4.0 AFFECTED ENVIRONMENT

4.1 What is the Environmental Setting of the Project?

Pursuant to CEQ regulations (40 CFR 1500-1508), the affected environment described in this section encompasses the natural, physical, and socioeconomic resources within the area (i.e., Permit Area) where the effects of the alternatives are anticipated to occur (Figure 4.1). As previously described in Section 2, the boundaries of the Permit Area were refined and finalized through scoping and the alternatives screening and development process. The Permit Area encompasses ~41,957 acres; including the entire island of Bogue Banks, Beaufort and Bogue Inlets, portions of the adjacent islands of Shackleford Banks and Bear Island that may be affected by the proposed action, and the ocean waters and seafloor offshore of Bogue Banks that comprise proposed borrow sites and potential sand transport routes.

Bogue Banks is an approximately 25-mile-long barrier island with an average width of approximately 2,000 feet. It is located in NC approximately ten miles west of Cape Lookout along the Carteret County coast in northern Onslow Bay (Figure 4.1). The east-west trending island fronts the open Atlantic Ocean to the south and Bogue Sound separates the island from mainland Carteret County to the north. Beaufort Inlet separates the island from Shackleford Banks to the east and Bogue Inlet separates the island from Bear Island to the west. Fort Macon State Park occupies the easternmost 1.4-mile section of the island along Beaufort Inlet and the remainder of the island is divided (from east to west) among the municipalities of Atlantic Beach, Pine Knoll Shores, Indian Beach, Salter Path, and Emerald Isle.

The Permit Area encompasses a diverse assemblage of terrestrial, marine, and estuarine biotic community types. Visual interpretations of biotic community types were digitally mapped using ArcView 9.3 software over high-resolution georeferenced digital multispectral aerial photographs as part of the initial pre-construction assessment of biotic communities. The methods employed for interpretation of aerial photography included visual analysis of color variations in the photographs to delineate habitats (dark areas = submerged land; white areas = sediment exposed above high tide line). Resolution of this imagery (< 2 feet) allowed for adequate delineation of the habitats and features within the Permit Area. These habitat types are summarized in Table 4.1 and depicted in Figure 4.2. Additional details about the marine, beach and dune, and inlet and estuarine communities are included in the Sections below. Residential community acreages were calculated to take into account all possible community types within the Permit Area.

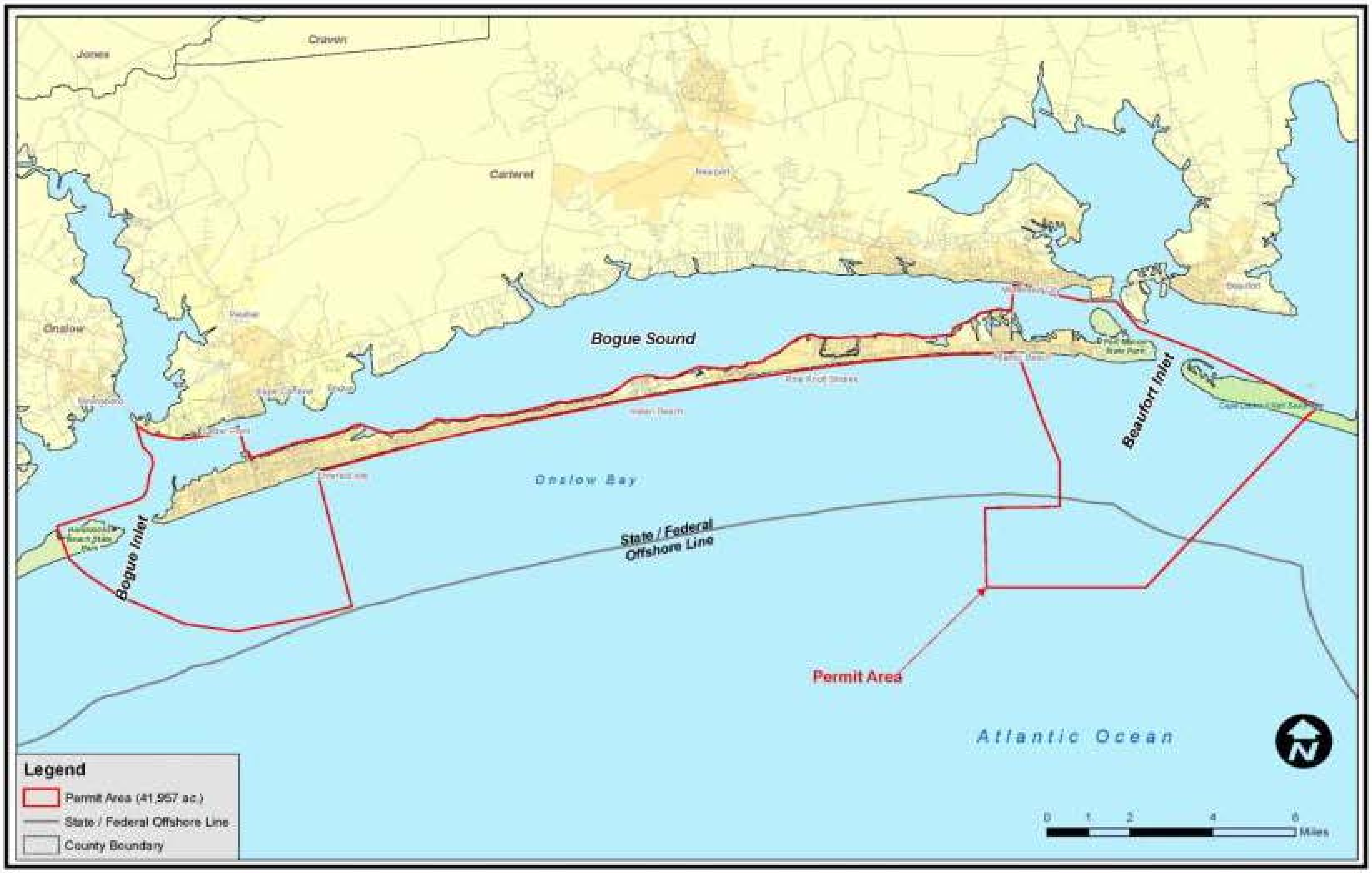


Figure 4.1. Permit Area

Table 4.1. Biotic communities in the Permit Area.

Habitat Type	Area (acres)
Urban/Residential	3,694
Beach and Foredune	769
Dune Grasses	708
Estuarine and Marine Wetland (Marsh)	1,377
Freshwater Pond	66
Maritime Forest	1,886
Upland Shrub-Scrub	283
Wetland Mixed Forest	121
Wetland Shrub-Scrub	230
Intertidal	958
Submerged Aquatic Vegetation	435
Subtidal	31,430
Total	**41,957**

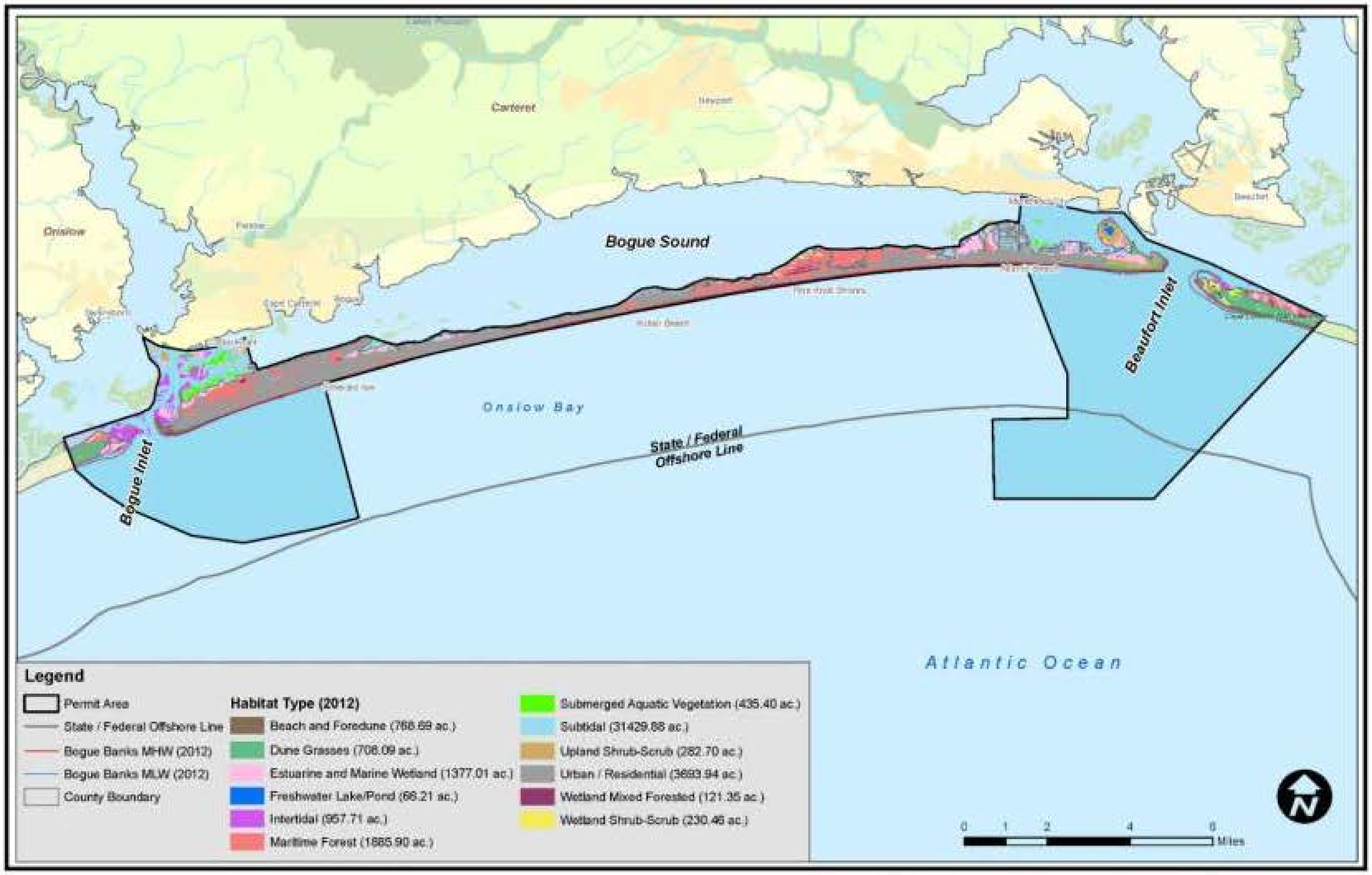


Figure 4.2. Biotic Communities within the Permit Area

Bogue Banks is a relatively high elevation barrier island with characteristic large oceanfront dunes and extensive interior forested dune ridges that reach heights of over 39 feet. Portions of the island are also very wide, with maximum widths along Pine Knoll Shores and western Emerald Isle reaching 4,000 feet. These wide sections of the island contain multiple shore-parallel forested dune ridges. The width of the island along Indian Beach/Salter Path ranges from 1,000 to 2,000 feet. The island narrows to a minimum width of 800 to 1,000 feet along eastern Emerald Isle. Although the central portion of Atlantic Beach reaches a width of over 5,000 feet, most of the width was created by filling tidal marshes on the back side of the island. The width of the natural dune and dune ridge system along central Atlantic Beach ranges from approximately 1,000 to 1,500 feet. The natural vegetation on Bogue Banks is characterized by the typical barrier island ocean-to-sound sequence of plant communities. Dune grass communities on the active oceanfront dunes grade landward into maritime shrub/forest communities on the interior dune ridges. The maritime forest communities eventually transition to tidal salt marshes along the margins of Bogue Sound.

The large frontal dunes and forested dune ridges were formed during a period of seaward island migration that began approximately 4,000 years ago. During this period, an abundant supply of sand on the adjacent continental shelf fueled the formation of new oceanfront dunes. As successive rows of new sand dunes developed along the oceanfront, the older dunes were relegated to the more stable island interior where they were colonized by dense maritime forest vegetation; thus forming the forested dune ridges that exist today. Eventually, the supply of sand on the adjacent continental shelf was exhausted and the island ceased its seaward progression. Bogue Banks has since shifted to an erosional state and is currently experiencing active erosion along both the oceanfront and soundside shorelines. The 50-year long-term average annual shoreline erosion rate, according to NCDCM, along most of the oceanfront shoreline is approximately two feet per year (See: https://deq.nc.gov/about/divisions/coastal-management/coastal-management-oceanfront-shorelines/oceanfront-construction-setback-erosion-rate). Due to the island's east-west orientation and the sheltering effect of Cape Lookout, Bogue Banks is protected against the high energy northeast wind and wave pattern that dominates the majority of the coast. However, the island is highly exposed to tropical storms and hurricanes approaching from the south, which can cause severe short-term erosion.

Bogue Sound is a shallow (approximate average depth three to six feet), high-salinity estuary connected to the ocean via tidal inlets at either end of Bogue Banks. The sound is widest (~2.5 miles) behind central Bogue Banks and narrowest (~0.7 miles) behind the eastern and western ends of the island. The AIWW runs east-west through the sound along the northern mainland shoreline. The majority of the sound is open and free of emergent marshes. Natural sandy shoals, shellfish beds, and submerged aquatic vegetation (SAV) beds are distributed throughout the sound (USFWS 2002). Bogue Sound converges with Bogue Inlet and the White Oak River estuary at the western end of Bogue Banks. The northern (landward) side of the inlet contains an extensive estuarine complex of marsh islands, tidal creeks, and sandy shoals. The main section of the inlet between Bogue Banks and Bear Island (inlet throat) contains a large mid-inlet shoal complex. The depth of the main deepwater channel through Bogue Inlet between the AIWW and the ocean is maintained by the USACE via periodic dredging. At the opposite (eastern) end of Bogue Banks, Bogue Sound converges with Beaufort Inlet and the Newport River. Beaufort Inlet is a federally-maintained navigation channel authorized to approximately 45 feet across it's entire range.

4.2 Physical Oceanographic Processes

Physical oceanographic processes in Onslow Bay are controlled primarily by interactions with the Gulf Stream, tides, and local wind stress. Significant Gulf Stream effects are limited to the mid-shelf (depths of 20-40 m) and outer-shelf (depths >40 m) regions of Onslow Bay. On the inner-shelf (depths <20 m), which is the area of interest in this EIS, tides are responsible for much of the cross-shelf current, whereas wind stress is the principal driver of alongshore currents (Pietrafesa et al. 1985a and 1985b). The tidal regime is dominated by the lunar semidiurnal (2 cycles/day) tidal constituent, which has a mean annual tidal range of approximately 3.7 feet and a spring tidal range of approximately 4.3 feet along Bogue Banks. Wind driven currents are strongly correlated with synoptic scale (2-14 day) wind events that are driven by low/high pressure systems and associated cold/warm fronts (Pietrafesa et al. 1985b). Alongshore current velocities are much greater than cross-shelf current velocities. Mean annual alongshore tidal flow is to the northeast, as are monthly mean flows with the exception of reversals in February, July, and October. Mean cross-shelf flow is offshore during the winter and onshore during the summer.

Wave hindcast studies indicate that the wave climate along Bogue Banks is dominated by small (height less than three feet), short period (less than eight seconds) wind waves out of the southeast to southwest sector (Jensen 2010). During the spring and summer, prevailing winds are out of the southwest and the predominant direction of wave approach is from the south. As the prevailing winds shift to the northeast in the fall, the predominant direction of wave approach shifts towards the east to southeast sector. As the prevailing winds shift to the north-northwest during the winter, the predominant direction of wave approach pattern shifts back towards the southeast to south sector. The wave climate along Bogue Banks is influenced by Cape Lookout, which shelters the area from the high energy northeast winds and waves that dominate the region (Heron et al. 1984). The sheltering effect results in a relatively low energy wave regime dominated by small, short-period, southerly waves. Although protected against northeast winds and storm waves, the area is highly exposed to tropical storms and hurricanes approaching from the south.

4.3 Seafloor Geomorphology

The subtidal seafloor along Bogue Banks starts out below the low-tide line as a relatively steep, seaward-sloping surface known as the shoreface. Approaching onshore waves break as they interact with the shoreface, forming the nearshore surf zone. The shoreface along Bogue Banks extends seaward out to a depth of approximately 40 feet (distance of 1,640 to 2,625 feet from shore) where it flattens and matches the gentle slope of the continental shelf. Seaward of the shoreface on the inner-shelf, a thin (three to six feet) and discontinuous layer of modern sand is superimposed on ancient hard geological strata (rocks and cemented sediments). The shoreface and the vast majority of the inner shelf are covered by thin unconsolidated sediment layers that form benthic "soft bottom" habitats; however, hard strata are occasionally exposed on the lower shoreface and inner shelf, forming benthic "hardbottom" habitats (Hine and Snyder 1985).

Native seafloor sediments in the vicinity of the former and current ODMDS sites are predominantly poorly-sorted very fine sands with variable quantities of silt, clay, and shell (USEPA and USACE 2010). Seafloor geomorphology within the former and current ODMDS facilities has been modified by USACE dredged material disposal practices. As a result of past disposal events, a series of elevated dredged material disposal mounds are superimposed on the natural, relatively flat seafloor. The current ODMDS is subdivided into separate disposal areas for different types of dredged material. The northern third of the current ODMDS is designated for the disposal of coarse-grained material (i.e., sand) that is suitable for beach placement, while the remaining southern portion of the current ODMDS is designated for incompatible fine-grained material.

All beach compatible sediments within the former and current ODMDS facilities are contained in dredged material disposal mounds that are elevated above the natural seafloor. In the case of the former ODMDS, the coalescence of numerous dredged material deposits over time has produced a single large mound (see Section 3 Figure 3.7); whereas dredged material deposits within the current ODMDS facility consist of numerous discrete disposal mounds (see Section 3 Figure 3.8). A remote sensing survey by Hall (2011) found no potential hardbottom sites in the vicinity of the proposed former and current ODMDS borrow areas. The sediments of Area Y are those of the natural undisturbed seafloor. Sediments in the vicinity of Area Y are highly variable, but are generally fine sands with silt/clay fractions that are well in excess of the state standard (M&N 2013). Deposits of relatively clean, beach-compatible sand are confined to two small areas of the original Area Y assessment area (see Section 3 Figure 3.9). Hall (2011) identified areas of low relief hard bottom totaling ~22 acres within and along the eastern margin of the Area Y assessment area (see Section 4.4.2 Figure 4.6); however, the distances between the proposed borrow site deposits and the hardbottom features are greater than the state buffer requirement of 500m.

4.4 Marine Habitats and Communities in the Permit Area

The sections below describe the subtidal ocean bottom (benthic) and ocean water column (pelagic) habitats and communities that occur seaward of the intertidal ocean beach out to a depth of approximately 60 feet on the inner continental shelf of Onslow Bay. As previously described, the offshore areas considered in this DEIS encompass proposed ocean borrow sites; including the former and current MCH ODMDS facilities and Area Y.

4.4.1 Soft Bottom

Soft bottom habitats are substrate areas containing coarse to fine-grain sediment, varying in depths and comprised of unconsolidated sediment. These features are typically defined as "unvegetated", lacking visible structural habitat. This significant habitat is located throughout the oceanfront of Bogue Banks, generally beginning below the mean low water (MLW) line and extending seaward to the outer boundary of the Permit Area. This "soft" substrate supports an abundance of macroalgae and numerous burrowing organisms (macroinfauna) living below the surface (Deaton et al. 2010). Sediment mobilization and transport on the shoreface and inner shelf are driven primarily by waves and wave-generated currents. Under fair-weather conditions, significant sediment mobilization is largely confined to the upper shoreface where seafloor sediments are agitated by breaking waves. Along Bogue Banks, the seaward extent of significant fair-weather sediment mobilization has been estimated to occur at a depth of -20 to -30 feet (Moffatt and Nichol and Geodynamics 2010). Sediments mobilized on the shoreface are picked up by longshore currents and transported along the beach in a process known as longshore drift (a.k.a. littoral drift). Wave refraction analyses indicate a net westward longshore drift along the majority of Bogue Banks, with a reversal to net eastward drift along the easternmost 2.4-mile section of the island in the lee of the Beaufort Inlet ebb tidal delta (Olsen 2006). Model predictions indicate that longshore sediment transport is nearly balanced between westerly and easterly directed transport, with a slight overall net westward transport towards Bogue Inlet. Seaward of the depth of closure on the lower shoreface and inner shelf, significant sediment mobilization is controlled by high-energy storms (e.g., hurricanes) and associated increases in wave orbital velocities (Marshall 2004, Wren 2004). Marshall (2004) reported that fine-grained sediments <0.2041 mm were frequently suspended (even under average fair-weather conditions); however, full suspension conditions accounted for less than one percent of the total sediment suspension time over a period of 19 months. Furthermore, a single storm (Hurricane Isabel) accounted for 72% of the full suspension conditions. During Hurricane Isabel, near-bottom wave orbital velocities were more than six times higher than the fair-weather average, and full sediment suspension conditions occurred for more than 48 consecutive hours (Marshall 2004).

Marine soft bottom habitats in Onslow Bay support a diverse assemblage of benthic invertebrate infauna and epifauna. Peterson and Wells (2000) characterized the soft bottom benthic invertebrate assemblages at multiple nearshore (one to five miles) ocean sites along central Bogue Banks, including sites two miles inshore of the ODMDS. The stations were arranged in a grid of three transects with three stations on each transect at the 19-, 26-, and 36-foot isobaths. Taxa in order of abundance included polychaetes, annelids, bivalve mollusks, amphipod crustaceans, echinoderms, and nematodes. The total density of infaunal invertebrates ranged from 5-14 per 76 centimeters squared (cm^2) and total densities of larger epifaunal invertebrates ranged from three to 43 individuals per ten meters squared (m^2). Benthic community composition was similar across all sites, with polychaetes accounting for 65 to 75% of the total abundance. Additional studies have reported similar nearshore assemblages along eastern Bogue Banks (Hague and Massa 2010, Peterson et al. 1999) and in the southern portion of Onslow Bay (Posey and Alphin 2002).

The USACE collected sediment and macroinvertebrate samples at 96 stations in the vicinity of the Beaufort Inlet ebb tidal delta in September 2009 (USACE 2010). Benthic community characterizations and sieve analysis were performed on the sediment samples. Results of the study indicate a total of 7,053 organisms representing 260 taxa were identified from 95 samples. Polychaetes were the most numerous organisms, representing 43.9% of the total assemblage, followed by malacostracans (primarily amphipods) at 25.7%, bivalves (10.5%) and gastropods (10.0%). The number of taxa per station ranged from one to 57. Station densities ranged from 9.1 organisms/m^2 to 4,609 organisms/m^2. The data suggest that the nearshore site showing the closest correlation and strongest relationships between sample sites is located offshore of Shackleford Banks. This area has medium silt/clay content and benthic species diversity and richness values are moderate to high. The shallow water depths cause the benthic environment to be influenced by scour and sediment resuspension caused by wave action and tidal currents.

Soft bottom sites also provide important habitat for large mobile decapod crustaceans (i.e., crabs and shrimp). Annual trawl surveys in nearshore Onslow Bay indicate that the large decapod assemblage is dominated by white shrimp (*Litopenaeus setiferus*), brown shrimp (*Farfantepenaeus aztecus*), and the iridescent swimming crab (*Portunus gibbesii*). Soft bottom habitats and their associated benthic invertebrate communities provide important habitat and food resources for many species of demersal (bottom-dwelling) fishes. The Southeast Area Monitoring and Assessment Program (SEAMAP-SA) has conducted annual nearshore (depths of 15-60 feet) trawl surveys for demersal fishes in Onslow Bay since 1986. Catches have been consistently dominated by sciaenid fish, many of which utilize estuaries during part of their life cycle (SEAMAP-SA 2000). Overall patterns of abundance are strongly influenced by the abundance of spot (*Leiostomus xanthurus*) and Atlantic croaker (*Micropogonias undulatus*). These two species have been consistently dominant, accounting for more than 36% of the total catch between 1990 and 1999. Other numerically important demersal fishes include

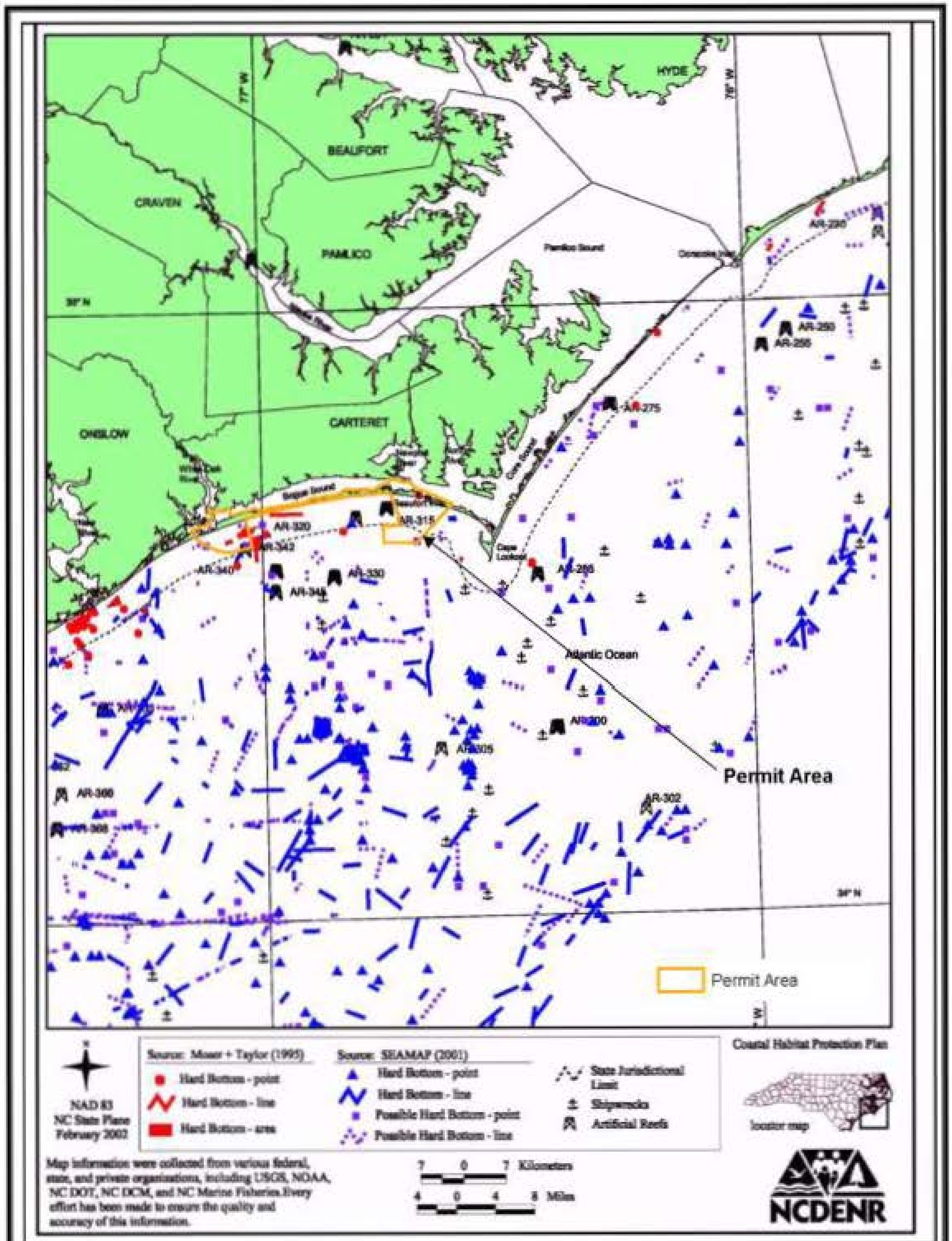
Atlantic bumper (*Chloroscombrus chrysurus*), scup (*Stenotomus* sp.), pinfish (*Lagodon rhomboides*), star drum (*Stellifer lanceolatus*), banded drum (*Larimus fasciatus*), gray trout (*Cynoscion regalis*), silver seatrout (*C. nothus*), southern kingfish (*Menticirrhus americanus*), and inshore lizardfish (*Synodus foetens*).

Many of the demersal fishes that are associated with marine soft bottom habitats are estuarine-dependent/ocean-spawning species that use estuarine waters for juvenile development and move into the ocean as adults. During the fall and winter, large numbers of these estuarine-dependent species leave the estuaries and enter the nearshore ocean zone (Deaton et al. 2010). Peterson and Wells (2000) documented seasonal variations (November, February, and May) in demersal fish communities at inshore (~1 mile) and offshore (~5 miles) soft bottom sites along Bogue Banks. In November, catches at the offshore sites were dominated by spot (>50% of total catch), pinfish, pigfish (*Orthopristis chrysoptera*), and croaker; whereas the inshore sites were dominated by croaker, silver perch (*Bidyanus bidyanus*), Atlantic silversides (*Menidia menidia*), pinfish, and striped mullet (*Mugil cephalus*). In February, total catches at the offshore and inshore sites were reduced by 96% and 59%, respectively. Pinfish, Atlantic menhaden (*Brevoortia tyrannus*), and silversides collectively accounted for 96.4% of the total combined inshore/offshore catch in February. The combined inshore/offshore totals for spot and croaker were reduced by 98.9% and 99.8%, respectively; and catches of all other taxa fell sharply, with the exception of silversides and pinfish at the inshore sites. During the May sampling period, large numbers of Atlantic silversides and Atlantic threadfin herring (*Polydactylus octonemus*) increased the total inshore catch by 1,200% over February; and the total offshore catch increased by 1,600%, largely due to increases in pigfish and scup. Peterson and Wells (2000) also analyzed the stomach contents of demersal fishes that were caught during the November sampling period. The results indicate that croakers and pinfish were primarily consuming polychaete worms, bivalves, grass shrimp (*Palaemonetes* sp.), and pinnotherid crabs. Silver perch, pigfish, and spot consumed polychaetes, grass shrimp, and other small bottom-dwelling crustaceans. Gray trout consumed grass shrimp, penaeid shrimp, and portunid crabs; whereas kingfishes primarily consumed pinnotherid crabs, portunid crabs, and large polychaete worms.

4.4.2 Hardbottom

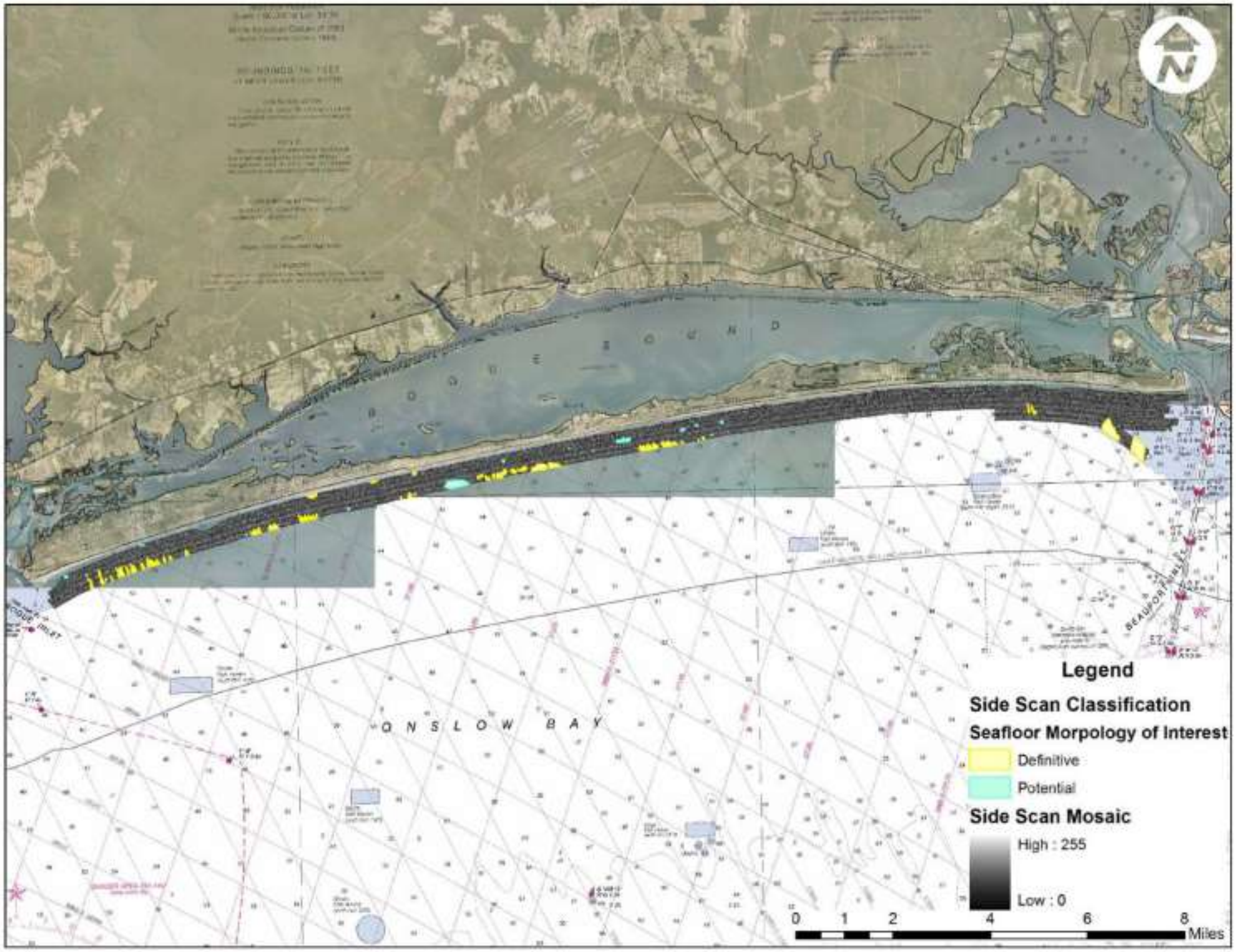
Hardbottom habitats are areas of exposed rock and hardened sediments exhibiting varying degrees of colonization by marine algae and sessile invertebrates (e.g., sponges, soft corals, and hard corals). Efforts, which include a combination of shallow water trawl surveys, anecdotal observations by fishermen, and a survey of available data, to map hardbottom sites in Onslow Bay have been undertaken by Moser and Taylor (1995) and SEAMAP-SA (2001). The vast majority of the identified hardbottom sites along Bogue Banks are located well seaward of the Permit Area on the mid to outer continental shelf (Figure 4.3). The majority of hardbottom sites in Onslow Bay are located south of Bogue Banks; however, Moser and Taylor (1995) identified a concentration of nearshore hardbottom sites seaward of Bogue Inlet.

The USACE has sponsored extensive remote sensing and ground-truthing surveys for nearshore hardbottom features along Bogue Banks. Under contract to the USACE, Greenhorne and O'Mara (2007) conducted a side-scan sonar survey of the nearshore region (~250 feet to ~2,500 feet offshore) along the entirety of Bogue Banks (Figure 4.4). The remote sensing survey identified a number of seafloor anomalies that were identified as areas of interest for further investigation. A subset of the anomalies consisting of those having side-scan signatures most similar to known hardbottom features was subsequently ground-truthed by Anamar Environmental Consulting and Coastal Planning and Engineering (CPE). All of the ground-truthed anomalies were found to consist of unconsolidated material ranging from coarse shell-hash to dense clay. Further analysis of beach profile survey data showed a relatively smooth seafloor surface along Bogue Banks without any of the readily identifiable bathymetric perturbations that are associated with confirmed hardbottom features along Topsail Island (Anamar and CPE 2009). Based on the results of the ground-truthing investigation, Anamar and CPE concluded that no hardbottom features were present within the nearshore side-scan sonar area. Hall (2011) conducted a remote sensing survey for hardbottom sites at potential borrow sites along Bogue Banks; including the current ODMDS, former ODMDS, and a third site offshore of Bogue Inlet (Borrow Area Y). No potential hardbottom sites were identified within the current ODMDS or former ODMDS area; however, areas of low relief hardbottom totaling ~22 acres were identified within and along the eastern boundary of Area Y (Figure 4.5). The hardbottom features were described as natural sandstone outcrops with extensive soft and hard coral growth. The locations of the Area Y hardbottom features are consistent with a cluster of hardbottom sites identified by Moser and Taylor (1995) off Bogue Inlet. In addition to natural hardbottom features, the Permit Area encompasses an artificial reef (AR-342) that is located just outside the southern boundary of Area Y (Figure 4.5). Several additional artificial reefs are located outside of the Permit Area between Area Y and the ODMDS (Figure 4.6).



Source: Adapted from North Carolina Coastal Protection Plan, NCDENR, 2002

Figure 4.3. Onslow Bay Potential Hardbottom Regional Map



Source: Greenhorne and O'Meara 2007

Note: Areas defined as definitive were groundtruthed.

Figure 4.4. Bogue Banks Nearshore Hardbottom Survey Area

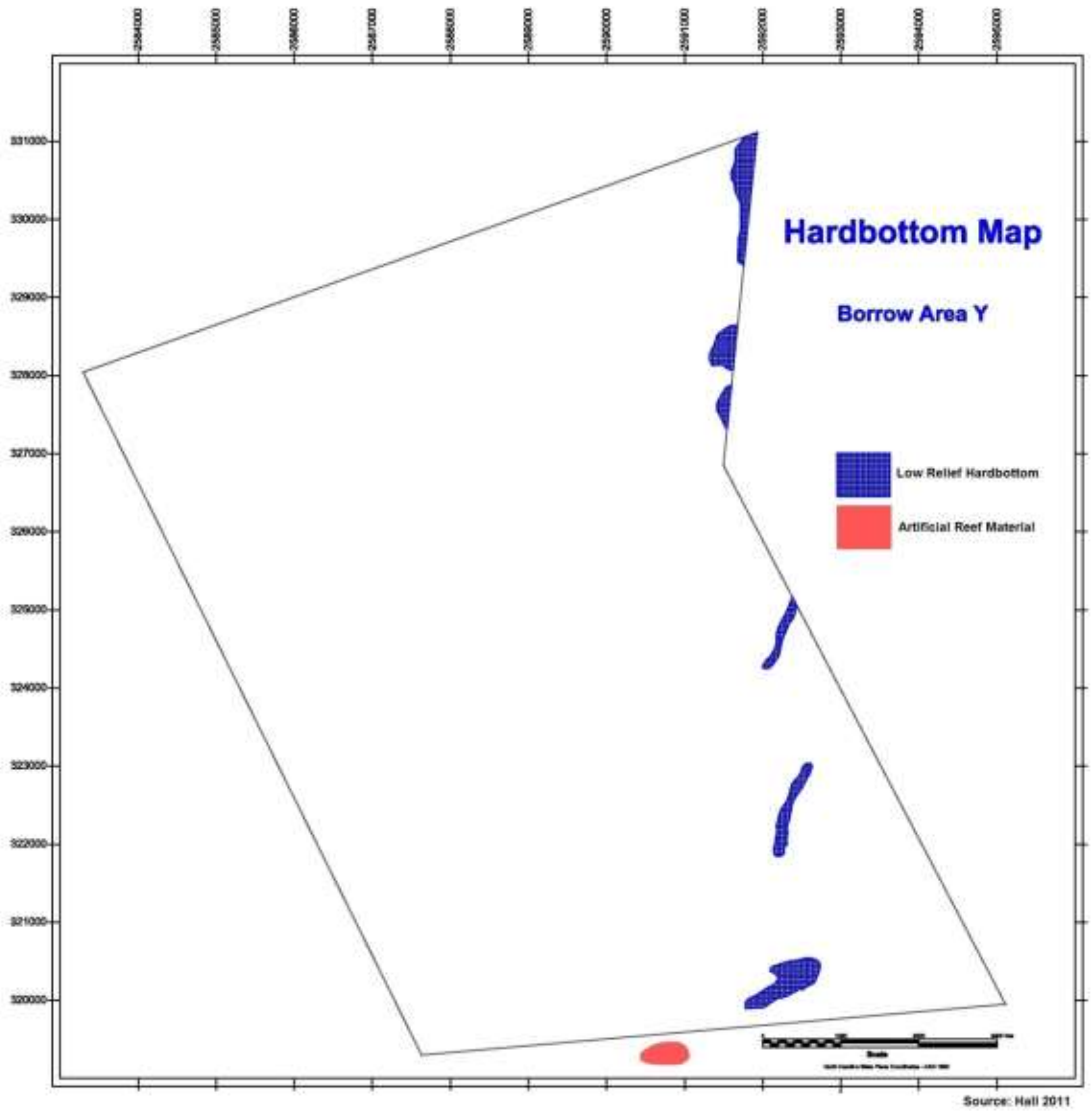


Figure 4.5. Area Y Hardbottom Map Based on Remote Sensing Technology

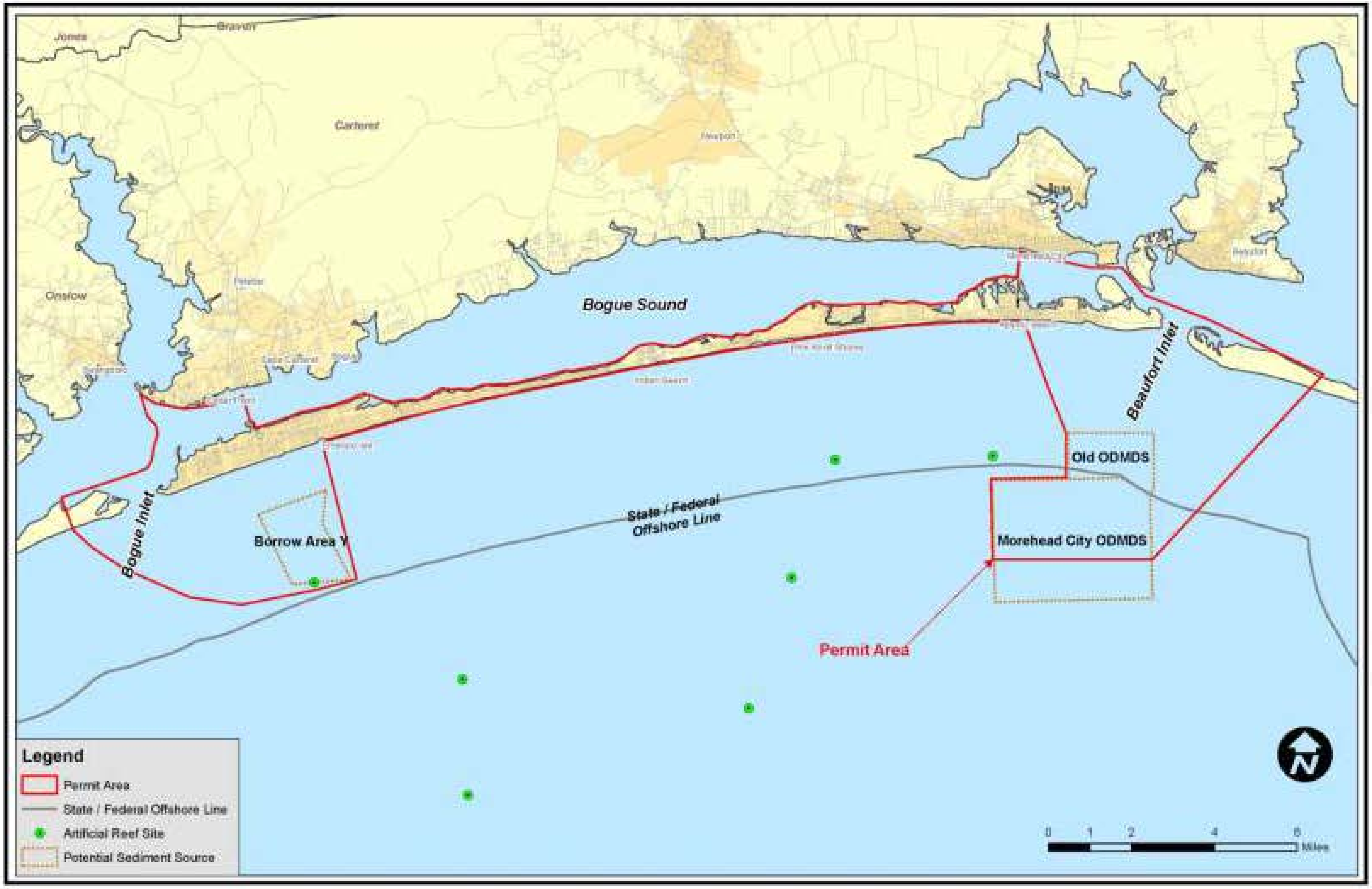


Figure 4.6. Artificial Reef Sites in the Vicinity of the Permit Area

Marine macroalgae are the dominant colonizing organisms on NC hardbottoms; and the coverage of attached, sessile invertebrates is typically 10% or less (Peckol and Searles 1984). Dominant large attached invertebrates include the soft corals (*Titandeum frauenfeldii, Telesto fructiculosa*) and the hard coral (*Oculina arbuscula*). The small macroinvertebrate community is dominated by mollusks, polychaetes, and amphipods (Kirby-Smith 1989); and the most common large mobile invertebrates are sea urchins (*Arbacia punctulata, Lytechinus variegatus*). Hard and soft corals are less prevalent on nearshore hardbottoms in NC compared to offshore and more southerly hardbottoms. In the nearshore environment, cooler water temperatures limit the growth of tropical corals (Kirby-Smith 1989, Fraser and Sedberry 2008) and macroalgae out-compete the dominant hard coral (Miller and Hay 1996). Along the NC coast, tropical reef building corals are restricted to deep offshore waters (>20 miles from shore) (MacIntyre and Pilkey 1969, MacIntyre 2003).

Natural hardbottoms along the NC coast provide important foraging habitat and protective cover for tropical, subtropical, and warm-temperate reef fishes. Inner-shelf hardbottoms support a higher proportion of temperate fishes such as black sea bass (*Centropristis striata*), spottail pinfish (*Diplodus holbrookii*), and estuarine-dependent migratory species (Huntsman and Manooch 1978, Grimes et al. 1982). Lindquist et al. (1989) recorded 30 species representing 14 families at a nearshore hardbottom site in Onslow Bay. Common species included juvenile grunts, round scad **(***Decapterus punctatus*), tomtate (*Haemulon aurolineatum*), spottail pinfish, black sea bass, slippery dick (*Halichoeres bivittatus*), scup, pigfish, cubbyu (*Equetus umbrosus*), belted sandfish (*Serranus subligarius*), and sand perch (*Diplectrum formosum*). Nearshore hardbottom sites support spawning by smaller and more temperate reef species such as black sea bass and sand perch; and provide larval settlement sites and juvenile nursery habitats for reef-associated fishes, including a number of taxa that are thought to spawn in deeper offshore waters (Powell and Robins 1998).

4.4.3 Marine Water Column

4.4.3.1 Physical Attributes

Marine water column is defined as the area from the surface of the ocean to the ocean floor, which has varying levels of turbidity. Physical ocean properties in Onslow Bay reflect relatively low riverine inputs of freshwater and sediments. Salinity is relatively high throughout the water column, with an observed range of approximately 34.0 to 36.5 practical salinity units (PSU) at inner shelf monitoring stations [Coastal Ocean Research and Monitoring Program (CORMP)]. The lack of significant sediment input is reflected in relatively low turbidity values, which are predominantly less than 4.0 Nephelometric Turbidity Units (NTU) at inner shelf monitoring stations (CORMP). High water clarity allows significant sunlight penetration to the bottom in relatively deep waters, thereby supporting abundant benthic microalgal growth to a distance of at least 45 kilometers (km) from shore (Mallin et al. 2005).

4.4.3.2 Pelagic Fishes

The ocean water column provides important habitat for pelagic fish species such as alewife (*Alosa pseudoharengus*), shad (*A. sapidissima*), blueback herring (*A. aestivalis*), bay anchovy (*Anchoa mitchilli*), silversides, Atlantic menhaden, striped mullet, bluefish (*Pomatomus saltatrix*), cobia (*Rachycentron canadum)*, Spanish mackerel (*Scomberomorus maculates*), and king mackerel (*S. cavalla*). Coastal pelagics, highly migratory species, and anadromous fish species are dependent on the water column for adequate foraging (Manooch and Hogarth 1983). The boundaries of water masses (coastal fronts) in the nearshore ocean are important foraging areas for mackerel and mahi mahi (*Coryphaena hippurus*) (SAFMC 1998). King and Spanish mackerel feed on baitfish that congregate seasonally over shoals, hardbottoms, and artificial reefs. Anadromous species such as shad, river herring, and striped bass (*Morone saxatilis*) utilize cape shoals as a staging area for migration along the coast. Some pelagic species, such as anchovies and king mackerel, rely on the nearshore boundaries of ocean water masses as nursery habitats (SAFMC 1998). Juveniles of other pelagic species, such as Spanish mackerel and bluefish, use the surf zone and nearshore waters seasonally while migrating between estuarine and ocean waters (Godcharles and Murphy 1986, Hackney et al. 1996, and Deaton et al 2010).

Ichthyoplankton (larval fish) are an important component of the zooplankton community in the ocean water column. Powell and Robbins (1994) collected ichthyoplankton taxa representing 66 families along an inshore-offshore transect in Onslow Bay. Abundance and diversity were lowest at inner shelf sampling stations and highest at mid-to-outer shelf stations. Additional sampling of the water column near hardbottom sites in Onslow Bay documented taxa from 110 families, including 40 families from ocean surface and 70 families from the subsurface (Powell and Robbins 1998). During late fall and winter, estuarine-dependent species such as Atlantic menhaden, spot, and Atlantic croaker are an important component of the zooplankton community. Ichthyoplankton from estuarine-dependent species that spawn in the sounds and inlets [e.g., pigfish, silver perch, and weakfish (*C. regalus*)] were found in the ocean water column shortly after the spring/early summer spawning period. Reef fish larvae were most abundant during spring, summer, and early fall. The larvae of deep-water oceanic species were frequently encountered, indicating that Gulf Stream waters transport these larvae to shelf waters. Current and wind patterns have a strong effect on the recruitment and retention of various fish larvae from different offshore areas. Gulf Stream waters are the transport mechanism for many larval fish species into NC’s shelf waters (Govini and Spach 1999).

4.4.3.3 Marine Mammals

A total of 38 marine mammal species have been reported from coastal waters between Cape Hatteras and New River Inlet [Department of the Navy (DoN) 2008a, 2008b]. These species include 33 cetaceans (whales, dolphins, and porpoises), four pennipeds (seals, sea lions, and fur seals), and one sirenian [West Indian manatee (*Trichechus manatus*)]. A number of these species are federally listed as threatened or endangered, including the North Atlantic right whale (*Eubalaena glacialis*), humpback whale (*Megaptera novaeangliae*), sei whale (*Balaenoptera borealis*), finback whale (*B. physalus*), blue whale (*B. musculus*), sperm whale (*Physeter macrocephalus*), and West Indian manatee. These federally listed species are addressed in-depth in Section 4.5. The majority of the remaining 26 non-listed species are not expected to occur in nearshore waters. Many of these species are typically found in offshore waters near the continental shelf break or beyond. A number of other species are known only from stranding records or rare sightings considered extralimital to their normal distribution. Marine mammal occurrence data compiled by the Department of the Navy (2008a and 2008b) indicate that the only non-listed species that are expected to occur regularly in the permit area are the bottlenose dolphin (*Tursiops truncates*) and Atlantic spotted dolphin (*Stenella frontalis*).

Bottlenose dolphins may be present in both estuarine and nearshore marine waters throughout the year, although estuarine occurrences peak during summer and most winter sightings are from the nearshore ocean (DoN 2008a, 2008b). Bottlenose dolphins along the South Atlantic coast include both resident and migratory populations. Studies indicate the presence of a year-round resident bottlenose dolphin population in the vicinity of Beaufort, NC. This resident Beaufort population is the northernmost documented site of year-round bottlenose dolphin residency in the western North Atlantic (Koster et al. 2000). Atlantic spotted dolphins regularly occur in inshore waters south of Chesapeake Bay (Mullin and Fulling 2003). Nearshore sightings of Atlantic spotted dolphins have been recorded in the vicinity of the permit area during winter, spring, and summer (DoN 2008a, 2008b)).

4.4.3.4 Birds

The marine water column provides important foraging habitat for colonial sea birds [i.e., terns (*Sterna* spp.), gulls (*Larus* spp.), brown pelicans (*Pelecanus occidentalis*), black skimmers (*Rynchops niger*), and double-crested cormorants (*Phalacrocorax auritus*)]. These species feed primarily on small fish that are captured by plunge diving (terns, gulls, and pelicans), skimming the surface of the water (black skimmer), or diving and pursuing prey beneath the water surface (cormorants). Colonial nesting sea birds are present year-round, but are most abundant along the NC coast during spring and fall migration periods. Additional non-colonial waterbirds that may occur in marine waters along Bogue Banks include common and red-throated loons (*Gavia immer, G. stellata*), diving ducks [black scoter (*Melanitta americana*)], bufflehead (*Bucephala albeola*), common eider (*Somateria mollissima)*, common goldeneye (*B. clangula*), scaup (*Aythya* spp.), horned grebe (*Podiceps auritus*), and hooded and red-breasted mergansers (*Lophodytes cucullatus*, *Mergus serrator*) (USFWS 2002, Rice and Cameron 2008).

4.5 Beach and Dune Communities in the Permit Area

4.5.1 Intertidal Ocean Beach

Characteristics. The intertidal ocean beach is alternately inundated and exposed by twice-daily ocean tides and waves and includes the zone of MHW and MLW. The intertidal zone is a high energy environment where sediments are continually reworked and sorted according to grain size. Sediments are generally coarse and highly sorted, with relatively little organic matter content. Wave action in the intertidal zone generally precludes the growth of benthic algae; however, waves result in the continuous re-suspension of inorganic nutrients, which support phytoplankton productivity. Phytoplankton production (primarily diatoms) supports benthic invertebrate filter feeders, which are an important food resource for surf zone fishes and shorebirds.

Macroinvertebrates. In NC, the dominant benthic macrofauna of the intertidal beach are mole crabs (*Emerita talpoida*), coquina clams (*Donax variablis, D. parvula*), several species of haustoriid amphipods, and the spionid polychaete (*Scolelepis squamata*) (Deaton et al. 2010). Leber (1982) documented seasonal changes in the intertidal macroinvertebrate community at Bogue Banks. Mole crabs and coquina clams dominated the macroinvertebrate community for most of the year. Mole crab densities were highest from April through October, and densities of the coquina clam *D. variabilis* were highest from May through November. Densities of both species declined sharply in the late fall and were completely absent between mid-January and mid-February. Recolonization by juveniles and adults of both species was evident by late February. Densities of the coquina clam *D. parvula* were highest from May through August. *D. parvula* disappeared from the intertidal zone in late August and remained absent from the intertidal zone until the following March. Haustoriid amphipods (*Haustorius* sp., *Amphiporeia virginiana*) dominated the benthic community for a brief period during early winter but were present in low numbers throughout the remainder of the year. Peterson et al. (2006) detected seasonal changes in polychaete abundance at Bogue Banks. Densities of intertidal polychaetes (*Scolelepis squamata*) increased after March, peaked during the warmer months, and declined in the fall.

Fishes. At high tide, the inundated intertidal beach provides important foraging habitat for surf zone fishes. The most common surf zone species along southeastern NC are Atlantic menhaden, striped anchovy (*A. hepsetus*), bay anchovy, rough silverside (*Membras martinica*), Atlantic silverside, Florida pompano (*Trachinotus carolinus*), spot, gulf kingfish (*M. littoralis*), and striped mullet (Ross and Lancaster 1996). Lindquist and Manning (2001) conducted summer sampling of surf zone fishes along Bogue Banks. Florida pompano accounted for 76% of the total number of fish caught, followed by gulf kingfish (15%) and silversides (6%).

Birds. North Carolina's intertidal beaches provide important foraging habitat for migrating, wintering, and breeding shorebirds. Shorebirds probe or search the surface of wet intertidal sediments for benthic invertebrates; including mole crabs, coquina clams, amphipods, and polychaetes. Shorebirds are present year-round, but are most abundant along the NC coast during spring and fall migration periods. Dinsmore et al. (1998) documented the seasonal abundance and distribution of non-breeding shorebirds on oceanfront beaches along the NC Outer Banks. As an assemblage, total shorebird numbers peaked during May and from July through September. Spring migration occurred almost entirely during the month of May. Fall migrants began arriving in July and some remained along the NC coast into November and December. Overall shorebird numbers were lowest during June and from January through March. Sanderlings (*Calidris alba*), red knots (*C. canutus*), and willets (*Tringa semipalmata*) were the most abundant species, accounting for 89% of the total number of shorebird observations. Other numerically important species included black-bellied plovers (*Pluvialis squatarola*), ruddy turnstones (*Arenaria interpres*), whimbrels (*Numenius phaeopus*), and American oystercatchers (*Haematopus palliates*).

4.5.2 Dry Ocean Beach and Dune

Characteristics. The dry ocean beach habitat is defined as the land between the toe of the dune to the MHW line. The dry upper beach is a highly dynamic environment that is continuously reworked by wind and water. The upper beach lies above mean high tide, but is subject to inundation by high spring tides and storm tides. Dune grass communities consist of vegetation within the upper beach and are dominated by a small number of herbaceous species, consisting primarily of annual succulents (Schafale and Weakley 1990). This community occurs on the frontal active dune system immediately landward of the ocean beach and is dominated by grasses [e.g., sea oats (*Uniola paniculata*), American beach grass (*Ammophila breviligulata*), seaside little bluestem (*Schizachyrium littorale*)] and other herbaceous species that are adapted to this highly dynamic and stressful environment. Continuous salt spray, excessive drainage, and shifting sands exclude most plant species and maintain this community type (Schafale and Weakley 1990).

Upland Hammock Habitat. Upland hammock habitat consist of maritime shrub and maritime evergreen forest communities which occur landward of the active frontal dunes on interior stabilized dune ridges. These communities are protected from saltwater flooding and extreme salt spray. Maritime shrub communities are characterized by a very dense shrub stratum dominated by wax myrtle (*Myrica cerifera*), yaupon (*Ilex* *vomitoria*), red cedar (*Juniperus virginiana*), and stunted live oak (*Quercus virginiana*). The maritime shrub community is exposed to fairly heavy salt spray, which limits shrub height and prevents succession to maritime forest. The maritime forest is characterized by a low to moderately high tree canopy dominated by live oak, sand laurel oak (*Q. hemisphaerica*), and loblolly pine (*Pinus taeda*) (Schafale and Weakley 1990).

Birds. North Carolina's barrier island beaches provide important migratory, wintering, and breeding habitat for numerous shorebirds (e.g., sandpipers, plovers, and godwits) and colonial nesting water birds (e.g., terns, gulls, and skimmers). Shorebirds and colonial waterbirds are present year-round, but are most abundant along the NC coast during spring and fall migration periods. Most shorebirds breed in the Arctic region; however, four species [American oystercatcher, piping plover (*Charadrius melodus*), willet, and Wilson's plover (*C. wilsonia*)] breed along the NC coast. Colonial waterbirds that breed in NC include the black skimmer, several gulls (laughing, herring, and great black-backed), and a number of terns (gull-billed, Caspian, royal, sandwich, common, Forster's, least, and sooty) (Parnell et al. 1995). Nesting habitats for these species include the dry upper ocean beach, inlet shorelines, and estuarine islands. Optimal nesting habitats include wide, flat, sparsely vegetated beaches with access to abundant moist substrate habitats for foraging. Nests are constructed on the ground, generally in substrates consisting of bare sand or shell.

Although dry ocean beach and dune habitats generally represent potential nesting habitat for a number of shorebirds and colonial nesting waterbirds, the developed ocean-facing beaches on Bogue Banks are unlikely to support shorebird/waterbird nesting [USFWS 2002; Personal communication, S. Schweitzer, North Carolina Wildlife Resources Commission (NCWRC) Coastal Waterbird Biologist, 2011]. As is the case for other developed beaches in NC, the lack of nesting activity is attributed to habitat loss and degradation from development, beach stabilization, and chronic human disturbance (Cameron et al. 2006; Personal communication, S. Schweitzer, NCWRC Coastal Waterbird Biologist, 2011). Some birds may continue to use the Bogue Banks dry ocean beach for loafing; however, loafing activity is primarily confined to inlet and estuarine habitats. A number of species continue to nest at Bogue Inlet, Beaufort Inlet, and/or on small islands in Bogue Sound (USFWS 2002). An in-depth discussion of inlet and estuarine breeding activity within the Permit Area is provided in Section 4.4.1; and additional information on the piping plover, a federally listed threatened species, is provided in Section 4.6.2.

Nesting sea turtles. Adult female sea turtles 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). Average annual loggerhead sea turtle nest densities for Bogue Banks between 2009 and 2015 were 1.8 nests/mile between Bear Island and Fort Macon (approximately total of 29 shoreline miles). Loggerhead sea turtle nesting does occur along the entire NC coast; however, nesting is concentrated along three sections of the coast: the Cape Fear region (Holden Beach, Oak Island, Caswell Beach, Bald Head Island, and Fort Fisher), Topsail Island and Onslow Beach, and the barriers that comprise Cape Lookout and Cape Hatteras from Shackleford Banks north to Bodie Island (NCWRC 2015b). Collectively, these three sections of the coast accounted for 83 percent of all loggerhead nesting in NC from 2009 through 2015.

A variety of different substrates and beach slopes are used for nesting, but in NC, sea turtles 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). Along with the beach slope, the composition, color, and grain size can affect the incubation time, gender, and hatchling success of turtle hatchlings as discussed further in Section 4.6.6. Sea turtles require deep, clean, relatively loose sand above the high-tide line for successful nest construction (Hendrickson 1982). 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).

Seabeach amaranth. Seabeach amaranth is an annual or sometimes perennial plant that usually grows between the seaward toe of the dune and the limit of the wave uprush zone occupying elevations ranging from 0.2 to 1.5 m above mean high tide (Weakley and Bucher, 1992). 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. Greatest concentrations of seabeach amaranth occur near inlet areas of barrier islands such as Emerald Isle and Fort Macon, but in favorable years many plants may occur away from inlet areas as further discussed in Section 4.6.8. The species is intolerant of competition, and requires habitats that are largely devoid of other 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.

4.6 Inlet and Estuarine Communities in the Permit Area

4.6.1 Bogue Inlet Spit-Shoal Complex

Morphology and dynamics. Bogue Inlet separates Bogue Banks from Bear Island and links the Bogue Sound/White Oak River estuarine system with the Atlantic Ocean and encompasses approximately 8,900 acres in size, including the ebb and flood tide deltas (Rosov and York 2009). Bogue Inlet is bordered to the east by Bogue Banks and is situated approximately 25 miles west of Beaufort Inlet. The Town of Emerald Isle comprises the western 11 miles of the barrier island complex in Carteret County. West of Bogue Inlet is Bear Island, an undeveloped barrier island approximately three miles in length in eastern Onslow County. The inlet drains an expansive marsh filled lagoon where Eastern and Western Channels, two large relatively deep tidal creeks, connect the inlet to the AIWW.

The main section of the inlet between the two islands (inlet throat) is exceptionally wide (6,180 feet) and contains a large mid-inlet shoal complex. Accreting sand spits extend into the inlet throat from the opposing inlet shorelines, forming expansive intertidal and supratidal flats. Along the seaward margin of the inlet throat, longshore sediment transport is disrupted by outgoing (ebb) and ingoing (flood) tidal currents. Sediments reworked and deposited by the ebb tidal current form a large ebb tidal shoal (a.k.a. tidal delta) along the seaward margin of the inlet throat, and sediments transported and deposited by flood tidal currents form a flood tidal delta along the estuarine margin of the inlet. In a previous habitat community assessment by Rosov and York (2009), fifteen biotic communities were identified within the Bogue Inlet complex including: low marsh, high marsh, upland shrub-scrub, upland mixed forest, upland hardwood forest, wetland shrub-scrub, wetland mixed forest, wetland hardwood forest, dune grasses, beach and foredune, intertidal, subtidal, unvegetated sand, SAV, and shellfish habitat.

Although the overall inlet has been a relatively stable feature over the last few centuries, the unstable ebb channel has a history of migration related to spit growth on the opposing inlet shorelines. Ebb channel breaching of the inlet shoals on several occasions since the late 1800s has led to rapid repositioning of the ebb channel (Cleary 2003). Rapid eastward migration of the throat ebb channel during the 1980s and 1990s resulted in chronic erosion of the Bogue Banks inlet shoreline, eventually threatening residential development on the west end of the island. In 2005, the ebb channel was relocated approximately 3,500 feet to the west towards Bear Island. The 2005 alignment was based on a long-term shoreline change analysis, which indicated that an alignment approximating the 1978 ebb channel configuration would provide optimal benefits for both inlet shoulders and both of the flanking oceanfront shoreline segments (Cleary 2008).

The depth of the main Bogue Inlet ebb channel is maintained under an ongoing USACE navigation project. The project authorizes maintenance of a channel six feet deep and 90 feet wide between the AIWW and Bogue Inlet and a channel eight feet deep and 150 feet wide across the ocean bar. The project does not include maintenance of a fixed channel alignment, as dredging is restricted to the deep water channel that exists at the time of the maintenance event. Bogue Inlet was dredged 79 times between 1975 and 2010, with an average of 82,510 cy of material removed per dredging event. Dredging has been performed primarily by sidecast dredges, with dredged materials being discharged to open waters adjacent to the navigation channel.

4.6.2 Intertidal Flats and Shoals

Macroinvertebrates. Intertidal flats support a highly productive benthic microalgal community. Benthic microalgae, along with imported primary production in the form of phytoplankton and detritus, support a diverse community of infaunal and epibenthic invertebrates. Important benthic invertebrates include nematodes, copepods, polychaetes, amphipods, decapods, bivalves, and gastropods (SAMFC 1998). Large mobile invertebrates that move onto intertidal flats with the rising tide include blue crabs, horseshoe crabs, and penaeid shrimp. Mobile predatory gastropods (e.g., whelks and moon snails) occur along the lower margins of submerged tidal flats, and fiddler crabs (*Uca* spp.) are common on exposed flats during low tide (Peterson and Peterson 1979). Benthic invertebrates are an important food source for numerous predatory fishes that move onto intertidal flats with the rising tide.

Fishes. Common predatory fishes on intertidal flats include Atlantic croaker, flounders, inshore lizardfish, pinfish, red drum (*Sciaenops ocellatus*), southern kingfish, and spot. Planktivores [e.g., anchovies, killifish (*Fundulus* sp.), and menhaden] and detritivores [e.g., striped and white mullet (*M. curema*) and pinfish] also forage on tidal flats during high tide. Intertidal flats function as an important nursery area for numerous benthic oriented estuarine dependent species, especially Atlantic croaker, penaeid shrimp, flounders, and spot. Shallow unvegetated flats provide an abundant food source and are relatively inaccessible to large predators (SAFMC 1998).

Birds. Habitats associated with coastal inlets (e.g., intertidal flats, sand spits, shoals, and small islands) are especially important to migrating shorebirds (Harrington 2008). Bogue Inlet and Beaufort Inlet both provide important foraging and roosting habitat for large numbers of migrating and wintering shorebirds. Rice and Cameron (2008) documented the seasonal abundance and distribution of non-breeding shorebirds at Bogue Inlet. Weekly surveys of habitat use and behavior (e.g., foraging, breeding, resting, etc.) were conducted from 2003 through 2008 documenting 28 shorebird species at Bogue Inlet (Table 4.2). Surveys documented the use of intertidal flats and the ebb and flood shoals by these shorebirds, specifically in the vicinity of the western

Table 4.2. Annual shorebird counts at Bogue Inlet.

Species	2003/04 (n=37)	2005 (n=46)	2006 (n=41)	2007 (n=41)	2008 (n=35)
Dunlin	7297	4981	2679	4821	3415
Short-billed dowitcher	3242	1664	1263	1881	2285
Sanderling	2858	1454	1629	1996	2381
Semipalmated plover	988	872	982	1079	2028
Black-bellied plover	978	690	1103	1240	1127
Western sandpiper	759	431	249	463	498
Semipalmated sandpiper	443	546	95	415	425
Wilson's plover	250	316	246	367	611
Willet	181	120	156	284	389
Red knot	41	250	278	138	409
Ruddy turnstone	256	172	124	150	260
Least sandpiper	395	72	119	123	198
Piping plover	179	149	106	181	275
American oystercatcher	76	84	121	138	135
Whimbrel	24	21	36	70	202
Greater yellowlegs	46	36	28	69	97
Spotted sandpiper	32	18	9	30	17
Killdeer	36	9	10	4	12
Marbled godwit	9	1	24	7	19
Peeps	5	2	32	5	10
Long-billed dowitcher	23	0	0	0	0
Snowy plover	0	0	0	0	3
Unknown shorebird	0	0	0	0	3
Buff-breasted sandpiper	1	0	0	1	0
Pectoral sandpiper	0	2	0	0	0
Stilt sandpiper	1	1	0	0	0
White-rumped sandpiper	0	0	0	1	1
Yellowlegs sp.	0	0	2	0	0
European whimbrel	1	0	0	0	0
Ruff	0	0	1	0	0
Wilson's phalarope	0	0	0	1	0
Total Individuals	**18121**	**11891**	**9292**	**13464**	**14800**

n = number of surveys conducted

end of Bear Island. These habitats are likely vital foraging and roosting habitats. The six most abundant shorebirds were dunlin (*C. alpina*), short-billed dowitcher (*Limnodromus griseus*), sanderling, semipalmated plover (*C. pusilla*), black-bellied plover, and western sandpiper (*C. mauri*). Collectively, these species accounted for 85% of the total number of shorebird observations at Bogue Inlet. Dunlins and short-billed dowitchers were most abundant during winter months. Semipalmated plovers and black-bellied plovers were generally most abundant during fall migration, although significant numbers were also observed during spring and winter. Numbers of western sandpipers and sanderlings varied by season and year, but were generally highest during fall and winter months. Overall shorebird abundance was generally highest during December and January, due in large part to the presence of large numbers of dunlin and short-billed dowitchers during the winter months. Shorebird numbers also peaked during spring and fall migration periods. Overall abundance was lowest during the months of June and July.

Habitats associated with Bogue Inlet and Beaufort Inlet, including the east end of Bear Island, the west end of Bogue Banks, and the west end of Shackleford Banks, are recognized as important stopover and wintering sites for the federally threatened piping plover. All three areas have been designated as critical habitat for the Atlantic Coast wintering population (see additional piping plover information below). Additional information regarding the occurrence of piping plovers in these areas is provided in Section 4.6.2.

All four species of shorebirds that breed in NC (American oystercatcher, piping plover, willet, and Wilson's plover) have nested recently in the vicinity of Bogue Inlet and/or Beaufort Inlet (USFWS 2002). The results of shorebird breeding surveys at Bogue Inlet from 2003 through 2008 are shown in Table 4.3 (Rice and Cameron 2008). Surveys documented nesting by American oystercatchers, piping plovers, and Wilson's plovers. The majority of the nests (77%) were located on the east end of Bear Island and Dudley Island. A total of five American oystercatcher nests and ten Wilson's plover nests were recorded on the west end of Bogue Banks from 2003 through 2008. The NPS has conducted annual piping plover breeding surveys on Shackleford Banks since 1989. Annual breeding surveys for American oystercatchers have been conducted since 1995 and annual Wilson's plover breeding surveys have been conducted since 2007. A few American oystercatcher nests are typically found each year on the west end of Shackleford Banks near Beaufort Inlet. Surveys have not recorded any piping plover or Wilson's plover nests on the western half of Shackleford Banks.

Habitats associated with coastal inlets (e.g., intertidal flats, sand spits, shoals, and small islands) are especially important to migrating colonial sea birds (Harrington 2008). Bogue Inlet and Beaufort Inlet both provide important foraging and roosting habitats for large numbers of migrating and wintering sea birds. Rice and Cameron (2008) documented the seasonal abundance and distribution of non-breeding colonial sea birds

Table 4.3. Numbers of shorebird breeding pairs observed at Bogue Inlet.

Bear Island	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Piping plover	0	0	0	1	1	1
Wilson's plover	1	2	2	3	6	8
Bogue Banks						
American oystercatcher	1	0	1	1	1	1
Wilson's plover	1	2	2	2	2	1
Dudley Island						
American oystercatcher	1	2	1	1	1	0
Wilson's plover	5	7	5	5	3	1
Bogue Inlet Shoals						
Wilson's plover	0	2	0	0	0	0
Total	**9**	**15**	**11**	**13**	**14**	**12**

Table 4.4. Annual colonial sea bird counts at Bogue Inlet.

Species	**2003/04 (n=37)**	**2005 (n=46)**	**2006 (n=41)**	**2007 (n=41)**	**2008 (n=35)**
Laughing gull	7194	809	1766	863	751
Royal tern	3269	2254	2565	1516	698
Black skimmer	1741	1257	2099	2096	1429
Herring gull	4841	1015	884	440	840
Brown pelican	2669	944	1595	766	1066
Cormorant	1821	422	1968	2185	408
Ring-billed gull	2484	2069	900	720	452
Least tern	641	827	251	512	1476
Sandwich tern	1302	264	466	637	673
Forster's tern	1509	268	251	171	588
Common tern	776	156	665	422	329
Caspian tern	491	201	343	425	738
Great black-backed gull	969	287	265	137	350
Bonaparte's gull	1207	175	229	125	196
Black tern	8	4	25	3	37
Lesser black-backed gull	40	2	2	2	19
Gull-billed tern	7	0	0	3	0
Glaucous gull	0	0	0	1	0
Sooty tern	0	0	0	1	0
Total Individuals	**30969**	**10954**	**14274**	**11025**	**10050**

n = number of surveys conducted

at Bogue Inlet. Weekly surveys conducted from 2003 through 2008 documented 19 colonial sea bird species at Bogue Inlet (Table 4.4). The five most abundant species were laughing gull, royal tern, black skimmer, herring gull, and brown pelican. Collectively, these species accounted for 59% of the total number of colonial sea bird observations at Bogue Inlet. Laughing gulls, royal terns, and black skimmers were most abundant during fall migration.

There was no clear pattern of seasonal abundance for herring gulls and brown pelicans. In general, overall sea bird abundance was highest during fall migration. The developed ocean-facing beach on Bogue Banks has not supported colonial sea bird nesting in many years (USFWS 2002). However, several species continue to nest at Bogue Inlet, Beaufort Inlet, and/or on small islands in Bogue Sound. The results of colonial sea bird breeding surveys at Bogue Inlet from 2003 through 2008 are shown in Table 4.5 (Rice and Cameron 2008). These surveys documented nesting by black skimmers, common terns, and least terns. The majority of the nests (84%) were located on the east end of Bear Island. Least terns accounted for the majority (89%) of the nests throughout Bogue Inlet. The only nest recorded on the west end of Bogue Banks was a single least tern nest in 2003.

Significant colonial sea bird nesting has occurred in the past on the west end of Shackleford Banks at Beaufort Inlet. Parnell et al. (1995) recorded 391 common tern nests, 157 black skimmer nests, 37 gull-billed tern nests, and seven least tern nests on the west end of Shackleford Banks in 1993. However, recent annual breeding surveys (2007-2010) conducted by the NPS have not recorded any colonial sea bird nesting on the western half of Shackleford Banks. Common terns, gull-billed terns, least terns, and black skimmers have also nested in the past on the east end of Bogue Banks at Beaufort Inlet (USFWS 2002).

Table 4.5. Annual colonial sea bird breeding pair observations at Bogue Inlet.

Bear Island	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**
Black skimmer	38	0	1	0	0	0
Common tern	2	1	2	0	0	2
Least tern	5	57	31	26	2	214
Bogue Banks						
Least tern	1	0	0	0	0	0
Dudley Island						
Least tern	1	0	5	0	0	0
Bogue Inlet Shoals						
Least tern	30	37	0	0	0	0
Total	**77**	**95**	**39**	**26**	**2**	**216**

4.6.3 Inlet Dry Beach and Dune Communities

Inlet dunes and inlet beaches are similar to coastal dunes and coastal beaches, however, as a result of episodic overwash, these habitats are typically not as established as coastal beaches and often lack the vegetation common on the coastal beach and dune systems. Inlet dunes are defined as any hill, mound, or ridge of sand along the inlet coastline created by natural or artificial forces. The inlet dry beach habitat is defined as the portion of the ocean beach in proximity to the inlet that is between MHW and the toe of the dune. These inlet dunes and beaches are also susceptible to forecasted sea level rise. Based on the three-year post-construction biotic community habitat mapping efforts associated with the 2005 Bogue Inlet Channel Erosion Project, there are approximately 127 acres of inlet beach and foredune habitat within Bogue Inlet. This acreage is likely to have shifted since 2008.

Birds. Most shorebirds are long distance migrants, who migrate through and winter in NC en route to find suitable breeding sites in the Arctic. To complete these flights, shorebirds must obtain a large food reserve. The inlet dunes and beaches in proximity to Bogue Inlet provides migration stop-over areas used by shorebirds to replenish food reserves and accumulate fat needed for the long flights. There are few places that have the necessary combination of resources. In some areas, between 50% and 80% of the entire population of a species may visit a single site (Harrington 2003). Migratory arctic-bound shorebird species that may be found during the non-breeding season within inlets of North Carolina include the red knot (*Calidris canutus rufa*), dunlin (*C. alpine*), western sandpiper (*C. mauri*), and sanderlings (*C. alba*). Many arctic breeding species are experiencing declines, including the red knot, which was recently federally listed for protection under the ESA.

Shorebirds utilize these inlet dunes and beaches for breeding, wintering and migrating. Many species rely on a few, key stopover sites to complete their annual migratory cycle. The Outer Banks of North Carolina constitute a prime example of a potentially important area for which only limited information on migratory birds is available (Dinsmore, et al., 1998). Some species of waterbirds, such as terns and black skimmers, nest on bare sand and shell with little or no vegetation. These species will change nesting areas in response to changing environmental conditions, such as increased vegetation or storm events. In selecting nesting habitat, waterbirds recognize the area and past success, but mainly adhere to group dynamics. This type of grouping creates nesting, resting, and foraging areas with large colonies that can include multiple species of waterbirds.

4.6.4 Inlet Overwash Habitats

One type of dry inlet beach habitat that is an important feature to barrier island formation is overwash areas. Natural processes, such as storms, create overwash features behind primary sand dune areas. Acreage of overwash habitat has not been delineated within the Permit Area as it is ever-changing. Overwash areas are usually created during strong storm events when tides wash over portions of the beach and move sand back towards the sound, creating new habitat. Overwash areas are characterized by the low sand flats left where storm waves have washed across a barrier island. This includes loose sand, perhaps piled into dunelets and/or divided by sluiceways, and usually scattered weedy shrubs and herbs. After the site has gone for an extended period without storm scouring, the vegetation may develop into a dense mat of vines and grasses.

Vegetation. As discussed previously, seabeach amaranth, a federally listed threatened annual herb, is an important species which can be found on barrier island beaches, lower foredune and overwash flats. Seabeach amaranth is most typically found along sparsely vegetated sand beaches. Small populations can occasionally develop along sound-side beaches, blowouts in foredunes, as well as renourished beaches containing sand and shell material or dredge spoil (USFWS 1993). Seabeach amaranth populations vary widely among years as noted in results from annual surveys on Bear Island (from Bogue Inlet to Bear Inlet), conducted by Hammocks Beach State Park personnel.

Birds. Overwash features are not unique to inlets; however, the dynamic and productive microhabitats formed as a result of inlet migration are very important to both breeding and non-breeding waterbirds. Overwash habitats include ephemeral pools and bayside mudflats which are important feeding areas to piping plovers at the start of the nesting season and throughout the year (Fraser 2005, USFWS 1996). Overwash habitat is utilized by wildlife, particularly shorebirds, colonial waterbirds and other waterbirds as they provide suitable foraging and nesting habitat for these birds. Overwash events usually occur during storm events or in low areas during spring high tide conditions when seawater flows through the primary dune line, spreading out sand from the beach and dunes. Recently created overwash fans are generally unvegetated and function similar to the dry beach community. Willets, American oystercatchers, piping plovers, Wilson’s plovers, and killdeers usually nest on open areas such as above the high tide line on coastal beaches, on sand flats at the ends of sand spits, and along blowout areas behind dunes and in overwash areas. These open habitats are utilized by breeding and nonbreeding colonial waterbirds. In particular, the Wilson's plover and the federally threatened piping plover are both dependent on hurricanes and storms to provide the overwash needed for nesting habitat (Deaton et al. 2010).

4.6.5 Inlet Water Column

Water column is a conceptual column of water from its surface to bottom sediments that characterize the waters and creeks in and around Bogue and Beaufort Inlet. The concept of water column is important, since many aquatic processes are explained by the vertical mixing of chemical, physical or biological parameters. The depth of water column varies greatly throughout the Permit Area. Historically, Bogue Inlet channel has been maintained by the USACE for commercial and recreational boating since 1981. The USACE is authorized to maintain the channel to a depth of 2.4 m (8 feet) mean low water (MLW) over a width of 45.7 m (150 feet). The USACE Navigation Branch has attempted to maintain the inlet channel using shallow draft U.S. Government sidecast dredges. However, this maintenance activity is limited to the deepwater channel that exists at the time maintenance is performed. As a result, the USACE Navigation Branch maintenance activities have been unable to control the location of the channel.

The morphology of Bogue Inlet is dependent upon sediment transport due to tidal currents through the inlet and wave action on the shoal / channel complex and adjacent beaches. Subtidal areas are found in areas east of the inlet, west of the inlet, and behind Dudley Island and Shackelford Banks. Soft-bottom, subtidal habitats consist of various percentages of sand, silt, and clay, occurring in sheltered bays and estuaries. These habitats are influenced to a great extent by tides and thus have a variety of different salinities and water temperatures.

Hydrodynamics and salinity: The tidal regime in Bogue Inlet is dominated by the lunar semidiurnal (two cycles/day) tidal constituent, with an observed mean annual tidal range of approximately 2.2 feet and a spring tidal range of approximately 2.6 feet (NOAA Water Level Station TEC2837). The only presently-operating NOAA tide gauge in the immediate study area is located at Beaufort, NC. Verified six-minute and hourly water level measurements, with associated predicted tidal water levels, are readily available from the NOAA's CO-OPS program website for the time period December 1995 – present.

The NOAA's published tidal datum sheet indicates a range of 1.078 m (3.54 feet) between MHWW and MLLW, with a range of 0.948 m (3.11 feet) between MHW and MLW. The Beaufort tide station is located well within the harbor at Beaufort Inlet, and as such does not accurately represent tidal water levels along the open Atlantic coast of Bogue Banks or at the Bouge Inlet channel and ebb shoal.

Long-term data sets for salinity and water quality data for Bogue Inlet are lacking; however, data are available from NCDWQ ambient monitoring stations in Bogue Sound and the mouth of the White Oak River at Swansboro (NCDWQ 2005). Salinities in Bogue Sound are high throughout the year, with an observed range of 23 to 37 ppt at the ambient monitoring stations.

Fish and Larval Transport: Many of NC's coastal fish spawn offshore on the continental shelf and use estuarine habitats for juvenile development. Water column environments in the Permit Area include the inlet subtidal areas and surf zones of Bear Island, Bogue Banks, Dudley Island, Shackelford Banks and the creeks. Fish that utilize these water columns of NC include: anadromous fish, which can be found in coastal waters but migrate into rivers to spawn in freshwater (e.g. striped bass, Atlantic and shortnose sturgeon, herring); estuarine-dependent species (e.g. flounder, blue crab, penaeid shrimp, red drum); permanent resident species (e.g. black sea bass, Atlantic bumper, lizardfish); and seasonal migrant species (e.g. bluefish, Spanish and king mackerel, cobia, spiny dogfish).

The transport of larval fish from the offshore water column to the estuarine nursery areas through inlets plays a vital role in the life cycle of many fish species. Peak spawning periods for many of these ocean-spawning/estuarine-dependent species occur during the fall and winter [e.g., Atlantic croaker, Atlantic menhaden, gag grouper (*Mycteroperca microlepis*), pinfish, southern flounder (*Paralichthys lethostigma*), summer flounder (*P. dentatus*), spot, and striped mullet); although a number of species spawn during the spring and summer [e.g., black sea bass, bluefish, sheepshead minnow (*Cyprinodon variegatus*), southern kingfish, and Spanish mackerel]. Larvae spawned offshore are transported shoreward by the prevailing currents, eventually passing through tidal inlets and settling in estuarine nursery habitats. Juveniles remain in the estuarine nursery areas for a period of one or more years before moving offshore and joining the adult spawning stock (Deaton et al. 2010).

Successful larval recruitment to estuarine nursery areas is dependent on transport through a relatively small number of narrow tidal inlets. Studies at Beaufort Inlet indicate that larvae accumulate in the nearshore ocean zone where they are picked up by along-shore currents and transported to the inlet (Churchill et al. 1999). Blanton et al. (1999) indicate that larvae are successfully drawn into Beaufort Inlet from a narrow, shallow-water (less than 7 m), withdrawal zone upwind of and just outside the mouth of the inlet. Within a single flood tide event, Blanton et al. (1999) estimated ten percent of the withdrawal zone larvae are successfully drawn into the inlet. A long-term larval fish sampling program has been in place at Beaufort Inlet since 1986. Taxa dominating the samples in terms of total cumulative numbers of individuals collected include spot, pinfish, croaker, menhaden, speckled worm eel (*Myrophis punctatus*), flounders, pigfish, gobies (Gobiidae), and striped mullet (Table 4.6) (Taylor et al. 2009).

Temporal patterns of larval transport through Beaufort Inlet were described by Hettler and Chester (1990). Overall larval densities within the inlet were highest from late May to early June and lowest in November. High densities during the late spring were largely attributable to high numbers of anchovies, which accounted for 85% of the individuals in the peak samples. Species richness was also highest (32 taxa) in the late spring and lowest (three taxa) in November. The most abundant species in the winter/early-spring samples were Atlantic menhaden, spot, Atlantic croaker, speckled worm eel, and summer flounder. Samples collected during late spring were dominated by anchovies, silver perch, weakfish, and pigfish; the most abundant taxa in the summer samples were striped anchovy, gobies, and Atlantic thread herring.

Table 4.6. Most abundant ichthyoplankton taxa captured at Beaufort Inlet (1987-2004).

Abundance Rank	Taxon
1	Spot
2	Pinfish
3	Atlantic croaker
4	Atlantic menhaden
5	Speckled worm eel
6	Gulf flounder
7	Pigfish
8	Gobies
9	Southern flounder
10	Striped mullet
11	Summer flounder

Source: Taylor et al. 2009

4.6.6 Inlet Soft Bottom Communities

Macroinvertebrates. Estuarine soft bottom habitats support a diverse assemblage of benthic invertebrates, with over 400 taxa reported from NC waters (Hyland et al. 2004). Dominant invertebrate macrofauna include amphipods, polychaetes, mollusks, echinoderms, and crustaceans (Peterson and Peterson 1979). Deposit feeders such as mud snails, polychaete worms, some bivalve clams, and some crustaceans ingest sediment/detritus and assimilate the associated bacteria, fungi, and microalgae. Suspension feeders such as the hard clam (*Mercenaria mercenaria*), razor clam (*Siliqua patula*), and some polychaete worms capture particulates suspended in the water column (Miller et al. 1996). Benthic epifauna consist of larger, mobile invertebrates that live on the surface of soft bottom.

Macroinfaunal data, collected as a component of the 2005 Bogue Inlet Channel Erosion Response Project, determined both species composition and species density during pre- and post-construction benthic sampling events (Hague and Carter 2007). It was evident during the study that Bogue Inlet is a dynamic system in a constant state of change and natural physical disturbance occurs on many spatial and temporal scales. Changes in species composition, diversity, abundance, and richness were analyzed and correlated as an indication of disturbance levels at the three habitat types. Post-disturbance recovery of the benthic communities at each habitat type was also assessed utilizing the successional colonization paradigm.

Baseline (pre-construction) monitoring occurred during 2003, while post-construction monitoring repeated seasonal sampling events in 2007 and 2008. In summary, as of the final 3-year post-construction monitoring event, both the intertidal and marsh habitats were not considered impacted as a result of the Bogue Channel Erosion Response Project. Sampling adjacent to the main ebb channel was initiated to provide evidence of change to the relic shoal habitat as a result of project activities. Results show that natural disturbances in the area, including Hurricane Ophelia, may have equaled project-related effects and that as of the final 2008 sampling assessment, the effects of disturbance in the project area have abated and Stage I of the successional paradigm is evident. This inlet environment remains dominated by physical stress, which is natural within a high energy inlet.

Macroinfaunal species are sensitive to physical and chemical changes in water quality and, therefore, are useful indicators of a wide range of natural and anthropogenic stresses. Macroinfauna indicative of a healthy benthic community depend upon variable particle sizes and available interstitial pore space in the substrate. Macroinfauna can therefore be useful for biomonitoring of aquatic habitats because of their limited mobility. This makes them a good indicator of local conditions. Changes in species diversity, abundance and richness can assist in determining disturbances in the benthic environment, as well as natural seasonal changes.

On submerged flats and shallow bottoms, the blue crab functions as an important predator and scavenger. The evidence for blue crabs spawning in inlet areas was enough to warrant their protection as Crab Spawning Sanctuaries [NCDMF 2004 – blue crab fisheries management plan (FMP)]. Other mobile epifauna include horseshoe crabs (*Limulus polyphemus*), whelks (*Busycon* spp.), tulip snails (*Fasciolaria* spp.), moon snails (*Polinices duplicatus*), penaeid shrimp, hermit crabs (*Pagurus* spp., *Petrochirus* spp., *Clibanarius vittatus*), sand dollars (*Mellita quinquiesperforata*), and spider crabs (*Libinia* spp.).

Fishes. Most fish that forage on estuarine soft bottom are predators of benthic invertebrates. These fish include rays, skates, flatfish, drums, pigfish, northern sea robins (*Prionotus carolinus*), lizardfish, gobies, and sturgeons (Peterson and Peterson 1979, Bain 1997). Larger piscivorous fish move onto estuarine flats during high tide to feed on schools of baitfish. These predators include sharks [sandbar (*Carcharhinus plumbeus*), dusky, smooth dogfish, spiny dogfish (*Squalus acanthias*), Atlantic sharpnose, and scalloped hammerhead (*Sphyrna lewini*)], drum, weakfish, spotted seatrout (*C. nebulosus*), striped bass, and estuarine-dependent reef fish (black sea bass, gag grouper, and sand perch) (Peterson and Peterson 1979, Thorpe et al. 2003). Small flatfish, [i.e. bay whiff (*Citharichthys spilopterus*), fringed flounder (*Etropus crossotus*), hogchoker (*Trinectes maculatus*), and tonguefish (Cynoglossidae)], feed mostly on copepods; amphipods; mysids; polychaetes; mollusks; and small fish. Summer and southern flounder primarily consume small fish (e.g., silversides and anchovies), as well as invertebrates (e.g, shrimp, crabs, small mollusks, annelids, and amphipods) (Peterson and Peterson 1979, Burke 1995).

Resident fish and invertebrates, as well as seasonal migratory fish, spawn over estuarine soft bottom habitats; particularly in summer. Resident flatfish, including hogchokers and tonguefish, use subtidal estuarine soft bottom as spawning grounds (Hildebrand and Schroeder 1972, Manooch 1984). Migratory estuarine spawners, including several species of drum, predominately spawn over soft bottom during the summer months. Spotted seatrout spawn on the east and west sides of Pamlico Sound during a similar time period with peak activity observed around Rose Bay, Jones Bay, Fisherman's Bay, and Bay River (Luczkovich et al. 1999 and 2008). Red drum are also documented spawning in the mouth of the Bay River on the west side of Pamlico Sound and in estuarine channels near Ocracoke Inlet (Luczkovich et al. 1999 and 2008).

The dominant fish using shallow estuarine soft bottom as nursery areas are estuarine-dependent species, which primarily spawn offshore in winter. For many species, the uppermost reaches of shallow creek systems correspond to the site of larval settlement; i.e., the primary nursery areas (Weinstein 1979, Ross and Epperly 1985). Abundance of juvenile species in estuarine nursery areas generally peaks between April and July (Ross and Epperly 1985). As they grow, fish move to deeper estuarine waters.

In moderate- and high-salinity estuarine zones, the young of offshore winter and spring spawners; such as Atlantic menhaden, spot, and Atlantic croaker, are predominate. The estuarine spawning species are mostly resident forage finfish species that spawn in estuaries during the warmer months. Estuarine-dependent migratory species including spot, Atlantic croaker, and penaeid shrimp are common during summer and fall (Weinstein 1979, Epperly 1984, Ross and Epperly 1985, Noble and Monroe 1991, and Ross 2003).

In the early 1980s, fishery independent data from shallow creeks and bays in Pamlico Sound documented 78 fish and invertebrate species over a two-year period (Ross and Epperly 1985). Eight species including spot, bay anchovy, Atlantic croaker, Atlantic menhaden, silver perch, blue crab (*Callinectes sapidus*), brown shrimp, and southern flounder comprised more than 97% of the total nekton abundance. Data from the NCDMF's ongoing juvenile fish monitoring program show that the same eight species continue to dominate NC's nekton assemblage, with pinfish and white shrimp also among the most abundant species collected.

4.6.7 Shell Bottom

Characteristics. Shell bottom habitats include oyster reefs, aggregations of non-reef building shellfish species [e.g., clams and scallops (*Argopecten irradians*, *A. gibbus*)], and surface concentrations of broken shells (shell hash). Oysters (*Crassostrea* *virginica*) are the dominant and principal reef-building species of estuarine shell bottom habitats in NC. Non-reef building shellfish species that occur at densities sufficient to provide structural habitat for other organisms include scallops, pen shells (*Atrina seratta*, *A. rigida*), and rangia clams (*Rangia cuneata*) (SAFMC 2009). The NCDMF has mapped shell bottom and other benthic habitats in Bogue Sound (Figure 4.7). Shell bottom areas are concentrated in the western portion of Bogue Sound behind Emerald Isle and the eastern portion of the sound behind Fort Macon State Park.

Functions. Shell bottom habitats perform a number of important ecological functions such as water filtration, benthic-pelagic coupling, sediment stabilization, and erosion reduction (Deaton et al. 2010, SAFMC 2009, Coen et al. 2007). Oysters and other suspension feeding bivalves reduce turbidity in the water column by filtering particulate matter, phytoplankton, and microbes. The consumption of particulates also results in the transfer of material and energy from the water column to the benthic community (i.e., benthic-pelagic coupling). Shell bottom structural relief alters currents and traps and stabilizes suspended solids, thus further reducing turbidity. By moderating waves and currents, oyster reefs and other shell bottom habitats reduce shoreline erosion.

Associated biota. The hard surfaces provided by existing oyster reefs and shell hash function as important settlement and accumulation sites for recruiting oysters, hard clams, and other shellfish. Although oysters and other shellfish also settle on pilings, seawalls, rip-rap, and the exposed roots of salt marsh vegetation; existing oyster reefs and shell hash provide the most abundant and preferred substrate for larval settlement (NCDMF 2008). Studies summarized by Deaton et al. (2010) have documented the importance of shell bottom as foraging, spawning, and nursery habitat for numerous species of invertebrates and fish. Shell bottom structure concentrates macroinvertebrates and small forage fish [e.g., grass shrimp, mud crabs (*Scylla* spp.), pinfish, and gobies], which in turn attract larger predatory fish such as Atlantic croaker, black drum, pigfish, southern and summer flounder, and spotted seatrout. Shell bottom habitats are utilized as spawning areas by a number of finfish and decapod crustaceans; including anchovies, blennies (Blennidae), gobies, mummichog (*F. heteroclitus*), oyster toadfish (*Opsanus tau*), sheepshead minnow, grass shrimp, and blue crab. Numerous finfish and decapod crustaceans also utilize shell bottom habitats as a nursery area; including anchovies, black sea bass, blennies, gobies, oyster toadfish, pinfish, red drum, sheepshead minnow, skilletfish (*Gobiesox strumosus*), spot, striped bass, weakfish, penaeid shrimp, blue crabs, and stone crabs (*Menippe mercenaria*).

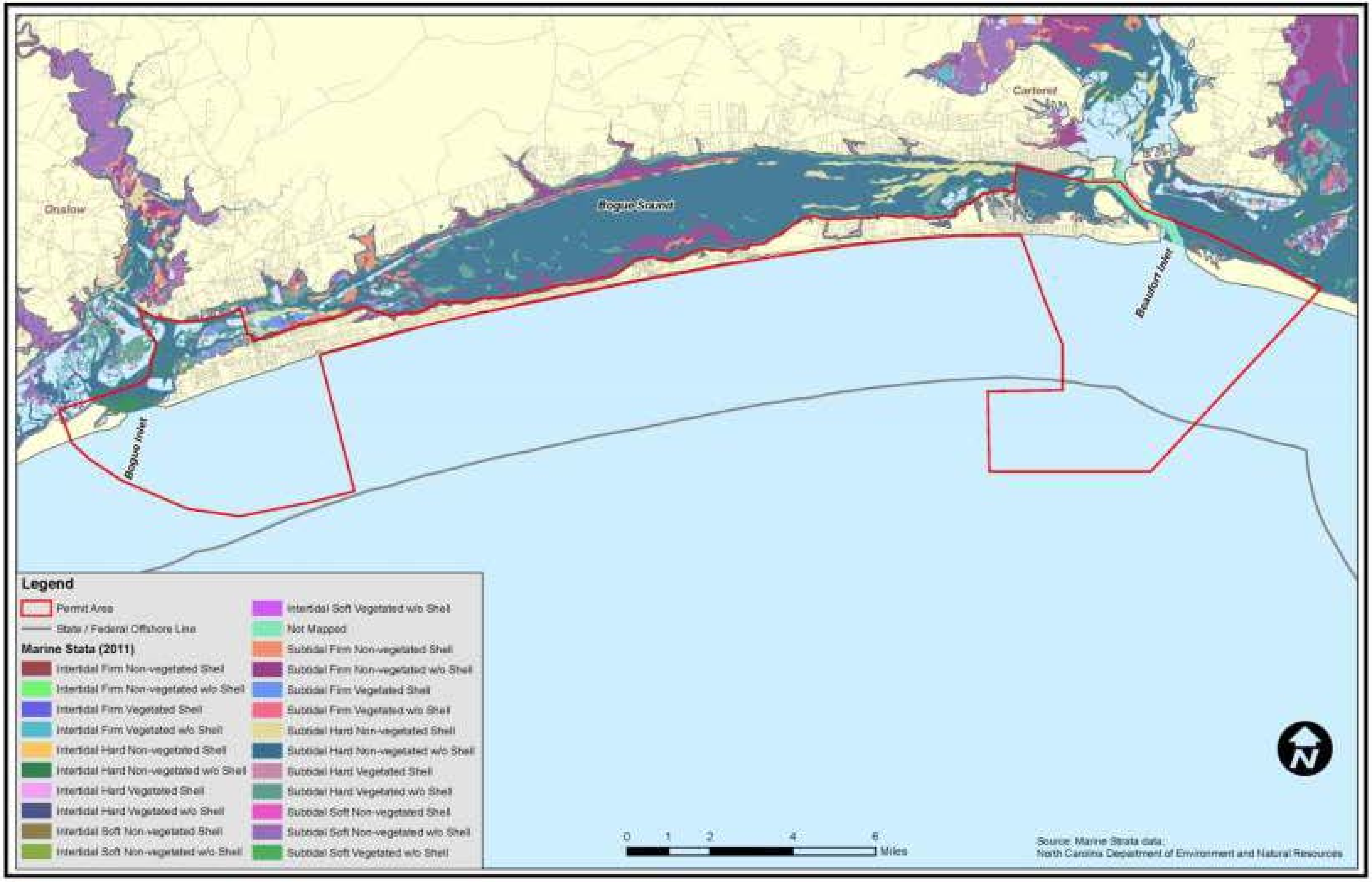


Figure 4.7. Benthic Habitats

4.6.8 Submerged Aquatic Vegetation

Several species of estuarine submersed, aquatic vascular plants form extensive beds in Bogue Sound. These species, which include eelgrass (*Zostera marina*), shoalgrass (*Halodule wrightii*), and widgeon grass (*Ruppia maritima*), are collectively referred to as SAV or seagrasses. SAV beds occur on subtidal and occasionally intertidal sediments in sheltered estuarine waters. Environmental requirements include unconsolidated sediments for root and rhizome development, adequate light reaching the bottom, and moderate to negligible current velocities (Thayer et al. 1984, Ferguson and Wood 1994). In NC, eelgrass is more common in shallow, protected estuarine waters during the winter and spring. During the summer when water temperatures are above 25–30°C, shoalgrass is more abundant in shallow, protected areas and eelgrass dominates only in deeper waters and/or on tidal flats with continuous water flow (i.e., where water temperatures are lower) (SAFMC 1998). NOAA mapped 6,100 acres of SAV in Bogue Sound in 1992 and more recently in 2011 by the NCDMF (Figure 4.8). SAV species produce large quantities of detritus which is broken down by invertebrates, zooplankton, and bacteria and transferred to higher trophic levels through the estuarine detrital food web. Epiphytic microalgae also provide an important source of food for fish and invertebrates. Invertebrates occurring on SAV leaves include protozoans, nematodes, polychaetes, hydroids, bryozoans, sponges, mollusks, barnacles, shrimp, and crabs. SAV beds provide important structural fish habitat and perform important ecological functions in estuarine systems (i.e., primary production, structural complexity, modification of energy regimes, sediment and shoreline stabilization, and nutrient cycling). Water quality enhancement and fish utilization are especially important functions relevant to the enhancement of coastal fisheries (Deaton et al. 2010).

Fish and invertebrates use SAV as nursery, refuge, foraging, and spawning habitat. Juvenile fish sampling in eastern Pamlico and Core sounds documented over 150 species of fish and invertebrates in SAV beds, of which 34 fish and six invertebrates were important commercial species (NCDMF 1990). Large predatory species such as Atlantic stingrays (*Dasyatis sabina*), bluefish, flounders, red drum, sharks, spotted seatrout, weakfish, and blue crabs are attracted to SAV beds for their concentrations of juvenile finfish and shellfish (Thayer et al. 1984). Important commercial and recreational fish that utilize SAV as juveniles during the spring and early summer include Atlantic croaker, black sea bass, bluefish, flounders, gag grouper, herrings, mullets, red drum, snappers, spot, spotted seatrout, weakfish, and southern kingfish. Bay scallops, hard clams, penaeid shrimp, and blue crabs are also strongly associated with SAV. SAV is considered EFH for red drum, penaeid shrimp, and species in the snapper-grouper complex (SAFMC 1998).

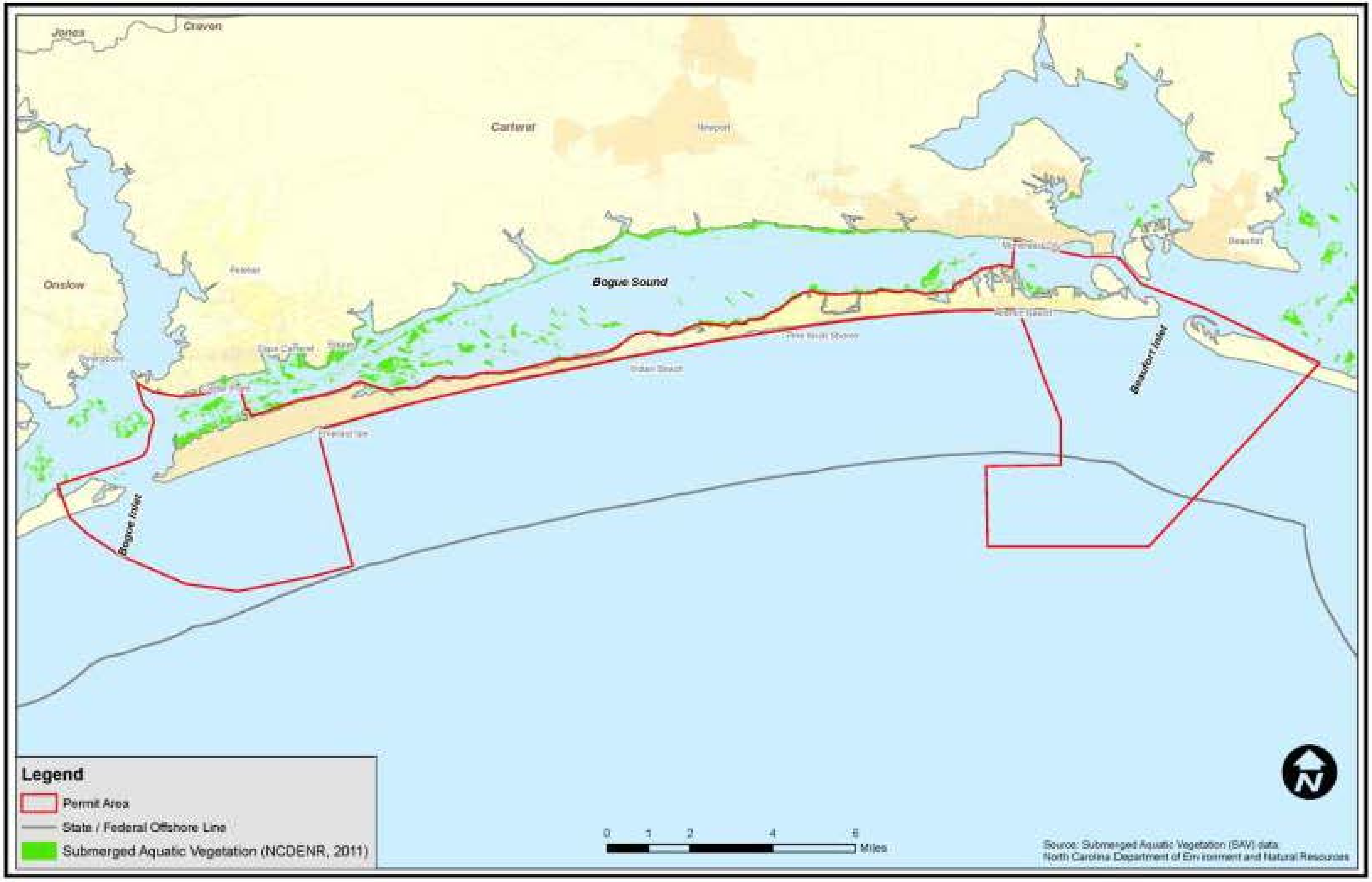


Figure 4.8. Known Submerged Aquatic Vegetation Habitats

4.6.9 Tidal Marsh

Tidal salt and brackish marshes occur along the margins of tidal estuarine waters at salinities ranging from 0.5 to >35 ppt (Wiegert and Freeman 1990). The vegetative community is dominated by emergent, salt-tolerant, herbaceous species including smooth cordgrass (*Spartina alterniflora*), salt-meadow grass (*S. patens*), salt reed-grass (*S. cynosuroides*), black needlerush (*Juncus roemerianus*), glasswort (*Salicornia* spp.), salt grass (*Distichlis spicata*), sea lavender (*Limonium* spp.), bulrush (*Scirpus* spp.), sawgrass (*Cladium jamaicense*), and cattail (*Typha* spp.) Fringing salt and brackish marshes are present in Bogue Sound along the Bogue Banks and mainland shoreline. Fringing marshes occupy approximately 51% of the 38-mile-long Bogue Banks soundside shoreline (USFWS 2002). Another 21% of the Bogue Banks shoreline is occupied by a mixture of fringing marsh and artificial materials (e.g., rip-rap, bulkheads, and groins). Bogue Sound also contains approximately 800 acres of free-standing salt and brackish marshes that are not connected to the mainland or Bogue Banks. The majority of these free-standing marshes are located along the margins of dredge material disposal islands. Extensive marshes are also present within the Bogue Inlet complex (e.g., Dudley and Huggins Islands) and the Beaufort Inlet complex (e.g., Rachael Carson NERR).

Salt and brackish marshes exhibit high primary productivity in the form of detritus, microalgae, and bacteria (Hackney et al. 2000). Tidal flooding connects the marsh with adjacent estuarine waters, allowing utilization by fish and other aquatic organisms. Slow-moving or sessile species residing in salt/brackish marsh and contributing to secondary production include fiddler crabs, mud snails, amphipods, oysters, clams, and Atlantic ribbed mussels (*Geukensia demissa*) (Wiegert and Freeman 1990). Marshes provide habitat for numerous species of decapods and fish. Resident marsh species such as grass shrimp, killifish, mummichogs, sheepshead minnows, gobies, bay anchovies, and silversides provide an important link between marsh primary production and transient predatory fish populations (Wiegert and Freeman 1990, SAFMC 1998). Tidal marshes are utilized as nursery and/or foraging areas by economically important species such as red drum, flounder, spotted seatrout, spot, Atlantic croaker, and blue crab. Other species (e.g., Atlantic menhaden) are not found in the marsh, but derive substantial food resources from the marsh in the form of detritus or microalgae. Along with the shallow soft bottom and shell bottom areas, the bordering salt and brackish marshes along the NC coast are an important nursery habitat for estuarine-dependent species. The majority of the Primary and Secondary Nursery Areas in NC are located in soft bottom areas surrounded by salt/brackish marsh (Deaton et al. 2010). In NC, penaeid shrimp and red drum are considered critically linked to marsh edge habitat (SAFMC 1998).

4.7 Protected Species

4.7.1 Summary of Federally Listed Species

A total of 12 ESA-listed threatened and endangered species are known from the Permit Area (Table 4.7). Additionally, the Permit Area encompasses a number of defined geographic areas that are designated under the ESA as critical habitats for threatened and endangered species (Table 4.8). Critical habitats are areas considered essential to the conservation of a species that may require special management or protection. Designated critical habitats have essential habitat features known as "primary constituent elements" that are required by a species for survival and reproduction. The following sections describe each listed species and any associated critical habitats that occur within the Permit Area.

Table 4.7. ESA-listed species known from the Permit Area.

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

Table 4.8. Critical habitat units within the Permit Area.

Critical Habitat Type	Unit ID	Description	Area/Length
Piping Plover Wintering Critical Habitat	NC-10 Bogue Inlet	East end of Bogue Banks Bogue Inlet emergent shoals West end of Bear Island	354 acres
Piping Plover Wintering Critical Habitat	NC-8 Shackleford Banks	West end of Shackleford Banks (Beaufort Inlet) East end of Shackleford Banks (Barden Inlet)[1]	1,769 acres
Loggerhead Sea Turtle Terrestrial Critical Habitat	LOGG-T-NC-01 Bogue Banks	Oceanfront dry beach from MHW line landward to the toe of the secondary dune or first structure.	24.2 miles
Loggerhead Sea Turtle Terrestrial Critical Habitat	LOGG-T-NC-02 Bear Island	Oceanfront dry beach from MHW line landward to the toe of the secondary dune or first structure.	4.1 miles
Loggerhead Sea Turtle Marine Nearshore Reproductive Critical Habitat	LOGG-N-03 Bogue Banks and Bear Island	Nearshore ocean waters (MHW line to 1.6 kilometers offshore) from Beaufort Inlet to Bear Inlet.	29.5 miles
[1]The east end component of the Shackleford Banks unit is located outside of the Permit Area			

4.7.2 Piping Plover

4.7.2.1 Status and Distribution

Piping plovers are divided into three distinct breeding populations: the Atlantic Coast population (NC to Canada), the Great Lakes population, and the Northern Great Plains population. The Great Lakes breeding population is currently listed as endangered, whereas the Northern Great Plains and Atlantic Coast breeding populations are currently listed as threatened (USFWS 2011). The breeding range of the Atlantic Coast population extends from NC to Newfoundland, Canada. Piping plovers arrive on the Atlantic Coast breeding grounds and initiate courtship in late March or early April. Clutch initiation may occur as early as mid-April and as late as mid-June. The incubation period ranges from 27 to 30 days and chicks fledge at an age of 25 to 35 days. Along the Atlantic Coast, most chicks fledge by the end of July; although flightless chicks may be present through late August (USFWS 1996).

Southward migration to the wintering grounds occurs during late July, August, and September. The wintering ranges of the three breeding populations overlap and include coastal areas from NC to Texas, as well as northern Mexico and the Caribbean (USFWS 1996). All piping plovers on the wintering grounds are considered threatened under the ESA, regardless of breeding origin. Although there is no exclusive partitioning of the wintering range based on breeding origin, recent studies indicate that piping plovers from the Great Lakes are most prevalent during migration and winter along the southern Atlantic Coast; while those breeding on the Northern Great Plains predominate in coastal Mississippi, Louisiana, and Texas. Piping plovers from the northernmost Atlantic Coast (i.e., eastern Canada) are most prevalent during migration and winter along the southern Atlantic Coast; however, the wintering range for the remainder of the Atlantic Coast breeding population is largely unknown (USFWS 2009a).

The breeding, migratory, and wintering ranges overlap in NC; consequently, piping plovers can be found in the state during every month of the year (Cameron et al. 2006). In NC, breeding sites are confined to undeveloped and unstabilized portions of barrier islands; most notably within the Cape Lookout National Seashore, Cape Hatteras National Seashore, Pea Island National Wildlife Refuge, and on Lea and Hutaff Islands (USFWS 2009a). Since 1986, the estimated number of breeding pairs in NC has ranged from 20 to 64 pairs (USFWS 2011). North Carolina's barrier islands serve as important migratory stop over and wintering sites. Piping plovers from all three breeding populations utilize the NC coastline during the non-breeding season. Important stop over and wintering sites in NC include undeveloped beaches along Cape Hatteras National Seashore, Cape Lookout National Seashore, Bear Island, Bird Shoals, and Lea/Hutaff Island; as well as some sites on developed islands such as the west end of Bogue Banks and the south end of Topsail Island (Cameron et al., 2006).

4.7.2.2 Habitat

Atlantic Coast nest sites are located above the high tide line on coastal beaches, sandflats at the end of sand spits, gently sloping foredunes, blowout areas behind primary dunes, and washover areas between dunes. Suitable dredge disposal sites may also be used as nesting locations. Nests consist of shallow scraped depressions in substrates ranging from fine-grained sand to mixed sand and pebbles, shells, or cobble. Nests are typically located in areas with little or no vegetation, although nests are occasionally located beneath American beachgrass or other vegetation (USFWS 1996). Breeding plovers require access to abundant moist substrate habitats for foraging (USFWS 2009a). Important foraging habitats include the intertidal zone of ocean beaches, overwash sites, mud flats, sand flats, tidal pools, wrack lines, and the shorelines of coastal ponds, lagoons, and salt marshes. Primary prey includes polychaete marine worms, insects, crustaceans, and bivalve mollusks (USFWS 1996).

Wintering plovers on the Atlantic coast are found at accreting ends of barrier islands, along sandy peninsulas, and near coastal inlets. Preferred foraging habitats include sandflats adjacent to inlets or passes, sandy mudflats along prograding spits, and overwash areas. Roosting sites generally include inlet and adjacent ocean and estuarine shorelines and nearby exposed tidal flats (USFWS 1996). Plovers may also use flat, sparsely vegetated dredge disposal islands that mimic natural habitats. Piping plover habitats are constantly changing in response to dynamic coastal processes (erosion, accretion, succession, and sea level change), with habitats disappearing and being replaced nearby. The availability of suitable habitat is dependent on natural sediment transport processes and major storm events that control the formation and movement of barrier islands, inlets, and other coastal landforms (USFWS 2003).

Critical Habitat

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 the wintering population have been designated along the Atlantic and Gulf coasts from NC to Texas (66 FR 36038 36143). In NC, a total of 18 critical habitat units have been designated from Dare County south to Brunswick County. Important critical habitat components include intertidal beaches and flats (mud flats, sand flats, algal flats, and washover passes); associated dune systems; and flats above high tide. Designated critical habitat units within the Permit Area include Bogue Inlet (Unit NC-10) and Shackleford Banks (Unit NC-8) (Figure 4.9) The Bogue Inlet Unit includes the west end of Bogue Banks, the east end of Bear Island, and sandy shoals within the inlet. The Shackleford Banks Unit includes the west end of Shackleford Banks within the Cape Lookout National Seashore.

4.7.2.3 Occurrence in the Permit Area

The majority of the developed ocean facing beach on Bogue Banks is not considered suitable nesting, roosting, or foraging habitat for the piping plover. In NC, piping plovers are very rarely seen on developed ocean facing beaches and such areas are not considered suitable habitat (Cameron 2009). The absence of piping plovers from developed beaches is attributed to beach erosion and high levels of human disturbance (Personal communication, S. Schweitzer, NCWRC Coastal Waterbird Biologist, 2011). Consequently, suitable piping plover habitats on Bogue Banks are restricted to the west end of the island along Bogue Inlet and the east end of the island along Beaufort Inlet (Figure 4.9). Additional areas of suitable habitat within the permit area include the east end of Bear Island, shoals and small islands in the Bogue Inlet complex, and the west end of Shackleford Banks.

There are few records of piping plover breeding activity within the permit area. The first piping plover nesting attempt at Bogue Inlet was documented in 2006 on the east end of Bear Island (Rice and Cameron 2008). Additional nesting attempts on the east end of Bear Island were recorded during 2007, 2008, and 2009; however, no breeding activity was detected during 2010. All of the nesting attempts on Bear Island involved a single breeding pair and none of the nesting attempts resulted in a successful reproductive

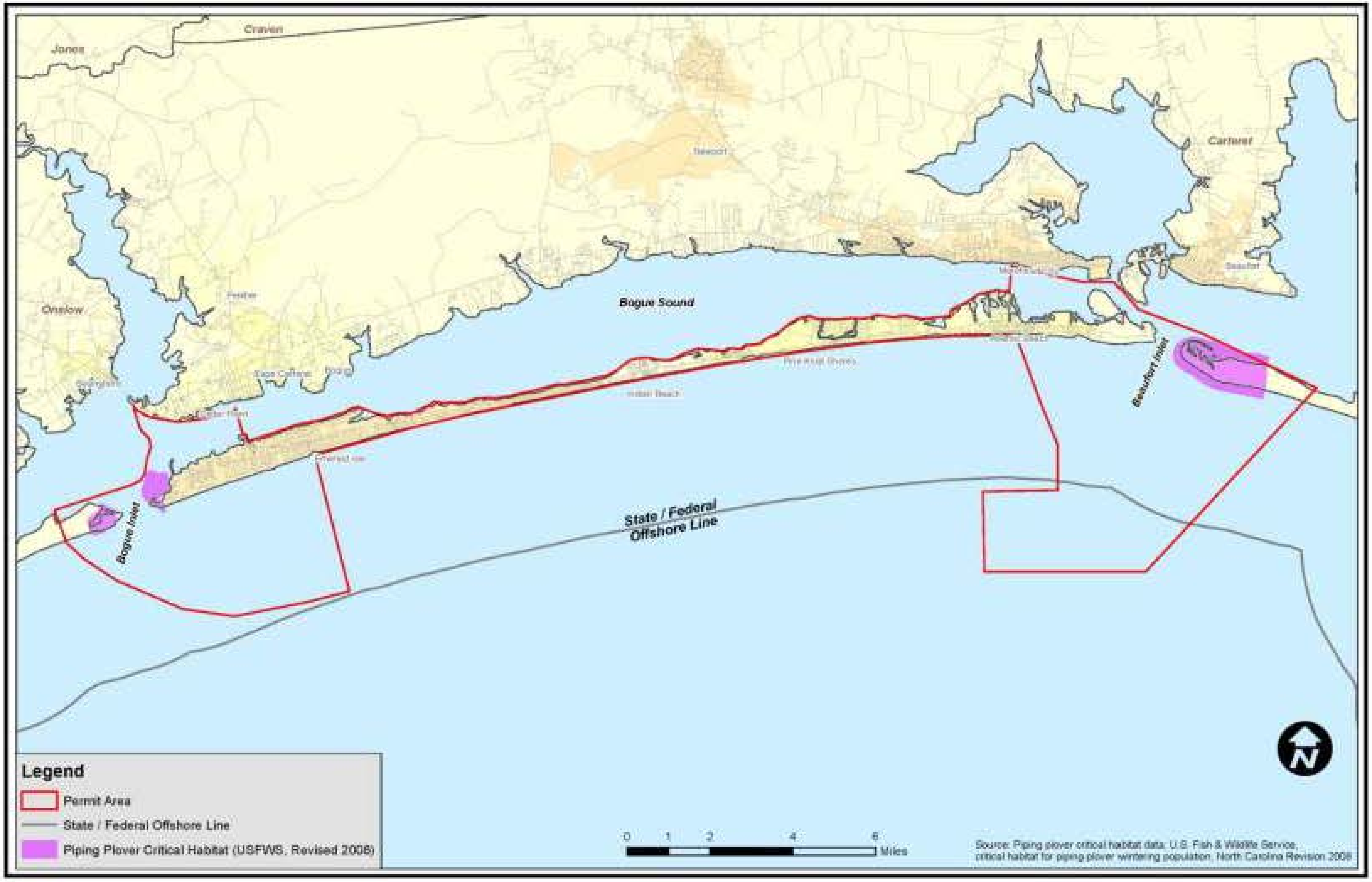


Figure 4.9. Piping Plover Critical Wintering Habitat

season (Rice and Cameron 2008; Personal communication, S. Schweitzer, NCWRC Coastal Waterbird Biologist, 2011). There are no records of piping plover breeding activity on Bogue Banks. Although potential breeding habitat may be present along the inlets at the eastern and western ends of the island, nesting at these locations is considered unlikely due to high levels of human disturbance. Breeding records for the west end of Shackleford Banks include one breeding pair in 1970 and two breeding pairs in 1980 (Personal communication, S. Schweitzer, NCWRC Coastal Waterbird Biologist, 2011).

The east end of Bear Island, the west end of Bogue Banks, and the west end of Shackleford Banks are important stopover and wintering sites for piping plovers. All three of these sites have been designated as critical habitat for the wintering population. Intensive piping plover monitoring was conducted at Bogue Inlet prior to, during, and following the 2005 Bogue Inlet relocation project (Table 4.9, Figure 4.10) (Rice and Cameron 2008). The total number of wintering plover observations within the Bogue Inlet complex decreased during 2005 and 2006. However, observations during 2007 and 2008 greatly surpassed pre-project numbers. The high numbers during 2007 and 2008 were attributed to substantial increases in the quantity and quality of foraging habitat on the east end of Bear Island. NCWRC records for Fort Macon are limited to one individual in 1996 and three individuals in 2006. However, piping plovers were observed at Fort Macon during five of 37 annual Christmas Bird Counts (Personal communication, J. Fussell, Consulting Biologist, Morehead City, NC, February 2010). The last observation at Fort Macon during the Christmas Bird Count occurred in 1989 when one bird was observed. Low numbers at Fort Macon are attributed to the stabilized inlet shoreline and the associated lack of high quality habitat for piping plovers. Annual winter counts on the west end of Shackleford Banks ranged from six to 72 birds between 2000 and 2008. Based on a review of aerial photography, it appears that the amount of intertidal foraging habitat at Shackleford Banks has been declining since the 1970s. Plant succession and dune development have caused declines in roosting habitat, and stabilization of Beaufort Inlet has apparently limited the creation of new habitat (Personal communication, J. Fussell, Consulting Biologist, Morehead City, NC, February 2010).

Table 4.9. Annual piping plover observations at Bogue Inlet 2003-2008.

Species	**2003/04 (n=37)**	**2005 (n=46)**	**2006 (n=41)**	**2007 (n=41)**	**2008 (n=35)**
Piping Plover	179	149	106	181	275
n = number of surveys conducted					

Source: Rice and Cameron 2008

Figure 4.10. Approximate Location of Transects Surveyed for Waterbirds and Shorebirds from 2003-2008 at Bogue Inlet

4.7.3 Red Knot

4.7.3.1 Status and Distribution

The rufa red knot (hereinafter referred to as "red knot") was listed as threatened under the ESA on 12 January 2015 (79 FR 73705 73748). 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. 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. The core southeastern US Atlantic wintering area is thought to shift from year to year between Florida, Georgia, and South Carolina (USFWS 2014).

4.7.3.2 Habitat

As long-distance migrants, red knots are highly dependent on quality foraging habitat at a limited number of key staging/stopover areas. These areas serve as stepping stones or refueling sites along the migratory routes between their wintering and breeding grounds. During migrations, red knots require frequent nourishment in the form of abundant and easily digestible forage at stopover sites. 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. 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. 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 (USFWS 2014). Foraging activity is largely dictated by tidal stage, as red knots rarely forage in waters more than 0.8 to 1.2 in [2-3 centimeters (cm)] deep (Harrington 2001). Access to quality high-tide sandy beach roosting habitat in close proximity to foraging areas is an important constituent of high quality stopover and wintering sites. 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. 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). No critical habitat has been designated for the red knot.

4.7.3.3 Occurrence in the Permit Area

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. Based on a peak count of 2,764 red knots in May, Dinsmore et al. (1998) estimated that at least one to two percent of the estimated North American population use stopover sites along the NC Outer Banks during the spring. A small number of red knots remain in NC throughout the summer (NPS 2014a; Dinsmore et al. 1998). As described above, an unknown number of birds consisting primarily of non-breeding subadults remain south of the breeding grounds throughout the year (USFWS 2014). 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 coordinated aerial surveys, which are conducted annually 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 8 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 barriers, including habitats associated with both developed and undeveloped islands (Table 4.10) (NCWRC 2015a).

Systematic shorebird surveys conducted by the NCWRC at Bogue Inlet following the 2005 ebb channel relocation project recorded peak annual red knot counts ranging from 17 to 204 individuals (Rice and Cameron 2008). The three highest peak counts, ranging from 68 to 204 individuals, occurred during May. However, two of the five annual peak counts occurred in February and March, and were limited to relatively small numbers of individuals (43 birds in February and 17 in March) (Table 4.11). The largest numbers of red knots were observed on the east end of Bear Island; however, birds were observed throughout the inlet complex, including the west end inlet shoreline of Bogue Banks.

Table 4.10. Numbers of red knots observed during aerial surveys of 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 8 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

Table 4.10. (concluded).

Location	Number of Red Knot Observations						
	2006	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Battery Island South			0		0		
Oak Island			0		0	22	0
Lockwood 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 2015a

Table 4.11. Annual red knot observations at Bogue Inlet 2003-2008.

Year	Inlet Transect					Peak Count	Peak Month
	Bear	Inlet	Dudley	Bogue	All		
2003/04 Pre-Project	24	12	3	0	**41**	17	Mar
2005 During/Post	52	65	65	68	**250**	68	May
2006 Post-Project	56	219	0	3	**278**	204	May
2007 Post-Project	40	98	0	0	**138**	43	Feb
2008 Post-Project	313	90	3	3	**409**	147	May
Total	**485**	**484**	**71**	**74**	**1116**	-	-

Source: Rice and Cameron 2008

4.7.4 North Atlantic Right Whale

4.7.4.1 Status and Distribution

The North Atlantic right whale population is divided into a western North Atlantic population, which numbers approximately 500 animals, and an eastern North Atlantic population that is nearly extinct. North Atlantic right whales in the western North Atlantic range from wintering and calving areas off the coast of the southeastern US to summer feeding and nursery areas that extend northward from New England to Nova Scotia. Important summer feeding and nursery areas are located in Massachusetts Bay and Cape Cod Bay, the Great South Channel (east of Cape Cod), the Bay of Fundy, and the Scotian Shelf in Canada. It is important to note that not all individuals in the population undertake a seasonal migration. In the fall, a portion of the western North Atlantic population consisting primarily of pregnant females, females with young calves, and some juveniles migrate southward to nearshore continental shelf waters off the coast of southern Georgia and northern Florida. In some cases, adult males and non-pregnant females are also observed in the calving areas. Calving takes place from December through March, and the peak migration periods are November/December and March/April. Surveys along the mid-Atlantic coast indicate that some mother-calf pairs may also use the area from Cape Fear, NC, to South Carolina as a wintering/calving area (Good 2008, McLellan et al. 2004). Other members of the population spend the winter in Cape Cod Bay; however, a majority of the population is unaccounted for in winter (NMFS 2005). While there is some evidence based on sightings data that there has been a small increase in the number of North Atlantic right whales, the species is still endangered and any future mortality or serious injury to this stock is significant.

Collision with ships is currently the most serious source of mortality threatening the right whale, followed closely by the threat of entanglement in commercial fishing gear. To address the collision issue, on October 10, 2008, the NMFS implemented regulations for mandatory vessel speed restrictions limiting the speed of vessels 65 feet or greater in overall length to 10 knots (about 11 miles per hour) at certain times of the year in certain locations along the east coast of the US Atlantic seaboard (73 FR 60173. The purpose of this rule is to reduce the likelihood of deaths and serious injuries to endangered North Atlantic right whales that result from collisions with ships and not to be confused with the designation of critical habitat. On Dec 9, 2013, the NOAA published an action to remove the December 31, 2013 sunset provision for the speed restriction (78 FR 80386). The rule states that "all other aspects of the rule remain in place until circumstances warrant further changes to the rule." The rule is implemented across three sub-areas of the US east coast: the Southeast US, the Mid-Atlantic US, and the Northeast US. Each area's boundaries or seasonal management areas, and the times during which the speed limits would be in effect, are defined as specifically as possible to reflect the known occurrences of right whales. Bogue Banks resides in the Mid-Atlantic US sub-area, and the speed limit (of 10 knots or 18.5 km/hour) is in effect each year from November 1 to April 30 within a 30-nautical mile (nm) radius from the Port of Morehead City (POM) (Figure 4.11).

4.7.4.2 Critical Habitat

Currently designated critical habitat units 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 4.12). The essential features of the southeastern calving critical habitat area include physical oceanographic conditions that support calving and nursing; including calm sea surface conditions, sea surface temperatures of 45° Fahrenheit (F) to 63° F, and water depths of 20 feet. to 92 feet. The essential features of the northern critical habitat areas include physical and biological features that provide optimal foraging areas with an abundance of the right whales' preferred copepod prey.

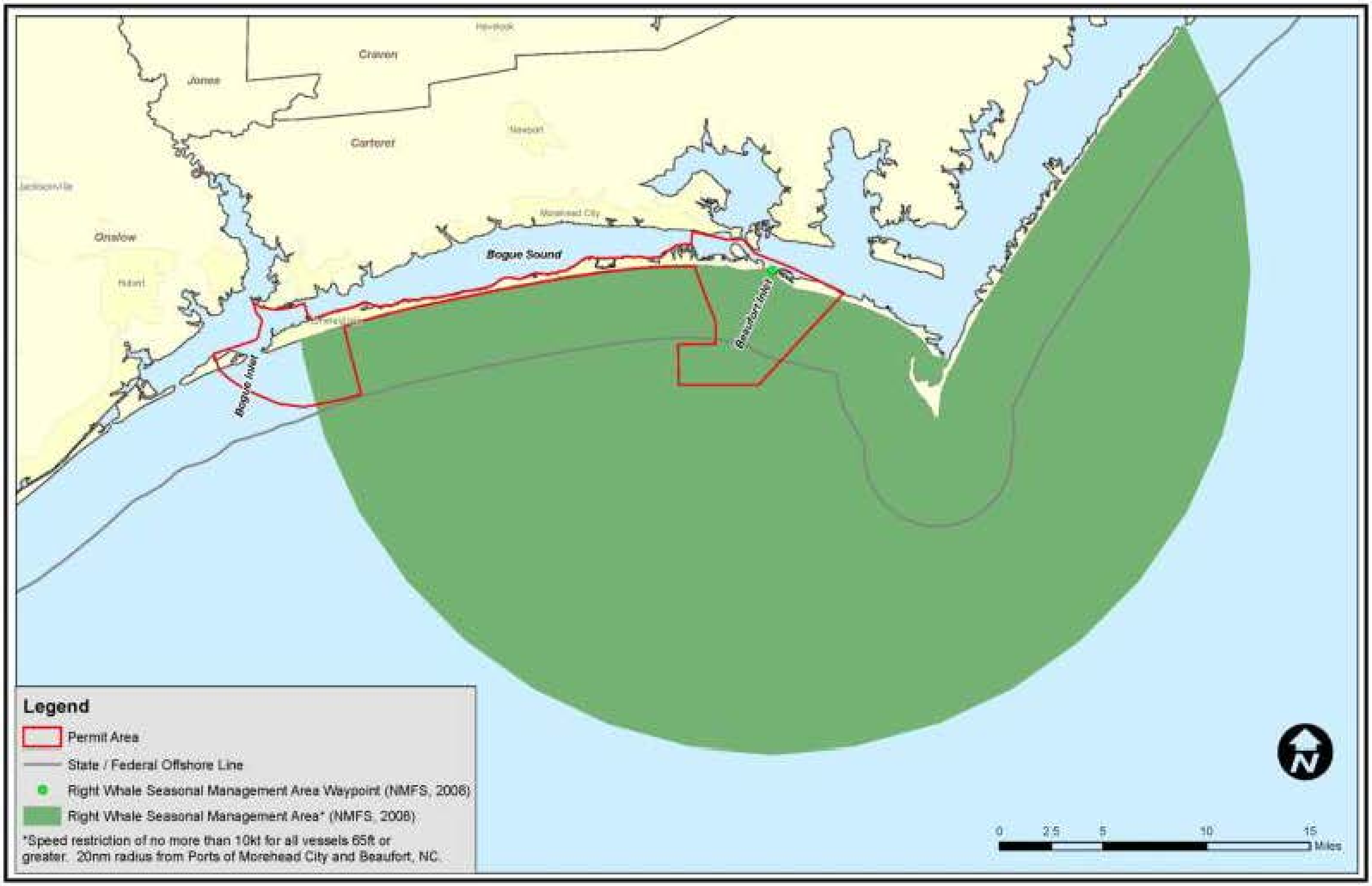


Figure 4.11. North Atlantic Right Whale MCH Speed Restriction Zone

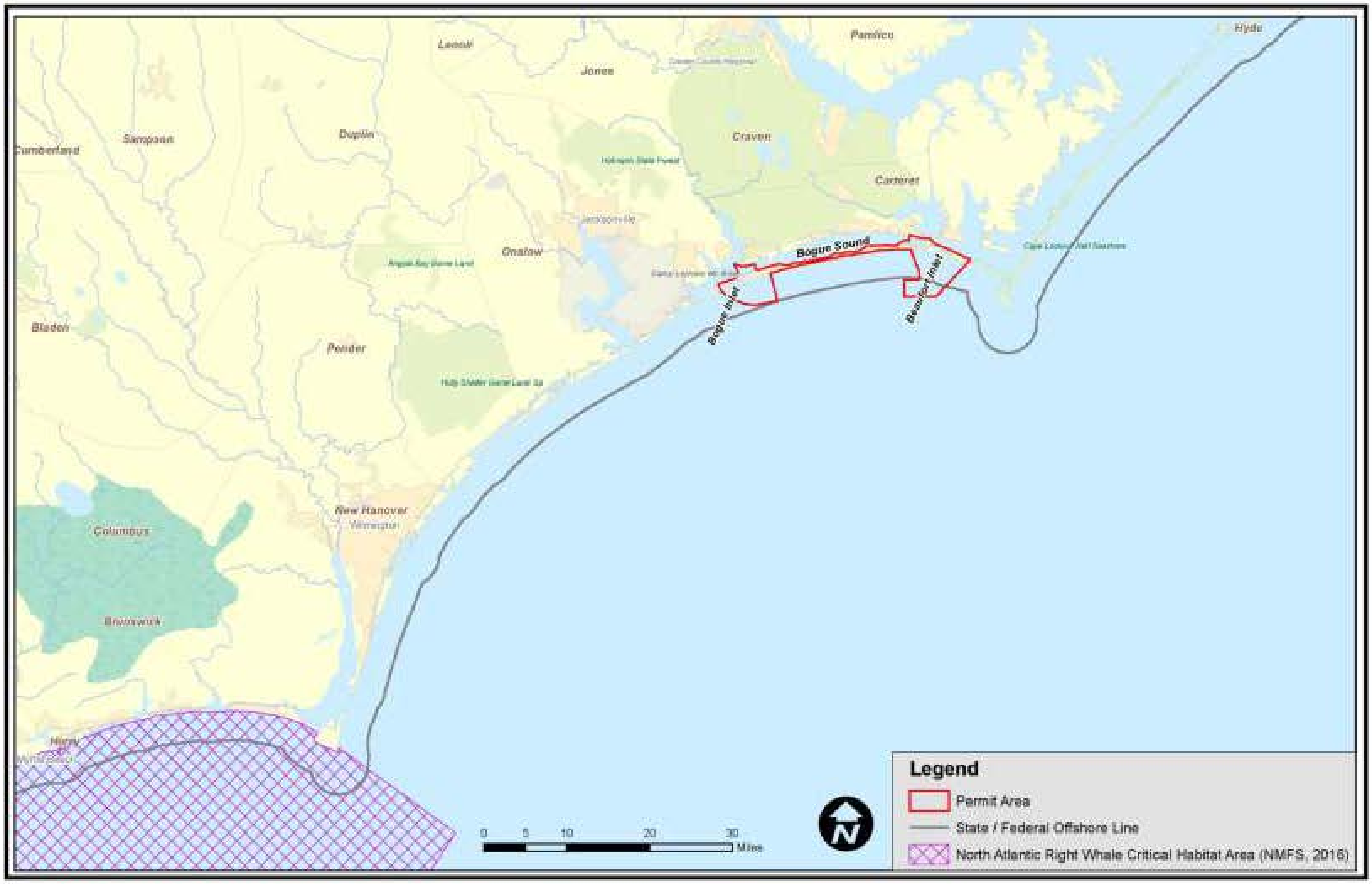


Figure 4.12. North Atlantic Right Whale Critical Habitat - Southeastern US Calving Area

4.7.4.3 Occurrence in the Permit Area

In an effort to better define the geographic and temporal extent of the right whale mid-Atlantic migratory corridor, Knowlton et al. (2002) analyzed 489 right whale sightings that occurred between 1974 and 2002. The largest number of sightings (34.4%) occurred within zero to five nm of land, and well over half of the sightings (63.8%) occurred within zero to ten nm of land. Nearly all of the sightings (94.1%) were within zero to 30 nm of land. A total of 17 sightings were within a 35 nm radius of the POM, and 15 of these sightings were within a 20 nm radius of the POM. Sightings in the vicinity of the POM occurred from October through April, with a peak during February and March. This same pattern also occurred in the vicinity of the NC Port of Wilmington (POW). It is assumed that migrating right whales may be present in the vicinity of the ocean borrow site(s) from October through April as they move back and forth between the summer feeding/nursery areas and winter calving sites.

4.7.5 West Indian Manatee

4.7.5.1 Status, Distribution, and Habitat

Manatees are intolerant of cold water temperatures; and consequently, are generally restricted to inland and coastal waters of peninsular Florida during the winter. In the fall, as water temperatures fall below 68°F, manatees aggregate at natural thermal refugia in the southern two-thirds of Florida or take up residence at power plants, paper mills, or other warm water industrial outfalls in Florida. The northernmost thermal refuge that is used regularly on the east coast is located in the St. Johns River in Florida; however, many minor aggregation sites are used as temporary thermal refuges when water temperatures in adjacent rivers and bays decline. In the spring, as water temperatures reach 68°F, manatees disperse from winter aggregation sites. Some remain near their thermal refuges, while others undertake extensive movements along the coast and up rivers and canals. Warm weather sightings are most common in Florida and Georgia. Summer sightings drop off rapidly north of Georgia, and sightings north of Cape Hatteras are rare (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 habitat consists of shallow seagrass beds with access to deep water. Manatees, in the vicinity of the Florida-Georgia border, 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).

Researchers have designated four regional management units that include an Atlantic Coast unit that occupies the east coast of Florida (including the Florida Keys and the lower St. Johns River north of Palatka, Florida), an Upper St. Johns River unit that occurs in the river south of Palatka, a northwest unit that occupies the Florida Panhandle south to Hernando County, and a southwest unit that occurs from Pasco County south to Whitewater Bay in Monroe County. Management units are composed of individual manatees that utilize the same warm-water sites during winter and exhibit similar warm season distribution patterns. The current best estimate of population size is 3,807 animals based on aerial surveys of warm water refugia in 2009 (USFWS 2009b).

4.7.5.2 Occurrence in the Permit Area

Manatee occurrences in NC are primarily restricted to the months of June through October. Of the 99 opportunistic manatee sightings that were reported in NC between July 1991 and September 2012, nearly all (93%) occurred between June and October when water temperatures were above 20º C (Cummings et al. 2014). Approximately 25 of the NC sightings during this period occurred in the vicinity of the Permit Area, with the vast majority of the sightings occurring in Beaufort and Bogue Inlets, Bogue Sound, and the mouths of the White Oak and Newport Rivers.

4.7.6 Sea Turtles

4.7.6.1 Status, Distribution, and Habitat

Loggerhead Sea Turtle. Loggerhead sea turtles (*Caretta caretta*) occur throughout temperate and tropical waters of the Atlantic, Pacific, and Indian oceans. In the US, loggerheads nest from Texas to Virginia; however, most nesting occurs from Alabama to NC. Loggerheads are commonly found throughout the North Atlantic, the northern Caribbean, the Bahamas, east to the west coast of Africa, the western Mediterranean, and the west coast of Europe. During non-nesting years, adult females from US nesting beaches occupy waters off the eastern coast of the US; the Bahamas; the Greater Antilles; Yucatán; and the Gulf of Mexico. Adult loggerheads undertake extensive migrations between foraging grounds and nesting beaches (NMFS and USFWS 2008).

Loggerheads are found in a wide variety of habitats that include nesting beaches, neritic waters (nearshore waters with depths <600 feet), and oceanic waters (depths >600 feet). Loggerheads nest on ocean beaches with nests typically positioned between the high tide line and the dune front. Relatively narrow, steeply sloped, coarse-grained beaches are the preferred nesting habitat. Hatchlings migrate offshore and reside in nearshore waters along the continental shelf. Post-hatchlings typically reside in convergence zones, which contain accumulations of floating material, especially sargassum. Following the post-hatchling transitional phase, which lasts for weeks or months, loggerheads enter the waters of the open ocean and begin a juvenile oceanic phase. The duration of the oceanic phase has been estimated at seven to 11.5 years. Following the juvenile oceanic phase, loggerheads return to neritic waters where juvenile development continues. Estuarine waters represent important inshore habitat during the juvenile neritic stage. During this stage, loggerheads inhabit essentially all continental shelf waters off the coast of the eastern US and in the Gulf of Mexico. Adults also inhabit nearshore waters, but are less likely to utilize enclosed, shallow estuarine waters. Shallow water habitats with expansive ocean access represent important foraging habitat for adults. Adults also inhabit offshore continental shelf waters from New York south throughout Florida and the Gulf of Mexico (NMFS and USFWS 2008).

In 2011, the loggerhead's ESA status was revised to threatened and endangered based on the recognition of nine distinct population segments (DPS). DPSs 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. The revised 2009 Recovery Plan for the Northwest Atlantic DPS designated five recovery units: the southeastern US coast from southern Virginia to the Florida-Georgia border (Northern Recovery Unit), peninsular Florida, the Dry Tortugas, the northern Gulf Coast, and the Greater Caribbean. Nesting data from 1989-2007 indicated an overall decline in nesting within the Northwest Atlantic DPS; however, substantial increases in nesting since 2007 indicate that the population may be stabilizing (USFWS 2015a). 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.

Green Sea Turtle. Green turtles (*Chelonia mydas*) are distributed circumglobally in tropical, subtropical, and to a lesser extent temperate waters. In the US, green turtles are distributed from Massachusetts to Texas. Nesting in the US is limited primarily to the east coast of Florida, although green turtles nest in small numbers in Georgia, South Carolina, and NC. Habitats include ocean beaches, convergence zones in the open ocean, and foraging grounds in shallow protected waters (NMFS and USFWS 1991). Post-hatchlings migrate to the open ocean and begin a juvenile oceanic phase. The duration of the oceanic phase has been estimated at five to six years, at which time juveniles move to nearshore foraging grounds where development continues. During this phase, juveniles occupy shallow protected waters and open coastal waters that are rich in seagrasses and/or marine macroalgae. Generally, adults remain in the nearshore environment but may enter the oceanic zone when migrating between foraging grounds and nesting beaches. Recent studies indicate that some adults may also reside in the oceanic zone (NMFS and USFWS 2007a).

The green sea turtle 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 April 2016, the NMFS and USFWS published a final rule that listed eight threatened and three endangered green sea turtle DPSs (81 FR 20057). The final rule listed all North Atlantic green sea turtles as threatened under a single North Atlantic Ocean DPS. Additional DPSs in the South Atlantic, Southwest Indian, North Indian, East Indian-West Pacific, Southwest Pacific, Central North Pacific, and East Pacific DPSs were listed as threatened; while DPSs in the Mediterranean, Central West Pacific, and Central South Pacific were listed as endangered.

Kemp's Ridley Sea Turtle. Kemp's ridley sea turtles (*Lepidochelys kempii*) 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. Nesting is limited primarily to the northeastern coast of Mexico, although rare nesting events have been recorded from the southeastern US. 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 feet deep. Juveniles utilize a wide range of bottom substrates but apparently depend on an abundance of crabs and other invertebrates (NMFS and USFWS 2007b).

Hawksbill Sea Turtle. Hawksbill sea turtles (*Eretmochelys imbricate*) are distributed circumglobally in tropical and to a lesser extent subtropical waters of the Atlantic, Indian, and Pacific Oceans. Nesting occurs on ocean beaches throughout the tropics and subtropics. In the continental US, hawksbill turtles have been reported from all of the Gulf States and along the east coast as far north as Massachusetts; however, sightings north of Florida are rare. Hawksbills are regularly sighted in the Florida Keys and on reefs off the coast of Palm Beach County. Texas is the only other state where sightings occur with any regularity. Major nesting areas in the western North Atlantic Ocean include the insular Caribbean, the Yucatan Peninsula in Mexico, and Panama. Nesting in the continental US is restricted to the southeastern coast of Florida and the Florida Keys (NMFS and USFWS 1993). Hatchlings are carried by ocean currents to the oceanic zone where they reside in major ocean gyres. Once a carapace length of eight to 12 inches is reached, juveniles leave the oceanic zone and move to nearshore habitats. Juveniles and adults are most commonly associated with coral reef habitats; however, additional habitats may include other hardbottom habitats, seagrass beds, algal beds, mangrove bays and creeks, or mud flats. As immature turtles increase in size, they occupy a series of habitats with larger turtles showing some preference for deeper sites. Post pelagic juveniles and adults utilize a variety of food items that include sponges and other invertebrates, as well as marine macroalgae. Adults undertake extensive migrations up to hundreds or thousands of miles between foraging grounds and nesting beaches (NMFS and USFWS 2007c).

Leatherback Sea Turtle. Leatherback sea turtles (*Dermochelys coriacea*) occur in all oceans of the world and have the largest geographic range of any sea turtle. Nesting occurs on beaches throughout tropical and subtropical regions and foraging turtles are distributed north and south into sub-polar regions. Major nesting areas in the western North Atlantic Ocean and Caribbean Sea include Florida, St. Croix, the US Virgin Islands, Puerto Rico, Costa Rica, Panama, Columbia, Trinidad and Tobago, Guyana, Surinam, and French Guiana. Adults and sub-adults migrate seasonally to foraging areas in the northern latitudes and during the summer and fall, the highest densities of leatherbacks in the north Atlantic are located in Canadian waters (NMFS and USFWS 2007d). Although leatherbacks are commonly known as highly pelagic animals, recent telemetry studies have documented high use foraging sites in continental shelf and slope waters (James et al. 2005). Leatherbacks undertake extensive migrations between northern foraging grounds and tropical and subtropical nesting beaches. Little is known of the distribution and developmental habitat requirements of hatchling, juvenile, and sub-adult leatherbacks (NMFS and USFWS 2007d).

4.7.6.2 Critical Habitat

The USFWS and NMFS have designated terrestrial (79 FR 39756) and marine (79 FR 39855) critical habitat units for the loggerhead sea turtle along the US South Atlantic and Gulf Coasts from NC to Mississippi. In NC, eight loggerhead terrestrial critical habitat units encompassing approximately 96 miles of nesting beaches have been designated along the southern coast from Beaufort Inlet to the Shallotte River in Brunswick County. Designated marine critical habitat units along the NC coast include areas containing nearshore reproductive habitat, wintering habitat, breeding areas, and migratory corridors. Three designated nearshore reproductive critical habitat units encompass all nearshore waters along the 96 miles of designated nesting beaches from the MHW line to 1.6 kilometers (km) offshore. A single migratory critical habitat unit encompasses offshore waters between the 20-m and 100-m bathymetric contours between Cape Hatteras and Cape Fear, and a single winter habitat unit encompasses waters between the shoreline and the 200-m bathymetric contour from Cape Lookout north to Oregon Inlet.

The Permit Area encompasses the entire Bogue Banks terrestrial critical habitat unit (LOGG-T-NC-01), which extends along the oceanfront beach from Beaufort Inlet to Bogue Inlet (Figure 4.13),   The Permit Area also encompasses the east end portion of the Bear Island terrestrial unit (LOGG-T-NC-02), which extends along the oceanfront beach from Bogue Inlet to Bear Inlet (Figure 4.13). The Bogue Banks terrestrial unit supports expansion of nesting from the adjacent Bear Island unit that has high-density nesting by loggerhead turtles in NC. All waters from the MHW line out to 1.6 km along Bogue Banks and Bear Island are encompassed by a single nearshore reproductive critical habitat unit (LOGG-N-03) that extends continuously from Beaufort Inlet to Bear Inlet (Figure 4.13). The inner boundary (20-m contour) of the winter habitat unit along Bogue Banks is located approximately 6.5 nm seaward of the outer Permit Area boundary at the current ODMDS, and the southern boundary of the Outer Banks migratory habitat unit is located approximately 8 nm east of the eastern Permit Area boundary (Figure 4.13).

Terrestrial critical habitat units encompass the dry ocean beach from the MHW 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 high nest densities. Critical nesting habitat PCEs include: 1) unimpeded ocean-to-beach access for adult females and unimpeded nest-to-ocean access for hatchlings, 2) substrates that are suitable for nest construction and embryonic development, 3) 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 4) natural coastal processes that maintain suitable nesting habitat or artificially maintained habitats that mimic those associated with natural processes. The PCEs in these units may require special management considerations or protections to ameliorate the effects of recreational use, beach driving, predation, beach sand placement activities, in-water and shoreline alterations, climate change, beach erosion, artificial lighting, human-caused disasters, and response to disasters (79 FR 39756). The corresponding nearshore marine critical habitat units represent 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 PCEs include: 1) nearshore waters directly off the highest density nesting beaches and their adjacent beaches, 2) waters sufficiently free of obstructions and artificial lighting to allow transit through the surf zone to open water, and 3) waters with minimal manmade structures that could promote predators, disrupt wave patterns necessary for orientation, and/or create excessive longshore currents (79 FR 39855).

No critical habitat has been designated for Kemp's ridley, green, hawksbill, or leatherback sea turtles within the Permit Area.

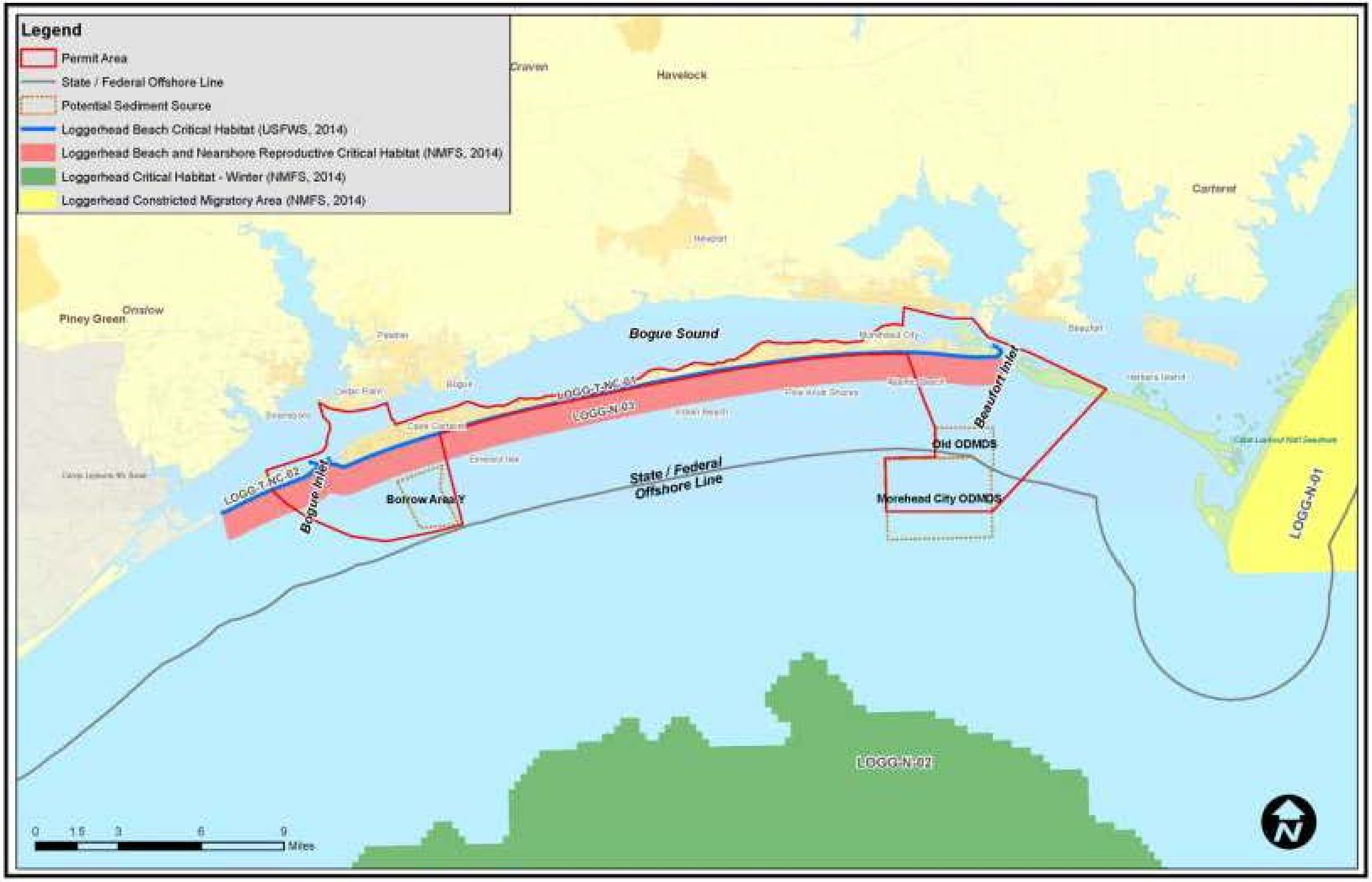


Figure 4.13. Loggerhead Critical Habitat

4.7.6.3 Occurrence in the Permit Area

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. Large numbers of loggerhead, green, and Kemp's ridley sea turtles are incidentally captured each year during commercial fishing operations in the Pamlico-Albemarle estuarine complex. 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 inshore waters from April through December. Goodman et al. (2007) reported inshore and nearshore ocean occurrences from April through November.

Leatherbacks are 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 inshore 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 inshore 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 very rare in NC waters, and they rarely enter inshore 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 off one hawksbill in Pamlico Sound.

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 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 was restricted to sea surface temperatures ≥13.3°C.

In NC, the sea turtle nesting and hatching season extends from May 1 through November 15 (Holloman and Godfrey 2008). Loggerheads account for the majority of the sea turtle nests in NC. Green sea turtles nest consistently in low numbers along the NC coast and leatherback nesting is rare in NC. North Carolina nesting records for the period of 2000 through 2009 included 6,575 loggerhead nests, 116 green sea turtle nests, and 33 leatherback nests. Kemp's ridley nesting is extremely rare in NC with only five nesting records for the state. There are two confirmed records of hawksbill nests in NC, specifically Cape Hatteras National Seashore in 2015. Sea turtles nest along the entire Bogue Banks ocean-facing beach. Nearly all of the records for Bogue Banks are loggerhead nests, although two leatherback nests and one green sea turtle nest were recorded in 2005. The average annual loggerhead nest density from 2009 to 2015 from Bear Island to Fort Macon was 1.8 nests/mile over 29 miles of oceanfront shoreline (NCWRC 2015b) (Figure 4.14).

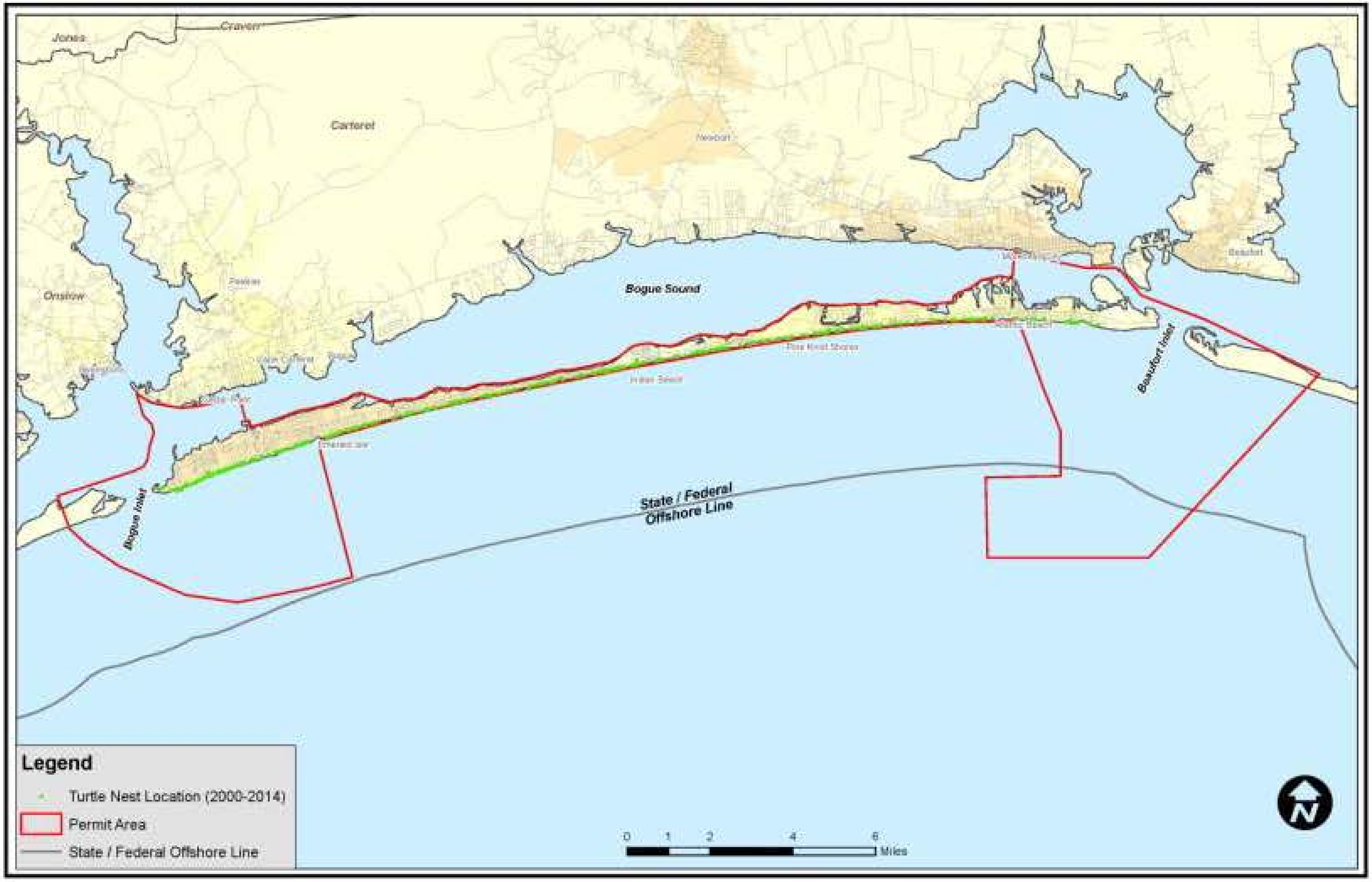


Figure 4.14. Loggerhead Sea Turtle Nesting Records from 2000 – 2015 along Bogue Banks

4.7.7 Shortnose Sturgeon and Atlantic Sturgeon

4.7.7.1 Status, Distribution, and Habitat

Shortnose sturgeon. The shortnose sturgeon (*Acipenser brevirostrum*) was listed as endangered throughout its range on March 11, 1967 (32 FR 4001) under the Endangered Species Preservation Act of 1966 (a predecessor to the ESA of 1973). The NMFS later assumed jurisdiction for shortnose sturgeons under a 1974 government reorganization plan (38 FR 41370).

Shortnose sturgeons inhabit large Atlantic coast rivers from the St. Johns River in northeastern Florida to the Saint Johns River in New Brunswick, Canada. Shortnose sturgeons occur primarily in slower moving rivers or nearshore estuaries associated with large river systems. Adults in southern rivers are estuarine anadromous, foraging at the saltwater-freshwater interface and moving upstream to spawn in the early spring. Shortnose sturgeons spend most of their life 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. Shortnose sturgeons are benthic omnivores feeding 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).

Atlantic sturgeon. On 6 February 2012, the NFMS published the Final Listing Rules for five distinct Atlantic sturgeon (*A. oxyrinchus*) population segments along the Atlantic Coast (77 FR 5914, 77 FR 5880). The New York Bight, Chesapeake Bay, Carolina, and South Atlantic DPSs were listed as endangered; and the Gulf of Maine DPS was listed as threatened. The historic range of the Atlantic sturgeon included estuarine and riverine systems from Labrador, Canada to the Saint Johns River, Florida. The historical distribution in the US 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 distribution in the US includes 35 rivers, with spawning known to occur in at least 20 rivers. Atlantic sturgeons spawn in freshwater, but spend most of their adult life in a marine environment. Spawning adults generally migrate upriver in the spring/early summer. 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 juvenile sturgeons 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 subadult and adult sturgeons are typically found in shallow (40-70 feet) 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 2007).

Spawning adult Atlantic sturgeons migrate upriver in spring, beginning in February-March in the southern US. Spawning occurs in flowing water between the salt front and fall line of large rivers. Following spawning, males may remain in the river or lower estuary until the fall; females typically exit the rivers within four to six weeks. Juveniles move downstream and inhabit brackish waters for a few months and when they reach a size of about 30-36 inches (76-92 cm) they move into nearshore coastal waters. Tagging data indicate that these immature Atlantic sturgeons travel widely once they emigrate from their natal (birth) rivers. Subadults and adults live in coastal waters and estuaries when not spawning, generally in shallow (10-50m depth) nearshore areas dominated by gravel and sand substrates. Long distance migrations away from spawning rivers are common. Atlantic sturgeons are benthic feeders and typically forage on "benthic" invertebrates (e.g. crustaceans, worms, mollusks) (NMFS Office of Protected Resources website).

A review of Atlantic sturgeon stock status in 1998 by the NMFS and the USFWS concluded that although abundance of sturgeons had declined significantly, adequate spawning stock remained for the persistence of the population and for juvenile production. However, since that review, only a few subpopulations show signs of increasing or stabilizing. Most show no signs of recovery and it is evident that stressors such as bycatch, ship strikes/entrainment, dams, and low dissolved oxygen (DO) levels can have substantial impacts on subpopulations. Sturgeon typically feed in the slow-moving waters of large rivers in their lower estuaries (on benthic organisms) and spawn upstream in fresh water, usually on coarse substrates in more swift waters. Therefore, conditions in multiple habitats must be optimal for their continued existence.

At the time of its listing under the ESA, the NMFS (2012a, 2012b) noted that less than 300 adults are spawning in the Atlantic sturgeon Carolina DPS. According to the Atlantic sturgeon status review (Atlantic Sturgeon Status Review Team 2007), projects that may adversely affect sturgeon include dredging; pollutant or thermal discharges; bridge construction/removal; dam construction, removal and relicensing; and power plant construction and operation. Other stressors on the populations are bycatch mortality, habitat impediments (e.g., Cape Fear and Santee-Cooper rivers), and apparent ship strikes (e.g., Delaware and James rivers). An Atlantic sturgeon stock assessment is currently being prepared under the auspices of the Atlantic States Marine Fisheries

Commission and is scheduled for completion by 2017 (as indicated at http://www.asmfc.org/species/atlantic-sturgeon).

4.7.7.2 Critical Habitat

No critical habitat has been designated for the shortnose sturgeon; however in June 2016, NMFS proposed critical habitat for the Atlantic sturgeon. In 2012, NMFS divided the Atlantic sturgeon into five different DPSs and each of these DPSs were listed as threatened or endangered. Proposed critical habitat for the endangered Carolina DPS encompasses portions of river systems to the north and south of the Permit Area, including the Roanoke, Tar-Pamlico, Neuse and Cape Fear, and the Pee Dee; however, no critical habitat has been proposed or designated in the Permit Area.

4.7.7.3 Occurrence in the Permit Area

Shortnose sturgeons were thought to be extirpated from NC waters until an individual was captured in the Brunswick River in 1987 (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 (Moser and Ross 1995). In 1998, the NCDMF reported the capture of a shortnose sturgeon in western Albemarle Sound (Armstrong and Hightower 1999). Surveys in the Neuse River during 2001 and 2002 failed to capture any shortnose sturgeons (Oakley and Hightower 2007). Additional surveys are currently underway in the Roanoke, Chowan, and Cape Fear River basins (NMFS 2010a). The shortnose sturgeon is not known to occur in the vicinity of the permit area; however, whether the lack of records from the area is due to its absence or the lack of survey effort is unknown. Based on its restriction primarily to river reaches above the saltwater-freshwater interface, an occurrence within permit area water bodies (i.e., Atlantic Ocean, Beaufort Inlet, Bogue Inlet, and Bogue Sound) is considered unlikely. However, genetic studies indicate that some individuals move between the various populations (Quattro et al. 2002, Wirgin et al. 2005). Consequently, the presence of a transient individual within the permit area cannot be entirely ruled out.

Atlantic sturgeons were historically abundant in most NC coastal rivers and estuaries. Populations are currently known from the Roanoke, Tar-Pamlico, Neuse, and Cape Fear River systems. Spawning is known to occur in the Roanoke, Tar-Pamlico, and Cape Fear River systems and possibly in the Neuse River (Atlantic Sturgeon Status Review Team 2007). Laney et al. (2007) analyzed Atlantic sturgeon incidental capture data from winter tagging cruises off the NC and Virginia coasts. Cruises conducted in nearshore ocean waters from Cape Lookout to Cape Charles, Virginia captured 146 Atlantic sturgeons between 1988 and 2006 (more recent data has been requested from the USFWS as of August 2016). Captures typically occurred over sand substrate in nearshore waters that were less than 60 feet deep. Laney et al. concluded that shallow nearshore waters off NC represent a winter (January-February) aggregation site and an important area of Atlantic sturgeon winter habitat.

4.7.8 Seabeach Amaranth

4.7.8.1 Status, Distribution, and Habitat

Seabeach amaranth (*Amaranthus pumilus*) was listed as threatened throughout its range in 1993 (58 FR 18035 18042). Historically, this species occurred on coastal barrier island beaches from Massachusetts to South Carolina. Extant populations are currently known from South Carolina, NC, Virginia, Delaware, Maryland, New Jersey, and New York. Although the historical range included Rhode Island and Massachusetts, seabeach amaranth has not been found in these states for over a century. Range-wide population numbers increased substantially during the 1990s, reaching a record high population estimate of 244,608 plants in 2000. However, the range-wide trend since 2000 is characterized by a dramatic decline to just 1,308 plants in 2013. All of the state-specific populations have experienced similar declines, with record or near record lows recorded in all states by 2013.

Primary habitats include overwash flats on the accreting ends of islands, lower foredunes, and the upper strand on non-eroding beaches. Seabeach amaranth is an annual, meaning that the presence of plants in any given year is dependent on seed production and dispersal during previous years. Seeds germinate from April through July, flowering begins as early as June, and seed production begins in July or August. Seeds are dispersed by wind and water; flowering and seed production both continue until the end of the growing season. Seabeach amaranth is intolerant of competition; consequently, its survival depends on the continuous creation of newly disturbed habitats. Prolific seed production and dispersal enable the colonization of new habitats as they become available. A continuous supply of newly created habitats is dependent on dynamic and naturally functioning barrier island beaches and inlets.

4.7.8.2 Occurrence in the Permit Area

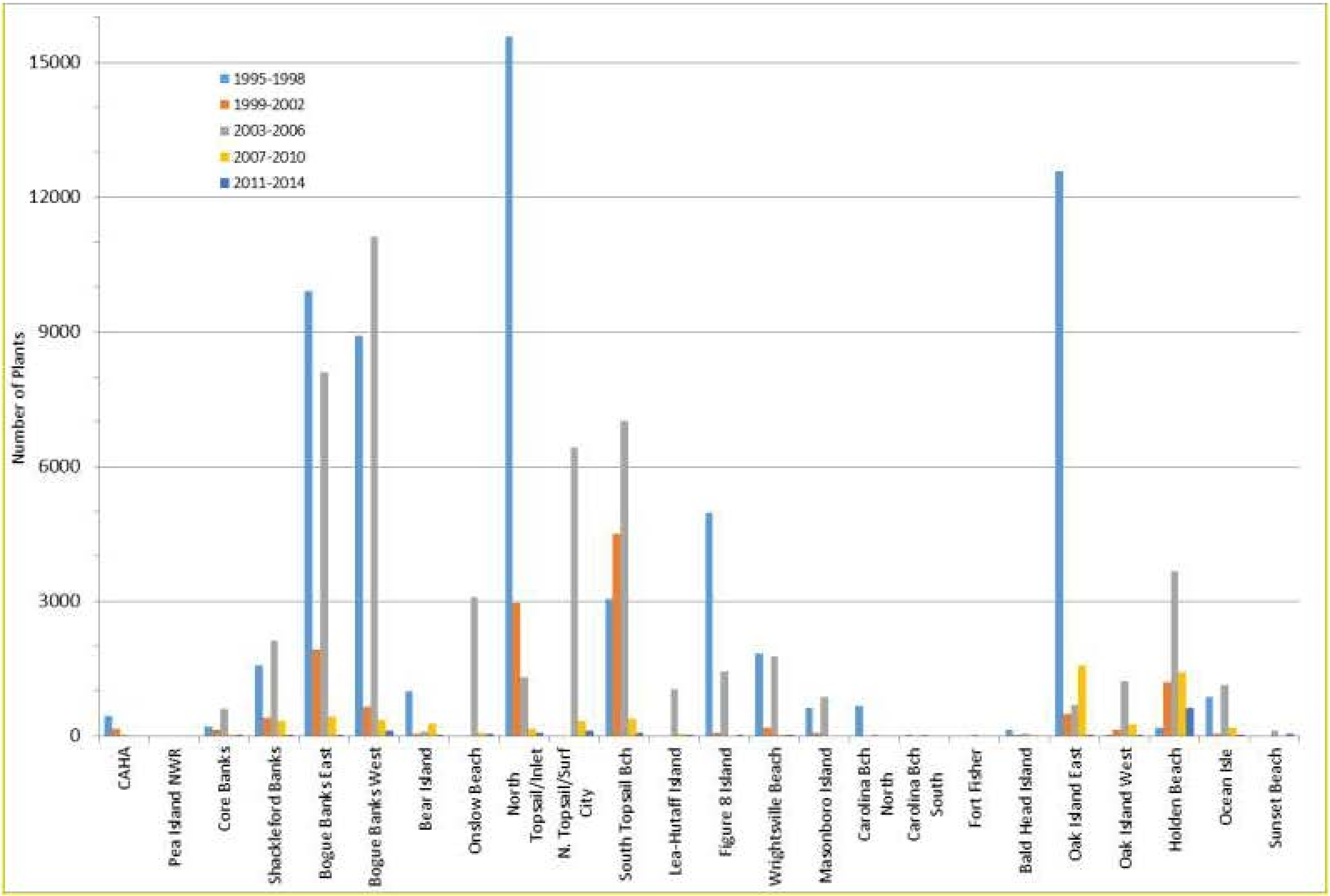
Although variable from year to year, the distribution of seabeach amaranth encompasses the entire barrier island coast of NC. Annual state-wide surveys from 1995 to 2014 recorded an average of 6,726 plants per year. Long-term population trends in NC have been similar to those of the overall range-wide 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 (Figure 4.15). However, smaller numbers of plants occur consistently along much of the NC coast.

Seabeach amaranth has been found along the entire Bogue Banks' ocean-facing beach and inlet shorelines; yet, distribution shifts from year to year. Annual surveys have been conducted on Bogue Banks since 1991 however data from 1995 through 2014 is represented here (Table 4.12). The entire island was surveyed from 1992 through 1995 and 2001 through 2014. Partial surveys were conducted in 1991 and 1997 through 2000. No surveys were conducted during 1996 due to Hurricanes Bertha and Fran. The total number of plants observed during complete survey years has varied widely, ranging from 130 to 23,180 plants. The Bogue Banks' population increased from 2,935 plants in 2004 to 23,180 plants in 2005 and subsequently decreased to 251 plants in 2006. Plants are widely distributed along the ocean shoreline between Bogue and Beaufort Inlets with few occurrences on Bear Island (Table 4.12).

4.7.9 State Listed Species and Federal Species of Concern

4.7.9.1 Regulatory Framework

The term "federal species of concern" is an informal designation that applies to former Category 2 (C2) candidate species that were removed from the official federal candidate list in 1996. Prior to 1996, species identified as candidates for federal listing were ranked as either Category 1 (C1) or C2 species. C1 species included those for which there was sufficient information to support listing as threatened or endangered and C2 species included those under consideration for which there was insufficient information to support listing. In 1996, the USFWS discontinued the practice of maintaining lists of C2 species (61 FR 7596). Subsequent candidate lists included only former C1 species for which there was sufficient information to support listing. Although former C2 species no longer have any official federal status, many of the USFWS regional offices continue to include these "federal species of concern" on county species lists that are distributed for purposes of conducting environmental project reviews. These species are not protected under the ESA and are not subject to Section 7 consultation; however, the USFWS advocates the consideration of these species during the NEPA process.



Source: USFWS 2015b and USACE 2014b

Figure 4.15. NC Seabeach Amaranth Census Data 1995-2014

Table 4.12. Seabeach amaranth census data 1995-2014 for the Permit Area.

Survey Reach	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Total
Shackleford Banks	1155	3	51	369	9	13	126	261	1354	58	671	30	125	76	100	28	18	7	0	0	**4,454**
Bogue Banks East	9318	0	74	525	4	18	217	1693	4011	2117	1915	56	61	221	150	2	2	1	1	0	**20,386**
Bogue Banks West	5458		7	3448	214	2	130	308	1319	818	8797	195	69	92	131	68	54	4	0	52	**21,166**
Bear Island				1000	1			50	66	22		2	6		71	187	0	1	0	0	**1,406**
TOTAL	**39,933**	**7,205**	**969**	**14,424**	**719**	**202**	**7,091**	**5,028**	**11,933**	**10,844**	**25,885**	**3,251**	**875**	**1,606**	**779**	**2,570**	**356**	**154**	**166**	**526**	**134,516**

Source: USFWS 2015b and USACE 2014b

Animal and plant species listed by the State of NC as threatened, endangered, or of special concern are afforded protection under the NC ESA (GS 113-331 to 113-337) and the NC Plant Protection Act of 1979 (GS 196 106-202.12 to 106-202.19). These laws are administered by the NCWRC and the NC Department of Agriculture, respectively. State laws are aimed primarily at protecting listed species from poaching and illegal trafficking. These laws do not restrict land use or development by private landowners. The state also maintains lists of significantly rare species that are not protected under state laws. Significantly rare species are those that exist in the state in small numbers and have been determined to need monitoring.

4.7.9.2 Species Considered

The species considered in this section include federal species of concern identified by the USFWS as occurring in Carteret and/or Onslow Counties and state listed species that are included on county rare species lists developed by the NC Natural Heritage Program (NCNHP). Based on a review of the NCNHP database and other appropriate scientific resources, the list of species considered has been refined to include only those species that may occur in estuarine, marine, and/or beach and dune habitats (Table 4.13).

4.7.9.3 Associations of Rare Species with Habitats

Detailed background information (e.g., status, ecology, and threats) is limited or lacking for many of the species considered in this section. In order to facilitate the impact analysis process, the species considered in this section are discussed in relation to the habitats in which they occur. Additional information specific to individual species or groups of species, when available, has been included in the following species-habitat descriptions.

Ocean Beach

Ocean beach habitats include the upper dry beach and the lower intertidal beach. The dry upper beach is a highly dynamic environment that is continuously reworked by wind and water. The upper beach lies above mean high tide, but is subject to inundation by high spring tides and storm tides. Vegetation of the upper beach is sparse and is dominated by a small number of herbaceous species consisting primarily of annual succulents (Schafale and Weakley 1990). In addition to the federally threatened seabeach amaranth, a number of state listed plant species occur on the upper beach: [southern seabeach sandmat (*Chamaesyce bombensis*), beach morning-glory (*Ipomoea imperati*), seabeach buckwheat (*Polygonum glaucum*), and shoreline sea-purslane (*Sesuvium portulacastrum*)]. The threats facing these state listed plant species are similar to those described for seabeach amaranth (Section 4.7.8).

Table 4.13. State-listed species that may occur in the permit area, with annotations for federal species of concern.

SCIENTIFIC NAME[1]	COMMON NAME	STATE STATUS[2]	HABITAT
BIRDS			
Charadrius wilsonia	Wilson's plover	SC	Nests on sandy beaches and dredge disposal islands. Forages on sand/mud flats and ephemeral pools.
Egretta caerulea	Little blue heron	SC	Nesting habitats include forest/shrub wetlands and dredge disposal islands. Forages in shallow sounds and estuaries.
Egretta thula	Snowy egret	SC	Nesting habitats include forest/shrub wetlands and dredge disposal islands. Forages in shallow sounds and estuaries.
Egretta tricolor	Tricolored heron	SC	Nesting habitats include forest/shrub wetlands and dredge disposal islands. Forages in shallow sounds and estuaries.
Gelochelidon nilotica	Gull-billed tern	T	Nests on sandy beaches and dredge disposal islands. Forages over marshes and marine/estuarine waters.
Haematopus palliatus	American oystercatcher	SC	Nests on sandy beaches and dredge disposal islands. Forages on mud/sand flats and shellfish beds.
Himantopus mexicanus	Black-necked stilt	SR	Nests along brackish ponds and impoundments. Forages in salt marshes and shallow ponds.
Ixobrychus exilis	Least bittern	SC	Found in brackish marshes.
Laterallus jamaicensis	Black rail	SC[3]	Found in brackish marshes.
Pelecanus occidentalis	Brown pelican	SR	Found on maritime islands.
Plegadis falcinellus	Glossy ibis	SC	Nesting habitats include forest/shrub wetlands and dredge disposal islands. Forages in shallow sounds and estuaries.
Rynchops niger	Black skimmer	SC	Nests on sandy beaches and dredge disposal islands. Forages over marine and estuarine waters.
Sterna hirundo	Common tern	SC	Nests on sandy beaches and dredge disposal islands. Forages over marine and estuarine waters.
Sternula antillarum	Least tern	SC	Nests on sandy beaches and dredge disposal islands. Forages over marine and estuarine waters.
REPTILES			
Malaclemys terrapin	Diamondback terrapin	SC[3]	Found in salt and brackish marshes.
Nerodia sipedon williamengelsi	Carolina watersnake	SC	Found in salt and brackish marshes.
FISHES			
Fundulus confluentus	Marsh killifish	SR	Found in brackish waters.
INSECTS			
Atrytonopsis sp. 1	Undescribed Skipper	SR[3]	Found in dunes and sandy flats.
Meropleon cinnamicolor	Owlet moth	SR	Found in coastal marshes.

Table 4.13. (concluded).

SCIENTIFIC NAME[1]	COMMON NAME	STATE STATUS[2]	HABITAT
VASCULAR PLANTS			
Arenaria lanuginosa var. *lanuginose*	Spreading sandwort	SR-P	Found in dunes and maritime forests.
Chamaesyce bombensis	Southern seabeach sandmat	SR-T	Found on ocean beaches and dunes.
Clematis catesbyana	Coastal virgin's bower	SR-P	Found on dunes and edges of maritime forests.
Cyperus tetragonus	Fourangle flatsedge	SC-V	Found in maritime forests and dunes.
Ipomoea imperati	Beach morning-glory	T	Found on ocean beaches and dunes.
Polygonum glaucum	Seabeach buckwheat	E	Found on ocean beaches and sandy sound shorelines.
Scleria verticillata	Savanna nutrush	SR-P	Found in maritime wet grasslands
Solanum gracilis	Graceful nightshade	SR-T	Found on dunes.
Solidago villosicarpa	Coastal goldenrod	E[3]	Found in maritime forest edges and openings.
Trichostema sp. 1	Dune bluecurls	SR-L[3]	Found on dunes.
Yucca gloriosa	Moundlily yucca	SR-P	Found on dunes.
NON-VASCULAR PLANTS			
Lejeunea dimorphophylla	Liverwort	SR-L	Found on maritime forests' bark.
Plagiochila miradorensis var. *miradorensis*	Liverwort	SR-P	Found in maritime forests and swamps.

[1] Bold = species that have been observed in the permit area based on NCNHP Element Occurrence records.
[2] E = Endangered, T = Threatened, SC = Special Concern, SC-V = Special Concern Vulnerable (all known populations are historical or extirpated), SR = Significantly Rare, SR-T = Significantly Rare Throughout (species is rare throughout its range), SR-L = Significantly Rare Limited (range of the species is limited to NC and adjacent states), SR-P = Significantly Rare Peripheral (species is at the periphery of its range in NC, generally more common elsewhere within its range), SR-O = Significantly Rare Other (species range is sporadic or does not correspond to any of the other SR categories)
[3] Federal Species of Concern

Sparsely vegetated upper beach habitats also represent potential nesting habitat for a number of state listed colonial-nesting waterbirds (gull-billed tern, black skimmer, common tern, and least tern) and shorebirds (Wilson's plover and American oystercatcher). However, due to oceanfront development and associated human disturbance, nesting on Bogue Banks is now restricted to the accreting ends of the island along Bogue and Beaufort Inlets. The threats facing these state listed waterbirds and shorebirds are similar to those described for the federally threatened piping plover (Section 4.5). The lower intertidal beach supports a diverse assemblage of benthic invertebrate infauna. Intertidal benthic invertebrates are an important food source for the federally threatened piping plover and the state listed Wilson's plover. However, due to oceanfront development and associated human disturbance, foraging activity on Bogue Banks is typically observed on the accreting ends of the island along Bogue and Beaufort Inlets.

Dunes

Dune grass communities occur on the frontal dune system immediately landward of the ocean beach. This community type is dominated by grasses (e.g., sea oats, American beach grass, and seaside little bluestem) and other herbaceous species that are adapted to this highly dynamic and stressful environment. Continuous salt spray, excessive drainage, and shifting sands exclude most plant species and maintain this community type (Schafale and Weakley 1990). A number of state listed plant species occur in dune grass communities: [spreading sandwort (*Arenaria lanuginosa* var. *lanuginose*), coastal virgin's bower (*Clematis catesbyana*), beach morning-glory, fourangle flatsedge (*Cyperus tetragonus*), southern seabeach sandmat, graceful nightshade (*Solanum gracilis*), dune bluecurls (*Trichostema* sp. 1), and moundlily yucca (*Yucca gloriosa*)]. These species are threatened by development, berm construction, beach scraping, beach nourishment, and other activities that effect suitable dune grass habitats or interfere with natural barrier island processes. These species are also threatened by the proliferation of non-native species such as beach vitex (*Vitex rotundifolia*), which may outcompete and exclude native species.

A federal species of concern/state listed butterfly is an undescribed skipper (*Atrytonopsis* sp. 1) which occurs in the dune grass community. *Atrytonopsis* sp. 1 is endemic to Shackleford Banks, Bogue Banks, Bear Island, and several dredge disposal islands at the eastern end of Bogue Sound (Brandt, Marsh, Radio, and North Radio Islands). The larval host plant for this species is seaside little bluestem (Leidner 2009). On Bogue Banks, seaside little bluestem occurs primarily on the northern slopes of the foredunes, rear dunes, and in interdune swales (Taggart 1980). *Atrytonopsis* sp. 1 has two flight periods: mid-April to mid-May and mid-July to mid-August. The largest populations of *Atrytonopsis* sp. 1 occupy undeveloped stretches of dunes on Bear Island and at Fort Macon State Park. Additional populations are smaller and are often surrounded by development. This species is threatened by habitat loss and loss of connectivity between the various subpopulations. Furthermore, given the limited range and small overall population size, this species is vulnerable to catastrophic natural events such as hurricanes. The ability of individuals to disperse between all of the populations is important to the survival of this species. Increasing urbanization and associated losses of native vegetation may reduce connectivity, placing the species at greater risk for extinction. Research indicates that small natural areas, undeveloped lots, and developed lots that retain native vegetation can support small populations and maintain connectivity across Bogue Banks. Recommended conservation strategies include the preservation and restoration of natural areas, and the retention of native vegetation on residential lots (Leidner 2009).

Intertidal Sand and Mud Flats

Intertidal sand and mud flats occur along inlets at the accreting ends of barrier islands and along the shorelines of sounds and estuaries. These moist substrate habitats are devoid of vascular plants, but support a diverse assemblage of benthic infaunal macroinvertebrates. In addition to the federally threatened piping plover, two state listed shorebirds (Wilson's plover and American oystercatcher) utilize sand and mud flats for foraging. The threats facing Wilson's plover and the American oystercatcher are similar to those described for the piping plover (Section 4.5.1).

Intertidal Marsh

Intertidal marshes occur along the margins of sounds and estuaries. Marshes associated with high salinity waters are strongly dominated by smooth cordgrass; whereas marshes associated with brackish waters are typically dominated by black needlerush, salt-meadow grass, big cordgrass (*S. cynosuroides*), and/or sawgrass (Schafale and Weakley 1990). Rare marsh birds that breed and forage in intertidal marshes include the federal species of concern/state listed black rail (*Laterallus jamaicensis*) and the state listed least bittern (*Ixobrychus exilis*). Ideal marsh habitats for these species have a shallow water component that supports tall emergent herbaceous plant species. The decline of these species has been attributed to losses of both inland and coastal marsh habitats. Additional threats include alteration of wetland hydrology, degradation of water quality, and the proliferation of non-native invasive species such as common reed (*Phragmites australis*). Recommended conservation measures include protection and restoration of freshwater and saltwater marshes, increasing the percent cover of emergent vegetation in managed waterfowl impoundments to 50-70%, and managing invasive species (Hunter et al. 2006). Intertidal marshes also provide foraging habitat for a number of state listed waterbirds (little blue heron, snowy egret, tricolored heron, glossy ibis, black-necked stilt (*Himantopus mexicanus*), and gull-billed tern). These waterbirds are also threatened by the loss and alteration of intertidal marsh habitats.

The federal species of concern/state listed diamondback terrapin (*Malaclemys terrapin*) also occurs in intertidal brackish and salt marshes. The diamondback terrapin forages in salt marshes and nests in adjacent sandy uplands along the estuarine shoreline. Winter brumation occurs in the muddy substrate of small tidal creeks. Threats to this species include habitat loss, drowning in crab pots, entanglement in fishing gear, commercial harvest, loss of critical nesting habitat, mortality by motorized vehicles, and nest predation by raccoons and other animals (Hart and Lee 2006). Additional state listed species that occur in intertidal marshes include the Carolina watersnake (*Nerodia sipedon williamengelsi*), marsh killifish (*F. confluentus*), spotfin killifish (*F. luciae*), an owlet moth (Noctuidae sp.), and gulf coast spikerush (*Eleocharis cellulosa*). All of these species are threatened by the loss and alteration of intertidal marsh habitats.

4.8 Cultural, Historic, and Archaeological Resources

4.8.1 Description of the Affected Environment

Historic properties are defined as any pre-contact or historic period districts, sites, buildings, structures, or objects included in, or eligible for inclusion in the National Register of Historic Places (NRHP). Historic properties that could experience impacts from the proposed activities include offshore historic properties on or below the seafloor within portions of the sand resource or sand placement areas, including anchoring areas, that could be affected by seafloor disturbing activities.

The types of historic properties expected within the offshore affected environment include submerged pre-contact and historic period archaeological sites. An overview of the nature and scope of submerged archaeological sites on the Atlantic Outer Continental Shelf that could be affected by site characterization and site assessment activities is presented in *A Summary and Analysis of Cultural Resources Information on the Continental Shelf from the Bay of Funday to Cape Hatteras* (Institute for Conservation Archaeology 1979), *A Cultural Resource Survey of the Continental Shelf from Cape Hatteras to Key West* (Science Applications 1981), and *Inventory and Analysis of Archaeological Site Occurrence on the Atlantic Outer Continental Shelf* (TRC 2012).

4.8.1.1 Pre-contact Period Archaeological Sites

The sand borrow areas offshore North Carolina are geographically located within portions of the Outer Continental Shelf once exposed as dry land and are designated as having a high potential for the presence of submerged pre-contact archaeological sites (TRC 2012: 106). Archaeologists categorize human occupation in the eastern United States into three broad temporal periods: Paleo-Indian (13,000 or earlier to 10,000 before present [B.P.]), Archaic (10,000 to 3000 B.P.), and Woodland (3000 B.P. to the arrival of Europeans in North America). Each temporal division is distinguished by the climate, technology, and subsistence patterns characteristic of the period.

Approximately 20,000 B.P., during the peak of the last ice age known as the Last Glacial Maximum, sea level was 120 meters below present level, leaving the sand borrow areas accessible to Paleo-Indian populations (TRC, 2012:97). The adaptive subsistence of humans during this period is generally associated with specialized hunting of large game and gathering of wild plants by semi-nomadic groups during a time of climatic and environmental change brought about by glacial retreat (Willey, 1966:37-38). Sudden rapid rises in sea level, known as Melt Water Pulses, occurred during the Paleo-Indian period and may have been caused in part by collapsing ice sheets and the associated release of immense quantities of melt water as ice dams associated with glacial lakes collapsed (Blanchon and Shaw, 1995; Shaw, 2002). By 10,000 B.P. sea level on the OCS offshore North Carolina was at approximately 30 meters below present level (TRC, 2012:97).

During the Archaic period, sea level rise slowed considerably and the sand resource areas were still likely exposed as areas of dry land. The Archaic period was marked by a change in climate following the Last Glacial Maximum that produced a more favorable environment for human subsistence. During the Archaic period, a wider range of habitats were utilized for subsistence, and thus likely a wider range of plants and animals were exploited including nuts, large and small game, seed-bearing plants, and fish (TRC, 2012:34). By the Woodland period, sea level rise had inundated the OCS to near its present level. During this time period the sand resource areas would have been fully submerged, removing any possibility for the presence of submerged archaeological sites dating to the Woodland period (TRC, 2012:8).

Not all of the formerly exposed areas within offshore sand resources areas may have survived the destructive effects of erosion caused by sea level rise and marine transgression; however, submerged landforms that are considered to have a higher probability for the potential presence and preservation of archaeological sites have been previously documented offshore North Carolina (TRC, 2012:99). Relict sub-bottom lagoonal and channel features have been identified both north and south of the sand resource areas, and portions of these features may extend into the sand resource areas. These include lagoonal complexes associated with Platt Shoal and paleochannels identified off Duck, Kitty Hawk, and Nags Head (Moir, 1979; Browder and McNinch, 2006 [in TRC, 2012:104]). In the vicinity of Cape Fear, relict channels of the Cape Fear River extend out onto the OCS in Long Bay (TRC, 2012:104).

4.8.1.2 Historic Period Archaeological Sites

The coast of North Carolina has a well-deserved reputation as the “graveyard of the Atlantic.” More than 4,000 vessel losses have been historically documented in the underwater archaeological site files of the North Carolina Department of Cultural Resources, Underwater Archaeology Unit (Morris pers. comm.). The Department of Cultural Resources functions as the State Historic Preservation Office (SHPO). High concentrations of reported shipwrecks on the North Carolina OCS are also identified in BOEM’s Atlantic Shipwreck Database (TRC, 2012:155). Documented patterns of maritime activity indicate that all areas of North Carolina’s Atlantic coastline and OCS have a high potential for containing the remains of historic period archaeological sites (TRC, 2012:218).

Shipwrecks along the North Carolina coast and within the sand resource areas have the potential to date from as early as the late sixteenth century and likely include vessels from every subsequent century. The earliest vessel losses in the region may well be associated with undocumented vessels of Spanish explorers or the fleet of Sir Francis Drake and Sir Walter Raleigh's efforts to establish a colony at Roanoke Island in the 1580s. As English colonies in North America developed, so did the loss of merchant vessels and warships. During the American Revolution, the Quasi-War with France, the War of 1812, the American War Between the States, World War I, and World War II, there was a corresponding increase in the numbers of vessels lost or destroyed at sea offshore North Carolina (TRC, 2012:207).

Historical records compiled by the NC Underwater Archaeology Branch (UAB) indicate that at least 92 shipwrecks have occurred in the vicinity of Beaufort Inlet and Bogue Banks (Lawrence 2007). A number of these wrecks have been located and positively identified. Most notably, the ship remains of the pirate Blackbeard's flagship the *Queen's Anne Revenge*, which ran aground at Beaufort Inlet in 1718. The wreck was designated a Protected Area by the state in 1997 and was listed on the National Register of Historic Places (NRHP) in 2004. The site is managed by the NC Department of Cultural Resources, UAB. The *Queen's Anne Revenge* is currently the only NRHP-listed shipwreck in the vicinity of Bogue Banks (SHPO 2012).

Other historical shipwrecks that have been located and identified or tentatively identified at Beaufort Inlet include a collection of mid-eighteenth century cannons and debris that may represent the Spanish merchant ship *El Salvador* (lost in 1750), the copper-bottom brig *Catherine and William* (lost in 1814), the remains of the US Navy transport steamer *Quinnebaugh* (lost in 1865), remains of the schooner *Lucinda A. Bailey* along with its cargo of railroad iron (lost in 1870), remains of a steel-hulled vessel that may represent the screw steamer *Maside* (lost in 1920), and debris most likely representing the schooner *Louise Howard* (lost in 1921) (Wilde-Ramsing 2009). The remains of the Confederate iron-hull, side-wheel steamer *Pevensey*, which grounded on Bogue Banks in 1864, are located approximately 100 yards from shore near the current location of the Iron Steamer Pier (Figure 4.16). The unidentified remains of several additional shipwrecks are located along Bogue Banks. A collection of granite stones in the surf zone along Emerald Isle are believed to be from a World War II gun emplacement. Fort Macon at the eastern end of Bogue Banks is the only NRHP-listed site on the island (SHPO 2012).

Archaeological remote sensing surveys of the proposed borrow areas including the current ODMDS, former ODMDS, and Borrow Area Y were conducted by Mid-Atlantic Technology and Environmental Research (Hall 2011). Based on analysis of magnetic and sidescan sonar data, 16 magnetic anomalies were recommended for further underwater analysis. Diving was subsequently conducted to identify six targets in the ODMDS, nine targets in the former ODMDS, and one target in Borrow Area Y. All of the identified targets in the ODMDS borrow areas were found to be associated with either modern dredged material disposal activity or artificial reefs that were created in the 1970s. The single target in Borrow Area Y was found to be a manmade object located near

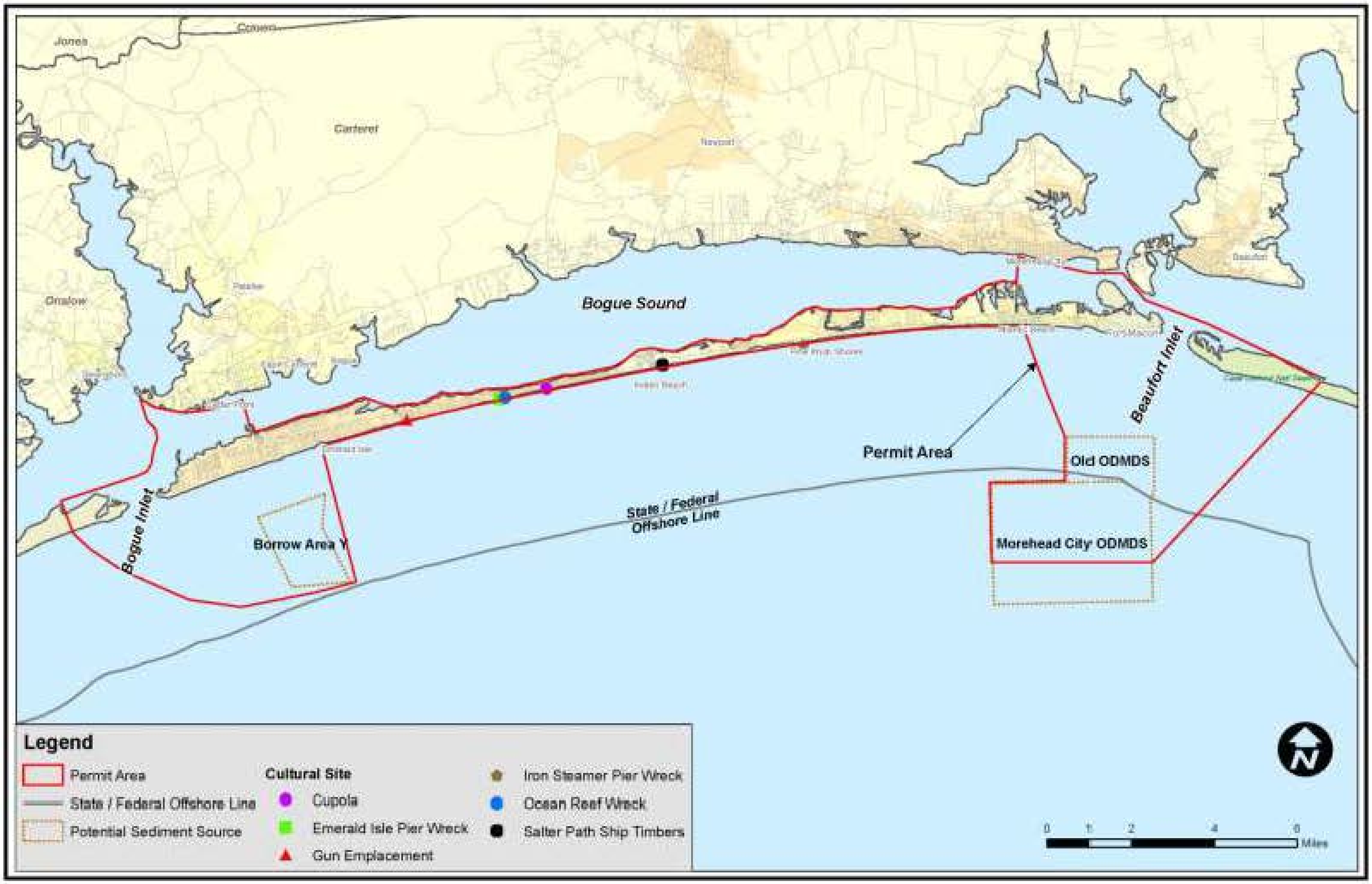


Figure 4.16. Cultural Resource Sites

a natural hardbottom feature. None of the magnetic anomalies was a historic property potentially eligible for listing on the NRHP.

As described in the Bogue Inlet Channel Relocation Project FEIS (CPE 2004), Tidewater Atlantic Research, Inc. (TAR), of Washington, NC, conducted a magnetometer survey in 2003 of the central portion of the Bogue Inlet ebb tide delta and the existing channel to determine the presence of potentially significant submerged cultural resources. Three anomalies were found, two on the ebb tide delta and a third in the existing channel at a point approximately 1,600 feet north of Inlet Drive. The two anomalies found on the ebb tide delta were relatively small and appeared to be consistent with modern debris such as small diameter pipes, boat anchors, or crab traps and therefore were of no archeological significance. The anomaly found in the existing channel exhibited characteristics consistent with a submerged cultural resource. However, since the only activity potentially affecting the existing channel (filling it with sand) was expected to provide a protective layer that would benefit the resource, TAR concluded that no further investigation was warranted. Although the status of this potential resource remains undetermined; additional underwater archaeological investigations will be conducted as necessary based on consultation with the SHPO.

Sites along Bogue Banks beaches (Figure 4.16) (NCSHPO 2010):

<u>0001BBB Iron Steamer Pier Wreck Site</u>
Believed to be the Civil War blockade-runner *Pevensey*, an iron-hull side-wheel steamer, lost June 9, 1864. The wreck is located approximately 100 yards offshore on the east side of the pier lying almost parallel to the beach. Portions of a paddle wheel are visible during low tide.

<u>0002BBB Gun Emplacement Site</u>
Granite stones located in the surf zone adjacent to the 6200 block of Ocean Drive at Emerald Isle, believed to be from a World War II coastal shore battery exposed by beach erosion.

<u>0003BBB Salter Path Site</u>
Ship timbers 14” square, approximately 42 feet and 18 feet long with 1.25” diameter iron fasteners located roughly 1,200 feet east of the beach access road near Squatters Campground.

<u>0004BBB Cupola Site</u>
Portions of a ship hull approximately 30 feet long and 14 feet wide fastened with iron pins, yellow pine planking on oak frames. This site is located in the surf zone near 18th Street, Emerald Isle. (Tag Numbers 134, 135)

0005BBB Emerald Isle Pier Wreck

Ship timber 40 feet long, 12" x 18" square, iron fasteners and one attached frame. This site is located near Emerald Isle Fishing Pier. (Tag Numbers 155, 156)

0006BBB Ocean Reef Site

Ship wreckage covering an area of approximately 100 feet by 35 feet near the Ocean Reef Condos (marked by a warning sign on the beach). This site consists of extensive debris with iron fasteners.

4.9 Public Interest Resources in the Permit Area

4.9.1 Socioeconomic Resources

4.9.1.1 Population

The 2010 US Census reported a total of 6,845 permanent residents on Bogue Banks (Table 4.14). The racial makeup of the 2010 permanent population was 96.3% white and less than one percent each Asian (0.8), African American (0.6), Native American (0.3), and Pacific Islander (0.2). In addition to race, 1.6% of the population identified their ethnic origin as Hispanic or Latino. Bogue Banks has a substantial number of retirees, with 28% of the population aged 65 or older and 36% of the households reporting retirement incomes. Median household incomes within the four municipalities ranged from $48,112 (Atlantic Beach) to $60,521 (Pine Knoll Shores). Although the percentage of persons living below the poverty level in Atlantic Beach (16.3) was higher than the county (12.5) and state (15.5), the percentage of the overall Bogue Banks population (7.9) was substantially lower than the county and state.

In contrast to the relatively small permanent population, the estimated peak seasonal population during the summer exceeds 88,000 (Table 4.14). The estimated peak population includes both permanent residents and persons spending the night on the island in private rental units, motels/hotels, and campgrounds (Table 4.15). The peak seasonal estimate does not account for day-trip visitation; consequently, the actual number of persons on the island at any given time during the peak season is substantially greater than 88,000.

Table 4.14. Demographic summary.

	Atlantic Beach	Pine Knoll Shores	Indian Beach/Salter Path	Emerald Isle	Bogue Banks	Carteret County	North Carolina
Total population	1,495	1,339	356	3,655	**6,845**	66,469	9,535,483
White, percent	94.4	96.3	99.2	96.7	**96.3**	89.3	68.5
Asian, percent	0.9	1.0	0.3	0.8	**0.8**	0.9	2.2
Black/African American, percent	0.7	0.7	0.3	0.6	**0.6**	6.1	21.5
American Indian/Alaska Native, percent	0.5	0.1	0.0	0.2	**0.3**	0.5	1.3
Native Hawaiian/Pacific Islander, percent	0.1	0.2	0.0	0.2	**0.2**	0.1	0.1
Other race, percent	1.1	0.7	0.0	0.5	**0.7**	1.2	4.3
Multi-racial, percent	2.1	1.0	0.3	1.0	**1.2**	2.0	2.2
Hispanic or Latino origin, percent	1.5	1.0	0	2.0	**1.6**	3.4	8.4
Percent of population aged 65 years or older	19.7	42.7	28.1	25.8	**27.9**	19.0	5.5
Peak seasonal population[1]	27,431	8,330	12,654	39,600	**88,015**	-	-
Median household income	48,112	60,521	53,688	50,380	**-**	46,155	45,570
Poverty	16.3	2.3	0.8	6.5	**7.9**	12.5	15.5
Housing units	4,935	1,802	6,735	2,049	**15,521**	48,179	4,327,528
Permanently Occupied	840	175	1,732	653	**3,400**	28,870	3,745,155
Seasonal use	3,972	1,382	3,931	1,338	**10,623**	15,402	191,508
Vacant	123	245	1,072	58	**1,498**	3,907	390,865

[1]Source: Holland Consulting Planners (2006, 2008a, and 2008b), Town of Emerald Isle (2004), US Census Bureau (2010a and 2010b)

Table 4.15. Housing characteristics of Bogue Banks.

Units in Structure	Atlantic Beach	Pine Knoll Shores	Indian Beach/Salter Path	Emerald Isle	Total	Percent of Total
1 unit, detached	1,502	1,059	217	3,562	**6,340**	**41.4**
1 unit, attached	229	141	0	718	**1,088**	**7.1**
2 units	209	10	9	535	**763**	**5.0**
3 or 4 units	380	90	0	92	**562**	**3.7**
5 to 9 units	280	222	9	176	**687**	**4.5**
10 to 19 units	390	300	135	81	**906**	**5.9**
20 or more units	873	449	334	395	**2,051**	**13.4**
Mobile home	1,123	19	730	1,031	**2,903**	**19.0**
Total housing units	**4,988**	**2,290**	**1,434**	**6,590**	**15,302**	**100**

Source: US Census Bureau 2010a

4.9.1.2 Economy

According to the NC Department of Commerce, direct traveler expenditures in Carteret County amounted to $336.96M in 2015 (See: https://partners.visitnc.com/contents/sdownload/62499/file/2015-County-Level-Visitor-Expenditures.PDF). Additional economic impacts directly attributable to visitor spending included 3,330 jobs, a $61.75M payroll, $15.22M in state tax revenues, and $19.71M in local tax revenues (US Travel Association 2016). In 2008, beach recreation on Bogue Banks generated over $206M in direct traveler expenditures (Table 4.16). The total estimated impact on sales and business activity due to direct beach recreation expenditures and economic multiplier effects was over $355M. In 2005-2006, direct expenditures and multiplier effects attributable to beach recreation on Bogue Banks supported an estimated 5,492 jobs in Carteret County. The economic impact of Bogue Banks is also reflected in its contribution to the county tax base. According to the NC Department of Revenue, the value of taxable real property on Bogue Banks accounts for 46% ($5.5 billion) of the overall Carteret County property tax base ($9.5 billion) (Table 4.17). Substantial economic impacts are also attributed to the area's inlets and waterways. In 2008, the estimated total economic impact of recreational fishing charters and private boating trips through Bogue Inlet exceeded $14M (Table 4.18). Bogue Inlet and Beaufort Inlet provide economically important connections between soundside harbors and ocean fishing waters. In 2008, commercial landings attributable to trips through Bogue Inlet had a total economic impact of $14.6M, and landings attributable to Beaufort Inlet had a total impact of $47.7M (Table 4.19) (NCDENR 2011).

Table 4.16. Economic impact of beach recreation, selected years.

Beach	2005-2006 Total Jobs Supported	2008 Direct Expenditures	2008 Total Impact Sales/Business Activity
Emerald Isle	3,314	$124,341,243	$214,672,550
Indian Beach/Salter Path	284	$10,638,487	$18,367,124
Pine Knoll Shores	485	$18,199,319	$31,420,743
Atlantic Beach	1,276	$47,882,384	$82,667,933
Fort Macon	133	$4,980,628	$8,598,950
Bogue Banks Total	**5,492**	**$206,042,061**	**$355,727,300**
Carteret County	**6,148**	**$230,657,481**	**$398,225,307**

Source: NCDENR 2011

Table 4.17. Value of taxable real property FY 2015/2016.

	Taxable Real Property ($)[1]
Atlantic Beach	1,546,111,600
Emerald Isle	2,709,151,411
Indian Beach	403,424,717
Pine Knoll Shores	902,251,524
Total Bogue Banks	**5,560,939,252**
Carteret County	**9,562,746,926**

[1]NC Department of Revenue (www.dor.state.nc.us/publications/property.html)

Table 4.18. Economic impact of marine recreation (2008).

Waterway/Inlet	2008 Total Jobs Supported	2008 Direct Expenditures	2008 Total Impact Sales/Business Activity
Coastal For-Hire Fishing (Charter/Headboat)			
AIWW, Barden Inlet, Beaufort Inlet, Drum Inlet	1,358	$41,087,038	$83,694,419
Bogue Inlet	194	$5,628,519	$11,465,311
Private Boating			
AIWW, Barden Inlet, Bear Inlet, Beaufort Inlet, Drum Inlet	1,433	$40,904,547	$77,457,546
Bogue Inlet	54	$1,532,032	$2,901,082

Source: NCDENR 2011

Table 4.19. Economic impact of commercial fishing.

Inlet	2007 Direct Sales Dockside Value	2008 Total Impact Sales/Business Activity
Beaufort Inlet	8,212,058	47,665,701
Bogue Inlet	2,520,786	14,631,537

Source: NCDENR 2011

Carteret County collects a six percent occupancy tax on all hotel, motel, and condominium rentals. The distribution of occupancy tax revenues is governed by NC Session Law 2013-223, with 50% going to the Tourism Development Authority for tourism promotion and 50% legislatively mandated to be used for beach nourishment projects. For FY 2015-2016, occupancy tax revenues are estimated at $6,671,688 with $3,335,844 attributable to beach nourishment. Additional beach nourishment funding is generated through municipal and county special tax service districts. Emerald Isle, Indian Beach, and Pine Knoll Shores have all established special beach nourishment tax districts. Atlantic Beach, which receives regular inputs of free sand via dredging of the Morehead City Harbor, does not have a special tax district for beach nourishment.

4.9.2 Land Use

A summary of existing land use within the four municipalities is provided in Table 4.20. Together, residential development; vacant land; and recreation/conservation areas account for 72.5% of the total municipal land area on Bogue Banks. Residential development accounts for 40.6% of the total municipal land area followed by vacant or undeveloped lands (20.1%) and areas designated for recreation or conservation (17.9%). Approximately 85% of the total residential area consists of single family detached housing, with the remaining area divided between multi-family housing and mobile home parks. Commercial and institutional land uses are a minor constituent, accounting for only 6.8% of the total municipal land area.

The availability of vacant land that is suitable for development is declining on Bogue Banks. Although Atlantic Beach contains 466 acres of vacant land, 50 acres are considered suitable for development with the remainder consisting of wetlands and protected natural areas. Pine Knoll Shores contains 140 acres of suitable land that has not already been platted for subdivision development. Indian Beach contains less than 30 acres of suitable vacant land that has not already been platted for subdivision

Table 4.20. Bogue Banks land use summary.

Land Use	Atlantic Beach		Indian Beach		Pine Knoll Shores		Emerald Isle		Total	
	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent	Acres	Percent
Single-family residential	351.8	21.3%	56.1	17.1%	433.0	33.3%	1,462.0	43.0%	**2,302.9**	**34.5%**
Vacant/Undeveloped	466.3	28.3%	83.8	25.5%	139.9	10.8%	651.0	19.1%	**1,341.0**	**20.1%**
Recreation/Conservation	1.3	0.1%	43.9	10.7%	525.6	40.5%	627.0	18.5%	**1197.8**	**17.9%**
Right-of-way	178.3	10.8%	0	0	0	0	430.0	12.6%	**608.3**	**9.1%**
Commercial	129.3	7.8%	8.8	2.7%	26.9	2.1%	147.0	4.3%	**312.0**	**4.7%**
Multi-family residential	180.2	10.9%	23.6	9.9%	21.8	1.7%	0	0	**225.6**	**3.4%**
Mobile home	110.6	6.7%	70.6	21.5%	0	0	0	0	**181.5**	**2.7%**
Water/Canal	146.3	8.9%	0	0	12.3	0.9%	0	0	**158.6**	**2.4%**
Office/Institutional	7.1	0.4%	0.9	0.3%	53.4	4.1%	79.0	2.3%	**140.4**	**2.1%**
Utilities	79.3	4.8%	6.2	1.9%	13.9	1.1%	0	0	**99.4**	**1.5%**
Municipal/Association owned	72.8	5.6%	0	0	0	0	0	0	**72.8**	**1.1%**
Camp ground	0	0	34.4	10.5%	0	0	0	0	**34.4**	**0.5%**
Total	**1,650.6**	**100%**	**328.3**	**100%**	**1,299.5**	**100%**	**3,400**	**100%**	**6,678.4**	**100%**

Source: Holland Consulting Planners (2006, 2008a, and 2008b), Town of Emerald Isle (2004)

development. Emerald Isle contains 279 acres of unplatted vacant lands that could potentially be developed. As the availability of vacant land declines, municipalities are anticipating an increase in higher density redevelopment projects. Due to the lack of a central sewer system, high density redevelopment projects will require an extensive area of land for wastewater treatment systems. The lack of sufficient land for wastewater treatment is an impediment to redevelopment projects (Holland 2006, 2008a, and 2008b; Town of Emerald Isle 2004).

4.9.3 Infrastructure

4.9.3.1 Water Supply

The Towns of Atlantic Beach and Pine Knoll Shores operate their own public water supply systems. Emerald Isle, Indian Beach, and Salter Path are served by the Bogue Banks Water Corporation; a nonprofit, customer-owned water utility. All three water supply systems rely on groundwater drawn from the Castle Hayne aquifer underlying

Bogue Banks. The Castle Hayne aquifer is the most prolific and high yielding aquifer in the NC Coastal Plain. This aquifer is characterized by high permeability and recharge rates. The Castle Hayne aquifer currently contains an ample supply of fresh groundwater (Lautier 2009). Bogue Banks is located within the state-regulated Central Coastal Plain Capacity Use Area (CCPCUA). The CCPCUA was established in response to declining groundwater levels within the Black Creek and Upper Cape Fear aquifers. Rates of groundwater withdrawal from these aquifers currently exceed recharge rates; consequently, these aquifers will soon fail to meet area water supply needs. Although the Castle Hayne aquifer has not been overused, the state regulates withdrawals from all aquifers in the CCPCUA ensuring that overuse problems are not shifted to other aquifers. Groundwater withdrawals are regulated in accordance with CCPCUA rules (15A NCAC 2E .0501 - .0507) which require permits for withdrawals of more than 100,000 gallons per day (gpd) and registration and reporting for withdrawals of more than 10,000 gpd. The CCPCUA rules are designed to reduce dependency on the depleted aquifers through the development of alternative water sources. The NCDWR has indicated that significant portions of withdrawals from the depleted aquifers can be shifted to the Castle Hayne aquifer without harming existing users (NCDWR 2009).

In accordance with NC GS 143-355 (l), all units of local government that provide public water service and all community water systems having 1,000 or more connections or serving more than 3,000 people must have a Local Water Supply Plan (LWSP). LWSPs provide information and data related to current water usage, system capacity, future demand, and planned future water supply sources. The information presented in this section is based on data submitted by the three water service providers in their 2016 LWSP updates (Pine Knoll Shores is based on 2015 LWSP). These LWSPs are available on the NCDWR website at www.ncwater.org.

The Atlantic Beach water supply system serves 2,584 residential and 205 commercial metered connections. The system draws water from six wells located within the town. The wells are capable of producing 1.74M gallons in a 12-hour period, and the water treatment plant has a permitted capacity of 2.5 million gallons per day (MGD) of finished water. The system has a total storage capacity of 1.5M gallons. Maximum daily use during 2016 varied from a low of 0.47 MGD in January to a high of 1.52 MGD in July (Table 4.21). Total water usage during 2016 was 249.91M gallons. The addition of a new well in 2016 added 0.36M gallons of daily capacity to the system. The Pine Knoll Shores water supply system serves 1,628 residential and 65 commercial metered connections. The system draws water from four wells located within the town. The wells are capable of producing 0.98M gallons in a 12-hour period, and the water treatment plant has a permitted capacity of 1.2M gallons of finished water per day. The system has a total storage capacity of 0.4M gallons. Maximum daily use per day during 2015 varied from a low of 0.225 MGD in December to a high of 0.745 MGD in July (Table 4.22). Total water usage during 2015 was 140.52M gallons.

Table 4.21. Town of Atlantic Beach water usage by month.

Month	Average Daily Use (MGD)	Maximum Day Use (MGD)
January	0.355	0.475
February	0.352	0.605
March	0.450	0.791
April	0.535	0.723
May	0.747	1.260
June	0.948	1.399
July	1.160	1.523
August	1.052	1.497
September	0.754	1.215
October	0.581	0.990
November	0.501	0.706
December	0.380	0.555

Source: Holland Consulting Planners 2016, Local Water Supply Plan

Table 4.22. Town of Pine Knoll Shores water usage by month.

Month	Average Daily Use (MGD)	Maximum Day Use (MGD)
January	0.201	0.261
February	0.217	0.412
March	0.222	0.278
April	0.285	0.329
May	0.415	0.619
June	0.536	0.648
July	0.595	0.745
August	0.487	0.564
September	0.390	0.486
October	0.283	0.325
November	0.240	0.338
December	0.208	0.225

Source: Holland Consulting Planners 2015b, Local Water Supply Plan

Bogue Banks Water Corporation provides water service to 6,053 residential and 142 commercial metered connections. The system draws water from 12 wells located in Emerald Isle, Indian Beach, and Salter Path. The wells are capable of producing 2.99M gallons in a 12-hour period and the system has a permitted maximum daily withdrawal of 5.76 MGD. The system has a total storage capacity of 3.8M gallons. Maximum daily use per day during 2016 varied from a low of 1.67 MGD in February to a high of 4.56 MGD in June (Table 4.23). Total water usage during 2016 was 533.93M gallons.

The NCDWR recommends that water systems maintain a demand-to-supply ratio such that average daily demand does not exceed 80% of the available supply. If the demand-to-supply ratio is projected to exceed 80% by 2030, LWSPs must outline a demand

Table 4.23. Bogue Banks Water Corporation water usage by month.

Month	Average Daily Use (MGD)	Maximum Day Use (MGD)
January	1.521	1.838
February	1.455	1.679
March	1.488	1.809
April	1.535	2.566
May	2.107	3.059
June	2.774	4.566
July	3.232	4.080
August	2.907	4.317
September	2.504	4.242
October	1.804	3.564
November	1.402	2.505
December	1.057	1.754

Source: Bogue Banks Water Corporation, 2016 Local Water Supply Plan

management program; use restrictions; and plans for obtaining additional water supplies. Demand-to-supply ratios based on projected demand and supply over the next 50 years are shown in Tables 4.24, 4.25, and 4.26. Based on these projections, none of the water supply systems on Bogue Banks are expected to experience demand-to-supply ratios greater than 80% over the next 50 years.

Table 4.24. Atlantic Beach water demand as percent of supply.

	2016	2020	2030	2040	2050	2060
Groundwater Supply	1.740	1.740	1.740	1.740	1.740	1.740
Future Supplies		0.000	0.000	0.000	0.000	0.000
Total Supply	1.740	1.740	1.740	1.740	1.740	1.740
Total Demand	0.649	0.660	0.694	0.725	0.759	0.801
Demand as Percent of Supply	**37%**	**38%**	**40%**	**42%**	**44%**	**46%**

Source: Holland Consulting Planners 2016, Local Water Supply Plan

Table 4.25. Pine Knoll Shores water demand as percent of supply.

	2015	2020	2030	2040	2050	2060
Groundwater Supply	0.982	0.982	0.982	0.982	0.982	0.982
Future Supplies		0.300	0.600	0.600	0.600	0.600
Total Supply	0.982	1.282	1.582	1.582	1.582	1.582
Total Demand	0.339	0.749	0.775	0.850	0.904	0.979
Demand as Percent of Supply	**35%**	**58%**	**49%**	**54%**	**57%**	**62%**

Source: Holland Consulting Planners 2015, Local Water Supply Plan

Table 4.26. Bogue Banks Water Corporation water demand as percent of supply.

	2016	2020	2030	2040	2050	2060
Groundwater Supply	5.243	5.243	5.243	5.243	5.243	5.243
Future Supplies		0.000	2.000	2.000	2.000	2.000
Total Supply	5.243	5.243	7.243	7.243	7.243	7.243
Total Demand	1.782	1.799	1.821	1.842	1.863	1.885
Demand as Percent of Supply	**34%**	**34%**	**25%**	**25%**	**26%**	**26%**

Source: Bogue Banks Water Corporation, 2016 Local Water Supply Plan

4.9.3.2 Wastewater Treatment

The information presented in this section is derived from the CAMA Land Use Plans prepared by the four municipalities on Bogue Banks (Holland Consulting Planners 2006, 2008a, and 2008b; Town of Emerald Isle 2004). There are currently no central sewer systems on Bogue Banks. Residences and businesses rely on individual septic tanks, shared septic tanks, or package treatment plants for wastewater disposal. Most single-family and manufactured homes utilize private individual or shared septic tanks, whereas high density and multi-family developments utilize privately-owned package treatment plants. Package plants are small, on-site wastewater treatment systems that utilize the soil for subsurface application of treated effluent. Septic tanks and package treatment plants are permitted and regulated by the NC Division of Environmental Health acting through an authorized agent with the Carteret County Department of Environmental Health. Package plants are inspected annually by the county; however, individual septic tanks are not inspected on a regular basis. Major wastewater management issues on Bogue Banks include water quality problems associated with failing treatment systems and development constraints associated with the land area required for new treatment facilities and drain fields.

Septic tank failures in Atlantic Beach have resulted in groundwater and estuarine water pollution. Approximately half of the land area in Atlantic Beach was created by the placement of dredged material over coastal wetlands. The fill areas are poorly suited for septic tanks; consequently, both commercial and residential septic tanks in these areas have experienced high failure rates. In addition, the older central portions of Atlantic Beach are characterized by high density development and undersized septic systems with little or no room for upgrades. Although package plants are generally more reliable and are more closely regulated than individual septic tanks, many of these systems in Atlantic Beach have also experienced failures resulting in raw sewage overflow; especially during periods when the water table has been high and the soils have been saturated. Failing wastewater disposal systems in Atlantic Beach are contributors to surface water pollution in adjacent estuaries.

The Carteret County Health Department indicates that soils in Emerald Isle are generally suited for septic tanks and that existing septic tanks are not a major water quality issue. However, package plants in Emerald Isle have experienced problems related to nutrient build-up and saturated drain fields that are incapable of accepting wastewater. The Carteret County Health Department indicates that wastewater treatment systems in Indian Beach and Pine Knoll Shores are not a major water quality issue.

Many of the residential areas on Bogue Banks are approaching full build-out. As the availability of vacant land declines, municipalities are anticipating a shift to high density redevelopment projects requiring extensive land area for wastewater treatment systems. Atlantic Beach and Indian Beach have identified adequate wastewater treatment facilities as the greatest impediment to future development. The Town of Pine Knoll Shores has also identified wastewater treatment as a significant impediment to development; however, the town views this constraint as a positive factor for controlling growth. Emerald Isle has determined that new septic tanks and package plants will be sufficient to meet current land use and development goals. The Town of Atlantic Beach is currently evaluating options for a public central sewer system. The town has estimated that a central system would need to have a minimum capacity of 2.0 MGD to support the town at build-out; however, the town has indicated that a capacity of 2.5 to 3.0 MGD should be pursued ensuring that demand associated with redevelopment efforts can be met. None of the other municipalities on Bogue Banks are currently pursuing a central sewer system; consequently, future development in these areas will continue to rely on private wastewater treatment systems.

4.9.3.3 Transportation

NC Highway 58 runs the entire length of Bogue Banks and is the only major thoroughfare serving Emerald Isle, Indian Beach, Salter Path, and Pine Knoll Shores. In addition to NC Highway 58, the Causeway [State Road (SR) 1182] in Atlantic Beach functions as a major thoroughfare for the commercial district. Atlantic Beach has experienced traffic congestion problems along both NC 58 and the Causeway during the peak summer months. A NC Department of Transportation (NCDOT) traffic count recorded 32,161 passing vehicles along the Causeway on Memorial Day 2004, exceeding the roads daily design capacity of 29,500.

The 2003 and future (2023) vulnerability of NC 58 to ocean shoreline erosion was evaluated by NCDOT in a report dated 1 December 2005. Using 2003 aerial photography, distances between the seaward edge of pavement and the wet/dry line on beach were measured along the entirety of Bogue Banks. Sections of the highway that were less than 230 feet from the wet/dry line were considered vulnerable to erosion. This process was repeated using the projected shoreline location in 2023. Most of NC 58 was just outside the critical 230-foot zone in both 2003 and 2023. A two-mile stretch along eastern Emerald Isle and a few isolated locations along Indian Beach/Salter Path fell within the 230-foot zone in both 2003 and 2023. Although the quantitative analyses did not account for beach nourishment, the NCDOT made the assumption that the impending Bogue Banks Restoration Project and establishment of a long-term beach nourishment project would reduce current and future vulnerability. The current and future vulnerability of NC 58 was classified as low based on continuing beach nourishment events (Overton and Fisher 2005).

4.9.4 Scenic/Aesthetic Resources

Scenic resources include the physical, biological, and cultural landscape elements that contribute to perceptions of scenic beauty. North Carolina's barrier islands are highly valued for their natural beauty. Important natural landscape elements include marine and estuarine water resources, sandy beaches, dunes, maritime forests, salt marshes, and associated wildlife. Cultural elements such as lighthouses and other historic coastal structures contribute to a sense of place and the perception of barrier islands as a unique scenic resource. The scenic beauty of NC's barrier islands is reflected in their popularity as a tourist destination. Surveys of beach visitors in NC indicate that tourists and residents consider natural beauty, wide sandy beaches, visible wildlife, and historical structures to be important elements of a positive beach experience (Ellis and Vogelsong 2005). The dune/beach/ocean system is a highly visible public resource that is readily accessible to the general public via numerous access points along the entire island. Restrictions on coastal development and shoreline stabilization in NC have largely preserved the scenic integrity of the dune/beach/ocean system on Bogue Banks.

The island also offers high quality scenic vistas to the north (Bogue Sound), west (Bogue Inlet and Bear Island), and east (Beaufort Inlet and Shackleford Banks).

The island interior has been largely developed resulting in losses and fragmentation of the island's extensive maritime forests. Relatively undisturbed examples of maritime forests and other natural communities have been preserved at the Theodore Roosevelt Natural Area in Pine Knoll Shores, Hoop Pole Creek Natural Area, Salter Path Maritime Forest Natural Area, and Fort Macon State Park. The natural area at Fort Macon State Park is especially unique, in that it contains a continuous sequence of typical plant communities between the ocean and the sound. Historic Fort Macon is a highly valued cultural landscape element that contributes to the island's overall scenic beauty and sense of place.

4.9.5 Water Quality

In NC, water quality is assessed primarily at the watershed or riverbasin (i.e., basinwide) level due to the watersheds' interconnectedness. Basinwide water quality plans are prepared by the NCDWR for each of the seventeen major river basins in the state and are updated at five-year intervals. The Permit Area is contained within the White Oak River Basin; water quality plans were developed by NCDWQ in February 1997 and updated in November 2001. All surface waters in NC are assigned a primary surface water classification by the NCDWQ. Each classification must meet a specific set of water quality standards. All ocean waters off Bogue Banks are classified as Saltwater Class B (SB) waters. SB waters support primary recreation, including frequent and/or organized swimming, and must meet water quality standards for fecal coliform bacteria. All waters within Bogue Sound, Beaufort Inlet, and Bogue Inlet have a primary classification of Saltwater Class A (SA). SA waters support commercial shellfishing and are subject to fecal coliform bacteria standards, restrictions on domestic wastewater discharges, and specific stormwater control measures. The SA waters within Beaufort Inlet and the eastern portion of Bogue Sound (Gales Creek to Beaufort Inlet) are also classified as High Quality Waters (HQW). HQW are those having excellent water quality and/or important functions such as primary nursery areas. The SA waters within Bogue Inlet and the western portion of Bogue Sound (Gales Creek to Bogue Inlet) are also classified as Outstanding Resource Waters (ORW). ORW are those having exceptional state or national recreational or ecological significance (NCDWR 2012). More limited stormwater controls are required under CAMA than the storm water controls required under higher water quality designations. There are no categorical restrictions on wastewater discharges (NCDWR 2012).

Based on the above classification, water quality standards include: (1) turbidity in the receiving water shall not exceed 25 NTU, (2) changes in salinity due to hydrological modifications shall not result in the removal of the functions of a Primary Nursery Area

(PNA), (3) temperature shall not be increased above the natural water temperature by more than 0.8ºC during the months of June, July, or August nor more than 2.2ºC during other months, and in no cases to exceed 32ºC due to the discharge of heated liquids, (4) DO cannot decrease below 5.0 mg/l, except in “poorly flushed tidally influenced streams or embayments, or estuarine bottom waters” which may have decreased values from natural causes, and (5) pH levels “shall be normal for the waters in the area, which generally range between 6.8 and 8.5 except that swamp waters may have a pH as low as 4.3 if it is the result of natural conditions” (NCDWR 2012).

Historically, infrequent water sampling has been conducted in the vicinity of the permit area. Data collected by Searcy (2003) off the Highway 24 Bridge in Swansboro, from November 2002 through January 2003, reported a range of salinities from 24.0 to 28.6 ppt, with an average of 26.7 ppt in the area. During the same period, water temperatures ranged from 4.0ºC (39.2ºF) to 17.1ºC (62.8ºF), with an average of 9.8ºC (49.6ºF).

The White Oak River Basinwide Assessment Report (NCDWQ 2005) states turbidity levels taken adjacent to Swansboro from 1994 through 1999 ranged from 1.0 to 13.0 NTU, with an average measurement of approximately 5.2 NTU. Elevated levels of turbidity are expected in the surf zone at the effluent discharge point on the beach. Schubel et al (1978) discovered that 97–99 percent of discharged slurry settled to the bottom within a few tens of meters from the discharge point. Other studies have found that the distribution of turbidity was confined to the discharge point (Nichols et al 1978; USACE 2001a).

In April 2002, Phase 1 of the Bogue Banks restoration project involved pumping 1.73 million cy of sand to renourish Pine Knoll Shores and Indian Beach. During operations, turbidity was measured along two cross-shore transects (4,000 feet) – one inside the pumping zone and one away from the pumping zone. Turbidity was also measured along shore in the surf zone (3.8 miles) within the permit area before pumping started and during sand pumping (CSE, unpublished data, April 2002).

The longshore turbidity measured before pumping provides background data with which to compare changes in turbidity. Background nearshore turbidity levels measured between 13.0 and 94.0 NTU with an average turbidity of ~50.0 NTU. After pumping started, turbidity in the surf zone showed a slight overall increase in the longshore direction (measurements averaged ~65 NTU) with a sharp increase at the point of sand discharge (>400 NTU). The sharp increase was seen only locally at the point of discharge and was drastically reduced within several hundred feet alongshore (CSE, unpublished data, April 2002). No offshore turbidity monitoring was required or conducted (Personal communication, Mickey Sugg, USACE SAW, 27 June 2012).

Turbidities are typically well below the state water quality standard of 25 NTU, with an observed range of 1.0 to 12.0 NTU in Bogue Sound and a range of 2.0 to 9.0 NTU at Swansboro. Concentrations of total suspended solids (TSS) in Bogue Sound range from 4.0 to 43.0 mg/l, whereas concentrations at Swansboro range from 2.0 to 39.0 mg/l. During the Bogue Inlet Channel Erosion Response Project, turbidity levels were shown to remain within ambient conditions (9.7 to 35.2 NTUs) during the dredging operations (unpublished data, Coastal Planning and Engineering). Turbidity measurements were recorded on a regular basis during the construction and results indicated that levels never exceeded the State standard. The highest recorded levels of turbidity was 16.4 NTU.

4.9.6 Air Quality

The NC Division of Air Quality (NCDAQ) maintains an ambient air monitoring network for those criteria pollutants requiring monitoring by the USEPA. Areas that exceed the USEPA's national ambient air quality standards, based on regional ambient air monitoring, are designated as non-attainment areas. Carteret County is included in the non-metropolitan statistical area of NC's southern coastal plain. Carteret County is also included within New Bern's micropolitan statistical area (MiSA) (NCDAQ 2010).

The NCDAQ operates two ambient air monitoring stations within this MiSA; one station in Kenansville and the other in Kinston at Lenoir Community College. The Kenansville, Duplin County site operates a fine particulate monitor (sampled each third day) and a high-volume particulate matter 10 microns or less (PM_{10}) monitor (sampled each sixth day). The Kenansville site is considered a general/background ambient air monitoring site. The Lenoir Community College site operates a seasonal continuous ozone monitor and a fine particulate monitor (sampled each third day). The ozone monitor at Lenoir Community College is considered a rural ozone monitor in a MiSA (NCDAQ 2010).

Carteret County is designated as within attainment for all criteria pollutants (Personal communication, B. Newland, NCDAQ, March 2012). State Implementation Plans are not triggered for areas in attainment with the National Ambient Air Quality Standards (NAAQS).

4.9.7 Floodplains

4.9.7.1 Federal Framework

In 1968, Congress created the National Flood Insurance Program (NFIP) in response to increasing flood damage and the rising cost of disaster relief for flood victims. The NFIP is administered by the National Insurance and Mitigation Administration (NIMA), which is a component of the FEMA. The NFIP develops flood hazard risk maps [i.e., Flood

Insurance Rate Maps (FIRMs)], offers federally backed flood insurance to property owners, and oversees the development of floodplain management plans for participating communities. In order to participate in the NFIP, local communities must adopt floodplain management ordinances that meet or exceed the NFIP management requirements. Communities that reduce flood risk through a floodplain management plan are eligible for reduced insurance rates through the NIMA Community Rating System.

In 2000, NC signed a Cooperating Technical Program agreement with FEMA. This agreement led to the creation of the NC Flood Mapping Program (NCFMP), which assumed responsibility for updating digital FIRMs for the entire state. The NCFMP completed the first set of updated FIRMs in 2008. FIRMs delineate floodplains with 100 year and 500 year return intervals. Areas that fall within the 100 year floodplain have a 1.0% chance of flooding in any given year, and areas that fall within the 500 year floodplain have a 0.2% chance of flooding in any given year. Major flood insurance rate zones include Unshaded Zone X (low risk), Shaded Zone X (moderate risk), Zone AE (high risk), and Zone VE (Coastal High Hazard Area). Unshaded Zone X corresponds to low risk areas above the 500 year floodplain. Shaded Zone X corresponds to moderate risk areas within the 500 year floodplain. Zone AE corresponds to high risk areas within the 100 year floodplain, and Zone VE corresponds to high risk areas within the 100 year floodplain that have additional vulnerability associated with high velocity wave action. The purchase of flood insurance is required for Zone AE and VE homes that are financed through federally regulated lenders. FIRMs also provide Base Flood Elevations (BFEs), which are specific flood elevations associated with 100 year flood events. BFEs for Zone AE are based on Coastal Stillwater Elevations (no wave component), whereas BFEs for Zone VE may include an additional wave height, wave run-up, or wave setup component. BFEs are used by local communities to establish minimum elevation requirements for new structures within the 100 year floodplain.

4.9.7.2 Permit Area (Federal) Flood Zones

Figure 4.17 depicts the distribution of flood zones on Bogue Banks, and Table 4.27 provides a summary of flood zone acreages for each of the municipalities on the island. Updated preliminary mapping has just recently been released for Bogue Banks, but the maps and revised zones are not expected to become final for up to two years. The majority of the ocean front properties on Bogue Banks fall within Zone VE, and many of the water front properties on Bogue Sound fall within Zone AE. The remaining interior portions of the island are divided between Unshaded Zone X, Shaded Zone X, and Zone AE. The interior portion of Emerald Isle is characterized by a series of high dune ridges; and consequently, much of this area falls within Unshaded Zone X. The remaining portions of the island contain relatively little land area within Unshaded Zone X. Interior areas that fall within Zone AE are typically associated with low-lying areas, man-made canals, and natural tidal creeks. The dominant source of flooding on Bogue Banks is

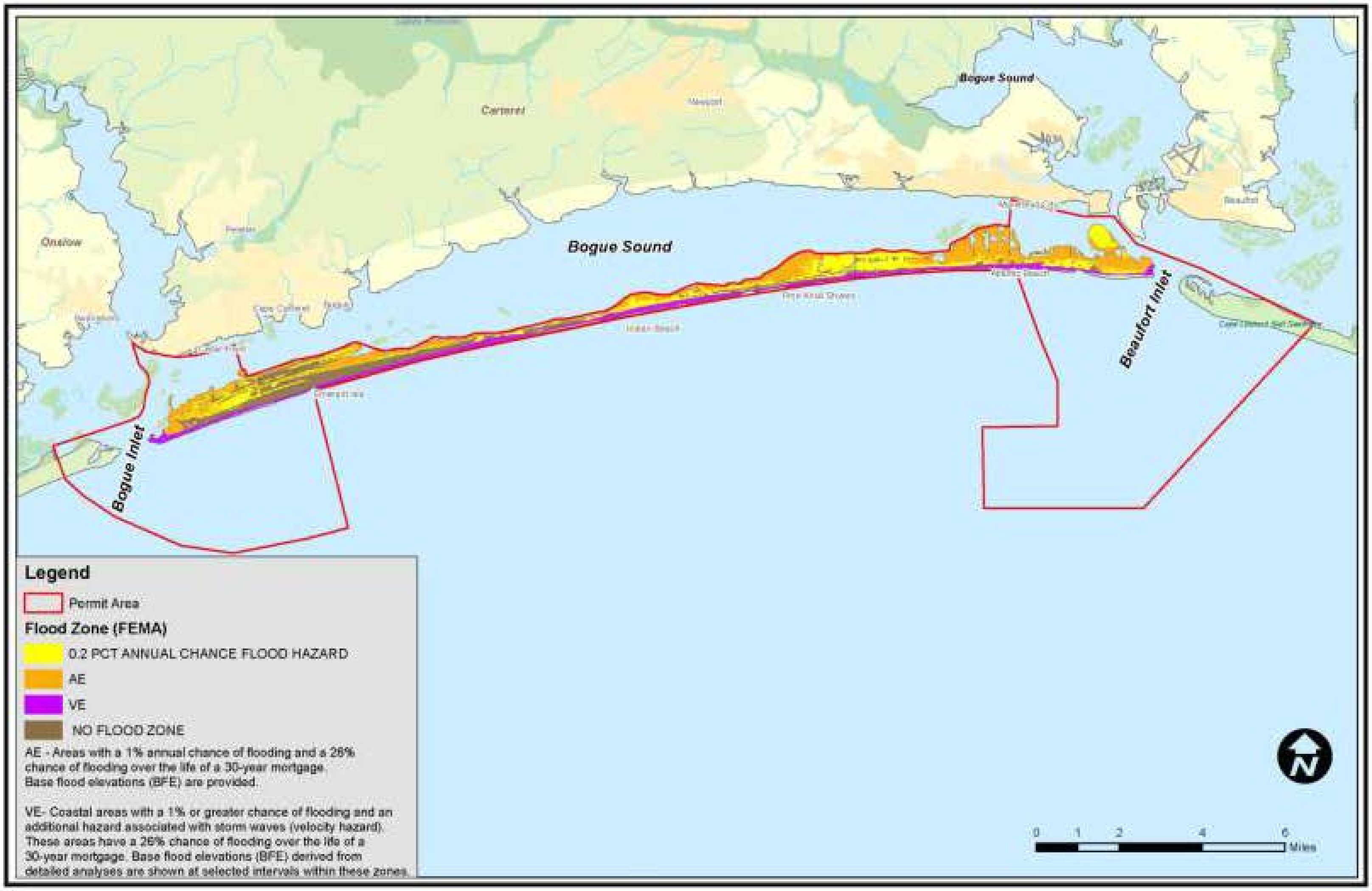


Figure 4.17. Flood Zones on Bogue Banks

Table 4.27. Municipal flood zone areas.

	Emerald Isle		Indian Beach/ Salter Path		Pine Knoll Shores		Atlantic Beach		Fort Macon	
Zone	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**	**Acres**	**%**
AE	807	25	170	31	410	29	906	59	334	54
VE	518	16	181	33	195	14	220	14	57	9
X	577	18	178	33	626	44	340	22	217	35
No Zone	1,367	42	18	3	180	13	70	5	9	1
Total	**3,269**	**100**	**547**	**100**	**1,411**	**100**	**1,536**	**100**	**617**	**100**

wind-driven surge created in the Atlantic Ocean by tropical storms and hurricanes. The surge propagates into the inlets, sounds, and estuaries. High wind can produce extremely high waves that create higher than normal surge. The wave action can be much more damaging than the high water level. Although Bogue Banks may also experience coastal flooding in association with extratropical nor'easters, these relatively minor flooding events do not influence the determination of base flood elevations or flood zone boundaries (FEMA and State of North Carolina 2003).

4.9.7.3 State and Local Floodplain Regulations

The State of North Carolina Floodplain Regulation (§143-215.51, et. seq.) is designed to minimize losses of life and property by regulating development and other uses within floodplains. Specifically, this statute was developed minimizing the extent of floods by preventing obstructions that inhibit water flow and increase flood height and damage. This statute authorizes counties and municipalities to adopt flood hazard prevention ordinances and grant permits for activities in flood hazard areas (i.e., 100 year floodplain). The statute sets minimum standards for local ordinances, specifies prohibited uses within flood hazard areas, and establishes criteria for granting variances for prohibited uses. Local ordinances must meet the minimum requirements for NFIP participation. Strictly prohibited uses within the 100 year floodplain include new solid waste treatment facilities, hazardous waste management facilities, chemical storage facilities, and salvage yards. The Floodplain Regulation also prohibits all other structures and obstructions; however, such uses may be allowed under a variance granted by the local county or municipality. Variances can only be granted under the following conditions: 1) the use serves a critical community need, 2) there is no feasible location outside of the flood hazard area, and 3) all proposed structures will be elevated above the 100 year BFE.

All of the incorporated municipalities on Bogue Banks (Emerald Isle, Indian Beach, Pine Knoll Shores, and Atlantic Beach) participate in the NFIP. As participants, these municipalities have adopted ordinances that meet the floodplain management requirements of the NFIP and the North Carolina Floodplain Regulation. NFIP participation by Carteret County includes the unincorporated areas on Bogue Banks, which fall under the jurisdiction of the Carteret County floodplain management ordinance.

4.9.8 Navigation

4.9.8.1 Overview

The USACE is responsible for constructing and maintaining federal navigation projects specifically authorized by Congress. The USACE also has the authority, under Section 107 (Continuing Authorities Program) of the River and Harbor Act, to construct certain water resource improvement projects without specific Congressional authorization. Section 107 also authorizes the USACE to undertake hurricane protection and beach erosion projects, which are frequently conducted in conjunction with the maintenance of federal navigation projects. The USACE is responsible for a number of federal navigation projects in the vicinity of Bogue Banks; including the MCH, the Beaufort Harbor, the AIWW, Bogue Inlet, and several other small regional navigation projects. These federal channels and basins are maintained either by USACE dredges or private dredges under contract to the federal government. Material dredged from the navigation channels has been placed beneficially on adjacent beaches and extended further along beaches under Section 933.

The following sections describe the federal navigation projects in Beaufort Inlet, Bogue Sound, and Bogue Inlet. Dredging statistics were obtained from the North Carolina BIMP Dredging Database (NCDENR 2011) and the USACE Navigation Data Center (http://www.ndc.iwr.usace.army.mil// dredge/dredge.htm). Information regarding beach placement of dredged materials was obtained from the Carteret County SPO (http://www.protectthebeach.com).

4.9.8.2 Beaufort Inlet

Federal navigation improvements at Beaufort Inlet were initiated by the RHA of March 3, 1881; which authorized projects to improve navigation between the Atlantic Ocean and Beaufort Harbor. The original Beaufort Harbor project included the construction of three jetties at Shackleford Point for purposes of controlling erosion and preventing deterioration of the ocean bar channel. Additional components of the original project included a channel nine feet deep and 200 feet wide between Beaufort Inlet and the wharves at Beaufort and a channel six feet deep and 100 feet wide connecting Beaufort with the North River and Core Sound. The RHA of March 3, 1905 authorized construction of a channel 20 feet deep and 300 feet wide across the ocean bar at Beaufort Inlet. The MCH project was established by the RHA of June 25, 1910; which authorized construction of a connecting channel between the ocean bar channel and the wharves at Morehead City. The original MCH project included a channel ten feet deep and 100 feet wide leading up to Morehead City and a channel ten feet deep and 200 feet wide along the city wharves.

MCH has undergone a number of major expansion projects, most recently in 1994 when the depth of the ocean bar channel was increased to -47 feet and the depths of the eastern channel and basin were increased to -45 feet. The current MCH project (Table 4.28) is designed for deep-draft commercial vessel access to the POM. The ocean bar entrance channel (Range A and Cutoff) is a channel 45 to 47 feet deep and 450 to 650 feet wide from deep water in the Atlantic Ocean through the ocean bar at Beaufort Inlet. The inner entrance channel (Range B) is a channel 45-feet deep and 400-feet wide connecting the ocean bar channel with the inner harbor. The inner harbor includes two turning basins (Range C and Northwest Leg) and connecting channels (East Leg and West Leg) ranging from 45 to 35 feet deep. The inner harbor also contains nine deep water berths along the wharves at the POM. Berths 8 and 9 are maintained by the USACE as part of the federal harbor project, and the remaining non-federal berths are maintained by the NCSPA. The POM services deep-draft cargo ships arriving from the Atlantic Ocean and transport barges arriving from the AIWW. Annual vessel calls between 2001 and 2010 averaged 147 ships and 366 barges (NCSPA Port Statistics http://www.ncports.com/Port_Statistics.htm). The POM handles dry bulk and breakbulk cargo. Major import commodities include sulfur products, rubber, and scrap metal. Major export commodities include phosphate, wood chips, and military products. The POM also serves as the embarkation facility for the United States Marine Corps (USMC) Second Division at Marine Corps Base Camp Lejeune. The POM is one of thirteen in the nation considered as a military "strategic port" (Personal communication, S. Moody, NCSPA, May 2012). The NCSPA is pursuing additional port industrial development on Radio Island. A potential development project includes berths along Radio Island accessing the current 45-feet deep East Leg harbor channel.

The inner harbor channels are dredged at intervals of approximately two years. Material from the inner channels is removed by a pipeline dredge and placed either in the Brandt Island upland disposal area or offshore in the ODMDS. Dredged materials that are placed on Brandt Island are stored until such time the non-beach compatible material is moved to the ODMDS. Historically, Brandt Island pump-outs of beach quality material to eastern Bogue Banks occurred in 1986, 1994, and 2005. Dredged materials from reaches with beach compatible material were pumped directly to eastern Bogue Banks during 1978, 1986, 1994, 2002, 2005, and 2007. Additional dredged material from the outer portion of Range C was placed on eastern Bogue Banks during Year 1 (2010/2011) of the MCH Interim Operation Plan (IOP). The outer harbor channels are

Table 4.28. Beaufort Inlet federal navigation projects.

Morehead City Harbor	
Port of Morehead City Deep Draft Component	
Range A	A channel 47 feet deep and 450 to 650 feet wide from deep water in the Atlantic Ocean to Beaufort Inlet
Cut-Off	A channel 45 feet deep and 600 feet wide connecting Range A with the inner harbor entrance channel (Range B)
Range B	A channel 45 feet deep and 400 feet wide connecting the Cutoff channel with Range C
Range C	A channel and turning basin 45 feet deep and 400 to 1,200 feet wide connecting Range B with the East Leg and West Leg
East Leg	A channel 45 feet deep and 800 to 1,000 feet wide connecting Range C with the eastern non-federal berthing areas
West Leg	A channel 35 feet deep and 780 feet wide connecting Range C with the western non-federal berthing areas and the Northwest Leg
Northwest Leg	A channel and turning basin 35 feet deep and 1,200 feet wide
Morehead City Shallow Draft Component	
Entrance Channel	A channel 12 feet deep and 100 feet wide from the Northwest Leg to 6th Street along the Morehead City Waterfront
Waterfront Channel	A channel 12 feet deep and 200 to 400 feet wide from 6th Street to 10th Street along the Morehead City Waterfront
Bogue Sound Channel	A channel 6 feet deep and 75 feet wide from 10th Street to the Atlantic Intracoastal Waterway in Bogue Sound
Beaufort Harbor	
Bulkhead Channel	A channel 15 feet deep and 100 feet wide from the Morehead City Harbor entrance channel (Range B) to a basin 12 feet deep and 600 feet wide at Beaufort
Gallants Channel	A channel 12 to 15 feet deep and 100 feet wide between Beaufort and the AIWW (Core Creek Range S)
Morgan Creek	A channel 14 feet deep and 70 feet wide from Bulkhead Channel to a to a turning basin 14 feet deep, 150 feet wide near the upper end of Morgan Creek
Taylors Creek	A channel 12 to 15 feet deep and 100 feet wide between Beaufort and the North River
Beaufort Harbor of Refuge	A channel 12 feet deep and 150 feet wide from Gallants Channel to a basin 12 feet deep and 400 feet wide in Town Creek

typically dredged on an annual basis. Material from the outer channels is removed by a hopper dredge and placed either in the ODMDS, the Morehead City nearshore disposal site, or directly on the eastern beaches of Bogue Banks. Dredged materials from the outer harbor were pumped directly to eastern Bogue Banks during 2004 (Section 933 Project - Phase I), 2007 (Section 933 Project - Phase II), 2010/2011 (Interim Operations Plan), and 2014 (Interim Operation Plan). MCH contains three distinct areas with respect to sediment quality. Most of the inner harbor (inner portion of Range C, West Leg, Northwest Leg, and East Leg) contains fine-grained material that is unsuitable for beach placement. Most of the outer harbor (outer portion of Range C, Range B, Cutoff, and Range A out to Station 110+00) contains coarse-grained material that is suitable for beach placement. The remaining outer portion of Range A contains fine-grained material that is unsuitable for beach placement (USACE 2009).

The MCH project also includes a shallow draft component consisting of channels and basins along the Morehead City and Beaufort waterfronts (Table 4.28). The current project includes a channel 12 feet deep and 100 feet wide from the western turning basin to 6th Street, a channel 12 feet deep and 200 to 400 feet wide between 6th to 10th Streets, and a channel six feet deep and 75 feet wide between 10th Street and Bogue Sound. Prior to 2011, the shallow-draft component had not received federal appropriations for maintenance dredging in 20 years. In January 2011, 37,020 cy of material was removed from the waterfront channel by a split hull hopper dredge.

The current Beaufort Harbor project includes 7.3 miles of channels ranging from 12 to 15 feet deep and 70 to 150 feet wide (Table 4.28). Additional components include a basin along the Beaufort waterfront, a harbor of refuge in Town Creek, and a turning basin near the upper end of Morgan Creek. Various components of Beaufort Harbor were dredged eighteen times between 1974 and 1994, with an average of 54,905 cy of material removed per dredging event. Dredging during this period was performed by pipeline dredges, with dredged material being stockpiled in the Brandt Island upland disposal site. The Bulkhead Channel was dredged five times between 2002 and 2010, with an average of 29,166 cy of material removed per dredging event. Since 2006, dredging has been performed by a split-hull hopper dredge.

The USCG Station Fort Macon is located adjacent to the MCH inner channel. An entrance channel connects the USCG basin with the inner harbor channel (Range B). The boat basin serves as a docking facility for USCG cutters. The USCG is responsible for maintenance of the channel and basin.

4.9.8.2.1 Morehead City ODMDS

The Morehead City ODMDS is a USEPA-designated ocean dredged material disposal site. The site is utilized by the USACE as a disposal area for material dredged during maintenance of the MCH navigation channels. Disposal is limited to dredged materials that have been evaluated and approved in accordance with USEPA Ocean Dumping Regulations and Criteria. The ODMDS occupies an area of approximately eight square nm offshore of eastern Bogue Banks at depths of -31 to -55 feet MLW. Depths are generally shallowest in the northern inshore portion of the ODMDS and gradually deepen towards the southern offshore portion. Sediments are predominantly sands with varying amounts of silts and clays. The quantity of shell material varies from a trace to 25 percent. The seafloor is essentially flat, with the exception of dredged material mounds in the northeastern third and central portion of the ODMDS due to navigation maintenance dredging disposal events. Remote sensing surveys have not identified any potential hardbottom features or cultural resources at the ODMDS. Bathymetric surveys indicate that sandy and coarse dredged materials have the potential to mound appreciably when specific areas are repeatedly used for disposal (USEPA and USACE 2010). The inner boundary of the ODMDS is just over three nm from shore, and the outer boundary is approximately 11 nm from shore. Sand from the ODMDS has been used during previous renourishment projects on Bogue Banks, including the 2004 Post-Isabel, the 2007 Post-Ophelia, and the 2013 Post-Irene sand replenishment projects that placed sand on Bogue Bank beaches. The typical sediment type in the ODMDS borrow site is medium sand (average mean sediment size = 0.31 mm), moderately to poorly sorted (average standard deviation = 1.09 phi), and strongly coarse-skewed (coefficient of skewness < - 0.3). Less than 2% of the material is >2 mm in diameter.

4.9.8.3 Bogue Inlet

The Bogue Inlet navigation project includes a channel six feet deep and 90 feet wide between the AIWW and Bogue Inlet and a channel eight feet deep and 150 feet wide across the ocean bar. Both channels were authorized under Section 107 (Continuing Authorities Program) of the RHA of July 14, 1960; the inner channel being authorized on November 29, 1963 and the ocean bar channel being authorized on September 7, 1983. Dredging is conducted within the channel that exists at the time maintenance dredging is performed, with no attempt being made to maintain a fixed channel alignment. Bogue Inlet was dredged 79 times between 1975 and 2010, with an average of 82,510 cy of material removed per dredging event. Dredging has been performed primarily by sidecaster dredges, with dredged materials being discharged to open waters adjacent to the navigation channel. Eastward migration of the Bogue Inlet channel during the 1980s and 1990s resulted in chronic erosion problems on the west end of Bogue Banks. Local efforts to protect infrastructure on the western end of the island included development of the Bogue Inlet Channel Response Project. This 2005 channel relocation project, which constituted Phase III of the Bogue Banks Restoration Project, relocated the Bogue Inlet channel approximately 3,500 feet to the west towards Bear Island. Material dredged from the relocated inlet channel (690,868 cy) was placed on the beach at the western end of Emerald Isle. Subsequent federal maintenance dredging has been conducted within the channel that exists at the time USACE sidecast maintenance dredging is performed.

The USCG Station Emerald Isle is located adjacent to the Bogue Inlet channel. An entrance channel connects the USCG basin with the Bogue Inlet. The boat basin serves as a docking facility for small USCG boats. The USCG is responsible for maintenance of the channel and basin.

4.9.8.4 Bogue Sound

The AIWW channel between Beaufort and Swansboro (Section 1 - Tangents A - H) was authorized by the RHA of January 21, 1927; which authorized a channel 12 feet deep and 90 feet wide between Beaufort and the Cape Fear River. Section 1 begins at the MCH turning basin, traverses Bogue Sound, crosses Bogue Inlet, and terminates at Swansboro. Maintenance dredging of the Bogue Inlet Crossing segment (Section 1 - Tangent G) is preferably conducted on an annual basis as part of the AIWW inlet crossings contract. This project utilizes a pipeline dredge, with the material pumped directly onto the beach at the western end of Emerald Isle. Dredged material was placed on the beach 13 times between 1984 and 2014. Other Section 1 tangents are typically dredged on an as needed basis, with material typically placed within upland disposal sites adjacent to the AIWW channel. However, material dredged from Section 1 Tangent B in 2008 was placed on the beach at the eastern end of Pine Knoll Shores.

Additional federal navigation projects in Bogue Sound include Atlantic Beach Channels and Peletier Creek. The Atlantic Beach Channels' project was authorized on November 23, 1965, under Section 107 (Continuing Authorities Program) of the RHA of July 14, 1960. The project includes two channels in Bogue Sound between the AIWW and Atlantic Beach. The Money Island Channel is a channel six feet deep and 50 feet wide between the AIWW and the Anchorage Marina at Money Island. The Causeway Channel is a channel six feet deep and 50 feet wide between the Money Island Channel and the Causeway Bridge at Atlantic Beach. The Peletier Creek project was authorized by the RHA of September 3, 1954. The project includes a channel six feet deep and 50 feet wide extending from the AIWW to a basin six feet deep and 200 feet wide in Peletier Creek.

4.9.9 Noise

Any harbor or open-water coastal environment has a number of ambient noise sources such as commercial and recreational vessel traffic, dredges, wharf/dock construction (e.g., pile driving), and natural sounds (e.g., storms, biological), etc. Ambient natural noise levels, such as wind and pounding surf, do vary and are considered as typical or persistent environmental background noise within the permit area. During storm events, decibel levels can increase. According to the Office of Marine Programs (OMP 2010) of the University of Rhode Island, spray and bubbles associated with breaking waves are the major contributions to ambient noise in the 500- to 100,000 Hertz (Hz) range. Ambient noise sources, especially noise from wave and tidal action, can cause coastal environments to have particularly high ambient noise levels.

Sources of ambient noise in the OCS include wind and wave activity, including surf noise near the land-sea interface; precipitation noise from rain and hail; lightning; biological noise from marine mammals, fishes, and crustaceans; and distant shipping traffic

(Greene and Moore 1995). Several of these sources may contribute significantly to the total ambient noise at any one place and time, although ambient noise levels above 500 Hz are usually dominated by wind and wave noise. Consequently, ambient noise levels at a given frequency and location may vary widely on a daily basis. A wider range of ambient noise levels occurs in water depths less than 200m (shallow water) than in deeper water. Ambient noise levels in shallow waters are directly related to wind speed and indirectly to sea state (Wille and Geyer 1984).

Sources of anthropogenic underwater noise within the permit area include commercial shipping operations at the State Port, recreational watercraft activity, and periodic maintenance dredging of the MCH and other federally-maintained navigation channels. Clarke et al. (2002) documented noise levels ranging from 120 to 140 decibels (dB) re 1 micropascal (µPa) root mean square (rms) at a distance of 40 m during navigation dredging in Mobile Bay, Alabama. Peak spectral levels for individual commercial ships are in the frequency band of 10 to 50 Hz and range from 195 dB re µPa 2/Hz @ 1 m for fast-moving (>20 knots) supertankers to 140 dB re µPa 2/Hz @ 1 m for small fishing vessels (NRC 2003). Small boats with outboard or inboard engines produce sound that is generally highest in the mid-frequency [1 to 5 kilohertz (kHz)] range and at moderate (150 to 180 dB re 1 µPa @ 1m) source levels (Erbe 2002, Kipple & Gabriele 2003 and 2004). For instance, small craft with outboard motors [14 to 18 feet (4.3 to 5.5m) in length with 25 to 40 horsepower [19 to 30 killowats (kW)] outboard motors, and operated at a speed of from 10 to 20 knots] had maximum source levels (one-third octave band) at 160 dB re 1 µPa @ 1m, with peak energy at 5 kHz (Kipple & Gabriele 2003). On average, noise levels were found to be higher for the larger vessels, and increased vessel speeds resulted in higher noise levels (Hildebrand 2009).

To better assess potential species effects (i.e., disturbance of communication among marine mammals) associated with dredge specific noise from navigation maintenance, deepening, or borrow area dredging operations, Clarke et al. (2002) performed underwater field investigations to characterize sounds emitted by bucket, hydraulic cutterhead, and hopper dredge operations. The variation in noise emitted by equipment type is related to how the machinery makes contact and extracts material from the sea floor.

Clarke et al. (2002) performed a study of underwater noise produced by various types of dredging equipment, including a hydraulic cutter suction dredge and a trailing suction hopper dredge. Recordings of a hydraulic cutter performing maintenance dredging in Mississippi Sound, Mississippi emitted noise as the cutterhead was turned at one to ten revolutions per minute within the substrate. Sounds were continuous and fell within the 70 to 1,000 Hz range while sound pressure levels (SPLs) peaked between 100 to 110 dB re 1µPa rms. In the case of a hopper dredge, much of the sounds emitted during the active dredging process are produced by propeller and engine noise, pumps and generators. Similar to a cutter suction dredge, most of the sound energy produced fell within the 70 to 1,000 Hz range and was continuous in nature. However, Clarke *et al.* (2002) reported peak pressure levels recorded by a listening platform ranged from 120 to 140 dB re 1µPa rms for hopper dredges, which is comparatively much higher than a cutter suction dredge. A more recent study evaluated sound levels produced by hopper dredges operating in an offshore environment during sediment excavation, transport of material, and pump-out of material (Reine et al., 2014). When averaged across all dredging activities, SPLs averaged 142.31 dB at a distance of 50m, and grew progressively less to 120.1 dB at 1.95 km. At all distances from dredging activity, sound levels were highest during sediment removal activities and transition from transit to pump-out, and were quietest during flushing of pipes at pump-out (132.45 dB). At a distance of 2.5 km, sounds attenuated to ambient levels.

4.9.10 Public Safety

A total of 314,105 recreational vessels were registered in NC during 2010, including 10,725 registered vessels in Carteret County. An average of 170 recreational boating accidents and 21 fatalities were reported each year between 2006 and 2010 (NCWRC 2013). Annual boating accidents declined steadily from a high of 217 during 2006 to a low of 154 during 2010. During the same five-year period, a total of 53 recreational boating accidents and nine fatalities were recorded in Carteret County, including four accidents and two fatalities in Beaufort Inlet and 16 accidents and one fatality in Bogue Inlet/Bogue Sound. The vast majority of accidents (>90%) occur during the months of April through October. Collision with vessel has been the number one type of non-fatal boating accident in NC since 1990. Local residents have expressed a general concern for recreational boat operators who utilize Bogue Inlet. The narrowing main ebb channel, coupled with the migration of inlet and increased velocities have raised local residents concerned about boating safety of recreational boaters, especially tourists unfamiliar with Bogue Inlet.

Numerous emergency service locations for fire and EMS, and police services exist on the island, allowing expedited response to urgent response incidents at Bogue Banks. For example, the Pine Knoll Shores Fire and EMS Department responsibilities include fire suppression, education, and prevention as well as emergency medical services, water rescue, and natural disaster response while their Police Department functions promoting public safety, preventing, suppressing, and investigating crimes, and providing emergency and non-emergency services. The emergency services offered by neighboring towns at Bogue Banks employ similar functionality.

Construction activities during nourishment events can be conducted during the daylight hours or during the night. Safety protocols have to be considered in all aspects of construction including the mobilization of equipment, staging of equipment and construction on the beach. These activities must meet USACE and the Occupational

Safety and Health Administration (OSHA) standards. The various construction areas are sited to minimize environmental impacts and roped off for safety considerations throughout project construction.

4.9.11 Recreation

The total environment of barrier islands, beaches, ocean, estuaries, and inlets attract many residents and visitors to the area to enjoy the total aesthetic experience created by the sights, sounds, winds and ocean sprays. Two ocean piers (Oceana and Sheraton Hotel) are located in the permit area and are considered important recreational facilities. During fall months, recreational surf fishing is a popular activity and vehicle beach access is available along the eastern bank of Bogue Inlet. Fort Macon State Park and the North Carolina State Aquarium in Pine Knoll Shores also provide recreational activities for residents and visitors.

The beaches of Bogue Banks are used by off-road vehicles (ORVs) and surf fishermen. These two interests constitute the major user groups of the project area and contribute to the local economy. The use of ORVs on Bogue Banks beaches is generally restricted to the months of October-April; however numerous public beach access points are available for foot travel year-round. These ORVs are generally not allowed for the general public on Shackleford Banks except for contractors working on the island. The inlet shoals of Bogue Inlet, eastern end of Bear Island and the western end of Shackelford Banks is primarily used in the summer months for swimming, fishing and shell collecting.