Shem Creek and other areas of Charleston Harbor. In fact, Crab Bank recently was fitted with a video camera so that viewers could watch the birds nesting, loafing, and foraging on and around the sand bank (https://www.youtube.com/watch?v=kYd66zI3_gY&feature=player_embedded).

Morris Island provides recreational opportunities for those who wish to boat out to the island. Numerous tour companies offer trips to the island. The island and the surrounding waters are used for recreational fishing including guided tours and individuals. Other opportunities include wildlife viewing, shell collecting, metal detecting, water sports, and other beach related activities.

5.16 Socioeconomics

On February 11, 1994, the President issued Executive Order (E.O.) 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations.* The order required that Federal agencies conducting programs, policies, and activities that substantially affect human health or the environment to determine whether there is a disproportionately high and adverse human health or environmental effects on minority and low-income populations.

6.0 Alternatives Evaluated

During the feasibility phase, USACE hosted a meeting with the Post 45 Interagency Coordination Team (ICT) on April 29, 2013 to discuss the various opportunities for beneficial uses of dredged material in more detail and provide preliminary information about the types of analyses that would be needed, monitoring requirements, construction methods, construction windows, physical characteristics of material, etc. Based on a review of the information gained from this meeting and subsequent follow up coordination including both USACE and resource agency prioritization the following options were identified and incorporated into the Final IFR/EIS:

- ODMDS berm creation
- Hardbottom habitat creation
- Crab Bank enhancement
- Shutes Folly Island (Castle Pinckney) protection
- Fort Sumter/Fort Moultrie protection
- Nearshore placement off Morris Island.

While this list presented a broad picture of the alternatives, the initiation of the PED phase allowed USACE the opportunity to reevaluate these and other alternatives. USACE met again with the ICT on September 30, 2015 to discuss the fine tuning of various alternatives. A field trip was held on October 1 to visit potential sites at Crab Bank, Shutes Folly, and Ft. Sumter. USACE started with the below detailed list of alternatives that were developed in coordination with the USACE Charleston District established Interagency Coordination Team (ICT).

Alternative 1a. Crab Bank Enhancement – Place material along the high point of the island and western side towards the navigation channel.

Alternative 1b. Crab Bank Enhancement – Place material along the south end of the island because it is more eroded and at a lower elevation than the northern portion of the island.

Alternative 1c. Crab Bank Enhancement – Place material on the Mt. Pleasant side (northeast side) of the island to create/expand marsh habitat

Alternative 1d. Crab Bank Enhancement – Place material on northwest side of the island to create more shallow sub-bottom habitat

Alternative 2a. Shutes Folly Enhancement – Create/expand marsh on west side of island.

Alternative 2b. Shutes Folly Enhancement – Enlarge eastern frontal sand bank of island that is currently covered in whole dead oyster shell.

Alternative 3a. Use rock material to build up a berm around the perimeter of the Ocean Dredged Material Disposal Site

Alternative 3b. Use rock material to create artificial reefs near the entrance channel

Alternative 4. Create an offshore bird nesting island

Alternative 5. Offshore fish attractant and wave attenuation berm

Alternative 6. Place sandy material into the used portions of the Folly Beach sand borrow areas

Alternative 7a. Marsh Creation on landward side of Morris Island

Alternative 7b. Marsh Creation at Drum Island fringing marshes

Alternative 7c. Marsh creation along fringing marshes of Clouter Creek and Daniel Island disposal areas.

Alternative 8. Use material to build up an eroding dike along the Intracoastal Waterway behind Breech Inlet.

Alternative 9a. Fort Sumter shoreline protection – Use dredged rock to create revetment or breakwater

Alternative 9b. Fort Sumter shoreline protection – Use dredged rock to create submerged reef to break up wave energy

Alternative 9c. Fort Sumter shoreline protection – fill geotextile tube(s) in front of Ft. Sumter and backfill with fine material.

Alternative 10. Place material around Morris Island Lighthouse

Alternative 11. Commercial sale

Alternative 12. Create oyster reefs with dredged rock and place along select locations within the harbor.

Alternative 13a. Place material in the nearshore area of Morris Island.

Alternative 13b. Place material on the beachfront of Morris Island

Alternative 14. Use dredged rock for shoreline protection in high erosion areas

Please see Appendix G of this Supplemental EA for a table depicting the interagency discussions about these alternatives.

Environmental considerations in alternative formulation for beneficial use of dredged material include whether placement would be in sensitive and incompatible areas, such as:

- Shipping lanes, anchorage areas, and navigation restrictions
- Essential fish habitat (EFH), including habitat areas of particular concern (HAPC)
- Breeding, spawning, nursery, feeding, or passage areas of living resources
- Geographically limited fisheries and shellfisheries
- Shrimp trawling areas
- Areas of hard and live bottom
- Artificial reefs, fish havens, known critical spawning areas
- Threatened and endangered species and critical habitat
- Mineral extraction sites (sand borrow areas)
- Significant natural or cultural resources of historical importance

6.1 Alternatives Considered but Eliminated from Further Evaluation

During the feasibility and PED phases, USACE considered the aforementioned wide range of alternatives. This section describes the alternatives that were considered during the project planning process for this proposed action but are not being carried forward for further analysis and the rationale for eliminating them. Based on the current conditions, the following alternatives were eliminated from detailed analysis in this Supplemental EA.

6.1.1 Alternative 1b - Crab Bank South End Enhancement

This alternative involved the placement of material along the south end of the island because it is more eroded and at a lower elevation than the northern portion of the island. This alternative was eliminated as a standalone alternative because it would essentially create two separate islands. This is not as desirable a condition due to the potential to create an inlet between the high points of the island: the northwest section and the newly created portion along the south end. This alternative was not preferred because keeping with the historical condition was deemed more favorable by the ICT.

6.1.2 Alternative 1c - Crab Bank Salt Marsh Enhancement

This alternative involved the placement of material on the Mt. Pleasant side (northeast side) of the island to create/expand marsh habitat. This alternative was eliminated because without enlarging the channel-side beachfront of the island, placement behind the island would not be as stable, as observed by the sparse marsh existing there now. Additionally, the preferred alternative would allow for the potential natural recruitment of saltmarsh by protecting the back side of the island from overwash on high tides.

This alternative could be a consideration for future beneficial use of finer grained maintenance dredging material and could be evaluated under a future USACE Continuing Authorities Program Study.

6.1.3 Alternative 1d - Crab Bank Sub-bottom Habitat Enhancement

This alternative involved a site specific project on Crab Bank whereby material would be placed on the northwest side of the island to create more shallow sub-bottom habitat. Working specifically on this portion of the island was not favorable because spreading the material across the island to restore the historic island profile and footprint was more preferred. Also, building up sub-bottom habitat on the northwest side could affect safe recreational navigation, as it's close to an area where recreational boaters currently leave and return to Shem Creek when not in the navigation channel.

6.1.4 Alternative 2a - Shutes Folly Enhancement-Enhance Marsh Habitat

This alternative consisted of using a cutterhead dredge for dredged material placement to build up shallow sub bottom habitat to achieve an elevation consistent with the existing marsh in the area. While there may be an opportunity to do this with future maintenance dredging, this option presented timing constraints and environmental constraints due to the necessary type of material and potential for EFH impacts and real estate issues. This option could be a consideration for a future beneficial use project using dredged maintenance material.

6.1.5 Alternative 4 - Island Creation

Island creation, similar to Tompkins Island that was created in the mouth of the Savannah River, was considered for this project. Since it would involve creating new high ground, USACE considered areas that were already relatively shallow in order to reduce costs. During coordination with resource agencies, an area was identified just south of the south jetty near where the jetty becomes emergent. This area is relatively shallow (< 20 feet MLLW) and would not be as much of an impediment to navigation. In order to create an island within this area, rip rap would be needed to stabilize the exposed portions of it. Without riprap, it would erode due to exposure to ocean wave action. This would allow it back into the littoral drift but would not provide stable bird habitat. The use of rip rap would increase the cost of the project and goes beyond a viable beneficial use alternative. There are environmental considerations that would need to be addressed dependent on the amount of sand percentage and EFH issues. This alternative could have ramifications on the shrimping industry as this area is used for shrimp trawling. A version of the island configuration was modeled using the Coastal Modeling System (Appendix I). The report concluded that a "considerable portion of the sediments (would migrate) back into the Navigation Channel. Some coarse sediment deposited along the outside of the southern jetty and some fine sediment moved offshore in front of Morris Island shorelines." It is possible that more detailed modeling would be required in order to determine the longevity of the project since it's in a high energy area. Due to the reasons presented above, this alternative was eliminated from further evaluation.

6.1.6 Alternative 5 - Offshore fish and wave attenuation berm

This alternative involved the placement of material in between the ODMDS and the shoreline of Morris Island. The purposed would be to create a sand mound to mimic a large sand shoal complex for fish habitat. A secondary purpose would have been to potentially attenuate wave energy. This alternative was considered but eliminated from further consideration due to complexities with surveying for hardbottom habitat and cultural resources. Material that would be suitable for this was more effective for utilization closer to shore due to pumping distances. As a result of interagency coordination, it was determined that where possible, material should go closer to the shoreline.

6.1.7 Alternative 6 – Refill Folly borrow areas

The historic borrow areas for Folly Beach renourishment have been depleted. While an ongoing search is currently underway, this alternative would have attempted to place beach quality material in the borrow areas for future reuse on Folly Beach. This alternative was eliminated due to lack of beach compatible material for future placement on a developed beach (i.e., insufficient sand content), excessive pumping/travel distance, and due to high costs associated with the double handling of material to realize these benefits. Could be further investigated with a cost sharing sponsor for the oceanward material which has an unknown sand content.

6.1.8 Alternatives 7a, 7b, and 7c – Marsh Creation (Thin Layer Placement)

This alternative involved thin layer placement of dredged material at Morris Island (in an area known as Cummings Point), Drum Island and fringing marshes of Cooper and Wando Rivers. This alternative provides a potential one time option that could be easy and inexpensive to implement with varying transportation costs due to pumping distances, and logistical requirements. This placement method consists of placing dredged material in a relatively "thin" layer over emergent vegetation or shallow bottom habitat to maximize positive environmental effects by nourishing/restoring/creating wetlands. For this type of project, typically a cutterhead dredge equipped with a nozzle on the discharge line to spray a small layer of dredged sediment onto the existing or degraded marsh. This placement method is becoming, in suitable site-specific conditions, a more attractive sustainable sediment management alternative as the adverse impacts of sea level rise on wetlands are becoming more appreciated by federal and state stakeholders. Areas that are most feasible for this are shorelines in close proximity to where cutterhead dredging occurs. These areas include fringing marshes along the Cooper River. Other opportunities exist along fringing marshes of the Wando River although they are not as likely to occur if dredging with a clamshell occurs. However, new material in the Cooper and Wando will contain marl and therefore would not make a suitable marsh substrate. Segregating a thin layer of unconsolidated materials from the marl will be expensive and inefficient. Maintenance material consisting of unconsolidated fine material mixed with sand could possibly be used for this purpose. For these reasons, this alternative was eliminated for this study that is only evaluating the uses associated with dredging of new work (deeper) material. This alternative could be a consideration for future beneficial use of finer grained maintenance dredging material and could be evaluated under a future USACE Continuing Authorities Program Study.

6.1.9 Alternative 8 – Dredged Material Containment Area Dike Rebuilding

This alternative involved using material to build up an eroding dike along the Intracoastal Waterway behind Breech Inlet. This alternative involved too long of a pumping distance to be cost-effective and would involve additional mobilization of land based equipment for precise earth moving work to create a suitable dike for sediment containment. Additionally, there were geotechnical concerns over the suitability of the material for dike material. Therefore, this alternative was eliminated from further analysis.

6.1.10 Alternative 9a –Ft. Sumter Revetment/Breakwater Creation

This alternative involved using dredged rock to create a revetment or breakwater in front of Ft. Sumter. This feature was conceptualized to be around the east and south face of the Fort. The feature would have served to break up wave energy prior to reaching the shoreline of Ft. Sumter. After a detailed geotechnical review of the rock strength data, the limestone rock material was not deemed strong enough (i.e., hard enough) to withstand the high energy environment in this exposed area of the harbor. The USACE determined that these engineering concerns would not allow it to meet the engineering specifications for either a breakwater or revetment contained with Engineering Regulation (ER) 1110-2-1407 (Hydraulic Design for Coastal Shore Protection Project). The USACE evaluated the possibility that the instability of the limestone in this environment could cause displacement of the material that may further compromise the existing concerns about the integrity of the Fort armoring.

6.1.11 Alternative 9b – Fort Sumter Underwater Berm/Reef Creation

This alternative involved using dredged rock to create an underwater berm/reef in front of Ft. Sumter. The submerged berm/reef was conceptualized to be around 1500 ft long and it would have been placed in approximately 5-10 feet of water and no higher than mean low water. The berm/reef would have served to break up wave energy prior to reaching the shoreline of Ft. Sumter. An additional benefit would have been the creation of substrate for benthic invertebrates and for fish habitat. After a geotechnical review of the rock strength data, the rock material was not deemed strong enough (i.e., hard enough) to withstand the high energy environment in this exposed area of the harbor. The USACE determined that these engineering concerns would not allow it to meet the engineering specifications for either a breakwater or revetment. The USACE evaluated the possibility that the instability of the limestone in this environment could cause displacement of the material that may further compromise the existing concerns about the integrity of the Fort armoring. No further analysis was done to support the wave dissipation capability of the concept.

6.1.12 Alternative 10 – Placement around Morris Island Lighthouse

This alternative involved the pumping of unconsolidated material into the nearshore environment off of Morris Island around the lighthouse. Construction was conceptualized as a pipeline being used to pump out a slurry of material into an identified location. The benefits of this involved getting material back into the littoral drift rather than removing it from the littoral system by placing in the ODMDS. Additionally, it could serve as material to attenuate wave action around the lighthouse. Ultimately, the material pumping distances were too far to be cost effective as a least cost option. This alternative could be pursued if a sponsor is willing to take on the additional cost of environmental compliance and construction.

6.1.13 Alternative 11 – Commercial Sale of Dredged Material

This alternative involved the ability of the dredging contractor(s) to sell the material for commercial uses such as development fill, brick creation, etc. This alternative was eliminated from this analysis because there are no blanket prohibitions if a contractor wants the dredged material, is willing to pay for transportation that doesn't delay the least cost disposal option, and has appropriate authorizations to do so.

6.1.14 Alternative 12 - Oyster Reef Creation

This alternative involved the use of limestone rock for oyster substrate. Limestone rock is a good substrate for oyster spat recruitment. If an eligible non-Federal sponsor is willing to pay the incremental cost difference, rock dredged from the entrance channel could be loaded onto a barge and a bulldozer could push the material into intertidal areas of select locations within the harbor. This alternative could be pursued if a sponsor is willing to take on the additional cost of environmental compliance and construction.

6.1.15 Alternative 13a – Nearshore Placement off Morris Island

This alternative involved the pumping of unconsolidated material into the nearshore environment off of Morris Island. Construction was conceptualized with a pipeline being used to pump out a slurry of material into an identified location. The benefits of this involved placing material back into the littoral drift rather than removing it from the littoral system by placing in the ODMDS. Ultimately, the material pumping distances were too far to be cost effective as least cost option. This alternative could be pursued if a sponsor is willing to take on the additional cost of environmental compliance and construction.

6.1.16 Alternative 14 – Use Rock as Shoreline Protection

During the feasibility phase, USACE explored the possibility of using dredged limestone rock to protect the shorelines of sensitive historic and/or natural resources within the harbor. Some of these areas included Ft. Sumter, Castle Pinckney/Shutes Folly, Crab Bank, and Ft. Moultrie. This alternative was eliminated for the same reasons discussed in Alternative 9b.

6.2 Description of Alternatives Evaluated in Detail

6.2.1 No Action Alternative

Future conditions associated with not providing for beneficial use opportunities would result in dredged material capacity being used at placement areas rather than potential environmental enhancement locations. The no action alternative does not capitalize on environmental enhancements that could be achieved through the use of dredged material.

6.2.2 Alternative 1a - Crab Bank Enhancement

Dredged material could be used to enlarge Crab Bank by placing material on the west side of the island running from north to south. This would help support the avian species that utilize the island for nesting, roosting, and foraging (Figure 27). Crab Bank has been designated as an “Important Bird Area” in South Carolina and is established as “Crab Bank Seabird Sanctuary”. SCDNR indicates that, “Crab Bank supports colonies of nesting water birds because of its isolated nature and lack of mammalian predators. Although all species may not nest on the island each year, examples of species that have used the island include: brown pelican, least tern, royal tern, black skimmer, gull-billed tern, sandwich tern, common tern, laughing gull, Wilson's plover, American oystercatcher, willet, great egret, snowy egret, tricolored heron and ibis. Besides providing nesting habitat, the sanctuary provides winter loafing and feeding areas for numerous species (https://www.dnr.sc.gov/mlands/managedland?p_id=215). While the island fluctuates in size constantly, it has largely been migrating towards the north over the last 15 years. Further demonstrating a need for beneficial use of dredged material at Crab Bank, the USACE performed a shoreline change assessment and determined that the island has decreased in size from 17.94 acres of dry beach habitat in 1994 to 5.01 acres in 2011 (IFR/EIS, USACE 2015, Appendix A). USACE coordinated with resource agencies to discuss this option and agencies seemed to indicate that Crab Bank was the preferred option. Several agencies noted this in letters to USACE during the feasibility study (IFR/EIS, USACE 2015, Appendix Q). This size of the island is dependent upon obtaining funds from a cost-sharing sponsor for costs above the least cost disposal method.

Figure 26. Crab Bank beneficial use concept identified in Post 45 Final IFR/EIS

6.2.3 Alternative 2b – Shutes Folly Enhancement

Dredged material could be used to enlarge Shutes Folly to a previous condition by placing material on the northeast side of the island. This would help support the avian species that utilize the island for nesting, roosting, and foraging (Figure 28). Shutes Folly provides nesting habitat for colonial seabirds due to its isolated nature, small size, and lack of predators. It is one of only nine active nesting sites in the entire state. Skimmers and oystercatchers like the shell hash that faces the eastern side of Shutes Folly. The island has been noted by Charleston Harbor Wildlife as being “often considered for restoration.” They state that, “in 1997, wildlife biologists pressed for the island as a sight for dredge spoil to boost the small seabird colony there…” (http://charlestonharborwildlife.com/iwa/cp-sf/). Additionally, Castle Pinckney, a historic site, sits atop the island. This size of the island is dependent upon obtaining funds from a cost-sharing sponsor for costs above the least cost disposal method.

Figure 27. Shutes Folly beneficial use concept identified in Post 45 Final IFR/EIS

6.2.4 Alternative 3a – Rock berm around ODMDS

This action is fully described and evaluated in the Charleston Harbor Post 45 Final IFR/EIS (USACE 2015). Rock placement would consist of dredged rock from the entrance channel. The majority of the material would be smaller sized rock dredged with a cutterhead dredge. The Final IFR/EIS included a preferred design where the berm would be topped with rock dredged with a mechanical dredge as a beneficial use component of the project (USACE intent was to maximize the size of this rock consistent with beneficial use parameters) to remove rock from the channel. However, that document also stated that a cutterhead dredge could be used for the entire berm resulting in smaller size materials and reduced cost. See the Final IFR/EIS, USACE 2015, at Section 4.2.6.1, App. H at 5, and App. I at 22. Further evaluation has indicated that mechanical dredging would not be the least cost disposal alternative. The dredging contractor will not be required to use a certain equipment type in order to create the berm. The primary purpose of the berm is for sediment containment as per the evaluation of the berm performance that was modeled during the Environmental Assessment of the ODMDS modification. Secondary purposes include fish habitat creation and hardbottom habitat creation.

6.2.5 Alternative 3b – Rock Reefs near Navigation Channel

This alternative would involve the creation of two mitigation reefs, six beneficial use reefs, and additional reef creation at SCDNR identified artificial reefs. This action is fully described and evaluated in the IFR/EIS (USACE 2015), and all findings from that document are still valid. As with Alternative 3a above, further evaluation of construction methodologies and costs for the beneficial use reefs during PED have resulted in the conclusion that the beneficial use reefs will need to be constructed with restrictions on dredging equipment type being removed from consideration and rock size being un-specified. The USACE committed to evaluating the seafloor in the area of the proposed reefs in order to avoid impacts to existing hardbottom habitat and/or any cultural resources. During the PED phase, the USACE performed these geophysical surveys and groundtruthing to aid in the siting of these reefs.

6.2.9 Alternative 13b - Beach Placement on Morris Island

This alternative would involve the placement of predominantly sandy material on the eroding shoreface of Morris Island around the landward terminus of the south jetty of Charleston Harbor. The jetty has been experiencing some flanking and escarping of the dunes in that area. The alternative is described fully below.

7.0 Description of the Proposed Action

The proposed action consists of multiple beneficial use alternatives that were identified in the Final FR/EIS (USACE 2015) and which may be implemented and constructed contingent upon funding from a cost-sharing sponsor for incremental costs beyond the least cost disposal method. It is the intent of the US Army Corps of Engineers to use as much material for beneficial uses as is reasonably possible and where policies allow. Therefore this Supplemental EA further evaluates and selects multiple alternatives to assess potential impacts and benefits. It is important to note that all of the below options are dependent upon an eligible non-Federal sponsor partnering with the USACE on the additional costs beyond least cost disposal (none are least cost disposal methods).

7.1 Crab Bank Enhancement

Crab Bank, an eroding island in the middle of Charleston Harbor, could be enhanced/enlarged using new work dredged material from Bennis and Rebellion Reaches of the navigation channel (Figure 29). Figure 9 shows the area within the navigation channel that material will be dredged from. Geotechnical analysis of material within this area reveals that there is roughly 800,000 cy to 1,200,000 cy of material depending on if full overdepth dredging is reached. This beneficial use alternative is not a least cost disposal option and would require an eligible non-Federal sponsor to fund completely or share in the increased costs over the least cost placement alternative.

A clamshell dredge or a cutterhead pipeline dredge could be used to excavate the material from the available reaches of the channel. If a clamshell or other mechanical dredge is used, the material will be deposited into a scow. An offloader will be used in conjunction with the scow between the channel and Crab Bank (which would not be required if a cutterhead is used). Approximately 4,000 ft of pipeline would run from the dredging area or offloader area to the Crab Brank placement area. Similar to beach nourishment jobs, some heavy machinery will likely be utilized to control the placement and flow of material. This equipment could include front end loaders and bulldozers. The equipment could be used to build up temporary containment dikes using existing material from the island in order to contain the discharge of material. Effluent would be allowed to discharge from discrete breaks in the containment berms. The contractor would be required to make efforts to minimize turbidity released from the site; however, it is assumed that fine material would wash away into the surrounding waters similar to what occurs during the dredging operation. This would be temporary in nature and would cease upon completion of construction. The USACE will not dictate exact construction methodology, and other methods could be used if deemed cost-effective. It is anticipated that construction would initiate on the northern portion of the island because this is currently the highest elevation and provides a good starting platform for shore-based equipment. Construction could occur in this area between October 15 and April 15 to avoid periods of high bird nesting activity. Temporary protection would be afforded to the existing saltwater marsh only in the northwestern part of the island, which provides the greatest area of wetland habitat. Similar avoidance of the remaining small, patchy areas would limit cost effective construction and affect the outcome and viability of the beneficial use project. It is anticipated that construction would continue south and eastward. Once the construction has moved beyond the largest area of bird nesting (the northwestern portion), construction would be allowed to occur year-round. Discussions with SCDNR and USFWS have indicated that this approach would not have significant effects on the nesting birds and the long term benefit would outweigh any temporary disturbance. Section 5.4.14 of the IFR/EIS (USACE 2015) identified a dredging window in the channel at the mouth of the inlet and underneath the Ravenel Bridge for the new work construction only. The window states that no dredging will occur within Mt. Pleasant Reach, Rebellion Reach or between the jetties in Ft Sumter Reach between April 1 and September 30 to avoid impacts to larval fish in an SCDNR identified fish spawning hotspot. Additionally, no new work dredging will occur 1000’ on either side of the Ravenel bridge during this same time period.

It is anticipated that between 800,000 and 1,200,000 cy of material could be placed upon the island for this project. Placement will be in a non-uniform pattern to allow for greater topographic complexity and therefore greater habitat diversity. This will allow for minimal amount of upland equipment required to grade the material thereby creating a less uniform surface. The contractor could be provided a range of elevations to target for island height. For example, the current high point of the island is roughly 8’ MLLW. As a conceptual design, the contractor could target a range between 6.5’ (roughly 1’ above mean high tide) and 10’ (an acceptable maximum height from ICT coordination) MLLW (Figure 30). This should minimize construction cost and benefit habitat rather than creating a uniform and flat surface. These methods could change slightly depending on the contractor chosen method to complete the project construction. General guidelines will be provided to the contractor consistent with what is provided in this documentation. In order to achieve a better cost, exact construction methodology will not be specified.

Figure 28. Crab Bank conceptual design (MLLW)

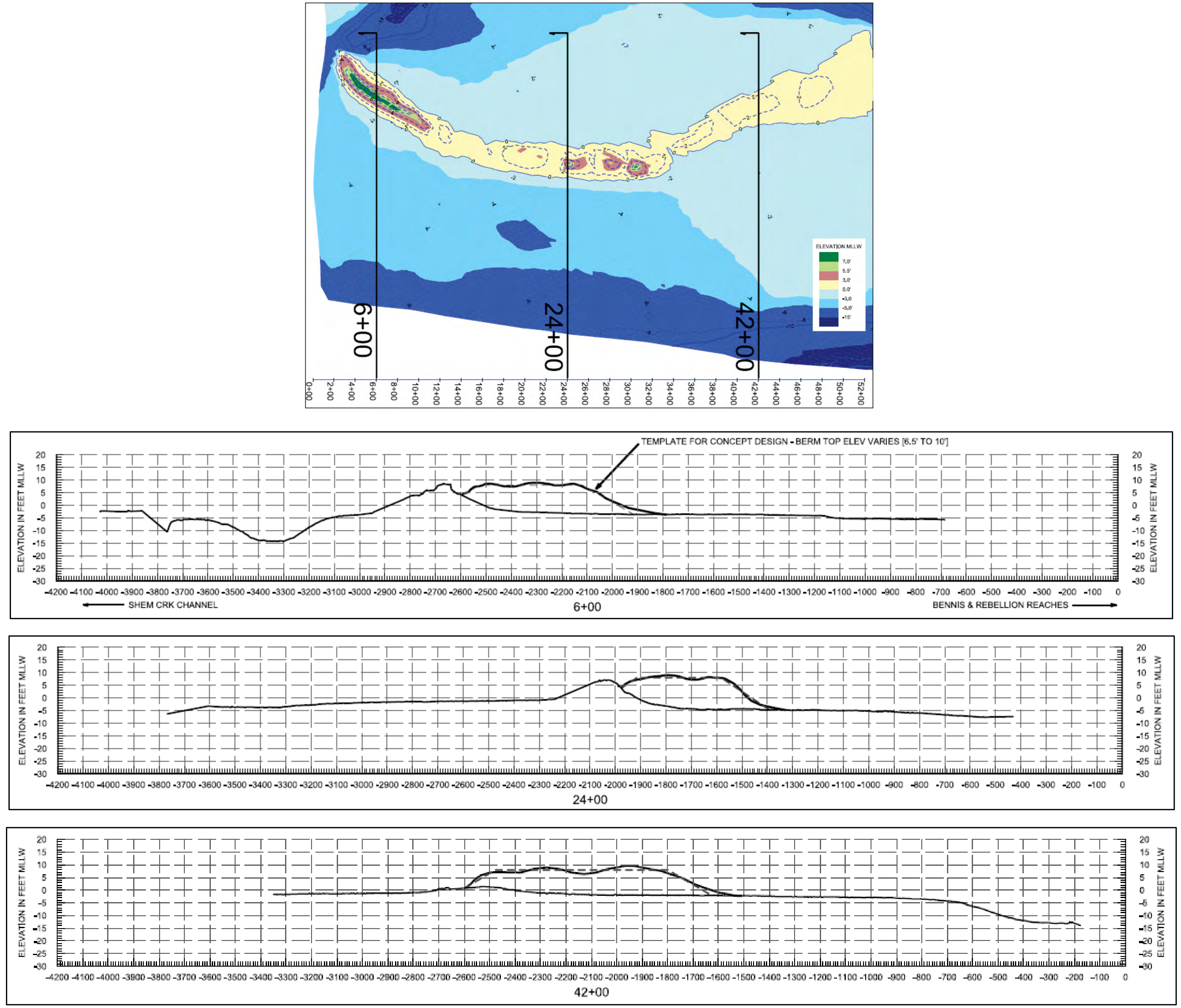


Figure 30. Conceptual design for variable surface elevation for Crab Bank

7.2 Shutes Folly Enhancement

Shutes Folly is also an eroding island in the middle of Charleston Harbor. It could be enhanced/enlarged using dredged material from Bennis and Rebellion Reaches of the navigation channel. Figure 9 shows the area within the navigation channel that material will be dredged from. As stated above, geotechnical analysis of material within this area reveals that there is roughly 800,000 cy to 1,200,000 cy of material depending on if full overdepth dredging is reached. Some material could go to Crab Bank and some could go to Shutes Folly if an eligible non-federal sponsor is willing to completely fund or share in the additional construction cost. This beneficial use alternative is not a least cost disposal option and could require an eligible non-Federal sponsor to fund the increased costs over the least cost placement alternative.

The anticipated methodology would be similar to the Crab Bank option description above. This potential beneficial use option anticipates roughly 300,000 cy of material to be placed along the eastern and southern faces of the island (Figure 31). For this potential option, approximately 2,000 ft of pipeline would run from the dredging area or offloader area to the Shutes Folly placement area. These methods could change slightly depending on the contractor chosen method to complete the construction. Temporary protection would be afforded to the existing saltwater marsh along the western part of the island during the construction process. Placement would be in a non-uniform pattern to allow for greater topographic complexity and therefore greater habitat diversity. This will allow for minimal amount of upland equipment required to grade the material thereby creating a less uniform surface. The contractor could be provided a range of elevations to target for island height. For example, the current high point of the island is roughly 10’ MLLW. As a conceptual design, the contractor could target a range between 6.5’ and 10’ MLLW, similar to the Crab Bank option (Figure 31).General guidelines will be provided to the contractor consistent with what is provided in this documentation. In order to achieve a better cost, exact construction methodology will not be specified. This option, if constructed, could provide increased area for shorebird nesting, roosting, and foraging. It could also provide temporary protection to Castle Pinckney on the southern portion of the island. It is important to note that the size of this option is dependent upon funding from a cost-sharing sponsor and enough suitable material.

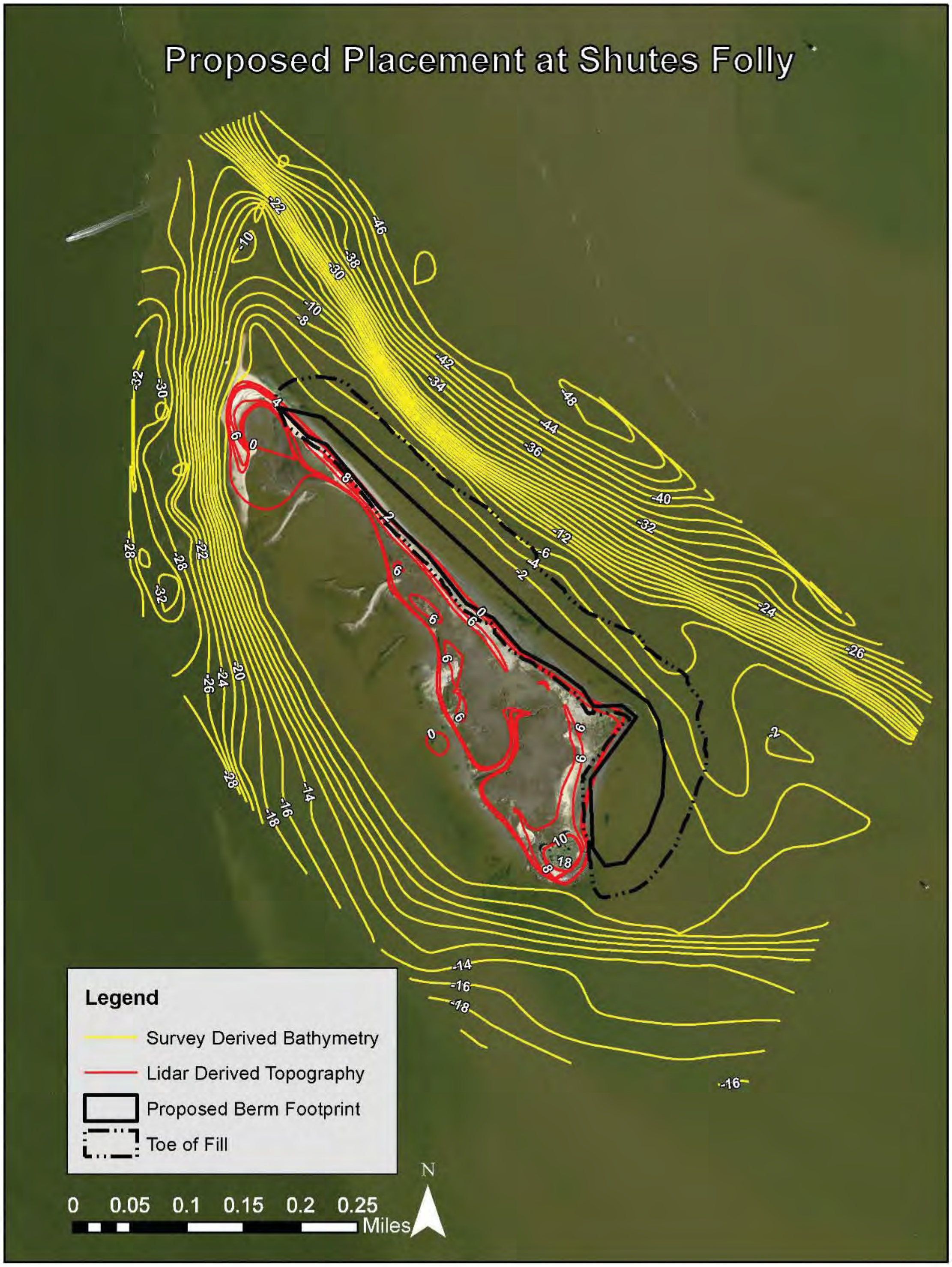


Figure 29. Shutes Folly conceptual design (MLLW)

7.3 Morris Island Beach Placement

Morris Island, an eroding island at the mouth of Charleston Harbor could be enhanced by providing for the placement of approximately 350,000 cy of material from the Ft. Sumter Reach of the Navigation Channel (Figure 10). Placement would occur north and south of the terminus of the south jetty of Charleston Harbor (Figure 32). As previously noted, this area of the island is undergoing flanking of the jetty which could create a bypass channel, further erode the island, potentially undermine the emerged jetty on the land and adversely affect the function of the jetties. This alternative is not the least cost, but may be constructed as a part of the USACE Charleston Harbor Operation and Maintenance program if the benefits to protect the Southern Jetty are deemed cost effective.

It is anticipated that a hopper dredge would be used to excavate material within this portion of the navigation channel. Physical testing of samples taken from within the Ft. Sumter Reach indicates available new work dredged material to consist of greater than 65% sand. A pumpout station located just north of the south jetty could be used to initiate pumpout of material from the hopper dredge. Approximately 7,500 ft of pipeline would be required to run from the pumpout station to the beach placement area. Work would occur from October through March due to the dredging window for new work construction established in the Post 45 IFR/EIS. Shore-based equipment, such as bulldozers and front end loaders would be required to move the pipeline around and ensure proper placement of material. It is anticipated that work would proceed similar to beach nourishment projects with temporary dikes for containment of material. The conceptual design beachfill concept consists of an 8 ft MLLW elevation berm, about 200 ft wide along about 6,000 ft of beachfront (3000 south of the jetty, 3000 north of the jetty). This berm ties in to the existing 8 ft contour line. In the area about 800 feet either side of the jetty a 12 ft berm extends from the existing 12 ft contour line with a width of about 150 ft, then stepping down to a 8 ft berm about 100 ft wide. The exact dimensions of this beachfill would be dependent upon design and cost considerations. The conceptualized option gives an idea of a maximum footprint. Design and construction are such that a protrusion will not be created whereby excessive erosion of the new material would occur.

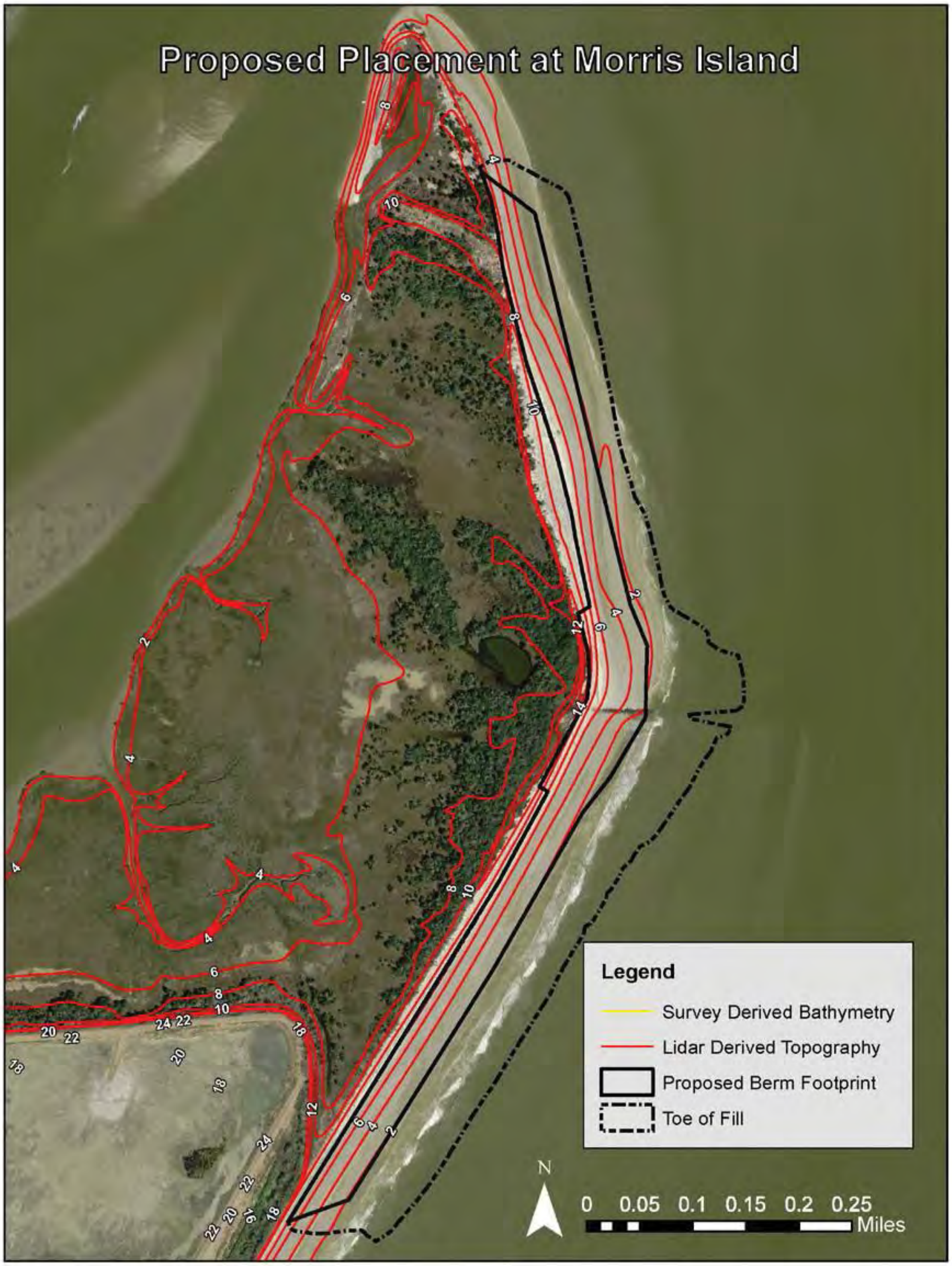


Figure 30. Morris Island conceptual design (MLLW)

7.4 Artificial Reef Creation / ODMDS Berm Construction

In the Charleston Harbor Post 45 Final IFR/EIS (USACE, 2015), USACE committed to disclosing the locations of these reefs (Figures 33 and 34) after an analysis of existing hardbottom and cultural resources to avoid. This section serves to disclose the locations of the artificial reefs proposed for construction. As explained in the Final IFR/EIS (USACE 2015), it is anticipated that eight 33-acre reefs will be created with dredged rock from the entrance channel. All environmental clearances for artificial reef creation with dredged material have been obtained during the feasibility phase. Two of the reefs will be created for mitigation resulting from the impacts to hardbottom habitat within the entrance channel. Six of the reefs could be created as beneficial use options if the dredging methods are the least cost placement alternative, consistent with the USACE/EPA “Federal Standard” (33 CFR Parts 335 to 338). Additional rock material could be placed at the existing SCDNR Charleston Nearshore Reef Site. An additional beneficial use of rock material was conceptualized to result from the creation of a “U”-shaped berm around the western, southern, and eastern side of the Ocean Dredged Material Disposal Site (ODMDS). The berm could serve 3 purposes: (1) Sediment containment, (2) Fish habitat, and (3) Hardbottom habitat.

The Final IFR/EIS discussed that the 2 mitigation reefs could be created using a mechanical dredge (e.g., clamshell or backhoe dredge) to dredge large (size undefined) rock from the channel to create substrate for low to high relief reef creation in an otherwise patchy and low relief area. The 6 additional beneficial use reefs, the Charleston Nearshore Reef and the ODMDS berm were conceptualized with a preferred design using a “base” of material dredged with a cutterhead and then topped with larger material from a mechanical dredge. In this way, these beneficial use options would create substantial habitat for nearshore fish species and substrate for invertebrates. The PED phase resulted in an opportunity for USACE to further refine the options and anticipated construction methodology, develop plans and specifications for construction, and assess the cost of various beneficial use options.

During the PED phase it was confirmed that the mitigation reefs will have a size requirement to ensure larger pieces of rock for the placement. In order to achieve this, it is anticipated that a mechanical dredge (either backhoe or clamshell) will be used; however, the contractor could meet these requirements through other methods as well. Regarding the beneficial use reefs and ODMDS berm, through further geotechnical analysis and discussions with industry, USACE determined that the likely least costly dredging and disposal method for the rock material is the use of a cutterhead dredge. Due to this, the beneficial use reefs (6 total) as well as the ODMDS berm and SCDNR reefs will have no size restriction and could be dredged with either a cutterhead or a mechanical dredge. This will ensure the best costs are achieved and that it will remain with the Federal Standard as the least cost, environmentally acceptable, disposal option. A cutterhead dredge could result in the rock being dredged into smaller rock pieces (i.e., jagged pieces likely up to basketball size) as well as a mixture of gravel and cobble. If the contractor uses a mechanical dredge for the construction of the beneficial use, the rock fragments could be larger in size. A combination of material types may also occur. While smaller rock from a cutterhead may not produce a substrate quite as stable for a hardbottom benthic community, it will still be a beneficial use for fish habitat enhancement and provide some hardbottom benefits from rock fragments. Consistent with the Final IFR/EIS, ROD, and Final Chief’s Report, the reef construction is anticipated to create essential fish habitat and result in significant habitat benefits to a variety of offshore resources, including incidental benefits to both recreational and commercial fishing. The beneficial use reefs will be constructed in water ranging from roughly -35 to -45 feet MLLW and will not be subject to frequent wave activity. The beficial use reefs will not likely be as stable as the mitigation reefs; however, the 100' buffer between the reef sites and nearby hardbottom habitat will minimize any sediment transport impacts to hardbottom communities. The dredging method will still allow for some larger rock to be present which will provide substrate for benthic invertebrates and structure for fish species.

Figure 33 demonstrates the proposed layout for these reefs and distinguishes between the mitigation reefs and the beneficial use reefs. The reefs were located to avoid existing hardbottom habitat and cultural resources. These areas to be avoided are indicated in Figure 28. Scows could be used to transport the material to the reefs. Each reef could be established as sixteen 300' x 300' cells to ensure an even distribution of material across the reef locations (Figure 34). In this manner, the reefs would maintain a mounded shape and allow for more diverse habitat structure across approximately 33 acres each. If constructed with larger rock, the habitat could be more suitable for invertebrate growth and hardbottom habitat development along with the fish habitat benefits. If constructed with smaller rock and/or gravel/cobble, the habitat could serve as a fish attractant and still have the potential for benthic invertebrate recruitment. Any of the placement techniques results in an enhancement to nearshore fisheries resources. After construction, bathymetric surveys will be performed of all rock placement and can be made available for viewing.

Since the feasibility study, USACE and SCDNR have discussed the possibility of placing more dredged rock material at additional SCDNR reef sites. Two of the possible reef sites are part of the Marine Protected Area program. Area 51 is a 1.5 mile x 1.5 mile area located in 70 feet of water off the SC coast and was established in April of 1998. Area 53 was established in April of 2003 with the same dimensions as Area 51 however it was located in 105 feet of water. Each of the SCDNR reefs would be created similar to the beneficial use reefs, in that the type of dredge / size of rock will not be specified. SCDNR has agreed to receive this material at these reefs depending upon the additional cost above the least cost disposal option. SCDNR could choose to select none of the reefs or could select any and/or all of the reefs for construction. All the identified reef sites are presently approved. Table 6 presents some of the characteristics of the reefs for easier viewing.

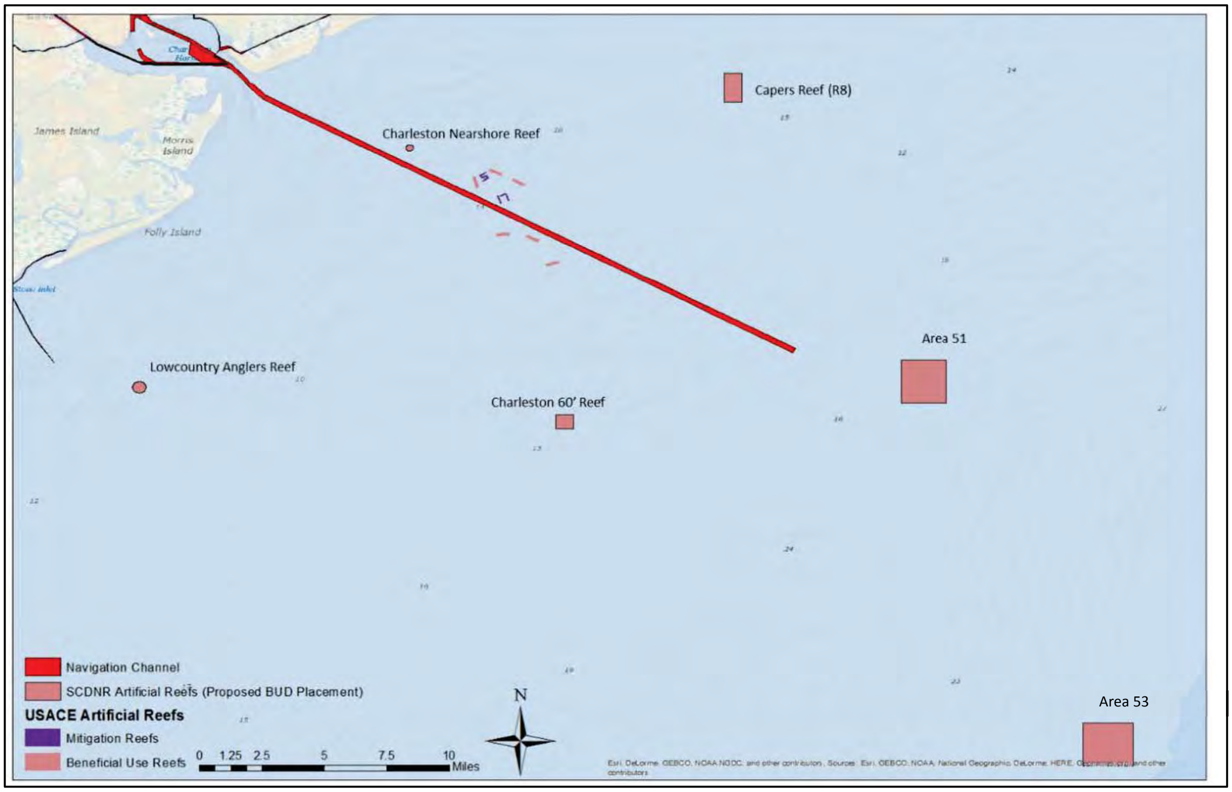


Figure 31. Broad view locations for proposed artificial reef creation

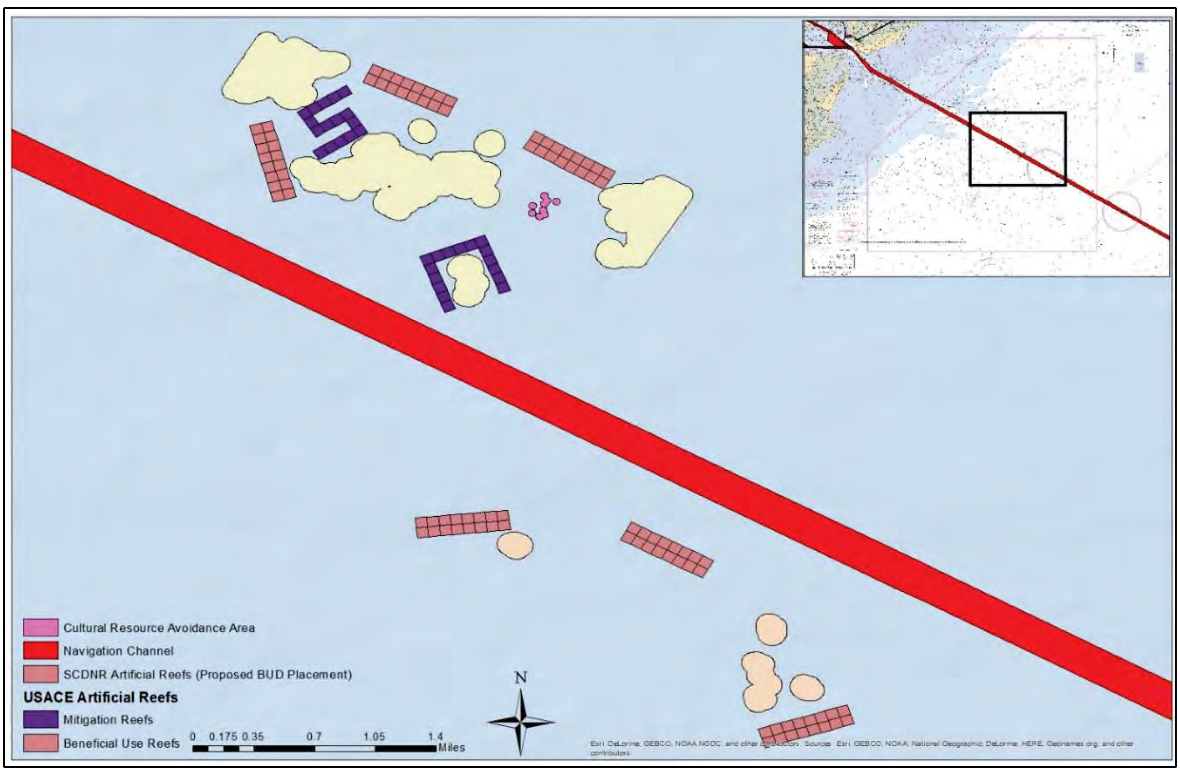


Figure 32. Design layout for USACE artificial reefs near the entrance channel

Table 6. Description of characteristics for proposed artificial reefs

Reef Name	Predominant Material Type	Excavation Method (anticipated)	Transportation Method (anticipated)	Placement Description	Benefits
USACE Mitigation Reef 1	Limestone Rock (Edisto Formation)	Mechanical Dredge (clamshell or backhoe)	Scow	16 300’x300’ cells (mounded formation – large rock)	Hardbottom habitat creation and fisheries enhancement
USACE Mitigation Reef 2	Limestone Rock (Edisto Formation)	Mechanical Dredge (clamshell or backhoe)	Scow	16 300’x300’ cells (mounded formation – large rock)	Hardbottom habitat creation and fisheries enhancement
ODMDS Berm Creation	Limestone Rock (Edisto Formation)	Unspecified (likely cutterhead)	Scow	“U” shaped berm approximately 46,000 linear feet roughly 10 feet off the bottom (max height <25’ MLLW)	Sediment containment, fisheries enhancement, potential hardbottom habitat
USACE Beneficial Use Reef 1	Limestone Rock (Edisto Formation)	Unspecified (likely cutterhead)	Scow	16 300’x300’ cells (mounded formation – small rock/cobble)	Fisheries enhancement, potential hardbottom habitat
USACE Beneficial Use Reef 2	Limestone Rock (Edisto Formation)	Unspecified (likely cutterhead)	Scow	16 300’x300’ cells (mounded formation – small rock/cobble)	Fisheries enhancement, potential hardbottom habitat
USACE Beneficial Use Reef 3	Limestone Rock (Edisto Formation)	Unspecified (likely cutterhead)	Scow	16 300’x300’ cells (mounded formation – small rock/cobble)	Fisheries enhancement, potential hardbottom habitat
USACE Beneficial Use Reef 4	Limestone Rock (Edisto Formation)	Unspecified (likely cutterhead)	Scow	16 300’x300’ cells (mounded formation – small rock/cobble)	Fisheries enhancement, potential hardbottom habitat
USACE Beneficial Use Reef 5	Limestone Rock (Edisto Formation)	Unspecified (likely cutterhead)	Scow	16 300’x300’ cells (mounded formation – small rock/cobble)	Fisheries enhancement, potential hardbottom habitat

USACE Beneficial Use Reef 6	Limestone Rock (Edisto Formation)	Unspecified (likely cutterhead)	Scow	16 300'x300' cells (mounded formation – small rock/cobble)	Fisheries enhancement, potential hardbottom habitat
SCDNR Charleston Nearshore Reef	Limestone Rock (Edisto Formation)	Unspecified (likely cutterhead)	Scow	Placement of dredged rock material with targeted center point within designated area	Fisheries enhancement, potential hardbottom habitat
SCDNR Lowcountry Anglers Reef	Limestone Rock (Edisto Formation)	Unspecified (likely cutterhead)	Scow	Placement of dredged rock material with targeted center point within designated area	Fisheries enhancement, potential hardbottom habitat
SCDNR Charleston 60' Reef	Limestone Rock (Edisto Formation)	Unspecified (likely cutterhead)	Scow	Placement of dredged rock material with targeted center point within designated area	Fisheries enhancement, potential hardbottom habitat
SCDNR Capers Reef	Limestone Rock (Edisto Formation)	Unspecified (likely cutterhead)	Scow	Placement of dredged rock material with targeted center point within designated area	Fisheries enhancement, potential hardbottom habitat
SCDNR MPA Area 51	Limestone Rock (Edisto Formation)	Unspecified (likely cutterhead)	Scow	Placement of dredged rock material with targeted center point within designated area	Fisheries enhancement, potential hardbottom habitat
SCDNR MPA Area 53	Limestone Rock (Edisto Formation)	Unspecified (likely cutterhead)	Scow	Placement of dredged rock material with targeted center point within designated area	Fisheries enhancement, potential hardbottom habitat

8.0 Environmental Impacts

This section will evaluate impacts associated with the Crab Bank and Shutes Folly enhancement options, the Morris Island beach placement option, and the no action alternative. The impacts of these proposed beneficial use options will be evaluated together in this section, since the methodology is similar for all three possible options. This section will only evaluate the construction of the aforementioned options. All dredging (i.e., excavation) related impacts have been previously evaluated in the Final IFR/EIS and do not warrant further evaluation.

Regarding the artificial reef creation, this document merely serves to publicly disclose the location of the mitigation and beneficial use reefs after cultural and hardbottom surveys were performed in PED. The five additional SCDNR artificial reef sites which are being considered by SCDNR and their partners for augmentation using limestone rock from the entrance channel are existing, approved reefs (see Figure 33). Generally, no new impacts would be realized beyond what was discussed within the Final IFR/EIS and supporting documentation, including 404(b)(1) evaluation (see Appendix M2 of the Final IFR/EIS for SCDNR nearshore reef placement 404(b)(1) analysis) and endangered species (the creation of artificial reefs was addressed through the previous NMFS consultation – no new consultation is warranted for reef siting). However, additional discussion of reef siting is included in section 8.9 Cultural and Historic Resources, below. Implementation of these beneficial use reef creation options is contingent upon costs and/or the availability of a cost-share partner.

8.1 Physical Characteristics (Wind, Waves, Tides, Currents)

As previously stated, Charleston Harbor is a tidal estuary that experiences diurnal tides. These tidal changes result in relatively strong currents on the ebb and flood tide. Wind waves and swell from the ocean also affect the hydrodynamics within the harbor and therefore shoreline changes.

No Action Alternative: Under the no action alternative, waves, tides, and currents will not be changed. Continued tidal and current action will further erode these islands and cause shifts in the amount of subaerial beach present. Sea level rise would exacerbate the loss of surface area of the islands and habitat.

Action Alternatives: Under the proposed action alternatives, one or more islands will be increased in their respective sizes. However, each of the alternatives is merely expanding the island footprint back to a similar historical footprint. Since no significant new features are being created, it is not anticipated that any of the proposed beneficial use options would have any distinctive hydrodynamic changes, nor will they impact natural circulation or sedimentation patterns from what has historically occurred in the past. Placement of material to enlarge and elevate the islands could temporarily offset the impacts of sea level rise.

8.2 Water Quality

No Action Alternative: Under the no action alternative, water quality will not be altered within the harbor and/or nearshore waters.

Action Alternatives: Significant impacts to water quality are not anticipated from implementation of any of the proposed beneficial use options. The dredging of material and resultant temporary turbidity plumes have previously been evaluated in the Final IFR/EIS. The sediment testing and elutriate analyses performed during the feasibility phase did not reveal that these reaches contained significant concentrations of any toxic or harmful substances. However, temporary and minor decreases in water quality are anticipated. Increased turbidity will be associated with construction at the immediate sites. The duration of the turbidity plume in the water column depends upon water temperature, salinity, currents, and sediment grain size (ICES 1992). The distance of sediment transport is dependent upon current strength, storm resuspension, water salinity and temperature, and sediment grain size (ICES

1992). For the potential beneficial use options (Crab Bank, Shutes Folly, Morris Island), the material from the channel is approximately 65% sand or greater. The remainder of the material is silts and clays.

Safeguards (i.e., containment dikes) could be used to minimize excess turbidity and suspended solids entering any adjacent water body. If necessary, additional temporary erosion and sedimentation control features will be conducted. At all times, protective measures shall be taken to prevent chemicals, fuels, oils, and greases from entering area waters. Chemical analysis of sediments from the navigation channel has revealed no significant concentration of toxic or harmful substances that could adversely affect water quality of the area (USACE 2015). Hence, water quality impacts from project construction would only be temporary and minor and the State's Classification Standards should not be contravened. Waters of the State of South Carolina would not be significantly affected and water clarity would return to ambient conditions shortly after completion of construction. No significant impacts are expected to result from the construction, dredging, and disposal operations. As required by the Clean Water Act, a Section 404(b)(1) evaluation for the effects of conducting the proposed action has been prepared and is included as Appendix H. A water quality certification (WQC) for the proposed action was granted by the SC Department of Health and Environmental Control on March 16, 2015. This WQC is still considered valid. This document was prepared in partial compliance with one of the conditions of the WQC (i.e., "provide DHEC the opportunity to review additional beneficial use plans"). If DHEC has concerns with the proposed action, USACE will work with them to resolve these problems for the Final EA.

8.3 Wetlands

No Action Alternative: Under the no action alternative, land loss along Crab Bank and Shutes Folly would continue to occur and potentially cause all or most of the supratidal area to be inundated on high tides. This could reduce the amount of intertidal marsh in the area. The patchy wetlands would continue to experience temporal changes in size and structure composition as the erosion continues. This scenario would severely limit the ability for continued use of the island for nesting shorebirds as their nests would become inundated on high tides. Sea level rise rate increases would exacerbate these impacts and cause them to occur sooner.

Action Alternatives: Under the various action alternatives, material from the navigation channel would be placed on the islands. As stated in Section 5.8, roughly 1.9 acres of wetlands exist on Crab Bank. This number changes from year to year based upon movement and erosion of the island. Wetland protection is only anticipated for the marsh complex on the northwest portion of the island. This marsh is the only significant area of existing marsh habitat. The approximately 0.8 acre fragment of marsh on the northern end would be protected with temporary sediment containment measures during construction. The remainder of the patchy wetlands will be impacted by the placement of material during construction. As previously stated, these wetlands are patchy and sporadic in nature and the overall benefit of the project outweighs the loss of this sporadic vegetation. Avoidance of these pocket wetlands would create additional expenses and inefficiencies when constructing the project. These areas are not supporting significant nursery habitat. The total estimated acreage of small wetland impacts is approximately 1.1 acres. These patchy wetlands are not significant in the overall context of saltwater wetland habitat within Charleston Harbor. Additionally, enlarging the channel-facing beachfront of the island would allow for the potential natural recruitment of saltmarsh by protecting the back side of the island from overwash on high tides. For Shutes Folly, the placement is not anticipated to have a significant impact on the approximately 12 acres of saltwater marsh on the west side of the island. Temporary sediment containment will be provided during the construction to prevent material from filling in the marsh. No wetlands on Morris Island will be impacted.

Both the Crab Bank and Shutes Folly options afford the opportunity for natural expansion of marsh habitat due to the increased volume of material placed on the island. Neither option would vegetate any areas; rather, natural vegetation would be allowed to occur. A more substantial island could allow for sediments to fall out behind the island and create new marsh over time.

8.4 Benthic Habitat

No Action Alternative: This alternative would result in no additional impacts to benthic habitat. Benthic community structure would change in areas of Crab Bank, Shutes Folly and Morris Island where erosion is likely to continue in the future. As these areas transition to subbottom habitat and are less exposed to intertidal variation the macroinvertebrate community will change.

Action Alternatives: The placement of the dredged material within the ecosystem would temporarily displace benthos; however, the area should repopulate rapidly. Impacts to benthos would occur through direct burial of the benthic habitat on all constructed portions of the islands. The disposal can adversely affect infauna, including both macro and micro benthic organisms by burying them or forcing motile organisms to migrate from the area. The area of burial is expected to be approximately 80, 27, and 64 acres for Crab Bank, Shutes Folly, and Morris Island, respectively. These impacts will be temporary in nature as repopulation will commence immediately after construction is completed. Recovery would be similar to beach projects and is expected within 6 months to one year. Species composition should be similar to that which existed prior to construction. These impacts are acceptable due to the long-term benefits of island enhancement outweighing the temporary burial impacts, and the fact that the proposed options are merely restoring the islands to a historical position.

Benthic impacts can also occur due to burial of benthic organisms in the area of the turbidity plume where sedimentation can occur. The effects of sedimentation on the benthos include smothering and decreased gas exchange, toxicity from exposure to anaerobic sediments, reduced light intensity, and physical abrasion (Wilber et al., 2005). Mobile species may be forced to leave; however, surrounding habitat is similar in nature and impacts will be minor and temporary. Benthic infauna can exhibit some ability for vertical migration activity following sediment placement (Bolam, 2011), although the degree of migration depends upon species and sediment type. Since sedimentation from the proposed beneficial use options would be dispersed across a broad area and no substantial depositional areas are anticipated, benthic impacts are anticipated to be minor.

8.5 Essential Fish Habitat

Impacts to EFH for the placement of material for these options could be to emergent wetlands, subbottom habitat, oyster reef, estuarine water column, and coastal inlets.

No Action Alternative: Essential Fish Habitat would immediately remain unaffected in its current state; however, as previously discussed, as Crab Bank and Shutes Folly continue to erode and migrate, there could be less area that is intertidal and more area that is consistently submerged. This could reduce the amount of intertidal marsh in the area. The patchy wetlands on Crab Bank would continue to experience temporal changes in size and structure composition as the erosion continues. In the vicinity of Morris Island, minor changes to EFH related to sea level rise (SLR) and erosion would continue in the future.

Action Alternatives: Impacts to EFH for all projects consists of the reduction of shallow sub-bottom habitat, the loss of minimal amounts of saltwater wetlands, and the loss of a minimal amount of oyster reef habitat. As stated in Section 8.3, roughly 1.9 acres of wetlands exist on Crab Bank, and approximately 1.1 acres of those wetlands would be impacted by burial during the construction of the proposed beneficial use project. This acreage area changes from year to year based upon movement and erosion of the island. Wetland impacts to Shutes Folly and Morris Island are not anticipated.

Shallow subbottom habitat will be buried during the construction of the proposed options. The loss or burial of subbottom habitat is not significant because the harbor has a large amount of this habitat type and recovery is expected to occur quickly. Edge habitat surrounding the islands will increase due to a larger circumference of all islands.

As stated in the No Action Alternative section, without the proposed options, wetland losses and migration could continue to occur. Habitat loss on each of the islands has been substantial over the years (see Section 5.4). These options would increase their size to a previous condition and in the case of Crab Bank, it could allow for the natural establishment of wetlands on the north and east side of the island. Because the benefits of this project to the shorebirds are substantial compared to the loss of shallow water habitat and small patchy wetlands, no mitigation is being proposed, nor is any warranted. These options are being pursued as beneficial use alternatives to traditional disposal in the ODMDS.

Temporary increase in turbidity will be associated with the placement of material for the proposed beneficial use options. However, these impacts will not be significantly greater than those already anticipated to occur as a result of the dredging itself. The location of the plumes will, however, be different than the dredging operations within the channel. Turbidity affects different life stages of fishes. Colby and Hoss (2004) found that sediment concentrations affect estuarine fish foraging success differently for different species. The severity of turbidity effects tends to be greatest for early life stages and for adults of some highly sensitive species (Newcombe and Jenson 1996, Wilber and Clarke 2001). In fact, many fish thrive in turbid estuarine environments (Blaber and Blaber 1980 and Cyrus and Blaber 1992). This may be due to reduced risk of predation due to reduced visibility and potentially greater availability of prey due to recently removed substrate containing benthic organisms. Due to the relatively small scale of these options, the additional, temporary turbidity impacts are anticipated to be minimal. No managed species will be adversely affected by the proposed construction of beneficial use options and no long term adverse effects to any managed species are anticipated. USACE previously proposed a dredging window (no dredging from April 1 through September 30) to avoid potential impacts to spawning fish by avoiding dredging at two separate SCDNR fish spawning ‘hotspots’. The first of these is at the mouth of the harbor (called the “Grillage”) and the second is 1000’ on either side of the Ravenel Bridge.

In the Mitigation, Monitoring and Adaptive Management Plan (Appendix P, USACE 2015) for the Post 45 Final IFR/EIS, USACE committed to refining the area of direct impacts to hardbottom habitat within the Entrance Channel. The data would be used to increase the resolution of the direct impact footprint and better characterize the resources within the direct impacts area. The Final IFR/EIS indicated that an approximately 28.6 acres of hardbottom habitat could be impacted as a result of new dredging impacts within the Entrance Channel. This approximation was determined using best available data at that time. During the PED phase USACE issued two contracts to refine the area of hardbottom impacts. Dial Cordy and Associates performed the identification and characterization of hardbottom habitat within the anticipated direct impacts area (Appendix C). Based upon these results, USACE contracted with Geodynamics, LLC to perform additional side scan sonar and hardbottom analysis further seaward of the Dial Cordy survey area to ensure that all potential areas of hardbottom habitat were identified (Appendix H). USACE then merged the two datasets and found that approximately 32.7 acres of direct impacts to hardbottom habitat would occur as a result of the deepening of the channel (Figure 35).

USACE previously described the mitigation calculations and methods within Appendix I of the Final IFR/EIS (USACE, 2015). The mitigation calculations factored in both direct and indirect impacts. Indirect impacts were determined to be from turbidity related temporary disturbance to 186.3 acres of hardbottom within 75 m from the edge of the channel. Using the same parameters in a Habitat Equivalency Analysis (HEA) that were shown in Appendix I of the Final IFR/EIS (USACE, 2015), and updating the HEA with the refined impact acreage resulted in a required mitigation reef of 34 acres assuming a 3.5 year recovery time. If the recovery took up to 10 years, the required mitigation reef would need to be 36.4 acres (Appendix L). This is an increase from the predicted 29.8 acres to 32.5 acres from the IFR/EIS, for 3.5 years and 10 years of recovery, respectively.

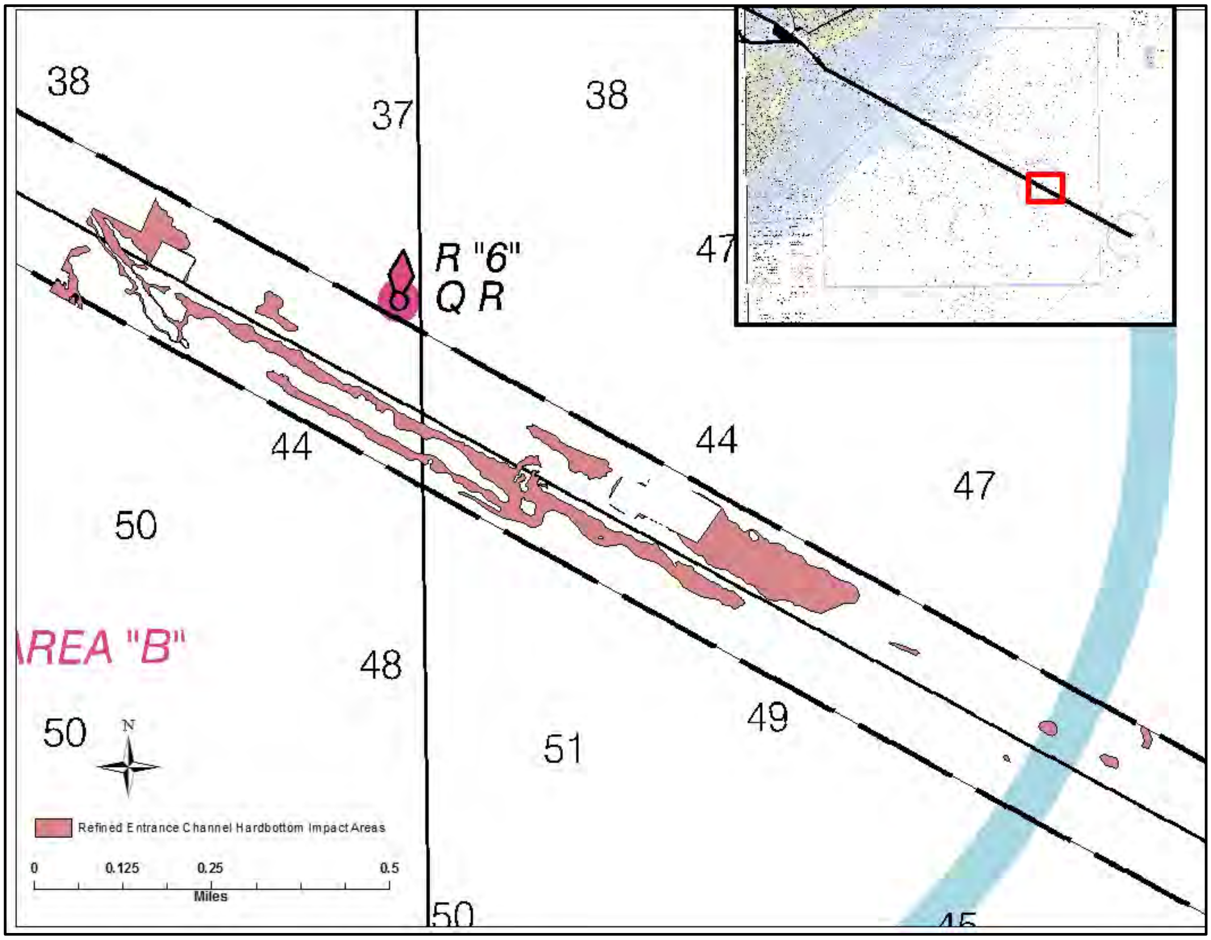


Figure 335. Location of new dredging hardbottom impacts within the Entrance Channel

8.6 Threatened and Endangered Species

No Action Alternative: The no action alternative would not have an impact on any T&E species.

Action Alternatives: All dredging related impacts have been previously addressed in the USACE 2014 Biological Assessment and the NMFS 2015 Biological Opinion (Final IFR/EIS, USACE 2015, Appendices F1 and F2). Therefore, this assessment will only address additional impacts from the construction of the proposed beneficial use options.

The impact producing factors associated with dredged material disposal include:

- Burial of habitat
- Increased turbidity and sedimentation
- Disturbance of sessile biota and finfish assemblages
- Modification of bathymetry and topography
- Potential change in benthic community structure

The following sections discuss the USACE decision-making for an effects determination for the relevant threatened and endangered species. Table 7 summarizes the potential effects on these listed species from the placement of material for these options.

Sea Turtles:

(1) **Habitat.** Located within Charleston Harbor, the proposed options will not affect nesting beaches or nearshore habitats for sea turtles. Morris Island is infrequently used by nesting sea turtles and the addition of sand to the island will only serve to increase the footprint of suitable habitat. Turtles utilizing the inshore waters of Charleston Harbor will be able to find suitable habitat for feeding and will not be impacted by the proposed beneficial use options. Loggerhead sea turtles may infrequently use Morris Island for nesting. Since the proposed options will not occur within designated loggerhead critical habitat, there will be no effect on critical habitat.

(2) **Food Supply.** As previously discussed, the principal food sources of these species are crustaceans, mollusks, other invertebrates, fish, and plant material. Construction activities at the proposed beneficial use sites (Morris Island, Shutes Folly, and Crab Bank) have the potential for a temporary and minor impact on food availability by burying and altering the benthic habitat and creating temporary increases in turbidity. The effect of increased turbidity on sea turtles is expected to be minimal due to the short duration of the reduced water clarity. The effects of burial on benthic infauna are considered minor because it is anticipated that the recovery time for benthic epifauna and infauna will be relatively quick. In a study on the effects of dredging and open-water disposal on benthic macroinvertebrates in SC, Van Dolah et al., (1984) found that the detrimental effects on the benthic macrofauna were minimal. They attributed the minimal impacts to strong currents dispersing sediments, surface disposal, and disposal during a period of time with low faunal recruitment. The disposal operations at Crab Bank and Shutes Folly are anticipated to similarly have no detrimental effect on the community structure and any higher trophic affects.

(3) **Life Period**. The proposed options will have no effect on the life period of any sea turtles.

(4) **Effect Determination**. None of the options will adversely affect sea turtle nesting nor their ability to access beach nesting habitat. Sea turtles do not utilize Crab Bank or Shutes Folly and nesting is very uncommon on Morris Island. Each of the last 2 years has seen only four nests along all of Morris Island (seaturtle.org). Because of this, USACE has determined that the proposed beneficial use options at Crab Bank and Shutes Folly will have no effect on either the loggerhead, Kemp's ridley, green, or leatherback sea turtles. The Morris Island placement may affect, but is not likely to adversely affect, loggerhead sea turtles, and it will have no effect on the green, Kemp's ridley, or leatherback sea turtles. Additionally, the proposed beneficial use options will have no effect on loggerhead Critical Habitat since none of the primary constituent elements will be significantly altered.

Marine Mammals:

(1) **Habitat.** Located within Charleston Harbor, the proposed options at Crab Bank, Shutes Folly, and Morris Island will not affect habitats for any species of marine mammals. Right whales rarely come near the coast or within the harbor near the proposed beneficial sites. Given their coastal habits and their pattern of distribution and migration, humpback whales are not likely to be in the vicinity of the proposed beneficial use option areas during their migration to and from the Caribbean, and a few may winter in or near the area. None of the options will affect any of the primary constituent elements for the right whale critical habitat. Manatees are frequent visitors to Charleston Harbor,

but their habitat will not be altered by the proposed beneficial use options.

(2) **Food Supply.** The proposed beneficial use options involve the disposal of predominantly sandy material on harbor islands (Crab Bank and Shutes Folly) and along an eroding beach front (Morris Island). The options would have no effect on the food supply for the humpback and right whale, nor the manatee. The productivity of the nearshore ocean will not be diminished by the proposed options.

(3) **Life Period.** The occurrence of these species is usually associated with migrations. The NMFS indicates that the areas off South Carolina are increasingly utilized as calving grounds (Federal Register 81:17, 1/27/2016). Since the proposed action does not alter any of the primary constituent elements (PCE's) for right whale critical habitat it will have no effect on critical habitat, nor the ability of the right whale or humpback whale to travel through the region. While the projects may affect manatees through operation of waterborne construction equipment, it is not likely to adversely affect them because USFWS standard manatee conditions will be used for the construction to minimize and avoid impacts to this species.

(4) **Effect Determination.** It is the determination of USACE that the proposed beneficial use projects will have no effect on the right whale or humpback whale. Additionally, the proposed options will not adversely modify right whale critical habitat. The proposed beneficial use options may affect, but are not likely to adversely affect, the manatee with the implementation of the USFWS standard manatee conditions.

<u>Fish – Shortnose and Atlantic Sturgeon:</u>

(1) **Habitat.** Located within Charleston Harbor, the proposed options will not significantly affect habitats for either the shortnose or Atlantic sturgeon. These fish are highly mobile and will likely swim to another area of the harbor during the construction process. Extensive studies have been done on the behavioral responses of fish to increased turbidity. These studies measured reactions such as cough reflexes, swimming activity, gill flaring, and territoriality that may lead to physiological stress and mortality; however, specific studies on sturgeon responses are limited, and the effects here will be very short-term. The effects of suspended sediment on fish should be viewed as a function of concentration and exposure duration (Wilber and Clarke, 2001). The behavioral responses of adult salmonids for suspended sediment dosages under dredging-related conditions include altered swimming behavior, with fish either attracted to or avoiding plumes of turbid water (Newcombe and Jensen, 1996). Water quality impacts to sturgeon as a result of proposed activities are expected to be temporary, with suspended particles settling out within a short time frame or moved out of the area due to tidal influences. These sediment disturbance impacts are expected to be minimal in nature and are not expected to have a measurable effect on water quality beyond the frequent natural increases in sediment load from storm activity. If constructed, there would be no long term impacts to sturgeon habitat in Charleston Harbor as a result of these beneficial use options. The options are not significantly altering the islands and are merely restoring the islands back to a previous historical position. The proposed listing of Critical Habitat for the Atlantic sturgeon includes waters of Charleston Harbor; however, since the options are just outside the designated area, there will be no effect on Atlantic Sturgeon critical habitat.

(2) **Food Supply.** The proposed beneficial use options involve the disposal of predominantly sandy material. Impacts to food supply would be similar to those discussed above under Sea Turtles. The productivity of the area will not be diminished by the proposed dredging.

(3) **Life Period.** Atlantic and shortnose sturgeon are both anadromous fish species; however, their habitat ranges, as a component of their migration cycle, are slightly different. Atlantic sturgeon spawn in freshwater but primarily lead a marine existence; whereas, shortnose sturgeon spawn at or above head-of-tide in most rivers and rarely occur in the marine environment aside from seasonal migrations to estuarine waters. However, recent research by SCDNR indicates that interbasin and interstate movements do occur for shortnose sturgeon. Both species are likely to travel by or spend time near the project area. In the Cape Fear River, NC, Moser and Ross (1995) observed that shortnose sturgeon appeared to be most active in the night and early morning and, when migrating, they stayed mid-channel, in the upper to middle portion of the water column. During the daytime shortnose sturgeon preferred deep holes. Since spawning occurs upstream of the construction operations, impacts to eggs and larvae are not expected. However, spawning migration pathways may occur within the vicinity of proposed beneficial use options. Specific migratory pathways of significance within the action area are not known, although ongoing SCDNR studies are indicating heavy usage of Charleston Harbor for both species of sturgeon (Bill Post, Unpublished data). However, the proposed options will not significantly alter their ability to migrate to and from spawning grounds or to utilize habitat in their range.

(4) **Effect Determination.** It is the determination of USACE that ~~while~~ the proposed beneficial use options will have no effect on ~~may affect~~ Atlantic and shortnose sturgeon based on a temporary disturbance during construction, ~~the beneficial use options are not likely to adversely affect them~~and the area being impacted. Additionally, the proposed options will have no effect on the proposed Critical Habitat for the Atlantic Sturgeon.

Birds:

(1) **Habitat.** Located within Charleston Harbor, the proposed options will not significantly affect habitats for either the red knot or the piping plover. Discussions with USFWS indicate that the red knot and piping plover do not use Crab Bank or Shutes Folly. There is a greater potential for both of those shorebirds to utilize the north end of Morris Island, although documented sightings are rare. Wood storks form large colonies in shallow waterbodies containing inundated vegetation or man-made platforms. Wood storks have been sighted in the Charleston Harbor vicinity, but these islands are not commonly used by wood storks. There is no established critical habitat within the option areas for any of the bird species.

(2) **Food Supply.** Piping plovers feed along sandy shorelines digging for small macroinvertebrates. They display a characteristic "foot trembling" scratch to bring their prey to the surface. Red knots are migratory shorebirds stopping along the Carolina coast to feed along sandy shorelines and mud flats. One important food source along the eastern Atlantic is horseshoe crab eggs. Wood storks forage for small fish in estuarine rivers or impoundments in South Carolina. They use tactile feeding techniques, foraging in shallow water and snapping their bills closed as soon as contact with prey is made. Within the area wood storks have been observed foraging but not nesting (Personal Communication, Morgan Wolf, USFWS- Charleston ES office, 28 Oct 2013).

(3) **Life Period.** While the lifespan of the piping plover is unknown, mating in the Atlantic Coast populations is known to occur in the spring from Canada to North Carolina with occasional nesting recorded in South Carolina. Red knots are a long lived species but exact lifespan remains unknown. One bird was documented to be 20 years old or more (http://www.fws.gov/northeast/redknot/pdf/Redknot_BWfactsheet092013.pdf). Red knots breed in northern Canada and Alaska in the summer and typically have 4 eggs to a nest. Red knots are territorial during breeding and gather in huge numbers to nest and then migrate in the winter. Migration routes take birds through South Carolina in the spring/fall on their way to their final wintering grounds in southern Argentina. Wood storks typically reproduce at age 4 and fledge 2 to 3 chicks per nest. The storks are monogamous and raise offspring together. Their lifespan is between 11 and 15 years old (http://ecos.fws.gov/speciesProfile/profile/speciesProfile.action?spcode=B06O).

(4) **Effect Determination.** Based upon the information provided above, the proposed beneficial use options at Crab Bank and Shutes Folly will have no effect on the piping plover, red knot, or wood stork. The beneficial use options may affect, but is not likely to adversely affect the piping plover and red knot on Morris Island due to a higher likelihood of presence. The Morris Island option will have no effect on the wood stork.

Table 7. Summary of Effect Determination by Species

Listed Species	Effect Determination	Summary
West Indian Manatee	May affect, not likely to adversely affect	Temporary habitat disturbance
North Atlantic Right Whale	No effect; No effect on Critical Habitat	Rarely present in action area
Humpback Whale	No effect	Rarely present in action area
Piping Plover	No effect; May affect, not likely to adversely affect for Morris Island; No effect on Critical Habitat	Not present at Crab and Shutes; Temporary beach disturbance at Morris Island
Rufa Red Knot	No effect; May affect, not likely to adversely affect for Morris Island	Not present at Crab and Shutes; Temporary beach disturbance at Morris Island
Wood Stork	No effect	Not likely to utilize habitat
Atlantic Sturgeon	No effect~~May affect, not likely to adversely affect~~; No effect on Critical Habitat	Disturbance of foraging habitat
Shortnose Sturgeon	No effect~~May affect, not likely to adversely affect~~	Disturbance of foraging habitat
Loggerhead Sea Turtle	No effect; May affect, not likely to adversely affect for Morris Island; No effect on Critical Habitat	Unlikely to utilize the action area
Kemp's Ridley Sea Turtle	No effect	Unlikely to utilize the action area
Leatherback Sea Turtle	No effect	Unlikely to utilize the action area
Green Sea Turtle	No effect	Unlikely to utilize the action area

8.7 Avian Habitat

Various shorebirds and seabirds birds utilize areas in the general vicinity of the beneficial use options. The immediate project area at Crab Bank contains minimal area of suitable nesting habitat for shorebirds. However, this habitat has been documented by SCDNR as supporting significant shorebird nesting habitat for the State.

No Action Alternative: This alternative would result in diminishing habitat for shorebirds over time as the islands slowly continue to erode.

Action Alternatives: It is anticipated that the proposed activities will in the long run provide up to approximately 80 acres at Crab Bank and approximately 27 acres at Shutes Folly of additional habitat that can be used by these birds and minimize competition on the island and decreasing chance of disease. The USACE Savannah District created a dredged material island (called Thompkins Island) at the mouth of the Savannah River is the early 2000s. It was noted that gulls and pelicans began to use the site immediately as deposited sands became emergent from the water surface. The District also noted that the construction equipment only displaced birds from the immediate construction area and not from the entire island. Costa (2004) indicated that local birders estimated that in mid-summer in the middle of construction of the island that about 2,000 birds of various types, including migrating birds, were found on the island. Thompkins Island is now part of the SCDNR Heritage Trust Program, which recognizes the site for the valuable habitat it provides. Due to these factors, it is anticipated that the action alternatives will have a long term positive impacts on bird usage in the area, even if some temporary displacement occurs during the construction.

8.8 Coastal Barrier Resources

No Action Alternative: This alternative would result in no additional impacts on the Morris Island Unit; however, without a beneficial use project, erosion will continue to occur. Continued erosion could cause additional loss of dune habitat and the amount of dry beach habitat on the island.

Action Alternatives: The USFWS was consulted with on the beneficial use alternatives and they indicated that the USFWS Regional Office confirmed that dredged material placement behind the south jetty of Morris Island is an allowable action within the CBRA zone and is not prohibited (Mark Caldwell, email dated July 21, 2016). The proposed project at Morris Island would have a beneficial effect on the island by providing for additional sediment placement in an area that is experiencing erosion. This placement introduces new material to the littoral system and could temporarily minimize the habitat loss along this portion of the island.

8.9 Cultural and Historic Resources

Cultural and historic resources were considered during the project planning. Coordination has been ongoing with the South Carolina Department of Archives and History and the State Underwater Archaeologist at the South Carolina Institute for Anthropology and Archaeology pertaining to any known anomalies that would have to be avoided for any of the beneficial use alternatives.

No Action Alternative: This alternative will not result in additional impacts to any historic properties. Erosion of Shutes Folly will continue to cause a concern for Castle Pinckney on the south end of the island. An existing breakwater provides protection; however harbor islands are constantly in a state of flux and the erosion that has been occurring on the eastern flank will likely continue in the future.

Action Alternatives: Battery Wagner was a concern to the SHPO and the SCIAA due to its assumed location near the terminus of the south jetty on Morris Island. SCIAA performed magnetometer work in certain nearby areas to try to identify any portions of the historic fort. While the exact boundaries are still unknown, SCIAA provided USACE a map detailing avoidance areas due to potential anomalies. The construction contractor will be provided this information within the plans and specifications as avoidance areas. USACE will require the construction contractors to be aware that the potential for finding cultural resources in this area still exists. In addition, SCIAA requested that an archaeologist monitor the construction site when operating within 100 yards on either side of the jetty due to the potential for the undertaking to encounter remains of Battery Wagner. If during the course of work, cultural resources are uncovered, work will cease immediately and the Charleston District will coordinate with SHPO and SCIAA before additional work is performed. Additionally, placement operations will have no impact on any historic structures on Crab Bank or Shutes Folly. Prior to construction, an archaeologist will perform a pedestrian survey of the intertidal zone at Shutes Folly due to the potential for encountering historic resources and/or human remains. At Crab Bank, a preconstruction side scan sonar and magnetometer survey will be performed on the main channel (southwest) side of Crab Bank. The survey will cover the extent of the construction footprint. Results will be shared with SHPO and SCIAA.

Regarding the proposed construction of eight artificial reefs (Final IFR/EIS, USACE, 2015), USACE performed a background investigation and a remote sensing survey in consultation with the South Carolina Department of Archives and History and the South Carolina Institute for Archaeology and Anthropology (SCIAA) (Appendix E). Two survey zones were evaluated and consisted of side scan sonar, subbottom profiling, and magnetomer surveys (Figure 36). A total of 144 magnetic anomalies and 25 sidescan sonar contacts were recorded within the APE. A total of 104 anomalies and 16 sonar targets were recorded in Mitigation North, and 40 anomalies and seven sonar targets were recorded in Mitigation South. Analysis of the data indicates a lack of anomalies or sonar targets that can be considered potentially significant. Furthermore, a review of the subbottom data did not detect any buried paleofeatures that would have the potential to contain submerged prehistoric sites in Mitigation South. The single paleofeature recorded in Mitigation North is buried approximately 10 feet deep and will not be affected. On August 17, 2016, the SHPO conditionally concurred that no additional survey work is necessary and that, with a 100-foot buffer around the cluster of magnetic anomalies (M18, 19, 22, 23, 57, and 24) and the acoustic anomaly (C008), no historic properties will be affected (see Appendix E).

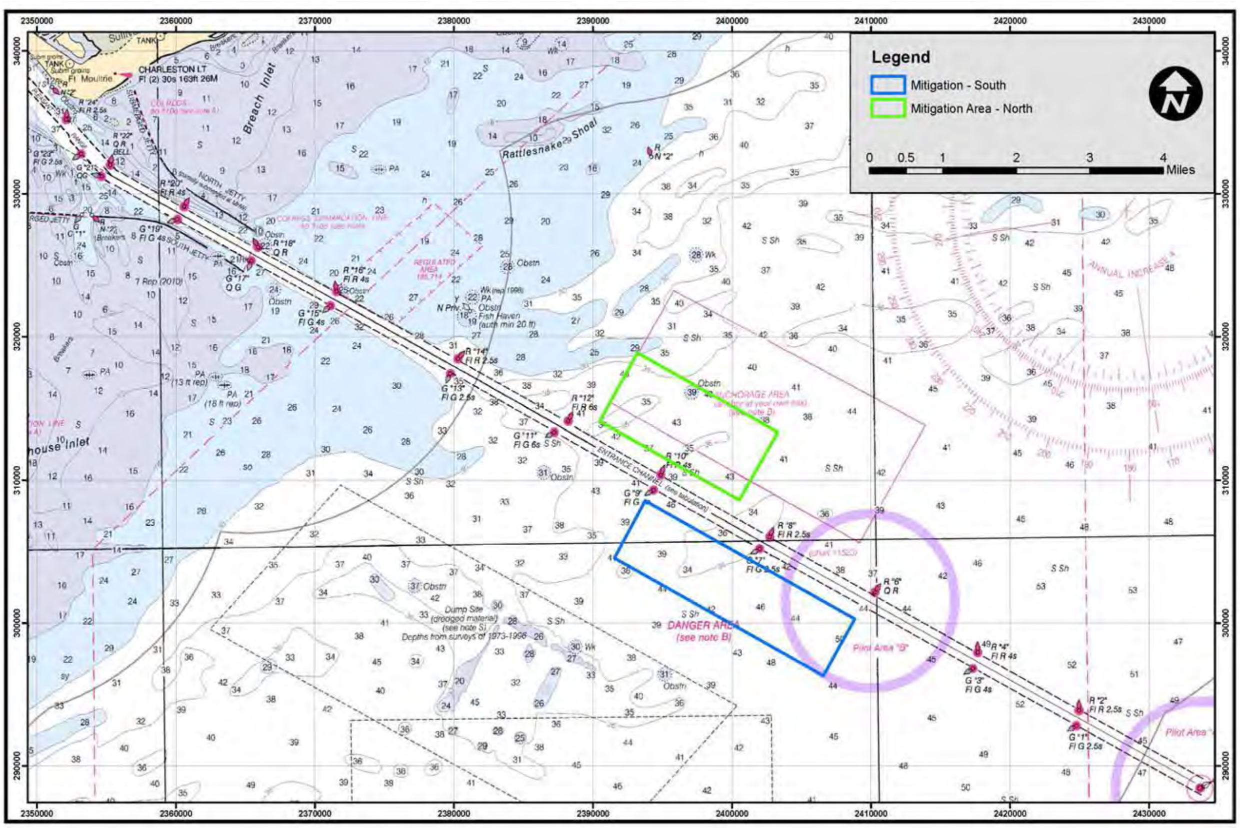


Figure 346. Location of North and South Mitigation Survey Areas

8.10 Aesthetics and Recreation

No Action Alternative: Minor impacts to aesthetics and recreation would be anticipated under this scenario. Presently, multiple companies offer ecotours to Crab Bank for recreation and for bird watching. As the island continues to erode, opportunities for recreation will decrease. Additionally, the Coastal Conservation League and the Nature Conservancy have recently installed a bird video camera on Crab Bank called the "pelicam". This camera could be compromised over time under the no action alternative scenario if erosion and migration of the island continues to occur. Shutes Folly and Morris Island also receive recreational activity. Many people fish in the surrounding areas.

Action Alternatives: Aesthetics would be reduced in the project area during construction, due to the physical presence of the heavy equipment used in the construction process. However, these impacts would be temporary and insignificant. Once the construction is complete, the aesthetic values provided by the restored habitats would have many beneficial impacts. Presently, Crab Bank is barely visible on spring high tides. Since the island has been migrating and eroding over the years, this trend would continue without the project. Depositing of material at Crab Bank would make it a more prominent feature in the lower harbor. Crab Bank is a major tourist attraction and fishing area. Multiple companies offer waterborne tours of Crab Bank originating from Shem Creek. A more prominent island will be a benefit to these companies and will provide more opportunity outside of bird nesting season for people to utilize the island. Shellfish harvesting will not be impacted because it is restricted within Charleston Harbor.

8.11 Socioeconomics

No Action Alternative: This alternative will not create disproportionately high and adverse human health or environmental impacts on any minority or low income populations.

Action Alternatives: All of the dredging related aspects have been previously addressed in the Post 45 Final IFR/EIS. These proposed beneficial use options are not designed to create a benefit for any group or individual, but rather benefits on a nationwide basis. The proposed beneficial use of dredged material options occur relatively far from any areas of significant populations. There are no indications that the proposed activities would be contrary to the goals of E.O. 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, or would create disproportionately high and adverse human health or environmental impacts on minority or low income populations of the surrounding community.

8.12 Air Quality

The impacts to regional air quality are described within the Final IFR/EIS.

No Action Alternative: This alternative would not result in additional adverse impacts to air quality.

Action Alternatives: The proposed beneficial use options would result in in some minor, short term air quality impacts. Emissions are expected to occur and would result from the operation of the dredge, construction equipment, and any other support equipment, which may be on or adjacent to the job site. The Final IFR/EIS evaluated the emissions from the Post 45 Project. The only additional emissions would come from the temporary use of shore-based equipment such as bulldozers and front end loaders. An additional pump out station may also be used depending on the dredging method. The proposed beneficial use options would have negligible additional air quality impacts as the additional equipment used for construction would be offset by the reduction in travel distance for dredge material disposal. The project area is currently in attainment with National Ambient Air Quality Standards parameters. The proposed action would not affect the attainment status of the project area or region.

8.13 Noise.

No Action Alternative: This alternative would not result in additional adverse impacts to surrounding noise levels.

Action Alternatives: The impacts from noise to the human environment and wildlife are described within the Final IFR/EIS and are incorporated here by reference. Noise from the additional construction equipment, and other associated support equipment would be evident in the project area. While this noise would be evident to workers, immediate residences, and passersby in proximity of the project, it would be short-term and insignificant.

8.14 Hazardous, Toxic, and Radioactive Waste (HTRW)

No HTRW concerns are anticipated for the proposed beneficial use options. The dredged material will be the same as described in the Final IFR/EIS (USACE, 2015) and associated appendices, as well as in Section 5.6 above.

8.15 Protection of Children.

On April 21, 1997, the President issued Executive Order (EO) 13045*, Protection of Children from Environmental Health and Safety Risks*. To the extent permitted by law and appropriate, and consistent with the federal agencies' mission, the Corps of Engineers shall make it a high priority to identify and assess environmental health risks and safety risks that may disproportionately affect children; and shall ensure that its policies, programs, activities, and standards address disproportionate risks to children that result from environmental health risks or safety risks. Neither the No Action nor the Action alternatives pose disproportionate environmental health risks or safety risks to children in the vicinity of the project.

8.16 Cumulative Impacts

The National Environmental Policy Act (NEPA), as implemented by Council on Environmental Quality (CEQ) regulations (40 CFR §§ 1500 -1508) requires federal agencies, including the USACE, to consider cumulative impacts in rendering a decision on a federal action under its jurisdiction. According to 40 CFR § 1508.7, a *cumulative impact* is the impact on the environment that results from the incremental impact of the proposed beneficial use options when added to other past, present, and reasonably foreseeable future actions regardless of the agency (federal or non-federal) or person that undertakes such other actions; cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

Many wetlands within Charleston Harbor and other important habitats have been and continue to be lost or eroded. Much of this loss is due to the cumulative impacts of associated with sea level rise and wave/wake/current action associated with an estuarine environment in a developed area, and many of these impacts are not directly recoverable. The proposed beneficial use options could result in improvements in environmental quality to minimize these losses. The options provide the opportunity to establish such benefits towards improving environmental quality and minimizing the loss of these important resources.

As a result of the implementation of any or all of the proposed beneficial use options there will be a minor temporary cumulative impact on water quality, benthic habitat, and EFH; however, all these impacts are temporary and minor. The cumulative impacts from the beneficial use options would be different than if the material were disposed of in a conventional manner (in this case, the alternative for disposal would mean loss of capacity at the ODMDS). However, this cumulative impact is only a short term affect and will recover quickly after completion of the beneficial use options. No long term impacts to these resources of concern are anticipated. Regulations require the dredged material to be disposed of such that all suspended and dissolved portions after dilution meet all applicable water quality criteria [40 CFR 227.13(c)(2)(i)] and do not cause any adverse biological effects [40 CFR 227.27(b)]. The goal of these requirements is to eliminate any adverse effects associated with individual contaminants or any synergistic effects of multiple contaminants present in the dredged material. Consequently, the proposed action is not expected to contribute significantly to the cumulative impacts of regional activities on water quality.

The options will not induce development on any of the islands. The options could result in more research efforts to monitor bird activity on the island and could result in increased recreational visitation. Additionally, if either the Crab Bank or Shutes Folly options are constructed, there is a potential to use future maintenance material for beneficial creation or enhancement of saltmarsh associated with those islands. This concept could be evaluated separately through a Section 204 Continuing Authorities Program study.

Based on the positive environmental benefits of the proposed options and the temporary and minor nature of the cumulative impacts, it has been determined that no significant cumulative impacts would occur.

8.17 Climate Change and Air Quality

Section 6.21 of the Final IFR/EIS includes a brief discussion of EO 13653, “Preparing the United States for the Impacts of Climate Change,” and references the more detailed discussion in Appendix A to the IFR/EIS which was conducted consistent with ETL 1100-2-1 and the USACE Responses to Climate Change (RCC) Program. Using the USACE Institute of Water Resources (IWR) online Sea-Level Rise calculator and spreadsheet (ER 1110-2-8162), the historical trend at Charleston is estimated to be 2.94 mm (0.12 inches)/yr. The ER was also used to determine various rates of sea level change under different scenarios (low, intermediate, and high) and could result in 0.57 ft of sea level rise over 50 years. The analysis indicated that sea level rise would increase over 50 years 0.57 ft in the low scenario (based on the historical rate), 1.08 feet in the intermediate scenario, and 2.74 feet in the high scenario. Based on these scenarios, it is even more important to implement the proposed beneficial use actions, as keeping sand within the harbor or nearshore littoral system is preferable to placing the material in an ODMDS. In addition to the fisheries development and enhancement provided by the Artifical Reefs and ODMDS Berm, the proposed beneficial placements in Charleston Harbor will decrease vulnerability and increase resilience to sea level rise. Implementation of one or more of the proposed beneficial use options will not appreciably change the overall Greenhouse Gas (GHG) emissions for the Post 45 Project. An Air Emission Inventory is contained within the Final IFR/EIS for the Post 45 Project. The addition of shore based equipment such as bulldozers and front end loaders will not substantially alter the findings of the Air Emission Inventory or increase GHG emissions for the Project."

8.18 Irreversible and Irretrievable Commitment of Resources.

NEPA (42 U.S.C. § 4332 Section 102(2)(C)(v) as implemented by CEQ regulation 40 CFR 1502.16) requires an analysis of significant, irreversible effects resulting from implementation of a proposed action. An irreversible commitment of resources is one in which the ability to use and/or enjoy the resource is lost forever. An irretrievable commitment of resources is one in which, due to decisions to manage the resource for another purpose, opportunities to use or enjoy the resources as they presently exist are lost for a period of time. The commitment of resources refers primarily to the use of nonrenewable resources such as fossil fuels, water, labor, and electricity. It may also refer to natural resources.

The construction of any or all of the proposed beneficial use options indirectly requires:

- An irreversible commitment of energy and resources used to transport and dispose of material at the site;
- An irreversible commitment related to economic costs associated with monitoring activities;
- An irreversible commitment related to human labor resources associated with these beneficial use options.

Energy (electricity and natural gas) and water consumption, as well as demand for services, would not increase significantly as a result of implementation of the proposed action. The commitment of these resources does not present any significant impacts.

The proposed beneficial use options would, if constructed, represent an improvement over the No-Action alternative from the standpoint of reducing the irretrievable commitment of resources. Dredged material would be put to a positive use of value to the environment rather than being simply disposed of and taking up disposal capacity.

9.0 Environmental Compliance

NEPA requires that all Federal agencies use a systematic, interdisciplinary approach to protect the human environment. This approach promotes the integrated use of natural and social sciences in planning and decision-making that could have an impact on the environment. NEPA requires the preparation of an environmental impact statement (EIS) for any major Federal action that could have a significant impact on quality of the human environment. Since the proposed beneficial use options, if constructed, will not significantly affect human health or the environment, supplementation of the Final IFR/EIS is not warranted. Upon completion of the Final Supplemental EA, the project will be in full compliance with the NEPA.

9.1 Clean Water Act

The USACE has obtained a water quality certification from the State of South Carolina pursuant to the Clean Water Act (CWA) for the discharge of dredged or fill material into navigable waters by the proposed activity. All state water quality standards would be met. In conjunction with the Final IFR/EIS, this Final Supplemental EA contains sufficient information to demonstrate that the proposed options are in compliance with the CWA. A joint public notice was filed for the release of the Draft IFR/EIS and the 401 certification. On 16 March 2015, SCDHEC issued a certification in accordance with Section 401 of the CWA, with conditions pursuant to R. 19-450 et. seq., 1976. The conditions of the 401 can be found within the Final IFR/EIS and the USACE is committed to adhering to all conditions of the Certification. One of the conditions was that, "The final plans for beneficial uses of the dredged spoil material shall be provided to the DHEC for final approval prior to finalizing the Pre-construction Engineering and Design or PED." This document serves to satisfy that requirement. After review of the Draft Supplemental EA, SCDHEC had no additional comments on the project (Email dated 28 November 2016).

9.2 Wetlands

CWA Section 404 and implementing USACE regulations at 33 C.F.R. 336(c) (4) and 33 C.F.R. 320.4(b) require the USACE to avoid, minimize, and mitigate impacts to wetlands. The proposed beneficial use alternatives have been evaluated using the CWA Section 404(b)(1) Guidelines and found to be in compliance with the requirements of these guidelines (Appendix J).

9.3 Coastal Zone Management Act (CZMA)

In accordance with the CZMA, it was been determined that the proposed deepening of the Federal navigation channel would be carried out in a manner that is fully consistent with the enforceable policies of the SC CMP. With conditions, the SCDHEC – concurred with the USACE consistency determination for the Final IFR/EIS on 8 December 2014. One of the conditions was that, "The final plans for beneficial uses of the dredged spoil material shall be provided to the Department for final approval." This document serves to satisfy that requirement. After review of the Draft Supplemental EA, SCDHEC had no additional comments on the project (Email dated 28 November 2016).

9.4 Clean Air Act (CAA)

The proposed beneficial use options are in compliance with the CAA. All air emissions resulting from the proposed action would be temporary and minor. No long term changes would occur to air quality in the region as a result of any of the proposed options. The study area is in an attainment area for all air quality criteria and the proposed option will not cause the study area to go out of attainment. The SCDHEC – Bureau of Air Quality offered strategies to benefit air quality during construction, including utilizing alternatively fueled equipment, utilizing emission controls applicable to equipment, reducing idling time on equipment, minimizing fugitive dust emissions through good operating practices.

9.5 US Fish and Wildlife Coordination Act

This project is in compliance with this Act. The project has been coordinated with the US Fish and Wildlife Service and other State and Federal natural resource agencies. Input from the USFWS, including any conservation recommendations under Section 2(b) of this Act, will be considered and incorporated into the Final EA and project plans as they are developed.

9.6 Endangered Species Act

The ESA protects threatened and endangered species by prohibiting federal actions that would jeopardize the continued existence of such species or that would result in the destruction or adverse modification of any critical habitat of such species. ESA Section 7 (Interagency Cooperation) requires that consultation regarding conservation of such species be conducted with USFWS and/or NMFS prior to project implementation. Integrated within this Final Supplemental EA, the USACE has evaluated potential impacts of the proposed beneficial use options on threatened and endangered species and associated critical habitat. USFWS and NMFS are asked to certify or concur with the USACE findings that the proposed activity will have no effect or will not adversely affect endangered or threatened species.

9.7 Marine Protection Research and Sanctuaries Act (MPRSA)

The transportation of dredged material for the purpose of dumping (or disposal) into ocean waters is regulated by Section 103 of the Marine, Protection, Research and Sanctuaries Act (MPRSA) of 1972, as amended. EPA promulgated implementing regulations in 40 CFR Subchapter H - Ocean Dumping (Parts 220-228). Section 103 does not govern the proposed beneficial uses of dredged material. The Crab Bank Enhancement, the Shutes Folly Enhancement, and the Morris Island Beach Placement would all occur within Charleston Harbor and outside of the ocean waters subject to the MPRSA. The SCDNR Nearshore Reef Placement would occur within the Territorial Sea, and is regulated pursuant to Section 404 of the CWA (33 USC 1344) and the 404(b)(1) Guidelines (40 CFR 230.2; Beneficial Use Planning Manual, EPA/USACE, Oct. 2007). The Artificial Reefs include fisheries development as a sole or a primary purpose. EPA regulations exclude the "placement or deposit of ... materials for the purpose of developing, maintaining, or harvesting fisheries resources; provided such placement is regulated under or is a part of an authorized State or Federal program ..." (40 CFR 220.1(c)(2)). The placement of dredged material for the reefs will be regulated under Section 10 of the Rivers and Harbors Act of 1899 and the National Fishing Enhancement Act of 1984. Therefore, evaluation under Section 103 of MPRSA is not required."

9.7 Magnuson-Stevens Fishery Conservation and Management Act (MSA)

This Act requires federal action agencies to consult with the National Marine Fisheries Service (NMFS) if a proposed action may affect Essential Fish Habitat (EFH). Incorporated into this Final Supplemental EA, the USACE evaluated potential project impacts on NMFS-managed fish species and their Essential Fish Habitats. Impacts would occur to the water column, shallow sub-bottom habitat, wetlands, and oyster reefs. These impacts are temporary and minor considering the positive environmental benefits associated with any or all of the options. Concurrent with this EA, USACE is requesting conservation recommendations, if any, from NMFS pursuant to the Magnuson-Stevens Act.

9.8 Anadromous Fish Conservation Act

All beneficial use options under consideration within this Supplemental EA are in compliance with this Act. USACE considered habitat impacts specifically to sturgeon species. Mitigation would not be required for the minor, localized, and unlikely adverse effects on these species due to temporary turbidity increases affecting water quality. No long term impacts are anticipated.

9.9 Marine Mammal Protection Act (MMPA)

The MMPA prohibits the take of marine mammals including the West Indian manatee, North Atlantic right whale, and humpback whale. Protective measures for marine mammals would be implemented. The project is being coordinated with USFWS and NMFS. The project is in compliance with this Act and no incidental harassment would occur with the implementation of USFWS standard manatee conditions. NMFS and USFWS are asked to concur with the USACE findings that the proposed activity will have no effect or will not adversely affect endangered or threatened marine mammal species.

9.10 National Historic Preservation Act (NHPA)

The USACE evaluated the potential for adverse impacts to archaeological or historic resources within an Area of Potential Effects (APE). For the artificial reef siting, two anomalies will be avoided with a 100 foot buffer around anomalies C008 and M18, 19, 22, 23, 57, 24, and around a feature marked, “terrace” within Appendix D. The SC Institute for Archaeology and Anthropology (SCIAA) also provided avoidance areas for pipelines for beach placement on Morris Island if constructed. These avoidance areas will be incorporated in future plans and specifications. USACE has determined that the proposed beneficial use options would have no effect on historic properties, and the SHPO concurred with this determination on December 13, 2016.

9.11 Executive Order 11990, Protection of Wetlands

This EO directs all Federal agencies to minimize the destruction, loss, or degradation of wetlands; and preserve and enhance the natural beneficial values of wetlands in the conduct of the agency's responsibilities. Direct wetland impacts resulting from the disturbance and burial of small patchy wetlands on Crab Bank would occur as a result of this option. USACE has planned to avoid the most significant area of marsh in the northwestern area of Crab Bank. The positive impacts of this option outweigh the loss of the insignificant patchy wetlands and no mitigation is proposed. It is anticipated that the proposed option at Crab Bank could allow for the natural recruitment of saltmarsh species on the northern (Mt. Pleasant) side of the island. No other wetland impacts are anticipated

9.12 Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low Income Populations

In accordance with this EO, the USACE has determined that no group of people would bear a disproportionately high share of adverse environmental consequences resulting from the proposed beneficial use options.

9.14 Migratory Bird Treaty Act; Executive Order 13186, Responsibilities of Federal Agencies to Protect Migratory Birds

This Act makes it illegal for anyone to take, possess, import, export, transport, sell, purchase, barter, or offer for sale, purchase, or barter, any migratory bird, or the parts, nests, or eggs of such a bird except under the terms of a valid permit issued pursuant to Federal regulations. The USACE does not anticipate that migratory birds would be adversely (directly or indirectly) affected by the proposed action. The proposed beneficial use options could create expanded habitat to support seabird and migratory bird nesting as well as other habitat usage. USACE has proposed to avoid construction during the nesting season between March 15 and October 15 in the northwestern portion of Crab Bank where seabird nesting is currently concentrated.

10.0 Monitoring

USACE has already conducted pre-disposal surveys of the potential beneficial use sites to determine the topography of the islands and the bathymetry of the aquatic area and surroundings. Additional surveys of the benthic community and sediment composition have also been completed. These data will used as a baseline for comparisons of future monitoring information. Following dredging activities, USACE will conduct surveys to evaluate and document the final constructed footprint of the island. It is anticipated that the island will continue to be susceptible to environmental variables that affect sediment transport, erosion and movement of the island. Due to the public and agency interest in these beneficial use options, USACE will work with SCDNR and other agencies and organizations, where possible and funding allows, to assist with surveys of the islands and to document their changes over time. These efforts could consist of vegetation monitoring, island topography monitoring, bird usage, benthic characterization, sediment composition, etc. Since the proposed actions are for the beneficial use of dredged material, no requirement for specific mitigation or monitoring is warranted.

11.0 List of Agencies, Interested Groups and Public Consulted

- Ashley River Scenic Advisory Council
- Cape Romain Bird Observatory
- Castle Pinckney Historical Society
- Coastal Conservation Association
- Coastal Conservation League
- Environmental Protection Agency
- National Marine Fisheries Service
- National Park Service
- Natural Resources Conservation Service
- South Atlantic Fishery Management Council
- South Carolina Department of Archives and History
- South Carolina Aquarium
- South Carolina Department of Health and Environmental Control – Bureau of Water

- South Carolina Department of Health and Environmental Control – Office of Ocean and Coastal Resource Management
- South Carolina Department of Natural Resources
- South Carolina Institute for Archaeology and Anthropology
- South Carolina Sea Grant Consortium
- South Carolina Saltwater Anglers
- South Carolina State Ports Authority
- United States Fish and Wildlife Service
- United States Geological Survey

12.0 References

Anamar Environmental Consulting, Inc. 2015. *Final Report: Lower Harbor Sediment Sampling and Analysis, Charleston Harbor Federal Navigation Channel, Charleston, Berkeley County, South Carolina*. Prepared for U.S. Army Corps of Engineers, Charleston District. June 2015.

American Vibracore Services. 2016. *Subsurface Investigation and Geotechnical Laboratory Testing Results, Charleston Harbor Post 45 Preconstruction Engineering and Design, Beneficial Use of Dredged Material, Charleston County, South Carolina*. Prepared for U.S. Army Corps of Engineers. July 2016.

Bailey, William. Construction of an offshore bird nesting island at Savannah Harbor. Proceedings of the Georgia Water Resources Conference, held April 25-27, 2005, at the University of Georgia. Kathryn J. Hatcher, editor, Institute Ecology, The University of Georgia, Athens, Georgia.

Blaber, S.J.M. and T.G. Blaber. 1980. Factors affecting the distribution of juvenile estuarine and inshore fish. Journal of Fish Biology. 17: 143-162.

Bolam, S.G. 2011. Burial survival of benthic macrofauna following deposition of simulated dredged material. Environmental Monitoring Assessment. 181: 13-27.

Colby, D., and D. Hoss. 2004. Larval fish feeding responses to variable suspended sediment and prey concentrations. USACE, Engineering Research Development Center. DOER Technical Notes Collection. ERDC TN-DOER-E16.

Costa, H, 2004. Savannah Morning News, article dated Jun 27, 2004.

Cyrus, D.P. and S.J.M. Blaber. 1992. Turbidity and salinity in a tropical northern Australian estuary and their influence on fish distribution. Estuarine Coastal and Shelf Science. 35: 545-563.

Dias, Nathan, Executive Director Cape Romain Bird Observatory McClellanville, SC

DoN (Department of the Navy). 2007. Final Integrated Natural Resources Management Plan for the Naval Station Mayport. Mayport, Florida

Fritts, T.H., A.B. Irvine, R.D. Jennings, L.A. Collum, W. Hoffman, and M.A. McGhee. 1983. Turtles, Birds, and Mammals in the Northern Gulf of Mexico and nearby Atlantic Waters. FWS/OBS-82/64. U.S. Fish and Wildlife Service, Washington D.C.

FWC (Florida Fish and Wildlife Conservation Commission). 2002. Sea Turtle Conservation Guidelines. FWC, FWRI, St. Petersburg, F

Hands, E. B. and M. C. Allison. 1991. Mound migration in deeper water and methods of categorizing active and stable depths. In Proceedings of Coastal Sediments '91. American Society of Civil Engineers, pp 1985-1999.

ICES (International Council for the Exploration of the Sea). 1992. Report of the ICES working group on the effects of extraction of marine sediments on fisheries. Copenhagen (Denmark): ICES Cooperative Research Report #182.

IUCN (International Union for the Conservation of Nature). 2008. Red List of Threatened Species [website]. Accessed 01/02/11 online at: http://www.iucnredlist.org/

Lazell, J.D., Jr. 1980. New England waters: critical habitat for marine turtles. Copeia 1980:290–295

Manomet Center for Conservation Sciences. 2004. International Shorebird Surveys. http://shorebirdworld.org/template.php?g=13&c=11, September 10, 2004.

McLellan, T. N. and N. C. Kraus. 1991. Design guidance for nearshore berm construction. In Proceedings of Coastal Sediments '91

MMS (Minerals Management Service). 2009. Charleston ODMDS Sand Borrow Project Final Environmental Assessment. Prepared by Moffatt & Nichol Engineers. October 2009 for Minerals Management Service Branch of Environmental Assessment. Published by the U.S. Department of the Interior Minerals Management Service Environmental Division

Murphy, Thomas M., Sally R. Murphy, and DuBose Griffin. 2009. Colonial Nesting Seabird Guild. http://www.dnr.sc.gov/cwcs/pdf/Colonialnestingseabirds.pdf. Accessed on October 6.

NOAA (National Oceanic and Atmospheric Administration). 2009. Final Amendment 1 to the Consolidated Atlantic Highly Migratory Species Fishery Management Plan. Essential Fish Habitat, Including a Final Environmental Impact Statement. Department of Commerce, NOAA, NMFS, Highly Migratory Species Management Division, Office of Sustainable Fisheries, Silver Spring, MD

NAVFAC (Naval Facilities Engineering Command, Southeast). 2008. Final Environmental Impact Statement for the Proposed Homeporting of Additional Surface Ships at Naval Station Mayport, Florida. NAVFAC, Mayport, FL

NMFS (National Marine Fisheries Service). 2004. Essential Fish Habitat Consultation Guidance. Version NMFS, Office of Habitat Management, Silver Spring, MD.

NMFS (National Marine Fisheries Service). 2005. Marine Mammal Protection Act [website]. Accessed 01/02/11 online at http://www.nmfs.noaa.gov/pr/laws/mmpa/

NMFS (National Marine Fisheries Service). 2006a. ESA Section 7 letter from R. Crabtree to N. Ball. October 31, 2006.

NMFS (National Marine Fisheries Service). 2006b. Draft Recovery Plan for the Fin Whale (Balaenoptera physalus). Office of Protected Resources.

Newcombe, C.P. and J.O. Jenson. 1996. Channel suspended sediment and fisheries: a synthesis for quantitative assessment of risk and impact. North American Journal of Fisheries Management. 16(4): 693-727.

Rebel, T.P. 1974. Sea Turtles and the Turtle Industry of the West Indies, Florida, and the Gulf of Mexico. University of Miami Press, Coral Gables, FL

Sanders, F.J., T.M. Murphy and M.D. Spinks. 2004. Winter abundance of the American Oystercatcher in South Carolina. *Waterbirds* 27: 83–88.

Sanders, F.J., T.M. Murphy. 2009. Migratory Shorebird Guild. http://www.dnr.sc.gov/cwcs/pdf/Migratoryshorebirdguild.pdf.%20Accessed%20on%20October%206.

Thompson, Bruce C., Jerome A. Jackson, Joannna Burger, Laura A. Hill, Eileen M. Kirsch and Jonathan L. Atwood. 1997. Least Tern (Sternula antillarum), The Birds of North America Online (A. Poole, Ed.). Ithaca: Cornell Lab of Ornithology; Retrieved from the Birds of North America Online: http://bna.birds.cornell.edu/bna/species/290.

Tweel, Andrew and Denise Sanger. 2015a. Charleston Harbor Dredging Project Environmental Assessment: Crab Bank and Shutes Folly, Surficial Sediment Characterization. Final Report. Submitted to US Army Corps of Engineers, by SC Department of Natural Resources, Marine Resources Division. May 2015.

Tweel, Andrew and Denise Sanger. 2015b. Charleston Harbor Dredging Project Environmental Assessment: Crab Bank and Shutes Folly, Benthic Macrofaunal Abundance and Distribution. Final Report. Submitted to US Army Corps of Engineers, by SC Department of Natural Resources, Marine Resources Division. May 2015.

USACE (U.S. Army Corps of Engineers). 2006. Final Environmental Impact Statement, Proposed Marine Container Terminal at the Charleston Naval Complex, North Charleston, South Carolina. USACE Charleston District, Charleston, SC. http://www.porteis.com/project/documents.htm

USACE. 2015. Charleston Harbor Post 45. Final Integrated Feasibility Report and Environmental Impact Statement. June 2015. Online at: http://www.sac.usace.army.mil/Missions/Civil-Works/Charleston-Harbor-Post-45/

Van Dolah, R.F., J.B. Boynton, K.S. Schulte, and J.C. Felber. 2011. A comprehensive spatial mapping effort of South Carolina's Coastal Resources and Activities. Final Report. Submitted to: South Carolina Energy Office, Columbia, SC

Waring, G.T., E. Josephson, C.P. Fairfield-Walsh and K. Maze-Foley, eds. 2009. U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments--2008. NOAA Tech Memo. NMFS NE 210. 440 pp

Wilber, D.H., Clarke D.G. 2001. Biological effects of suspended sediments: a review of suspended sediment impacts on fish and shellefish with relation to dreding activities in estuaries. North American Journal of Fisheries Management. 21 (4): 855-75.

Wilber, D.H., W. Brostoff, D. Clarke, and G. Ray. 2005. Sedimentation: potential biological effects of dredging operations in estuarine and marine environments. DOER Technical Notes Collection.

USACE, Engineering Research Development Center. ERDC TN-DOER-E20. 14p. http://el.erdc.usace.army.mil/dots/doer/pdf/doere20.pdf.

ALL APPENDICES TO THIS REPORT ARE LOCATED ON THE SAC PUBLIC WEB-PAGE FOR POST 45, UNDER POST 45 DOCUMENTATION, FINAL SUPPLEMENTAL ENVIRONMENTAL ASSESMENT:

http://www.sac.usace.army.mil/Missions/Civil-Works/Charleston-Harbor-Post-45/

Appendix D
Brown Pelican Habitat Suitability Index

Charleston Harbor Cap 204 Detailed Project Report

Biological Report 82(10.90)
May 1985

HABITAT SUITABILITY INDEX MODELS: EASTERN BROWN PELICAN

Fi... and Wildlife Service

... Department of the Interior

This model is designed to be used by the Division of Ecological Services in conjunction with the Habitat Evaluation Procedures.

This is one of the first reports to be published in the new "Biological Report" series. This technical report series, published by the Research and Development branch of the U.S. Fish and Wildlife Service, replaces the "FWS/OBS" series published from 1976 to September 1984. The Biological Report series is designed for the rapid publication of reports with an application orientation, and it continues the focus of the FWS/OBS series on resource management issues and fish and wildlife needs.

MODEL EVALUATION FORM

Habitat models are designed for a wide variety of planning applications where habitat information is an important consideration in the decision process. It is impossible, however, to develop a model that performs equally well in all situations. Each model is published individually to facilitate updating and reprinting as new information becomes available. Assistance from users and researchers is an important part of the model improvement process. Please complete this form following application or review of the model. Feel free to include additional information that may be of use to either a model developer or model user. We also would appreciate information on model testing, modification, and application, as well as copies of modified models or test results. Please return this form to the following address.

National Coastal Ecosystems Team
U.S. Fish and Wildlife Service
1010 Gause Boulevard
Slidell, LA 70458

Thank you for your assistance.

Species______________ Geographic Location______________________________________

Habitat or Cover Type(s)____

Type of Application: Impact Analysis___Management Action Analysis_________
Baseline______Other____

Variables Measured or Evaluated____
____
____
____

Was the species information useful and accurate? Yes___ No___

If not, what corrections or improvements are needed?_____________________
____
____
____

Were the variables and curves clearly defined and useful? Yes____ No____

If not, how were or could they be improved?________________________________

____

____

____

Were the techniques suggested for collection of field data:

Appropriate? Yes____ No____

Clearly defined? Yes____ No____

Easily applied? Yes____ No____

If not, what other data collection techniques are needed?____________________

____

____

____

Were the model equations logical? Yes____ No____

Appropriate? Yes____ No____

How were or could they be improved?________________________________

____

____

____

____

____

____

Other suggestions for modification or improvement (attach curves, equations, graphs, or other appropriate information)________________________________

____

____

____

Additional references or information that should be included in the model:

____

____

____

____

____

____

Model Evaluator or Reviewer____________________ Date____________________

Agency____

Address____

____

____

Telephone Number Comm:____________________ FTS____________________

Biological Report 82(10.90)
May 1985

HABITAT SUITABILITY INDEX MODELS: EASTERN BROWN PELICAN

by

Terrence M. Hingtgen
Rosemarie Mulholland
Alexander V. Zale

Florida Cooperative Fish and Wildlife Research Unit
School of Forest Resources and Conservation
117 Newins-Ziegler Hall
University of Florida
Gainesville, FL 32611

Project Officer

Carroll L. Cordes
National Coastal Ecosystems Team
U.S. Fish and Wildlife Service
1010 Gause Boulevard
Slidell, LA 70458

Performed for
National Coastal Ecosystems Team
Division of Biological Services
Research and Development
Fish and Wildlife Service
U.S. Department of the Interior
Washington, DC 20240

This report should be cited as:

Hingtgen, T. M., R. Mulholland, and A. V. Zale. 1985. Habitat suitability index models: eastern brown pelican. U.S. Fish Wildl. Serv. Biol. Rep. 82(10.90). 20 pp.

PREFACE

The eastern brown pelican habitat suitability index (HSI) model is intended for use in the habitat evaluation procedures (HEP) developed by the U.S. Fish and Wildlife Service (1980) for impact assessment and habitat management. The model was developed from a review and synthesis of existing information and is scaled to produce an index of habitat suitability between 0 (unsuitable habitat) and 1 (optimally suitable habitat). Assumptions involved in developing the HSI model and guidelines for model applications, including methods for measuring model variables, are described.

This model is a hypothesis of species-habitat relationships, not a statement of proven cause and effect. The model has not been field-tested. For this reason, the U.S. Fish and Wildlife Service encourages model users to convey comments and suggestions that may help increase the utility and effectiveness of this habitat-based approach to fish and wildlife management. Please send any comments and suggestions you may have on the HSI model to the following address.

National Coastal Ecosystems Team
U.S. Fish and Wildlife Service
1010 Gause Boulevard
Slidell, LA 70458

CONTENTS

ACKNOWLEDGMENTS

Development of the habitat suitability index model for the eastern brown pelican was reviewed and constructively criticized by Erwin E. Klaas and Jaime A. Collazo, Iowa Cooperative Wildlife Research Unit, Iowa State University, Ames; Steven A. Nesbitt, Florida Game and Fresh Water Fish Commission, Wildlife Research Laboratory, Gainesville; Ralph W. Schreiber, Museum of Natural History, Los Angeles, California; David J. Wesley, Endangered Species Field Office, U.S. Fish and Wildlife Service (FWS), Jacksonville, Florida; Lovett E. Williams, Jr., Florida Game and Fresh Water Fish Commission, Wildlife Research Laboratory, Gainesville; and Don A. Wood, Florida Game and Fresh Water Fish Commission, Tallahassee. Thorough evaluations of model structure and functional relationships were provided by personnel of the FWS National Coastal Ecosystems Team (NCET). Supportive narrative and model reviews also were provided by Regional personnel of the FWS. Funding for model development and publication was provided by the FWS. The cover illustration was prepared by Patrick J. Lynch.

EASTERN BROWN PELICAN (*Pelecanus occidentalis carolinensis*)

INTRODUCTION

Brown pelicans (*Pelecanus occidentalis*) are large marine birds (3.5 kg or 7.7 lb) with a wingspan of 2 m (6.6 ft) that prey on fish by plunge-diving. Two brown pelican subspecies occur along coastal regions of the continental United States (Wetmore 1945). The eastern brown pelican (*P. o. carolinensis*) is found along the Atlantic coast from North Carolina to Florida and along the entire gulf coast to northern South America; it also ranges along the Pacific coast from southern Mexico to Columbia. The California brown pelican (*P. o. californicus*) is found along the Pacific coast from Washington south into Mexico. The eastern subspecies is smaller, with a wingchord averaging 25 mm (1 inch) shorter (526 mm or 21 inches total length) than the California subspecies, and has lighter breeding plumage on the hindneck (Wetmore 1945). This habitat suitability index model applies only to the eastern brown pelican.

Dramatic declines in brown pelican populations have been observed twice during this century (King et al. 1977a). In the 1930's, brown pelicans were destroyed by fishermen in Texas and Louisiana because of presumed competition for commercial fish (Gustafson et al. 1939). Food habit studies since then have shown that commercially important fish species comprise only 1% to 10% of the brown pelican diet (Palmer 1962); consequently, these birds probably have little impact on the commercial fishery (see Anderson et al. 1980).

The decline in breeding populations in Texas and South Carolina has been attributed to disease, inclement weather, and pollution (Blus 1970; Schreiber and Risebrough 1972; King et al. 1977b). Organochlorines in the food chain have been implicated as the cause of eggshell thinning and lowered reproductive success since the late 1950's (Mount and Putnicki 1966; Anderson et al. 1975; Nesbitt et al. 1978; Blus et al. 1979a; Mendenhall and Prouty 1979; Blus 1982). The western subspecies of brown pelican experienced complete reproductive failure in California in 1969 (Risebrough et al. 1971), and the eastern subspecies was extirpated in Louisiana in the late 1950's and early 1960's (King et al. 1977a). Both subspecies were placed on the Federal Endangered Species List in 1970 (USNFWL 1980). A breeding population of eastern brown pelicans was reintroduced into Louisiana from Florida (Williams and Joanen 1974; Nesbitt et al. 1978). Eastern brown pelican populations have become stable or have even increased in the Southeastern United States under protection. The subspecies and its habitats in North and South Carolina, Georgia, Florida, and Alabama were recently removed from Endangered Species Act protection (U.S. Fish and Wildlife Service 1985).

Distribution

In the United States, the eastern brown pelican breeding range includes the Atlantic coast of North Carolina, South Carolina, and Florida and the gulf coast of Florida, Alabama, Louisiana, and Texas (Palmer 1962).

Along the Atlantic Coast in North Carolina, the brown pelican nesting population has been divided between Shell Castle and North Rock Islands or, in some years, between Beacon Island and Cape Fear River spoil islands (Williams 1979; Clapp et al. 1982; Donald McCrimmon, Cornell University Laboratory of Ornithology; pers. comm.). Two colonies occur in South Carolina, one on Deveaux Bank and one at Cape Romain National Wildlife Refuge (Mendenhall and Prouty 1979). On the Atlantic coast of Florida, the species nests from Port Orange in Volusia County to the Florida Keys (Nesbitt et al. 1982). Brown pelicans nest along the gulf coast of Florida from Cedar Key in Levy County south to the Florida Keys; exceptions are a colony in Bay County near Panama City and a former colony near Port St. Joe (Florida Game and Fresh Water Fish Commission 1984). Brown pelican nesting colonies in Florida have been mapped and numbered by Williams (1979). Breeding populations on Florida's Atlantic and gulf coasts tend to remain separate (Schreiber 1976b). Additional colonies along the gulf coast include one in Mobile Bay, Alabama, and two restored colonies in Louisiana, one on Queen Bess Island near Grand Terre, and one on an island near the northern Chandeleur Islands. Texas recently has had four colony sites from Matagorda Bay south to Corpus Christi Bay (Texas Parks and Wildlife Department 1983).

In 1983, at least 1,382 pairs of eastern brown pelicans bred in North Carolina (McCrimmon, pers. comm.), 4,919 pairs in South Carolina (Phillip Wilkinson, South Carolina Wildlife and Marine Resources Department; pers. comm.), 6,980 pairs in Florida (Florida Game and Fresh Water Fish Commission 1984), at least 500 pairs in Louisiana (Larry McNease, Louisiana Department of Wildlife and Fisheries; pers. comm.), and 96 pairs in Texas (Texas Parks and Wildlife Department 1983).

Locations of peak concentrations of nonbreeding eastern brown pelicans and breeding colony sites have been listed for the Atlantic (Osborn and Custer 1978; Portnoy et al. 1981; Nesbitt et al. 1982) and gulf coasts (Williams 1979; Clapp et al. 1982; Nesbitt et al. 1982; Texas Colonial Waterbird Society 1982; Keller et al. 1984).

Life History Overview

Eastern brown pelicans usually begin to breed when they are 3 to 5 years old (Williams and Joanen 1974; Blus and Keahey 1978); their longevity approaches 20 years (Clapp et al. 1982). They nest in colonies of 10 to 1,500 pairs, though colonies usually average several hundred pairs (Schreiber 1978). The nesting season can vary by more than a month from year to year and probably is related to patterns of unseasonably high or low temperatures (Schreiber 1980a). Brown pelicans often begin nesting in February on Florida's west coast and in December on the east coast and Florida Keys. Nesting in North and South Carolina and in Texas often begins in March (Schreiber 1980a).

Transplanted colony offspring in Louisiana have retained the nesting season timing of the source population from Florida. They nest several months earlier than the native population that was extirpated in Louisiana (Portnoy 1977).

Although most eggs are laid during the season's first 3 months, egg-laying can span 6 months with both fledglings and eggs present in mid- season (Schreiber 1979). The usual clutch size is three eggs. Production of young fledglings requires about 18 weeks, including 1 to 2 weeks for nest building. Pelicans begin a 30-day incubation period after laying the first egg, resulting in asynchronous hatching (Schreiber 1979) and a greater chance of fledging for the first hatchling (Schreiber 1976a). Both sexes attend the altricial young for 10 to 12 weeks (Schreiber 1979). Breeding success is dependent upon the foraging success of the adults and varies greatly from year to year (Schreiber 1979; Anderson et al. 1982). Factors, in addition to starvation, that cause reduced breeding success include flooding of nests, nest desertion due to heavy tick infestation, egg breakage caused by adult birds' flushing in response to human disturbance, and predation of disturbed, unattended nests (reviewed by Clapp et al. 1982). Survival of nestlings and fledglings, not clutch size or hatching success, is the major source of variation in annual productivity of brown pelicans. Highest nestling mortality occurs during the first 30 days after hatching (Schreiber 1979). Captive brown pelicans have re-layed up to three times in a season and within 1 to 3 months after the previous loss. Schreiber (1979) found that re-laying occurred in as many as 26% (N=23) of nests in wild colonies. Later attempts had lower hatching success but were more likely to fledge hatchlings (85% success, N=39) than nests with only initial clutches (52% success, N=610) (Schreiber 1979).

Postfledging mortality for the first year averages 69% to 76% and then declines to an annual mortality of 16% as the birds become more proficient at foraging (Henny 1972; Schreiber 1976b, 1978). After the nesting season, birds along the Atlantic coast disperse to the south along the Florida east coast to the Keys (Schreiber 1976b). Pelicans on the gulf coast also disperse southward, and many probably winter south of the United States (Schreiber and Schreiber 1983).

SPECIFIC HABITAT REQUIREMENTS

Food

Eastern brown pelican food habits vary within its breeding range. In South Carolina, brown pelicans feed almost exclusively on young Atlantic menhaden (*Brevoortia tyrannus*) found in coastal estuaries (Blus et al. 1979b). In Louisiana and Texas, 90% to 95% of the diet (weight or volume not specified) consists of gulf menhaden (*B. patronus*), mullet (*Mugil* sp.), and other species not considered sportfish (Pearson 1921; Krantz 1968). Fogarty et al. (1981) found that regurgitated food boluses of Florida nestlings consisted of 14% menhaden by weight, with the remainder comprising 28% Atlantic threadfin (*Polydactylus octonemus*), 17% mullet, 11% spot (*Leiostomus xanthurus*), and 8% pinfish (*Lagodon rhomboides*). Adults must supply about 57 kg (125 lb) of fish to each young before fledging and require about 90 kg (198 lb) for themselves during nesting (Schreiber 1976a, 1982). Indirect evidence from parasitological studies indicates that nestlings are fed progressively larger fish of greater diversity as they grow older and that fledglings along the Florida coast are heavily dependent on mullet while learning to feed (Humphrey et al. 1978).

Brown pelicans plunge-dive from heights of up to 20 m (66 ft) to capture prey with their bill and pouch (Schreiber et al. 1975). Percentage estimates of successful plunge-dives have ranged from 30% (Gunter 1958) to 84% (Schnell et al. 1983). The lowest estimate includes data from immatures, which tend to be less successful (10% to 20% less) than adults (Orians 1969; Schnell et al. 1983). Pelicans usually capture prey items less than 25 cm (10 inches) long, and most captures occur in the top 1 m (3.3 ft) of water (Krantz 1968; Schreiber 1979; Schnell et al. 1983). These birds are not suited for underwater pursuit of prey (Sivak et al. 1977) but can capture fish by scooping them up while swimming at the surface (Dinsmore 1974; Rodgers 1978). Brown pelicans will scavenge offal thrown from boats or fishing piers (Sefton 1950; Schreiber 1978).

Eastern brown pelicans forage primarily in shallow estuarine waters (Schreiber 1978) and in marine waters within 32 km (20 mi) of shore (Williams 1979). The western subspecies may feed regularly up to 175 km (105 mi) offshore and 75 km (45 mi) from the nearest island (Briggs et al. 1981). California brown pelicans may forage at distances up to 75 km (45 mi) from their nesting colonies (Shannon 1933; Clapp et al. 1982), although most foraging occurs within 20 km (12 mi) of the nest site (Briggs et al. 1981).

Water

The dietary water requirements of brown pelicans can be satisfied by consumption of seawater (Schmidt-Nielsen and Fange 1958).

Nesting, Loafing, and Roosting Cover

Eastern brown pelican nesting colonies occur on coastal islands small enough to be free from human habitation and recreation and far enough from the mainland to be inaccessible to potential mammalian predators (Schreiber 1979; Williams 1979). Nesting colonies may abandon islands accessible to mammalian predators (Schreiber 1979).

Brown pelicans use both natural and man-made islands for nesting. In Florida, 20% of the breeding population nests on dredged-material islands (Schreiber and Schreiber 1978), reaching densities of 105 nests/ha (42 nests/acre) (Maxwell and Kale 1974). In addition, birds make extensive use of undisturbed dredged-material islands and sandbars for loafing and roosting (Schreiber and Schreiber 1982). Natural islands may be avoided because of their use by humans for recreation. Colony size (number of nests) is related to the amount of suitable nesting habitat. In areas where there are fewer islands with suitable nesting habitat, the average number of nests per colony is larger (Williams and Martin 1968).

Brown pelicans in the Carolinas and Texas nest on the ground or in small shrubs (Mendenhall and Prouty 1979; Clapp et al. 1982). In Louisiana, nests are built in black mangroves (Avicennia germinans) and on the ground (Blus et al. 1979a). Nests in Florida are usually constructed on open branches of mangrove trees (A. germinans, Rhizophora mangle, Laguncularia racemosa) 0.6 to 10 m (2 to 35 ft) above the ground, with the exception of one colony along the east coast consisting entirely of ground nests (Williams and Martin 1968; Schreiber 1978). Along the Florida gulf coast, nests are occasionally constructed in southern redcedar (Juniperus silicicola), redbay (Persea borbonia), seagrape (Coccoloba uvifera), and live oak (Quercus virginiana) (Williams and Martin 1970; Lovett E. Williams, Jr., Florida Game and Fresh Water Fish Commission; pers. comm.).

Brown pelicans nesting in trees are less vulnerable to flooding, human disturbance, and opportunistic predators than those nesting on the ground (Schreiber 1979; Lovett E. Williams, Jr., pers. comm.). When ground nesting occurs within the mangrove range, it is often on deteriorating islands where birds previously nested in trees (Schreiber and Schreiber 1978). Island elevation is important for nesting colonies outside the range of mangroves, where nesting is usually on the ground or in small shrubs. Nests on a colony's periphery are often flooded (Blus and Keahey 1978; Mendenhall and Prouty 1979). Potential nesting cover must be able to support a nest from 0.6 m (2 ft) to 10.7 m (35 ft) above the ground or high tide (Schreiber 1978).

Suitable branches for perching are important in nest site selection in mangroves (Schreiber 1977). Branches used for perching are usually within 1.2 m (3.9 ft) of the nest. Mangrove branches are also used in nest construction and are usually gathered from trees away from the nesting site. This results in areas of defoliation away from the colony but on the same island (Schreiber 1977). Distances between nests in mangroves are not less than 1.3 m (4.3 ft) or the distance neighboring pairs can reach while on the nest (Schreiber 1977). The number of active nests in colonies reported to the Colonial Bird Register (unpublished data) averaged 204 ± 32 nests per colony (Mean ± SE, N=99).

In Florida, Schreiber and Schreiber (1982) found that nesting adults may spend all of their nonforaging time on the colony island (Schreiber and Schreiber 1982). When not on the nests, they make use of sandbars and spits for loafing and roosting. These areas are essential drying sites for pelicans that become waterlogged after more than an hour on the water (Schreiber and Schreiber 1982). Older nestlings use vegetation and rocks on the island for shade during the hottest part of the day (Bartholomew and Dawson 1954), and new fledglings use the island for loafing and roosting (Schreiber and Schreiber 1982). Sandbars and spits are especially important to new fledglings that have not developed the coordination necessary to land on branches.

Although brown pelicans tend to use the same colony islands from one year to the next, factors such as proximity to food resources, human disturbance, predation, ectoparasites (see Special Considerations), and defoliation due to nesting activities may cause birds to shift breeding sites on a particular island as well as between islands from year to year (Williams and Martin 1968; Maxwell and Kale 1974; Schreiber and Schreiber 1982; Anderson and Gress 1983).

Establishment of a new colony on an island is preceded by use of that island for non-nesting activities (Schreiber and Schreiber 1982). Birds first use an island for loafing during the non-nesting season, then for roosting and loafing year-round, and then as a colony site. This progression of use may occur over a 3- to 4-year period (Lovett E. Williams, Jr., pers. comm.). Whether previous use is a necessary condition for establishment of a new colony has not been determined. Potential nesting habitat previously used for roosting and loafing is assumed to be more suitable than unused habitat.

Special Considerations

Several sources of human-induced stress can limit the productivity of brown pelicans. Organochlorines introduced into the food chain result in eggshell thinning (Blus et al. 1971; Blus et al. 1977; Mendenhall and Prouty 1979). Eggshell thickness was log-linearly related to DDE concentrations in eggs (Blus et al. 1972). Fat in starvation-stressed birds contained the highest levels of pesticide (Thompson et al. 1977). Some California colonies exposed to DDT-related compounds in food fish at concentrations of 4.3 parts per million have produced almost no young during the nesting season (Anderson et al. 1975). Organochlorines, particularly endrin, also have been implicated in the 1975 die-off of 150 adult birds (40% of the population) in Louisiana (Blus et al. 1979a).

The principal source of eastern brown pelican nesting failure is direct and indirect human interference with nesting colonies (Clapp et al. 1982). California brown pelican productivity (young per nest) may decline 52% to 100% as a result of one disturbance at the beginning of the nesting season (Anderson and Keith 1980). Eastern brown pelican nests disturbed two or more times per week have fewer eggs laid and reduced hatching success compared to nests disturbed once per week (Schreiber 1979). Flushing birds from nests allows avian predators like the fish crow (Corvus ossifragus) to destroy many eggs and young (Schreiber and Risebrough 1972). In addition, adults may not take time to step off the nest before flushing, resulting in crushed or displaced eggs or young. Nesting brown pelicans become alert to human presence within 100 m (328 ft) of the colony (Schreiber 1979), and loafing pelicans on colony islands prefer sandbars that are undisturbed by human activity.

Brown pelicans often scavenge food from fish-cleaning areas at marinas. Lincer et al. (1979) suggested that this unusual prey may have higher pesticide levels than the natural prey, which are fish lower in the food chain. Another hazard around marinas is entanglement in fishing lines, accounting for the deaths of more than 700 birds annually (Schreiber 1980b).

Oil spills cause an undetermined amount of mortality (Stevenson 1970). Adult mortality may occur at the time of the spill or after resuspension of oil accumulated in sediment (King et al. 1979). Hatching success may be reduced by oil contamination of eggs. Following an oil spill in North

Carolina, Parnell et al. (1983) found that 66% of the oil-contaminated eggs hatched, compared to 84% of unoiled eggs.

Another limiting factor to successful reproduction is ectoparasite load at the nest site. Excessive tick infestation in nesting areas has been implicated in the desertion of eggs and young by adult birds in Texas, California, and Peru (King et al. 1977b, 1977c; Duffy 1983). Ticks can number more than 700 per nest in severe infestations, can carry pathogenic viruses, and may cause birds to avoid the nesting area the following year.

HABITAT SUITABILITY INDEX (HSI) MODEL

Model Applicability

This model can be used to evaluate estuarine island habitat (Cowardin et al. 1979), natural islands, and dredge islands within the eastern brown pelican breeding range (Figure 1). The minimum habitat area required for breeding has not been established.

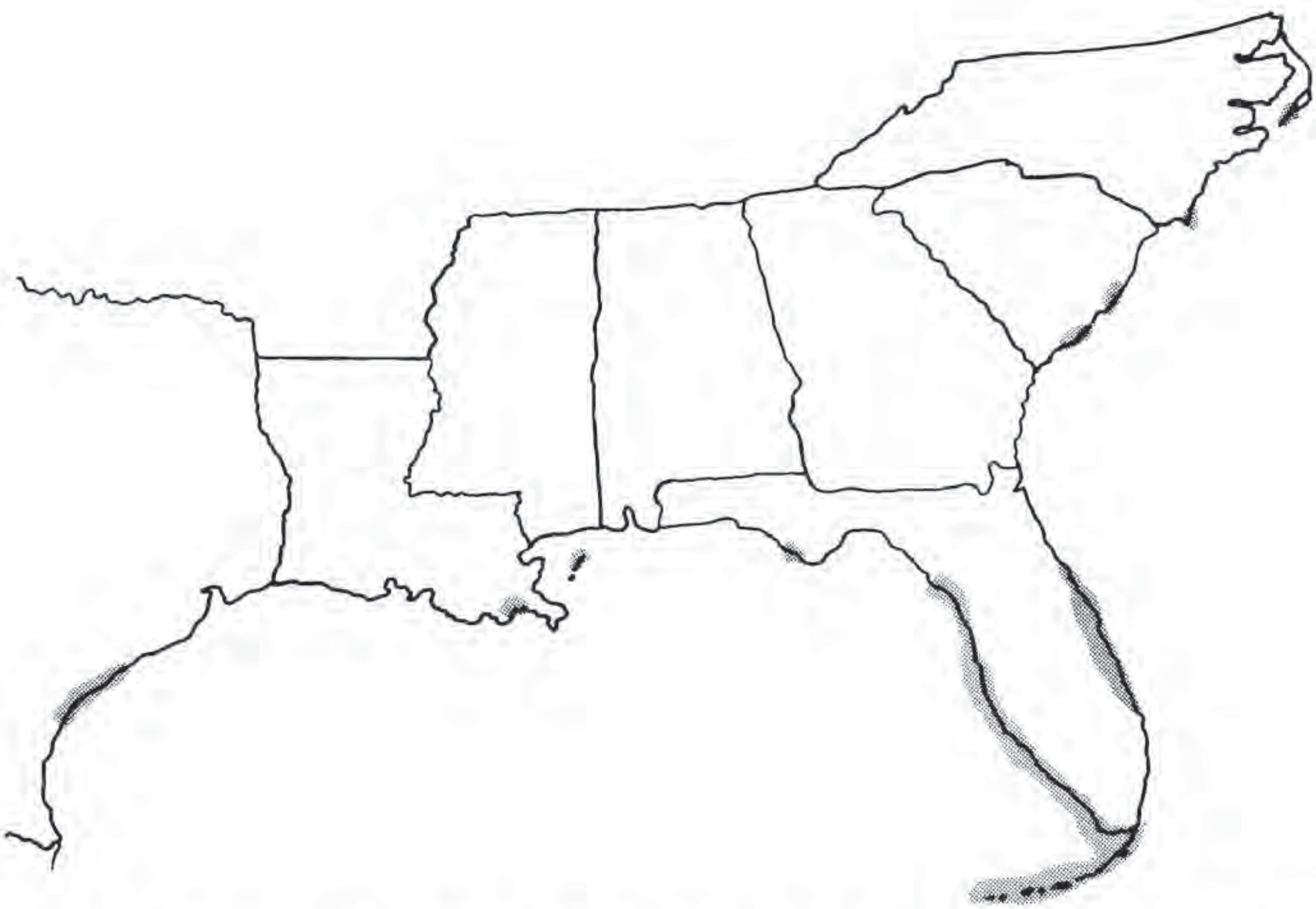


Figure 1. Breeding range of the eastern brown pelican and regions (shaded) of model applicability (Clapp et al. 1982).

Season. Eastern brown pelican breeding season can be year-round in southern Florida but tends to be late winter, spring, and/or early summer at more northern latitudes. The model should be used to evaluate breeding habitat at the beginning of the breeding season.

Verification level. The acceptable model output is an index value between 0.0 and 1.0 that reflects the habitat potential for eastern brown pelican nesting. A value of 1.0 indicates optimal suitability and 0.0 indicates unsuitability. The model has not been field-tested. Hypothetical data sets were used to verify that the model output was reasonable. Reviewers' comments have been incorporated, but the authors are responsible for the final version of this model.

Model Description

Overview. Components of the eastern brown pelican breeding habitat are nesting, roosting, loafing, and foraging sites. The quality of feeding sites around a colony may account for year-to-year variation in colony use and may limit the use of potential nesting habitat. Although the breeding success of California brown pelicans is dependent on food resources around their colony islands (Anderson et al. 1982), food distribution has not been incorporated as a variable in the eastern brown pelican habitat evaluation model because of lack of knowledge about the seasonal distributions of surface fish schools (see Schreiber and Schreiber 1983). Nesting, roosting, and loafing sites are evaluated by measuring habitat variables for the single life requisite of nesting/loafing cover (Figure 2). Use of this model assumes that the nesting habitat under evaluation comprises estuarine islands that do not support known populations of quadruped predators.

Nesting/loafing cover. Habitat variables in the model related to breeding habitat quality of an estuarine island are island surface area, distance from mainland, distance from human activity centers, and relative coverage of nesting vegetation.

The island surface area (V_1) and its distance from mainland (V_2) are assumed to be indications of its accessibility to quadruped predators. Islands larger than 8 ha (20 acres) may be able to support resident populations of predators (Landin 1978). Because brown pelicans are colonial nesters and mean colony size is probably 100 nests or more (Colonial Bird Register, unpublished data), the minimum area of highest suitability is assumed to be 2 ha (5 acres). This includes 1 ha (2.5 acres) of nesting area required by colonies of about 100 pairs at a density of 105 nests/ha (42 nests/acre), and 1 ha (2.5 acres) for loafing and drying.

Optimal distance from the mainland (V_2) is assumed to be 0.4 km (0.25 mi) or more, and suitability increases to a maximum at that distance (see Lewis 1983). Distance of islands from human activity centers (V_3) also influences habitat quality for nesting brown pelicans. Islands that have permanent human inhabitants or are visited by humans for recreational or commercial purposes during the breeding season are less suitable for nesting. Islands that are at least 100 m (328 ft) from areas of human activity may be used by brown pelicans for nesting, but suitability increases with distance to an optimum of

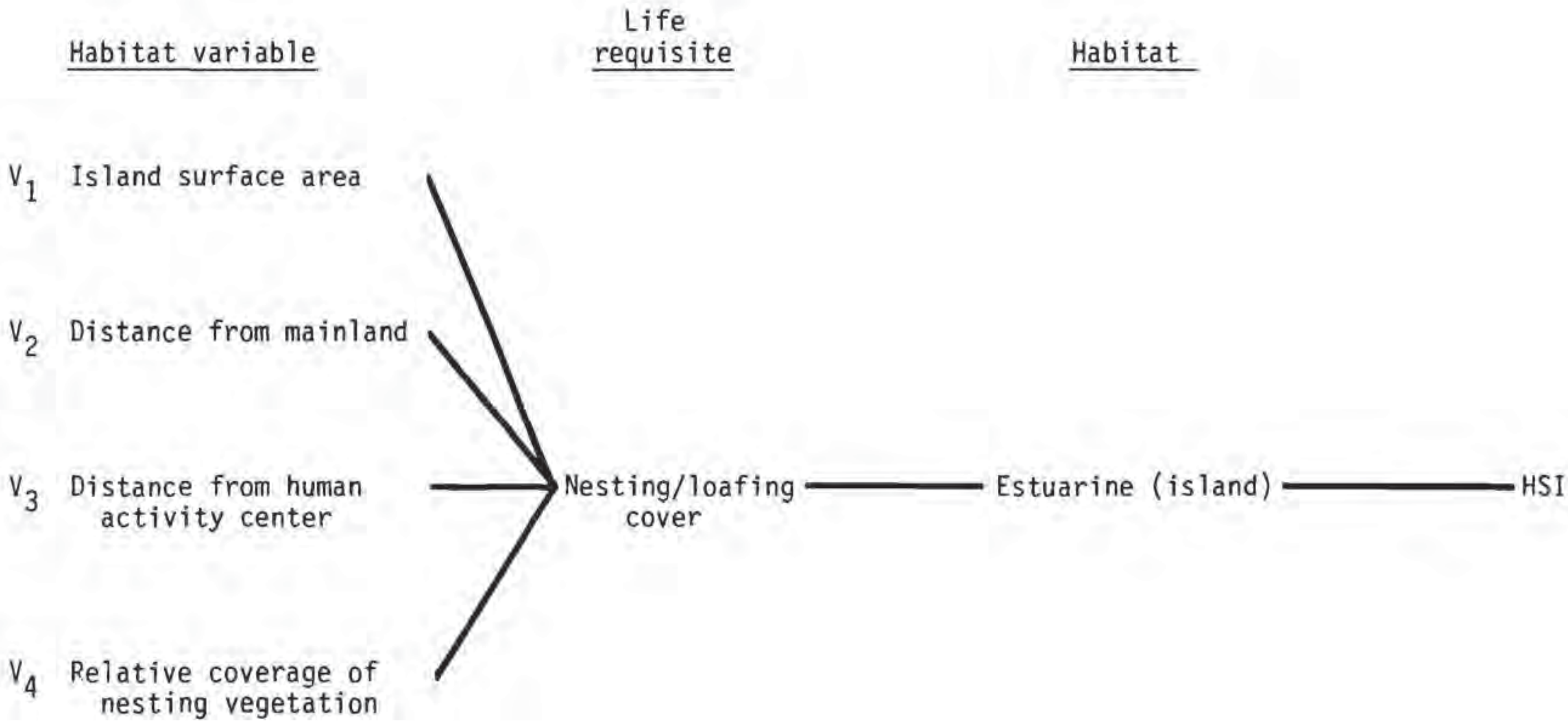


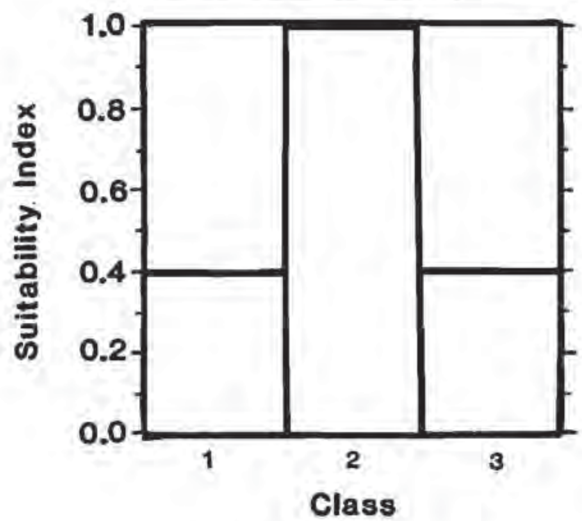
Figure 2. Relationships of habitat variables, life requisite, and habitat type in the HSI model for the eastern brown pelican.

0.4 km (0.25 mi) or more. This distance was chosen because it minimizes spurious visits by humans or their domestic animals.

Nesting cover (V_4) is identified differently for Florida, Alabama, and Louisiana than for Texas and the Carolinas. Where mangroves occur (FL, AL, LA), tree or shrub nesting is considered optimal for brown pelicans because nests can be constructed above high tide on low elevation islands, and pelicans are less vulnerable to human disturbance and opportunistic predators. Eastern brown pelicans nesting outside the mangrove range, including eastern Texas and the Carolinas, usually nest on the ground or in small shrubs. Island elevation is important for these colonies. Therefore, island surface and shrubs that are potential nesting cover must be at least 0.6 m (2 ft) above high tide. Nesting vegetation covering 50% or more of an island is considered optimal.

Suitability Index (SI) Graphs for Model Variables

The relationships between the habitat variables and breeding habitat suitability for brown pelicans are presented graphically in this section. The assumptions necessary to construct the model are summarized in Table 1. The SI values on the ordinate axis range from optimal habitat (1.0) to unsuitable habitat (0.0).

Habitat	Variable	Description	Suitability Graph
E	V_1	Island surface area 1) Less than 2 ha (4.9 acres) 2) 2 to 8 ha (4.9 to 19.8 acres) 3) Greater than 8 ha (19.8 acres).	

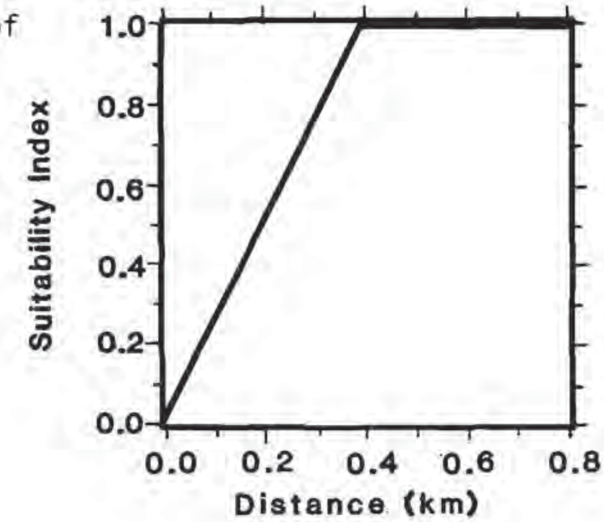
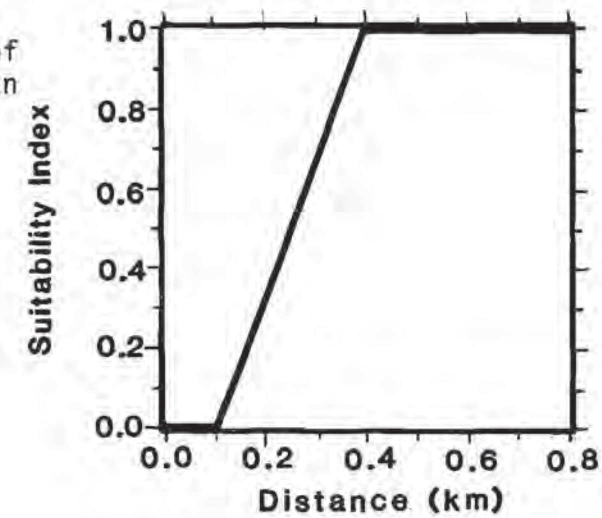
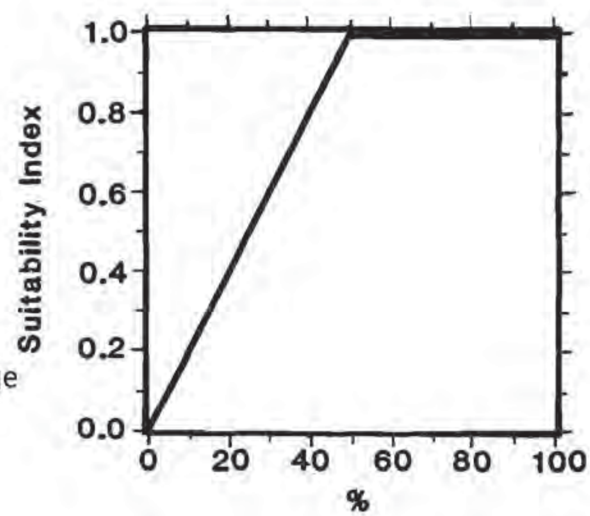
Habitat	Variable	Description	Suitability Graph
E	V_2	Straight-line distance of island from mainland.	
E	V_3	Straight-line distance of island from nearest human activity center.	
E	V_4	Relative coverage of nesting vegetation. Within the range of mangrove (FL, AL, LA), relative coverage is the percentage of the island supporting woody vegetation 0.6 to 10.7 m (2 to 35 ft) in height. Outside this range (NC, SC, TX), relative coverage is the percentage of the island surface area at least 0.6 m (2 ft) in elevation.	

Table 1. Sources of information and assumptions regarding breeding habitat variables used to calculate the HSI for eastern brown pelicans.

	Variable and sources	Assumptions
V_1	Landin 1978 Schreiber 1977 Colonial Bird Register, unpublished data	Islands that are 8 ha (20 acres) or larger are most likely to support resident populations of quadruped predators. Average colonies require at least 1.0 ha (2.5 acres) of nesting cover and a similar size sandy area for drying and loafing.
V_2	Schreiber 1979 Buckley and Buckley 1980 Briggs et al. 1981	Colony islands close to mainland are more accessible to mammalian predators. Islands that are 0.4 km (0.25 mi) or more from the mainland are virtually inaccessible. Island is assumed to be initially free of quadruped predators.
V_3	Williams and Martin 1970 Jehl 1973 Schreiber 1979 Schreiber and Schreiber 1982	Brown pelicans respond to human activity within 100 m (330 ft) of nesting colonies. One disturbance can disrupt production. Islands that are 0.4 km (0.25 mi) from the nearest center of human activity have less chance of being disturbed.
V_4	Nesbitt et al. 1977 Schreiber 1977, 1978 Blus and Keahey 1978 Schreiber and Schreiber 1978 Blus et al. 1979a	Tree heights of 0.6 to 10.7 m (2 to 35 ft) are optimal for nesting within the range of mangroves. Outside that range, ground nests higher than 0.6 m (2 ft) have a low risk of flooding.

Component Index (CI) Equation and HSI Determination

Nesting/loafing cover is the only life requisite considered in this model. Therefore, the HSI value equals the component index (CI) for cover. We suggest the following equation to obtain the CI and HSI values.

Component	Equation
Cover (C)	$(SI_{V_1} \times SI_{V_2} \times SI_{V_3} \times SI_{V_4})^{1/4}$

HSI = C

The output of the model is demonstrated for hypothetical data in Table 2. The first data set represents a situation where cover is limiting, while the second and third data sets represent situations where colonies are more vulnerable to predation and human disturbance.

Field Use of the Model

Suggested methods for measuring habitat variables are presented in Table 3. These methods were chosen for their efficient use of time and resources. If neither of these is limiting, methods producing a larger, more comprehensive data base may not only increase the precision of the model but may also provide information leading to its improvement.

Interpreting Model Output

When areas with similar HSI values are compared, an area previously used by pelicans for roosting and loafing is more likely to be used for nesting in the near future than an unused area. As with other HSI models, the HSI value obtained may have no relationship to nesting population size but indicates the potential of an area as nesting habitat.

Further studies of brown pelican ecology are necessary to provide information for model improvement. Especially needed are studies on nesting colony distribution relative to food fish distribution in surface waters, the effect of vegetation characteristics on nesting success, and the development of new colonies. Modifications and improvements should be incorporated as new data are collected.

Table 2. Model output of the component index (CI) and habitat suitability index (HSI) for three hypothetical data sets with their corresponding suitability index (SI) values.

Model	Data set 1		Data set 2		Data set 3	
component	Data	SI	Data	SI	Data	SI
V_1	2 ha	1.00	17 ha	0.40	4 ha	1.00
V_2	0.5 km	1.00	0.1 km	0.25	0.4 km	1.00
V_3	0.5 km	1.00	0.1 km	0	0.2 km	0.33
V_4	40%	0.80	50%	1.00	25%	0.50
C	0.95		0		0.64	
HSI	0.95		0		0.64	

Table 3. Suggested techniques for measuring breeding habitat variables for the brown pelican HSI model.

Habitat variable		Technique
V_1	Island surface area	Measure area of the island on a topographic map or aerial photo taken at high tide.
V_2	Distance from mainland	Measure straight-line distance from mainland shore to island shore at low tide.
V_3	Distance from nearest human activity center	Measure straight-line distance from closest area of any center of human activity to colony island. Identify the closest area of current human activity or projected human activity during the nesting season, whichever is the shorter distance.
V_4	Relative cover of nesting vegetation	Use aerial photos and topographic maps of estuarine islands to measure coverage of trees and shrubs 0.6 m (2 ft) to 10.7 m (35 ft) high (FL, AL, LA) or the area of island surface at least 0.6 m (2 ft) in elevation (NC, SC, TX). Visit islands to confirm vegetation physiognomy. Branches should provide nonsagging support of 6.5 kg (14 lb) (weight of two adults) at least 0.6 m (2 ft) above the ground.

REFERENCES

Anderson, D. W., and F. Gress. 1983. Status of a northern population of California brown pelicans. Condor 85:79-88.

Anderson, D. W., and J. D. Keith. 1980. The human influence on seabird nesting success: conservation implications. Biol. Conserv. 18:65-80.

Anderson, D. W., J. R. Jehl, Jr., R. W. Risebrough, L. A. Woods, Jr., L. R. Deweese, and W. G. Edgecomb. 1975. Brown pelicans: improved reproduction off the southern California coast. Science 190:806-808.

Anderson, D. W., F. Gress, K. F. Mais, and P. R. Kelly. 1980. Brown pelicans as anchovy stock indicators and their relationships to commercial fishing. Calif. Coop. Oceanic Fish. Invest. Rep. 21:54-61.

Anderson, D. W., F. Gress, and K. F Mais. 1982. Brown pelicans: influence of food supply on reproduction. Oikos 39:23-31.

Bartholomew, G. A., Jr., and W. R. Dawson. 1954. Temperature regulation in young pelicans, herons, and gulls. Ecology 35:466-472.

Blus, L. J. 1970. Measurements of brown pelican eggshells from Florida and South Carolina. Bioscience 20:867-869.

Blus, L. J. 1982. Further interpretation of the relation of organochlorine residues in brown pelican eggs to reproductive success. Environ. Pollut. Ser. A Ecol. Biol. 28:15-33.

Blus, L. J., and J. A. Keahey. 1978. Variation in reproductivity with age in the brown pelican. Auk 95:128-134.

Blus, L. J., R. G. Heath, C. D. Gish, A. A. Belisle, and R. M. Prouty. 1971. Eggshell thinning in the brown pelican: implications of DDE. Bioscience 21:1213-1215.

Blus, L. J., C. D. Gish, A. A. Belisle, and R. M. Prouty. 1972. Further analysis of the logarithmic relationship of DDE residues to eggshell thinning. Nature 240:164-166.

Blus, L. J., B. S. Neely, Jr., T. G. Lamont, and B. Mulhern. 1977. Residues of organochlorines and heavy metals in tissues and eggs of brown pelicans, 1969-1973. Pestic. Monit. J. 11:40-53.

Blus, L., E. Cromartie, L. McNease, and T. Joanen. 1979a. Brown pelican: population status, reproductive success, and organochlorine residues in Louisiana, 1971-1976. Bull. Environ. Contam. Toxicol. 22:128-135.

Blus, L. J., T. G. Lamont, and B. S. Neely, Jr. 1979b. Effects of thickness, organochlorine residues on eggshell reproduction, and population status of brown pelicans (Pelecanus occidentalis) in South Carolina and Florida, 1969-76. Pestic. Monit. J. 12:172-184.

Briggs, K. T., D. B. Lewis, W. B. Tyler, and G. L. Hunt, Jr. 1981. Brown pelicans in southern California: habitat use and environmental fluctuations. Condor 83:1-15.

Buckley, F. G., and P. A. Buckley. 1980. Habitat selection and marine birds. Pages 69-112 in J. Burger, B. L. Olla, and H. E. Winn, eds. Behavior of marine animals, current perspectives in research. Vol. 4: Marine birds. Plenum Press, N.Y.

Clapp, R. B., R. C. Banks, D. Morgan-Jacobs, and W. A. Hoffman. 1982. Marine birds of the Southeastern United States and Gulf of Mexico. Part I. Gaviiformes through Pelecaniformes. U.S. Fish Wildl. Serv. Biol. Serv. Program FWS/OBS-82/01. 637 pp.

Colonial Bird Register. Unpublished data courtesy of N. P. McGinnis and D. A. McCrimmon, Jr. National Audubon Society Research Department, Cornell Laboratory of Ornithology, Ithaca, N.Y.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe. 1979. Classification of wetlands and deepwater habitats of the United States. U.S. Fish Wildl. Serv. Biol. Serv. Program FWS/OBS-79/31. 103 pp.

Dinsmore, J. J. 1974. White and brown pelicans feeding together. Fla. Field Nat. 2:11.

Duffy, D. C. 1983. The ecology of tick parasitism on densely nesting Peruvian seabirds. Ecology 64:110-119.

Florida Game and Fresh Water Fish Commission. 1984. Florida endangered and threatened species management and conservation plan - 1984 update and progress report. Unpublished. 34 pp.

Fogarty, M. J., S. A. Nesbitt, and C. R. Gilbert. 1981. Diet of nestling brown pelicans in Florida. Fla. Field Nat. 9:38-40.

Gunter, G. 1958. Feeding behavior of brown and white pelicans on the gulf coast of the United States. Proc. La. Acad. Sci. 21:34-39.

Gustafson, A. F., C. H. Guise, W. J. Haminton, Jr., and H. Rise. 1939. Conservation in the United States. Comstock Publishing Co., Ithaca, N.Y. 534 pp.

Henny, C. J. 1972. An analysis of the population dynamics of selected avian species. With special reference to changes during the modern pesticide era. U.S. Bureau Sport Fish. Wildl. Res. Rep. 1:41-46.

Humphrey, S. R., C. H. Courtney, and D. J. Forrester. 1978. Community ecology of the helminth parasites of the brown pelican. Wilson Bull. 90:587-598.

Jehl, J. R., Jr. 1973. Studies of a declining population of brown pelicans in northwestern Baja California. Condor 75:69-79.

Keller, C. K., J. A. Spendelow, and R. D. Greer. 1984. Atlas of wading bird and seabird nesting colonies in coastal Louisiana, Mississippi and Alabama: 1983. U.S. Fish Wildl. Serv. FWS/OBS-84/13. vi and 127 pp.

King, K. A., E. L. Flickinger, and H. H. Hildebrand. 1977a. The decline of brown pelicans on the Louisiana and Texas gulf coast. Southwest. Nat. 21:417-431.

King, K. A., D. R. Blankinship, R. T. Paul, and R. C. A. Rice. 1977b. Ticks as a factor in the 1975 nesting failure of Texas brown pelicans. Wilson Bull. 89:157-158.

King, K. A., J. D. Keith, C. A. Mitchell, and J. E. Keirans. 1977c. Ticks as a factor in nest desertion of California brown pelicans. Condor 79:507-509.

King, K. A., S. Macko, P. L. Parker, and E. Payne. 1979. Resuspension of oil: probable cause of brown pelican fatality. Bull. Environ. Contam. Toxicol. 23:800-805.

Krantz, W. C. 1968. A literature review of the ecology and reproductive biology of the brown pelican. Unpublished Staff Report. Upland Ecology Section, U.S. Fish and Wildlife Service, Patuxent Wildlife Research Center. 49 pp.

Landin, M. C. 1978. National perspective of colonial waterbirds nesting on dredged material islands. Trans. N. Am. Wildl. Nat. Resour. Conf. 43:89-99.

Lewis, J. C. 1983. Habitat suitability index models: roseate spoonbill. U.S. Fish. Wildl. Serv. FWS/OBS-82/10.50. 16 pp.

Lincer, J. L., D. Kricit, and J. E. Shaw. 1979. People and "pan-handling" pelicans. Fla. Field Nat. 7:13-18.

Maxwell, G. R., II, and H. W. Kale II. 1974. Population estimates of breeding birds on a spoil island in the Indian River, Indian River County, Florida. Fla. Field Nat. 2:32-39.

Mendenhall, V. M., and R. M. Prouty. 1979. Recovery of breeding success in a population of brown pelicans. Proc. 1978 Conf. Colonial Waterbird Group 2:65-70.

Mount, D. I., and G. J. Putnicki. 1966. Summary report of the 1963 Mississippi fish kill. Trans. N. Am. Wildl. Nat. Resour. Conf. 31:177-184.

Nesbitt, S. A., M. J. Fogarty, and L. E. Williams, Jr. 1977. Status of Florida nesting brown pelicans, 1971-1976. Bird-Banding 48:138-144.

Nesbitt, S. A., L. E. Williams, Jr., L. McNease, and T. Joanen. 1978. Brown pelican restocking efforts in Louisiana. Wilson Bull. 90:443-445.

Nesbitt, S. A., J. C. Ogden, H. W. Kale II, B. W. Patty, and L. A. Rowse. 1982. Florida atlas of breeding sites for herons and their allies: 1976-78. U.S. Fish Wildl. Serv. Biol. Serv. Program FWS/OBS-81/49. 449 pp.

Orians, G. H. 1969. Age and hunting success in the brown pelican (Pelecanus occidentalis). Anim. Behav. 17:316-319.

Osborn, R. G., and T. W. Custer. 1978. Herons and their allies: atlas of Atlantic coast colonies, 1975 and 1976. U.S. Fish Wildl. Serv. Biol. Serv. Program FWS/OBS-77/08. 211 pp.

Palmer, R. S. 1962. Handbook of North American birds. Vol. 1: Loons through flamingos. Yale University Press, New Haven, Conn. 567 pp.

Parnell, J. F., M. A. Shields, and D. Frierson, Jr. 1983. Comparison of hatching success of oiled and unoiled brown pelican eggs. Colonial Waterbird Group, 7th Annual Meeting, San Juan, Puerto Rico. (Abstr.)

Pearson, T. G. 1921. Notes on the birdlife of southeastern Texas. Auk 38:513-523.

Portnoy, J. W. 1977. Nesting colonies of seabirds and wading birds - coastal Louisiana, Mississippi, and Alabama. U.S. Fish Wildl. Serv. Biol. Serv. Program FWS/OBS-77/07. 126 pp.

Portnoy, J. W., R. M. Erwin, and T. W. Custer. 1981. Atlas of gull and tern colonies: North Carolina to Key West, Florida (including pelicans, cormorants, and skimmers). U.S. Fish Wildl. Serv. Biol. Serv. Program FWS/OBS-80/05. 121 pp.

Risebrough, R. W., F. C. Sibley, and M. N. Kirven. 1971. Reproductive failure of the brown pelican on Anacapa Island in 1969. Am. Birds 25:8-9.

Rodgers, J. A., Jr. 1978. Feeding association between brown pelicans and wood storks. Fla. Field Nat. 6:44-45.

Schmidt-Nielsen, K., and R. Fange. 1958. The function of the salt gland in the brown pelican. Auk 75:282-289.

Schnell, G. D., B. L. Woods, and B. J. Ploger. 1983. Brown pelican foraging success and kleptoparasitism by laughing gulls. Auk 100:636-644.

Schreiber, R. W. 1976a. Growth and development of nestling brown pelicans. Bird-Banding 47:19-39.

Schreiber, R. W. 1976b. Movements of colormarked brown pelicans. Bird-Banding 47:101-111.

Schreiber, R. W. 1977. Maintenance behavior and communication in the brown pelican. Am. Ornithologists' Union Monogr. 22. 78 pp.

Schreiber, R. W. 1978. Eastern brown pelican. Pages 23-25 in H. W. Kale II, ed. Rare and endangered biota of Florida, Vol. 2: Birds. University Presses of Florida, Gainesville. 121 pp.

Schreiber, R. W. 1979. Reproductive performance of the eastern brown pelican, Pelecanus occidentalis. Contrib. Sci. Nat. Hist. Mus. Los Ang. 317:1-43.

Schreiber, R. W. 1980a. Nesting chronology of the eastern brown pelican. Auk 97:491-508.

Schreiber, R. W. 1980b. The brown pelican: an endangered species? Bioscience 20:742-747.

Schreiber, R. W. 1982. A brown study of the brown pelican. Nat. Hist. 91:38-42.

Schreiber, R. W., and R. W. Risebrough. 1972. Studies of the brown pelican. Wilson Bull. 84:119-135.

Schreiber, R. W., and E. A. Schreiber. 1978. Colonial bird use and plant succession on dredged material islands in Florida. Vol. 1: Sea and wading bird colonies. U.S. Army Engineer Waterways Exp. Stn., Vicksburg, Miss. Tech. Rep. D-78-14. 127 pp.

Schreiber, R. W., and E. A. Schreiber. 1982. Essential habitat of the brown pelican in Florida. Fla. Field Nat. 10:9-17.

Schreiber, R. W., and E. A. Schreiber. 1983. Use of age-classes in monitoring population stability of brown pelicans. J. Wildl. Manage. 47:105-111.

Schreiber, R. W., G. E. Woolfenden, and W. E. Curtsinger. 1975. Prey capture by the brown pelican. Auk 92:649-654.

Sefton, J. W., Jr. 1950. The brown pelican as a scavenger. Condor 52:136-137.

Shannon, W. E. 1933. The eastern brown pelican at Brevard Reserve. Fla. Nat. 6:41-44.

Sivak, J. G., J. L. Lincer, and W. Bobier. 1977. Amphibious visual optics of the eyes of double-crested cormorant (Phalacrocorax auritus) and the brown pelican (Pelecanus occidentalis). Can. J. Zool. 55:782-788.

Stevenson, H. M. 1970. The changing seasons: the winter season December 1, 1969-March 31, 1970: Florida region. Audubon Field Notes 24:493-497.

Texas Colonial Waterbird Society. 1982. An atlas and census of Texas waterbird colonies 1973-1980. Caesar Kleberg Wildlife Research Institute, Texas Agricultural Industrial University, Kingsville. 358 pp.

Texas Parks and Wildlife Department. 1983. Nongame wildlife investigations: brown pelican study. Tex. Parks Wildl. Dep. Fed. Aid Proj. W-103-R-8, Job 41. 18 pp.

Thompson, N. P., C. H. Courtney, D. J. Forrester, and F. H. White. 1977. Starvation pesticide interactions in juvenile brown pelicans. Bull. Environ. Contam. Toxicol. 17:485-490.

U.S. Fish and Wildlife Service. 1980. Habitat evaluation procedures (HEP). ESM 102. Washington, D.C. n.p.

U.S. Fish and Wildlife Service. 1985. Brown pelicans in Southeastern U.S. delisted after recovering from effects of DDT. U.S. Fish Wildl. Serv. Tech. Bull. Endangered Species Program 10(3):1.

USNFWL (U.S. National Fish and Wildlife Laboratory). 1980. Selected vertebrate endangered species of the seacoast of the United States - brown pelican eastern and California subspecies. U.S. Fish Wildl. Serv. Biol. Serv. Program. FWS/OBS-80/01.40. 16 pp.

Wetmore, A. 1945. A review of the forms of the brown pelican. Auk 62:577-586.

Williams, L. E., Jr., ed. 1979. Recovery plan for the eastern brown pelican (Pelecanus occidentalis carolinensis). U.S. Fish Wildl. Serv. 46 pp.

Williams, L. E., Jr., and T. Joanen. 1974. Age of first breeding in the brown pelican. Wilson Bull. 86:279-280.

Williams, L. E., Jr., and L. Martin. 1968. Nesting status of the brown pelican in Florida in 1968. Q. J. Fla. Acad. Sci. 31:130-140.

Williams, L. E., Jr., and L. L. Martin. 1970. Nesting populations of brown pelicans in Florida. Proc. Southeast. Assoc. Game Fish Comm. 24:154-169.

50272-101

REPORT DOCUMENTATION PAGE	1. REPORT NO. Biological Report 82(10.90)	2.	3. Recipient's Accession No.

4. Title and Subtitle
Habitat Suitability Index Models: Eastern Brown Pelican

5. Report Date
May 1985

6.

7. Author(s)
Terrence M. Hingtgen, Rosemarie Mulholland, and Alexander V. Zale

8. Performing Organization Rept. No.

9. Performing Organization Name and Address
Florida Cooperative Fish and Wildlife Research Unit
School of Forest Resources and Conservation
117 Newins-Ziegler Hall, University of Florida
Gainesville, FL 32611

10. Project/Task/Work Unit No.

11. Contract(C) or Grant(G) No.
(C)
(G)

12. Sponsoring Organization Name and Address
National Coastal Ecosystems Team
Division of Biological Services
Research and Development
Fish and Wildlife Service
U.S. Department of Interior
Washington, DC 20240

13. Type of Report & Period Covered

14.

15. Supplementary Notes

16. Abstract (Limit: 200 words)

A review and synthesis of existing information were used to develop a habitat model for the eastern brown pelican (Pelecanus occidentalis carolinensis). The model is scaled to produce an index of habitat suitability between 0 (unsuitable habitat) and 1.0 (optimal habitat) for coastal areas within the eastern brown pelican's breeding range. Habitat suitability indices are designed for use with the Habitat Evaluation Procedures previously developed by the U.S. Fish and Wildlife Service. Guidelines for application of the eastern brown pelican habitat model and techniques for measuring model variables are described.

17. Document Analysis a. Descriptors

Mathematical models
Wildlife
Birds

b. Identifiers/Open-Ended Terms

Habitat
Impact assessment
Pelecanus occidentalis carolinensis
Habitat suitability index
Eastern brown pelican

c. COSATI Field/Group

18. Availability Statement	19. Security Class (This Report)	21. No. of Pages
Unlimited	Unclassified	20
	20. Security Class (This Page)	22. Price
	Unclassified	

(See ANSI-Z39.18)

☆U.S. GOVERNMENT PRINTING OFFICE: 1985 — 573-260

OPTIONAL FORM 272 (4-77)
(Formerly NTIS-35)
Department of Commerce

REGION 1
Regional Director
U.S. Fish and Wildlife Service
Lloyd Five Hundred Building, Suite 1692
500 N.E. Multnomah Street
Portland, Oregon 97232

REGION 2
Regional Director
U.S. Fish and Wildlife Service
P.O. Box 1306
Albuquerque, New Mexico 87103

REGION 3
Regional Director
U.S. Fish and Wildlife Service
Federal Building, Fort Snelling
Twin Cities, Minnesota 55111

REGION 4
Regional Director
U.S. Fish and Wildlife Service
Richard B. Russell Building
75 Spring Street, S.W.
Atlanta, Georgia 30303

REGION 5
Regional Director
U.S. Fish and Wildlife Service
One Gateway Center
Newton Corner, Massachusetts 02158

REGION 6
Regional Director
U.S. Fish and Wildlife Service
P.O. Box 25486
Denver Federal Center
Denver, Colorado 80225

REGION 7
Regional Director
U.S. Fish and Wildlife Service
1011 E. Tudor Road
Anchorage, Alaska 99503

DEPARTMENT OF THE INTERIOR
U.S. FISH AND WILDLIFE SERVICE

As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally owned public lands and natural resources. This includes fostering the wisest use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also has a major responsibility for American Indian reservation communities and for people who live in island territories under U.S. administration.

Appendix E
News Articles

Charleston Harbor Cap 204 Detailed Project Report

Opinion

http://www.postandcourier.com/opinion/editorials/make-the-effort-to-save-crab-bank/article_98d44668-4fab-11e7-9315-3ff0fb5376f6.html

Make the effort to save Crab Bank

Jun 18, 2017

This still captured from a webcam Monday, June 5, 2017, shows what is left of Crab Bank. Provided

Crab Bank may seem like an insignificant speck of land at the mouth of Shem Creek — unless you're a pelican, tern, gull or oystercatcher. To them, the protected islet is vital real estate. That why it's formally known as Crab Bank Seabird Sanctuary, one of only five protected pelican nesting sites in the state.

It's a nearly barren spit of sand now, its high ground decorated only by a few rocks and an abandoned boat. But just a few years ago Crab Bank had lush patches of vegetation and, at low tide, formed a miniature archipelago stretching about 2,000 feet from end to end. Images from 2003 show a grassy strip of seabird paradise dotted with pelican nests, each containing two or three eggs, the maximum for brown pelicans.

Blame its destruction on storms, wakes from passing ships and pleasure craft, even rising sea levels. After a spate of violent weather in May, a state wildlife biologist confirmed that only abo 40 seabird nests remained on the forlorn spit. About 60 shorebird eggs were found washed up on the beach at Sullivan's Island, The Post and Courier's Bo Petersen reported.

Crab Bank is the kind of sanctuary that helped brown pelicans rebound from near extinction in the 1960s and '70s, and was home to thousands of seabird nests not so long ago. Now, dry lan for nesting is almost gone and soon the pelicans and other seabirds will be too, if something isn't done.

The sandbar, documented more than 250 years ago, morphed into a tiny island in the 1950s, thanks largely to dredge spoil from Shem Creek dumped there. And once again, a human hand — and some heart — is needed.

Restoring Crab Bank wouldn't just be good for pelicans and other nesting seabirds; it would be good for Charleston to have a functioning rookery in its bustling harbor.

Aside from year-round pelicans, Crab Bank is a summertime nesting spot for black skimmers, royal terns, gull-billed terns, sandwich terns, laughing gulls, American oystercatchers and willet according to the Coastal Conservation League. In winter there are double-breasted cormorants ring-billed gulls, greater black-backed gulls, black-bellied plovers, semi-palmated plovers, sanderlings, dunlin and dowitchers. These seabirds are part of what define the Lowcountry; Cra Bank gives them a safe place to nest in the heart of the metropolitan area.

Restoring Crab Bank can be done, but it will take the coordinated efforts of federal and state agencies, as well as local public-private support.

The Army Corps of Engineers, which oversees dredging in the harbor, and the State Ports Authority need to take a leading role in the restoration.

Nathan Dias of the Cape Romain Bird Observatory, who helped develop a plan for restoring Cra Bank that unfortunately never materialized, argued in an October 2016 op-ed in The Post and Courier for rebuilding the islet with dredge spoil. But that could only happen "if the right entitie come together," he wrote.

With plenty of dredging in the harbor's near future, now is a good time to chart a course towar restoring the spit. Mr. Dias also suggested that state agencies such as the Department of Natur Resources and the state Parks, Recreation and Tourism Commission get involved.

The idea of rebuilding Crab Bank with dredged sand already has the backing of the Audubon Society and other environmental groups.

Because an active rookery would again be a draw for kayakers and tour boats, local governments could help fund the effort with revenue from hospitality taxes that support tourism-related projects.

Support also could be sought from shipping companies and other corporate sponsors. And the SPA is enjoying a shipping boom. Surely, it has assets to spare.

Saving Crab Bank is a worthy project that should draw all the "right entities" together. It's good for Charleston and good for seabirds. It's also a convenient place to dispose of sand and a way for the increasingly industrialized port to balance its interests with nature.

http://www.postandcourier.com/news/may-s-storms-wiped-out-almost-all-the-pelican-nests/article_d676f8ca-49f8-11e7-aff1-53ed3e585ee8.html

TOP STORY

May's storms wiped out almost all the pelican nests on Charleston's Crab Bank

By Bo Petersen bopete@postandcourier.com Jun 5, 2017

This still captured from a webcam Monday, June 5, 2017, shows what is left of Crab Bank. Provided

The few remaining nesting pelicans huddle around the hull of a derelict boat surrounded by barren sands on Crab Bank.

The vital, eroding shorebird rookery is all but gone after storms tore hundreds of nests away last month.

Forty or fewer pelican nests and a single oystercatcher nest holding chicks are all that are left on an island that in a normal year holds thousands of nests.

"Everything else washed away, including all the tern, laughing gull and most of the oystercatcher nests," said Felicia Sanders, a S.C. Department of Natural Resources wildlife biologist.

Most of the nesting grounds are gone because high tides now wash over the sliver of sand that makes up the bank, at the mouth of Shem Creek off Mount Pleasant.

South Carolina Coastal Conservation League Live PELICAM from...

"Sadly the only terns left on the island were five tangled up in fishing line, dead," Sanders said.

May's storm tides swept the island so fiercely that at least 60 shorebird eggs were found strewn across the Sullivan's Island beach at the mouth of Charleston Harbor, more than a mile away. The island is in such bad shape that DNR turned off one angle of the island's livestream pelicam because there's nothing to show, Sanders said.

The bank is one of only a handful of publicly owned and protected rookery islands in the state for threatened species of shorebirds. It is considered a critical, mid-state link because the masses of birds tend to move from island to island, since islands can erode year to year, and there's the annual threat of a tropical storm wiping out any of them.

Crab Bank, like the other rookeries, is off limits to landings. Viewed from the water, the aerial melee of visiting birds year to year has become an eco-tourism boating trip some have called an urban Galapagos. But nests are laid just above the tide line, and Crab Bank has been significantly eroding in recent years.

The bank is partly made up of spoils from previous harbor dredging projects, and a move to use spoils from the deepening project underway to shore it up has been preliminarily approved by both the DNR and the Army Corps of Engineers Charleston District, which is overseeing the deepening project.

But it would require an extra dredge and equipment. Both agencies must compete for the extra funding in a political atmosphere where administrations and legislators are focused on cost savings. The Corps and DNR would have to come up with two-thirds and one-third, respectively, of a $3 million cost to move sand to renourish the bank from the harbor deepening's spoils.

"There's still a lot up in the air," said Holly Carpenter, the deepening project manager for the Army Corps' Charleston District.

Dredging for the deepening is now scheduled to start by the end of the year. The offshore stretch at the mouth of the shipping channel will be dredged first, so the agencies have more time to secure the funding, she said.

Reach Bo Petersen Reporter at Facebook, @bopete on Twitter or 1-843-937-5744.

Bo Petersen

http://www.postandcourier.com/news/may-s-storms-wiped-out-almost-all-the-pelican-nests/article_d676f8ca-49f8-11e7-aff1-53ed3e585ee8.html

TOP STORY

May's storms wiped out almost all the pelican nests on Charleston's Crab Bank

By Bo Petersen bopete@postandcourier.com Jun 5, 2017

This still captured from a webcam Monday, June 5, 2017, shows what is left of Crab Bank. Provided

The few remaining nesting pelicans huddle around the hull of a derelict boat surrounded by barren sands on Crab Bank.

The vital, eroding shorebird rookery is all but gone after storms tore hundreds of nests away last month.

Forty or fewer pelican nests and a single oystercatcher nest holding chicks are all that are left on an island that in a normal year holds thousands of nests.

"Everything else washed away, including all the tern, laughing gull and most of the oystercatcher nests," said Felicia Sanders, a S.C. Department of Natural Resources wildlife biologist.

Most of the nesting grounds are gone because high tides now wash over the sliver of sand that makes up the bank, at the mouth of Shem Creek off Mount Pleasant.

South Carolina Coastal Conservation League Live PELICAM from...

"Sadly the only terns left on the island were five tangled up in fishing line, dead," Sanders said.

May's storm tides swept the island so fiercely that at least 60 shorebird eggs were found strewn across the Sullivan's Island beach at the mouth of Charleston Harbor, more than a mile away. The island is in such bad shape that DNR turned off one angle of the island's livestream pelicam because there's nothing to show, Sanders said.

The bank is one of only a handful of publicly owned and protected rookery islands in the state for threatened species of shorebirds. It is considered a critical, mid-state link because the masses of birds tend to move from island to island, since islands can erode year to year, and there's the annual threat of a tropical storm wiping out any of them.

Crab Bank, like the other rookeries, is off limits to landings. Viewed from the water, the aerial melee of visiting birds year to year has become an eco-tourism boating trip some have called an urban Galapagos. But nests are laid just above the tide line, and Crab Bank has been significantly eroding in recent years.

The bank is partly made up of spoils from previous harbor dredging projects, and a move to use spoils from the deepening project underway to shore it up has been preliminarily approved by both the DNR and the Army Corps of Engineers Charleston District, which is overseeing the deepening project.

But it would require an extra dredge and equipment. Both agencies must compete for the extra funding in a political atmosphere where administrations and legislators are focused on cost savings. The Corps and DNR would have to come up with two-thirds and one-third, respectively, of a $3 million cost to move sand to renourish the bank from the harbor deepening's spoils.

"There's still a lot up in the air," said Holly Carpenter, the deepening project manager for the Army Corps' Charleston District.

Dredging for the deepening is now scheduled to start by the end of the year. The offshore stretch at the mouth of the shipping channel will be dredged first, so the agencies have more time to secure the funding, she said.

Reach Bo Petersen Reporter at Facebook, @bopete on Twitter or 1-843-937-5744.

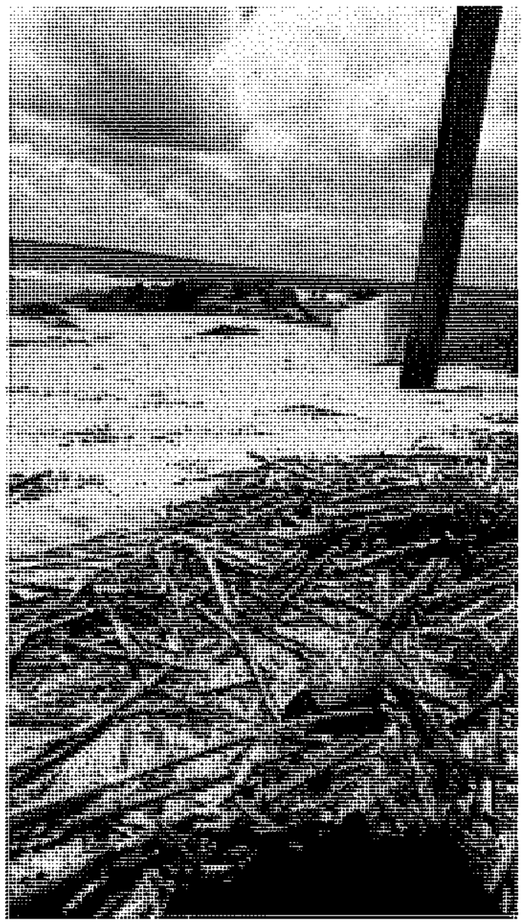
Bo Petersen

http://www.postandcourier.com/news/coastal-storms-wash-away-south-carolina-shorebird-eggs-around-charleston
/article_9e6c0278-4173-11e7-8287-affa02cf2bfc.html

TOP STORY

Coastal storms wash away South Carolina shorebird eggs around Charleston Harbor

By Bo Petersen bopete@postandcourier.com May 25, 2017



A laughing gull egg lies in the beach wrack on Sullivan's Island after storms and high tides this week washed out nests. Norm Schillerstrom/Audubon South Carolina/Provided

At least 60 shorebird eggs were found Thursday strewn across the Sullivan's Island beach at the mouth of Charleston Harbor.

The mostly intact eggs evidently were washed there from the nearby Crab Bank rookery and other nests — pushed during this week's king tides, high winds and storms.

The eggs included brown pelican and laughing gull. Once washed from the nests, the eggs no longer are viable, and wildlife biologists warned people not to pick them up. Shorebirds are a protected species, many of them considered threatened or endangered. Messing with the eggs violates federal law.

"Overwash is a top cause of nest failure for shorebirds and seabirds and quite common in South Carolina this time of year," said Erin Weeks, a spokeswoman for the S.C. Department of Natural Resources.

"Because it's still early in the season, some of these birds will re-nest. But it's a great reminder, especially on the eve of Memorial Day weekend, that beach-nesting birds face a host of natural and man-made threats, making it all the more important for us to respectfully share our beaches with them," she said.

Thousands of the birds nest each year on Crab Bank, a sliver of sand at the mouth of Shem Creek off Mount Pleasant. The swarm has been characterized as an urban Galapagos. A signature of Charleston Harbor, the bank is one of only a handful of publicly owned and protected rookery islands in the state.

Nests are laid just above the tide line and Crab Bank has been significantly eroding in recent years. It is considered a critical mid-state link because the masses of birds tend to move from island to island. The islands can be overwashed year to year, and there's the annual threat of a tropical storm wiping them out.

For humans, landing on the bank is off limits, although it is a popular paddling destination to circumnavigate.

"These events make us realize the dangers of sea level rise and coastal squeeze. As more people move to Charleston and we experience more frequent nuisance flooding, nesting beach bird habitat gets 'squeezed' thinner and thinner," said Nolan Schillerstrom, coastal program coordinator for Audubon South Carolina.

Reach Bo Petersen Reporter at Facebook, @bopete on Twitter or 1-843-937-5744.

Bo Petersen

Appendix F
Real Estate

Charleston Harbor Cap 204 Detailed Project Report

REAL ESTATE SUMMARY

Table of Contents

SECTION 1. THE REAL ESTATE REPORT

1.1 Statement of Purpose

This report is tentative in nature, focuses on the Tentatively Selected Plan (TSP), and is to be used for planning purposes only. There may be modifications to the plans that occur during the implementation phase, thus changing the final acquisition area(s) and/or administrative and land cost. The Real Estate Appendix is intended to support the Detailed Project Report for the Charleston Harbor, Charleston, South Carolina Section 204 project. The author of this report is familiar with the Project area. The South Carolina Department of Natural Resources (SCDNR) is the non-Federal sponsor for the project. Date of this report is November, 2017.

1.2 Study Authority

Section 204 of the Water Resources Development Act (WRDA) (P.L. 102-580) of 1992, as amended provided authority for this study. This is a CAP study. The Section 204 program is designed for the protection, restoration, and creation of aquatic and ecologically related habitats, including wetlands, in connection with dredging for construction, operation, or maintenance dredging of an authorized navigation project. This study would be part of the federally authorized from both existing O&M practices in Charleston Harbor and new work dredged material associated with the construction of the Charleston Harbor Post 45 Navigation project.

1.3 Project Location

The project area is located in the lower Charleston Harbor between Shem Creek and Fort Sumter, in Charleston County, South Carolina (Figure 1). The State of South Carolina claims ownership of Crab Bank. The approximate 22 acre islet was documented on earlier maps as a sandbar. In the 50s and 60s, placement of dredged materials formed the island. The island's shape and size frequently shift due to erosion caused by storms and passing wakes, however has not completely submerged since before 1979. The island is currently used as a nesting site for seabirds. Crab Bank is designated as a National Seabird Sanctuary and was established to protect significant nesting habitat of sea and shorebirds.

Charleston is a part of the Charleston-North Charleston-Summerville, SC Metropolitan Statistical Area (MSA) consisting of three counties, Berkeley, Charleston, and Dorchester. In 2016 census, this MSA had a population of 761,155, the third-largest in the state. Fort Sumter and Fort Moultrie are National Historic Monuments. Sullivan's Island has extensive homes and infrastructure.

Charleston is a major tourist destination with approximately 41,000 accommodation and food service employees. Natural resources are the basis for most recreational activities in the state of South Carolina with bird watching being the most significant recreational activity with respect to trips. The city has two shipping terminals, owned and operated by the South Carolina Ports Authority, which are part of the fourth-largest container seaport on the East Coast. Charleston is becoming a prime location for information technology jobs and corporations. The region is ranked the ninth-best performing economy in the US by the Miliken Institute due in large part to the growing IT sector. In June 2017, the average sales price for a home in Charleston was $351,186 and the median was $260,000.

Healthcare employs more than 43,000 medical and social assistance professionals. Charleston is the primary medical center for the eastern portion of the state. Several major hospitals are located in the downtown area to include Medical University of South Carolina Medical Center (MUSC). MUSC is the state's first school of medicine, the largest medical university in the state, and the sixth-oldest continually operating school of medicine in the United States.

Charleston Harbor is positioned on a natural tidal estuary formed around the confluence of the Cooper, Ashley, and Wando Rivers. The harbor includes about 14 square miles of open water. Crab Bank Island and Shutes Folly Island are within the lower Charleston Harbor.

Figure 1.3-1. Project Vicinity/Location Map

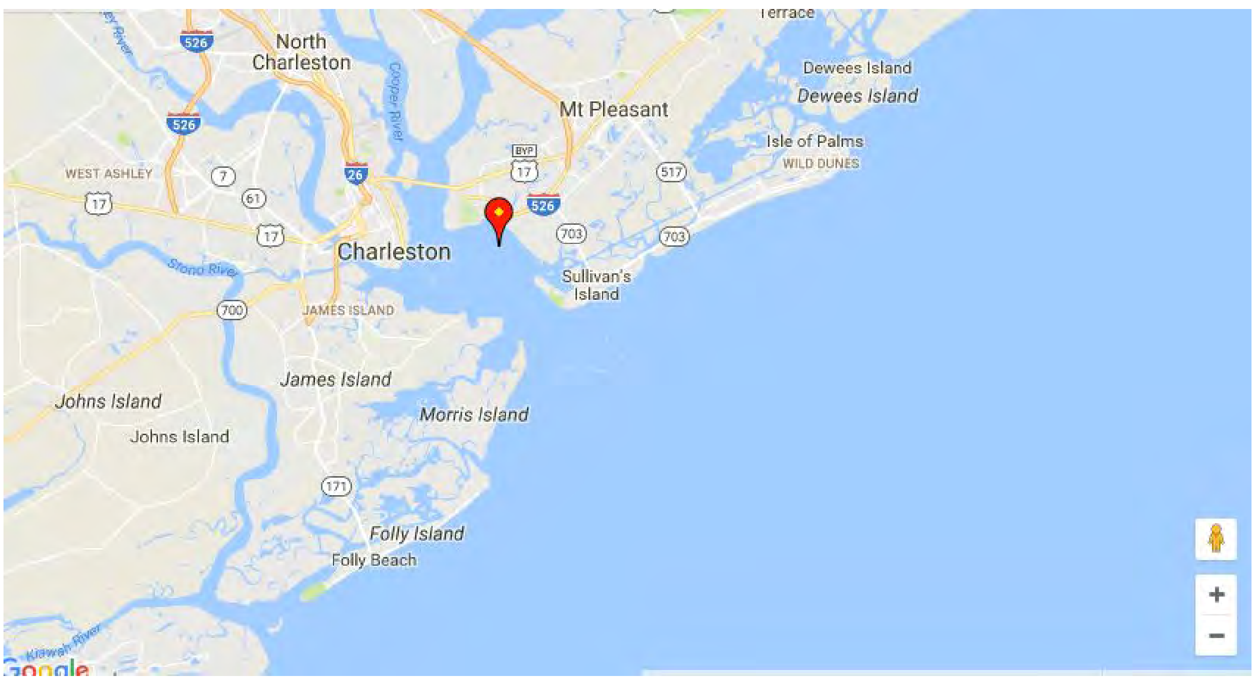


Figure 1 Crab Bank National Seabird Sanctuary

1.4 Project Description

The project is the use of dredged material from the federal channels of Charleston Harbor for marsh restoration and/or shoreline erosion protection to improve and expand bird habitat within Charleston Harbor. The project would enhance and prolong the existence of the seabird sanctuary and would create significant avian habitat for nesting, foraging, and loafing.

The TSP is Crab Bank Island Medium A. The plan involves using new work dredged material from Bennis and Rebellion Reaches of the navigation channel to enlarge the island. Materials from the available reaches will be transported via pipeline and discharged on a designated placement area on Crab Bank. Mechanized equipment will be used for construction. Placement will be in a non-uniform pattern to allow for greater topographic complexity and therefore greater habitat diversity. The resulting island will be 79.4 acres in size, with 27.8 acres of useable brown pelican nesting habitat. It is anticipated that the recommended plan will have long-term positive impacts on bird usage in the area, even if some temporary displacement occurs during the construction.

1.5 Real Estate Requirements

There will be minimal Real Estate requirements for this project. Construction will occur in the lower Charleston Harbor using dredged material from the Bennis and Rebellion Reaches of the navigation channel. Should the need for a staging area be identified after project approval, the sponsor will be responsible for obtaining real estate interests using the standard temporary work area easement shown in section 1.20 of this report. Prior to advertisement of the construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit “A” to the Real Estate Appendix) to all LERRDs, as necessary.

1.6 Utility/Facility Relocation

There are no utility/facility relocations with this project.

1.7 Existing Projects

With the exception of the existing Operation and Maintenance of the Charleston Harbor Deepening/Widening, South Carolina, completed in 2004 and the Charleston Harbor Post 45 (not yet constructed), there are no other federal projects within the study area.

1.8 Environmental Impacts

Environmental impacts are addressed in the Supplemental Environmental Assessment as part of the Post 45 Charleston Harbor Deepening project as described in the main feasibility report for this study.

1.9 Project Sponsor Responsibilities and Capabilities

The South Carolina Department of Natural Resources will be the non-Federal Project Sponsor (NFS). The NFS has the responsibility to acquire all real estate interests required for the Project. The NFS shall accomplish all alterations and relocations of facilities, structures and improvements determined by the government to be necessary for construction of the Project. The sponsor will have operation and maintenance responsibility for the project after construction is completed.

Title to any acquired real estate will be retained by the NFS and will not be conveyed to the United States Government. Prior to advertisement of any construction contract, the NFS shall furnish to the government an Authorization for Entry for Construction (Exhibit “A” to the Real Estate Appendix) to all lands, easements and rights-of-way, as necessary. The NFS will also furnish to the government evidence supporting their legal authority to grant rights-of-way to such lands. The NFS shall comply with applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, approved 2 January 1971, and amended by Title IV of the Surface Transportation Uniform Relocation Assistance Act of 1987, Public Law 100-17, effective 2 April 1989, in acquiring real estate interests for the Project, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act(s). An Assessment of the Non-Federal Sponsor’s Capability to Acquire Real Estate is at Exhibit “B” to the Real Estate Appendix

The non-Federal sponsor is entitled to receive credit against its share of project costs for the value of lands it provides and the value of the relocations that are required for the project. Generally, for the purpose of determining the amount of credit to be afforded, the value of the Land, Easements, Rights-of-way, Relocation, and Disposal areas (LERRDs) is the fair market value of the real property interest, plus certain incidental costs of acquiring those interests, that the non-federal sponsor provided for the project as required by the Government.

The NFS should not acquire lands required for the project prior to execution of the Project Partnership Agreement (PPA). Should the NFS proceed with acquisition of lands prior to execution of the PPA, it is at the risk of not receiving credit or reimbursement for any costs incurred in the connection with the acquisition process should the PPA not be signed. There is also risk in acquiring lands either not needed for the project or not acquired in compliance with requirements for crediting purposes in accordance with 49 CFR Part 24, dated March 2, 1989.

1.10 Government Owned Property

There are no Federal lands available for construction of this project. The South Carolina Department of Natural Resources (State of South Carolina), non-federal sponsor is the owner of Crab Bank Island.

1.11 Historical Significance

Historical significance is addressed in the Cultural Resources section in the main report.

1.12 Mineral Rights

There are no known mineral activities within the scope of the proposed project.

1.13 Hazardous, Toxic, and Radioactive Waste (HTRW)

No hazardous or toxic waste sites are known to occur in the project area, nor will any toxic substances be introduced as part of this project.

1.14 Navigation Servitude

Due to the nature of this project, Navigational Servitude does not apply.

1.15 Zoning Ordinances

Zoning ordinances are not of issue with this project. Application or enactment of zoning ordinances is not to be used in lieu of acquisition.

1.16 Induced Flooding

There will be no flooding induced by the construction or the operation and maintenance of the project.

1.17 Public Law 91-646, Relocation Assistance Benefits

There are no relocations of individuals, businesses or farms for this project.

1.18 Attitude of Property Owners

The project is fully supported. There are no known objections to the project from landowners within the project area.

1.19 Acquisition Schedule

The project sponsor is responsible for acquiring any real estate interests required for the project. The Project Sponsor, Project Manager and Real Estate Technical Manager will formulate the milestone schedule upon project approval to meet dates for advertisement and award of a construction contract.

1.20 Estates for Proposed Project

As stated in section 1.5, should the need for a staging area be identified after project approval, the following Standard Temporary Work Area Easement will be required.

A temporary easement and right-of-way in, on, over and across (the land described in Schedule A) (Tracts Nos. _____, _____ and _____), for a period not to exceed _____________, beginning with date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a (borrow area) (work area), including the right to (borrow and/or deposit fill, spoil and waste material thereon) (move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the___________________Project, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

1.21 Real Estate Estimate

The real estate requirements are minimal for this project. The estimated real estate costs include the federal and non-federal administrative costs. Administrative costs are those costs incurred for verifying ownership of lands, certification of those lands required for project purposes, legal opinions, analysis or other requirements that may be necessary during Implementation Phase. There are no estimated real estate costs included for acquisition of land. The non-federal sponsor claims ownership to Crab Bank Island and lands will not be creditable due to offsetting benefits to the island once construction is completed. A 25% contingency is applied to the estimated total for these items. Table 1.21-1 is a summary of the real estate cost.

Table 1.21-1. Real Estate Estimate

Charleston Harbor Section 204 - Real Estate Estimate

a. Lands			$	-
b. Improvements			$	-
c. Mineral Rights			$	-
d. Damages			$	-
e. P.L. 91-646 Relocation costs			$	-
f. Acquisition Cost - Admin			$	2,500
Federal	$	1,000		
Non-federal	$	1,500		
	$	2,500		
Sub-Total			$	2,500
Contingencies (25%)			$	625
TOTAL			**$**	**3,125**
ROUNDED			**$**	**3,200**

1.22 Chart of Accounts

The cost estimate for all Federal and non-Federal real estate activities necessary for implementation of the project after completion of the feasibility study for land acquisition, construction, LERRD, and other items are coded as delineated in the Cost Work Breakdown Structure (CWBS). This real estate cost estimate is then incorporated into the Total Current Working Estimate utilizing the Microcomputer Aided Cost Engineering System (MCACES).

Table 1.22-1. Chart of Accounts

Charleston Harbor Section 204 - Chart of Accounts

		FEDERAL	NON-FEDERAL	TOTALS
01A	PROJECT PLANNING			
	Other			
	Project Cooperation Agreement	$	$	$
01AX	Contingencies (25%)	$	$	$
	Subtotal	$	$	$
01B	LANDS AND DAMAGES			
01B40	Acq/Review of PS	$ 1,000.00	$	$ 1,000.00
01B20	Acquisition by PS	$	$ 1,500.00	$ 1,500.00
01BX	Contingencies (25%)	$ 250.00	$ 375.00	$ 625.00
	Subtotal	$ 1,250.00	$ 1,875.00	$ 3,125.00
01G	Temporary Permits/Lic/ROEs			
01G10	By Govt			
01G20	By PS	$	$ -	$ -
01G30	By Govt on Behalf of PS	$	$	$
01GX	Contingencies (25%)	$	$ -	$ -
	Subtotal	$	$ -	$ -
01H	AUDIT			
01H10	Real Estate Audit	$	$	$
01HX	Contingencies (15%)	$	$	$
	Subtotal	$	$	$
01R	REAL ESTATE LAND PAYMENTS			
01R1B	Land Payments by PS	$	$ -	$ -
01R2B	PL91-646 Relocation Pymt by PS	$	$ -	$ -
01R2D	Review of PS	$	$	$
01RX	Contingencies (25%)	$	$ -	$ -
	Subtotal	$	$ -	$ -
	TOTALS	$ 1,250.00	$ 1,875.00	$ 3,125.00
	ROUNDED TO			**$ 3,200.00**

Exhibits

Exhibit A - Authorization for Entry for Construction

Exhibit B – Assessment of Non-Federal Sponsor's Real Estate Acquisition Capability

AUTHORIZATION FOR ENTRY FOR CONSTRUCTION

I ________________________________, __________________________ for the
(Name of accountable official) (Title)

_(Sponsor Name)______, do hereby certify that the ___(Sponsor Name)________ has acquired the real property interest required by the Department of the Army, and otherwise is vested with sufficient title and interest in lands to support construction for (Project Name, Specifically identified project features, etc.). Further, I hereby authorize the Department of the Army, its agents, employees and contractors, to enter upon ___(identify tracts) _________ to construct (Project Name, Specifically identified project features, etc.) as set forth in the plans and specifications held in the U. S. Army Corps of Engineers' (district, city, state) to include abiding by all State Historical Preservation Office requirements referenced in the plans and specifications.

WITNESS my signature as ___________________ for the ___________________________
(Title) (Sponsor Name)

this ____ day of _________________, 20______.

BY: ____
(Name)

____
(Title)

ATTORNEY'S CERTIFICATE OF AUTHORITY

I, _________________________ , ________________________________ for the
(Name) (Title of legal officer)

________________________________, certify that _________________________________ has
(Sponsor Name) (Name of accountable official)

authority to grant Authorization for Entry; that said Authorization for Entry is executed by the proper duly authorized officer; and that the Authorization for Entry is in sufficient form to grant the authorization therein stated.

WITNESS my signature as _________________________ for the ________________________,
(Title) (Sponsor Name)

this___________day of_______________, 20_____.

BY: ____
(Name)

____
(Title)

Exhibit "A"

Assessment of Non-Federal Sponsor's
Real Estate Acquisition Capability
Noyes Cut Satilla River Basin Section 1135

I. Legal Authority:

a. Does the sponsor have legal authority to acquire and hold title to real property for project purposes? **YES**

b. Does the sponsor have the power to eminent domain for this project? **YES**

c. Does the sponsor have "quick-take" authority for this project? **YES**

d. Are any of the land/interests in the land required for this project located outside the sponsor's political boundary? **NO**

e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn? **NO**

II. Human Resource Requirements:

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including P. L. 91-646, as amended? **NO**

b. If the answer to II.a. is "yes", has a reasonable plan been developed to provide such training? (yes/no)

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project? **YES**

d. Is the sponsor's projected in-house staffing level sufficient considering its other work load, if any, and the project schedule? **YES**

e. Can the sponsor obtain contractor support, if required in a timely fashion? **YES**

f. Will the sponsor likely request USACE assistance in acquiring real estate? **YES - only in advisory capacity**

III. Other Project Variables:

a. Will the sponsor's staff be located within reasonable proximity to the project site? **YES**

b. Has the sponsor approved the project/real estate schedule/milestones? **NO – Project Milestone will be developed during PED; will be joint effort between RE, PM and NFS**

Exhibit B
1st page

IV. Overall Assessment:

a. Has the sponsor performed satisfactory on other USACE projects? **YES**

b. With regard to the project, the sponsor is anticipated to be: **Highly capable**

V. Coordination:

a. Has this assessment been coordinated with the sponsor? **YES**

b. Does the sponsor concur with this assessment? **YES**

Prepared by:

Patricia Casey

Patricia Casey
Senior Realty Specialist

Reviewed and approved by:

Ralph J. Werthmann
Chief, Real Estate Division

Exhibit B
2nd page