

III. Environmental Considerations

A. Ecological Habitat

The North Carolina Coastal Habitat Protection Plan (CHPP) identifies six primary habitats in coastal North Carolina that are vital to the health and function of coastal ecosystems and fisheries (water column, shell bottom, submerged aquatic vegetation, wetlands, soft bottom and hard bottom). This section identifies available data sources pertaining to these habitat types that are critical to the development of the BIMP and local strategy development. Detailed discussions of the environmental considerations at a localized level can be found in the individual region sections (Sections VIII – XI). Plots of the available environmental datasets for each of the habitat concerns listed in this section can be found in Appendix F.

1. Water Column

a) Habitat Description and Ecological Value

“The flow and quality of water in the water column are key factors linking fish, habitat, and people. The coastal fisheries ecosystem along the North Carolina coast is supported by a range of water column conditions. Water column properties that may affect fisheries resources include temperature, salinity, dissolved oxygen (DO), total suspended solids, nutrients (nitrogen, phosphorus), and chlorophyll *a* (SAFMC 1998a). Other factors, such as depth, pH, water velocity and movement, and water clarity, also affect the distribution of aquatic organisms. Those properties are affected by growing development pressures along our coast as well as far inland. Determining the best course of action for enhancing water quality requires detailed knowledge of the water quality characteristics that various species require throughout their life cycle, along with the status, trends, and threats to those characteristics.” (CHPP 2010)

Water column habitat is defined by the CHPP as “the water covering a submerged surface and its physical, chemical, and biological characteristics.” The water column, defined as such, includes any area where surface waters exist for any length of time. This area includes surface waters up to the mean high water level (in tidal systems) or mean normal water level (in non-tidal systems). However, the area of fish utilization includes wetland areas and non-navigable streams subject to periodic flooding. The coastal aquatic ecosystem is divided among several river basins draining into North Carolina’s estuarine and marine systems. Within a river basin, characteristics of the water column change markedly from the basin’s extreme headwaters to the ocean. These factors also determine spatial and temporal differences in fish assemblage structure.

The water column is the dominant component of North Carolina’s coastal aquatic ecosystem and is comprised of rivers, creeks, lakes, impoundments, barrier sounds and estuaries, as well as ocean waters within the state’s three-nautical-mile offshore territorial jurisdiction. All of the habitats documented in the CHPP are connected by the water column, and all can be adversely affected by both natural and anthropogenic impacts.

Productivity in the water column is derived mostly from phytoplankton, but detritus and organic matter flushed from upstream sources also provides a foundation for this productivity. In its most basic function, the water column allows fish species to navigate through it to utilize other habitats during various stages of their life cycle (CHPP 2005).

The Environmental Management Commission (EMC) classifies surface waters according to the best use of the water (*e.g.*, water supply, aquatic life propagation, swimming, etc.) and designates water quality standards that are intended to protect the designated uses (CHPP 2005). The North Carolina Division of Water Quality (DWQ) maintains best use data for EMC-classified surface waters. The North Carolina Marine Fisheries Commission (MFC) and the North Carolina Wildlife Resources Commission (NCWRC) also designate areas with ecological functions vital to fish and shellfish production, including nursery and spawning areas (CHPP 2005).

b) Current Threats to the Water Column

Human activities that can adversely affect the water column include, but are not limited to, hydrological modifications, water withdrawal, channelization, shoreline stabilization, dredging, point source discharges and non-point source discharges (CHPP 2005). Urban stormwater runoff, urban construction, croplands and phosphate mining are identified by the CHPP as the most severe threats to water column fish habitat. Dredging and beach nourishment projects may adversely affect the water column due to increased turbidity, which can deter recruitment of larvae, clog the gills of fish, reduce foraging opportunities, reduce the distribution of nearshore infaunal prey and redistribute toxins contained in the sediment back into the water column.

c) Available Data

Available data regarding water column habitat can be found in the following resources:

- CHPP – In addition to a detailed description of the water column habitat, the CHPP also provides numerous citations referencing research conducted on the water column.
- North Carolina Division of Water Quality – DWQ provides numerous data sources with regard to the water quality of coastal waters. This data includes Basin-Wide Management Plans, Water Quality Reports, Best Usage Classifications, Surface Water Classifications, Outstanding Resource Waters, High Quality Waters, Riparian Buffer and Bioclassifications. The majority of this information can be found at <http://portal.ncdenr.org/web/wq>.
- North Carolina Department of Environment and Natural Resources – DENR has designed a GIS-based conservation planning tool to streamline the process of identifying and prioritizing essential conservation areas. Information on this planning tool is available at <http://www.onencnaturally.org>.
- North Carolina Division of Marine Fisheries – DMF maintains maps of all habitats described in the CHPP and some can be accessed at <http://www.ncfisheries.net>.

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- North Carolina Division of Water Resources – DWR manages programs regarding water basin management, water supply, conservation, and water resources development. Information on these programs is available at <http://www.ncwater.org/>.
 - North Carolina Division of Environmental Health – DEH promotes human health and protects the environment in various ways including through coastal recreational water quality monitoring and monitoring the health of shellfish and crustaceans sold to the public. Information on DEH is available at <http://www.deh.enr.state.nc.us/index.htm>.
 - North Carolina Division of Land Resources – DLR promotes the wise use and protection of North Carolina's land and geologic resources through scientific investigations and maps of the N.C. Geological Survey, through the mining, dam safety, and sedimentation control programs of the division's Land Quality Section, and through the Geodetic Survey Section to maintain the official survey base of the State to support mapping, boundary determination, and property delineation. <http://www.dlr.enr.state.nc.us/>.
 - North Carolina Division of Soil & Water Conservation – The Division of Soil and Water Conservation works in cooperation with the Soil and Water Conservation Commission to protect and improve soil and water resources throughout the state. <http://www.enr.state.nc.us/DSWC/>.
 - North Carolina Center for Geographic Information and Analysis – CGIA is the lead agency for GIS services and coordination in North Carolina. <http://www.cgia.state.nc.us/>.
 - Albemarle-Pamlico National Estuary Program – APNEP is a community-based watershed program that focuses not only on improving water quality in estuaries, but also on maintaining the integrity of the whole ecosystem. APNEP's primary purpose is to implement the Comprehensive Conservation and Management Plan (CCMP) with guidance from its citizen advisory boards. The Comprehensive Conservation and Management Plan presents strategies to better manage and integrate the environmental and economic resources in the Albemarle-Pamlico estuary. <http://www.apnep.org/>.
 - Clean Water Management Trust Fund – CWMTF receives a direct appropriation from the General Assembly in order to issue grants to local governments, state agencies and conservation non-profits to help finance projects that specifically address water pollution problems. The 21-member, independent, CWMTF Board or Trustees has full responsibility over the allocation of moneys from the Fund. CWMTF will fund projects that (1) enhance or restore degraded waters, (2) protect unpolluted waters, and/or (3) contribute toward a network of riparian buffers and greenways for environmental, educational, and recreational benefits. <http://www.cwmtf.net/>.
 - North Carolina National Estuarine Research Reserve – <http://www.ncnerr.org/>.

- North Carolina Department of Environment and Natural Resources Stormwater and Runoff Pollution Website – <http://www.ncstormwater.org/>.
- United States Geological Survey - National Water Information System – <http://waterdata.usgs.gov/nc/nwis/current/?type=flow>.
- United States Environmental Protection Agency – Results of fisheries sampling in various NC estuaries and coastal waters can be obtained online through EPA’s Environmental Monitoring & Assessment Program. Information available at <http://www.epa.gov/emap/nca/sampling.html>.
- United States Geologic Survey – Data layers including information about erosion rates, dissolved oxygen contours, and various other data useful for coastal studies are available at <http://nmviewogc.cr.usgs.gov/viewer.htm>.

d) Identified Data Gaps and Research Needs

The CHPP identifies several areas where research or monitoring needs to be enhanced to provide better information regarding beach and inlet management as it relates to the overall effect on water column habitat. Items identified in the CHPP include:

- Areas where dredging could enhance habitat should be identified and studied for habitat restoration efforts. This may be especially important along the mouths of certain tidal creeks that may be nearly blocked due to sedimentation. Dredging these creek mouths will promote increased flushing and improve overall water quality within the creeks.

2. Shell Bottom

a) Habitat Description and Ecological Value

Shell bottom is defined by the CHPP as “estuarine intertidal or subtidal bottom composed of surface shell concentrations of living or dead oysters (*Crassostrea virginica*), hard clams (*Merceneria merceneria*), and other shellfish.” Shell bottom habitats are commonly referred to as “oyster beds,” “oyster rocks,” “oyster reefs,” “oyster bars,” and “shell hash.” While most of these terms describe concentrations of living and dead oysters, shell hash refers to an accumulation of unconsolidated broken shell (oyster, clam, bay scallop and/or other shellfish) on sand or mud substrates (CHPP 2005). Shell bottom is both intertidal and subtidal, and can consist of fringing or patch oyster reefs, surface aggregations of living shellfish, and shell accumulations (Coen, *et al.* 1999; ASMFC 2007). Shell bottom habitat plays a vital role in the overall water quality of our coastal waters and provides beneficial fish habitat for recreationally and commercially important finfish, mollusks and crustaceans. Many of these species utilize shell bottom habitat for refuge, foraging, spawning and as a nursery area. Healthy shell bottom containing oysters, clams and other shellfish also represents a commercially valuable fishery resource that is economically important to North Carolina.

b) Current Threats to Shell Bottom Habitat

Although shell bottom consists of both living and non-living shell material, annual recruitment of live shellfish is needed to sustain the supply of shell material and the three-dimensional structure of oyster reefs. Mollusks that contribute shell material include oysters, hard clams, bay scallops, as well as many non-fishery species. Since oysters are the dominant contributor to shell bottom, the threats discussed below focus primarily on oyster reefs. Therefore, any activity that directly removes or destroys live shellfish, or indirectly prevents or slows growth and survival, is a threat to shell bottom habitat.

Potential adverse effects to shell bottom habitat primarily result from physical threats, water quality degradation, disease, the introduction of non-native species and climate change. Physical threats include channel dredging, infrastructure projects, boating activity, water dependent development such as marinas and docks, hand harvesting, and the use of bottom disturbing fishing gear.

The CHPP has identified urban stormwater runoff and fishing related impacts to shell bottom fish habitat as the most severe threats, while channel and inlet dredging is identified as a moderate threat due to increased turbidity and sedimentation. Beach nourishment and dredge material disposal are identified as unknown or potential threats to shell bottom fish habitat.

c) Available Data

Available data regarding shell bottom habitat can be found in the following resources:

- **CHPP** – In addition to a detailed description of the natural history and occurrence of shell bottom in North Carolina, the CHPP also provides several generalized maps identifying areas along the coast where shell bottom habitat occurs. Not all of the shell bottom data documented in the CHPP has been digitized or converted to metadata for GIS applications. The CHPP also identifies extensive research that has been conducted on shell bottom habitat and provides specific citations. The *2008-2009 CHPP Annual Report* identifies accomplishments and goals achieved related to each of the six primary habitat types. It also identifies the status of major data collection efforts being managed by various state agencies as they relate to the recommended actions identified in the CHPP.
- **DMF** – DMF maintains oyster reef maps and shell bottom maps as described in the CHPP. Information is available at <http://www.ncfisheries.net/>. However, not all of these maps are available on the website. Shellfish sanctuaries are identified at <http://www.ncfisheries.net/shellfish/sanctuary3.htm>.
- **DEH** – Additional information on shellfish habitat and closures may be found at <http://www.deh.enr.state.nc.us/shellfish/index.htm>.

d) Identified Data Gaps and Research Needs

The CHPP identifies several areas where research or monitoring needs to be enhanced to provide better information regarding beach and inlet management as it relates to the overall effect on shell bottom habitat. Items identified in the CHPP include:

- Spatially delineate and quantify where and how much of the coastal shoreline is hardened.
- Evaluate the effect of channel deepening to saltwater intrusion and subsequent oyster mortality to better define management action.

3. Submerged Aquatic Vegetation

a) Definition and Ecological Value

Submerged aquatic vegetation (SAV) consists of rooted, vascular plants that flower and, unlike algae, contain specialized parts such as leaves, stems, rhizomes and roots. Unlike other coastal plants, SAV lives completely submerged in water during its entire life cycle and is fully adapted to life underwater. Habitat for SAV includes marine, estuarine, brackish, and freshwater systems containing sandy or muddy sediment. Both high and low salinity SAV species occur in North Carolina waters. High salinity species that are most often found closer to coastal inlets include eelgrass (*Zostera mariana*), shoalgrass (*Halodule wrightii*) and widgeon grass (*Ruppia maritima*). The co-occurrence of these three species is unique to North Carolina, resulting in high coverage of shallow bottoms in North Carolina's estuaries (Ferguson and Wood 1994). Water quality and light penetration are two important factors contributing to the health of SAV habitat. In coastal North Carolina, SAV can grow in water up to 8.2 ft deep (Ferguson and Wood 1994).

SAV is considered a vital part of coastal ecosystems due to its role as a nursery for juvenile fish and other aquatic life, and also because it is an important link in the coastal food chain. SAV is classified as Essential Fish Habitat (EFH) for penaeid shrimp, red drum, and snapper/grouper species (CHPP 2005). SAV is considered EFH because of five interrelated features: primary production, structural complexity, modification of energy regimes, sediment and shoreline stabilization and nutrient recycling (CHPP 2005). Studies have shown that upwards of 150 different species of fish and shellfish have been documented to utilize North Carolina SAV habitat during some stage of their life cycle (CHPP 2005).

b) Current Threats to SAV

Potential adverse effects to SAV and SAV habitat primarily result from physical threats and water quality degradation. Physical threats include channel dredging, infrastructure projects, boating activity, marinas and docks, and fishing gear impacts (CHPP 2005). Each of these physical threats can lead to direct and/or indirect impacts to SAV and SAV habitat.

Water quality degradation is also a major cause of SAV decline and loss of habitat. Excess nutrient levels, low dissolved oxygen levels, sedimentation, turbidity, toxic chemicals, and nuisance species are all indicative of water quality degradation and all can have an adverse affect on SAV and SAV habitat. Excess nutrients entering coastal waters can cause algae blooms, which in turn decrease dissolved oxygen and light penetration. Land disturbing activities as well as in-water construction can cause sedimentation and turbidity problems that can also adversely affect SAV. The CHPP identifies channel and inlet dredging as a moderate threat to SAV fish habitat due to turbidity, sedimentation, and alteration of circulation patterns. Beach nourishment is identified as an unknown or potential threat. Shoreline hardening can also adversely affect SAV primarily due to increased wave energy on shorelines resulting from hardened structures. This increased wave energy accelerates shoreline erosion and often leads to loss of intertidal soft bottom habitat (SAV habitat).

Current state and federal regulations require avoidance and minimization of impacts to SAV from permitted dredge and fill activities, and have reduced the overall impact. New dredging is currently prohibited in SAV beds; however, maintenance dredging can occur if four criteria are met pursuant to 15A NCAC 07H .0208. These criteria are: 1) the applicant demonstrates and documents that a water-dependent need exists for the excavation, 2) there exists a previously permitted channel which was constructed or maintained under permits issued by the state or federal government, 3) excavated material can be removed and placed in an approved disposal area without significantly impacting adjacent nursery areas and beds of SAV, and 4) the original depth and width of human-made or natural channel will not be increased to allow a new or expanded use of the channel. NCDMF and the MFC currently review all projects that have the potential to affect SAV and/or SAV habitat along with the U.S. Army Corps of Engineers (USACE), NCDCM, NCDWQ, U.S. Fish and Wildlife Service (USFWS), and National Oceanic and Atmospheric Administration (NOAA).

c) Available Data

Available data regarding SAV habitat can be found in the following resources:

- CHPP – In addition to a detailed description of the natural history and occurrence of SAV in North Carolina, the CHPP also provides several generalized maps identifying areas along the coast where SAV beds have been identified. Not all of the SAV data documented in the CHPP has been digitized or converted to metadata for GIS applications. The CHPP recommends that more comprehensive mapping efforts be conducted to better evaluate the extent and health of SAV in coastal North Carolina. The CHPP also identifies extensive research that has been conducted on SAV habitat and provides specific citations. The *2008-2009 CHPP Annual Report* identifies accomplishments and goals achieved related to each of the six primary habitat types. It also identifies the status of major data collection efforts being managed by various state agencies as they relate to the recommended actions identified in the CHPP.

- Inventory of SAV Maps and Survey Work in Coastal North Carolina (1981-2006), NCDMF-Habitat Protection Section, 2007 – This comprehensive inventory of previous mapping studies identifies those areas along the North Carolina coast where SAV surveys and mapping have occurred. The specific data may be requested from the identified contributors, which includes academic institutions and regulatory agencies. Most of the surveys were based on analysis of aerial photography and also in-water data collection. This data can be obtained directly from the DMF-Habitat Protection Section.
- DMF – Maps depicting the Primary and Secondary Nursery Areas in coastal North Carolina are available at:
http://www.ncfisheries.net/maps/FNA_maps/index.html.
- Guidelines for the Conservation and Restoration of Seagrasses in the United States and Adjacent Waters, 1998. Fonseca M.S., W.J. Kenworthy, and G.W. Thayer. NOAA-Coastal Ocean Program.
- Submerged Aquatic Vegetation in the Albemarle-Pamlico Estuarine System, Project No. 88-10, 1990. Ferguson R.L., J.A. Rivera, and L.L. Wood.
- Rooted Vascular Beds in the Albemarle-Pamlico Estuarine System, Report No. 94-02, 1994. Ferguson R.L. and L.L. Wood.
- Mapping of Submerged Grass Beds in Core and Bogue Sounds, Carteret County, North Carolina, By Conventional Aerial Photography, 1983. R.J. Carraway and L.J. Priddy.

d) Identified Data Gaps and Research Needs

The CHPP identifies several areas where research or monitoring needs to be enhanced to provide better information regarding beach and inlet management as it relates to the overall effect on submerge aquatic vegetation habitat. Items identified in the CHPP include:

- DMF and the EMC should continue to use existing permit review authorities, and the CRC and EMC should provide more protection to SAV to assess indirect impacts.
- DMF should assess the effect of dredging in Core and Bogue sounds on SAV.

4. Wetlands

a) Definition and Ecological Value

Section 404 of the Clean Water Act requires regulation of discharges into “Waters of the United States.” Water bodies such as rivers, lakes, and streams are subject to jurisdictional consideration under the Section 404 program. However, by regulation, wetlands are also considered “Waters of the United States.” DCM and the CRC administer the Coastal Area Management Act, which affords additional protection to

certain areas located within the state's 20 coastal counties. Activities that impact a CAMA Area of Environmental Concern, including coastal wetlands, water column (public trust waters), and the upper edge of soft bottom (coastal shorelines) require approval through the DCM permitting program.

The CHPP focuses primarily on riparian wetlands that are found in estuarine and riverine systems. Estuarine wetlands include salt/brackish marsh, estuarine forested wetlands and estuarine shrub/scrub. Riverine wetlands comprise freshwater marshes, bottomland hardwood forests and headwater swamps (CHPP 2005). The focus on these types of wetlands in the CHPP is a result of the overall function and value of wetlands on water quality and ecosystem health and stability. Wetlands act as filters, removing pollutants from surface runoff, while also acting as sources of high primary productivity. The high primary productivity also enables wetlands to retain, and sometimes export large amounts of organic materials that are vital to the coastal waters of North Carolina. Salt marshes are thought to be nutrient sinks during the winter and spring and a source for nutrients during the summer and growing season. This exported organic material forms the basis for the food chain in the coastal waters. A 1987 study concluded that over 95 percent of the finfish commercially harvested in the United States are wetland-dependant at some time during their life cycle (CHPP 2005).

Wetlands also protect the shoreline from erosive forces of tides and wind. Additionally, wetlands slow and store flood waters and help disperse sediment, which decrease sedimentation and turbidity in our coastal waters. This buffering effect helps improve water clarity, which is beneficial for SAV and benthic algae (CHPP 2005).

b) Current Threats to Wetlands

It is estimated that 40-50 percent of North Carolina's original wetland coverage has been lost. Threats to wetlands, both estuarine and riverine systems, include physical threats, water quality degradation, introduced/nuisance species, and sea level rise/storm events. Each of these threats has been identified in the CHPP as a major factor in the degradation of the wetland systems along the North Carolina coast. The physical threats results primarily from land use and wetland alteration, shoreline stabilization, impervious surfaces, channelization/ditching, dredging for navigation, boating, and marinas, docks, and piers. Water quality degradation results from excess nutrient or contaminants entering the wetland system and affecting the soil chemistry and/or plant communities. Introduced and nuisance species such as the common reed (*Phragmites australis*) are degrading coastal wetland systems due to their aggressive growth and tendency to out-compete native wetland species. Sea level rise represents a major threat as water levels may be rising faster than the wetlands can naturally accrete (CHPP 2005). The CHPP identifies dams, urban/suburban construction, mining related activities and the most severe threats to wetland fish habitat. Dredging and shoreline hardening have also been identified by the CHPP as being often detrimental to wetland habitats.

c) Available Data

Available data regarding wetland habitat can be found in the following resources:

- CHPP – The CHPP provides a quantitative breakdown of the wetland types that occur along the North Carolina coast. The CHPP also identifies extensive research that has been conducted on wetland habitat and provides specific citations. The *2008-2009 CHPP Annual Report* identifies accomplishments and goals achieved related to each of the six primary habitat types. It also identifies the status of major data collection efforts being managed by various state agencies as they relate to the recommended actions identified in the CHPP.
- USFWS National Wetlands Inventory – NWI mapping is available either as 7.5-minute quadrangles or online. The landscape approach to NWI wetlands mapping is a useful tool; however, ground truthing is usually necessary to verify the wetlands identified by NWI. Information is available at www.nwi.fws.gov.
- DCM – North Carolina Coastal Region Evaluation of Wetland Systems – NC-CREWS evaluates the ecological significance of wetlands assessing functions such as water quality, wildlife habitat, water storage, shoreline stabilization, etc. GIS data collected and managed by DCM is available at <http://dcm2.enr.state.nc.us/Wetlands/nccrews.htm>. Additional wetland data compiled by DCM is available at <http://dcm2.enr.state.nc.us/Wetlands/download.htm>.
- NCFMP – Digital floodplain maps and data are available at www.ncfloodmaps.com.
- USGS – Additional data layers including information about wetlands are available at <http://nmviewogc.cr.usgs.gov/viewer.htm>.
- U.S. Department of Agriculture and Natural Resource Conservation Service – County soil surveys provide information on soil mapping units, including hydric soils, and are useful in identifying possible wetland areas. An online version is available at <http://websoilsurvey.nrcs.usda.gov>.

d) Identified Data Gaps and Research Needs

The CHPP identifies several areas where research or monitoring needs to be enhanced to provide better information regarding beach and inlet management as it relates to the overall effect on wetland habitat. Items identified in the CHPP include:

- Updated coast-wide estuarine shoreline change rates are needed to determine adequate development guidelines and rules along the coast.
- Additional research and monitoring is needed to determine the effectiveness of estuarine shoreline stabilization measures.

- Research is needed on site specific erosion and accretion rates and their relationship to sea level rise and storm events (Brinson and Moorhead 1989).
- The CRC should continue its review of their estuarine shoreline management rules.

5. Soft Bottom

a) Habitat Description and Ecological Value

The CHPP defines soft bottom as unconsolidated, unvegetated sediment that occurs in freshwater, estuarine and marine systems. This includes deeper subtidal bottom as well as shallow bottom areas. Soft bottom habitat is an important part of designated Primary Nursery Areas, Anadromous Fish Spawning Areas, and Anadromous Nursery Areas (CHPP 2005). Soft bottom requires sediment supply and can often evolve to other habitat types such as shell bottom or SAV habitat. Soft bottom habitats in North Carolina consist of the following: Freshwater – unvegetated shoreline, river, creek, and lake bottom; Estuarine – intertidal flats and unvegetated shorelines, subtidal river bottoms, creeks, and sounds; and Marine – intertidal beach and subtidal bottom (CHPP 2005). Soft bottom habitat enhances aquatic ecosystems through a variety of ways including enhancing community structure, increasing primary productivity of estuaries through benthic macro and micro algae, as well as providing foraging, spawning, and nursery habitat for fish.

b) Current Threats to Soft Bottom

Physical threats to soft bottom includes dredging, mining, dredge disposal on subtidal bottom, marinas and docks, fishing gear impacts, and shoreline stabilization. Shoreline stabilization includes both shoreline hardening and soft stabilization such as beach nourishment. In addition to physical threats, water quality degradation has also been identified as a major threat to soft bottom habitats. Toxic chemicals and excess nutrients often accumulate in soft bottom sediment leading to water column degradation when these sediments are disturbed. Oxygen depletion in bottom sediments, turbidity and sedimentation are also responsible for adverse impacts to soft bottom habitat. The primary alterations to soft bottom habitat are associated with dredging for navigational channels and marina basins (CHPP 2005). Dredging affects soft bottom habitat primarily by converting the bottom habitat into deepwater habitat and increasing turbidity and sedimentation. Beach nourishment affects soft bottom habitat through increased turbidity and redistribution of near shore sediment. Shoreline hardening affects soft bottom habitat by accelerating erosion of wetlands, which leads to loss of intertidal soft bottom habitat.

c) Available Data

Available data regarding soft bottom habitat can be found in the following resources:

- CHPP – In addition to a detailed description of the natural history and occurrence of soft bottom in North Carolina, the CHPP also provides several generalized maps identifying coastal and marine topographic features as well

as existing/proposed dredge and beach nourishment locations. The CHPP also identifies extensive research that has been conducted on soft bottom habitat and provides specific citations. The *2008-2009 CHPP Annual Report* identifies accomplishments and goals achieved related to each of the six primary habitat types. It also identifies the status of major data collection efforts being managed by various state agencies as they relate to the recommended actions identified in the CHPP.

- EPA – Results of EPA’s National Coastal Assessment Surveys for various soft bottom biological and physical components including benthic invertebrate data and sediment analysis can be obtained online through EPA’s Environmental Monitoring & Assessment Program at <http://www.epa.gov/emap/nca/sampling.html>.
- DMF – DMF maintains maps of all habitats described in the CHPP and some of this data is available at <http://www.ncfisheries.net>.
- University of North Carolina Institute for Marine Science – Dr. Pete Peterson has authored and co-authored numerous papers on the effects of beach nourishment on beach fauna and coastal food chains, which includes soft bottom habitat. This research is readily available and is cited extensively in the CHPP.
- USGS – Additional data layers including information about coastal wetlands, which can include the upper limits of soft bottom habitat, are available at <http://nmviewogc.cr.usgs.gov/viewer.htm>.

d) Identified Data Gaps and Research Needs

The CHPP identifies several areas where research or monitoring needs to be enhanced to provide better information regarding beach and inlet management as it relates to the overall effect on soft bottom habitat. Items identified in the CHPP include:

- More research is needed to assess direct and indirect dredging impacts on blue crabs and inlet spawning species;
- Commenting and permitting agencies should continue to use their authorities to minimize, limit or prevent direct and indirect impacts to soft bottom habitat;
- A state policy of dredge material management that is consistent with federal guidelines should be developed;
- Toxic chemical sources at marinas should be addressed through public outreach and education;
- A comprehensive dock and marina policy is needed to help eliminate or minimize adverse effects to soft bottom;

- Examination of current CRC shoreline stabilization rules are needed to minimize impacts to soft bottom habitat, particularly intertidal estuarine shorelines;
- Research is needed to determine if oyster shell could be used as an alternative to rock or wooden stabilization structures;
- Research is needed to determine the effectiveness and cumulative impact of beach bulldozing in order to develop appropriate guidelines;
- Additional research is needed to quantify the cumulative impact of near shore dredge disposal on fish populations;
- Adequate monitoring of the effects of large-scale or long-term beach nourishment on the soft bottom community is needed;
- Continue to thoroughly monitor biological recovery rates to adequately assess direct and cumulative impacts of beach nourishment; and
- Multi-agency efforts are necessary to educate local governments and the general public on natural hazards associated with dynamic coastal systems.

6. Hard Bottom

a) Habitat Description and Ecological Value

The CHPP defines hard bottom as “exposed areas of rock or consolidated sediments, distinguished from surrounding unconsolidated sediments, which may or may not be characterized by a thin veneer of live or dead biota, generally located in the ocean rather than in the estuarine system.” Hard bottom habitat is often referred to as live bottom or live rock, tends to occur in clusters across the continental shelf, and is a very important component of North Carolina’s coastal ecosystems (CHPP 2005). Hard bottom habitat is important to a variety of fish and invertebrate species, including many commercially valuable species. Numerous species utilize hard bottom habitat during at least one stage of their life cycle for refuge, foraging, spawning and as nursery areas. Hard bottom habitat, including all artificial reefs, have been designated Essential Fish Habitat (EFH) by the N.C. Division of Marine Fisheries. In addition to the EFH designation, hard bottom habitat is protected through several state and federal designations (CHPP 2005). All near shore hard bottom areas have been federally designated as Habitat Areas of Particular Concern for snapper and grouper species.

b) Current Threats to Hard Bottom

A study conducted by the South Atlantic Fisheries Management Council (SAFMC) concluded that dredging and beach nourishment represent the most damaging physical activities that affect this habitat type from a fisheries perspective. In particular, the most damaging impacts result from dislocation of coral or live rock, excessive sedimentation, elevated turbidity and movement of fill material from the beach to nearby hard bottom sites (SAMFC 1998). Fishing, diving, infrastructure projects, and water quality degradation also contribute to declining health of hard bottom habitat. The CHPP

identifies beach nourishment and dredge material disposal as moderate threats to hard bottom fish habitat due to partial or complete burial of nearby hard bottom areas due to redistributed sediment and increased turbidity in the water column. Dredging can adversely affect hard bottom by increasing turbidity and sedimentation. Lastly, the state has a policy of no wastewater discharge into the ocean in place to prevent hard bottom impacts from water quality degradation.

c) Available Data

Available data regarding hard bottom habitat can be found in the following resources:

- CHPP – In addition to a detailed description of the natural history and occurrence of hard bottom in North Carolina, the CHPP also provides several maps identifying hard bottom areas previously mapped by Moser & Taylor (1995) and SEAMAP (2001). The CHPP also identifies extensive research that has been conducted on hard bottom habitat and provides specific citations. The *2008-2009 CHPP Annual Report* identifies accomplishments and goals achieved related to each of the six primary habitat types. It also identifies the status of major data collection efforts being managed by various state agencies as they relate to the recommended actions identified in the CHPP.
- DMF – DMF maintains maps of all habitats described in the CHPP. Some information is available at <http://www.ncfisheries.net>.
- Southeast Area Monitoring and Assessment Program (SEAMAP-SA) 2001 – South Atlantic Bight Hard Bottom Mapping. The final report and ArcView GIS CD were completed in 1998 and updated in 2001. The majority of identified sites were located in federal waters off North Carolina (more than three nautical miles from shore). It is widely believed that the hard bottom estimate identified in the program is an underestimate. More than 92 percent of hard bottom in North Carolina waters are located south of Cape Lookout, particularly in the southern half of Onslow Bay and in northern Long Bay (CHPP 2005). Moser and Taylor (1995) estimate that the majority of the bottom in North Carolina waters from mid-Onslow Bay to south of New Inlet and the area from Yaupon Beach west to Tubbs Inlet is comprised of hard bottom with a thin layer of sand. The SEAMAP 2006-2010 Management Plan is available at <http://www.seamap.org/documents/seamapDocs/seamap2006-2010MgmtPlan.pdf>.
- DENR – The Marine/Estuarine Ecosystems Assessment chapter of the One N.C. Naturally Conservation Planning Tool report and metadata supporting available mapping is available at www.onencnaturally.org.
- Hard bottom habitat in North Carolina state waters; a survey of available data. 1995. M.L. Moser and B.L. Taylor – This study is cited as an unpublished document prepared for the N.C. Division of Coastal Management.

- SAFMC-Habitat and Ecosystem Section – SAFMC provides an online GIS-based mapping program (South Atlantic Habitat and Ecosystem Internet Map Server) that allows users to query and view data regarding hard bottom habitat as mapped by SEAMAP and Moser and Taylor (1995). The GIS mapping program can be found at http://ocean.floridamarine.org/efh_coral/ims/viewer.htm. This map server application also contains useful data with regard to primary and secondary nursery areas, essential fish habitat, significant waters, artificial reefs, sand resources, beach nourishment projects and ocean dredge disposal sites. Some of the North Carolina data sets are limited; however, the map server appears to be a useful tool that can be used by decision makers and permit reviewers. Much of the data represented on this map server can be downloaded as shape files from: http://ocean.floridamarine.org/efh_coral/ims/Description_Layers.htm.

d) Identified Data Gaps, Public Outreach, Recommendations, and Research Needs

The CHPP identifies several areas where either research, monitoring or public outreach need to occur to provide better information for decision makers regarding beach and inlet management as it relates to the overall effect on hard bottom habitat. Items identified in the CHPP include:

- Adequate monitoring of the Ocean Dredge Material Disposal Site (ODMDS) should be conducted during the disposal of dredged materials from Beaufort Inlet, as well as during sand pumping activities for beach nourishment projects along Bogue Banks, to determine the effect the use of the ODMDS has on hard bottom habitat;
- More research is needed to evaluate the status and trends of hard bottom habitat in North Carolina state territorial waters;
- The transport of sand from nourished beaches over time needs to be monitored to evaluate the overall effect on hard bottom habitat;
- Additional monitoring is needed to determine the effects of estuarine outflow, particularly nutrient and sediment loading, on hard bottom habitat; and
- Hard bottom designated as Strategic Habitat Areas could be considered for incorporation into a Marine Protected Area.

B. Threatened & Endangered Species

Species with the federal classifications of Endangered (E), or Threatened (T), are protected under the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531 *et seq.*). Critical Habitat Areas as designated by USFWS may involve some of the primary habitats identified in the CHPP, or more broadly encompass beach and/or inlet areas. Additional federal wildlife protection mechanisms that may need to be addressed include the Migratory Bird Treaty Act (MBTA) pursuant to 16 U.S.C. 703-712 as amended, the Bald and Golden Eagle Protection Act (BGPA) pursuant to 16 U.S.C. 668-668d, 54 Stat. 250) as amended, and the Marine Mammal Protection Act (MMPA) pursuant to 16 U.S.C. 1361-1407 as amended. Species listed on the ESA or protected by other regulations that could potentially be affected by dredging or beach nourishment activities have been identified below. These species are listed by USFWS as having ranges that extend into the 20 coastal counties of North Carolina pursuant to the January 31, 2008 update to their published list and are identified because the six habitat types identified in the CHPP are important to these species during some period of their life cycle. The one plant species identified is included because its primary habitat consists of beach dunes. Note that the moratoria for specific species and habitats as they pertain to beach and inlet management are discussed in detail within Section VI.

1. Endangered Species Act (ESA) and Migratory Bird Treaty Act (MBTA)

Five marine sea turtles are listed by USFWS as either Threatened or Endangered under the ESA. These include the loggerhead sea turtle (*Caretta caretta*), green sea turtle (*Chelonia mydas*), leatherback sea turtle (*Dermochelys coriacea*), hawksbill sea turtle (*Eretmochelys imbricata*) and the Kemp's Ridley sea turtle (*Lepidochelys kempi*). The loggerhead sea turtle is the most common sea turtle on the coast of the North Carolina and is most numerous from late April to October. Loggerhead sea turtles utilize North Carolina barrier beaches for nesting, and occasionally feed in estuarine waters; other sea turtles may be found in North Carolina waters in lesser numbers and may sporadically rest on North Carolina beaches. Agency and volunteer monitoring programs along with mandated beach construction moratoria help protect these species. The primary concerns raised by the NCWRC, regarding the protection of sea turtles, focus on the type of material placed on the beach and on the actual dates for construction/development of beach nourishment projects. Additional research and monitoring are needed to fully evaluate the effect of beach nourishment, including emergency nourishment projects, on sea turtle beach selection and nesting. The primary detrimental effects of beach nourishment are that shifting and settling sands generated post beach construction may limit initial nesting activities, while sand that is placed on an eroded beach may bury nests and reduce the ability of hatchlings to emerge (Mann 1977).

The West Indian manatee (*Trichechus manatus*) is listed as Endangered by the USFWS. Manatees may be encountered in North Carolina waters during the warmer summer months; however, they are considered transients and are much more common in Georgia and Florida waters. Manatees prefer warm waters, but have been found in water

temperatures as low as 59° Fahrenheit (Webster, *et al.* 1985). Manatees inhabit both salt and fresh water bodies typically with depths of 5 to 20 feet. They may be encountered in canals, rivers, estuarine habitats, saltwater bays, and near-shore waters. Manatees feed on aquatic vegetation, therefore, impacts to SAV and soft bottom habitat could affect this species.

The shortnose sturgeon (*Acipenser brevirostrum*) is listed as Endangered by the USFWS. It is a bottom-feeding fish that reaches lengths of 3 to 4 feet in length and occurs in Atlantic seaboard rivers from the St. Johns River, Florida to eastern Canada. The sturgeon is anadromous in the Southeast, spending most of the year in brackish estuarine environments and moving into freshwater only when spawning (NMFS 1998). In North Carolina waters, shortnose sturgeons migrate upstream to spawn between January and March (NMFS 1998). Juveniles are found in deeper portions of the lower reaches of rivers near the freshwater/saltwater boundary (NMFS 1998). In late spring through early winter adult shortnose sturgeon are typically found in estuaries and lower sections of large rivers although some adults reportedly move into the Atlantic Ocean as well.

The American alligator (*Alligator mississippiensis*) is listed as Threatened due to Similarity in Appearance (T S/A) to other federally listed crocodilians; however, there are no other crocodilians within North Carolina. The American alligator typically inhabits fresh water swamps, fresh and brackish marshes, abandoned rice fields, ponds, lakes and backwaters of large rivers. Although typically associated with barrier beaches and inlets, American alligators are reported as established on Bogue Banks and have been reported occasionally from barrier beaches south of Cape Hatteras (Palmer and Braswell 1995). Females lay eggs in June and hatchlings emerge in late summer or early fall (Martof *et al.* 1980). USFWS does not require a biological conclusion for the American alligator when assessing potential impacts resulting from projects due to the (T S/A) designation.

The wood stork (*Mycteria Americana*) is listed as Endangered by the USFWS. Wood storks have recently (2005) been documented as breeding in North Carolina in Columbus County (USFWS 2007a) and additional birds disperse to southeastern North Carolina following breeding season. A post-breeding assemblage of wood storks ranging from 15-100 individuals has frequented Sunset Beach for several years recently during early June through mid September. This assemblage represents the northernmost extent of this Federally-endangered species' range, and is the only known assemblage of wood storks in North Carolina (USFWS 2008). Storks are birds of freshwater and brackish wetlands, primarily nesting in cypress or mangrove swamps. They feed in freshwater marshes, narrow tidal creeks, or flooded tidal pools. Particularly attractive feeding sites are depressions in marshes or swamps where fish become concentrated during periods of falling water levels. This foraging habit makes coastal wetlands and soft bottom habitats especially important to the viability of this species in North Carolina, although it is not a permanent resident.

Seabeach amaranth (*Amaranthus pumilus*) is listed as Threatened by the USFWS and is an annual plant that grows from seeds germinating from April through July. This species occurs on barrier island beaches where its primary habitat consists of over-wash flats at

accreting ends of islands, and lower foredunes and upper strands of non-eroding beaches. Seabeach amaranth appears to be intolerant of competition and does not occur on well-vegetated sites. The only remaining large populations of seabeach amaranth are in coastal North Carolina (USFWS 1996). Most of the remaining seabeach amaranth in North Carolina is found south of Cape Hatteras. The slope of the beaches and dunes north of Cape Hatteras does not provide the optimal habitat for this species. The most serious threat for this species is the construction of beach stabilization structures, beach erosion, and beach grooming.

The piping plover (*Charadrius melodus*) is listed as Threatened by the USFWS. These small shorebirds occur along beaches above the high tide line, sand flats at the ends of sand spits and barrier islands, gently sloping foredunes, blowout areas behind primary dunes, and washover areas cut into or between dunes (Dyer *et al.* 1987). Nests are most often on open, wide sandy stretches of beach similar to those associated with inlets and capes. Piping plovers arrive on their breeding grounds in late March or early April. Breeding birds on the North Carolina coast are mostly found from the vicinity of Cape Lookout northward. The primary threats to the piping plover are habitat modification and destruction. The USFWS is currently considering amending the designation of critical habitat for wintering piping plovers. These proposed critical habitat areas are located in Dare and Hyde Counties (USFWS 2007b).

The roseate tern (*Sterna dougallii*) is listed as Threatened by the USFWS and is an occasional visitor along the Outer Banks, south of Cape Hatteras, particularly at Cape Point within Cape Hatteras National Seashore, during the months of July and August. They may be seen late spring and early summer on a rare occasion. Roseate terns breed primarily on small offshore islands, rocks, cays, and islets. Rarely do they breed on large islands. They have been reported nesting near vegetation or jagged rock, on open sandy beaches, close to the waterline on narrow ledges of emerging rocks, or among coral rubble (USFWS 2008). This species is not a regular breeder in North Carolina, but a few pairs may occasionally nest on North Carolina islands usually in association with common tern colonies or colonies of black skimmers or least terns (Spendelow and Patton 1988).

2. Bald and Golden Eagle Protection Act (BGPA) and Migratory Bird Treaty Act (MBTA)

The bald eagle (*Haliaeetus leucocephalus*) was officially delisted and removed from the Federal Endangered Species List on 28 June 2007, but they are still protected under the BGPA and the MBTA. The National Bald Eagle Management Guidelines prohibit disturbance to bald eagles. The guidelines define disturb as “to agitate or bother a bald or golden eagle to a degree that causes, or is likely to cause, based on the best scientific information available, 1) injury to an eagle, 2) a decrease in its productivity, by substantially interfering with normal breeding, feeding, or sheltering behavior, or 3) nest abandonment, by substantially interfering with normal breeding, feeding, or sheltering behavior.” The definition also covers impacts that result from human-caused alterations

initiated around a previously used nest site during a time when eagles are not present, if, upon the eagles return, such alterations agitate or bother an eagle to a degree that injures an eagle or interferes with normal breeding, feeding, or sheltering behavior. Bald eagles forage and nest by large bodies of water.

USFWS and the NCWRC maintain data on the bald eagle population in North Carolina. NCWRC conducts annual aerial surveys to assess the bald eagle population and this data can be obtained from NCWRC on a site specific basis.

3. Marine Mammal Protection Act (MMPA)

The MMPA is administered by the National Oceanic and Atmospheric Administration and serves to protect all marine mammals including those that are already listed as Threatened or Endangered by USFWS under the ESA. The MMPA prohibits, with certain exceptions, the taking of marine mammals in U.S. waters and by U.S. citizens on the high seas, and the importation of marine mammals and marine mammal products into the United States. Threatened or Endangered species under the jurisdiction of NOAA-Fisheries in North Carolina, as listed by NOAA-Fisheries Service, Southeast Regional Office, include blue whale (*Balaenoptera musculus*), finback whale (*Balaenoptera physalus*), right whale (*Balaena glacialis*), humpback whale (*Megaptera novaeangliae*), sei whale (*Balaenoptera borealis*) and sperm whale (*Physeter catodon*). Additional information and data can be obtained at <http://www.nmfs.noaa.gov/pr/laws/mmpa/>.

4. Protected Species Data Sources

- North Carolina Natural Heritage Program (NHP) – NHP has provided a CD containing GIS data that is current as of January 2008 for the following: Significant Natural Heritage Areas (terrestrial and aquatic), Natural Heritage Element Occurrences which identify recorded locations of threatened or endangered species, and also Dedicated and Registered Natural Heritage Program Areas. <http://www.ncnhp.org/>
- DMF – DMF may also have data and maps documenting marine and/or coastal threatened and endangered species. Information may be available at <http://www.ncfisheries.net>.
- WRC – Matthew Godfrey of WRC maintains two databases on sea turtle nesting and stranding. The stranding database is largely online, and available at <http://www.seaturtle.org/groups/ncwrc/>. The nest database has been provided by Mr. Godfrey as an Excel spreadsheet. Sue Cameron, also of NCWRC, maintains a colonial water bird nesting database and shorebird database. The colonial water bird nesting database was started in 1977 and is updated every three years, so there is about 10 years worth of data (has counts of active nests; locations of nests; basic habitat descriptions; survey method; nest substrate; and any disturbances). Shorebird database (mostly piping plovers, contains number of birds, number breeding, number of fledglings; there is also some red knot, oystercatcher data). NCWRC notes that they are not able to survey every possible piping plover habitat, and while it may appear that there are not piping plovers in

certain areas, this may just be because NCWRC has not surveyed that location. Other shorebird data is sporadic and does not represent systematic survey efforts. Additional NCWRC information is available at <http://www.ncwildlife.org/>. David Allen of NCWRC maintains up-to-date information regarding known bald eagle occurrences, including nest sites, in eastern North Carolina.

- USACE – The USACE collects maintains data sets for seabeach amaranth and possibly other federal protected species due to their oversight of beach renourishment and dredging projects. The data that USACE collects is provided to USFWS, NCWRC and NHP. Data regarding USACE operation in the Wilmington District may be available at <http://www.saw.usace.army.mil/>.
- United States National Park Service (NPS) – The NPS also maintains data on coastal birds and sea turtles. Larry West is the Inventory & Monitoring coordinator for the southeast region. Some data is also available online at <http://science.nature.nps.gov/im/index.cfm>.
- USFWS – USFWS can provide state-specific data regarding federal protected species with ranges extending into coastal North Carolina, including piping plover, seabeach amaranth, sea turtles, and other species <http://www.fws.gov/nc-es/>. Dale Suiter of USFWS has provided some site specific data regarding seabeach amaranth.
- NOAA – NOAA-Fisheries information on marine mammal species protected under the MMPA is available online at <http://sero.nmfs.noaa.gov/>.
- Southeast Water Bird Conservation Plan – Provides valuable information and data on seabirds and marsh birds that may be protected by either the ESA or the MBTA online at http://www.waterbirdconservation.org/southeast_us.html.
- The most recent Piping Plover Recovery Plan as prepared by USFWS can be found at <http://www.fws.gov/northeast/pipingplover/recplan/index.html>.

C. Cultural Resources

Awareness of cultural resources along the coast is important in the development of beach and inlet management strategies and any associated projects. For example, ship wrecks near an inlet may require special precautions and avoidance when dredging.

As part of the development of the BIMP, research was conducted at the North Carolina State Historic Preservation Office (SHPO) Survey and Planning Branch (SPB) and Office of State Archaeology (OSA) in Raleigh, North Carolina. While no direct research was conducted at the Underwater Archaeology (UWA) unit office in Fort Fisher, North Carolina, the UWA did supply some digital information. The purpose of this research was to identify structures and archaeological sites (both terrestrial and underwater) that are potentially eligible for, or are listed in the *National Register of Historic Places* (National Register), and that are located in areas that could potentially be impacted by dredging and/or beach nourishment activities.

Typically, the research focused on the barrier islands between the Atlantic Ocean and the Intracoastal Waterway (AIWW) from the South Carolina border to Beaufort Inlet and the Outer Banks from Beaufort Inlet to the Virginia Border, excluding Roanoke Island. A total of 82 properties (either individual structures or collections of structures) were identified at the SPB as being on the Study List (*i.e.*, potentially eligible for National Register), Determined Eligible (*i.e.*, eligible for National Register), listed in the National Register, a locally designated property, a local district, or a National Historic Landmark. National Historic Landmarks identified within the study area include Fort Fisher in New Hanover County and the Wright Brothers National Memorial in Dare County. Locally designated properties and local districts are individual structures or groups of structures that have been identified as locally important by a municipal government. One additional location, the ruins of Fort Clark (Hatteras Island), was also noted, though its National Register eligibility status has not been determined.

The location or boundary of each property was digitized and integrated into a GIS database for general planning purposes. Figure III-1 illustrates some of the historic properties and areas along the North Carolina Coast. Due to the scale of the maps on which the data were collected, the locations of the properties are considered general in nature, with errors of ± 800 ft. The maps at the OSA office in Raleigh depict all recorded terrestrial archaeological sites as well as some, but not all, of the underwater archaeological sites documented in the state. A total of 368 terrestrial and underwater archaeological sites were identified on the OSA maps in the study area. The vast majority of these sites have not been assessed for their National Register eligibility status or their status is unknown.

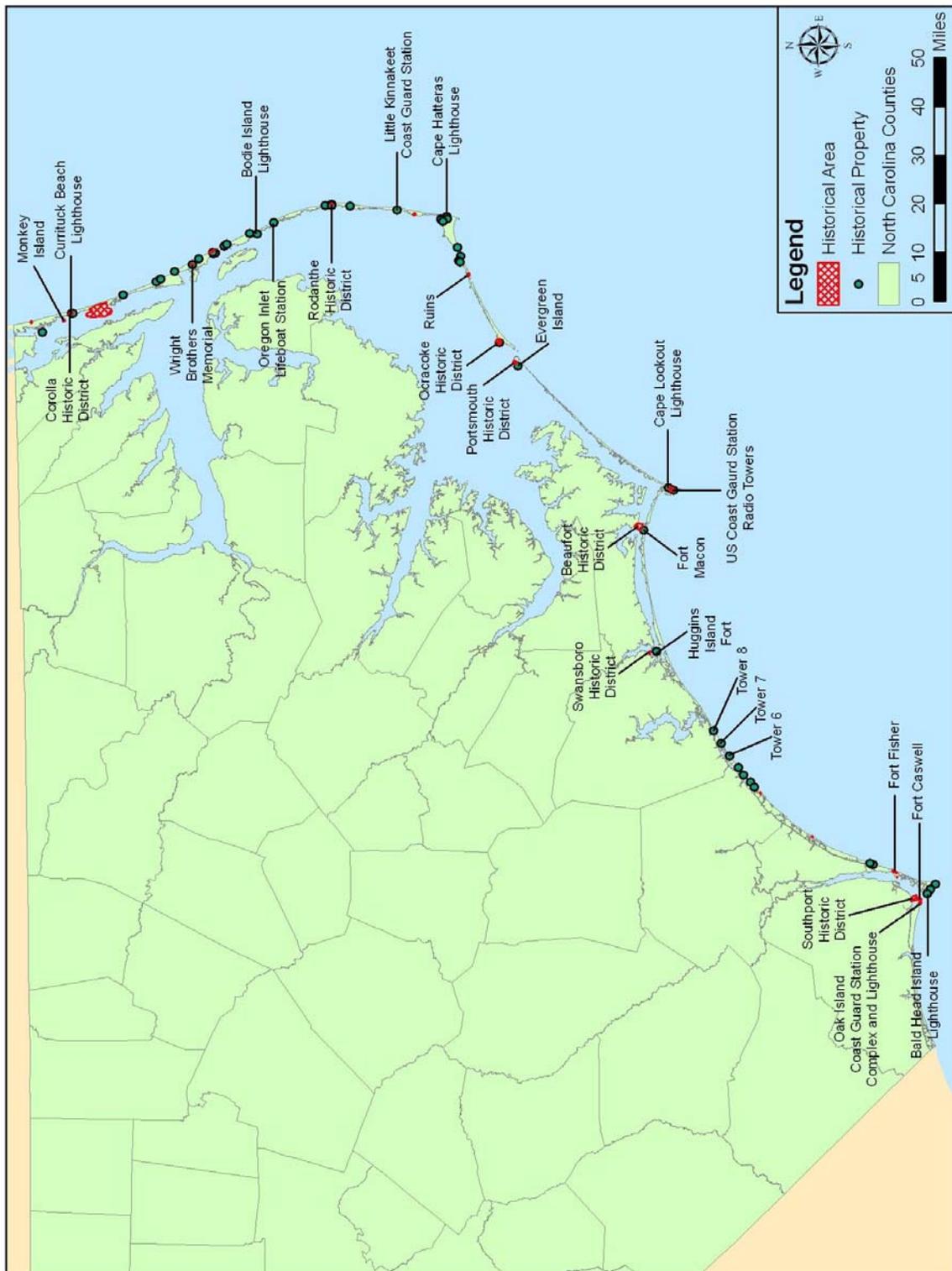


Figure III-1. Historic Areas and Properties

Three main sources of data on submerged archaeological sites along the North Carolina coast, specifically within a six-mile radius of major inlets, include: 1) Wilson Angley's histories of major inlets; 2) list of ocean shipwrecks compiled by the North Carolina Division of Coastal Management (DCM); and 3) maps, files, and reports at the UWA office at Fort Fisher. The first two sources were compiled in the 1980s and the late 1990s, respectively, and contain only partial information. The DCM shipwrecks list contains approximate coordinates for 87 shipwrecks. This list, however, is not a comprehensive listing of all the known shipwrecks in the waters of North Carolina. The maps, files, and reports at the Fort Fisher office contain the most comprehensive information on the approximately 5,000 known submerged archaeological sites in North Carolina.

Some inlets along the North Carolina coast have been open in some form since the 1700s or earlier. These inlets are typically not static in time or space; rather their locations constantly shift due to erosion and sediment deposition. Shifting sediments bury and expose shipwrecks on a frequent basis, especially in the main channel of an inlet where sediment movement is very active. Therefore, the potential for underwater shipwreck sites is greatest near the entrances to an inlet rather than in the existing channel of an inlet.

Commercial shipping has been using North Carolina inlets since the early eighteenth century, although until dredging became commonplace in the twentieth century, most could only allow passage for shallower draft vessels. Cape Fear Inlet is a notable exception. Major inlets associated with Colonial-era ports include Cape Fear Inlet, Bogue Inlet, Beaufort Inlet, and Ocracoke Inlet. An inlet referred to as "Roanoke Inlet" (possibly referring to a now-closed inlet near current Oregon Inlet) is also mentioned in a 1737 book by John Brickell (*The Natural History of North Carolina*).

The southern inlets, from Shallotte Inlet northward to Bogue Inlet, were all used by blockade runners during the Civil War. Many Civil War shipwrecks are documented in this region and multiple National Register Historic Districts containing collections of Civil War shipwrecks have been identified. Inlets such as Ocracoke, Hatteras, and Oregon were closed to Confederate shipping and foreign blockade runners in 1861 due to Union occupation, while Beaufort Inlet was in the control of Union forces by 1862.

Areas around inlets in the Outer Banks, specifically Ocracoke, Hatteras, and Oregon Inlets, all have a high potential to have underwater shipwrecks in the vicinity. The Outer Banks is part of the "Graveyard of the Atlantic," which references the highly traveled and often treacherous shipping lanes along the eastern seaboard from the Outer Banks northward. The potential for shipwrecks from World War II is fairly high around Ocracoke and Hatteras inlets, an area known as "Torpedo Junction."

The regional sections (Section VIII to Section XI) contain an assessment of shipwreck potential near the inlets.