Wilmington Harbor, North Carolina
Navigation Improvement Project

Integrated
Section 203 Study
&
Environmental Report

APPENDIX K

BIOLOGICAL ASSESSMENT

February 2020

Table of Contents

List of Tables

List of Figures

List of Acronyms

ASSRT	Atlantic Sturgeon Status Review Team
BA	Biological Assessment
CAHA	Cape Hatteras National Seashore
CALO	Cape Lookout National Seashore
CFR	Code of Federal Register
CY	Cubic Yards
dB	Decibel
DO	Dissolved Oxygen
DPS	Distinct Population Segment
ER	Engineer Regulations
ESA	Endangered Species Act
FR	Federal Register
ft	Feet
FWC	Florida Fish and Wildlife Conservation Commission
FWI	Fish and Wildlife Research Institute
FWOP	Future without Project
km	Kilometer
m	Meter
MLLW	Mean Lower Low Water
MMPA	Marine Mammal Protection Act
NC	North Carolina
NCSPA	North Carolina State Ports Authority
NCWRC	North Carolina Wildlife Resources Commission
NM	Nautical Miles
NMFS	National Marine Fisheries Service
NPS	National Park Service
ODMDS	Ocean Dredged Material Disposal Site
PL	Public Law
PPT	Parts per Thousand
PSI	Pounds per Square Inch
PSO	Protected Species Observer
PTS	Permanent Threshold Shift
rkm	River Kilometer
RMS	Root Mean Square
SEL_{cum}	Cumulative Sound Exposure Level
SMA	Seasonal Management Area
SMP	Sand Management Plan
SPL	Sound Pressure Level
SSSRT	Shortnose Sturgeon Status Review Team
TEWG	Turtle Expert Working Group
TEU	Twenty-foot Equivalent
TSP	Tentatively Selected Plan
TTS	Temporary Threshold Shift
US	United States

USC	United States Code
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
WHNIP	Wilmington Harbor Navigation Improvement Project
WRDA	Water Resources Development Act

1 INTRODUCTION

The North Carolina State Ports Authority (NCSPA) has prepared this Biological Assessment (BA) in accordance with Section 7 of the Endangered Species Act, as amended (ESA) [16 United States Code (USC) 1531 *et seq*.] to address the effects of the proposed Wilmington Harbor Navigation Improvement Project (WHNIP) on threatened and endangered species and critical habitats under the jurisdiction of the United States Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS). The proposed project would deepen the existing federally authorized navigation channel from the lower end of the Anchorage Basin at the Port of Wilmington to the seaward limit of the ocean entrance channel, and create a new approximately (~) 9-mile seaward extension of the ocean entrance channel for purposes of accommodating a larger class of container vessels. This BA has been prepared as a component of the WHNIP Integrated Feasibility and Environmental Study under the authority of Section 203 of the Water Resources Development Act (WRDA) of 1986 [Public Law (PL) 99-662] as amended.

1.1 Background

The existing Wilmington Harbor federal navigation channel extends 38.1 miles from the Atlantic Ocean offshore of Cape Fear to the City of Wilmington (Figure 1). Construction of the federal navigation channel to its current dimensions was originally authorized as three separate projects by the WRDA 86 Public Law 99-662 and 1996 (WRDA 96) Public Law 104-303. Public Law 105-62, The Energy and Water Development Appropriations Act of 1998, combined the Wilmington Harbor Northeast Cape Fear River Project (WRDA 1986), the Wilmington Harbor Channel Widening Project (WRDA 1996), and the Cape Fear-Northeast (Cape Fear) Rivers Project (WRDA 1996) under a single project known as the Wilmington Harbor 96 Act Project. Improvements under the Wilmington Harbor 96 Act Project included deepening the ocean entrance channel and the lower inner harbor channel up through the Battery Island reach from -40 to -44 feet (ft); deepening the inner harbor channel from the Battery Island reach up to the Cape Fear Memorial Bridge from -38 to -42 ft; and widening various channel reaches, turns, and bends. Additional authorized improvements to the -32-foot and -25-foot channel reaches that comprise the remainder of the federal project from the Cape Fear Memorial Bridge to the upper project limit in the Northeast Cape Fear River were deferred due to a marginal cost to benefit ratio.

The Port of Wilmington has experienced significant growth in cargo volume and in the size of vessels calling at the port since the last major channel improvements were completed under the Wilmington Harbor 96 Act Project. The NCSPA has made major investments in landside infrastructure to accommodate growth at the Port of Wilmington and the region that it serves. At the present time, the Port of Wilmington is the largest port in North Carolina (NC) and is a major component of the state's economy. Due to expansion of the Panama Canal and harbor deepening projects at all other major United States (US) East Coast ports, the US East Coast to Asia shipping alliances are transitioning to vessels that are substantially larger than those that the existing -42-foot Wilmington Harbor channel was designed to accommodate. Inadequate channel capacity is currently impacting trade at the Port of Wilmington and is projected to have a greater detrimental impact on trade in the future as ocean carriers continue to transition from the existing fleet of 8,000 Twenty-foot Equivalent Unit (TEU) vessels to a new fleet of larger 12,400 TEU vessels. The proposed improvements to the federal navigation channel would accommodate larger cargo vessels at Wilmington Harbor and enable the Port of Wilmington to continue as a port-of-call for shipping alliances with direct service to Asian markets.

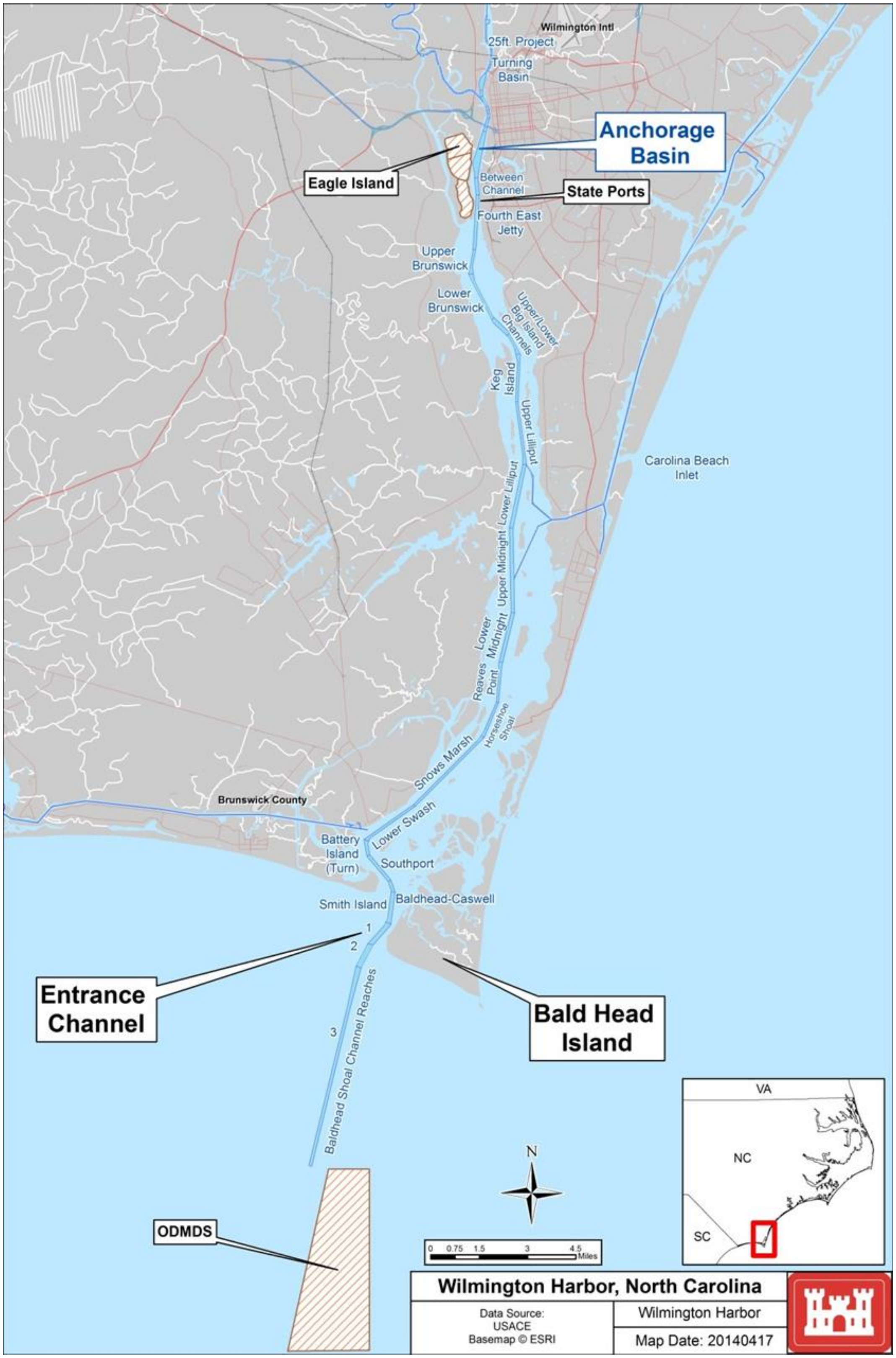

Figure 1
Existing Wilmington Harbor Federal Navigation Project

2 PROPOSED ACTION

2.1 Channel Design

Under the proposed action, improvements to accommodate larger vessels would include deepening the federal navigation channel from the Port of Wilmington to the seaward limit of the ocean entrance channel (~33 miles), extending the ocean entrance channel an additional 9.1 miles offshore, and expanding wideners at turns along the channel. The existing -42-foot channel from the lower Anchorage Basin at the Port of Wilmington to the inland boundary of the Battery Island reach (~23 miles) would be deepened to -47 ft. The existing -44-foot channel from the inland boundary of the Battery Island reach to the seaward terminus of the existing ocean entrance channel (~10 miles) would be deepened to -49 ft. The increased depth of -49 ft in the channel seaward of Battery Island is required to account for the effects of ocean waves on under keel clearance. The entrance channel would be extended an additional 9.1 miles offshore at the same -49-foot depth. In relation to the existing Baldhead Shoal 3 outer entrance channel reach, the alignment of the extension reach would be shifted ~16 degrees (°) to the southwest. The proposed alignment and length of the extension reach represent the shortest route to waters that are consistently deeper than the proposed entrance channel depth of -49 ft. Proposed increases in the authorized bottom width of the channel (Table 1) are based on model simulated 12,400 TEU vessel operations in the improved channel and are designed to accommodate the maneuver capabilities of individual larger class vessels. The Battery Island reach and portions of the adjoining Lower Swash and Southport reaches would be reconfigured as part of a 4,000-foot radius curve redesign of the Battery Island turn. The remaining reaches that are proposed for widening would retain their existing alignments.

2.2 Dredging and Dredged Material Disposal

Construction of the proposed Wilmington Harbor navigation improvements would employ hydraulic pipeline (cutterhead), mechanical (bucket), and hopper dredges. Associated disposal operations would include hydraulic (cutterhead) loading of barges for offshore transport to the Offshore Dredged Material Disposal Site (ODMDS), mechanical (bucket dredge) scow loading for offshore transport to the ODMDS, direct transport to the ODMDS via self-propelled hopper dredges, and direct hydraulic (cutterhead) pipeline disposal to the beaches of Bald Head Island and Oak Island and waterbird nesting islands in the lower estuary. Table 2 provides a breakdown of dredging and disposal operations by equipment type, channel reach, and applicable environmental work windows. The use of hopper dredges would be limited to the outer Baldhead Shoal 2 and 3 entrance channel reaches and the proposed offshore extension reach. Construction of the remaining channel reaches would be accomplished predominantly by cutterhead dredges. Mechanical (bucket) dredges would be used for the specific purpose of removing pre-treated rock from the ~4.4-mile Keg Island to Lower Brunswick channel reach. Hopper dredging operations would adhere to the established Wilmington Harbor hopper dredge environmental work window of 1 December to 15 April. Pursuant to established fisheries environmental work windows for Wilmington Harbor, cutterhead dredging would occur year-round in the channel reaches below Snows Cut and from 1 July to 31 January in the reaches above Snows Cut. Bucket dredge operations are not subject to any environmental work window restrictions, and thus could occur year-round depending on the need for pre-treated rock removal.

Table 1
WHNIP Proposed Increases in Authorized Channel Bottom Width

Channel Reach	Channel Widths[1] [ft]		Widening Details[2]
	Existing	Proposed	
Entrance Channel Extension	N/A	600	New
Bald Head Shoal Reach 3	500 - 900	600 - 900	Symmetric
Bald Head Shoal Reach 2	900	900	No Change
Bald Head Shoal Reach 1	700	900	West Side Only
Smith Island	650	900	East Side Only
Bald Head - Caswell	500	800	East Side Only
Southport	500	800	Re-orientation East and West Sides Asymmetric
Battery Island	500	800 - 1300	New 4,000-ft radius curve East and West Sides Asymmetric
Lower Swash	400	800 - 500	West Side (lower) and Symmetric (upper)
Snows Marsh	400	500	Symmetric
Horseshoe Shoal	400	500	Symmetric
Reaves Point	400	500	Symmetric
Lower Midnight	600	600	No Change
Upper Midnight	600	600	No Change
Lower Lilliput	600	600	No Change
Upper Lilliput	400	500	Symmetric
Keg Island	400	500	Symmetric
Lower Big Island	400	500	Symmetric
Upper Big Island	660	660	No Change
Lower Brunswick	400	500	Symmetric
Upper Brunswick	400	500	Symmetric
Fourth East Jetty	500	550	West Side Only
Between Channel	550	625	West Side Only
Anchorage Basin	625	625 - 1500	No Change

[1]Authorized channel widths are defined by the channel bottom width only, excluding the channel slopes.

Table 2
Proposed Action Dredging and Disposal Summary

Construction Activity	Channel Reaches	Environmental Work Window	Reason for Window
Hopper dredging with ODMDS disposal	Baldhead Shoal 2 Baldhead Shoal 3 Entrance channel extension reach	1 Dec – 15 April	Minimization of sea turtle entrainment risk
Cutterhead dredging with ODMDS disposal via barges	Baldhead Shoal 3 Battery Island Lower Swash Snows marsh Horseshoe Shoal	Year round	NA
Cutterhead dredging with ODMDS disposal via barges	Reaves point Lower Midnight Upper Midnight Lower Lilliput Upper Lilliput Keg Island Lower Big Island Upper Big Island Lower Brunswick Upper Brunswick Fourth East Jetty Between Reach Anchorage Basin	1 Aug – 31 Jan	Avoidance of anadromous fish spawning period
Cutterhead dredging with direct beach disposal	Baldhead Shoal 1 Smith Island Baldhead-Caswell Southport	16 Nov - 30 April	Avoidance of sea turtle nesting season
CU blasting with drill barge	Keg Island Lower Big Island Upper Big Island Lower Brunswick	1 Aug – 31 Jan	Avoidance of anadromous fish spawning period
Bucket dredging with ODMDS disposal via scows	Keg Island Lower Big Island Upper Big Island Lower Brunswick	Year round	NA

2.2.1 Dredged Material Volumes

The estimated total volume of material to be dredged in constructing the channel improvements is 26.9 million cubic yards; including 22.7 million cubic yards of unconsolidated sand and silt and 4.2 million cubic yards of rock (siltstone and sandstone). Dredged material volume estimates are based on the proposed channel dimensions with an additional one-foot buffer added to reaches where rock is likely to be encountered and an additional two feet of allowable overdredge depth added to the remaining reaches. All dredged material other than beneficial use material would be taken offshore for disposal in the Wilmington ODMDS. Estimated construction and maintenance volumes are well within the capacity of the ODMDS.

2.2.2 Rock Pre-treatment

Confined underwater blasting would be used as a pretreatment measure to break up hardened rock for subsequent removal by cutterhead and mechanical (bucket) dredges. Areas potentially requiring confined blasting encompass ~188 acres of rock surface area within the Keg Island, Lower Big Island, Upper Big Island, and Lower Brunswick channel reaches (Figure 2). These four reaches comprise a contiguous ~4.4-mile section of the navigation channel from a point ~18 miles above the estuary mouth to a point approximately two miles below Eagle Island. Confined underwater blasting operations would employ stemmed charges and charge delays to reduce the magnitude of blast shock waves. Drill holes containing the individual charges would be stemmed (capped) with angular rock or other suitable material for the purpose of containing blast energy within the rock. Studies indicate that the use of stemmed charges with confined blasting can reduce shock wave peak pressure by 60 to 90 percent (%) in relation to unconfined open water blasts (Nedwell and Thandavamoorthy 1992, Hempen et. al. 2005). The use of delays between individual charge detonations limits the development of cumulative blast pressure. Pursuant to the established fisheries environmental work window for Wilmington Harbor, confined underwater blasting operations would be conducted from 1 July to 31 January.

2.2.3 Beneficial Uses of Dredged Material

Beneficial uses of dredged material during channel construction would include beach disposal on Bald Head Island and Caswell Beach/Oak Island and the restoration and enhancement of waterbird nesting islands in the lower estuary (Figure 3). Beach compatible dredged material from the Southport, Baldhead-Caswell, Smith Island, and Baldhead Shoal 1 channel reaches would be placed on the beaches on Bald Head Island and Caswell Beach/Oak Island via direct cutterhead pipeline disposal (Figure 4). Beach disposal of navigation dredged material on the beaches of Bald Head Island and Caswell Beach/Oak Island is an ongoing practice that was initiated by the Wilmington Harbor Sand Management Plan (SMP) [United States Army Corps of Engineers (USACE) 2000]. Pursuant to the SMP, Bald Head Island receives material on a two, four, and eight-year cycle; while Oak Island receives material on a six-year cycle (USACE 2000). Beach disposal of dredged material under the proposed action would occur during Year 2 of the three-year channel construction project and subsequently every two years in accordance with the existing SMP maintenance cycle. Due to an increase in volumetric availability, beach disposal during construction Year 2 would be expanded to encompass an additional 1.5 to 2.5 linear miles of beach in relation to typical ongoing maintenance events under the existing SMP. Based on projected channel shoaling rate increases, post-construction maintenance beach disposal volumes would increase by five percent in relation to current beach disposal operations under the existing SMP. A five percent volumetric increase would equate to an additional 0.14 mile of beach disposal on Bald Head Island or an additional 0.25 mile of disposal on Oak Island, thus indicating that maintenance beach disposal operations under the proposed action would not differ significantly from current operations under the existing SMP. Beneficial uses in the lower

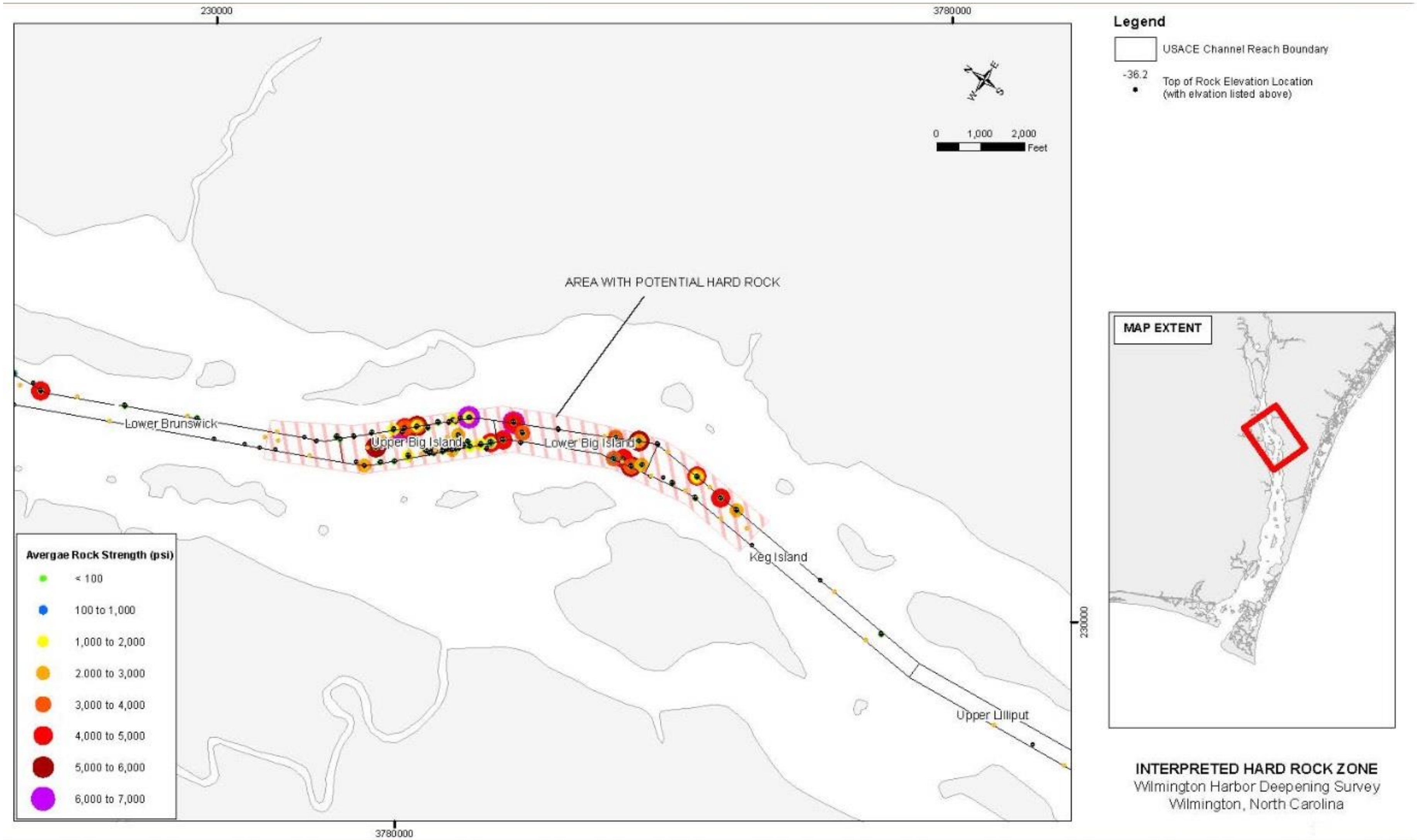

Figure 2
Rock Pre-Treatment Areas - Wilmington Harbor Navigation Improvement Project

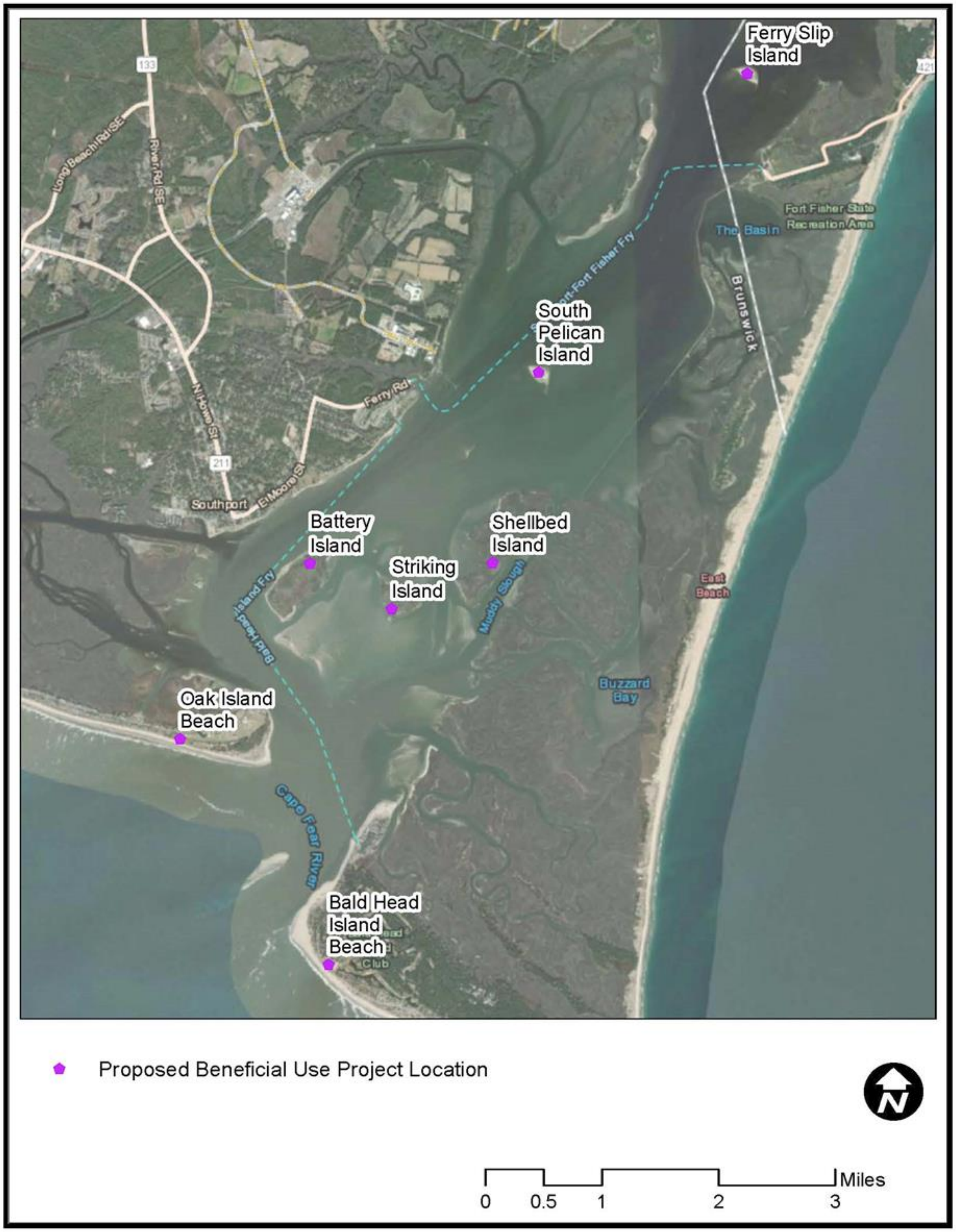

Figure 3
Beneficial Use of Dredged Material Sites

Figure 4
Beach Disposal Areas on Bald Head Island and Caswell Beach/Oak Island

estuary would include the use of thin layer disposal to restore subsiding marshes on Battery, Striking, and Shellbed Islands.

2.3 Construction Schedule

The proposed improvements to the Wilmington Harbor navigation channel would be constructed over a period of three years. The proposed three-year construction schedule (Table 3) is based on equipment types, production rates, and the previously described environmental work windows (Table 2). The proposed schedule is considered to be representative of a typical construction plan in that it uses the most likely equipment and maximizes dredging efficiency. However, the schedule would not be a requirement of the Contract and may not be the plan that is implemented.

Table 3
WHNIP Proposed Construction Schedule

Equipment Type	Year 1	Year 2	Year 3
	Channel Reach		
Hopper Dredge	Entrance Extension	Baldhead Shoal 2	Baldhead Shoal 3
Cutterhead Suction Dredge 1	Baldhead Shoal 3 Battery Island Lower Swash Snows Marsh	Baldhead Shoal 1 Smith Island Baldhead-Caswell Southport	Lower Lilliput Upper Lilliput
Cutterhead Suction Dredge 2	Horseshoe Shoal Reaves Point Lower Midnight Upper Midnight	Keg Island Lower Big Island Upper Big Island Lower Brunswick	Upper Brunswick Fourth East Jetty Between Reach Anchorage Basin
Drill Barges and Mechanical Dredge	---	Keg Island Lower Big Island Upper Big Island Lower Brunswick	---

3 DESCRIPTION OF THE ACTION AREA

The action area encompasses areas potentially affected by proposed harbor channel modifications and associated dredged material disposal activities; including the Cape Fear River estuary, the barrier island beaches of Bald Head Island and Oak Island, and offshore areas encompassing the ocean entrance channel and Wilmington ODMDS (Figure 5). As defined for purposes of this study, the Cape Fear River estuary encompasses the tidally affected river systems and wetlands of the lower Cape Fear River basin; including the mainstem Cape Fear River from the Atlantic Ocean up to Lock and Dam #1 at Kelly, NC (~60 river miles), the Northeast Cape Fear River from its confluence with the Cape Fear River up to NC HWY 53 (~48 river miles), and the Black River from its confluence with the Cape Fear River up to NC HWY 53 (~24 river miles).

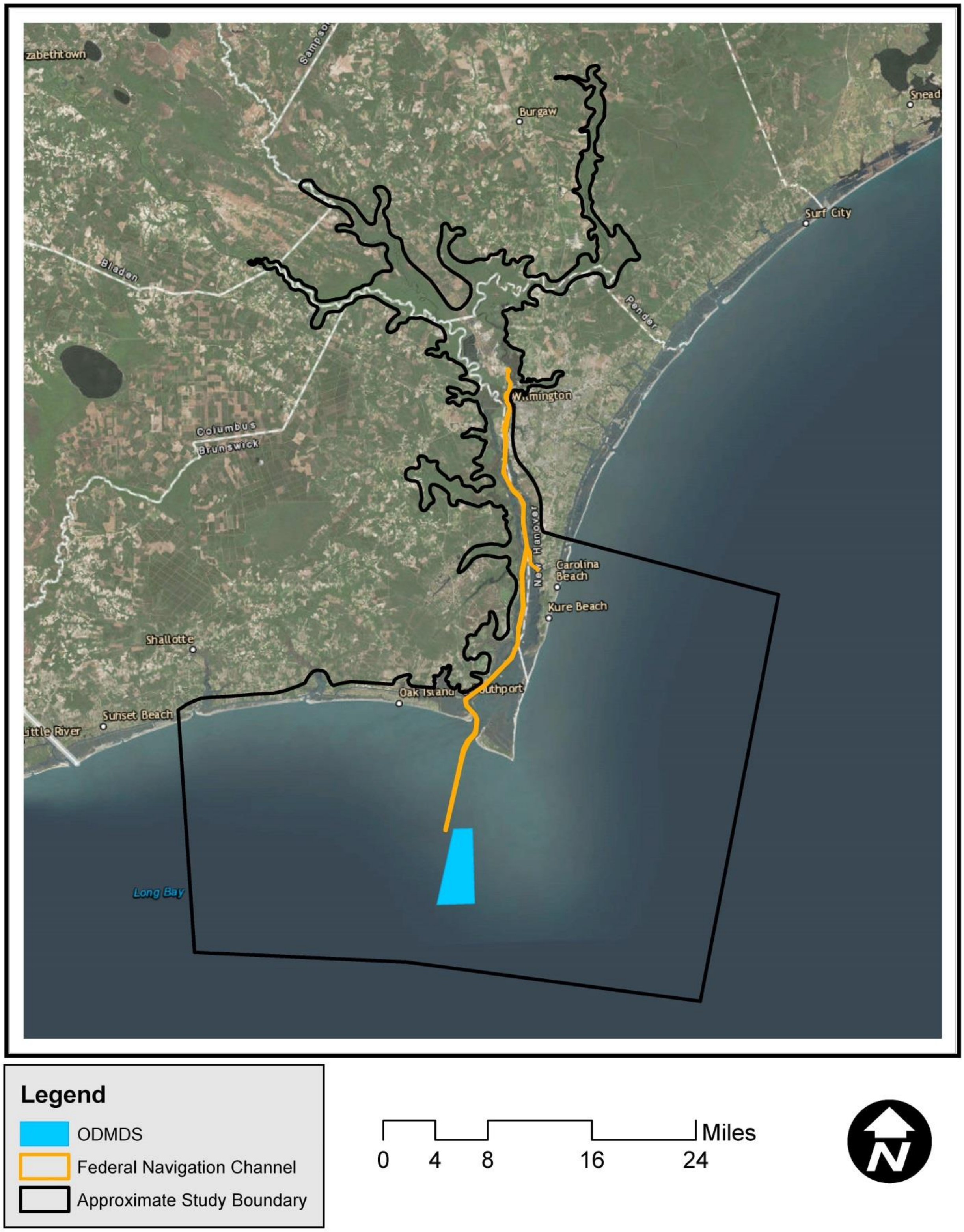

Figure 5
Action Area - Wilmington Harbor Navigation Improvement Project

4 SPECIES CONSIDERED UNDER THIS ASSESSMENT

This BA addresses potential effects on federally listed threatened and endangered species that occur or may occur in the action area (Table 4). Additionally, this assessment addresses potential effects on a number of designated critical habitat units that fall within the boundaries of the action area (Table 5). County species lists from the USFWS and the NMFS statewide species list for NC were reviewed and subsequently refined based on consideration of the species' documented ranges and habitat requirements. A number of species on the USFWS county lists were excluded from further consideration based on their association with terrestrial and/or non-riverine wetland habitats that are absent from the action area; including the red-cockaded woodpecker, American chaffseed, Cooley's meadowrue, golden sedge, pond berry, rough-leaved loosestrife, and smooth coneflower. Similarly, a number of highly pelagic species on the NMFS list were excluded based on their restriction to deep oceanic waters beyond the limits of the action area; including blue, finback, and sei whales and the oceanic white shark.

Table 4
Federally Listed Endangered and Threatened Species That May Occur in the Action Area

COMMON NAME	SCIENTIFIC NAME	FEDERAL STATUS
North Atlantic right whale	*Eubalaena glacialis*	Endangered
Florida manatee	*Trichechus manatus latirostris*	Threatened
Piping plover	*Charadrius melodus*	Threatened
Red knot	*Calidris canutus rufa*	Threatened
Wood stork	*Mycteria americana*	Threatened
Hawksbill turtle	*Eretmochelys imbricata*	Endangered
Kemp's ridley turtle	*Lepidochelys kempii*	Endangered
Green turtle	*Chelonia mydas*	Endangered
Leatherback turtle	*Dermochelys coriacea*	Endangered
Loggerhead turtle	*Caretta caretta*	Threatened
Atlantic sturgeon	*Acipenser oxyrinchus oxyrinchus*	Endangered
Shortnose sturgeon	*Acipenser brevirostrum*	Endangered
Seabeach amaranth	*Amaranthus pumilus*	Threatened

Table 5
Action Area Critical Habitat Units

Critical Habitat Type	Unit ID	Description
Piping Plover Wintering Critical Habitat	NC13 Masonboro	North end of Masonboro Island Masonboro Inlet
Piping Plover Wintering Critical Habitat	NC14 Carolina Beach Inlet	South end of Masonboro Island Carolina Beach Inlet emergent shoals North end of Carolina Beach
Piping Plover Wintering Critical Habitat	NC15 Fort Fisher	Fort Fisher Islands and ocean beach south of the ferry terminal
Piping Plover Wintering Critical Habitat	NC16 Lockwoods Folly Inlet	West end of Oak Island Lockwoods Folly Inlet emergent shoals
Piping Plover Wintering Critical Habitat	NC17 Shallotte Inlet	West end of Holden Beach Shallotte Inlet emergent shoals
Piping Plover Wintering Critical Habitat	NC18 Mad Inlet	West end of Sunset Beach Marshes behind west end of Sunset Beach East end of Bird Island
Loggerhead Sea Turtle Terrestrial Critical Habitat	LOGG-T-NC-05	Pleasure Island/Ft Fisher
Loggerhead Sea Turtle Terrestrial Critical Habitat	LOGG-T-NC-06	Bald Head Island
Loggerhead Sea Turtle Terrestrial Critical Habitat	LOGG-T-NC-07	Oak Island
Loggerhead Sea Turtle Terrestrial Critical Habitat	LOGG-T-NC-08	Holden Beach
Loggerhead Sea Turtle Nearshore Reproductive Critical Habitat	LOGG-N-05	Mean High Water to 1.6 kilometers offshore from Carolina Beach Inlet to Shallotte Inlet
Loggerhead Sea Turtle Winter Critical Habitat	LOGG-N-02	Offshore waters between 20-meter and 100-meter depth contours from Cape Fear to Cape Hatteras
Atlantic Sturgeon Carolina DPS Critical Habitat	Carolina Unit 4	Cape Fear River from mouth (river kilometer 0) to Lock and Dam #2 Northeast Cape Fear River from mouth to Roans Chapel Rd Bridge at Mount Olive
North Atlantic Right Whale Southeastern US Calving Critical Habitat	Unit 2	Nearshore waters from Cape Fear, NC, to Cape Canaveral, FL

5 EFFECTS OF THE PROPOSED ACTION

5.1 North Atlantic Right Whale

5.1.1 Status, Distribution, and Habitat

Right whale populations in the North Atlantic and North Pacific were originally listed as a single endangered species in June 1970 (35 FR 8495) under the Endangered Species Conservation Act (a predecessor to the ESA of 1973). In 2008, the two populations were reclassified as separate endangered species; the North Atlantic right whale (*Eubalaena glacialis*) and the North Pacific right whale (*E. japonica*) were listed as two separate endangered species under the ESA (73 FR 12024). The most recent stock status assessment in 2017 estimated the size of the North Atlantic right whale population at 458 individuals (NMFS 2018). North Atlantic right whales calve in warm subtropical waters during winter, and migrate to feeding grounds in highly productive cold temperate and subpolar waters in spring and summer (Greene and Pershing 2004). The majority of the western North Atlantic population ranges from wintering and calving areas in coastal waters off the southeastern US to summer feeding grounds in coastal waters off New England (Massachusetts Bay, Cape Cod Bay, and the Great South Channel) and Canada (Bay of Fundy, Scotian Shelf, and Gulf of St. Lawrence). Waters along the southeastern US coast constitute the only known calving habitat for North Atlantic right whales (Kraus et al. 1986, Knowlton et al. 1994, and Reeves et al. 2001). Reproductive females typically arrive in the calving areas during late November and early December after migrating south from feeding grounds in the northeastern US and Canada (Fujiwara and Caswell 2001, Garrison 2007, and Hamilton et al. 2007). Mothers and newborn calves reside within the southeast through winter and generally depart the calving grounds by the end of March or early April (Reeves et al. 2001). Other members of the population spend the winter on the northern feeding grounds, and a substantial portion of the population may spend the winter in several northern areas such as the Gulf of Maine and Cape Cod Bay (Cole et al. 2013, Clark et al. 2010, and Mussoline et al. 2012). Currently designated critical habitats for the right whale include northeastern feeding grounds in the Gulf of Maine/Georges Bank region, and southeastern nearshore ocean calving habitats from central Florida to Cape Fear, NC (81 FR 4838) (Figure 6).

5.1.2 Occurrence in the Action Area

The coastal waters of the Carolinas are part of the migratory corridor for the North Atlantic right whale (Winn et al. 1986, Knowlton et al. 2002). In an effort to better define the geographic and temporal extent of the right whale migratory corridor, Knowlton et al. (2002) analyzed 489 right whale sightings that occurred along the mid-Atlantic coast between 1974 and 2002. The largest number of sightings (34.4%) occurred within five nautical miles (nm) of shore, and well over half of the sightings (63.8%) occurred within ten nm of shore. Nearly all of the sightings (94.1%) were within 30 nm of shore. Despite extensive survey effort, sightings farther offshore were very rare. Sightings near Wilmington, NC, occurred from October through April with a peak during February and March (Knowlton et al. 2002). A total of 18 sightings occurred within a 40 nm radius of the entrance to Wilmington Harbor; including 14 sightings within a 20 nm radius of the harbor entrance. At Morehead City Harbor, 17 sightings occurred within a 35-nm radius of the harbor entrance, including 15 sightings within 20 nm of the harbor entrance. Surveys conducted off the southern NC coast during the winters of 2001 and 2002 sighted eight.

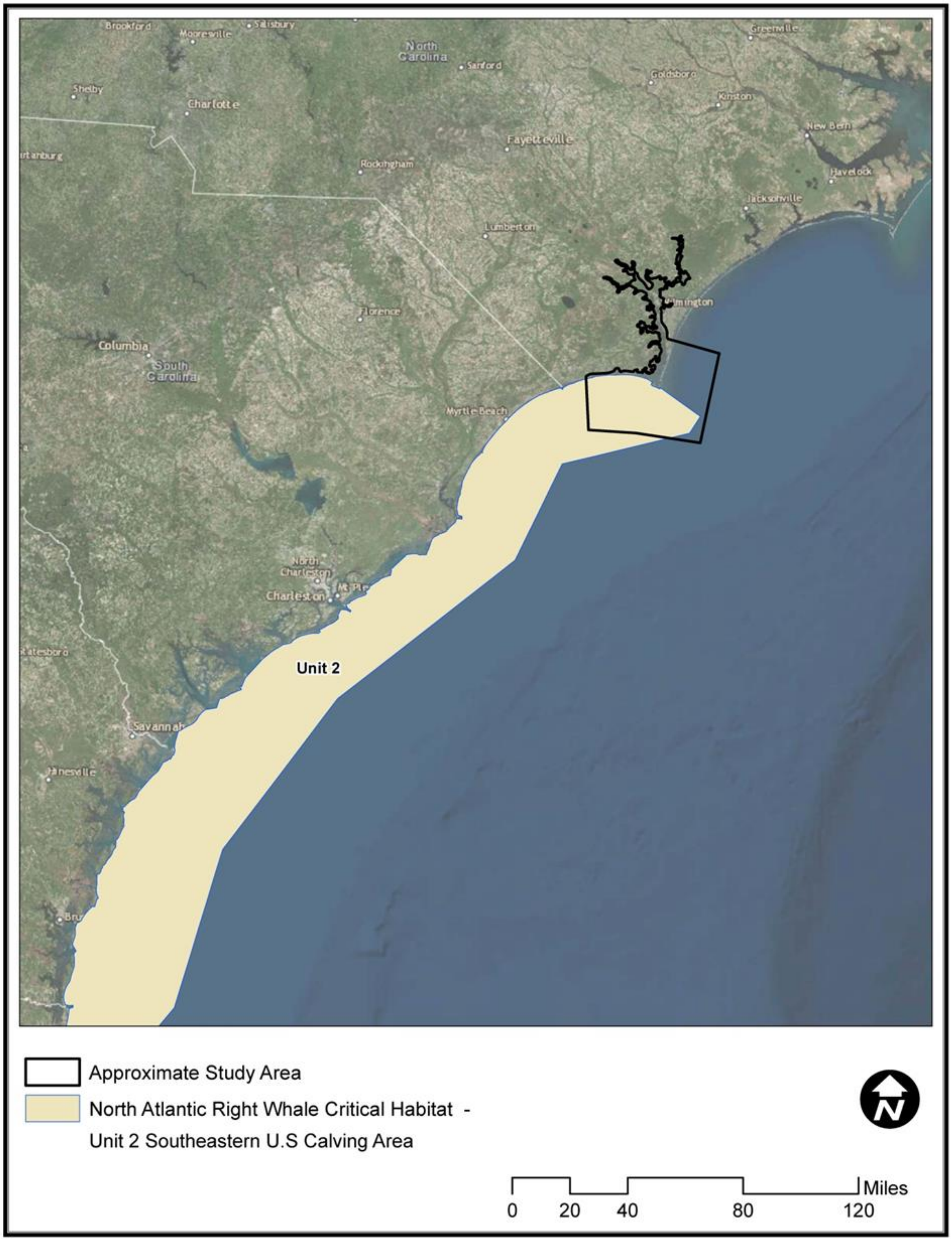

Figure 6
North Atlantic Right Whale Southeastern Calving Critical Habitat

calves, including four calves that were not sighted by surveys conducted farther south (McLellan et al. 2003). The NC calve sightings suggest that the right whale calving grounds may extend north to southern NC waters. In 2016, Southeastern Calving Area Critical Habitat for the right whale was extended north to Cape Fear (Figure 6). The essential features of the southeastern calving critical habitat include physical oceanographic conditions that support calving and nursing; including calm sea surface conditions, sea surface temperatures of 45 degrees Fahrenheit (°F) to 63°F, and water depths of 20 ft to 92 ft.

5.1.3 Threats

Ship collisions and fishing gear entanglements are the principal anthropogenic causes of North Atlantic right whale mortality. A total of 22 mortalities were attributed to ship strikes between 1970 and 2004, and it is estimated that approximately 60% of all right whales have scars associated with fishing gear entanglement (NMFS 2005). For the period of 2011 through 2015, the average minimum rate of annual human-caused right whale mortality and serious injury was 5.36 per year; including incidental fishery entanglements at an average rate of 4.55 per year and vessel strikes at an average rate of 0.81 per year (NMFS 2018). Analyses of whale-vessel interactions indicate that the probability of vessel strikes and the probability of serious injuries from vessel strikes both increase with ship speed (NMFS 2008). In an effort to reduce ship strikes, the NMFS published the Right Whale Ship Strike Reduction Rule (50 CFR 224.105). The Ship Strike Reduction Rule established Seasonal Management Areas (SMAs) with mandatory large vessel (≥65 ft) speed restrictions. The southernmost Mid-Atlantic SMA encompasses waters within a 20-nm radius of MCH and a continuous 20 nm zone along the southeastern US coast from Wilmington, NC, to Brunswick, Georgia (Figure 7). Vessels ≥65 ft in length are restricted to speeds of ten knots or less in the Mid-Atlantic SMA from 1 November to 30 April (73 FR 60173). Additional federal regulations prohibit the approach of any vessel within 500 yards of a right whale [50 CFR 224.103(c)]. Although instances of lethal whale-dredge interactions (i.e., vessel collisions) have not been documented, a non-lethal interaction was reported in 2005 when a hopper dredge collided with an apparent right whale along the Georgia coast near the Brunswick Harbor entrance channel (NMFS 2012b).

5.1.4 Project Effects

5.1.4.1 Vessel Strikes

Hopper dredging operations in the outer harbor entrance channel and dredged material ocean disposal at the ODMDS would coincide with right whale migration and calving periods along the NC coast. The risk of collisions between hopper dredges and whales during active dredging operations would be minimal, as hopper dredges travel at slow speeds during the active dredging process. The potential for vessel strikes would primarily be associated with hopper dredge transits between the dredging site and the ODMDS and support vessel operations. Hopper dredges and support vessels would employ conservation measures to reduce the risk of vessel collisions; including the continuous presence of Protected Species Observers (PSOs) on hopper dredges during active dredging and transit, and the application of a 10-knot speed restriction to

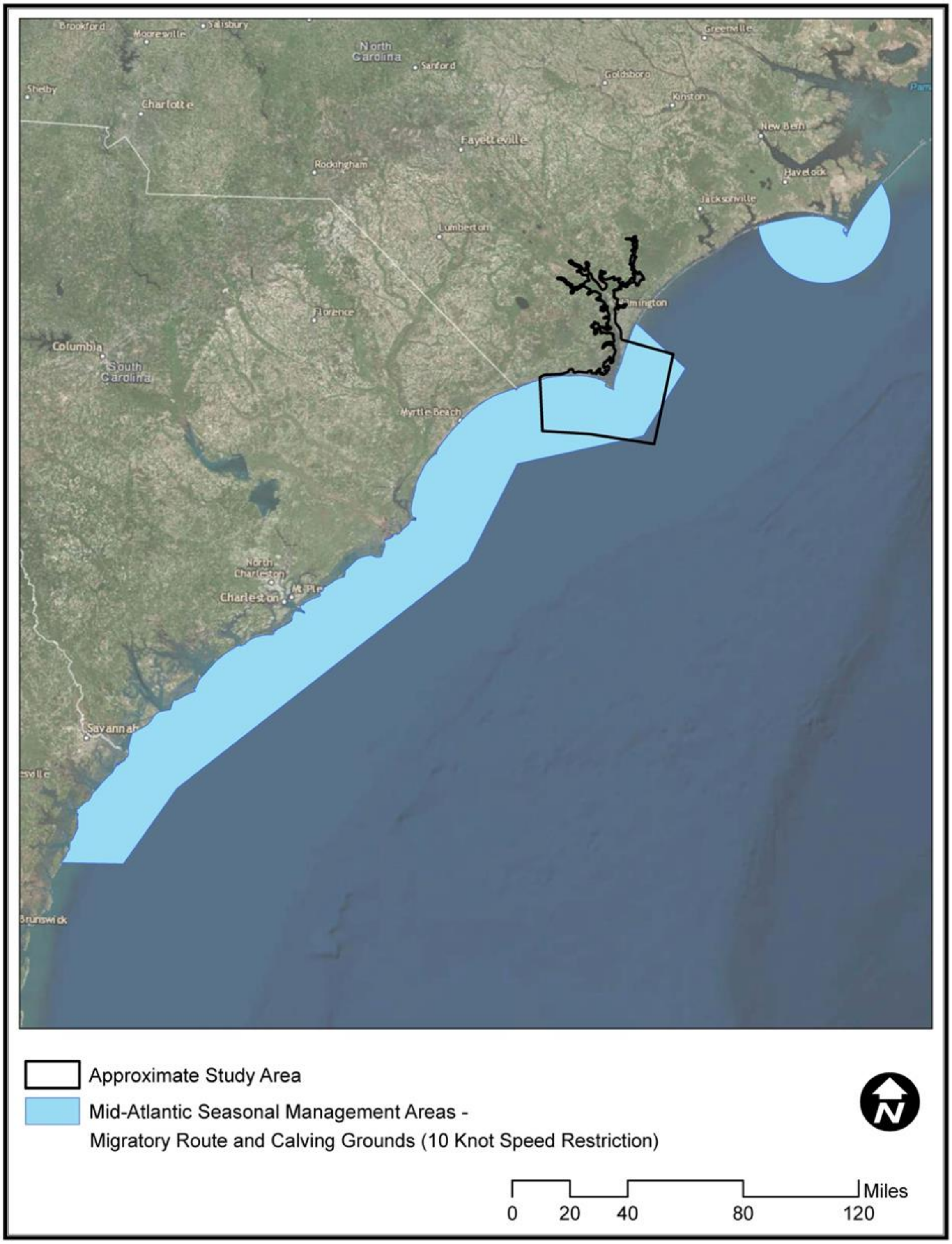

Figure 7
Mid-Atlantic Seasonal Management Areas for the North Atlantic Right Whale

all hopper dredges and support vessels. It is expected that these conservation measures would reduce the risk of collisions to negligible levels.

5.1.4.2 Dredging Acoustic Effects

The NMFS defines two levels of acoustic "take" under the Marine Mammal Protection Act (MMPA). Actions that may expose marine mammals to noise in excess of the values shown in Table 6 constitute Level A harassment with the potential to cause injury, and actions that may expose marine mammals to impulse (e.g., pile driving, blasting) noise levels ≥140 decibels (dB) re 1 micropascal (µPa) root mean square (rms) or continuous (e.g., dredging) noise levels ≥120 dB re 1µPa constitute Level B harassment with the potential to cause behavioral disruption. A study of the sounds produced by hopper dredges during sand mining at offshore borrow sites in Virginia reported noise levels ranging from 161 to 179 dB re 1µPa rms (Reine et al. 2014). Peak source levels did not exceed the former generic Level A harassment threshold (≥180 dB re 1µPa rms) for injurious effects on marine mammals; however, noise levels generally exceeded the NMFS Level B harassment threshold (≥120 dB re 1µPa rms) within 1.2 kilometers (km) of the source and generally remained at or near 120 dB re 1µPa rms out to 2.1 km. According to a study by Clarke et al. (2002), cutterhead dredges produce peak sound levels in the range of 100 to 110 dB re 1µPa rms with rapid attenuation occurring at short distances from the dredge and sound levels becoming essentially inaudible at a distance of approximately 500 meters (m). Mechanical dredges produce non-continuous but repetitive sound, with maximum sound level spikes of ~120 dB peak pressure occurring when the bucket or clamshell contacts the bottom (Clarke et al. 2002).

Based on the noise studies described above, the sound levels produced by cutterhead and mechanical dredges would not be expected to exceed the NMFS thresholds for behavioral or injurious effects on marine mammals. In the case of hopper dredging, these studies indicate that sound levels would not be expected to exceed the NMFS thresholds for injurious effects on marine mammals (Level A harassment), but may exceed the threshold for behavioral effects on marine mammals (Level B harassment) within 2.1 km of the dredge. Most observations of baleen whale responses to anthropogenic noise have been limited to short-term responses; including avoidance of the source area, cessation of feeding, rapid swimming away from the source, altered dive patterns, vocalization changes, and changes in respiration (Fisheries and Oceans Canada 2010). Therefore, it is expected that any behavioral effects on right whales would be limited to minor short-term avoidance responses.

Table 6
Level A Permanent Threshold Shift Onset Harassment Values for Marine Mammal Hearing Groups

Hearing Group	PTS Onset (Received Level)	
	Impulsive	Non-Impulsive
Low-Frequency (LF) Cetaceans	PK: 219 dB SEL $_{cum}$: 183 dB	SEL $_{cum}$: 199 dB
Mid-Frequency (MF) Cetaceans	PK: 230 dB SEL $_{cum}$: 185 dB	SEL $_{cum}$: 198 dB
High-Frequency (HF) Cetaceans	PK: 202 dB SEL $_{cum}$: 155 dB	SEL $_{cum}$: 173 dB
Phocid Pinnipeds (PW)	PK: 218 dB SEL $_{cum}$: 185 dB	SEL $_{cum}$: 201 dB
Otariid Pinnipeds (OW)	PK: 232 dB SEL $_{cum}$: 203 dB	SEL $_{cum}$: 219 dB
PTS = Permanent Threshold Shift; PK = Peak sound level; SEL_{cum} = Cumulative sound exposure level		

Source: NMFS 2016

5.1.4.3 Confined Underwater Blasting

The proposed confined blasting areas are located in the Keg Island, Lower Big Island, Upper Big Island, and Lower Brunswick channel reaches in the mid-estuary at a distance of 18 miles or more from the ocean. Based on sound pressure and dB levels produced by test blasting in the Cape Fear River for the Wilmington Harbor 96 Act project, the Wilmington District USACE determined that the sound pressure levels meeting or exceeding the NMFS thresholds for injurious and behavioral marine mammal effects would occur within ~560 ft and ~3,500 ft of the blast locations, respectively (USACE 2000). Therefore, blasting would not be expected to have any adverse effects on North Atlantic right whales.

The proposed confined blasting areas encompass ~188 acres of rock surface area within the Keg Island, Lower Big Island, Upper Big Island, and Lower Brunswick channel reaches. The proposed confined blasting areas are located in the mid-estuary at a distance of 18 miles or more from the ocean. Based on sound pressure and dB levels produced by test blasting conducted in the Cape Fear River for the Wilmington Harbor 96 Act project, the Wilmington District determined that the NMFS thresholds for injurious and behavioral marine mammal effects would be met or exceeded within ~560 ft and 3,500 ft of the blast locations, respectively (USACE 2000). Therefore, blasting would not be expected to have any adverse effects on North Atlantic right whales.

5.1.4.4 Effects on North Atlantic Right Whale Critical Habitat

The essential features of right whale southeastern US critical calving habitat are those associated with optimal calving habitat; including calm sea surface conditions, sea surface temperatures of

45°F to 63°F, and water depths of 20 ft to 92 ft. The proposed action would not be expected to affect any of these essential features.

5.1.5 Conservation Measures

5.1.5.1 Vessel Speed Restrictions and Contractor Briefings

During transit between the dredge area and disposal sites, dredges, material transport vessels, and other associated support vessels would adhere to a set speed limit (e.g. <10 knots) that would minimize the risk of vessel strikes to important species. Contractors will also be briefed on the presence of species within the project area along with the requirements for protection of these species. All contractor personnel should be informed of the civil and criminal penalties for harming, harassing, or killing protected species under the ESA and MMPA. Dredges and associated vessels will be required to stop or alter course when North Atlantic right whales are encountered. Additional caution will be taken during periods of limited visibility.

5.1.5.2 Endangered Species Observers

During daylight hours (dawn to dusk), one PSO would be onboard all hopper dredges during active dredging operations and transit to conduct observations for large whales. If a right whale is sighted within 500 yards during dredging operations, operations will cease until the PSO is confident that the whale has left the area. If a whale is sighted during transit, the crew would reduce speed and alter course as necessary to maintain a distance of 500 yards between the vessel and the whale. All whale sightings would be documented and reported to the NMFS.

5.1.6 Determination of Effects

5.1.6.1 Vessel Strikes

The conservation measures addressed above would be effective in reducing the risk of right whale vessel collisions. It is expected that adherence to speed restrictions and the use of qualified endangered species observers would reduce the risk of collisions to negligible levels. Therefore, it is determined that the proposed action may affect, but is not likely to adversely affect the North Atlantic right whale.

5.1.6.2 Dredging Acoustic Disturbance

The previously described noise studies indicate that the sound levels produced by dredging would not be expected to exceed the NMFS thresholds for injurious effects on marine mammals (Level A harassment). Hopper dredges may produce sound levels that exceed the thresholds for behavioral effects on marine mammals (Level B harassment) within 2.1 km of the dredge. Behavioral effects may include short-term avoidance of the area, cessation of feeding, resting, or social interactions. However, since North Atlantic right whales are transient within the action area, any behavioral effects are anticipated to be short-term and minor. Therefore, it is determined that the proposed action may affect, but is not likely to adversely affect the North Atlantic right whale.

5.1.6.3 Confined Blasting

The proposed confined blasting areas are located in the mid-estuary at a distance of 18 miles or more from the ocean. Therefore, it is determined that blasting would have no effect on the North Atlantic right whale.

5.1.6.4 North Atlantic Right Whale Southeastern US Calving Critical Habitat

It is determined that the proposed action may affect, but is not likely to adversely affect southeastern U.S. calving critical habitat for the North Atlantic right whale.

5.2 Florida Manatee

5.2.1 Status, Distribution, and Habitat

The Florida manatee (*Trichechus manatus latitostris*), a subspecies of the West Indian manatee, was originally listed as endangered in 1967 (32 FR 4001) under the ESAt of 1966 (a predecessor to the ESA of 1973). In 1969, the endangered listing was expanded to encompass the species throughout its range, including the Antillean manatee (*Trichechus manatus manatus*), a subspecies occurring in the Caribbean and South America. In May 2017, both subspecies were reclassified from endangered to threatened throughout their ranges (82 FR 16668). Manatees are intolerant of cold water temperatures; and consequently, are generally restricted to warm water sites of peninsular Florida during the winter. In the spring, as water temperatures reach 68°F, manatees disperse from winter sites and can undertake extensive movements along the coast and up rivers and canals (USFWS 2001). Manatees inhabit marine, brackish, and freshwater environments where they are found in seagrass beds, salt marshes, freshwater bottom areas, and many other habitat types. Manatees feed on a wide variety of submerged, floating, and emergent vegetation. Seagrasses are a staple in coastal habitats, and preferred foraging habitats consist of shallow seagrass beds with access to deep water. Manatees are also known to feed on salt marsh vegetation (i.e., smooth cordgrass), which they access at high tide. Although manatees tolerate a wide range of salinities, they prefer areas where osmotic stress is minimal or areas that have a natural or artificial source of fresh water (USFWS 2001). The most recent abundance estimate for the Florida subspecies within the southeastern US was 6,350 individuals (Martin et al. 2015). Numerous coastal water bodies in Florida have been designated as critical habitat for the manatee; including waters as far north as Nassau County on the east coast of Florida and as far north as Citrus County on the west coast of Florida (42 FR 47840-47845).

5.2.2 Occurrence in the Action Area

Cummings et al. (2014) described the temporal and spatial distribution of manatees in NC based on sighting and stranding records for the period of 1991-2012. Although sightings were reported along the entire NC coast, most were concentrated around the densely populated areas of Wilmington and Beaufort, NC. Sightings were most common in the Atlantic Intracoastal Waterway; however, manatees were also observed in sounds, bays, rivers, creeks, marinas, and the open ocean. Manatee occurrences in NC are primarily restricted to the months of June through October. Nearly all (93%) of the NC sighting (n=99) and stranding (n=9) records that were analyzed by Cummings et al. (2014) occurred between June and October when water temperatures were above 68°F [20 degrees Centigrade (°C)]. Reported sightings in the mainstem Cape Fear River estuary were confined to the lowermost estuary below Snows Cut; however, two sightings were reported in the northeast Cape Fear River approximately 20 to 30 river miles above Wilmington. A number of additional sightings were reported from the Atlantic Intracoastal Waterway channels behind Oak Island and Carolina Beach.

5.2.3 Threats

The principal anthropogenic causes of manatee mortality are watercraft strikes, entrapment and/or crushing in water control structures, ingestion of marine debris, and entanglement in fishing gear. Natural causes of mortality include cold stress syndrome and exposure to red tide (brevetoxicosis). Of 2,372 human-caused manatee deaths that occurred from 1978-2012; 84% (n=1,980) were attributed to watercraft strikes, 9% (n=204) to water control structures, and the remaining 8% (n=188) to ingestion of marine debris, entanglement in fishing gear, and other human causes. Based on 493 deaths that were attributed to human causes during the most recent 5-year period of 2008-2012, the average annual rate of human-caused mortality is estimated at 99 manatees per year (USFWS 2014). Although no manatee strandings have been reported from the action area, nine strandings were reported along the NC coast from 1991-2012. Rapid declines in water temperature during the early fall can cause cold stress syndrome in manatees that have not departed NC waters for Florida (Cummings et al. 2014). Of the nine strandings that were reported in NC from 1991-2012; seven occurred during the months of November, December, and January; with four showing signs of cold stress at necropsy.

5.2.4 Project Effects

5.2.4.1 Dredging

Hopper dredging operations in the outer harbor entrance channel would adhere to a dredging window of 1 December to 30 April; thus limiting operations to periods of relatively cold water temperatures when manatees are unlikely to be present in NC waters. The use of hopper dredges would be limited to the outermost Baldhead Shoal 2 and 3 ocean entrance channel reaches where manatees would be unlikely to occur even during the warmer months. Cutterhead and bucket dredging in the inner harbor channels would occur from 1 October to 31 March in the reaches south of Snow’s Cut and 1 July to 31 January in the reaches north of Snow’s Cut; thus coinciding with the months of July-October when manatees could potentially be present the in the Cape Fear River estuary. Cutterhead and bucket dredges operate from anchored barges, and would present only a minimal collision risk during brief periods of barge repositioning. The principal collision risk associated with inner harbor dredging would occur from support vessel operations and the use of scows to transport dredged material to disposal sites. As a measure to reduce the risk of vessel strikes, all dredging and disposal operations and supporting vessel activities would implement: Guidelines for Avoiding Impacts to the West Indian Manatee: Precautionary Measures for Construction Activities in North Carolina Waters (USFWS 2003) (Appendix A). Based on the implementation of these measures, the stationary operational mode of cutterhead and bucket dredges, and the rarity of manatees in NC waters; it is expected that the vessel strike risk would be negligible.

5.2.4.2 Confined Underwater Blasting

Manatees may be present in the Cape Fear River estuary during the proposed 1 July-31 January blasting window; although the analyses conducted by Cummings et al. (2014) indicate that the likelihood of occurrences would be greatly reduced after the end of October. Underwater explosions produce shock waves that can have physiological effects on marine mammals ranging from mortality and non-auditory physical injuries to auditory injuries involving Permanent Threshold Shift (PTS) and Temporary Threshold Shift (TTS) hearing loss. In-water blast waves travel through the bodies of marine animals and can cause internal injury to gas-filled organs. Injuries most commonly reported in marine mammals that have been exposed to underwater explosions include hemorrhaging in the fine structure of the lungs and injuries to the gastrointestinal tract (Richmond et al. 1973, Yelverton et al. 1975, and Finneran and Jenkins 2012). Blasting can also have behavioral effects on marine mammals ranging from startle reactions to single detonations to negative effects on feeding, sheltering, reproduction, or other important biological functions when exposed to multiple detonations in the same area over an extended period of time (NMFS 2008a).

Areas potentially requiring confined blasting encompass ~188 acres of rock surface area within the Keg Island, Lower Big Island, Upper Big Island, and Lower Brunswick channel reaches. These four reaches comprise a continuous ~4.4-mile section of the navigation channel from a point ~18 miles above the estuary mouth to a point approximately two miles below Eagle Island. Blasting operations under the proposed action would employ stemmed charges and charge delays to reduce the magnitude of potentially injurious blast shock waves. Drill holes containing the individual charges would be stemmed (capped) with angular rock or other suitable material for the purpose of containing blast energy within the rock. Studies indicate that the use of stemmed charges with confined blasting can reduce shock wave peak pressure by 60 to 90% in relation to unconfined open water blasts (Nedwell and Thandavamoorthy 1992, Hempen et. al. 2005). The use of delays between individual charge detonations limits the development of cumulative blast pressure.

Blasting operations would implement protective measures for marine mammals and sea turtles similar to those previously approved by the NMFS in 2000 and 2012 for blasting operations under the Wilmington Harbor 96 Act Project (NMFS 2000, 2012). Protective measures would include the establishment of blast zones of influence and the development of a Watch Program in accordance with NMFS Southeast Region guidance for mitigating the effects of marine blasting on protected species; including marine mammals and sea turtles (Baker 2008). The NMFS guidance provides specific procedures and equations for calculating zones of influence based on the blasting method used and project-specific details. In the case of confined blasting, the required zones of influence include Danger, Harassment, and Watch zones (Table 7). The innermost Danger Zone encompasses the area nearest to the blast location where mortality and injury may occur. The intermediate Harassment Zone encompasses the area where TTS and behavioral effects may occur, and the outermost Watch Zone is an additional area that is monitored to detect animals that are moving towards the inner blast impact zones.

Table 7
Recommended Zones of Influence for Confined Blasting with Stemmed Charges

Influence Zone	Definition	Equation
Danger Zone	Mortality and Injury (Onset of PTS)	260 $\sqrt[3]{lb/delay}$
Harassment (Safety) Zone	Onset of TTS and Behavioral Effects	520 $\sqrt[3]{lb/delay}$
Watch Zone	Monitoring to detect approaching animals	3 x distance of danger zone

Source: Baker 2008

5.2.5 Conservation Measures

5.2.5.1 USFWS Manatee Impact Avoidance Guidelines

The contractor will implement: Guidelines for Avoiding Impacts to the West Indian Manatee: Precautionary Measures for Construction Activities in North Carolina Waters (USFWS 2003) (Appendix A).

5.2.5.2 Blast Mitigation Watch Program

Blast zones of influence (Danger Zone, Harassment Zone, and Watch Zone) will be calculated for each blast event in accordance with NMFS guidelines (Table 6). The zones of influence cannot be calculated until the weights of all charges that will comprise each blast are known. The contractor will calculate the zones of influence and include the information in the blasting plans and monitoring reports for each blast event. Information regarding the influence zones will be provided to the PSOs prior to each blast for incorporation into the event-specific watch plans.
A site-specific watch program will be developed and implemented in coordination with the USFWS and other federal and state resource agencies. Based on protective measures that were approved for prior Wilmington Harbor deepening projects (NMFS 2000, 2012), it is anticipated that the watch program would include the following:

- The watch program will begin at least one hour prior to the scheduled start of blasting to identify the possible presence of protected species and will continue until at least one half-hour after detonations are complete.

- A combination of sonar and other imaging techniques will be used to monitor a 500-ft zone surrounding the blast area for schools of fish. Monitoring will begin 20 minutes prior to the detonation and no blasting will occur until any observed fish have left the area.

- The watch program for each blast shall consist of a minimum of five PSOs.

- PSOs will be equipped with two-way radios, polarized sunglasses, binoculars, a red flag for backup visual communication, and a sighting log with a map to record sightings.

- All blasting events will be weather dependent. Climatic conditions must be suitable for optimal viewing conditions, as determined by the observers.

- The event shall be halted if any animals are spotted within the Safety Zone.

- The blasting event shall be halted immediately upon request by any of the PSOs.

- If marine mammals or sea turtles are sighted, the blast event shall not take place until the animal(s) moves out of the area under its own volition. Animals shall not be herded away, and will not be intentionally approached by project watercraft. If the animal(s) is not sighted a second time, the event may resume 30 minutes after the last sighting.

- Blasting will not occur within the 2-hour period after sunrise or the 1-hour period before sunset.

- Blasting will be limited to the period of 1 July to 31 January in accordance with the NC Division of Marine Fisheries Anadromous Fish Moratorium (1 February -30 June).

- A delay of at least 25 milliseconds shall be applied to the charge in each drill hole to prevent cumulative blasting impacts.

- Maximum peak pressure shall not exceed 120 pounds per square inch (psi) at a distance of 140 ft.

- Average peak pressure shall not exceed 70 pounds psi at a distance of 140 ft. This average will be based on each series of five consecutive charge detonations.

- Blast pressures will be monitored and upper limits will be imposed on each series of 5 consecutive detonations. Pressure will be monitored for each blast only at a distance of 140 ft.

- The PSOs and contractors shall evaluate any problems encountered during blasting events and logistical solutions shall be presented to the Contracting Officer. Corrections to the watch program shall be made prior to the next blasting event. If any one of the aforementioned conditions is not met prior to or during blasting, the watch observers shall have the authority to terminate the blasting event until resolution can be reached with the Contracting Officer. The Contracting Officer will contact NMFS.

- If an injured or dead protected species is sighted after the blast event, the PSOs shall contact the USACE, and the USACE shall contact the following resource agencies:
  - UNC Wilmington, Marine Mammal Stranding Program: 910-254-5713
  - NC Wildlife Resources Commission, Sea Turtle Stranding Hotline: 252-241-7367
  - NMFS SERO-PRD: 727-824-5312 (Sea Turtles)

  - NMFS Southeast Marine Mammal Stranding Hotline: 1-877-433-8299

- The PSOs shall maintain contact with the injured or dead mammal or sea turtle until authorities arrive. Blasting shall be postponed until consultations are completed and determinations can be made as to the cause of injury or mortality. If blasting injuries are documented, all blasting activities shall cease, and the USACE will submit a revised plan to the NMFS for review.

- A watch plan will be formulated based on the required monitoring zones of influence and optimal observation locations. The watch plan will consist of at least two (2) boat-based PSOs, and two (2) PSOs stationed on the drill barge. A fifth PSO will be placed in the most optimal observation location (boat or barge) on a day-by-day basis, depending on the location of the blast and the placement of dredging equipment. This process will ensure complete coverage of the three zones as well as any critical areas. The watch will begin at least 1-hour prior to each blast and continue for one-half hour after each blast (Jordan et al. 2007).

- Within 30 days of the completion of each blasting event, the primary PSO shall submit a report to the USACE, which will provide the report to the NMFS. The report for each blast will describe the event, number and location of animals seen, actions that were taken when animals were observed, any problems encountered during the event, and suggestions for improvements.

5.2.6 Determination of Effect

5.2.6.1 Dredging

Based on adherence to the USFWS manatee impact avoidance guidelines, and considering the relatively stationary operational mode of cutterhead and bucket dredges that would be used in the nearshore ocean and estuarine channel reaches, it is determined that the proposed action may affect, but is not likely to adversely affect the Florida manatee.

5.2.6.2 Confined Underwater Blasting

Cummings et al. (2014) identified just two reported manatee sightings in the Cape Fear River estuary above Snow’s Cut (river mile 13); thus, indicating that manatee occurrences are rare in the vicinity of the proposed blasting areas (river mile 18 to river mile 22). Based on the use of stemmed charge confined blasting methods, the proposed watch program and other blast mitigation measures, and the apparent rarity of manatee occurrences in the vicinity of the blasting areas; it is determined that confined underwater blasting under the proposed action may affect, but is not likely to adversely affect the Florida manatee.

5.3 Piping Plover and Red Knot

5.3.1 Status, Distribution, and Habitat

5.3.1.1 Piping Plover

The piping plover (*Charadrius melodus*) was listed as endangered and threatened under the ESA on 10 January 1986 (50 FR 50726 – 50734). The final listing rule recognized three demographically independent populations that breed in three separate regions: the Atlantic Coast from NC to Canada, the Great Lakes watershed, and the Northern Great Plains region. Birds that breed along the Atlantic Coast are recognized as the subspecies *C. m. melodus*, while birds belonging to the interior Great Lakes and Northern Great Plains breeding populations are recognized as the subspecies *C. m. circumcinctus* (Miller et al. 2010). The piping plover is classified as endangered within the Great Lakes watershed and as threatened throughout the remainder of its breeding**,** migratory, and wintering range. The shared migratory and wintering range of the three breeding populations encompasses the Atlantic and Gulf Coasts from NC to northern Mexico, as well as the Bahamas and West Indies. Outside of their breeding range, birds belonging to the endangered Great Lakes breeding population are indistinguishable from those belonging to the threatened Great Plains and Atlantic coast populations; and consequently, all piping plovers are classified as threatened within their shared migratory and wintering range (USFWS 2009b). Critical habitat has been designated for the Great Lakes (66 FR 22938 22969) and Northern Great Plains (67 FR 57638 57717) breeding populations. Critical habitat has not been designated for the Atlantic Coast breeding population; however, critical habitat units for US wintering population have been designated along the Atlantic and Gulf coasts from NC to Texas (66 FR 36038 - 36143).

The 1996 revised Recovery Plan for the Atlantic Coast breeding population established a recovery goal of 2,000 breeding pairs maintained for five years and distributed among four recovery units (Eastern Canada, New England, New York-New Jersey, and Southern) (USFWS 1996a). The Southern Recovery Unit, encompassing NC, Virginia, Delaware, and Maryland; was assigned a subpopulation goal of 400 breeding pairs. Additional recovery criteria include a five-year average annual productivity rate of 1.5 fledged chicks per pair in each of the four recovery units, and the long-term maintenance of wintering habitat sufficient to maintain a breeding population of 2,000 breeding pairs. Annual Atlantic Coast population abundance estimates are reported as numbers of breeding pairs [i.e. adult pairs that exhibit sustained (>2 weeks) territorial or courtship behavior or are observed with nests or unfledged chicks] (USFWS 1996a). Since its listing, the overall Atlantic Coast population has increased by 137% from approximately 790 pairs in 1986 to an estimated 1,870 pairs in 2015 (Table 8). The estimated number of breeding pairs in the New York-New Jersey Unit, which includes the study area, experienced an increase of 98%.

Table 8
Net Change in Estimated Atlantic Coast Breeding Pairs 1986 to 2015

Recovery Unit	Net Change Number Breeding Pairs	Percent Increase/Decrease
Eastern Canada	-61	-25%
New England	+734	+399%
New York – New Jersey	+203	+98%
Southern	+204	+129%
Overall Atlantic Coast Net Change	**+1,080**	**+137%**

Source: USFWS 2016

Although there is no exclusive partitioning of the wintering range based on breeding origin, band sightings indicate that Atlantic Coast breeding birds from Eastern Canada and the majority of the Great Lakes population winter along the southeast coast from NC to Southwest Florida (Gratto-Trevor et al. 2012). Banded Eastern Canada plovers are more heavily concentrated in NC, whereas a larger proportion of banded birds from the Great Lakes are found in South Carolina, Georgia, and Florida. Banded piping plovers from the Northern Great Plains population are concentrated farther west and south along the Gulf Coast, although a few banded individuals from Prairie Canada occur along the Atlantic Coast from NC to Florida. Of 57 piping plovers banded in the Bahamas in 2010, 79% have been reported breeding on the Atlantic Coast (USFWS 2012). Banding efforts on the Atlantic Coast breeding grounds have been less extensive; and consequently, the distribution of these birds during winter remains poorly understood.

5.3.1.2 Red Knot

The rufa red knot (*Calidris canutus rufa*) (hereinafter referred to as "red knot") was listed as threatened under the ESA on 12 January 2015 (79 FR 73705 73748). The USFWS has not approved a recovery plan for the red knot, and no critical habitat has been designated for the species. Red knots migrate between breeding grounds in the central Canadian High Arctic and wintering areas that are widely distributed from the southeastern US coast to the southern tip of South America. Migration occurs primarily along the Atlantic coast, where red knots use key stopover and staging areas for feeding and resting. Departure from the Arctic breeding grounds occurs from mid-July through August, and the first southbound birds arrive at stopover sites along the US Atlantic coast in July. Numbers of southbound birds peak along the US Atlantic coast in mid-August; and by late September, most birds have departed for their wintering grounds. Major fall stopover sites along the US Atlantic coast include the coasts of Massachusetts and New Jersey and the mouth of the Altamaha River in Georgia. Principal wintering areas include the southeastern US Atlantic Coast from NC to Florida, the Gulf Coast from Florida to northern Mexico, the northern Atlantic coast of Brazil, and the island of Tierra del Fuego along the southern tip of South America. Smaller numbers of red knots also winter along the central and northeastern US Atlantic coast and in the Caribbean. The core southeastern US Atlantic wintering area is thought to shift from year to year between Florida, Georgia, and South Carolina (USFWS 2014). Although long term monitoring efforts in key migratory and wintering areas since the 1980s have shown sustained declines in red knot numbers on the order of 75%, population estimates for the southeastern US Atlantic Coast wintering population were approximately the same during the 1980s and 2000s (USFWS 2014). Recent evidence suggests that the southeast wintering population may number as high as 20,000 birds (USFWS 2014). Consistent aerial surveys of the Virginia coast since 1995 have produced stable counts during peak migration periods, and more recent ground surveys in Virginia suggest an upward trend since 2007.

Red knots typically arrive at southeastern US and Caribbean wintering sites in November, but may arrive as early as September. Birds wintering along the US Atlantic coast and in the Caribbean typically remain on their wintering grounds through March, and in some cases as late as May. Northbound birds from both North and South American wintering areas use stopover sites along the US mid-Atlantic coast from late April through late May/early June (USFWS 2014). Important spring stopover sites in the US include Delaware Bay and the Atlantic Coast from Georgia to Virginia; however, small to large groups of northbound red knots may occur in suitable habitats along all of the Atlantic and Gulf Coast states. Unknown numbers of non-breeding red knots, many consisting of one-year-old subadult birds, remain south of the breeding grounds throughout the year (USFWS 2014). Migrating and wintering red knots use similar habitats, generally expansive intertidal sand and mud flats for foraging and sparsely vegetated supratidal sand flats and beaches for roosting. The red knot is a specialized molluscivore, feeding on hard-shelled mollusks that are swallowed whole and crushed in the gizzard. The diet is sometimes supplemented with softer invertebrate prey such as shrimp- and crab-like organisms, marine worms, and horseshoe crab eggs. Both high-energy oceanfront intertidal beaches and sheltered estuarine intertidal flats are used for foraging. Preferred habitats include sand spits and emergent shoals associated with tidal inlets, and habitats associated with the mouths of bays and estuarine rivers. Access to quality high-tide roosting habitat in close proximity to foraging areas is an important constituent of high quality stopover and wintering sites (USFWS 2014).

5.3.2 Occurrence in the Action Area

5.3.2.1 Piping Plover

The breeding, migratory, and wintering ranges of the piping plover overlap in NC; and consequently, piping plovers can be found in the state during every month of the year (Cameron et al. 2006). Breeding and nesting sites in NC are principally confined to undeveloped and unstabilized barrier islands along the northern section of the coast, mostly within the Cape Lookout National Seashore, Cape Hatteras National Seashore, Pea Island National Wildlife Refuge, and on Lea and Hutaff Islands (USFWS 2009b, Dinsmore et al. 1998). The accreting south end of Topsail Island along New Topsail Inlet is the only site associated with a developed island that supports any notable breeding activity in NC. Since 2000, all other developed islands in NC combined have accounted for just four breeding pair observations. Breeding pair observations in the Cape Fear region from 2000-2017 include just two pairs at Fort Fisher; one each during 2002 and 2005.

The largest numbers of non-breeding plovers have been observed in NC during the fall migration period, with peak numbers occurring during August and September. Observations decline sharply during the months of October and November; and by December, the relatively small numbers of plovers that remain in NC are presumed to be winter residents (Cohen 2005). Spring migrants begin to arrive along the NC coast in late February, with numbers peaking in late March. Migrating and wintering plovers are highly concentrated on inlet shoals and the adjoining inlet-influenced ends of the barrier islands. Habitat use patterns are characterized by movements between different inlet complex habitats, with some sites being used exclusively for foraging while others are used for roosting (Cameron et al. 2006). Migrating piping plovers use stopover sites at essentially all of the inlets along the NC coast (Cameron et al. 2006). Data from the International Piping Plover Winter Census indicate that wintering plovers along the southern NC coast are highly concentrated at the Lea-Hutaff/New Topsail Inlet/South Topsail complex and the Bear Island/Bogue Inlet complex (Table 9). International Piping Plover Winter Census wintering plover observations in the vicinity of the action area have been relatively sparse. Piping plovers in NC are very rarely seen on developed ocean facing beaches, and these areas are not considered to be suitable habitat (Cameron 2009). Designated critical habitat units in the vicinity of the action area are located along Carolina Beach (NC-14), at Fort Fisher (NC-15), and at Lockwoods Folly Inlet on the west end of Oak Island (NC-16) (Figure 9).

Table 9
International Piping Plover Winter Census Data

Site Name	1991	1996	2001	2006	2011	2016	Total
Cape Hatteras National Seashore			18	15	10	16	**59**
Cape Lookout National Seashore			46	17	15	35	**113**
Rachael Carson Estuarine Reserve			0	18	3	7	**28**
Regional Subtotal			**64**	**50**	**28**	**58**	**1200**
Bogue Inlet/Bear Island			9	9	2	10	**30**
Onslow Beach			0	0	0	-	**0**
New River Inlet/North Topsail			0	0	1	0	**1**
New Topsail Inlet/South Topsail/Lea-Hutaff			0	13	11	11	**35**
Rich Inlet/Lea-Hutaff			11	2	0	8	**21**
Masonboro Inlet/Masonboro Island			2	3	0	8	**13**
Bald Head to Fort Fisher			1	3	0	0	**4**
Ocean Isle			0	4	1	0	**5**
Regional Subtotal			**23**	**34**	**15**	**43**	**7109**
STATEWIDE TOTAL	**20**	**50**	**87**	**84**	**43**	**101**	**214**

(shaded) Site-specific data not available

Source: [North Carolina Wildlife Resources Commission (NCWRC) 2016 Winter Census]

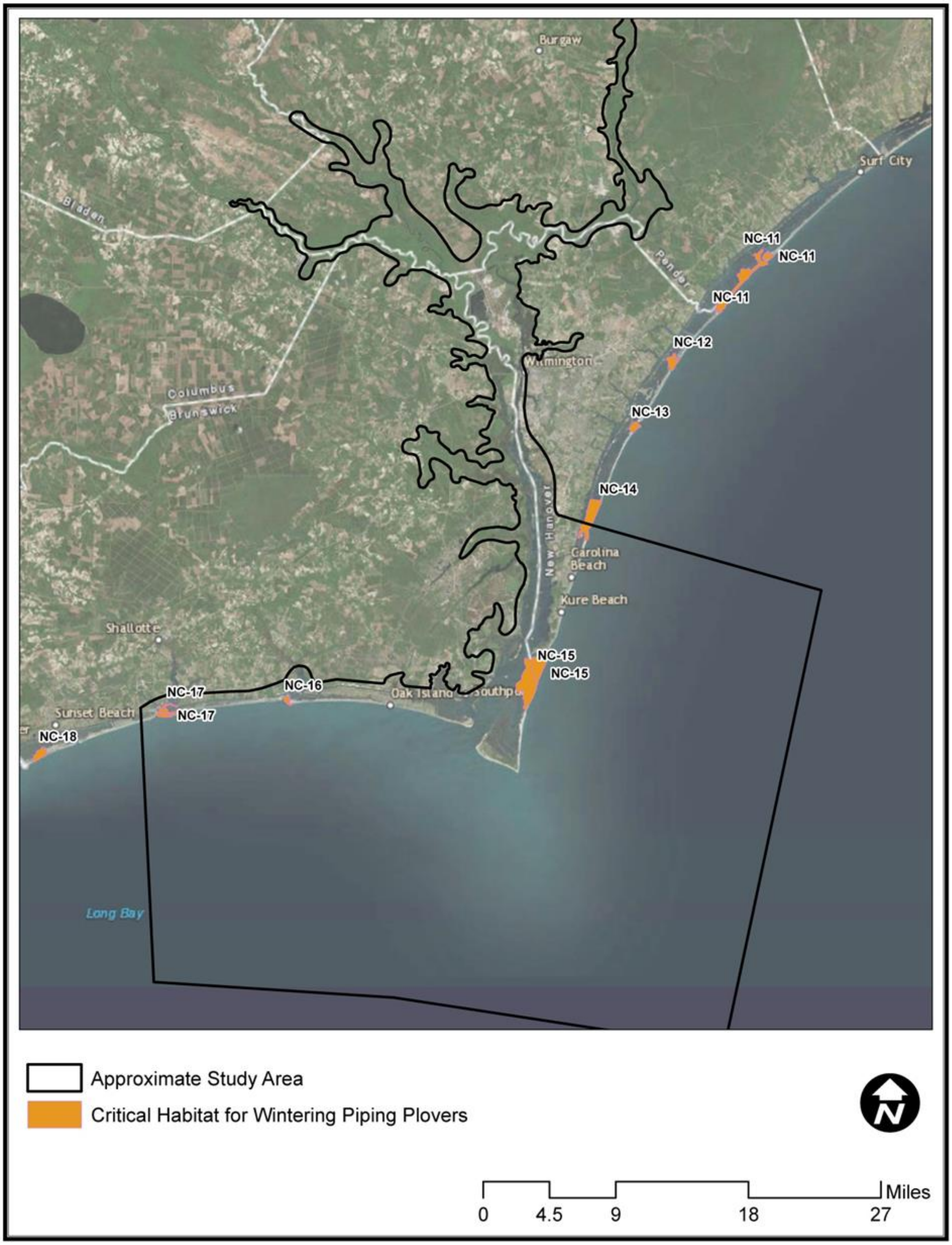

Figure 8
Critical Habitat for Wintering Piper Plovers in the Action Area

5.3.2.2 Red Knot

Red knots have been observed in NC during all seasons (Dinsmore et al. 1998); however, they are most common in NC during spring and fall migration periods (mid-April through May and July to mid-October) (Personal communication, K. Matthews, USFWS 28 August 2014). Red knots appear to be most abundant in May during the spring migration (Personal communication, S. Schweitzer, NCWRC 17 October 2014). The largest numbers of red knots are observed along the NC coast during spring migration from mid-April to early June. Numbers of northbound birds generally peak during the first two weeks of May, and most spring migrants depart NC by mid-June. A small number of red knots consisting primarily of non-breeding subadults remain in NC throughout the summer [National Park Society (NPS) 2014a, Dinsmore et al. 1998]. A smaller secondary peak occurs during late July and August as southbound migrants move along the NC coast. Numbers decline rapidly after the end of August; and by the end of September, most red knots have departed NC for their wintering grounds. Small numbers red knots winter along the NC coast, and these birds are present throughout the late fall and winter months. Systematic survey efforts have been relatively limited along the southern NC coast; and consequently, patterns of red knot distribution and abundance along some portions of the southern coast remain poorly understood. Systematic surveys along the southern NC coast have primarily been limited to annual coordinated aerial surveys, which are conducted from 20-24 May during the peak spring migration period. The aerial survey data suggest that the west end of Bogue Banks (Emerald Isle), Lea-Hutaff Island, Figure Eight Island, Masonboro Island, and Bald Head Island are important stopover sites for northbound red knots during the spring; however, the data also indicate that red knots make wide use of habitats along many of the southern region barrier islands, including habitats associated with both developed and undeveloped islands (Table 10) (NCWRC 2015). The aerial surveys have recorded red knots along all of the action area ocean beaches from Carolina Beach Inlet to Lockwoods Folly Inlet.

Table 10
Red Knot Aerial Survey Data for the Southern NC Coast 2006-2012

Location	Number of Red Knot Observations						
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Bogue Banks			24	345	0	37	33
Bear Island		0		34		0	25
Onslow Beach				336			
North Topsail Overwash					42	8	16
New Topsail Inlet					0	0	0
Lea-Hutaff Island	38	0	34	68	26	7	34
Rich Inlet				40	0		
Figure Eight Island	2	85		64	9	0	54
Mason Inlet			57		0		
Wrightsville Beach	6	0	1	72	5	0	0
Masonboro Island	111	30	1	27	15	22	58
Carolina Beach Inlet			36	11			
Carolina Beach		0	14		0		
Fort Fisher				81	4	20	8
Bald Head Island	78	67		21	5	26	40
Battery Island South			0		0		
Oak Island			0		0	22	0
Lockwoods Folly Inlet		0	25	18			
Holden Beach					0	15	56
Ocean Isle Beach					0	23	112
Tubbs Inlet		0		11			
Sunset Beach				0	0	35	75
Bird Shoal (Rachael Carson)		40		0			
Total	**235**	**222**	**192**	**1128**	**106**	**215**	**511**

Source: NCWRC 2015

5.3.3 Threats

The primary threat to piping plovers and red knots is the loss and degradation of habitat; primarily due to anthropogenic activities such as inlet relocation and stabilization, beach nourishment, sand mining, and the construction of groins, seawalls, and revetments (USFWS 2009b). Sand placement and grading may eliminate important microhabitat elements such as wrack lines, tidal pools, and isolated clumps of vegetation; thereby temporarily reducing the quality of piping plover and red knot foraging and roosting habitats. Direct losses of intertidal benthic invertebrates within sand placement areas via direct burial may temporarily reduce benthic invertebrate prey resources for piping plovers and red knots. Inlet relocation and stabilization projects may alter natural hydrodynamic and sediment transport processes that maintain optimal habitat conditions for piping plovers and red knots. Additional threats include human disturbance and introductions of predators and non-native invasive plants (USFWS

2009b). Human disturbance associated with vehicular and pedestrian recreational activities is a severe threat to the Atlantic Coast breeding population of piping plovers. Predation or harassment by free-roaming domestic and feral cats, domestic dogs, foxes, raccoons, and skunks may result in the loss of adults, eggs, and chicks. Invasive species such as beach vitex (*Vitex rotundifolia*) may out-compete native plant species and form dense colonies that reduce the availability of sparsely vegetated supratidal habitat.

5.3.4 Project Effects

5.3.4.1 Beach Placement

Beach disposal of dredged material under the TSP would occur during Year 2 of the three-year channel construction project and subsequently every two years in accordance with the existing SMP maintenance cycle. Expanded beach placement during construction Year 2 would impact an additional 1.5 to 2.5 linear miles of intertidal beach foraging habitat, resulting in additional temporary losses of benthic infaunal prey resources. Based on projected channel shoaling rate increases, post-construction maintenance beach disposal volumes would increase by five percent in relation to current beach disposal operations under the existing SMP. A five percent volumetric increase would equate to an additional 0.14 mile of beach disposal on Bald Head Island or an additional 0.25 mile of disposal on Oak Island, thus indicating that the effects of maintenance beach disposal under the TSP would not differ significantly from those of current operations under the existing SMP.

Piping plover breeding activity has not been documented in the vicinity of the proposed beach placement areas; therefore, no effects on nesting or breeding activity would be expected. Beach placement of dredged material on Bald Head Island and Oak Island would occur within and/or adjacent to potential foraging and roosting habitats for piping plovers and red knots. Beach placement operations may disrupt the foraging and/or roosting activities of migratory and wintering piping plovers and red knots; however, disturbance would be temporary and confined to a relatively short section of the beach at any given point during the beach construction process. Beach placement would result in the temporary loss of intertidal benthic invertebrate infauna within the beach fill templates, thereby reducing the availability of potential benthic prey for piping plovers and red knots. However, most benthic recovery studies have reported rapid recovery within one year of the initial impact when highly compatible beach fill sediments were used and larval recruitment periods were avoided (Jutte et al. 1999a, Burlas et al. 2001, Van Dolah et al. 1994, Van Dolah et al. 1992, Gorzelany and Nelson 1987, Salomon and Naughton 1984, Parr et al. 1978, and Hayden and Dolan 1974). Peak benthic invertebrate recruitment periods in NC [May to September (Hackney et al. 1996, Diaz 1980, and Reilly and Bellis 1978)] would be avoided through adherence to a 16 November to 30 April beach placement window. Additionally, only compatible beach fill material that is similar in grain size composition and color to the native beach sediments would be placed on the beach. It is expected that these measures would minimize the extent and duration of effects on habitat and benthic prey resources. Therefore, it is expected that the effects of beach placement on piping plovers and red knots would be short-term and localized.

5.3.4.2 Dredging

Dredging would not have any direct impacts on piping plover or red knot habitats, as there are no intertidal or supratidal habitats within that proposed channel deepening footprint. The potential indirect effects of channel deepening on hydrodynamics and shoreline change were evaluated through numerical modeling. The GenCade shoreline change and sand transport model was used to simulate deepening effects on sediment transport and shoreline erosion rates along Bald Head Island and Oak Island. GenCade was used to simulate shoreline changes over a 14-year period using input wave conditions derived from DELFT 3D wave transformation modeling results. On Bald Head Island, the GenCade model results indicate that channel deepening would have minor adverse effects on the central South Beach shoreline and minor beneficial effects on the western South Beach shoreline in relation to future without project conditions (FWOP). The model results indicate that erosion rates would increase slightly along the central South Beach shoreline from Stations 92+15 to 170+02, with the largest relative increase of ~0.6 ft/year occurring between Stations 118+2 and 129+98. The model results indicate that erosion rates would decrease by an average of ~1.3 ft/year along the westernmost ~1,200-ft shoreline reach adjacent to Cape Fear River Inlet. Westerly longshore sediment transport rates along the western half of the South Beach shoreline are projected to increase by 3,800 cy/year or less in relation to FWOP. In the case of Oak Island, the model results indicate that deepening would have negligible effects on the shoreline in relation to FWOP, with projected erosion rate increases of <0.1 ft/year along most of the island and ~0.2 ft/year along the east end of Caswell Beach. Model-projected changes in sediment transport along Oak Island are negligible. The model results indicate that deepening would have minimal effects on potential piping plover and red knot habitats in the vicinity of Cape Fear River Inlet.

5.3.4.3 Effects on Wintering Critical Habitat for Piping Plovers

There are no designated piping plover wintering critical habitat units within or adjacent to the proposed beach disposal areas on Bald Head Island and eastern Oak Island. The nearest critical habitat units are located at Lockwoods Folly Inlet, approximately nine miles west of the Oak Island disposal area and at the Fort Fisher State Recreation Area approximately four miles north of Cape Fear. Estuarine intertidal flats along the eastern Cape Fear River shoreline that comprise part of the Fort Fisher wintering critical habitat unit are located approximately one mile east of the proposed channel deepening footprint. Additionally, the estuarine critical habitat areas at Fort Fisher are separated from the navigation channel and the main body of the Cape Fear River estuary by a rock wall (New Inlet Dam) that extends continuously from Federal Point to Zekes Island. The DELFT 3D hydrodynamic model results indicate that the effects of deepening on current velocities and sediment transport are negligible outside of the proposed navigation channel footprint. Ship wake modeling results indicate that the potential for increased erosion from larger ship wakes is limited to shorelines that are immediately adjacent to the channel. Therefore, channel deepening and beach placement would not be expected to have any effects on wintering critical habitat for the piping plover.

5.3.5 Conservation Measures

5.3.5.1 Environmental Windows

The proposed action would adhere to a 16 November to 30 April beach placement window. Adherence to this placement window would avoid the majority of the piping plover breeding season, the peak red knot migration period in NC (May), and peak benthic invertebrate recruitment periods in NC.

5.3.5.2 Sediment Compatibility

Only compatible beach fill material that is similar in grain size composition and color to the native beach sediments would be placed on the beach. The use of compatible material would increase the likelihood of rapid benthic infaunal recovery, thereby minimizing the extent and duration of temporary beach disposal impacts on the infaunal prey base for piping plovers and red knots.

5.3.6 Determination of Effect

5.3.6.1 Piping Plover and Red Knot

Based on the proposed measures to minimize disturbance and impacts on benthic infaunal prey resources, including the proposed 16 November to 30 April beach placement window and the use of compatible beach fill, it is determined that the proposed action may affect, but is not likely to adversely affect the piping plover and red knot.

5.3.6.2 Piping Plover Critical Habitat

Based on the absence of critical habitat in the vicinity of proposed beach disposal areas and the location of estuarine critical habitat areas at Fort Fisher in relation to the navigation channel, it is determined that the proposed action would have no effect on wintering critical habitat for the piping plover.

5.4 Wood Stork

5.4.1 Status, Distribution, and Habitat

The wood stork (*Mycteria americana*) US breeding population was initially listed under the ESA as threatened in 1984 (49 FR 7332). In 2014, the ESA status of the US wood stork breeding population was revised from endangered to threatened (79 FR 37078). The 2014 listing rule also designated the US breeding population as a Distinct Population Segment (DPS). Wood storks comprise a mosaic of breeding populations in North, Central, and South America, and the Caribbean. The current US breeding range encompasses peninsular Florida and the coastal regions of Georgia, South Carolina, and southeastern NC. The US breeding population has been increasing and expanding northward. The three-year annual nesting averages for Florida, Georgia, South Carolina, and NC have exceeded 6,000 nests since 2003, and the average annual nest total for 2011-2013 was 9,692 nests (79 FR 37078). Wood storks from northern Florida to southeastern NC lay eggs between March and late May, with fledging occurring in July and August (79 FR 37078). Post-breeding wood storks depart the colony sites and disperse widely throughout the Coastal Plain of the southeastern US, but many remain in NC through the early fall before migrating to Florida to spend the winter. Twin Lakes at Sunset Beach in Brunswick County is an important post-breeding site where numerous wood storks congregate each year. Wood storks use a wide variety of freshwater and estuarine wetlands for nesting, foraging, and roosting. Nesting colonies are primarily established in cypress swamps, but other freshwater to estuarine forested habitats are also used; including mangroves, black gum, willow, and buttonbush (Coulter et al. 1999). Wood storks tend to use the same colony site over many years as long as the site remains undisturbed and there is sufficient feeding habitat in the surrounding area (USFWS 1997). Foraging habitat consists of natural and artificial wetlands with suitable prey and appropriate water depths (<50 centimeters) (Coulter et al. 1999). Wood storks also forage in man-made wetlands such as storm water treatment areas, golf course ponds, borrow pits, reservoirs, agricultural ditches, and dredge spoil sites (USFWS 2007). Roosting sites are generally in trees over water, but storks may also rest on the ground near feeding sites (Coulter et al. 1999).

5.4.2 Occurrence in the Action Area

The first NC nesting colony, consisting of 32 pairs, was discovered at Lays Lake in Columbus County in 2005 (USFWS 2007). Three additional breeding colonies have since been discovered at Mill Branch Swamp in Columbus County, Steep Run along the Cape Fear River in Bladen County, and Warwick Mill Bay in Robeson County. There are no known breeding colonies within the action area. The Steep Run colony is located along the southwest side of the Cape Fear River approximately four miles upriver of Lock and Dam #1. Annual nesting pair totals in NC increased from 32 pairs in 2005 to nearly 600 pairs in 2016 (Schweitzer 2016). Wood storks may use various wetland habitats in the action area for foraging, especially during the post-breeding season when they disperse widely throughout the Coastal Plain.

5.4.3 Threats

Wood storks are primarily threatened by the loss and degradation of wetland habitats. Habitat losses affecting the wood stork are primarily attributed to anthropogenic causes, including coastal development and water management activities that have eliminated optimal foraging habitats (USFWS 2007).

5.4.4 Project Effects

No nesting colonies are known from the action area, and no potential nesting or foraging habitat would be directly affected under the proposed action. Indirect salinity effects on potential wetland habitats are anticipated to be minor. As described in Appendix F (Main Report, Wetlands Impact Analysis), the model-projected effects of the proposed action on surface salinities are limited to increases of 0.3 parts per thousand (ppt) or less at the upper ends of existing salinity gradients where any effects on wetlands would be expected to occur. Although the projected salinity increases could have minor effects on the composition of tidal freshwater marsh and swamp forest communities, conversions of tidal swamp forest to tidal marsh would not be expected. Therefore, the proposed action would not be expected to have any adverse effects on the wood stork.

5.4.5 Determination of Effect

Based on the absence of breeding colonies in the action area, and considering that the proposed action would not be expected to have any direct or indirect impacts on potential nesting or foraging habitats, it is determined that the proposed action would have no effect on the wood stork.

5.5 Sea Turtles

5.5.1 Status, Distribution, and Habitat

5.5.1.1 Loggerhead Sea Turtle

The loggerhead sea turtle (*Caretta caretta*) was initially listed under the ESA as threatened throughout its range on 28 July 1978 (43 FR 32800). In 2011, the loggerhead's ESA status was revised to threatened and endangered based on the recognition of nine DPSs. Distinct population segments encompassing populations in the Northwest Atlantic Ocean, South Atlantic Ocean, Southwest Indian Ocean, and Southeast Indo-Pacific Ocean were reclassified as threatened; while the remaining five populations in the Northeast Atlantic Ocean, Mediterranean Sea, North Pacific Ocean, South Pacific Ocean, and North Indian Ocean were reclassified as endangered. Nesting in the US occurs along the Atlantic and Gulf coasts from southern Virginia to Texas, but is concentrated from NC through Alabama (NMFS and USFWS 2008). Nesting populations along the southeastern US coast from southern Virginia to the Florida-Georgia border comprise the Northern Recovery Unit, one of five designated recovery units within the Northwest Atlantic DPS (USFWS 2009). Nesting in the Northern Recovery Unit had been declining at an annual rate of 1.3% through 2007; however, nesting has increased substantially since 2008, with the three highest annual nest totals on record occurring in 2012, 2013, and 2015. Similar nesting increases throughout the Northwest Atlantic DPS since 2007 indicate that the population may be stabilizing (USFWS 2015b). A total of 38 terrestrial critical habitat units encompassing ~245 miles of nesting beaches have been designated within the Northern Recovery Unit; including eight units (~96 miles) in NC, 22 units (~79 miles) in South Carolina, and eight units (~69 miles) in Georgia (79 FR 39756). Nesting in these 38 units comprises approximately 86% of all loggerhead nesting within the Northern Recovery Unit.

Adult female loggerheads return to their natal region to nest, and show a high degree of site fidelity to the nesting beach selected during their initial reproductive season, typically nesting during subsequent years within zero to three miles of the initial nesting site (Miller et al. 2003). A variety of different substrates and beach slopes are used for nesting, but loggerheads appear to prefer relatively narrow, steeply sloped, coarse-grained beaches (Provancha and Ehrhart 1987). Slope has been found to have more influence on nest-site selection than temperature, moisture, and salinity; and nest sites along a given beach are typically located on the steepest slopes, which generally correspond to the highest elevations on the beach (Wood and Bjorndal 2000). Loggerheads require deep, clean, relatively loose sand above the high-tide line for successful nest construction (Hendrickson 1982). Embryonic development requires a high-humidity substrate with sufficient gas exchange (Mortimer 1990, Miller 1997, and Miller et al. 2003). The gender of hatchlings is determined by prevailing sand temperatures during the middle of the incubation period (Mrosovsky and Yntema 1980, Yntema and Mrosovsky 1982). The pivotal incubation temperature that produces equal numbers of males and females is approximately 29.0°C (84.2°F) (Limpus et al. 1983, Mrosovsky 1988, and Marcovaldi et al. 1997). Incubation temperatures near the upper end of the tolerable range produce only female hatchlings, while temperatures near the lower end of the range produce only males. Loggerhead hatchlings pip (break through the egg shell) and escape from their eggs over a period of one to three days, and move upward and out of the nest over a period of two to four days (Christens 1990). The time from pipping to emergence averages 4.1 days, but can be as long as seven days (Godfrey and

Mrosovsky 1997). Hatchlings emerge from their nests en masse almost exclusively at night, and initial emergences are sometimes followed by secondary emergence events on subsequent nights (Carr and Ogren 1960, Witherington 1986, Ernest and Martin 1993, and Houghton and Hays 2001). Hatchlings use light cues to guide their movement from the nest to the surf zone, relying on the contrast between the relatively bright ocean horizon and the relatively dark dune line (Daniel and Smith 1947, Limpus 1971, Salmon et al. 1992, Witherington and Martin 2003, and Witherington 1997).

5.5.1.2 Green Sea Turtle

The green sea turtle (*Chelonia mydas*) was initially listed as endangered and threatened under the ESA on 28 July 1978 (43 FR 32800). Breeding populations in Florida and along the Mexican Pacific Coast were listed as endangered, while all other populations throughout the species' range were listed as threatened. In 2011, the green sea turtle's ESA status was revised to threatened and endangered based on the recognition of eight DPSs (81 FR 20057). All green sea turtles in the North Atlantic were listed as threatened under the North Atlantic Ocean DPS. Nesting in the US is primarily limited to Florida, although nesting occurs in small numbers along the southeast coast from Georgia to NC and the Gulf Coast of Texas. Nesting turtles appear to prefer high wave energy barrier island beaches with coarse sands, steep slopes, and prominent foredunes; with the highest nesting densities occurring on sparsely developed beaches that have minimal levels of artificial lighting (Witherington et al. 2006). Nesting in Florida has increased exponentially over the last 20 years, with record highs of 36,195 and 37,341 nests recorded in 2013 and 2015, respectively [Florida Fish and Wildlife Conservation Commission (FWC)/Fish and Wildlife Research Institute (FWRI) 2016]. No critical habitat has been designated in the continental US. In US waters, green sea turtles are distributed along the Atlantic and Gulf Coasts from Massachusetts to Texas (NMFS and USFWS 2007a). Post-hatchlings migrate to oceanic waters and begin an oceanic juvenile phase of development. Oceanic phase juveniles appear to move with the predominant ocean gyres for several years before returning to neritic waters where juvenile development continues to adulthood. Neritic phase juveniles inhabit shallow estuarine waters and nearshore continental shelf waters that are rich in seagrasses and/or marine macroalgae. Adults generally remain in relatively shallow foraging habitats with abundant seagrasses and macroalgae, but may enter the oceanic zone when migrating between foraging grounds and nesting beaches. No critical habitat has been designated in the continental US.

5.5.1.3 Leatherback Sea Turtle

The leatherback sea turtle (*Dermochelys coriacea*) was listed as endangered throughout its range on 2 June 1970 (35 FR 8491). The leatherback has a circumglobal oceanic distribution that extends north and south into sub-polar regions. Leatherbacks undertake extensive migrations between northern foraging grounds and tropical and subtropical nesting beaches (NMFS and USFWS 2007e). During the summer and fall, the highest densities of adult and subadult leatherbacks in the North Atlantic are found in Canadian waters (James et al. 2005). Little is known of the distribution and developmental habitat requirements of leatherbacks from hatchling to adulthood (NMFS and USFWS 2013). Nesting in the US is primarily restricted to Florida, Puerto Rico, and the US Virgin Islands; but nesting occurs in small numbers along the Gulf Coast of Texas and the southeastern US Atlantic Coast from Georgia to NC. The 1992 Recovery Plan for the US Caribbean, Atlantic, and Gulf of Mexico populations established recovery criteria for the assemblage of nesting populations in Florida, Puerto Rico, and the US Virgin Islands; including an increasing adult female population over 25 years and the protection of nesting beaches encompassing at least 75% of all nesting activity (NMFS and USFWS 1992). Nesting in Florida has increased substantially over the last 20 years, with record and near-record highs of 1,747 and 1,712 nests recorded in 2009 and 2012, respectively.

5.5.1.4 Kemp's Ridley Sea Turtle

The Kemp's ridley sea turtle (*Lepidochelys kempii*) was listed as endangered throughout its range on 2 December 1970 (35 FR 18320). Kemp's ridley sea turtles occur primarily in coastal waters of the Gulf of Mexico and the western North Atlantic Ocean. Data indicate that adults utilize coastal habitats of the Gulf of Mexico and the southeastern US. Adults inhabit nearshore waters and are commonly found over crab-rich sandy or muddy bottoms (NMFS and USFWS 2007c). Nesting is primarily restricted to coastal beaches along the Mexican states of Tamaulipas and Veracruz, although a small number of turtles nest consistently along the Texas coast (Turtle Expert Working Group (TEWG) 1998). Rare nesting events have also occurred along the coasts of NC, South Carolina, Georgia, Florida, and Alabama. A total of 80 Kemp's ridley nests were documented in Florida from 1979 to 2013 (FWC/FWRI 2016). Hatchlings migrate to the oceanic zone where they are carried by currents into various areas of the Gulf of Mexico and the North Atlantic Ocean. At approximately two years of age, juveniles leave the oceanic zone and move to coastal benthic habitats in the Gulf of Mexico and the Atlantic Ocean along the eastern US. During this stage, juveniles occupy protected coastal waters such as bays, estuaries, and nearshore waters that are less than 165 ft deep. Juveniles utilize a wide range of bottom substrates but apparently depend on an abundance of crabs and other invertebrates (NMFS and USFWS 2007c). No critical habitat has been designated for the Kemp's ridley sea turtle.

5.5.1.5 Hawksbill Sea Turtle

The hawksbill sea turtle (*Eretmochelys imbricate*) was listed as endangered throughout its range on 2 June 1970 (35 FR 8491). Hawksbill sea turtles are globally distributed in tropical and to a lesser extent subtropical waters of the Atlantic, Indian, and Pacific Oceans. Nesting occurs on sandy beaches throughout the tropical and subtropical regions of the Atlantic, Pacific, and Indian Oceans. Nesting in the US is primarily limited to Florida and the US Caribbean (NMFS and USFWS 1993). Rare nesting events in the continental US are essentially restricted to the southeastern coast of Florida and the Florida Keys (Meylan 1992, Meylan et al. 1995), although two hawksbill nests were recently confirmed in NC (NPS 2015). A total of 46 hawksbill nests were documented in Florida from 1979-2013 (FWC/FWRI 2016). Although documented nesting in the continental US is extremely rare, hawksbill tracks are difficult to differentiate from those of the loggerhead and may not be recognized by surveyors. Therefore, surveys in Florida likely underestimate actual hawksbill nesting numbers (Meylan et al. 1995). In US waters, hawksbills have been reported along the Atlantic and Gulf Coasts from Massachusetts through Texas; however, sightings north of Florida are rare. Hawksbills are commonly observed in the Florida Keys and on reefs off the coast of Palm Beach County, Florida. Texas is the only other state where sightings occur with any regularity. Hatchlings are carried by currents to the oceanic zone where they reside in major ocean gyres. Juveniles eventually depart the oceanic zone and move to nearshore habitats. Juveniles and adults are primarily associated with coral reef habitats; but may use other habitats such as hardbottoms, seagrass beds, algal beds, mangrove bays and creeks, and mud flats. Adults undertake extensive migrations between foraging grounds and nesting beaches (NMFS and USFWS 2007d).

5.5.2 Occurrence in the Action Area

5.5.2.1 Nesting

Loggerhead nesting occurs along the entire NC coast, but is concentrated along three sections of the coast; including the Cape Fear region from Holden Beach to Fort Fisher, Topsail Island, and Onslow Beach, and the barriers that comprise Cape Lookout National Seashore (CALO) and Cape Hatteras National Seashore (CAHA). Collectively, these three sections of the coast accounted for 83% of all loggerhead nesting in NC from 2000-2016. Nesting in NC is typically restricted to the period of 1 May to 15 September. Relatively few nests are recorded during the first three weeks of May, but nesting increases rapidly from late May onward, peaking from mid-June through the end of July. Nesting declines abruptly after July, and few nests are recorded after the third week of August. The Cape Fear region from Holden Beach to Fort Fisher supports the highest concentration of loggerhead nesting in NC, accounting for 30% of all loggerhead nests recorded in the state from 2000-2016. The average annual nest density for the region was 7.5 nests per mile from 2000-2016. A total of 1,196 loggerhead nests were recorded on Bald Head Island from 2000-2016, while 1,958 nests were recorded on Caswell Beach/Oak Island (Table 11). Annual nesting from 2000-2016 averaged 70 nests per year on Bald Head and 115 nests per year on Caswell Beach/Oak Island.

Green sea turtles nest in relatively small numbers along the NC coast, with reported nesting from 2000-2016 averaging 18 nests per year. Annual NC nest totals from 2000-2012 ranged from four to 26 nests. Nesting has increased since 2012, with the two highest nest totals on record occurring during 2013 (n=39) and 2015 (n=38). An average of 27 nests per year were recorded in NC from 2013-2018. Green sea turtle nesting is concentrated along the barrier islands of CALO and CAHA. Along the southern NC coast, areas supporting consistent nesting in small numbers include Bald Head Island, Topsail Island, and Onslow Beach. Nesting along the remainder of the NC coast has generally occurred sporadically in very small numbers. NC nesting data show a peak in nesting activity from the last week of June through the third week of August, with 79% of all nesting occurring during this period. A total of 25 green sea turtle nests were recorded on Bald Head Island from 2000-2016. Additional nests that were recorded in the action area from 2000-2016 include four nests at Fort Fisher, three nests on Oak Island, and two nests on Holden Beach (Table 11).

Leatherback nesting is rare in NC, with just 33 nests reported from 2000 through 2016. Nesting records span the entire NC coast, but are heavily concentrated along the northern barrier islands of CALO and CAHA. Leatherback nesting in the southern region from 2000-2016 was limited to two nests along Bogue Banks and one nest each along Carolina Beach, Bald Head Island, and Holden Beach. Reported leatherback nest establishment dates in NC range from 16 April to 30 July. Kemps ridley nesting is extremely rare in NC, with just 12 nests reported during the period of 2000-2016. Of the 12 nests, eight were reported from the northern Outer Banks. Reported Kemp's ridley nesting in the action area is limited to one nest at Fort Fisher in 2015. Reported nest establishment dates for the Kemp's ridley in NC range from 25 May to 23 June. Hawksbill nesting records for NC are limited to two nests that were identified at CAHA in 2015 through

Table 11
Cape Fear Region Sea Turtle Nests 2000-2016

Shoreline Reach	Loggerhead	Green	Leatherback	Kemp's Ridley
Fort Fisher	516	4	0	1
Bald Head Island	1,196	25	1	0
Caswell Beach	850	0	0	0
Oak Island	1,108	3	0	0
Holden Beach	608	2	1	0
Total	**4,278**	**34**	**2**	**1**

Source: NCWRC 2015, Seaturtle.org 2017

DNA testing (NPS 2015). However, the similarity of hawksbill tracks to those of the loggerhead suggests that some hawksbill nesting may go undetected along the southeastern US coast (USFWS 2015b, Meylan et al. 1995).

5.5.2.2 Spatial and Temporal Distribution of Non-Breeding Sea Turtles

North Carolina's sounds and estuaries provide important developmental and foraging habitats for post-pelagic juvenile loggerhead, green, and Kemp's ridley sea turtles. Most of the information regarding the inshore distribution of sea turtles in NC has been generated by studies in the Pamlico-Albemarle estuarine complex, where large numbers of loggerhead, green, and Kemp's ridley sea turtles are incidentally captured annually by commercial fishing operations. All three species are represented primarily by juveniles, with few reported captures of older juveniles and adults (Epperly et al. 2007). All three species move inshore during the spring and disperse throughout the sounds during the summer. All three species leave the sounds and move offshore during the late fall and early winter. Epperly et al. (1995a) reported the presence of sea turtles in back-barrier estuaries along the NC coast from April through December. Goodman et al. (2007) reported the presence of sea turtles in Core and Pamlico Sounds and the nearshore (≤1 mile) ocean waters of Raleigh Bay from April through November. Juvenile loggerhead, green, and Kemps ridley sea turtles utilize the lower Cape Fear River estuary during the warmer months. Sea turtles have been observed in the Cape Fear River estuary as far upstream as river mile 15 (NMFS 1996). Although there are no published data on the distribution and movements of juvenile sea turtles in the Cape Fear River estuary, during a tracking study of 18 gill netted green and Kemps ridley juveniles in the lower estuary, only one individual (a presumed mortality) moved north of Snows Cut (Snoddy and Williard 2010).

Several studies have reported a strong relationship between sea turtle distribution and sea surface temperature. Goodman et al. (2007) conducted aerial sea turtle surveys and sea surface temperature monitoring in Core Sound, Pamlico Sound, and adjacent nearshore ocean waters within 1 mile of shore from July 2004 to April 2006. All but one of the 92 sea turtle observations occurred in waters where sea surface temperatures were above 11°C. All sightings in the sounds occurred between 16 April and 20 November, and all sightings in the nearshore ocean occurred between 23 April and 27 November. The winter distribution of sea turtles offshore of Cape Hatteras was also correlated with sea surface temperatures above 11°C (Epperly et al. 1995c). In a similar study by Coles and Musick (2000), sea turtle distribution offshore of Cape Hatteras (from shore to edge of Gulf Stream) was restricted to sea surface temperatures ≥13.3°C.

The leatherback sea turtle is primarily a pelagic species preferring deep, offshore waters. Leatherbacks may be present in nearshore ocean waters during certain times of the year; however, they rarely enter estuarine waters. Epperly (1995b) reported the appearance of significant numbers of leatherback turtles in nearshore ocean waters during May, coincident with the appearance of jellyfish prey. Sightings declined sharply after four weeks and only a few sightings were reported after late June. Leatherbacks were infrequently observed in estuarine waters during this period. The surveys conducted by Goodman et al. (2007) recorded only one leatherback observation, during the summer in the nearshore ocean south of Cape Hatteras. Epperly et al. (1995a) reported the occurrence of three leatherbacks in Core and Pamlico Sounds during December 1989. Hawksbill sea turtles are rare in NC waters, and they rarely enter estuarine waters (Epperly et al. 1995a). A total of nine hawksbill stranding incidents were reported along NC beaches between 1998 and 2009 (Seaturtle.org 2011). Strandings were reported during the months of January, March, April, and November. Epperly et al. (1995b) reported the incidental capture of one hawksbill in Pamlico Sound.

5.5.2.3 Loggerhead Critical Habitat

In the action area, all of the ocean-facing barrier island beaches from Carolina Beach Inlet to Shallotte Inlet are encompassed by four loggerhead terrestrial critical habitat units; including Pleasure Island/Fort Fisher (LOGG-T-NC-05), Bald Head Island (LOGG-T-NC-05), Oak Island (LOGG-T-NC-05), and Holden Beach (LOGG-T-NC-05) (Figure 9). Terrestrial critical habitat units encompass the dry ocean beach from the Mean High Water line landward to the toe of the secondary dune or the first developed structure. The units represent beaches that are capable of supporting a high density of nests or those that are potential expansion areas for beaches with

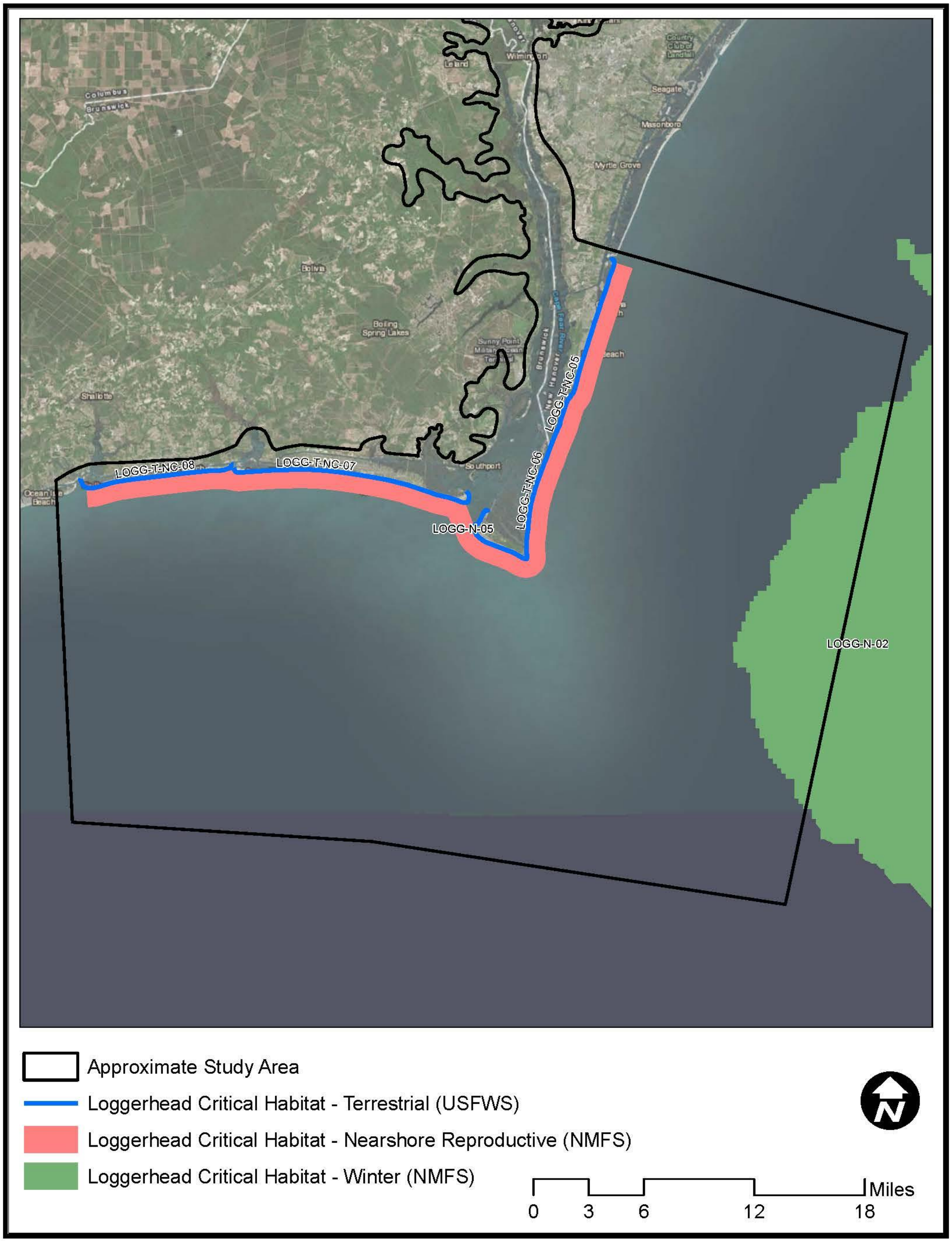

Figure 9
Loggerhead Nearshore Reproductive Critical Habitat

high nest densities. Critical nesting habitat primary constituent elements include unimpeded ocean-to-beach access for adult females and unimpeded nest-to-ocean access for hatchlings, substrates that are suitable for nest construction and embryonic development, a sufficiently dark nighttime environment to ensure that adult females are not deterred from nesting and that hatchlings are not disoriented and delayed or prevented from reaching the ocean, and natural coastal processes that maintain suitable nesting habitat or artificially maintained habitats that mimic those associated with natural processes (79 FR 39756).

All nearshore ocean waters from the Mean High Water line out to 1.6 km along the designated terrestrial units are encompassed by a single nearshore reproductive critical habitat unit (LOGG-N-05) that extends continuously from Carolina Beach Inlet to Shallotte Inlet (Figure 11). Nearshore reproductive marine critical habitat units encompass reproductive habitat along nesting beaches that is used by hatchlings for egress to the open ocean and by nesting females for movements between beaches and the open ocean during the nesting season. Critical nearshore reproductive habitat primary constituent elements include nearshore waters directly off the highest density nesting beaches and their adjacent beaches, waters sufficiently free of obstructions and artificial lighting to allow transit through the surf zone to open water, and waters with minimal manmade structures that could promote predators, disrupt wave patterns necessary for orientation, and/or create excessive longshore currents (79 FR 39855). An additional winter critical habitat unit (LOGG-N-02) encompasses offshore waters between the 20-m and 100-m bathymetric contours from Cape Fear to Cape Hatteras. The inner boundary (20-m contour) of LOGG-N-02 is located ~11 nm (13 m) seaward of the east-facing beaches to the north of Cape Fear (Figure 11). Winter critical habitat encompasses warm waters near the western edge of the Gulf Stream that are used by a high concentration of juveniles and adults during the winter. Primary constituent elements include water temperatures above 10°C from November through April, continental shelf waters in proximity to the boundary of the Gulf Stream, and water depths between 20 and 100 m.

5.5.3 Threats

Threats that are common to all sea turtle species in the terrestrial nesting environment include loss or degradation of nesting habitat due to beach armoring, beach nourishment, coastal development, artificial lighting, and the proliferation of non-native invasive plant species (NMFS and USFWS 2007a-e). Threats that are common to all sea turtle species in estuarine and marine environments include fisheries by-catch, vessel strikes, marine debris ingestion or entanglement, intake into the cooling systems of power plants, environmental contamination, and disease. Threats associated with fisheries by-catch include entrapment in trawls and entanglement in a wide variety of other fishing gear. Shrimp trawling is the most detrimental fishing practice and the greatest overall anthropogenic cause of loggerhead mortality. In 1990, loggerhead mortality attributable to offshore shrimp trawling in the southeastern US and Gulf of Mexico was estimated to be 5,000 to 50,000 turtles per year (NMFS and USFWS 2007a). Mortality attributable to shrimp trawling was estimated to be ten times that of all other anthropogenic activities combined. Vessel strikes are also a common cause of sea turtle mortality. Approximately 15% of all loggerhead strandings that were reported from 1997 through 2005 exhibited signs of vessel strikes. Loggerhead, green, and Kemp’s ridley sea turtles are vulnerable to direct injury by hopper dredges as a result of being entrained in the dredge intake pipe.

Sand placement projects can affect sea turtles through direct impacts on nesting females, nests, and hatchlings and indirectly through nesting habitat modifications such as changes in beach morphology and/or substrate properties. Observed declines in nesting on nourished beaches have been attributed to substrate compaction, escarpment formation, and/or modification of the natural beach profile (Crain et al. 1995, Steinitz et al. 1998, Ernest and Martin 1999, Herren 1999, Rumbold et al. 2001, Byrd 2004, and Brock et al. 2009). By design, sand placement projects typically construct a flat dry beach or "berm" that gradually steepens to the natural equilibrium profile as the placed material is redistributed by natural wave and wind driven transport processes. This equilibration process often results in the formation of escarpments that can prevent sea turtles from accessing upper dry beach nesting habitats. The use of heavy machinery to redistribute and establish the design beach profile can result in compaction of the newly deposited beach sediments, which in turn can impede sea turtle nest excavation. Sediment compaction and changes in sediment composition may also affect the suitability of the nest incubation environment and the ability of hatchlings to emerge from the nest (Nelson and Dickerson 1988, Crain et al. 1995). Embryonic development and hatching success are influenced by temperature, gas exchange, and moisture content within the nest environment (Carthy et al. 2003). Changes in substrate characteristics such as grain size, density, compaction, organic content, and color may alter the nest environment; potentially affecting embryonic development and hatching success (Nelson and Dickerson 1988, Nelson 1991, Ackerman et al. 1991, Crain et al. 1995, Ehrhart 1995, and Ackerman 1996). Artificial lighting on the ocean beach may deter nesting sea turtles from emerging onto the nesting beach (Witherington 1992, Witherington and Martin 2003). Artificial lighting may also impair the ability of sea turtle hatchlings to properly orient to the ocean. Disoriented hatchlings that are delayed in reaching the ocean may experience high mortality from dehydration and predation; and those that are attracted to lighted parking lots or streetlights are often crushed by passing vehicles (Witherington and Martin 2003).

5.5.4 Project Effects

5.5.4.1 Dredging

The NMFS has previously determined that hydraulic cutterhead and mechanical (clamshell and bucket) dredging activities are not likely to adversely affect sea turtles (NMFS 2012). Sea turtle takes by cutterhead dredges have not been reported along the southeastern US coast, and only one take by a mechanical dredge has been reported along the southeastern coast over the past several decades. Therefore, proposed cutterhead and bucket dredging activities would not be expected to have any adverse effects on sea turtles. Takes of hawksbill and leatherback sea turtles by hopper dredges have not been reported along the southeastern US coast. Hawksbill sea turtles are rare in NC waters (Epperly et al. 1995a) and are primarily associated with coral reef habitats (NMFS and USFWS 2007c). Coral reef habitats along the NC coast are restricted to deep offshore waters >20 miles from shore (MacIntyre and Pilkey 1969, MacIntyre 2003). Leatherback sea turtles have been observed in nearshore waters along the NC coast during the warmer months; however, the leatherback is primarily a species of deep oceanic waters with a pelagic feeding habit that reduces its vulnerability to entrainment. Therefore, hopper dredging under the proposed action would not be expected to have any adverse effects on hawksbill or leatherback sea turtles.

The Wilmington District USACE reported takes of 30 loggerhead, four Kemp's ridley, and three green sea turtles by hopper dredges in the vicinity of Wilmington Harbor from 1992-2013. All but one of the takes occurred outside of the 1 December to 15 April hopper dredging window that is proposed for the harbor deepening project. The one exception was a Kemp's ridley that was taken during mid-December. The use of hopper dredges under the proposed action would be limited to deepening of the outer harbor Baldhead Shoal 2 and 3 entrance channel reaches and construction of the new Baldhead Shoal 3 seaward extension reach. Adherence to the proposed 1 December to 15 April hopper dredging window would limit operations to the colder months when most loggerhead, green, and Kemp's ridley sea turtles have moved to warmer offshore waters beyond the proposed dredging areas. The risk of entrainment would be further minimized through the use of rigid draghead deflectors, which dramatically reduce sea turtle entrainment rates when they are used and deployed correctly (Dickerson et al. 2004). Given that only one sea turtle take has been reported at Wilmington Harbor during the proposed hopper dredging window; it is expected that the risk of loggerhead, green, and Kemp's ridley entrainment by hopper dredges would be negligible.

5.5.4.2 Confined Blasting

Sea turtles have been observed in the Cape Fear River estuary up to river mile 15, but apparently prefer higher salinity waters of the lower estuary (NMFS 2000, 2012). During a tracking study of 18 gill-netted green and Kemps ridley juveniles in the lower Cape Fear River estuary, only one individual (a presumed mortality) moved north of Snows Cut (river mile 13) (Snoddy and Williard 2010). Based on the location of the proposed blasting areas between river mile 18 and river mile 22, it is unlikely that sea turtles would be affected by blasting activities. However, as previously described, blasting operations would implement protective measures for sea turtles and marine mammals similar to those previously approved by the NMFS in 2000 and 2012 for proposed blasting operations under the Wilmington Harbor 96 Act Project (NMFS 2000, 2012). Protective measures would include the establishment of blast zones of influence and the development of a Watch Program in accordance with NMFS Southeast Region guidance for mitigating the effects of marine blasting on sea turtles and marine mammals (Baker 2008). The NMFS guidance provides specific procedures and equations for calculating zones of influence based on the blasting method used and project-specific details. In the case of confined blasting, the required zones of influence include Danger, Harassment, and Watch zones. The innermost Danger Zone encompasses the area nearest to the blast location where mortality and injury may occur. The intermediate Harassment Zone encompasses the area where TTS and behavioral effects may occur, and the outermost Watch Zone is an additional area that is monitored to detect animals that are moving towards the inner blast impact zones. The zones of influence determine how and where specific protective measures are implemented to mitigate the potential effects of blasting protected species. Specific watch program measures and procedures would be implemented as previously outlined in Section 5.2.5.

5.5.4.3 Beach Disposal of Dredged Material

Beach disposal of dredged material under the TSP would occur during Year 2 of the three-year channel construction project and subsequently every two years in accordance with the existing SMP maintenance cycle. Expanded beach placement during construction Year 2 would impact an additional 1.5 to 2.5 linear miles of sea turtle beach nesting habitat, resulting in additional temporary reductions in nesting habitat suitability. Based on projected channel shoaling rate increases, post-construction maintenance beach disposal volumes would increase by five percent in relation to current beach disposal operations under the existing SMP. A five percent volumetric increase would equate to an additional 0.14 miles of beach disposal on Bald Head Island or an additional 0.25 miles of disposal on Oak Island, thus indicating that the effects of maintenance beach disposal under the TSP would not differ significantly from those of ongoing disposal operations under the existing SMP. The environmental work window for each beach disposal event (16 November - 30 April) would avoid the NC sea turtle nesting and hatching season as defined by the NCWRC (1 May - 15 November); thereby, minimizing the likelihood of direct impacts on nesting adult females, nests, and hatchlings. Beach disposal would have temporary indirect effects on sea turtle nesting through changes in beach morphology and/or nesting substrate characteristics; however, measures to minimize beach disposal effects on sea turtle nesting habitat would include adherence to beach fill compatibility standards and the implementation of escarpment and compaction monitoring in accordance with established Wilmington District practices. Only compatible material that is similar in grain-size composition and color to native beach sediments would be placed on the beach. Therefore, it is expected that effects on sea turtle nesting habitat suitability would be minor and short-term.

5.5.4.4 Beneficial Effects

In the case of severely eroded beaches, the restoration of wider and higher dry beaches through proposed beneficial use projects may enhance the quality of sea turtle nesting habitat. Studies have reported immediate increases in nesting success following sand placement on chronically eroded beaches (Davis et al. 1999, Byrd 2004). It is expected that the placement of compatible material on the erosional shorelines of Bald Head Island and Oak Island would maintain a wider beach, thereby increasing the availability of dry beach nesting habitat for sea turtles.

5.5.4.5 Effects on Loggerhead Critical Habitat

Beach disposal of dredged material would occur within loggerhead terrestrial critical habitat units LOGG-T-NC-06 (Bald Head Island) and LOGG-T-NC-07 (Oak Island). As described above, projected shoaling rate increases indicate that channel maintenance beach disposal events under the TSP would not differ significantly from current disposal operations under the existing SMP. The additional 1.5 to 2.5 linear miles of beach disposal during construction Year 2 would not be expected to have any significant relative impacts on loggerhead critical habitat. Measures to minimize temporary effects on beach nesting habitat would include adherence to the established sea turtle nesting environmental work window (16 Nov – 30 April), the placement of only compatible material that is similar in grain-size composition and color to native beach sediments, and the implementation of escarpment and compaction monitoring. Beach placement activities may include the placement of delivery pipelines within nearshore reproductive critical habitat unit LOGG-N-05; however, based on avoidance of the sea turtle nesting and hatching season in NC, it is unlikely that pipelines would affect critical habitat primary constituent elements.

5.5.5 Conservation Measures

5.5.5.1 Hopper Dredging Window

Hopper dredging operations would adhere to a 1 December to 15 April environmental work window. The proposed window would limit hopper dredging to periods when sea turtles are unlikely to present in the dredging areas due to low water temperatures.

5.5.5.2 Rigid Draghead Deflectors

The use of rigid draghead deflectors would be required on all hopper dredges to reduce the risk of sea turtle entrainment.

5.5.5.3 Inflow/Overflow Screening

Hopper dredges would employ 100% inflow screening and monitoring.

5.5.5.4 Endangered Species Observers

Protected Species Observers would monitor inflow screens, dragheads, and hoppers during active dredging. When dragheads are submerged, during active dredging, PSOs would continuously monitor the inflow screening for turtles and/or turtle parts. At the completion of each load cycle, dragheads would be physically inspected as they are lifted from the sea surface and placed on the saddle to account for sea turtles that may be impinged within the draghead. During daylight hours PSOs would survey for the presence of endangered species during transits between the dredging sites and disposal areas.

5.5.5.5 Blast Mitigation Watch Program

Specific watch program measures and procedures for sea turtles and marine mammals would be implemented as previously outlined in Section 5.2.5.2.

5.5.5.6 Beach Placement Window

Sand placement operations would be limited to a 16 November to 30 April construction window. Adherence to the placement window would avoid direct impacts on nesting females, nests, eggs, and hatchlings.

5.5.5.7 Sediment Compatibility

All material placed on the beach and in associated dune systems would consist of beach compatible sediment that is suitable for sea turtle nesting.

5.5.5.8 Escarpment Monitoring

Immediately after construction and to the maximum extent practicable prior to 1 May, surveys for escarpments will be conducted within the limits of construction areas. Identified escarpments that that may interfere with sea turtle nesting (>18 inches in height and ≥ 100 ft in length) will be leveled to the natural beach profile. If it is determined that escarpment leveling is required during the nesting season, leveling activities would be coordinated with the USFWS and NCWRC.

5.5.5.9 Compaction Monitoring

Immediately after construction and to the maximum extent practicable prior to 1 May, the limits of construction areas will be evaluated for compaction in coordination with the USFWS and NCWRC. If it is determined that tilling is required for sea turtle nesting habitat suitability, the construction areas will be tilled to a depth of 36 inches. All tilling activity shall be completed prior to 1 May to the maximum extent practicable. In the case of projects that run until the 30 April nesting window cutoff, any tilling activities required after 1 May would be coordinated with the USACE, USFWS, and NCWRC.

5.5.6 Determination of Effect

5.5.6.1 Dredging

Based on the pelagic feeding habit of the leatherback, its association with deep oceanic waters, and the absence of reported takes by dredges; it is determined that dredging under the proposed action may affect, but is not likely to adversely affect the leatherback sea turtle. Based on the rarity of the hawksbill in NC waters, its association primarily with coral reef habitats, and the absence of reported takes by dredges; it is determined that dredging under the proposed action may affect, but is not likely to adversely affect the hawksbill sea turtle. Adherence to a 16 November - 15 April hopper dredging window and the use of rigid draghead deflectors on hopper dredges would minimize the risk of loggerhead, green, and Kemp's ridley entrainment. Given that only one sea turtle take has been reported at Wilmington Harbor during the proposed hopper dredging environmental work window; it is determined that dredging under the proposed action may affect, but is not likely to adversely affect loggerhead, green, and Kemp's ridley sea turtles.

5.5.6.2 Confined Blasting

Based on the low probability of sea turtle occurrences in the vicinity of the blasting areas, and considering the proposed blast protection measures that would be implemented; it is determined that blasting under the proposed action may affect, but is not likely to adversely affect loggerhead, green, Kemp's ridley, leatherback, and hawksbill sea turtles.

5.5.6.3 Beach Disposal of Dredged Material

Based on the proposed beach disposal environmental work window and the proposed measures to minimize effects on sea turtle nesting habitat; it is determined that beach placement under the proposed action may affect, but is not likely to adversely affect loggerhead, green, Kemp's ridley, leatherback, and hawksbill sea turtles.

5.5.6.4 Loggerhead Critical Habitat

Based on the proposed measures to minimize effects on sea turtle nesting habitat; including the use of compatible beach fill and escarpment and compaction monitoring; it is determined that the proposed action may affect, but is not likely to adversely affect loggerhead terrestrial critical habitat. Based on avoidance of the sea turtle nesting and hatching season in NC, it is unlikely that beach placement and associated pipeline placement activities would affect the critical habitat primary constituent elements of nearshore reproductive habitat. Therefore, it is determined that the proposed action may affect, but is not likely to adversely affect loggerhead nearshore reproductive critical habitat.

5.6 Atlantic and Shortnose Sturgeon

5.6.1 Status, Distribution, and Habitat

5.6.1.1 Atlantic sturgeon

The Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) was listed under the ESA in 2012 as DPS segments; including the endangered New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs and the threatened Gulf of Maine DPS (77 FR 5914, 77 FR 5880). The Carolina DPS encompasses subpopulations from the Roanoke, Tar/Pamlico, Cape Fear, Waccamaw, Pee Dee, and Santee-Cooper Rivers in NC and South Carolina. The historical US distribution of the Atlantic Sturgeon included approximately 38 rivers from the Saint Croix River in Maine to the Saint Johns River in Florida, including spawning populations in at least 35 rivers. The current US distribution includes 35 rivers with spawning known to occur in at least 20 rivers. Atlantic sturgeon spawn in freshwater, but spend most of their adult life in a marine environment. Spawning adults generally migrate upriver in the spring/early summer, although a fall spawning migration may also occur in some southern rivers. Spawning is believed to occur in flowing water between the salt front and fall line of large rivers. Post-larval juveniles move downstream into brackish waters and eventually move to estuarine waters where they reside for a period of months or years. Subadult and adult Atlantic sturgeons emigrate from rivers into coastal waters, where they may undertake long range migrations. Migratory adult and subadult sturgeon are typically found in shallow (40-70 ft) nearshore waters with gravel and sand substrates. Although extensive mixing occurs in coastal waters, Atlantic sturgeons return to their natal river to spawn [Atlantic Sturgeon Status Review Team (ASSRT) 2007]. In 2017, the NMFS designated critical habitats for the Atlantic sturgeon in large spawning river systems throughout the five DPSs (82 FR 39160). Critical habitat for the Carolina DPS was designated in the Roanoke, Tar-Pamlico, Neuse, Cape Fear, and Pee Dee Rivers of NC and South Carolina.

5.6.1.2 Shortnose Sturgeon

The shortnose sturgeon (*A. brevirostrum*) was listed as endangered throughout its range on 11 March 1967 (32 FR 4001). The species inhabits large Atlantic coast rivers from the St. Johns River in northeastern Florida to the Saint Johns River in New Brunswick, Canada. Adults in southern rivers are estuarine anadromous, foraging at the saltwater-freshwater interface and moving upstream to spawn in the early spring. Shortnose sturgeon spend most of their lives in their natal river systems and rarely migrate to marine environments. Spawning habitats include river channels with gravel, gravel/boulder, rubble/boulder, and gravel/sand/log substrates. Spawning in southern rivers begins in later winter or early spring and lasts from a few days to several weeks. Juveniles occupy the saltwater-freshwater interface, moving back and forth with the low salinity portion of the salt wedge during summer. Juveniles typically move upstream during the spring and summer and move downstream during the winter, with movements occurring above the saltwater-freshwater interface. In southern rivers, both adults and juveniles are known to congregate in cool, deep thermal refugia during the summer. The shortnose sturgeon is a benthic omnivore that feeds on crustaceans, insect larvae, worms, and mollusks. Juveniles randomly vacuum the bottom and consume mostly insect larvae and small crustaceans.

Adults are more selective feeders, feeding primarily on small mollusks (NMFS 1998). No critical habitat has been designated for the shortnose sturgeon.

5.6.2 Occurrence in the Action Area

5.6.2.1 Atlantic Sturgeon

The Atlantic sturgeon was historically abundant in most NC coastal rivers and estuaries; however, at the time of its listing under the ESA, the Carolina DPS spawning population was estimated at less than 300 individuals (NMFS 2012a). Extant spawning populations in NC are currently known from the Roanoke, Tar-Pamlico, Cape Fear, and potentially the Neuse River systems (ASSRT 2007). Gill net surveys in the Cape Fear River system have captured substantial numbers of Atlantic sturgeon in the Cape Fear River mainstem, Brunswick River, and Northeast Cape Fear River (Moser and Ross 1995, ASSRT 2007). Subadult Atlantic sturgeon in the Cape Fear River system exhibit seasonal movements and distribution patterns; moving upriver during the summer and migrating out of the river to estuarine or ocean waters during the coldest time of the year (Post et al. 2014). High inter-annual return rates of tagged fish demonstrate fidelity to the Cape Fear River system; indicating that the Cape Fear River system may be the natal river system for these individuals (Post et al. 2014). Reports of Atlantic sturgeon above Lock and Dam #1 indicate that some fish are successful at passing Lock and Dam #1 via the recently constructed rock arch ramp. Although eggs have not been detected, the collective body of evidence suggests that both the Cape Fear River and the Northeast Cape Fear River may be important spawning areas.

Portions of the mainstem Cape Fear River and Northeast Cape Fear River were designated as critical habitat (Carolina Unit 4) for the Carolina DPS in 2017. Carolina Unit 4 encompasses the mainstem Cape Fear River from the estuary mouth (river mile 0) up to Lock and Dam #2 and the Northeast Cape Fear River from its confluence with the Cape Fear River up to Rones Chapel Road Bridge at Mount Olive, NC (Figure 10). The physical or biological features of Atlantic sturgeon critical habitat that are essential to the conservation of the species include hardbottom substrate in low salinity waters for egg settlement and early life stage development; aquatic habitat encompassing a gradual salinity gradient (0.5-30 ppt) and soft bottom (sand/mud) substrate for juvenile foraging and development; waters of sufficient depth and absent physical barriers to passage to support unimpeded movements of adults, subadults, and juveniles; and water quality conditions (temperature and oxygen) that support spawning, survival, development, and/or recruitment of the various life stages (82 FR 39160).

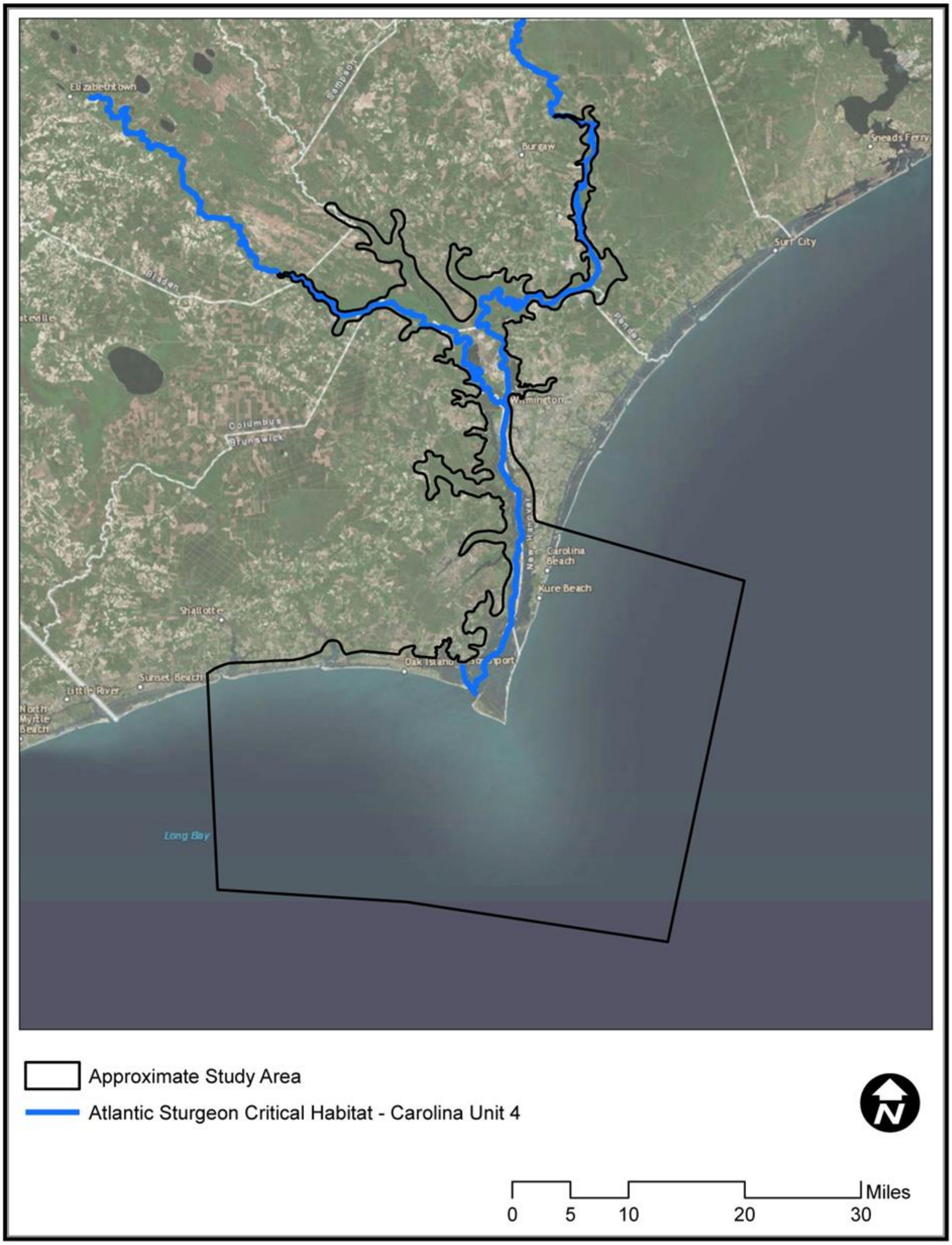

Figure 10
Critical Habitat (Carolina Unit 4) for Atlantic Sturgeon within the Project Area

5.6.2.2 Shortnose Sturgeon

The current distribution of the shortnose sturgeon in NC is thought to include only the Cape Fear and Pee Dee Rivers, and no spawning populations have been confirmed in the state [Shortnose Sturgeon Status Review Team (SSSRT) 2010]. Shortnose sturgeons were thought to be extirpated from NC waters until 1978 when an individual was captured in the Brunswick River (Ross et al. 1988). Subsequent gill net studies (1989-1993) resulted in the capture of five shortnose sturgeons, thus confirming the presence of a small population in the lower Cape Fear River below Lock and Dam #1 (Moser and Ross 1995). Movements of tagged shortnose sturgeons were detected from rkm 16 up to Lock and Dam #1. Moser and Ross (1995) observed directed upstream migrations by gravid females that suggested the possible existence of a reproducing population above Lock and Dam #1. However, the current distribution, abundance, and reproductive status of the shortnose sturgeon in the Cape Fear River is unknown (SSSRT 2010).

5.6.3 Threats

Historical overharvesting contributed to drastic declines in shortnose and Atlantic sturgeon populations. Commercial exploitation of shortnose sturgeons continued into the 1950s, and Atlantic sturgeons were commercially exploited throughout most of the 20th century (NMFS 1998, ASSRT 2007). Although directed commercial harvest is no longer permitted, by-catch mortality associated with other fisheries remains a major threat. By-catch mortality associated with the shad and shrimp fisheries and water quality degradation in nursery habitats are the primary threats currently facing southeastern sturgeon populations (Collins et al. 2000). Dams that block access to spawning grounds are a major stressor in some southern river systems, including the Cape Fear River. Additional stressors include ship strikes and dredging (ASSRT 2007). A total of 18 Atlantic sturgeons were taken by hopper dredges during federal navigation dredging along the South Atlantic Coast from October 1990 to March 2012 (USACE 2014). Incidental takes occurred at Wilmington Harbor, NC (n=2), Winyah Bay, South Carolina (n=1), Charleston Harbor, South Carolina (n=4), Savannah Harbor, Georgia (n=5) and Brunswick Harbor, Georgia (n=6).

5.6.4 Project Effects

5.6.4.1 Dredging

Entrainment

The proposed harbor deepening project would employ: 1) hopper dredging in the outer entrance channel reaches (existing Baldhead Shoal Reaches 2 and 3 and the proposed offshore extension reach) with ocean disposal at the ODMDS; 2) cutterhead dredging in Baldhead Shoal Reach 1 channel and inner harbor channel reaches with a combination of direct pipeline beach disposal, direct pipeline disposal to estuarine waterbird nesting islands, and ocean disposal at the ODMDS via scows; and 3) bucket dredges as needed for the removal of pretreated rock from the Keg Island, Lower Big Island, Upper Big Island, and Lower Brunswick channel reaches with ocean disposal at the ODMDS via barges. Dredging operations can potentially impact Atlantic and shortnose sturgeon directly through entrainment in the dredge intake pipe. Although shortnose sturgeon have been taken by both hopper and cutterhead dredges in rivers along the North Atlantic Coast, no dredge takes have occurred along the South Atlantic Coast. The shortnose sturgeon is typically found in the upper portions of rivers above the freshwater-saltwater interface, which reduces the potential for dredge interactions. Based on the absence of reported dredge interactions along the South Atlantic Coast and its restriction primarily to the upper portions of rivers, it is expected that the risk of shortnose sturgeon entrainment would be negligible.

All confirmed Atlantic sturgeon takes (n=5) by cutterhead dredges have occurred in the upper Delaware River, with all five entrainments occurring during the winter months in an area that is known to contain dense aggregations of sturgeon that are resting on the bottom and exhibiting little movement. Analyses of cutterhead dredge intake velocities and sturgeon swimming capabilities indicate that the risk of entrainment is limited to juveniles within 1.0 meter of the dredge pipe intake (NMFS 2012). Analysis of historical Atlantic sturgeon take along the South Atlantic Coast indicates that the risk of dredge entrainment is primarily limited to hopper dredging within riverine channels (USACE 2014). A total of 18 Atlantic sturgeon were taken by hopper dredges during federal navigation dredging operations along the southeastern US coast from October 1990 to March 2012 (USACE 2014b). Takes occurred at Wilmington Harbor, NC (n=2), Winyah Bay, South Carolina (n=1), Charleston Harbor, South Carolina (n=4), Savannah Harbor, Georgia (n=5) and Brunswick Harbor, Georgia (n=6). The two takes at Wilmington Harbor included one in the upper Cape Fear River near the state port in 1998, and one in the lower river near Horse Shoe Shoals in 2010. The small number of reported takes at Wilmington Harbor indicates that the potential hopper dredge entrainment risk to Atlantic sturgeon is low. Under the TSP, hopper dredges would be used only in the outer ocean entrance channel where any occurrences of Atlantic sturgeon would likely consist of subadults and adults that would be able to avoid the dredge. As a conservation measure to reduce the risk of entrainment, all hopper dredges would employ rigid draghead deflectors. The potential risk of entrainment to adult sturgeon is presumed to be low, and the use of rigid deflecting dragheads and associated operating requirements likely reduces the risk (Dickerson et al. 2004). The NMFS has previously determined in dredging consultations that mechanical dredges are extremely unlikely to overtake or adversely affect sturgeon (NMFS 2019). Based on all of the above considerations, it is anticipated that the risk of direct injury to Atlantic sturgeon from dredging operations would be negligible under the TSP.

Impacts on Soft Bottom Habitat

New dredging would increase the area of soft bottom habitat that is subject to recurring dredging disturbance by ~925 acres; including ~557 acres of estuarine soft bottom habitat and ~368 acres of marine soft bottom habitat (Table 12). Depending on reach-specific maintenance intervals, newly impacted soft bottom habitats in the estuary would experience recurring dredging disturbance every one to four years for the duration of the 50-year project. Temporary losses of benthic invertebrate infauna would reduce benthic prey availability for Atlantic and shortnose sturgeon. Reported rates of recovery in the Wilmington Harbor channel indicate that the effects of individual dredging events on benthic infaunal communities in silty channel reaches would be relatively short-term (<6 months), whereas infaunal communities in the coarse sand reaches of the lower estuary and nearshore ocean would experience longer term effects lasting one to two years (Ray 1997). Recurring periods of infaunal depression would reduce total benthic infaunal productivity over the 50-year project life. Total losses of benthic productivity

Table 12
Soft Bottom Dredging Impacts under the TSP

Channel Reach	Existing Width[1]	Proposed Width[1]	Dredging Frequency (Years)	Dredging Area (acres)		
				New[2]	Existing Channel[3]	Total
Anchorage Basin	625	625-1509	1	2	95	97
Between Channel	550	625	1	8	37	45
Fourth East Jetty	500	550	2	30	111	141
Upper Brunswick	400	500	2	21	48	69
Lower Brunswick	400	500	2	40	87	127
Upper Big Island	660	660	2	11	59	70
Lower Big Island	400	500	2	16	43	59
Keg Island	400	500	2	37	81	118
Upper Lilliput	400	500	2	41	102	143
Lower Lilliput	600	600	2	15	160	175
Upper Midnight	600	600	2	19	205	224
Lower Midnight	600	600	2	9	122	131
Reaves Point	400	500	9	22	67	89
Horseshoe Shoal	400	500	3	23	59	82
Snows Marsh	400	500	3	59	143	202
Lower Swash	400	800-500	2	48	62	110
Battery Island	500	800-1300	2	111	80	191
Southport	500	800	4	13	10	23
Baldhead-Caswell	500	800	4	10	21	31
Smith Island	650	900	2	22	62	84
Total Inner Harbor				**557**	**1,656**	**2,213**
Baldhead Shoal Reach 1	700	900	2	207	0	207
Baldhead Shoal Reach 2	900	900	2	132	398	530
Baldhead Shoal Reach 3	500-900	600-900	1	5	99	104
Entrance Extension	N/A	600	10	24	73	97
Total Ocean Entrance				**368**	**570**	**938**

[1]Channel bottom width, excluding side slopes
[2]New dredging encompasses the area between the existing channel top-of-slope and the proposed channel top-of-slope, along with the bottom and slopes of the proposed entrance channel extension reach.
[3]Existing channel dredging encompasses the existing channel bottom and side slopes.

over the 50-year project life would vary among channel reaches in accordance with reach-specific maintenance intervals and recovery rates.

5.6.4.2 Salinity and Water Quality Effects

The DELFT 3D hydrodynamic model results indicate that the proposed action would have negligible effects on temperature and dissolved oxygen (DO) concentrations. In relation to the

FWOP, DO concentrations in the estuary are projected to decrease by 0.3 milligrams per liter or less; and the maximum decreases are projected to occur during the winter months when DO concentrations are typically the highest of the year (8-10 milligrams per liter). Therefore, changes in DO under the TSP would not be expected to have any significant adverse effects on Atlantic or shortnose sturgeons. The model results indicate that channel deepening would increase surface, mid-depth, and bottom salinities in relation to the FWOP. Under typical flow conditions, the maximum relative increases in average annual salinity occur in the mid-depth (3.9 ppt) and bottom (4.1 ppt) layers in the vicinity of the Anchorage Basin and Battleship channel reaches. Projected salinity increases at all depths are rapidly reduced in the reaches above and below Wilmington under typical flow conditions.

The juveniles of Atlantic and shortnose sturgeon, and to lesser extent the adults, are known to follow the salt front during certain times of the year. The largest increases in salinity are projected in the vicinity of downtown Wilmington where there are known concentration areas for sturgeon in the estuary such as the Brunswick River below the US 74/76 Bridge. Although the location of the salt front in the Cape Fear River estuary varies widely throughout the year, the projected increases in salinity would shift the average position of the salt front upstream, potentially affecting habitat suitability in the vicinity of Wilmington during certain times of the year. Reductions in habitat suitability would be most likely to occur during the late summer/fall period when the salt front typically reaches its uppermost limit in the estuary. The presence of known sturgeon concentration areas in the vicinity of the maximum projected salinity increases suggests that Atlantic and shortnose sturgeons could experience a loss of habitat or a reduction in habitat suitability.

5.6.4.3 Confined Blasting

The effects of confined blasting on shortnose sturgeon were investigated through a series of test blasts conducted in the Cape Fear River estuary during the fall and winter of 1998/1999 (USACE 1999; Moser 1998, 1999). Test blasts consisting of 32 or 33 stemmed 52 to 62 pound charges on a 25 millisecond delay were conducted in a portion of the Big Island channel reach where pre-treatment rock blasting was proposed as part of the Wilmington Harbor 96 Act Project. Hatchery reared shortnose sturgeons were held in cages at distances of 35, 70, 140, 280, and 560 ft from the blast locations. Fish were evaluated and assigned an index of injury score immediately after the blasts and again after a holding period of 24 hours. Subsamples of the surviving sturgeons that appeared to be uninjured based on external examination were subsequently necropsied to document internal injuries and assess the likelihood that fish would have recovered from any injuries that were identified. Additional subsamples of surviving sturgeons were held in tanks for a period of two months to evaluate long-term survival. Blasts were also conducted with and without the use of air bubble curtains that were designed to reduce blast pressure impacts; however, bubble curtains were determined to have had little or no effect on fish survival, and were ultimately abandoned as a mitigative measure (Moser 1999, USACE 2000).

Sturgeon survival rates at distances of 140 ft and beyond were similar to survival rates at control stations located 0.5 mile from the blast locations, thus indicating that effects were confined to the area within a 140-foot radius of the blast location (Moser 1999). At the 35-foot and 70-foot locations, shortnose sturgeon mortality and injury rates were much lower than those for other species that were included in the study (striped bass, white mullet, and killifish). Immediate post-blast survival rates for sturgeon at distances of 35 ft and 70 ft ranged from 82.2% to 99.8%. Sturgeon survival rates did not change over the 24-hour post-blasting holding period, and the long-term (2-month) survival rates of sturgeons from the 35 ft and 70 ft locations were similar to those from the control station. Necropsies indicated that 88% and 100% of the surviving sturgeon from the 35-foot and 70-foot locations would have recovered and survived long-term. Sturgeon injuries consisted primarily of distended intestines and hemorrhaging of the interior body wall. In contrast to the other species that were exposed to blasting, sturgeon suffered very few swim bladder injuries. Moser (1999) attributed the low incidence of swim bladder injuries and relatively high survival rates of sturgeon to a direct connection between the swim bladder and the esophagus that allows gas to escape rapidly.

Areas potentially requiring confined blasting under the proposed action encompass ~188 acres of rock surface area within the Keg Island, Lower Big Island, Upper Big Island, and Lower Brunswick channel reaches. These four reaches comprise a continuous ~4.4-mile section of the navigation channel from a point ~18 miles above the estuary mouth to a point approximately two miles below Eagle Island. All blasting would occur between August and January when fish density is expected to be lowest. Blasting operations would employ stemmed charges and charge delays to reduce the magnitude of potentially injurious blast shock waves. Drill holes containing the individual charges would be stemmed (capped) with angular rock or other suitable material for the purpose of containing blast energy within the rock. Studies indicate that the use of stemmed charges with confined blasting can reduce shock wave peak pressure by 60 to 90% in relation to unconfined open water blasts (Nedwell and Thandavamoorthy 1992, Hempen et. al. 2005). The use of delays between individual charge detonations limits the development of cumulative blast pressure. Blasting operations would implement additional protective measures for Atlantic and shortnose sturgeon similar to those previously approved by NMFS in 2000 and 2012 for blasting operations under the Wilmington Harbor 96 Act Project (NMFS 2000, 2012). Previously approved protective measures included the use of sinking gill nets, sonar surveys, and scare charges prior to each blast event.

5.6.5 Conservation Measures

5.6.5.1 Rigid Draghead Deflector

The use of rigid draghead deflectors would be required on all hopper dredges to reduce the risk of sturgeon entrainment. The potential risk of entrainment to adult sturgeon is presumed to be low, and the use of rigid deflecting dragheads and associated operating requirements likely reduces the risk (Dickerson et al. 2004).

5.6.5.2 Blast Protection Measures

- Blasting would be limited to the established Wilmington Harbor fisheries environmental work window of 1 August through 31 January.

- Blasting operations would employ stemmed charges and charge delays to reduce the magnitude of potentially injurious blast shock waves.

- A site-specific blast mitigation protection program will be developed and implemented in coordination with the NMFS and other federal and state resource agencies. Based on protective measures that were approved for prior Wilmington Harbor deepening projects (NMFS 2000, 2012), it is anticipated that protective measures specifically for sturgeon would include the following:
    - Sinking gillnets will be set for a duration of two hours prior to each blast. The nets will surround the blast area to the extent feasible, and will not be removed sooner than one hour before the blast. Any sturgeon captured will be released in the Brunswick River within 300 ft of the US 74/76 Bridge. The nets will be manned continuously and will be retrieved if any marine mammal or sea turtle is observed in the area. The nets will have floats with reflective tape that extend to the surface. If the floats indicate that a large animal has become entangled, the nets will be immediately retrieved and the animal released. If nets are set in the dark (0.5 hours or more before sunrise) prior to any early morning blast, night vision equipment will be used to monitor the net floats and water surface. No overnight sets will be used.
    - Surveillance for fish will be conducted by vessels equipped with side-scan sonar fish finders for a period of 20 minutes before each blast. If fish are detected, blasting will be delayed until they leave. The surveillance zone will encompass a radius of 500 ft extending outward from each blast set.
    - Scare charges will be detonated prior to each blast for the purpose of excluding aquatic organisms from the area of an impending blast. Two scare charges similar to those described by Collins et al. (2000) and Yelverton et al. (2000) will be used for each blast. One scare charge will be detonated 45 seconds prior to the blast and one 30 seconds prior to the blast.

5.6.6 Determination of Effect

5.6.6.1 Dredging

Based on the location of proposed hopper dredging in the outer ocean entrance channel reaches, it is determined that the dredging under the proposed action may affect but is not likely to adversely affect Atlantic and shortnose sturgeon.

5.6.6.2 Salinity and Water Quality Effects

Based on projected salinity increases and reductions in foraging habitat suitability in the vicinity of known sturgeon concentration areas (i.e., Brunswick River), it is determined that the proposed action may affect and is likely to adversely affect the Atlantic sturgeon and shortnose sturgeon.

5.6.6.3 Blasting

Based on the potential for injury and mortality, it is determined that confined blasting under the proposed action may affect and is likely to adversely affect the Atlantic sturgeon and shortnose sturgeon.

5.6.6.4 Atlantic Sturgeon Critical Habitat

Based on the projected shift in the salinity gradient in the vicinity of known Atlantic sturgeon concentration areas (i.e., Brunswick River), it is determined that the proposed action may affect and is likely to adversely affect critical habitat for the Atlantic sturgeon.

5.7 Seabeach Amaranth

5.7.1 Status, Distribution, and Habitat

Seabeach amaranth (*Amaranthus pumilus*) was listed as threatened throughout its range on 7 April 1993 (58 FR 18035 18042). No critical habitat has been designated for this species. The current distribution includes coastal beaches from New York to South Carolina. Historically, this species was also found as far north as Rhode Island and Massachusetts, but has not been observed in these states in over a century. Range-wide populations increased substantially during the 1990s and reached a population estimate of 244,608 plants in 2000. During this period, seabeach amaranth was rediscovered in New York after an absence of 40 years. Between 1998 and 2000, additional populations were rediscovered in Virginia, Maryland, Delaware, and New Jersey after periods of absence ranging from 30 to 125 years (USFWS 2005). All of the state-specific populations have experienced similar declines, with record or near record lows recorded in all states by 2013.

Seabeach amaranth is an annual flowering plant that overwinters entirely in the form of small seeds. Due to its annual life cycle, the presence of plants in any given year is dependent on seed production and dispersal during previous years. Seed germination begins in April or May and continues through July. Flowering begins as early as June, and seed production is initiated in July or August. Flowering and seed production continue until the death of plant in late fall or early winter. Under favorable climatic conditions, some plants may survive and continue to produce seed into January (USFWS 1996b).

Seabeach amaranth is a pioneering colonizer of newly formed and recently disturbed barrier island habitats; including supratidal overwash flats on the accreting ends of barrier islands, the upper dry ocean beach, and the lower exposed faces of foredunes. The species is intolerant of competition, and relies on regular disturbances to create areas devoid of other competitive plant species. Suitable habitats are eventually lost to dynamic erosional processes or succession to more stable dune grass communities. Consequently, seabeach amaranth is dependent on continual new habitat formation through dynamic barrier island and inlet processes. The species is well-adapted to this ephemeral habitat niche, producing vast numbers of tiny seeds that are widely dispersed throughout the coastal barrier system, thereby providing for the rapid colonization of new suitable habitats as they are formed

5.7.2 Occurrence in the Action Area

Although variable from year to year, the distribution of seabeach amaranth encompasses the entire barrier island coast of NC. Annual state-wide surveys from 1995 to 2014 recorded an average of 6,726 plants per year. Long-term population trends in NC have been similar to those of the overall range-wide population. After a record high annual count of 39,933 plants in 1995, annual survey totals from 1996 through 2002 fluctuated between approximately 200 and 14,000 plants. Beginning in 2003, the NC population increased substantially over three consecutive years, reaching 25,885 plants in 2005. The NC population has since been in rapid decline, reaching a record low annual total of 154 plants in 2012. Numbers remained low in 2013 and 2014, with surveys recording just 166 and 526 plants, respectively. The largest numbers of plants have been found along the southern NC coast, with concentrations occurring along Topsail Island and Bogue Banks. Since 2000, occurrences of seabeach amaranth in the action area have been heavily concentrated on the Brunswick County beaches to the west of Cape Fear, primarily on the beaches of Oak Island and Holden Beach (Table 13). Annual numbers in the action area have varied considerably from a low of just 22 plants in 2000 to a high of 2,420 in 2006. Since 2010, the population trend within the action area has mirrored the statewide and range-wide trend of steadily declining plant numbers, with annual totals from 2011 to 2014 ranging from just 51 to 350 plants (Table 13).

Table 13
Seabeach Amaranth Counts for the Cape Fear Region between 2000-2014

Survey Reach	Year															Total
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	
Fort Fisher	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	**1**
Bald Head Island	3	1	0	0	0	45	4	0	2	2	0	0			0	**226**
Oak Island East	9	63	413	302	4	92	291	105	51	40	1372	1	5	1	1	**15,341**
Oak Island West	0	3	129	965	7	82	171	11	14	24	204	15	0	0	0	**1,626**
Holden Beach East	1	12	0	18	4	8	9	0	0	0	0	0	0	0	26	**272**
Holden Beach West	9	211	702	825	75	792	1945	281	574	123	434	116	46	108	323	**6,829**
Total	**22**	**290**	**1244**	**2110**	**90**	**1020**	**2420**	**397**	**641**	**189**	**2010**	**132**	**51**	**109**	**350**	**24,295**

5.7.3 Threats

The principal factors affecting seabeach amaranth include habitat loss and degradation. These are usually attributable to anthropogenic activities such as inlet dredging, beach nourishment, and the construction of groins and revetments for shoreline and inlet stabilization (USFWS 2005). Sand placement and other shoreline stabilization projects may affect seabeach amaranth by altering the dynamic coastal processes that create and maintain suitable habitat. Sand placement projects typically include the construction of berms and continuous artificial dunes that may impede natural ocean-to-sound overwash events that are responsible for the creation of new sparsely vegetated seabeach amaranth habitat. Sand placement during the growing season may affect seabeach amaranth directly through the burial and mortality of plants. Placement and grading operations may redistribute seeds, depositing them in unsuitable habitats where they are unable to germinate. Groins and jetties may impede seed dispersal, thereby limiting the species' ability to colonize new habitats. Pedestrian foot traffic, off-road vehicle use, and beach raking can damage or uproot plants. Seabeach amaranth is also threatened by the proliferation of non-native invasive plant species. Beach vitex has been widely planted in NC, and has the potential to displace seabeach amaranth from suitable habitat.

5.7.4 Project Effects

5.7.4.1 Beach Disposal

Seed germination generally does not begin in NC until May (Personal communication, Dale Suiter, USFWS, April 2016); thus adherence to a 16 November - 30 April beach disposal environmental work window would generally avoid the seabeach amaranth growing season, thereby minimizing the likelihood of direct impacts on actively growing plants. Some seeds that are redistributed by sand placement and grading operations may be redeposited in unsuitable habitats, thereby preventing successful germination or growth. Conversely, some seeds that are banked in unsuitable habitats may be redistributed to suitable dry beach habitats. Beach disposal would contribute to the maintenance of a wider vegetation-free dry beach, thereby increasing habitat availability for seabeach amaranth along the erosional shorelines that adjoin the inlet.

Beach disposal of dredged material under the TSP would occur during Year 2 of the three-year channel construction project and subsequently every two years in accordance with the existing SMP maintenance cycle. Expanded beach placement during construction Year 2 would affect an additional 1.5 to 2.5 linear miles of seabeach amaranth habitat. Based on projected channel shoaling rate increases, post-construction maintenance beach disposal volumes would increase by five percent in relation to current beach disposal operations under the existing SMP. A five percent volumetric increase would equate to an additional 0.14 miles of beach disposal on Bald Head Island or an additional 0.25 miles of disposal on Oak Island, thus indicating that maintenance beach disposal operations and any associated effects on seabeach amaranth under the TSP would not differ significantly from those of current disposal operations under the existing SMP.

5.7.5 Conservation Measures

5.7.5.1 Environmental Work Window

Beach disposal operations would adhere to a 16 November to 30 April environmental work window, thereby avoiding the seabeach amaranth growing season in NC.

5.7.5.2 Sediment Compatibility

All material placed on the beach and in associated dune systems would consist of beach compatible sediment that is similar in grain size composition to that of the native beach sediments.

5.7.6 Determination of Effect

Based on the proposed conservation measures, it is determined that the proposed action may affect, but is not likely to adversely affect seabeach amaranth (Table 14).

Table 14
Summary of Effect Determinations

Species/Critical Habitat	ESA Listing Status	Effect Determination[1]			
		Dredging	Blasting	Salinity Change	Beach Disposal
North Atlantic right whale *(Eubalaena glacialis)*	Endangered	MANLAA	NE	NE	NE
Florida manatee *(Trichechus manatus)*	Endangered	MANLAA	MANLAA	NE	MANLAA
Leatherback sea turtle *(Dermochelys coriacea)*	Endangered	MANLAA	MANLAA	NE	MANLAA
Loggerhead sea turtle *(Caretta caretta)*	Threatened	MANLAA	MANLAA	NE	MANLAA
Green sea turtle *(Chelonia mydas)*	Endangered	MANLAA	MANLAA	NE	MANLAA
Hawksbill sea turtle *(Eretmochelys imbricata)*	Endangered	MANLAA	MANLAA	NE	MANLAA
Kemp's ridley sea turtle *(Lepidochelys kempii)*	Endangered	MANLAA	MANLAA	NE	MANLAA
Shortnose sturgeon *(Acipenser brevirostrum)*	Endangered	MANLAA	MANLAA	MALAA	NE
Atlantic sturgeon *(Acipenser oxyrinchus)*	Endangered	MANLAA	MANLAA	MALAA	NE
Piping plover *(Charadrius melodus)*	Threatened	NE	NE	NE	MANLAA
Red knot *(Calidris canutus rufa)*	Threatened	NE	NE	NE	MANLAA
Wood Stork (*Mycteria Americana)*	Threatened	NE	NE	NE	NE
Seabeach amaranth *(Amaranthus pumilus)*	Threatened	NE	NE	NE	MANLAA
North Atlantic Right Whale Southeastern US Calving Critical Habitat	Critical Habitat	NE	NE	NE	NE
Atlantic Sturgeon Critical Habitat	Critical Habitat	MANLAA	MANLAA	MALAA	NE
Loggerhead Nearshore Reproductive Critical Habitat	Critical Habitat	MANLAA	NE	NE	MANLAA
Loggerhead Terrestrial Critical Habitat	Critical Habitat	NE	NE	NE	MANLAA
Piping Plover Wintering Critical Habitat	Critical Habitat	NE	NE	NE	NE

[1] NE = No Effect; MANLAA = May affect, not likely to adversely affect; MALAA = May affect, likely to adversely affect

6 REFERENCES

Ackerman, R.A. 1996. The nest environment and embryonic development of sea turtles. In: Lutz, P.L. and J.A. Musick (eds.) The Biology of Sea Turtles. CRC Press.

Ackerman, R.A., T. Rimkus, and R. Horton. 1991. The Hydric Structure and Climate of Natural and Renourished Sea Turtle Nesting Beaches along the Atlantic Coast of Florida. Unpublished report prepared by Iowa State University for Florida Department of Natural Resources, Tallahassee.

Armstrong, J.L., and J.E. Hightower. 1999. Movement, habitat selection, and growth of early juvenile Atlantic sturgeon in Albemarle Sound, North Carolina. Final Report to U.S. Fish and Wildlife Service and Virginia Power. North Carolina Cooperative Fish and Wildlife Research Unit, NC State University, Raleigh, NC.

Atlantic Sturgeon Status Review Team (ASSRT). 2007. Status Review of Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*). Report to National Marine Fisheries Service, Northeast Regional Office. February 23, 2007.

Bishai, H.M. 1961. The effect of pressure on the survival and distribution of larval and young fish. Journal du Conseil, 26: 292-311.

Brock, K.A., J.S. Reece, and L.M. Ehrhart. 2009. The effects of artificial beach nourishment on marine turtles: differences between loggerhead and green turtles. Restoration Ecology 17(2): 297–307.

Burlas, M., G.L. Ray, and D.G. Clarke. 2001. The New York District's biological monitoring program for the Atlantic coast of New Jersey, Asbury Park to Manasquan section beach erosion control project. Final report. U.S. Army Corps of Engineers (USACE) New York District.

Byrd, B.L., A.A. Hohn, G.N. Lovewell, K.M. Altman, S.G. Barco, A. Friedlaender, C.A. Harms, W.A. McLellan, K.T. Moore, P.E. Rosel, and V.G. Thayer. 2014. Strandings as indicators of marine mammal biodiversity and human interactions off the coast of North Carolina. Fishery Bulletin 112:1-23.

Byrd, J.I. 2004. The effect of beach nourishment on loggerhead sea turtle (*Caretta caretta*) nesting in South Carolina. Master's Thesis, College of Charleston, Charleston, SC.

Cameron, S.E. 2009. The 2006 International Piping Plover Winter Census in North Carolina. In: Elliott-Smith, E., S. M. Haig, and B. M. Powers (eds.) Data from the 2006 International Piping Plover Census, U.S. Geological Survey Data Series 426.

Cameron, S., D.H. Allen, M.M. Lyons, J.R. Cordes, and S.B. Maddock. 2006. Compilation and Assessment of Piping Plover Wintering and Migratory Staging Area Data in North Carolina. In: Rabon, D.R. (compiler). Proceedings of the Symposium on the Wintering

Ecology and Conservation of Piping Plovers. U.S. Fish and Wildlife Service, Raleigh, NC.

Carr, A. and L. Ogren. 1960. The ecology and migrations of sea turtles. Bulletin of American Museum of Natural History, 121: 1-48.

Carthy, R.R., A.M. Foley, and Y. Matsuzawa. 2003. Incubation environment of loggerhead turtle nests: effects on hatching success and hatchling characteristics. In: Bolten, A.B. and B.E. Witherington (eds.) Ecology and Conservation of Loggerhead Sea Turtles. University Press of Florida, Gainsville, Florida, pp.145-153.

Christens, E. 1990. Nest emergence lag in loggerhead sea turtles. Journal of Herpetology 24:400-402.

Clapham, P.J. and J.G. Mead. 1999. *Megaptera novaeangliae*. Mammalian Species 604:1-9.

Clarke, D. and D.H. Wilber. 2000. Assessment of potential impacts of dredging operations due to sediment resuspension. DTIC, ERDC TN-DOER-E9. 14 pp.

Clark, C.W., M.W. Brown, and P. Corkeron. 2010. Visual and acoustic surveys for North Atlantic right whales, *Eubalaena glacialis*, in Cape Cod Bay, Massachusetts, 2001–2005: Management implications. Marine Mammal Science 26(4):837-854.

Clarke, D., C. Dickerson, and K. Reine. 2002. Characterization of Underwater Sounds Produced by Dredges Dredging 2002. ASCE, Orlando, Florida, USA, p 64-64.

Cohen, J.B. 2005. Management and protection protocols for the threatened piping plover (*Charadrius melodus*) on Cape Hatteras National Seashore, North Carolina. Virginia Tech University, Blacksburg, Va.

Cole, T.V.N., P. Hamilton, A.G. Henry, P. Duley, R.M. Pace III, B.N. White, and T. Frasier. 2013. Evidence of a North Atlantic right whale *Eubalaena glacialis* mating ground. Endangered Species Research 21:55-64.

Coles, C.C. and J.A. Musick. 2000. Satellite Sea Surface Temperature Analysis and Correlation with Sea Turtle Distribution off North Carolina. Copeia 2000: 551-554.

Collins, M.R. , S.G. Rogers , T.I.J. Smith , and M.L. Moser . 2000. Primary Factors Affecting Sturgeon Populations in the Southeastern United States: Fishing Mortality and Degradation of Essential Habitats. Bulletin of Marine Science 66:917–928.

Coulter, M.C., Rodgers, J.A., Ogden, J.C., Depkin, F.C., 1999. Wood stork (*Mycteria americana)* The Birds of North America, Issue No.409 (A. Poole, ed.). Cornell Lab of Ornithology, Ithaca, New York.

Crain, D.A., A.B. Bolten, and K.A. Bjorndal. 1995. Effects of beach nourishment on sea turtles: Review and research initiatives. Restoration Ecology 3(2): 95-104.

Cummings, E.W., D.A. Pabst, J.E. Blum, S.G. Barco, S.J. Davis, V.G. Thayer, N. Adimey, and W.A. McLellan. 2014. Spatial and temporal patterns of habitat use and mortality of the Florida manatee (Trichechus manatus latirostris) in the mid-Atlantic states of North Carolina and Virginia from 1991 to 2012. Aquatic Mammals 40(2):126-138.

Daniel, R.S. and K.U. Smith. 1947. The sea-approach behavior of the neonate loggerhead turtle (*Caretta caretta*). Journal of Comparative and Physiological Psychology 40(6):413-420.

Davis, R.A., M.V. Fitzgerald, and J. Terry. 1999. Turtle nesting on adjacent nourished beaches with different construction styles: Pinellas County, Florida. Journal of Coastal Research 15(1), 111-120.

Department of the Navy. 2008. Marine resources assessment update for the Charleston/Jacksonville operating area. Final report. Prepared for Atlantic Division, Naval Facilities Engineering Command, Norfolk, Virginia, by Geo-Marine, Inc., Plano, Texas.

Dey, A., L. Niles, H. Sitters, K. Kalasz, and R.I.G. Morrison. 2011. Update to the status of the red knot, *Calidris canutus* in the Western Hemisphere, April, 2011, with revisions to July 14, 2011. Unpublished report to New Jersey Department of Environmental Protection, Division of Fish and Wildlife, Endangered and Nongame Species Program.

Diaz, H. 1980. The mole crab *Emerita talpoida* (say): A case study of changing life history pattern. Ecological Monographs 50(4):437–456.

Dickerson, D.D., M.S. Wolters, C.T. Theriot, and C. Slay. 2004. Dredging impacts on sea turtles in the Southeastern USA: A historical review of protection. In: Proceedings of World Dredging Congress XVII, Dredging in a Sensitive Environment. 27 September-1 October 2004, Central Dredging Association, ISBN 90-9018244-6, CD-ROM.

Dickerson, D., C. Theriot, M. Wolters, C. Slay, T. Bargo, and W. Parks. 2007. Effectiveness of relocation trawling during hopper dredging for reducing incidental take of sea turtles. In: Proceedings of the World Dredging Congress XVIII,USACE ERDC Research Initiatives. Central Dredging Association, 27 May-1 June 2007, Lake Buena Vista, Florida.

Dinsmore, S.J., J.A. Collazo, and J.R. Walters. 1998. Seasonal Numbers and Distribution of Shorebirds on North Carolina's Outer Banks. Wilson Bull. 110: 171-18.

Ehrhart, L.M. 1995. The relationship between marine turtle nesting and reproductive success and the beach nourishment project at Sebastian Inlet, Florida, in 1994. Melbourne, Florida, University of Central Florida, Technical Report to the Florida Institute of Technology.

Einarsson, A., and Magnusdottir, M. L. 1993. The effect of sediment dredging on the distribution of diving duscks at Lake Myvatn, Iceland. Biological Conservation 66:55-60.

Epperly, S.P., J. Braun, and A.J. Chester. 1995a. Aerial surveys for sea turtles in North Carolina inshore waters. Fishery Bulletin 93: 254-261.

Epperly, S.P., J. Braun, and A. Veishlow. 1995b. Sea turtles in North Carolina waters. Conservation Biology 9: 384-394.

Epperly, S.P., J. Braun, A.J. Chester, E.A. Cross, J.V. Merriner, and P.A. Tester. 1995c. The winter distribution of sea turtles in the vicinity of Cape Hatteras and their interactions with the summer flounder trawl fishery. Bull. Mar. Sci. 56: 547-568.

Epperly, S.P., J. Braun-McNeill, and P.M. Richards. 2007. Trends in catch rates of sea turtles in North Carolina, USA. Endangered Species Research 3: 283–293.

Ernest, R.G. and R.E. Martin. 1999. Martin County beach nourishment project: sea turtle monitoring and studies, 1997 annual report and final assessment. Unpublished report prepared for the Florida Department of Environmental Protection.

Ernest, R.G. and R.E. Martin. 1993. Sea turtle protection program performed in support of velocity cap repairs, Florida Power & Light Company St. Lucie Plant. Applied Biology, Inc., Jensen Beach, Florida. 51 pages.

Ernest, R.G. 2001. The Effects of Beach Nourishment on Sea Turtle Nesting and Reproductive Success, a Case Study on Hutchinson Island, Florida Proceedings of the Coastal Ecosystems and Federal Activities Technical Training Symposium August 20-22, 2001.

Finneran, J.J., C.E. Schlundt, D. Randall, D.A. Cardera, and S.H. Ridgway. 2002. Temporary shift in masked hearing thresholds (MTTS) in odontocetes after exposure to single underwater impulses from a seismic watergun. Journal of the Acoustical Society of America 111:2929-2940.

Firestone, J., S.B. Lyons, C. Wang, and J.J. Corbett. 2008. Statistical modeling of North Atlantic right whale migration along the mid-Atlantic region of the eastern seaboard of the United States. Biological Conservation 141:221-232.

Fisheries and Oceans Canada. 2010. Recovery Strategy for the North Pacific Humpback Whale (*Megaptera novaeangliae*) in Canada [DRAFT]. Species at Risk Act Recovery Strategy Series. Fisheries and Oceans Canada, Ottawa.

Florida Fish and Wildlife Conservation Commission and Fish and Wildlife Research Institute (FWC/FWRI). 2016. Statewide Nesting Beach Survey Program Database, accessed April 2016. http://myfwc.com/research/wildlife/sea-turtles/nesting/.

Fujiwara, M. and H. Caswell. 2001. Demography of the endangered North Atlantic right whale. Nature 414: 537-41.

Garrison L.P. 2007. The big picture: modeling right whales in space and time. *In*: Kraus S.D., Rolland R.M. (eds) The urban whale: North Atlantic right whales at the crossroads. Harvard University Press, Cambridge, MA, p 460–487.

Gitschlag, G. R. 1990. Sea turtle monitoring at offshore oil and gas platforms. Pp. 223-246 in Proceedings of the 10th Annual Workshop on Sea Turtle Biology and Conservation, T. H. Richardson, J. I Richardson, and M. Donnelly, compilers. NOAA Technical Memorandum NMFS SEFC 278.

Gitschlag, G. R., and B. A. Herczeg. 1994. Sea turtle observations at explosive removals of energy structures. Marine Fisheries Review 56:1-8.

Godfrey, M.H. and N. Mrosovsky. 1997. Estimating the time between hatching of sea turtles and their emergence from the nest. Chelonian Conservation and Biology 2(4): 581-585.

Good C. 2008. Spatial ecology of the North Atlantic right whale (*Eubalaena glacialis*). PhD dissertation, Duke University, Durham, NC.

Goodman, M.A., J.B. McNeill, E. Davenport, and A.A. Hohn. 2007. Protected species aerial survey data collection and analysis in waters underlying the R-5306A Airspace: Final report submitted to U.S. Marine Corps, MCAS Cherry Point. NOAA Technical Memorandum NMFSSEFSC-551.

Goertner, J.F., M.L. Wiley, G.A. Young, and W.W. McDonald. 1994. Effects of underwater explosions on fish without swim bladders. Report No. NSWC TR 88-114. Naval Surface Warfare Center, White Oak Lab., Silver Spring, MD.

Gorzelany, J.F. and W.G. Nelson. 1987. The effects of beach replenishment on the benthos of a sub-tropical Florida beach. Marine Environmental Research 21 (2): 75-94.

Govoni, J.J., West, M.A., Settle, L.R., Lynch, R.T., Greene, M.D. 2008. Effects of Underwater Explosions on Larval Fish: Implications for a Coastal Engineering Project. Journal of Coastal Research 24 (2B): 228-233.

Gratto-Trevor, C, D. Amirault-Langlais, D. Catlin, F. Cuthbert, J. Fraser, S. Maddock, E. Roche, and F. Shaffer. 2012. *Connectivity in piping plovers: Do breeding populations have distinct winter distributions? Journal of Wildlife Management*, 76(2): 348-355.

Greene, C. H. and Pershing, A. J. 2004. Climate and the conservation biology of North Atlantic right whales: the right whale at the wrong time? Frontiers in Ecology and the Environment 2: 29-34.

Hackney, C.T., M.H. Posey, S.W. Ross, and A.R. Norris. 1996. A review and synthesis of data on surf zone fishes and invertebrates in the South Atlantic Bight and the potential impacts from beach renourishment. UNC-Wilmington, Wilmington, NC, 111p. Prepared for Wilmington District, US Army Corps of Engineers.

Hamilton, P.K., A.R. Knowlton, and M.K. Marx. 2007. Right whales tell their own stories: The photo-identification catalog. Pages 75-104 *In*: S.D. Kraus and R.M. Rolland, (eds.) The urban whale: North Atlantic right whales at the crossroads. Harvard University Press, Cambridge, MA.

Hatin, D., Lachance, S., and Fournier, D. 2007. Effect of Dredged Sediment Deposition on Use by Atlantic Sturgeon and Lake Sturgeon at an Open-Water Disposal Site in the St. Lawrence Estuarine Transition Zone. American Fisheries Society Symposium 56: 235-255.

Hayden, B. and R. Dolan. 1974. Impact of beach nourishment on distribution of *Emerita talpoida*, the common mole crab. Journal of the American Waterways, Harbors, and Coastal Engineering Division; ASCE 100:WW2. pp. 123-132.

Hayes, D. and P.Y. Wu. 2001. Simple approach to TSS source strength estimates. In Proceedings of the WEDA XXI Conference, Houston, TX, June 25-27, 2001.

Hayes, D., T. Crockett, T. Ward, and D. Averett. 2000. Sediment resuspension during cutterhead dredging operations. Journal of Waterway, Port, Coastal, and Ocean Engineering 126(3):153–161.

Hays, G.C., J.S. Ashworth, M.J. Barnsley, A.C. Broderick, D.R. Emery, B.J. Godley, and E.L. Jones. 2001. The importance of sand albedo for the thermal conditions on sea turtle nesting beaches. Oikos 93: 87-94.

Hendrickson, J.R. 1982. Nesting behaviour of sea turtles with emphasis on physical and behavioural determinants of nesting success or failure. In: K.A. Bjorndal (ed.), Biology and Conservation of Sea Turtles. Washington, D.C.: Smithsonian Institution Press, pp. 53-57.

Herren, R.M. 1999. The effect of beach nourishment on loggerhead (*Caretta caretta*) nesting and reproductive success at Sebastian Inlet, Florida. Orlando, Florida: University of Central Florida, Master's Thesis.

Hill, S.H. 1978. A guide to the effects of underwater shock waves on arctic marine mammals and fish. Pacific Marine Report 78-26. Institute of Ocean Sciences, Patricia Bay, Sidney, B.C., 50 pp.

Holloman, K.T. and M.H. Godfrey. 2008. Sea turtle monitoring project report, Bogue Banks, North Carolina, 2002-2007 final report. NC Wildlife Resources Commission.

Houghton, J.D.R. and G.C. Hays. 2001. Asynchronous emergence by loggerhead turtle (*Caretta caretta*) hatchlings. Naturwissenschaften 88:133-136.

James, M.C., C.A. Ottensmeyer, and R.A. Meyers. 2005. Identification of High-Use Habitats and Threats to Leatherback Sea Turtles in Northern Waters: New Directions for Conservation. Ecology Letters 8: 195-201.

Jutte, P.C., R.F. Van Dolah, and M.V. Levisen. 1999. An environmental monitoring study of the Myrtle Beach Renourishment Project: Intertidal benthic community assessment of Phase II, Myrtle Beach. Supplemental Report. Prepared for US Army Corps of Engineers, Charleston District. Marine Resources Division, South Carolina Department of Natural Resources, Charleston, SC.

Keevin, T.M., G.L. Hempen, R.D. Davinroy, and R.J. Rapp. 2002. The use of high explosives to conduct a fisheries survey at a bendway weir field on the middle of the Mississippi River. International Society of Explosives Engineers 2002(1):381-391.

Keevin, T.M. and G.L. Hempen. 1997. The environmental effects of underwater explosions with methods to mitigate impacts. U.S. Army Corps of Engineers, St. Louis District. August 1997.

Klima E.F., G.G. Gitschlag,and M.L. Renaud. 1988. Impacts of the explosive removal of offshore petroleum platforms on sea turtles and dolphins. Marine Fisheries Review 50(3):3342.

Knowlton, A., J. Ring, and B. Russell. 2002. Right whale sightings and survey effort in the mid-Atlantic region: migratory corridor, time frame, and proximity to port entrances. A report submitted to the NMFS Ship Strike Working Group.

Knowlton A.R., S.D. Kraus, and R.D. Kenney. 1994. Reproduction in North Atlantic right whales (*Eubalaena glacialis*). Can J Zool 72: 1297−1305.

Kraus S.D., J.H. Prescott, A.R. Knowlton, and G.S. Stone. 1986. Migration and calving of right whales (*Eubalaena glacialis*) in the western North Atlantic. *In*: Brownell R.L., Best P.B., and Prescott J.H. (eds) Right whales: past and present status. IWC, Cambridge, p 139−144.

Laney, R.W., J.E. Hightower, B.R. Versak, M.F. Mangold, W.W. Cole Jr., and S.E. Winslow. 2007. Distribution, habitat use, and size of Atlantic sturgeon captured during cooperative winter tagging cruises, 1988–2006. Am. Fish. Soc. Symp. 56, 167–182.

LaSalle, M.W., D.G. Clarke, J. Homziak, J.D. Lunz, and T.J. Fredette. 1991. A framework for assessing the need for seasonal restrictions on dredging and disposal operations. Technical Report D-91-1, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

LeGrand, H. 2013. Wood stork – Mycteria americana in Birds of North Carolina: Their distribution and abundance. Accessed 2 November 2014. http://www.carolinabird club.org/ncbirds/accounts.php.

Limpus, C.J., P. Reed, and J.D. Miller. 1983. Islands and turtles: the influence of choice of nesting beach on sex ratio. pp. 397-402 in Baker, J.T., R.M. Carter, P.W. Sammarco, and K.P. Stark (editors). Proceedings of the Inaugural Great Barrier Reef Conference, James Cook University Press, Townsville, Queensland, Australia.

Limpus, C.J. 1971. Sea turtle ocean finding behaviour. Search 2(10): 385-387.

Marcovaldi, M.A., M.H. Godfrey, and N. Mrosovsky. 1997. Estimating sex ratios of loggerhead turtles in Brazil from pivotal incubation durations. Canadian Journal of Zoology 75:755-770.

Martin, J., H.H. Edwards, C.J. Fonnesbeck, S.M. Koslovsky, C.W. Harmak, and T.M. Dane. 2015. Combining information for monitoring at large spatial scales—First statewide abundance estimate of the Florida manatee: Biological Conservation, v. 186, p. 44–51.

Matsuzawa, Y., K. Sato, W. Sakamoto, and K.A. Bjorndal. 2002. Seasonal fluctuations in sand temperature: effects on the incubation period and mortality of loggerhead sea turtle (*Caretta caretta*) pre-emergent hatchlings in Minabe, Japan. Marine Biology 140: 639-646.

McLellan, W.A., E. Meagher, L. Torres, G. Lovewell, C. Harper, K. Irish, B. Pike and A.D. Pabst. 2003. Winter right whale sightings from aerial surveys of the coastal waters of the US mid-Atlantic. 15th Biennial Conference on the Biology of Marine Mammals.

Meylan, A. 1992. Hawksbill turtle *Eretmochelys imbricata*. Pages 95-99 in Moler, P.E. (editor). Rare and Endangered Biota of Florida, Volume III. University Press of Florida, Gainesville, Florida.

Meylan, A., B. Schroeder, and A. Mosier. 1995. Sea turtle nesting activity in the State of Florida 1979-1992. Florida Marine Research Publications Number 52, St. Petersburg, Florida.

Miller, M.P., S.M. Haig, C.L. Gratto-Trevor, and T.D. Mullins. 2010. Subspecies Status and Population Genetic Structure in Piping Plover (*Charadrius melodus*). The Auk 127(1): 57-71.

Miller, J.D., C.J. Limpus, and M.H. Godfrey. 2003. Nest site selection, oviposition, eggs, development, hatching, and emergence of loggerhead turtles. Pages 125-143 in Bolten, A.B. and B.E. Witherington (editors). Loggerhead Sea Turtles. Smithsonian Books, Washington D.C.

Miller, J.D. 1997. Reproduction in sea turtles. Pages 51-81 in Lutz, P.L. and J.A. Musick (editors). The Biology of Sea Turtles. CRC Press. Boca Raton, Florida.

Miller, D.C., C.L. Muir and O.A. Hauser. 2002. Detrimental effects of sedimentation on marine benthos: What can be learned from natural processes and rates? Ecological Engineering 19(3):211-232.

Mortimer, J.A. 1990. The influence of beach sand characteristics on the nesting behavior and clutch survival of green turtles (*Chelonia mydas*). Copeia 1990: 802-817.

Moser, M. L. and S. W. Ross. 1995. Habitat use and movements of shortnose and Atlantic sturgeon in the lower Cape Fear River, North Carolina. Transactions of the American Fisheries Society 124: 225-234.

Moser, M. 1999a. Cape Fear River Blast Mitigation Tests: Results of Caged Fish Necropsies. CZR, Inc.

Moser, M. 1999b. Wilmington Harbor Blast Effect Mitigation Tests: Results of Sturgeon Monitoring and Fish Caging Experiments. CZR, Inc.

Mrosovsky, N. 1988. Pivotal temperatures for loggerhead turtles from northern and southern nesting beaches. Canadian Journal of Zoology 66:661-669.

Mrosovsky, N. 1995. Temperature and sex ratio. In: Bjorndal, K. (ed.) Biology and Conservation of Sea Turtles, revised edition. Smithsonian Institution Press, Washington, DC, pp. 597–598.

Mrosovsky, N. and C.L. Yntema. 1980. Temperature dependence of sexual differentiation in sea turtles: Implications for conservation practices. Biological Conservation, 18, 271-280.

Mussoline, S.E., D. Risch, L.T. Hatch, M.T. Weinrich, D.N. Wiley, M.A. Thompson, P.J. Corkeron, and S.M. Van Parijs. 2012. Seasonal and diel variation in North Atlantic right whale up-calls: implications for management and conservation in the northwestern Atlantic Ocean. Endangered Species Research 17:17-26.

National Marine Fisheries Service (NMFS) and Fedearl Highway Administration. 2018. Best Management Practices Manual for Transportation Activities in the Greater Atlantic Region. April 2018.

National Marine Fisheries Service (NMFS). 2012a. Endangered and Threatened Wildlife and Plants; Final Listing Determinations for Two Distinct Population Segments of Atlantic Sturgeon (*Acipenser oxyrinchus oxyrinchus*) in the Southeast. 77 FR 5914.

NMFS. 2016. Technical Guidance for Assessing the Effects of Anthropogenic Noise on Marine Mammal Hearing. National Marine Fisheries Service. July 2016. https://www.westcoast.fisheries.noaa.gov/protected_species/marine_mammals/threshold_guidance.html

NMFS. 2012b. BOEM Authorization for Dredging of Gulf of Mexico Sand Mining ("Borrow") Areas Using Hopper Dredges for the Town of Longboat Key, Beach Renourishment Project. NMFS, Southeast Regional Office, St. Petersburg, Florida.

NMFS. 2010a. Recovery plan for the fin whale (Balaenoptera physalus). National Marine Fisheries Service, Silver Spring, MD.

NMFS. 2010b. Biological Opinion on the Wallops Island Shoreline Restoration and Infrastructure Protection Program. NMFS, Northeast Regional Office, Gloucester, MA.

NMFS. 2008a. Final Environmental Impact Statement to Implement Vessel Operational Measures to Reduce Ship Strikes to North Atlantic Right Whales. National Marine Fisheries Service, Silver Spring, MD.

NMFS. 2008b. Assessment and Mitigation of Marine Explosives: Guidance for Protected Species in the Southeast U.S. Draft. National Marine Fisheries Service, Southeast Regional Office, St. Petersburg, FL.

NMFS. 2006. Review of the Status of the Right Whales in the North Atlantic and North Pacific Oceans. National Marine Fisheries Service, Silver Spring, MD.

NMFS. 2005. Recovery Plan for the North Atlantic Right Whale (*Eubalaena glacialis*). National Marine Fisheries Service, Silver Spring, MD.

NMFS. 1998. Recovery Plan for the Shortnose Sturgeon (*Acipenser brevirostrum*). Prepared by the Shortnose Sturgeon Recovery Team for the National Marine Fisheries Service, Silver Spring, MD.

NMFS. 1997. Biological Opinion for Continued Hopper Dredging of Channels and Borrow Areas in the Southeastern United States. National Marine Fisheries Service, Southeast Regional Office.

NMFS. 1995. Biological Opinion for Hopper Dredging of Channels and Beach Nourishment Activities in the Southeastern United States from North Carolina through Florida East Coast. National Marine Fisheries Service, Southeast Regional Office.

NMFS. 1991. Biological Opinion for Dredging of Channels in the Southeastern United States from North Carolina through Cape Canaveral, Florida. National Marine Fisheries Service, Southeast Regional Office.

NMFS and U.S. Fish and Wildlife Service (USFWS). 2013. Pacific Leatherback 5-Year Action Plan Leatherback Sea Turtle (*Dermochelys coriacea*) 5-Year Review: Summary and Evaluation. National Marine Fisheries Service, Silver Spring, MD and U.S. Fish and Wildlife Service, Jacksonville, FL.

NMFS and USFWS. 2008. Recovery Plan for the Northwest Atlantic Population of the Loggerhead Sea Turtle (*Caretta caretta*), Second Revision. National Marine Fisheries Service, Silver Spring, MD and U.S. Fish and Wildlife Service. Atlanta, GA.

NMFS and USFWS. 2007a. Loggerhead Sea Turtle (*Caretta caretta*) 5-Year Review: Summary and Evaluation. National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD and U.S. Fish and Wildlife Service, Southeast Region, Jacksonville Ecological Services Field Office, Jacksonville, FL.

NMFS and USFWS. 2007b. Green Sea Turtle (*Chelonia mydas*) 5-Year Review: Summary and Evaluation. National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD and U.S. Fish and Wildlife Service, Southeast Region, Jacksonville Ecological Services Field Office, Jacksonville, FL.

NMFS and USFWS. 2007c. Kemp's Ridley Sea Turtle (*Lepidochelys kempii*) 5-Year Review: Summary and Evaluation. National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD and U.S. Fish and Wildlife Service, Southwest Region, Albuquerque, NM.

NMFS and USFWS. 2007d. Hawksbill Sea Turtle (*Eretmochelys imbricata*) 5-Year Review: Summary and Evaluation. National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD and U.S. Fish and Wildlife Service, Southeast Region, Jacksonville Ecological Services Field Office, Jacksonville, FL.

NMFS and USFWS. 2007e. Leatherback Sea Turtle (*Dermochelys coriacea*) 5-Year Review: Summary and Evaluation. National Marine Fisheries Service, Office of Protected Resources, Silver Spring, MD and U.S. Fish and Wildlife Service, Southeast Region, Jacksonville Ecological Services Field Office, Jacksonville, FL.

NMFS and USFWS. 1993. Recovery Plan for Hawksbill Turtles in the U.S. Caribbean Sea, Atlantic Ocean, and Gulf of Mexico. National Marine Fisheries Service, St. Petersburg, FL.

NMFS and USFWS. 1992. Recovery plan for leatherback turtles (*Dermochelys coriacea*) in the U.S. Caribbean, Atlantic, and Gulf of Mexico. National Marine Fisheries Service, Washington, D.C.

National Park Service (NPS). 2014. Draft Cape Lookout National Seashore off-road vehicle management plan/environmental impact statement. Spring-Summer 2014. U.S. Department of the Interior, National Park Service, Cape Lookout National Seashore, North Carolina.

National Park Service (NPS). 2015. Sea Turtle Annual Report Cape Hatteras. Cape Hatteras National Seashore. North Carolina. https://www.nps.gov/articles/caha_st2015.htm

Nelson, D.A. 1991. Issues associated with beach nourishment and sea turtle nesting. Proceedings of the Fourth Annual National Beach Preservation Technology Conference. Florida Shore and Beach Association, Tallahassee, FL, p. 277-294.

Nelson, D.A., and D.D. Dickerson. 1988. Effects of beach nourishment on sea turtles. In L.S. Tait (ed.) Proceedings of the beach preservation technology conference. 1988. Florida Shore & Beach Preservation Association, Incorporated; Tallahassee, Florida.

North Carolina Division of Coastal Management (NCDCM) 2016. Not complete

NCWRC. 2016. Status of Piping Plover in North Carolina: 2016 Breeding Season Census and International Winter Census Results. Unpublished data provided by E. Kornega, A, Andersson, and S. Schweitzer, NCWRC, Wildlife Diversity Program, Waterbird Investigations and Management Project, New Bern, NC.

NCWRC. 2015. NCWRC shorebird database, piping plover and red knot statewide data 2000-2014. Unpublished data provided by S. Schweitzer, NCWRC, Wildlife Diversity Program, Waterbird Investigations and Management Project, New Bern, NC.

Nowacek D, M.P. Johnson, and P.L. Tyack. 2004. North Atlantic right whales (*Eubalaena glacialis*) ignore ships but respond to alerting stimuli. Proceedings of the Royal Society of London. Series B. Biological Sciences 271: 227-231.

Oakley, N.C. and J.E. Hightower. 2007. Status of shortnose sturgeon in the Neuse River, North Carolina. Pages 273–284 In: Munro, J., D. Hatin, J. Hightower, K. McKown, K.J. Sulak, A.W. Kahnle, and F. Caron (eds.) Anadromous sturgeons: habitats, threats, and management. American Fisheries Society, Symposium 56, Bethesda, Maryland.

Parr, T., D. Diener, and Lacy, L. 1978. Effects of beach replenishment on the nearshore sand fauna at Imperial Beach, California. U.S. Army Corps of Engineers, CERC Misc. Rep. 78-4, 1-125.

Pettis, H. 2013. North Atlantic Right Whale Consortium 2013 annual report card. Report to the North Atlantic Right Whale Consortium, November 2013.

Post, W. C., T. Darden, D. L. Peterson, M. Loeffler, and C. Collier. 2014. Research and management of endangered and threatened species in the southeast: riverine movements of Shortnose and Atlantic sturgeon. South Carolina Department of Natural Resources, Project NAIONMF4720036, Final Report, Charleston.

Provancha, J.A. and L.M. Ehrhart. 1987. Sea turtle nesting trends at Kennedy Space Center and Cape Canaveral Air Force Station, Florida, and relationships with factors influencing nest site selection. Pages 33-44 in Witzell, W.N. (editor). Ecology of East Florida Sea Turtles: Proceedings of the Cape Canaveral, Florida Sea Turtle Workshop. NOAA Technical Report NMFS-53.

Quattro, J.M., T.W. Greig, D.K. Coykendall, B.W. Bowen, and J.D. Baldwin. 2002. Genetic issues in aquatic species management: the shortnose sturgeon (*Acipenser brevirostrum*) in the southeastern United States. Conservation Genetics 3: 155-166.

Ray, G. 1997. Benthic characterization of Wilmington Harbor and Cape Fear River Estuary, Wilmington, North Carolina. USACE, Waterways Experiment Station, Coastal Ecology Branch. Report prepare for the USACE, Wilmington District. July 1997.

Reeves, R.R., R. Rolland, and P. Clapham, (eds.). 2001. Report of the workshop on the causes of reproductive failure in North Atlantic right whales: new avenues of research. Northeast Fish. Sci. Cent. Ref. Doc. 01-16.

Reilly, F.J. Jr., and V.J. Bellis. 1978. A study of the ecological impact of beach nourishment with dredged materials on the intertidal zone. Institute for Coastal and Marine Resources, Technical Report No. 4.

Reine, K.J., D. Clarke, C. Dickerson, and G. Wikel. 2014. Characterization of Underwater Sounds Produced by Trailing Suction Hopper Dredges during Sand Mining and Pump-out Operations. U.S. Department of the Interior, Bureau of Ocean Energy Management and U.S. Army Corps of Engineers. ERDC/EL TR 14-3, BOEM 2014-055. Herndon, VA, March 2014.

Richmond, D.R., Yelverton, J.T., & Fletcher, F.R. 1973. Far-field underwater blast injuries produced by small charges, Rep. No. DNA 3081T. Lovelace Foundation for Medical Education and Research.

Riggs, S.R., D.V. Ames, S.J. Culver, D.J. Mallinson, D.R. Corbett, and J.P. Walsh. 2009. Eye of a human hurricane: Pea Island, Oregon Inlet, and Bodie Island, northern Outer Banks, North Carolina, in Kelley, J.T., O.H. Pilkey, and J.A.G. Cooper, eds., America's Most Vulnerable Coastal Communities: Geological Society of America Special Paper 460, p. 43–72.

Rosenthal, H. and Alerdice, D.F. 1976. Sublethal effects of environmental stressors, natural and pollutional, on marine fish eggs and larvae. Journal of the Fisheries Research Board of Canada, 33: 2047-2065.

Ross, S.W., F.C. Rohde, and D.G. Lindquist. 1988. Endangered, threatened, and rare fauna of North Carolina, Part 2. A re-evaluation of the marine and estuarine fishes. North Carolina Biological Survey, Occasional Papers 1988-7, Raleigh, North Carolina.

Rumbold, D.G., P.W. Davis, and C. Perretta. 2001. Estimating the effect of beach nourishment on (*Caretta caretta*) loggerhead sea turtle nesting. Restoration Ecology, 9(3): 304-310.

Salmon, M., J. Wyneken, E. Fritz, and M. Lucas. 1992. Seafinding by hatchling sea turtles: role of brightness, silhouette and beach slope as orientation cues. Behaviour 122(1-2): 56-77.

Saloman, C.H. and S.P. Naughton. 1984. Beach restoration with offshore dredged sand: effects on nearshore macroinfauna. *NOAA Technical Memorandum*, NMFS-SEFC(133). US Department of Commerce. NOAA, National Marine Fisheries Service, Southeast Fisheries Center: Panama City. 20 pp.

Schick, R.S., P.N. Halpin, A.J. Read, C.K. Slay, S.D. Kraus, B.R. Mate, M.F. Baumgartner, J.J. Roberts, B.D. Best, C.P. Good, S.R. Loarie, and J.S. Clark. 2009. Striking the right balance in right whale conservation. Canadian Journal of Fisheries and Aquatic Sciences 66:1399-1403.

Schroeder, P.R. 2009. USACE Technical Guidelines for Practicing the 3R's of Environmental Dredging. Proceedings of the Western Dredging Association Twenty-ninth Technical Conference and 40th Annual Texas A&M Dredging Seminar, Tempe, AZ, June 2009.

Schweitzer, S.H., Anderson, A., Kornegay, E., Hand, C., Kays, R., Bryan, L. 2016. Wood Stork Nesting Population Survey Results 2016 and Radio-tracking Dive. Presentation. http://ncpif.ncbirdingtrail.org/wp-content/uploads/2018/03/2016-Storks-LETE2017-CWB-surveySchweitzeretal.pdf

Seaturtle.org. 2011. Sea turtle rehabilitation and necropsy database, North Carolina stranding reports. On-line: http://www.seaturtle.org.

Shortnose Sturgeon Status Review Team (SSSRT). 2010. A biological assessment of shortnose sturgeon (Acipenser brevirostrum). Report to National Marine Fisheries Service, Northeast Regional Office.

Southall, B.L., A.E. Bowles, Ellison, J.J. Finneran, R.L. Gentry, C.R.J. Greene, D. Kastak, D.R. Ketten, J.H. Miller, P.E. Nachtigall, W.J. Richardson, J.A. Thomas, P. Tyack. 2007. Marine mammal noise exposure criteria: initial scientific recommendations. Aquatic Mammals 33:411-521.

Stadler, J.H., and Woodbury, D.P. 2009. Assessing the effects to fishes from pile driving: Application of new hydroacoustic criteria. 38th International Congress and Exposition on Noise Control Engineering 2009. Inter-Noise 2009.

Steinitz, M.J., M. Salmon, and J. Wyneken. 1998. Beach renourishment and loggerhead turtle reproduction: A seven year study at Jupiter Island, Florida. Journal of Coastal Research 14: 1000-1013.

Thomsen, F., S.R. McCully, D. Wood, P. White, F. Page. 2009. A generic investigation into noise profiles of marine dredging in relation to the acoustic sensitivity of the marine fauna in UK waters: PHASE 1 Scoping and review of key issues. Aggregates Levy Sustainability Fund/Marine Environmental Protection Fund, Lowestoft, UK.

Turtle Expert Working Group (TEWG). 1998. An Assessment of the Kemp's; Ridley (*Lepidochelys kempii*) and Loggerhead (Caretta caretta) Sea Turtle Populations in the Western North Atlantic. NOAA Technical Memorandum NMFS-SEFSC-409. 96 pp.

United States Army Corps of Engineers (USACE). 2016. Sea Turtle Protection and Data Warehouse. Available at: http://el.erdc.usace.army.mil/seaturtles/.

USACE. 2014. Section 7(a)(2) and 7(d) Endangered Species Act Jeopardy Analysis of the Effect on Atlantic Sturgeon of Navigation Channel Maintenance Dredging and Dredging of Offshore Borrow Sources for Beach Sand Placement on the South Atlantic Coast (21 April 2014). USACE, South Atlantic Division, Atlanta, GA.

United States Fish and Wildlife Service (USFWS). 2016. Estimated abundance of Atlantic Coast piping plovers 1986 - 2014 and preliminary 2015 estimates. USFWS, Sudbury, Massachusetts.

USFWS. 2015. Statewide Programmatic Biological Opinion (Revised) for the U.S. Army Corps of Engineers (Corps) planning and regulatory shore protection activities in Florida. 27 February 2015. South Florida Ecological Services Field Office, Vero Beach, FL.

USFWS. 2014. Rufa red knot background information and threats assessment. Supplement to endangered and threatened wildlife and plants; final threatened status for the rufa red knot (*Calidris canutus rufa*). Docket No. FWS-R5-ES-2013-0097; RIN AY17. New Jersey Field Office; Pleasantville, New Jersey.

USFWS. 2012. Comprehensive conservation strategy for the piping plover (*Charadrius melodus*) in its coastal migration and wintering range in the continental United States. U.S. Fish and Wildlife Service; East Lansing, Minnesota.

USFWS. 2009a. Draft (5/18/09) West Indian Manatee (*Trichechus manatus*) Florida Stock Florida subspecies (*Trichechus manatus latirostris*). U.S. Fish and Wildlife Service, Jacksonville, FL.

USFWS. 2009b. Piping plover (*Charadrius melodus*) 5-year review: summary and evaluation. U.S. Fish and Wildlife Service, Hadley, Massachusetts.

USFWS. 2005. Wood stork (*Mycteria americana)* 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Raleigh Ecological Services Field Office, Raleigh, NC.

USFWS. 2005. Seabeach Amaranth (*Amaranthus pumilus*) 5-Year Review: Summary and Evaluation. U.S. Fish and Wildlife Service, Raleigh Ecological Services Field Office, Raleigh, NC.

USFWS. 2001. Florida Manatee Recovery Plan, (*Trichechus manatus latirostris*), Third Revision. U.S. Fish and Wildlife Service. Atlanta, GA.

USFWS. 1997. Revised Recovery Plan for the U.S. Breeding Population of the Wood Stork. U.S. Fish and Wildlife Service, Atlanta, GA.

USFWS. 1996a. Piping Plover (*Charadrius melodus*), Atlantic Coast Population, Revised Recovery Plan. U.S. Fish and Wildlife Service, Hadley, MA.

USFWS. 1996b. Recovery Plan for Seabeach Amaranth (*Amaranthus pumilus*), Southeast Region, Atlanta, Georgia.

Van Dolah, R.F., P.H. Wendt, R.M. Martore, M.V. Levisen, W.A. Roumillat. 1992. A physical and biological monitoring study of the Hilton Head beach nourishment project. Marine Resources Research Institute, South Carolina Marine Resources Division, Charleston, S.C. 159 pp.

Van Dolah, R.F., R.M. Martore, A.E. Lynch, P.H. Wendt, M.V. Levisen, D.J. Whitaker, and W.D. Anderson. 1994. Final Report. Environmental evaluation of the Folly Beach nourishment project. South Carolina Department of Natural Resources, Marine Resources Division, Charleston SC. Prepared for the United States Army Corps of Engineers, Charleston District, Charleston, SC.

Wibbels, T. 2003. Critical approaches to sex determination in sea turtles. In: Biology of Sea Turtles, Vol. II (Eds. Lutz, P.L., J.A. Musick, and J. Wyneken) pp. 103-134. Boca Raton: CRC Press.

Wilber, D.H., W. Brostoff, D.G. Clarke, and G.L. Ray. 2005. Sedimentation: Potential biological effects from dredging operations in estuarine and marine environments. DOER Technical Notes Collection (ERDC TN-DOER-E20). Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Wiley, M.L., J.B. Gaspin, and G.F. Goertner. 1981. Effects of underwater explosions on fish with a dynamic model to predict fishkill. Ocean Science and Engineering 6:223-284.

Winn, H.E., C.A. Price, and P.W. Sorensen. 1986. The distributional biology of the right whale (*Eubalaena glacialis*) in the western North Atlantic. Reports of the International Whaling Commission (Special Issue 10):129-138.

Wirgin, I., C. Grunwald, E. Carlson, J. Stabile, D.L. Peterson, and J. Waldman. 2005. Range-wide population structure of shortnose sturgeon, (*Acipenser brevirostrum*), based on sequence analysis of the mitochondrial DNA control region. Estuaries Vol. 28(3): 406-421.

Witherington, B.E. 1997. The problem of photopollution for sea turtles and other nocturnal animals. Pages 303-328 in Clemmons, J.R. and R. Buchholz (editors). Behavioral Approaches to Conservation in the Wild. Cambridge University Press, Cambridge, United Kingdom.

Witherington, B.E. 1992. Behavioral responses of nesting sea turtles to artificial lighting. Herpetologica 48(1):31-39.

Witherington, B.E. 1986. Human and natural causes of marine turtle clutch and hatchling mortality and their relationship to hatchling production on an important Florida nesting beach. Unpublished Master of Science thesis. University of Central Florida, Orlando, Florida. 141 pages.

Witherington, B.E., S. Hirama, and A. Mosier. 2006. Changes to armoring and other barriers to sea turtle nesting following severe hurricanes striking Florida beaches. Final Project Report to the U.S. Fish and Wildlife Service. 11 pages.

Witherington, B.E. and R.E. Martin. 2003. Understanding, Assessing, and Resolving Light-Pollution Problems on Sea Turtle Nesting Beaches. Third edition revised 2003. Florida Marine Research Institute Technical Report. Technical Report TR-2.

Wood, D.W. and K.A. Bjorndal. 2000. Relation of temperature, moisture, salinity, and slope to nest site selection in loggerhead sea turtles. Copeia 2000(1):119-128.

Wursig, B., Greene, C. R., and Jefferson, T.A. 2000. Development of an air bubble curtain to reduce underwater noise of percussive piling. Marine Environmental Research 49: 79-93.

Yelverton, J.T., D.R. Richmond, W. Hicks, K. Sanders, and E.R. Fletcher. 1975. The relationship between fish size and their response to underwater blast. Defense Nuclear Agency, topical report DNA 3677T.

Yntema, C.L. and N. Mrosovsky. 1982. Critical periods and pivotal temperatures for sexual differentiation in loggerhead sea turtles. Canadian Journal of Zoology, 60, 1012-1016.

APPENDIX A

USFWS GUIDELINES FOR AVOIDING IMPACTS TO THE WEST INDIAN MANATEE

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Raleigh Field Office
Post Office Box 33726
Raleigh, North Carolina 27636-3726

GUIDELINES FOR AVOIDING IMPACTS TO THE WEST INDIAN MANATEE
Precautionary Measures for Construction Activities in North Carolina Waters

The West Indian manatee (*Trichechus manatus*), also known as the Florida manatee, is a Federally-listed endangered aquatic mammal protected under the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*) and the Marine Mammal Protection Act of 1972, as amended (16 U.S.C 1461 *et seq.*). The manatee is also listed as endangered under the North Carolina Endangered Species Act of 1987 (Article 25 of Chapter 113 of the General Statutes). The U.S. Fish and Wildlife Service (Service) is the lead Federal agency responsible for the protection and recovery of the West Indian manatee under the provisions of the Endangered Species Act.

Adult manatees average 10 feet long and weigh about 2,200 pounds, although some individuals have been recorded at lengths greater than 13 feet and weighing as much as 3,500 pounds. Manatees are commonly found in fresh, brackish, or marine water habitats, including shallow coastal bays, lagoons, estuaries, and inland rivers of varying salinity extremes. Manatees spend much of their time underwater or partly submerged, making them difficult to detect even in shallow water. While the manatee's principal stronghold in the United States is Florida, the species is considered a seasonal inhabitant of North Carolina with most occurrences reported from June through October.

To protect manatees in North Carolina, the Service's Raleigh Field Office has prepared precautionary measures for general construction activities in waters used by the species. Implementation of these measure will allow in-water projects which do not require blasting to proceed without adverse impacts to manatees. In addition, inclusion of these guidelines as conservation measures in a Biological Assessment or Biological Evaluation, or as part of the determination of impacts on the manatee in an environmental document prepared pursuant to the National Environmental Policy Act, will expedite the Service's review of the document for the fulfillment of requirements under Section 7 of the Endangered Species Act. These measures include:

1. The project manager and/or contractor will inform all personnel associated with the project that manatees may be present in the project area, and the need to avoid any harm to these endangered mammals. The project manager will ensure that all construction personnel know the general appearance of the species and their habit of moving about completely or partially submerged in shallow water. All construction personnel will be informed that they are responsible for observing water-related activities for the presence of manatees.

2. The project manager and/or the contractor will advise all construction personnel that

there are civil and criminal penalties for harming, harassing, or killing manatees which are protected under the Marine Mammal Protection Act and the Endangered Species Act.

3. If a manatee is seen within 100 yards of the active construction and/or dredging operation or vessel movement, all appropriate precautions will be implemented to ensure protection of the manatee. These precautions will include the immediate shutdown of moving equipment if a manatee comes within 50 feet of the operational area of the equipment. Activities will not resume until the manatee has departed the project area on its own volition (i.e., it may not be herded or harassed from the area).

4. Any collision with and/or injury to a manatee will be reported immediately. The report must be made to the U.S. Fish and Wildlife Service (ph. 919.856.4520 ext. 16), the National Marine Fisheries Service (ph. 252.728.8762), and the North Carolina Wildlife Resources Commission (ph. 252.448.1546).

5. A sign will be posted in all vessels associated with the project where it is clearly visible to the vessel operator. The sign should state:

> CAUTION: The endangered manatee may occur in these waters during the warmer months, primarily from June through October. Idle speed is required if operating this vessel in shallow water during these months. All equipment must be shut down if a manatee comes within 50 feet of the vessel or operating equipment. A collision with and/or injury to the manatee must be reported immediately to the U.S. Fish and Wildlife Service (919-856-4520 ext. 16), the National Marine Fisheries Service (252.728.8762), and the North Carolina Wildlife Resources Commission (252.448.1546).

6. The contractor will maintain a log detailing sightings, collisions, and/or injuries to manatees during project activities. Upon completion of the action, the project manager will prepare a report which summarizes all information on manatees encountered and submit the report to the Service's Raleigh Field Office.

7. All vessels associated with the construction project will operate at "no wake/idle" speeds at all times while in water where the draft of the vessel provides less than a four foot clearance from the bottom. All vessels will follow routes of deep water whenever possible.

8. If siltation barriers must be placed in shallow water, these barriers will be: (a) made of material in which manatees cannot become entangled; (b) secured in a manner that they cannot break free and entangle manatees; and, (c) regularly monitored to ensure that manatees have not become entangled. Barriers will be placed in a manner to allow manatees entry to or exit from essential habitat.

Prepared by (rev. 06/2003):
U.S. Fish and Wildlife Service
Raleigh Field Office
Post Office Box 33726
Raleigh, North Carolina 27636-3726
919/856-4520

Figure 1. The whole body of the West Indian manatee may be visible in clear water; but in the dark and muddy waters of coastal North Carolina, one normally sees only a small part of the head when the manatee raises its nose to breathe.

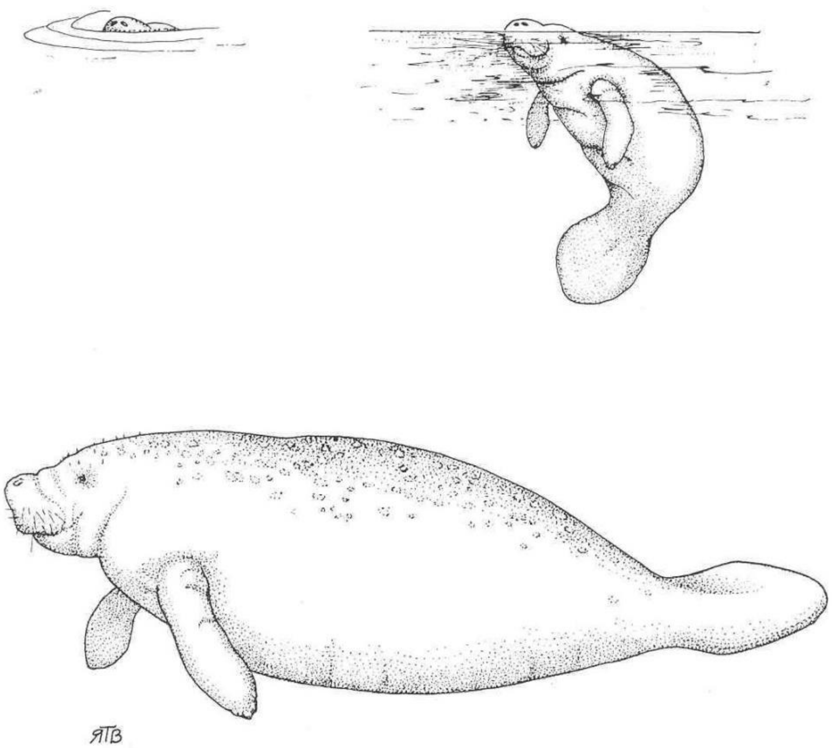

Illustration used with the permission of the North Carolina State Museum of Natural Sciences. Source: Clark, M. K. 1987. Endangered, Threatened, and Rare Fauna of North Carolina: Part I. A re-evaluation of the mammals. Occasional Papers of the North Carolina Biological Survey 1987-3. North Carolina State Museum of Natural Sciences. Raleigh, NC. pp. 52.