SECTION 4.0 - AFFECTED ENVIRONMENT

4.1 GENERAL ENVIRONMENTAL SETTING

Please refer to Figures 4.1 – 4.3 for specific study area boundaries.

4.1.1 Geology and Morphology of Study Area

The coastal system in the southern geologic province of North Carolina, from Cape Lookout south to South Carolina, is underlain by geologic units ranging in age from the Upper Cretaceous through the Pliocene with only a thin, variable layer of sediments of Quaternary age. The system is largely composed of rocks associated with the Carolina Platform, which underlies the region between Cape Fear and Myrtle Beach, South Carolina (Cleary et al. 2001). Bald Head Island represents the largest segment of the Cape Fear Foreland. The origin of the Cape Fear Foreland is related to a variety of mechanisms including ocean current eddies and erosion of remnant Pleistocene river deltas (Cleary 2008).

The Cape Fear River rises in the Blue Ridge of central North Carolina, the upper reach being the Haw River. The river has eroded the Late Proterozoic to Permian granitic, gneissic and volcanic rocks of the Blue Ridge and Piedmont provinces, delivering this detritus to the coast in a relatively fast moving current compared to nearby rivers draining only Coastal Plain sediments. The Cape Fear River valley lies astride a broad and temporally persistent feature, the Cape Fear arch, and five river terraces are present with successively older terraces farther from the river. An ancestral Cape Fear River began draining the region at least 2.75 million years ago (Mya) during the late Pliocene age and since that time has been migrating to the southwest. This pattern of erosion is evidenced by the pattern of the river's tributaries which are numerous and large on the northeast side of the river while tributaries on the southwest margin are comparably limited in development (Soller 1998).

Hydrologic modifications to the Cape Fear River mouth began in 1822 with initial navigation improvements conducted by the State of North Carolina. Improvements by the State continued until such time when the Federal government assumed responsibility for maintaining safe navigation in 1829 (Cleary 2008). The first major navigation improvement was initiated in 1871 with the construction of a 12-ft deep and 100-ft wide channel along the general alignment of the Bald Head Shoal. Prior to the dredging of this bar channel, the river entrance was characterized by the presence of two equally-sized channels, the Western Bar Channel and the Bald Head Shoal Channel. In 1871, construction began on the New Inlet Dam (between Federal Point and Zekes Island) which was intended to close New Inlet, thus eliminating shoaling issues within the main river channel (USACE 1989). Modification to the Cape Fear River entrance channel has continued since that time, and channel depths have gradually increased to accommodate the increasingly larger vessels calling at the Port of Wilmington (USACE 2000). Refer to the USACE Wilmington Harbor – Bald Head Island Reconnaissance Report (Section 111) (USACE 1989) for a more detailed description of navigation channel improvements from the late 1800's to through 1987. Since the implementation of the Wilmington Harbor Deepening Project in 2000, the Cape Fear River entrance channels have been regularly maintained at an authorized depth of -44 ft MLLW (+2 ft overdepth) and widened by as much as 900 ft (USACE 2008).

Federal navigation improvements have yielded an increased depth, width, and realignment of the channel. Geological investigations of the shoal configurations in the vicinity of Bald Head Island indicate that the reorientation and subsequent stabilization of the shipping channel in the 1880's led to significant changes in the morphology and volume of the ebb-tidal deltas. Large-scale dredging led to the segmentation of the ebb tide delta and an eventual re-organization of the shoal complex into two distinct east and west features. It is estimated that since that time, western Jay Bird Shoal has gained approximately 11.0 million cubic yards of material while the eastern Bald Head Island shoal segment has lost 28.8 million cubic yards of material (Cleary 2008).

Historical shoreline trends on Bald Head Island are described in the Section 111 Report referenced above (USACE 1989) and by Cleary (2008). Readers are referred to both of these reports for detailed information on shoreline patterns pre- and post-development of Bald Head Island. The following is a brief summary of some of the major trends cited in the referenced reports.

Stabilization of the newly aligned Bald Head Shoal Channel (beginning in the 1880s) allowed the remnant shoal of the 1851 channel to migrate and eventually weld to the west end of South Beach (USACE 1989). By 1923, this phenomenon had resulted in the progradation of western South Beach by more than 2,625 ft. In association with this, the eastern ebb-tide delta fronting South Beach (which was no longer being nourished by eastward moving longshore current) continued to reconfigure as bypassing ceased (Cleary 2008). According to the Section 111 Report, the west end of South Beach remained fairly stable from 1942 to 1975 (USACE 1989). Cleary (2008) states that since 1962, the western segment of South Beach has been eroding and attributes the shoreline recession to "a lack of sand by-passing and the continued reconfiguration of the often-poorly defined marginal flood channel juxtaposed along the southwestern portion of South Beach."

Development of Bald Head Island began in 1972 with the construction of the golf course and the Bald Head Island Inn. The Inn was located near the west end of South Beach. When first constructed, the Inn was located behind a substantial frontal dune. Severe erosion along this area of shoreline prompted the relocation of the structure 300 ft landward (USACE 1989). Continued erosion prompted the use of sand bags and a Longard tube to help stabilize the immediate shoreline area of interest (Moul, personal communication). However, erosion continued to the extent that ultimately required the demolition of the Inn. More recently (1989 to 1996) the shorelines along the western approximate third of South

Beach have continued to erode with the remaining portions of South Beach exhibiting greater stability. These general shoreline responses have continued until present, being influenced periodically by federal disposal and Village-sponsored nourishment events (USACE 2004). Detailed physical monitoring data of the shorelines of Bald Head have been collected and reported on by both the USACE and Olsen Associates since 2001.

Note that geo-rectified, historic aerial imagery of the shorelines of Bald Head Island (1938 to 1989) are provided for reference (Appendix I). In addition, Figures 4.4 - 4.6, adapted from the USACE Wilmington Harbor Physical Monitoring Report – Year 1 (USACE 2008), are provided for reference.

4.1.2 Sand Source and Quality

Pursuant to the tenets of SB 151, a proposed terminal groin must include the placement of a sand fillet updrift of the structure. As indicated earlier, the source of the sand fillet for the Village's proposed action may be any one of the following: (1) reaches of the Wilmington Harbor Entrance Channel; (2) Jay Bird Shoals; (3) Bald Head Creek Shoal; or (4) Frying Pan Shoals.

In 2007 the North Carolina Coastal Resources Commission (CRC) adopted new State Sediment Criteria language which established grain size standards for beach fill projects (15A NCAC 07H .0312). For the purpose of these standards, four grain size categories are defined by the State as the following:

> Gravel – sediment grain sizes greater than 4.76mm and less than 76mm
> Granular – sediment grain sizes 2mm and greater and less than 4.76mm
> Sand - sediment grain sizes .0625mm and greater and less than 2mm, and
> Fines – sediment grain sizes less than .0625mm (i.e. passing a no. 230 sieve).

It is important to note that while some level of sediment characterization is required for Wilmington Harbor, borrow sediment excavated from regularly maintained navigation channels is largely exempt from the state sediment criteria language. This high-quality sand is a key source of beach fill materials for many coastal communities (Limber and Warren 2006). Borrow site characterization of navigation channels requires at least five cores with a minimum spacing of 5,000 lf and no geophysical imaging is necessary. Sediment from navigation channels is assumed to originate from the adjacent beach and is therefore considered to be beach-quality. As such, characterization of the recipient beach is not required. Sediment completely confined to the permitted dredge depth of a regularly maintained navigation channel is considered beach-compatible if the average percentage by weight of fine-grained (<0.0625 mm) sediment is less than 10%.

The following is a summary of the sand quality within each of the potential sand source sites.

A. Wilmington Harbor Entrance Channel

Subsequent to the 2001 modification to the alignment of the Wilmington Harbor Entrance Channel and the development of the Sand Management Plan (SMP), the Corps of Engineers has performed on-going physical monitoring of the entrance channel reaches (both survey and geotechnical analyses). Prior federal channel maintenance and disposal events conducted under the Wilmington Harbor SMP have demonstrated that the Entrance Channel is a suitable source of beach-compatible material. Navigation channel surveys for three channel reaches (Smith Island Channel, Baldhead Shoal Channel 1, and Baldhead Shoal Channel 2) continue to be conducted at regular intervals. These surveys indicate the occurrence of continued shoaling in Smith Island Channel and Baldhead Shoal Reach 1 and 2 (USACE 2011). Areas of pronounced decreases in channel depth resulting from shoaling represent suitable sources for beach nourishment material. Note also that per the Wilmington Harbor Dredged Material Management Plan (USACE 1996) and the SMP (USACE 2000), beach quality sand can be found within the interior reaches north of the Smith Island

Channel. This material has recently (i.e. since the inception of the SMP) been disposed of on other beaches in New Hanover County (including Kure Beach and Fort Fisher).

B. Jay Bird Shoals

Detailed geotechnical analyses of the sediments within the Jay Bird Shoals depositional feature was performed as part of the Village-sponsored Bald Head Island Beach Restoration Project (implemented in 2009). The findings of these analyses were reported in the Sand Search Investigation Summary (Olsen 2007) and incorporated into the project Environmental Assessment (LMG and Olsen 2009). The general findings of this investigation are that sediments within the shoal feature are characterized as SP sands under the Unified Soil Classification System and defined as poorly graded sands-gravelly sands with little to no fine sand components. SP sands were found to occur to an average depth of -25 ft at which point a thin clay layer was identified to exist. Overall, the sediments were determined to be compatible with the existing beach substrate on South Beach and West Beach as confirmed via post-nourishment grain size analyses and inspections by the project engineer. In addition, staff of NC Wildlife Resources Commission (WRC) performed visual inspections of color, sediment content, and compaction of the nourished shoreline and found the sand suitable with respect to sea turtle nesting habitat.

C. Bald Head Creek Shoals

In December 2008, fifteen Vibracores were acquired by the firm of Athena Technologies, Inc. throughout portions of the ebb tidal shoal feature located at the entrance to Bald Head Creek. The purpose of the effort was to document sediment conditions in the proposed excavation area for the project being considered at that time as well as to characterize the sediments of the ebb tidal platform in general. The sediments encountered were predominantly medium grained, moderately well sorted sands. It was common for sand lithologies to show layered variations in grain size from medium sands to finer sands. The coarser lenses were typically cleaner and occasionally reflected a higher percentage shell content. Carbonate content on average was generally about 10%. Shell material was typically finer grained with few instances of large intact shells encountered. Fines content was also typically very low (i.e., about 1% ±) with a slight trend of increase with depth.

D. Frying Pan Shoals

The USACE has identified Frying Pan Shoals as a potential source site for the Brunswick County Beaches Coastal Storm Damage Reduction Project. Geotechnical evaluations of sediments within Frying Pan Shoals were conducted by the USACE as part of the General Reevaluation Report (GRR) for this 50-year project. The findings of these analyses were reported in the Brunswick County Beaches Renourishment Study (Catlin 2010). Review of the vibracore borings indicate that the Frying Pan Shoal borrow area identified in the GRR has an average silt content of 3.2% and an average percentage by weight shell content of 1.5%, within the NCDCM Sediment Criteria. Grain size testing results of the sediment samples ranged from 1.47 (phi) to 2.83 (phi) with a weighted mean average of 2.53 (phi). Based on compatibility analysis criteria for percent silt content, percent shell content, mean grain size and standard deviation from sediment sampling within Frying Pan Shoals, the material from the borrow area identified in the GRR is largely compatible with the native beach material (Catlin 2010).

4.2 THREATENED AND ENDANGERED SPECIES

Federal and state protected species known to occur within the project area are listed in Table 4.1. Federally-listed threatened and endangered species are protected under the Endangered Species Act of 1973 and/or the Marine Mammal Protection Act of 1972. State-listed animal species are protected under North Carolina General Statutes 113-331 through 113-337 (commonly known as the NC Endangered Species Act). State-listed endangered, threatened and rare plants are protected by the North Carolina Plant Protection and Conservation Act of 1979 (General Statutes, Article 19B, 106: 202.12-22), as amended.

4.2.1 Mammals

The federally-protected right whale, finback whale, humpback whale, sei whale, and sperm whale all occur infrequently in the ocean off the coast of North Carolina. Of these, only the right whale and the humpback whale pass close enough nearshore to encounter the study area. Humpback whales are often found in protected waters over shallow banks and shelf waters for breeding and feeding. They migrate toward the poles in summer and toward the tropics in winter and visit the North Carolina coast during seasonal migrations, especially between December and April (Conant 1993). While it usually winters in the waters between Georgia and Florida, the right whale can on occasion be found in the waters off North Carolina.

Sighting data provided by the Right Whale Program of the New England Aquarium found that most of the sightings in the vicinity of Wilmington from 1974 to 2002 occurred between October and April, with peak sightings in February and March (Knowlton et al. 2002). According to data from the University of North Carolina at Wilmington's Marine Mammal Stranding Program, right and humpback whales are documented in the region with some frequency. In December of 2008, a right whale and her calf were spotted off the coast of Wrightsville Beach. The same mother whale was seen with another calf four years earlier. Also in December of 2008, a very young right whale washed up on the Outer Banks with numerous health ailments. These sightings indicate that right whales are giving birth off the coast of North Carolina. Additionally, a humpback whale stranding was documented in Oak Island in February of 2009. In 2012, humpback whales have been confirmed in the waters near Topsail Beach and right whales have been observed swimming past Wrightsville Beach.

Table 4.1. List of Federally and State Protected Species Known to Occur in the Vicinity of the Study Area.

Common Name	Scientific Name	Status	
		Federal	State
Mammals			
Finback whale	*Balaenoptera physalus*	E	
Humpback whale	*Megaptera novaeangliae*	E	
Right whale	*Eubaleana glacialis*	E	
Sei whale	*Baleanoptera borealis*	E	
Sperm whale	*Physeter catodon*	E	
West Indian manatee	*Trichechus manatus*	E	E
Birds			
American oystercatcher	*Haematopus palliatus*		SC
Brown pelican	*Pelecanus occidentalis*		SR
Common tern	*Sterna hirundo*		SC
Eastern painted bunting	*Passerina ciris ciris*	FSC	SC
Least tern	*Sternula antillarum*		SC
Piping plover	*Charadrius melodus*	T	T
Tri-colored heron	*Egretta tricolor*		SC
Wilson's plover	*Charadrius wilsonia*		SC
Reptiles			
American alligator	*Alligator mississippiensis*	T(S/A)	T
Coachwhip	*Masticophis flagellum*		SR
Diamondback terrapin	*Malaclemys terrapin*	FSC	SC
Green sea turtle	*Chelonia mydas*	T	T
Hawksbill sea turtle	*Eretmochelys imbricata*	E	E
Kemp's ridley sea turtle	*Lepidochelys kempi*	E	E
Leatherback sea turtle	*Dermochelys coriacea*	E	E
Loggerhead sea turtle	*Caretta caretta*	T	T
Fish			
Atlantic sturgeon	*Acipenser oxyrinchus oxyrinchus*	E	SC
Shortnose sturgeon	*Acipenser brevirostrum*	E	E
Plants			
Dune bluecurls	*Trichostema sp. 1*	FSC	SR-L
Four-angled flatsedge	*Cyperus tetragonus*		SC-V
Seabeach amaranth	*Amaranthus pumilus*	T	T
Tough bumelia	*Sideroxylon tenax*	FSC	T

KEY TO TABLE 4.1:

Status	Definition
E	Endangered - A taxon in danger of extinction throughout all or a significant portion of its range.
T	Threatened - A taxon likely to become endangered within the foreseeable future throughout all or a significant portion of its range.
T(S/A)	Threatened due to similarity of appearance - A taxon that is threatened due to similarity of appearance with another listed species and is listed for its protection. Taxa listed as T(S/A) are not biologically endangered or threatened and are not subject to Section 7 consultation.
FSC	Federal Species of Concern - A species under consideration for listing, for which there is insufficient information to support listing at this time.
SC	Special Concern - Any species of wild animal native or once-native to North Carolina which is determined by the Wildlife Resources Commission to require monitoring but which may be taken under regulations adopted under the provisions of this Article.
SC-V	Special Concern- Vulnerable - Any species or higher taxon of plant which is likely to become a threatened species within the foreseeable future.
SR	Significantly Rare - Any species which has not been listed by the N.C. Wildlife Resources Commission as an Endangered, Threatened, or Special Concern species, but which exists in the state (or recently occurred in the state) in small numbers and has been determined by the N.C. Natural Heritage Program to need monitoring.
SR-L	Significantly Rare- Limited - The range of the species is limited to North Carolina and adjacent states (endemic or near endemic). These are species that may have 20-50 populations in North Carolina, but fewer than 100 populations rangewide.

The West Indian manatee (*Trichechus manatus*), also known as the Florida manatee, is an occasional summer resident off the North Carolina coast. The species can be found in shallow (5 feet to usually less than 20 feet), slow-moving rivers, estuaries, saltwater bays, canals, and coastal areas (USFWS 1991). Recent sightings include an individual being spotted in Carolina Beach in June of 2008. The West Indian manatee is herbivorous and eats aquatic plants such as hydrilla, eelgrass, and water lettuce (USFWS 2001). During winter months, the United States' manatee population confines itself to the coastal waters of the southern half of peninsular Florida and to springs and warm water outfalls as far north as southeast Georgia. They are sighted frequently in southeastern North Carolina with most records occurring in July, August, and September, as they migrate up and down the coast (Clark 1993). However, scattered records of this species in the region span all seasons. Based on these data, the manatee is considered a year-round resident with a maximum population in the summer months.

4.2.2 Birds

The Atlantic Coast piping plover population breeds on coastal beaches from Newfoundland to North Carolina (and occasionally in South Carolina) and winters along the Atlantic Coast from North Carolina south, along the Gulf Coast, and in the Caribbean (USFWS 1996b). Since being listed as threatened in 1986, the population has increased from approximately 800 pairs to 1676 pairs in 2003, although most of this increase may be attributable to an increase in surveying intensity. Of the 1676 pairs, 24 were observed in North Carolina (USFWS 2004). Piping plovers nest above the high tide line on coastal beaches, sand flats at the ends of sand spits and barrier islands, gently sloping foredunes, blowout areas behind primary dunes, sparsely vegetated dunes, and washover areas cut into or between dunes (USFWS 1996b). Feeding areas include intertidal portions of ocean beaches, washover areas, mud flats, sand flats, wrack lines, and shorelines of coastal ponds, lagoons, or salt marshes. Loss and degradation of habitat due to development and shoreline stabilization have been major contributors to the species' decline.

Staff of the NC Wildlife Resources Commission (WRC) perform annual surveys for piping plovers along the beaches of North Carolina during the breeding season and have not observed any nesting in the vicinity of the project area. However, non-breeding piping plovers have been observed using this area, most commonly the intertidal surf zone along South Beach (Cameron, Schweitzer, NC WRC, personal communication). Bird monitoring data available through WRC is provided in Appendix J. Staff of the Bald Head Island Conservancy surveyed the beaches of Bald Head Island on several occasions in July of 2012 and did not observe any piping plovers (Hancock, personal communication). Additional monitoring associated with the Wilmington Harbor Deepening Project was conducted by CZR, Inc. in 2001 and 2002. Three transects within Bald Head Island were surveyed. Year-round monitoring was conducted in two of the three transects. The other transect was monitored only during the non-breeding season. Piping plovers were noted on several occasions, especially along the southeastern tip of the island (CZR 2003). However, no breeding activity was observed. The US Fish and Wildlife Service (USFWS) has not designated any part of Bald Head Island as critical habitat for the piping plover.

4.2.3 Reptiles

A. Hawksbill Sea Turtle, Kemp's Ridley Sea Turtle, and Leatherback Sea Turtle

In North Carolina, the Kemp's ridley sea turtle is known to occur in estuarine and oceanic waters, whereas the hawksbill and leatherback are found primarily in oceanic waters (Schwartz 1977, Epperly et al. 1995). These species are found in North Carolina waters all year but can be present in inshore waters April through December (Epperly et al. 1995). Both the leatherback and the hawksbill sea turtles are only occasionally observed migrating through North Carolina waters. The Kemp's ridley sea turtle is commonly observed migrating within North Carolina inshore waters during the spring and fall. The principal food sources for these sea turtle species are crustaceans, mollusks, other invertebrates, fish, and plant material (Schwartz 1977).

The hawksbill sea turtle and Kemp's ridley sea turtle are not known to nest along the Brunswick County beaches. The hawksbill is found throughout the world's tropical waters. It is also found along the Atlantic coastline from Massachusetts southward to Brazil. This turtle has been known to nest in Florida, but is not common along the North Carolina coast (NMFS 1993). The Kemp's ridley sea turtle has been documented to nest only three times in North Carolina. The entire population generally nests on approximately fifteen miles of beach in Mexico between the months of April and June (USFWS 1991). The leatherback sea turtle primarily nests on beaches in the tropics, but is occasionally observed nesting in areas north of Florida (Rabon et al. 2003). In 2010, one leatherback sea turtle laid a nest on East Beach on Bald Head Island. Prior to that, the closest known leatherback nesting sites to the project area were in Georgetown County, SC and Carteret County, NC.

B. Loggerhead Sea Turtle

In North Carolina, the loggerhead and green sea turtles are known to occur in estuarine and oceanic waters (Schwartz 1977, Epperly et al. 1995). These species are found in North Carolina waters all year but can be present in inshore waters April through December (Epperly et al. 1995). Both species are known to frequently use coastal waters as travel corridors and have been observed migrating along the North Carolina coast (Epperly et al. 1995). Only the loggerhead is considered to be a regular nester in North Carolina, while the green nests occasionally in the state.

The loggerhead turtle utilizes Bald Head Island for its seasonal (May-November) nesting events. Nests are typically laid between the high tide line and the dune front (Routa 1968, Witherington 1986, Hailman and Elowson 1992). Loggerheads generally prefer high energy, relatively narrow, steeply sloped, coarse-grained beaches. In the southeastern United States mating occurs in late March to early June and females lay eggs between late April and early September. Females lay three to five nests, and sometimes more, during a single nesting season. The eggs incubate approximately two months before hatching sometime between late June and mid-November.

Off the Carolina coast, these turtles commonly occur at the edge of the continental shelf when they forage around coral reefs, artificial reefs, and boat wrecks. They feed on benthic invertebrates including mollusks, crustaceans, and sponges (Morrimen 1982). They have also been found to eat fish, clams, oysters, sponges, jellyfish, shrimp, and crabs when near shore. Research has shown that the turtle populations have greatly declined in the last 20 years due to a loss of nesting habitat along the beachfront and by incidental drowning in shrimp trawl nets. It appears that the combination of poorly placed nests coupled with unrestrained human use of the beach by auto and foot traffic has impacted this species greatly. Eroding steep beach escarpments, lights, sand fences, and other physical barriers (debris) often cause the mature females to select poor nesting sites at the dune toes which causes higher nestling mortality rates. Loggerhead turtles are known to regularly nest at

Bald Head Island. Staff of the Bald Head Island Conservancy (BHIC) patrol the beach front daily during the nesting season to document and monitor sea turtle nests. Between 1980 and 2011, an average of 97.4 nests per year was recorded on Bald Head Island, with the majority of the nests occurring along South Beach and East Beach (BHIC sea turtle data). Between 2007 and 2011, an average of 19 nests per year were noted within the project area.

The U.S. Fish and Wildlife Service recently proposed the designation of 739.3 miles of shoreline in the states of North Carolina, South Carolina, Georgia, Florida, Alabama, and Mississippi as critical habitat for the Northwest Atlantic Ocean Distinct Population Segment of the loggerhead sea turtle. This area accounts for approximately 84 percent of the documented nesting (numbers of nests) within these six states. This designation would include the project area. However, at the time of the publication of this DEIS, the proposal is currently in the rulemaking process and thus not in effect (Federal Register 2013).

C. Green Sea Turtle

With an estimated population of no more than 600,000 adults worldwide, the green sea turtle exists in both tropical and temperate seas and oceans (USFWS 1992). The North American distribution ranges from Massachusetts to Mexico, and from British Columbia to Baja California. Green sea turtles generally favor protected waters inside reefs, bays, estuaries, and inlets. Primary habitats appear to be lagoons and shoals supporting an abundance of marine grass and algae. These turtles are predominantly herbivorous, feeding upon marine algae and shallow beds of marine grasses. However, additional food sources may include mollusks, sponges, crustaceans, and jellyfish.

The major reasons for the decline in green sea turtle numbers include over-exploitation of eggs and meat for food, commercial fishing and dredging operations, and nesting habitat destruction associated with outer beach development (USFWS 1992). Green sea turtle nesting habitat consists of open beaches with a sloping platform and minimal human disturbance. Eastern United States nesting is primarily limited to Florida's east coast (300 to

1000 nests reported annually). However, occasional nesting has been documented as far north as North Carolina. In 2006, one green sea turtle nest successfully hatched from the south-facing beach of the project area (Dewire, personal communication.). In 2011, three nests successfully hatched from the south-facing beach of the project area. Since green sea turtles appear to have strong nesting site fidelity and often lay eggs on the same beach on which they hatched (USFWS 1992, Carr et al. 1978), surviving female green sea turtles will likely return to Bald Head Island for future nesting habitat.

4.2.4 Fish

A. Atlantic Sturgeon

The Atlantic sturgeon is an anadromous fish species whose range extends from Maine to Florida (NMFS 2011). The Atlantic sturgeon is a benthic feeder and typically forages on invertebrates such as crustaceans, worms, mollusks. Adults spawn in freshwater in the spring and early summer and then migrate into estuarine and marine waters where they spend most of their lives. They spawn in moderately flowing water (46-76 cm/s) in deep parts of large rivers. Juveniles usually reside in estuarine waters for months to years. Subadults and adults live in coastal waters and estuaries when not spawning, generally in shallow (10-50 m depth) nearshore areas dominated by gravel and sand substrates.

In 2012, four distinct population segments (DPS) of Atlantic sturgeon were listed as endangered under the Endangered Species Act: the Chesapeake Bay, New York Bight, Carolina, and South Atlantic populations. The Gulf of Maine population is listed as threatened. The project area is located within the Carolina DPS habitat range, which includes all Atlantic sturgeon that spawn in the watersheds from the Roanoke River, Virginia, southward along the southern Virginia, North Carolina, and South Carolina coastal areas to the Cooper River. The marine range of Atlantic sturgeon from the Carolina DPS extends from the Bay of Fundy, Canada to the Saint Johns River, Florida. While Atlantic sturgeon exhibit a high degree of spawning fidelity to their natal rivers, multiple riverine, estuarine, and marine habitats may serve various life (*e.g.,* nursery, foraging, and migration) functions. Historical landings data indicate that between 7,000 and 10,500 adult female Atlantic sturgeon were present in North Carolina prior to 1890 (Armstrong and Hightower 2002, Secor 2002). Prior reductions from the commercial fishery and ongoing threats such as dams have drastically reduced the numbers of Atlantic sturgeon within the Carolina DPS to less than 3 percent of what it was historically (ASSRT 2007). Because of the lack of suitable freshwater spawning areas in the project area, any Atlantic sturgeons present would most likely be non-spawning adults.

B. Shortnose Sturgeon

The shortnose sturgeon ranges along the Atlantic seaboard from southern Canada to northeastern Florida (NMFS 1998). It feeds on invertebrates and stems and leaves of macrophytes. From historical accounts, it appears that this species was once fairly abundant throughout North Carolina waters; however, many of these early records are unreliable due to confusion between this species and the Atlantic sturgeon. Because of the lack of suitable freshwater spawning areas in the project area and the requirement of low salinity waters by juveniles, any shortnose sturgeons present would most likely be non-spawning adults.

4.2.5 Plants

Seabeach amaranth is an annual herb that occurs on beaches, lower foredunes, and overwash flats (Fussell 1996). Weakley (1986) found that in North Carolina the plant is most common on overwash flats on accreting ends of barrier islands. This species occupies elevations ranging from 0.2 to 1.5 m above mean high tide (Weakley and Bucher 1992). Historically, seabeach amaranth was found from Massachusetts to South Carolina. But according to recent surveys (USACE 1992-1995), its distribution is now restricted to North and South Carolina with several populations on Long Island, New York. The decline of this species is caused mainly by development of its habitat, such as inlet areas and barrier islands, and increased ORV and human traffic which tramples individuals (Fussell 1996).

Seed dispersal of seabeach amaranth is achieved in a number of ways, including water and wind dispersal (USFWS 1996). Flowering begins as soon as plants have reached sufficient size, sometimes as early as June, but more typically commencing in July and continuing until the death of the plant in late fall. Seed production begins in July or August and peaks in September during most years, but continues until the death of the plant.

Since 1992, the US Army Corps of Engineers has performed annual surveys of amaranth from three reaches on Bald Head Island. Less than five amaranth plants have been observed annually on Bald Head Island since 2006.

4.3 PERMIT AREA HABITATS

4.3.1 Estuarine

A. Salt Marsh

Salt and brackish marshes occur in the intertidal zone, along the margin of coastal and estuarine waters. The acreage of salt marsh habitat in North Carolina is estimated to be 212,800 acres. Roughly 9,000 acres of this total have been mapped in the Cape Fear River basin (SAFMC 1998). Salt marshes are utilized for food and cover for juvenile and adult finfish and shellfish and have a significant role in coastal ecosystem processing by stabilizing unconsolidated sediment, filtering runoff from the upland watershed and controlling water volumes, especially during meteorological events. Tidal marsh habitat in the Bald Head Island vicinity is primarily located along the interior tidal creeks of Bald Head Island and the neighboring Smith Island Complex. Most of the tidal marsh habitat associated with the interior creeks is beyond the limits of the biological resource study areas (refer to Figure 4.7). Smaller areas of tidal marsh near the mouth of the Bald Head Creek are within the identified area of study and potential consequences to such are evaluated in the following environmental analyses.

Plant distribution within salt marsh habitat is linked to physical environmental factors, including, but not limited to, tidal inundation duration, frequency and amplitude as well as salinity. The salt marshes of North Carolina, including Bald Head Island, typically display a monoculture of smooth cord grass (*Spartina alterniflora*) in the low marsh zone where tidal amplitude is high and tidal inundation is frequent. As elevation increases, a more diverse floral community emerges mainly due to a decrease in both tidal amplitude and inundation period. Common vegetation in this transitional, high marsh area includes salt meadow hay (*Spartina patens*), salt reed grass (*Spartina cynosuroides*), black needlerush (*Juncus romerianus*), sea oxeye (*Borrichia frutescens*), salt grass (*Distichlis spicata*), glasswort (*Salicornia* spp.), sea lavender (*Limonium* spp.), *Scirpus* spp., and saw grass (*Cladium jamaicense*) (Weigert and Freeman 1990, SAFMC 1998).

Estuarine intertidal marshes provide habitat for fish and shellfish, including two South Atlantic Fishery Management Council species of concern (red drum and shrimp). Chemical and biological processing within salt marshes additionally supports the coastal migratory pelagics fishery and the snapper – grouper fishery (SAFMC 1998). Salt marshes also provide important roosting and foraging habitat for migrating and wintering waterbirds and shorebirds. Wading birds, such as herons and egrets, feed on fishes, shrimps and fiddler crabs. The diamond back terrapin, a state-listed species of concern, also utilizes the marsh foraging and refuge habitat.

B. Unvegetated Subtidal and Intertidal Bottom

Estuarine unconsolidated bottom, or soft bottom, is characterized by a number of physiochemical factors including sediment grain size and distribution, water depth, hydrography as well as water quality (dissolved oxygen and salinity). Collectively, these factors will affect the condition of the bottom habitat as well as the organisms that utilize it. Bottom habitat in North Carolina estuaries is generally categorized as subtidal bottom in rivers, creeks and sounds, intertidal flats and shell bottom. The approximate extent of soft bottom habitat in the study area is depicted in Figures 4.8 - 4.9.

Surficial sediments of subtidal bottom substrate (consisting of unvegetated and unconsolidated sands) act as a storage bank for nutrients, sediment and chemicals, cycling between the sediments and the water column (Deaton et al. 2010). Benthic microalgae on subtidal bottom are composed primarily of benthic diatoms and blue green algae, with benthic dinoflagellates and filamentous green algae also present (Peterson and Peterson 1979). Together, the benthic microalgal and invertebrate populations within subtidal bottom may serve as an important food source for many juvenile fish. Juvenile and adult fish species that forage on the abundance of microalgae, detritus, and small invertebrates in turn attract larger, economically valuable, predatory fish such as Florida pompano (*Trachinotus carolinus*), red drum (*Sciaenops ocellatus*), southern flounder (*Paralichthys lethostigma*), summer flounder (*Paralichthys dentalus*), spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*), and striped bass (*Morone saxatilis*).

Intertidal flats include the area of unvegetated bottom which lies between the high and low tide mark within estuarine and marine systems. Similar to subtidal soft bottom habitat, intertidal flats are considered unvegetated since macroscopic plants such as grasses and shrubs are not present; however, the benthic microalgal community within intertidal flats can be very abundant. The sediment texture of this habitat generally reflects the physical environment of the system. Coarser sediments (sands, shell fragments) are dominant in high energy systems while fine sediments (silts, clays) are more indicative of lower energy environments. Tidal current velocities are highest within the inlet complex, diminishing with increased distance from the inlet. As a result, inlet sediments can be highly mobile leading to the creation of new sand flats as well as erosion of existing flats.

The dynamic nature of the inlet system and the relative instability of sediment can create an inhospitable environment for the benthic community. Intertidal flats and shoals located upstream of the inlet complex and within semi-protected areas of the estuary are more stable and support a larger, more diverse benthic community. In conjuction with the Bald Head Island Beach Restoration Project (SAW-2007-2699), the Village of Bald Head Island intitiated a biological monitoring program to characterize the benthic macrofuanal communities inhabiting nearshore soft bottom communitites including Jay Bird Shoals and Bald Head Shoals. Benthic samples yielded three dominant taxa including approximately 37 crustacean, 22 polychaete and 12 mollusk taxa. In general, the mean taxa were low at all sites studied, however species inhabiting area shoals are highly resilient and many actually thrive in environments that are prone to disturbance (LMG 2011, 2012).

Intertidal shoals provide important foraging and roosting habitat for a variety of shorebirds and waterbirds. Federally-protected species such as the piping plover and state-listed species such as the Wilson's plover, least tern, common tern, and American oystercatcher are all known to utilize intertidal flats for foraging and roosting grounds.

In North Carolina, shell bottom is defined as estuarine intertidal or subtidal bottom composed of surface shell concentrations of living or dead oysters, hard clams and other shellfish (Deaton et al. 2010). Shell bottom, commonly referenced as oyster beds, oyster rocks, oyster reefs, oyster bars or shell hash, can be intertidal or subtidal, natural or man-made. Oysters are the principal builders of natural shell bottom in North Carolina's estuaries and generally co-exist with adjacent habitats including, salt marsh and mudflat habitat. Shell hash refers to an accumulation of unconsolidated broken shell fragments (oyster, hard clam, bay scallop and/or other shellfish) on soft bottom substrate.

Shell bottom is recognized as an important link in the transfer of productivity between surface waters and bottom habitat and oyster reefs have long been recognized for their importance in overall water quality through water filtration and sediment stabilization. In addition, shell bottom provides critical fisheries habitat not only for oysters, but also for recreationally and commercially important finfish, other mollusks, and crustaceans.

While salinities in the Cape Fear River estuary are suitable for larval settlement and recruitment, living shellfish resources (eastern oysters, hard clams and bay scallops) have not been identified in the immediate project area. A 2010 shellfish survey in the mouth of Bald Head Creek and adjacent intertidal shoals found individual relic oyster shells and clam shells and several small clumps of relic oyster shells which were isolated to an area around a remnant dock structure at the mouth of the creek.

4.3.2 Coastal Beach and Dune Habitats

There are three primary beach segments along Bald Head Island, the beachfront community from the point at Cape Fear facing east toward the Atlantic Ocean (East Beach), the south facing beach (South Beach) and the portion of the island bordering the Cape Fear River (West Beach). As indicated earlier in Section 4.1, there have been significant, long-term morphological changes to the shorelines and beach environs of Bald Head. Some of these changes have been characterized by prior studies (USACE 1989, Cleary 2008, USACE 2004). While beaches and dunes have not been surveyed in detail until recent times (i.e. 1999 to the present), qualitative changes may be assessed via nautical charts and historic aerial photography. Please refer to Figures 4.1-4.3 for a graphical depiction of approximate shoreline positions over the last 150 years (USACE 2004) and to Appendix I for geo-rectified, historical aerial imagery.

A. Wet Beach

Coastal beachfront environments are typically characterized by high wave energy and relatively low primary productivity (Steele 1968). The foreshore and nearshore zones of Bald Head Island consist of exposed bars and spits with sandy subtidal and intertidal substrates. As documented for similar barrier island complexes, percent organic matter of beachfront sediments is low relative to the sediments of protected, back-barrier sandflats. In addition, relative species diversity and abundance tends to be less than backwater habitats (Hackney et al. 1996). Overall, the wet beach habitat of Bald Head Island (particularly South Beach and West Beach) is a highly dynamic zone exposed to extreme physical forces that result in high rates of erosion and shoreline recession. In addition, these particular shorelines are affected by episodic sand disposal and nourishment events.

Benthic species along the ocean beachfront are adapted to coarser-grained substrates and high-energy environments. Collectively, the benthic assemblage represents an important food source for many shore birds and important recreational fish species such as flounders, pompanos, mullets and kingfish. While meiofaunal assemblages are rather diverse, the larger macrofaunal community in the swash zone is generally characterized by low density and abundance due to dynamic and active wave conditions (Posey et al. 1996).

In conjunction with the Bald Head Island Beach Restoration Project (SAW-2007-2699), the Village intitiated a biological monitoring program to determine the abundance of coquina clams and mole crabs along various beach segments including the intertidal surf zone of South Beach and West Beach. Results from the study indicate inter-year variability among all three invertebrate taxa likely attributed to seasonal fluctuations in species abundance with low abundances during the winter season (LMG 2010, 2011, 2012).

Many species of birds forage within this habitat type. Shorebirds and waterbirds such as sandpipers, willets, sanderlings, dunlins, terns, and gulls utilize the surf zone to prey on fauna that either wash out of the sand due to wave action, or come close enough to the shore to be captured. Furthermore, 25 red knot (*Calidris canutus rufa*) individuals were observed along the beaches of Bald Head during an annual survey conducted in May of 2012 (Schweitzer, personal communication). Rare species such as Wilson's plovers, American oystercatchers, least terns, common terns, and piping plovers have been observed foraging within the surf zone of Bald Head.

Subsequent to an acceleration of erosion along the western extremity of South Beach, the Village sponsored a 360,000 cy beach fill along 10,000 ft of shorefront in 1992. The material was eroded in its entirety in 18 months. As a direct result, the Village's engineer determined that any subsequent fill at that location would necessitate a groinfield suitable for improving the longevity of the nourishment material. The ensuing project constructed in 1996 provided for the installation of sixteen "soft groins" employing sand filled geotextile tubes. Although a "hard" structure ban was in existence at that time within N.C., the State provided a variance the Village allowing the installation of 16 sand filled geotextile tubes. Construction of the groins was performed concurrent with a 650,000 cy beach fill. No additional large-scale fill projects occurred on Bald Head Island until 1.89 Mcy of sand was disposed in 2001 along South Beach as a direct result of the construction of the Wilmington Harbor Deepening Project, with entrance channel realignment seaward of Bald Head Island.

All sixteen groins were replaced in 2005, immediately subsequent to the federal fill placement. The entire sixteen tube groinfield was again replaced in 2010 as part of a Village-sponsored fill project. In the spring of 2013, the westernmost five (5) sand tube groins (damaged by Hurricane Irene in 2012) were replaced concurrent with a 1.8 Mcy federal beach disposal project. Both the Village and the Wilmington District have concurred that the groinfield to date has served to reduce the effective loss rate of sand placed on South Beach.

B. Dry Beach

Upper-beach habitats are situated just above the mean high tide limit, but are flooded by high spring tides and storm surges. Substrates consist of unconsolidated sand and shell sediments that are constantly shifted by winds and floods thereby supporting less vegetation than the adjacent dune community. Vegetation is generally limited to the upper dry beach and, on Bald Head Island, commonly includes beach spurge (*Euphorbia polygonifolia*), sea rocket (*Cakile edentula*) and pennywort (*Hydrocotyle bonariensis*).

The dry beach of South Beach and West Beach is subject to continual morphological changes due to erosion. While sediment losses along western South Beach and West Beach occur irrespective of nourishment or federal disposal, the lack of nourishment actions for any extended period of time results in shoreline recession and deflation to an extent that dry beach can be effectively lost or severely degraded in some areas. Physical surveys of these segments of shoreline have documented the eroded condition exemplified by nearly vertical profiles from upland dune to the mean high water line (MHW). In addition, beach profiles often demonstrate the presence of a scarp of varying slope and height more pronounced along the chronically eroded segment of western South Beach than along beachfront areas to the east. The presence of the sixteen-tube groinfield has a net benefit in the retention of sand and stabilization of South Beach. However, it should be noted that when sand tubes become exposed or flanked, erosion and its associated effects (including escarpments and loss of dry beach) become more pronounced.

The sandy beaches are generally characterized by low productivity, both primary and secondary, likely attributed to the environmental instability of the exposed beach (Dexter 1992). As such, protected beaches buffered from physical extremes display greater species diversity than beaches associated with dynamic shorelines. Macroinvertebrates identified in the study area include relatively low densities of ghost crabs, mole crabs, and coquina clams (LMG 2010, 2011, 2012).

In addition to offering recreational benefits to residents of Bald Head Island and the general public, the dry beach is utilized by nesting and foraging shorebirds and waterbirds and provides a nesting ground for sea turtles. American oystercatchers, least terns, willets, and Wilson's plovers have been documented nesting at Bald Head. These species tend to nest just above the high tide line on bare sand and shell with little or no vegetation. Their nests are shallow unprotected depressions that can be as small as a teacup.

As stated above, the loggerhead and green sea turtles utilize Bald Head Island for their seasonal (May-November) nesting events. Nests are typically laid between the high tide line and the dune front (Routa 1968, Witherington 1986, Hailman and Elowson 1992). Loggerheads generally prefer high energy, relatively narrow, steeply sloped, coarse-grained beaches. Green sea turtle nesting habitat consists of open beaches with a sloping platform and minimal human disturbance.

Some mammals are also known to utilize beaches as feeding grounds. Among these are raccoons, feral cats and foxes, which are known to patrol the wrack line at the high water mark and scavenge eggs from sea turtle nests (Dewire, personal communication).

C. Dune

Dune habitat typically presents a rigorous environment of physical extremes with varying hydrologic regime, precipitation, wind, and salt spray influencing vegetation species growth and composition (Wagner 1964). Further, dune structure is significantly influenced by the physical effects of storms and extreme high tides. Therefore, morphology and ecological function can vary along any particular segment of shoreline. Coastal dunes and dune systems are closely tied to geologic processing and are products of sand source, transport and deposition. Upper beach areas that are relatively stable may begin to trap wind-borne sands (Rogers and Nash 2003). In these accretional zones between upper beach and dune, smaller features or “dunelets” that tend to be sparsely covered with vegetation capture wind-driven sand. Over time, these features increase in size and elevation and larger dunelets may attach to the foredunes. The lee slopes of foredunes tend to be more stable due to decreased exposure to wind and salt spray (Wagner 1964). Interdune flats and swales occupy more expansive areas behind the foredunes. Godfrey (1977) describes the barrier island dune complex of southeastern North Carolina as relatively low, irregular and discontinuous with overwash areas between dune structures.

Various definitions have been used to characterize dunes pending context and use. In the regulatory context, the North Carolina Division of Coastal Management (DCM) defines two principal types of dunes: (1) frontal dune; and (2) primary dune. Frontal dune is defined as the first mounds of sand that have enough vegetation, height, and continuity to offer protection. Primary dune is defined as the first mound of sand that is six feet taller than mean flood level (15A NCAC 07H .0305). Rogers and Nash (2003) present a singular and broader definition. According to these authors, dunes are defined as any area landward of the active beach where dune grasses are the dominant plants. Regardless of the specific definition ascribed, it is well recognized that dunes are dynamic features of the shoreline that provide important storm protection functions.

Dune communities occur in a highly dynamic and stressful environment. Long-term trends on shoreline accretion and recession on Bald Head Island have been summarized by others (USACE 1989; USACE 2004; Cleary 2008). Periods of progradation (e.g. 1888 to 1962) create conditions suitable for natural dune-building processes including vegetation establishment and the subsequent interception of wind-borne sands (as described above). Similarly, dunes may be susceptible to destabilization and collapse during periods of increased erosion. Refer to historic aerial photography provided in Appendix I depicting shoreline conditions on Bald Head Island from 1938 to 2010.

In addition to erosion, dune vegetation is susceptible to other physical forces (e.g. wind) that influence vegetation establishment and growth. Blowing sand may bury the vegetation and wind erosion may expose plant roots. Coastal dune vegetation experiences near constant exposure to salt spray and must be able to withstand soils with excessive drainage, low nutrients, extreme temperature fluctuations and oceanic overwash. Vegetative coverage within the dune community ranges from sparse on foredunes and dynamic areas to fairly dense on more stable dunes (Schafale and Weakley 1990). Common dune vegetation identified on Bald Head Island includes American beach grass (*Ammophila breviligulata*), panic grass (*Panicum amarum*), sea oats (*Uniola paniculata*), broom straw (*Andropogon virginicus*) and salt meadow hay (*Spartina patens*).

The dune-ridge system acts as a barrier to storm tides and waves thereby protecting low-lying backshore habitat as well as infrastructure. Dunes also provide habitat for a number of animals. Shorebirds, colonial waterbirds and other waterbirds utilize the dune community for breeding, foraging, nesting, roosting and overwintering during seasonal migrations. Among the nesting species are the willet, American oystercatcher, and Wilson's plover, which prefer nest sites in dune areas with sparse grass or herbaceous cover. Several gull species also nest in dunes, but prefer areas with somewhat more dense coverage.

Several mammals including mice, rabbits, foxes, raccoons, and feral cats also use dunes for feeding. Reptiles are also common inhabitants of dunes. Several species of anoles are quite common. Many different types of snakes also live and feed in dune systems. Eastern hognose snakes, yellow rat snakes, and eastern coachwhip snakes all utilize grassy dunes or more woody areas of backdunes as habitat.

D. Interdunal Wetlands

Wetlands in the project study area are confined primarily to herbaceous and shrub-dominated interdune depressions and swales of the maritime dune system. Figure 4.7 depicts the approximate location and extent of interdune wetlands mapped in the study area. The wetland depressions exhibit varying hydroperiods (seasonal saturation to intermittent inundation) depending upon elevation. Hydrologic inputs are from precipitation and episodic storm overwash. Soils are generally characterized by the presence of a thin muck (i.e. high organic) surface underlain by gleyed sand. The vegetative community is influenced by the specific hydrologic regime of each depression and its exposure to salt spray. Dominant herbaceous species include salt-meadow cordgrass (*Spartina patens*), sawgrass (*Cladium mariscus*), black-needle rush (*Juncus roemerianus*), bushy bluestem (*Andropogon glomeratus*), marsh fimbry (*Fimbristylis castanea*), and slender goldentop (*Euthamia caroliniana*). In areas of disturbed soils, common reed (*Phragmites australis*) is also prevalent. Characteristic shrub species include wax myrtle (*Morella cerifera*), red cedar (*Juniperus virginiana*), seacoast marsh elder (*Iva imbricata*) and groundsel tree (*Baccharis halimifolia*).

Intertidal and supratidal coastal wetlands exist northwest of the project area. These wetlands are associated with the tidal waters of Bald Head Creek and are dominated by S. alterniflora (in the lower marsh) and *S. patens*, coastal salt grass (*Distichlis spicata*), and marsh elder (*Iva frutescens*) in the high marsh.

E. Maritime Shrub/ Maritime Forest

Maritime shrub and maritime forest communities occur within sheltered areas of barrier island systems but are still somewhat subject to the extremes of the maritime environment. The more exposed areas of forest tend to grade to maritime shrub or dune grass community. Salt spray has long been recognized as an important on-going stress, sculpting the canopy and excluding most species (Schafale and Weakley 1990). Heavy winds and salt water intrusion resulting from episodic meteorological events such as hurricanes can damage significant portions of the forest, but typically do not destroy the entire forest canopy. Maritime forests play an important role in the barrier island ecosystem by providing habitat for wildlife, stabilizing soil thereby reducing island erosion, and store precipitation in the surface water table (Bellis 1995).

Vegetation of the maritime forest of Bald Head Island generally consists of live oak (*Quercus virginiana*), laurel oak (*Quercus laurifolia*), willow oak (*Quercus phellos*), and loblolly pine (*Pinus taeda*) in the canopy. These species, in addition to red cedar (*Juniperus virginiana*), yaupon (*Ilex vomitoria*), flowering dogwood (*Cornus florida*), and Carolina laurelcherry (*Prunus caroliniana*) tend to also occupy the sub-strata. Dwarf palmetto (*Sabal minor*) and various vines (including *Vitis rotundifolia*, *Toxicodendron radicans*, and *Smilax* spp.) tend also to be prevalent within these communities. Areas lacking a mature canopy tend to be dominated by shrubs (e.g. wax myrtle, yaupon), dwarf palmetto, vines, and stunted live oak. The southern and eastern exposure on Bald Head Island and associated high frequency disturbance has been cited to result in the higher occurrence of shrubs and less dense canopy in many of these areas (Lopazanski et al. 1988). Rare plant species that grow within this habitat include four-angled flatsedge and tough bumelia. Dune bluecurls are also known to occur in dunes and sandy openings in maritime scrub habitat.

Common fauna of maritime forests include wading birds such as herons, egrets, brown pelicans, as well as a variety of ducks and songbirds. Birds of prey such as red-tailed hawks and ospreys also utilize hammocks for feeding, roosting and nesting. Other bird species include the Carolina wren, blackburnian warbler, golden-winged warbler, and the Eastern painted bunting. Small mammals such as mice, rats, raccoons and the red fox are prevalent throughout the forest and shrub thickets. A variety of species of herpetofauna including the glass lizard, black racer, and five-lined skink can also be found within this habitat type.

Maritime forest is considered one of the most endangered community types in North Carolina. The principle source for loss or impairment is barrier island development and subsequent habitat fragmentation (Schafale and Weakly 1990).

4.3.3 Marine Habitats

A. Soft Bottom Communities

The *2010 NC Coastal Habitat Protection Plan* defines soft bottom as areas of primarily unvegetated, unconsolidated sediment (particles smaller than rocks) beneath the water column including both deeper subtidal bottom as well as shallow bottom areas (Deaton et al. 2010). Soft bottom habitat is an important component of primary nursery areas, anadromous fish spawning areas and anadromous nursery areas. Habitat varies according to geomorphology, sediment type, water depth, hydrography and/or salinity regime. Note that intertidal bottom and its associated functions are described in Section 4.3.1 (Estuarine Resources).

Benthic microalgae play a fundamental role in the ecological function of estuarine soft bottom habitat and are recognized as an important source of primary production in estuarine systems by supporting large numbers of benthic invertebrates. Benthic infaunal and epifaunal taxa provide an important link between primary production and consumers in estuarine ecosystems and are considered the primary food base to North Carolina's bottom feeding fish species. Juvenile and adult fish species that forage on the abundance of microalgae, detritus and small invertebrates in turn attract larger, economically valuable, predatory fish such as Florida pompano (*Trachinotus carolinus*), red drum (*Sciaenops ocellatus*), southern flounder (*Paralichthys lethostigma*), summer flounder (*Paralichthys dentalus*), spot (*Leiostomus xanthurus*), Atlantic croaker (*Micropogonias undulatus*) and striped bass (*Morone saxatilis*).

Marine soft bottom habitat in the vicinity of the project area occurs in areas seaward of MLW of the shoreline of Bald Head Island and includes bottom areas of the offshore prospective borrow sites (including Jay Bird Shoals, Frying Pan Shoals and the Baldhead Shoal Channel of the Wilmington Harbor Navigation Project).

B. Hardbottom Communities

Hard bottom habitat in the South Atlantic Bight generally consists of exposed rock or consolidated sediments in near-shore or off-shore marine waters. Exposed hard bottom provides the substrate surface area for colonization by invertebrates and algae. In turn, these areas serve as an important food source to a variety of invertebrate and fish species. Community structure varies widely with depth, location and season.

These habitats are characterized by a rich diversity of invertebrates (e.g. sponges, corals, anemones, tunicates, and mollusks) and reef fish such as gag grouper (*Micteroperca microplepis*), red grouper (*Epinephelus morio*), red snapper (*Lutjanus campechanus),* vermillion snapper (*Rhomboplites aurorubens*), black sea bass (*Centropristis striata*), greater amberjack (*Seriola dumerili*) and white grunt (*Haemulon plumieri*) and are thus commonly referred to as "live bottoms" or "live rock".

Ocean-bottom surveys conducted by the USACE in the vicinity of the new channel alignment for the Wilmington Harbor Navigation Project did not indicate the presence of hard bottoms within or near its path (USACE 2000). Hard bottoms have, however, been identified near the seaward limit of the former federal navigation channel (approximately five miles offshore). The presence of this hard bottom during the design of the last Harbor deepening project ultimately prompted the re-orientation of the channel alignment to avoid dredging impacts to this type of biological community. Natural hardbottom outcrops have been identified in federal waters of Onslow Bay and Long Bay (Deaton et al. 2010). Refer to Figure 4.10 depicting the locations of mapped hard bottom in the vicinity of Bald Head Island.

4.4 WATER COLUMN

Water column habitat is defined as "the water covering a submerged surface and its physical, chemical, and biological characteristics" (Deaton et al. 2010). This habitat is considered the primary component which binds the entire coastal aquatic ecosystem connecting a complex web of influences from both land and sea [15A NCAC 07H .0206(b)]. The water column provides a basic ecological role in the assimilation of energy and nutrients at the base of the food chain through primary productivity, largely by phytoplankton, and benthic-pelagic coupling. Open water provides nursery habitat for planktivorous larvae and a number of juvenile pelagic species and provides a corridor for numerous anadromous and catadromous species (Deaton et al. 2010). Primary Nursery Areas (PNA) as designated by the Marine Fisheries Commission are depicted in Figures 4.11 and 4.12.

Estuarine waters have moving boundaries and are maintained by tide and wind driven mixing coupled with freshwater supplied from the upland watershed. The estuarine water column is the medium of transport for nutrients and migrating organisms between river systems and the open ocean. While nearby wetlands contain some assimilative capacity abating nutrient enrichment, fresh water inflow and tidal flushing are primarily important for circulation and removal of nutrients and wastes from the estuary. Coarse-grained sediment, saline water and migratory organisms, including larvae, are introduced from the ocean while finer-grained sediments, fresh water, nutrients and organic matter are supplied by rivers and tidal creeks. The Cape Fear River is the only major river in North Carolina that flows directly into the Atlantic Ocean making its estuary unique compared to others in the state. The estuarine surface area totals 100km^2 (Ensign et al. 2004), and the river mouth is approximately one mile in width. The average flow rate of the Cape Fear River at its mouth is 9,700 cubic feet per second (USACE 2000) and the flushing rate is approximately 14 days which makes it the most rapid turnover of all major estuaries in North Carolina.

The marine water column includes waters overlying the continental shelf and associated high-energy coastlines where salinities exceed 30 ppt. (Deaton et al. 2010, Cowardin et al. 1979). Lunar tidal cycles are the major mixing mechanism in the marine water column with tidal amplitudes averaging 4.3 ft. near Cape Fear. Winds are also an important component to water movement and mixing in the marine water column. Winds move large water masses inshore, in turn, aiding larval transport of ichthyofauna spawned in the offshore waters of the continental shelf in their migration to the beachfronts, inlets and estuaries vital for the next phase of development.

4.5 WATER QUALITY

The Cape Fear watershed is the most heavily industrialized basin in North Carolina, with numerous industries utilizing the Cape Fear in the upper watershed and eleven major industrial dischargers in the tidal basin itself. The watershed (about 9,149 square miles) has 244 permitted wastewater discharges with a permitted flow of approximately 425 million gallons per day, and (as of 2000) over 1.83 million people residing in the basin (NCDENR 2005). Approximately 24% of the land use in the watershed is devoted to agriculture and livestock production (NCDENR 2005), with livestock production dominated by swine and poultry operations. Thus, the watershed receives considerable point and non-point source loading of pollutants. A map of the Lower Cape Fear River Basin (Cataloging Unit 03030005) is included for reference (Figure 4.13). In addition, the 14-digit watershed map of Bald Head Island is depicted in Figure 4.14).

The Cape Fear River estuary is unique in comparison to other North Carolina estuaries due to the magnitude of tidal exchange and relatively high light attenuation which inhibits algal bloom formation (Mallin et al. 1999). Physiochemical parameters are affected by freshwater river flow, tides and wind forces. The salinity of waters in the proposed project area are generally near 35 ppt, but may be lower during ebb tide conditions and associated freshwater outflow. Water quality parameters including temperature, salinity, dissolved oxygen, total suspended solids, nutrients (primarily nitrogen and phosphorus) and chlorophyll *a* have the potential to affect fisheries resources as fish and invertebrates occur where water characteristics suit their physical requirements.

According to the NC Division of Water Quality's (DWQ) classification of waterbodies, the lower section of the river, from Federal Point to the Atlantic Ocean, is designated as Class "SA". The waters of the Atlantic Ocean in the vicinity of the mouth of the Cape Fear River are designated "SB". "SB" waters are suitable for primary recreational uses as well as all uses identified for "SC" waters (e.g. fishing, fish and wildlife propagation, and secondary recreation). "SA" waters are suitable for marketable shellfishing and all uses identified under the "SC" and "SB" classes (15 NC AC 2B .0311).

4.6 AIR QUALITY

The Wilmington Regional Office of the NCDENR has jurisdiction over the air quality in this location. It has been determined that the ambient air quality for the area including Bald Head Island is in compliance with the National Ambient Air Quality Standards.

4.7 PUBLIC SAFETY

The Emergency Management staff monitor for both natural and manmade disasters and events. The Village of Bald Head Island utilizes an all-call phone dialing system to notify residents, visitors and island workers of emergency situations such as pending hurricanes, evacuation notices, problems with utilities, etc. South Bald Head Wynd has been identified as a primary evacuation route for residents and guests of Bald Head Island. The Emergency Management staff also has contingency plans in place in the event evacuation is not a viable option.

The United States Coast Guard (USCG) Boating Statistics of 2011 ranked North Carolina as 11 out of 56 for the total registered vessels within United States governed territories (USCG 2011). There was an average of 396,706 recreational boats (motor boats and sailboats greater than 14 ft in length) registered in North Carolina in 2011 and 2010. In 2011 there were 9,366 registered vessels in Brunswick County (NCWRC 2011). There has been an average of 150 boating incidences each year in the state over the past five years. In 2011 there were 7 reported boating accidents (0 fatal) in Brunswick County.

4.8 AESTHETIC RESOURCES

The coastline of Bald Head Island possesses visually pleasing attributes including the natural resources of the Atlantic Ocean and the Cape Fear River estuary. There is a natural aesthetic to Bald Head Island which provides uninterrupted natural vistas of maritime forest, salt marsh and barrier island ocean habitat. The Island also has a rich maritime history which is visually apparent and offers scenic opportunities to residents and guests alike.

4.9 RECREATIONAL RESOURCES

Bald Head Island is open to the general public for a variety of recreational uses. Regular public ferry service to Bald Head Island is operated by Bald Head Island Transportation, Inc. For most of the year, ferries leave the mainland on the hour and from the Island on the half-hour, beginning at 7 a.m. Typically, the winter schedule is abbreviated due to the reduced number of visitors to the Island. Round-trip ferry tickets are available for purchase by the public at the Bald Head Island Mainland Ferry Terminal. In the summer, round-trip tickets cost $24.75 for adults, $13.75 for children ages 3-12. There is no charge for children ages two and younger. Tram service may be provided based on ticket type and availability.

Bicycles and golf carts are available for rent in close vicinity to the ferry landing. The Village maintains 24 public beach accesses, including approximately nine in the project study area. Most beach access points also provide parking for golf carts. While there is a relatively small population of permanent, year-round residents (approximately 220), there are on average 5,000 visitors to the Island during a typical summer weekend day. Water-related activities along Bald Head Island include, boating, diving, sailing, windsurfing, surfing, kite surfing, stand-up paddle boarding and canoeing. The Bald Head Island Conservancy offers organized hikes, nature walks and kayak tours to permanent residents, guests and the general public.

An eighteen-hole golf course is also available at the Bald Head Island Club. The golf course is open to member guests and is available with rental properties that have memberships.

This area of coastal North Carolina offers an array of recreational fishing opportunities from the sandy beach, large sport-fishing boats and smaller jon boats and skiffs. According to the North Carolina Division of Marine Fisheries recreational fishing statistics, 15,891 Coastal Recreational Fishing Licenses (CRFL) were issued in New Hanover County, NC in 2011. An additional 10,296 CRFLs were issued in Brunswick County, NC in the same year, a testament to the popularity of recreational fishing in coastal counties. The National Oceanic and Atmospheric Administration (NOAA) – National Marine Fisheries Service (NMFS) recreational fishery database indicates that drums (Family Sciaenidae), porgies (Family Sparidae) and bluefish (Family Pomatomidae) were the most commonly caught fish recreationally along the coast of North Carolina over the past three years (NOAA - NMFS 2012).

4.10 NAVIGATION

The Cape Fear River ocean bar channel has been maintained by the federal government for over 100 years. Over this time period, the width and depth of the navigational channel has been increased numerous times to accommodate larger vessels. By 1945, the federal channel had been deepened to 32 feet. In 1964, the USACE initiated deepening of the main harbor channel to 38 feet to accommodate 34-foot-draft (26,000 deadweight ton) vessels to call at any tide. This project was completed in 1970. Since the 1970s, vessel sizes have continued to increase. By the 1990s, approximately 50% of the ocean-going ships exceeded the 26,000 deadweight ton (DWT) design vessel. As such, these vessels could enter or leave Wilmington Harbor only at high tide or only when light-loaded (USACE 1996). The resultant increased shipping costs prompted the more recent Wilmington Harbor Deepening Project in 2001. The channel modifications included realignment of the ocean bar channel (30-degree southern shift); deepening of the ocean bar channel and entrance channel to 44 feet; and deepening of the 24.3-mile river reach (from Battery Island Channel to the Cape Fear Memorial Bridge) to 42 feet (USACE 2008).

The Cape Fear River is utilized on a daily basis for both recreational and commercial navigation. In 2010, 442 cargo ships and 6 barges came through the mouth of the river to access the Port of Wilmington (NC State Ports Authority 2012).

4.11 HISTORIC PROPERTIES AND CULTURAL RESOURCES

The Cape Fear River is recognized as one the most significant and historically important waterways of the Carolinas. The attached cultural resources report (Appendix H) provides a brief history of the Cape Fear River from the earliest Spanish explorers in 1526 through the present. The Lower Cape Fear in particular has served as a commercially important navigational artery for over three hundred years serving both the ports of Brunswick and Wilmington. Numerous shipwrecks are known and identified within this section of the river.

Tidewater Atlantic Research, Inc. (TAR) conducted a magnetometer and sidescan sonar survey of the proposed construction area in May and August 2012. Analysis of the remote-sensing data generated during the Bald Head Island terrestrial and marine surveys identified a total of 104 magnetic anomalies. The cluster of four anomalies was associated with a shipwreck adjacent to the shoreline along South Beach. All other magnetic targets appear to have been generated by modern debris such as fish and crab traps, pipes, small diameter rods, cable, wire rope, chain, small boat anchors, etc. Following consultation with NCDCR personnel at Fort Fisher, NC, the vessel was investigated by TAR archaeological divers. The identified wreck remains appear to be a vessel approximately 160 to 190 ft in length, likely a sailing vessel. Per guidance received from the Division of Cultural Resources State Historic Preservation Office (SHPO), as the wreck has the potential for eligibility for Nomination to the National Register of Historic Places, a 150 ft buffer would be established to protect the wreck. Results of the 2012 archeological study and guidance received from SHPO can be found in Appendix H.

4.12 SOCIO-ECONOMIC CONSIDERATIONS

Population growth among permanent residents on Bald Head Island has been consistent since the Village's incorporation in 1985. Between 1990 and 2000, the population increased by 121.8%. Bald Head Island is a popular travel destination and the Village relies on seasonal visitors as a source of revenue. During summer months the population on the island increases significantly. In 2010 roughly 996 housing units of a total of 1,111 housing units were considered to be seasonal in nature. Businesses focus on providing the necessary services to support seasonal demands as well as servicing the year round clientele. The Island offers two bed and breakfasts, restaurants, a market and retail stores.

The Bald Head Island Club is the single largest employer on the Island and the largest source of tax revenue for the Village and thus its economic impact on the Island is considerable. The Club generates $10M in revenue annually and, as a not-for-profit entity, spends approximately the same amount each year.

In addition to a championship golf course, the Club houses a pool, fitness facility, tennis courts and two restaurants. Because the Club serves as the foundation for recreation and social activity island wide, the gross domestic product (GDP) of the Island is strongly associated with the Club, its associated activities, and the resultant effect on home purchases and rentals on the Island. On average, twenty-thousand rounds of golf are played each year on the Club's championship eighteen-hole golf course. A majority of these rounds (63%) are played by non-members that rent Island residences. It is estimated that 500 homes are rented each year (equivalent to $5,700 weekly in rental income) as a direct result of the amenities offered by the Club. Over 81,000 full meals were served at the club in 2011, totaling roughly $3 million in food and beverage sales. All of the Club's seafood and produce are locally sourced. The Club is also the single largest employer on the Island, employing 151 people during the summer and 75 people during the off-season. None of the Club's employees are Island residents. The Club's largest expense is payroll (accounting for an average of 57% of accounts payable) in most years. The Club is also the largest source of tax revenue for the Village (Norton, personal communication).

Bald Head Island serves the public, including residents of North Carolina and many other States and Countries, with its beachfront being among its principal draws. It is not atypical to find 5,000 or more visitors on a summer weekend day. As such, the Village has constructed and maintained numerous beach accesses to support the daily public demands.

4.13 LAND USE

Development of Bald Head Island began in 1972 with the construction of an inn and 18-hole golf course. The developer, Bald Head Island Limited, designed the phased plan development of the Island which encompasses 2,000 acres. With increasing build-out and anticipated increase of both permanent and part-time residents, along the with inherent advantages of municipal form of government for achieving the planned community goals, the Village of Bald Head Island was incorporated as a municipality in 1988.

The island is accessible to the public by means of a passenger ferry which operates between Southport, NC and Bald Head Island Marina. The Village exists primarily as a second home community and is a well known tourist and seasonal destination. Commercial activity is primarily limited to retail trade including: grocery, hardware and restaurants. Other than retail trade, the only other non residential construction activity involves the marina, country club, multifamily common areas, Bald Head Island Conservancy, office space, and town-owned facilities.

Though remaining under the general planning authority of the Brunswick County Land Use Plan, the Village has adopted its own policies regarding planning and resource management. Bald Head Island policies have been incorporated into the Brunswick County Land Use Plan. These policies promote natural resource protection and management and guide responsible development. The Village supports state and federal laws designed to manage development in Ocean Hazard Areas of Environmental Concern and Estuarine Shoreline Areas of Environmental Concern (AECs).

The proposed project area is located within an AEC, and is therefore considered to be within the conservation land class. According to the Brunswick County Land Use Plan, 'the purpose of the Conservation class is to provide for the effective long-term management and protection of significant, limited, or irreplaceable areas. Management is needed due to the natural, cultural, recreational, scenic or natural productive values of both local and more than local concern. As such, the Conservation class should be applied to areas that should be either not developed at all (preserved), or if developed, done so in a very limited manner characterized by careful planning and cautious attention to the conservation of environmental features.' Maps of current and future land use classifications are provided for reference (see Figure 4.15 and Figure 4.16). Likewise, FEMA floodzones are identified in Figure 4.17.

4.14 HYDRODYNAMICS

4.14.1 Tides and Tidal Flow

The astronomical tides in the vicinity of Bald Head Island are semi-diurnal and have average mean and spring ranges of approximately 4.3 ft and 5.0 ft, respectively. Tidal datums for Bald Head Island are listed in Table 4.2.

Table 4.2. Tidal Datums for Bald Head Island, North Carolina

Datum	Elevation (Relative to NGVD 1929*)
Mean Higher High Water (MHHW)	+2.82 FT
Mean High Water (MHW)	+2.51 FT
Mean Tide Level (MTL)	+0.35 FT
NGVD 1929	0.00 FT
Mean Low Water (MLW)	-1.81 FT
Mean Lower Low Water (MLLW)	-1.98 FT

* Approximations based upon extrapolation from Southport, NC.

Figure 4.18 plots the predicted astronomical tides for the 2014 calendar year near Bald Head Island. The water levels ranges suggest minor seasonal fluctuations in tide range whereby astronomical tides are minimally higher during fall (October through December). The lowest tides of the year are predicted to occur January through March.

As part of the monitoring program of the Wilmington Harbor Navigation Project, the USACE has conducted annual measurements of the tidal flows through the Cape Fear Inlet. Measurements are taken along predefined transects by boat mounted Acoustic Doppler Current Profiler (ADCP). The most recent set of ADCP measurements was completed on April 24-25, 2009 and include separate descriptions of upper and lower water column velocities (USACE, 2011a). Flow patterns measured in August 2009 are described in the 2010 USACE monitoring report as follows:

> *During flood flow, the currents are concentrated within the main channel between Bald Head Island and Jay Bird Shoals. Flow is also concentrated through the flood margin channel near Oak Island. A similar flow pattern is seen just off the Bald Head spit entering the main channel; however, there is not an associated flood margin channel visible. …One interesting feature is also evident with the flood flow pattern which reveals eddies off the main*

flow. These are evident in the lee of the point at the juncture between South Beach and West Beach [on Bald Head Island] and also near Oak Island.

The peak ebb flow patterns have two velocity peaks along the inlet transect, one near the marginal channel along Oak Island and the other within the main channel. These flows funneled into the main channel during ebb impinging on the bank along Bald Head's West Beach. … Previous surveys indicated that [ebb] flow was constrained within the main channel [at the seaward end of the survey transect]. The new survey transect shows that while significant velocities are still recorded within the main channel further offshore, they also begin to flow over the eastern ebb tidal delta. In addition, an eddy is noticed along the eastern side of the main channel just landward of the seaward extent of the current profile track.

Olsen Associates, Inc. developed a calibrated hydrodynamic model of the inlet using the numerical model Delft3D (Olsen, 2012). As part of hydrodynamic model verification, tidal currents throughout the inlet were simulated for the time period monitored by the Corps, April 2009. Figure 4.19 plots the predicted peak ebb and flood tidal currents. The numerical model results indicate the aforementioned measured concentration of flood tidal currents within the main navigation channel and Jay Bird Shoals and within a marginal flood channel off the eastern end of Oak Island. Also, the model reproduces a similar confluence of flood flow around the tip of Bald Head Island, which is less pronounced given the lack of a significantly developed marginal channel off the west-point spit. The monitoring data (described above) indicate eddies along the west point of Bald Head Island and near Oak Island, which the model also reproduces during various phases of the tide.

According to the project engineer (Olsen Associates), the model is in general agreement with ebb flow patterns identified by USACE (2010). Both identify strong ebb flows concentrated in both the main navigation channel and within Oak Island's marginal flood channel. The model results suggest that ebb flows tend to spread over the ebb shoal platform with increasing distance from shore. While this phenomenon was not identified in previous physical monitoring efforts, the most recent current study at the inlet did identify this pattern. Finally, while not shown in the still images of model results shown herein, the model does predict formation of a small eddy along the eastern side of the navigation channel, seaward of Bald Head Island.

Maximum flood tide, near surface currents measured by the Corps through the inlet in 2009 were about 1.39 m/s, while near bottom peak flood velocities were about 1.2 m/s. In comparison, the model results suggest peak depth averaged flood velocities of about 1.3 to 1.4 m/s. Peak surface ebb currents measured by the Corps were about 1.61 m/s, while near bottom peak ebb velocities were about 1.48 m/s. The model predicted peak, depth averaged ebb current speeds of about a 1.4 m/s. The Corps defines near surface and near bottom as being the lower and upper halves of the water column. Measured and predicted peak currents are summarized in Table 4.3.

Table 4.3: Maximum Magnitude of Mean Flows at Inlet Transect (USACE 2010).

		October-00	April-02	March-03	January-04	March-05	March-06	February-07	March-08		April-09	Delft3D Depth Averaged (April '09)
Near Bottom	ebb	1.06	1.17	1.18	1.57	1.35	1.1	1.75	1.62		1.48	
	flood	1	1.12	1.47	0.98	1.18	1.16	1.36	1.42		1.2	
Near Surface	ebb	1.35	1.97	1.65	1.18	1.7	1.38	1.65	1.62		1.61	1.4
	flood	1.1	1.26	1.27	1.14	1.34	1.37	1.4	1.42		1.39	1.3-1.4

Figure 4.20 plots the residual tidal flows resulting from a one-month long, tide-only simulation using the calibrated Delft3D hydrodynamic model. Residual flows is the “net” flow that remains after subtracting all of the flood flow vectors from the ebb flow vectors for one lunar month. This results in potential movement of sediment from each island. According to the applicant’s engineer, material tidally removed from Oak Island appears to

be directed towards Jay Bird Shoals and the navigation channel, suggesting to him that the material deposited into the shoals may remain in the local littoral system and/or be transported back onto Oak Island. The applicant's engineer states that the proximity of the navigation channel to Bald Head Island suggests that material moved off the island and ebb shoal enters the channel and may be subsequently transported offshore, out of the littoral system. However, the potential movement of sand within the tidal circulation pattern is interrupted by the deep navigation channel into which the sediment accumulates, as described in a subsequent result, described later.

According to the applicant's engineer, the large gyre indicated in the residual flow plot off Bald Head suggests potential for sediment transport back towards the island. It is unlikely, however, that sediment deposited into the channel bottom (-42 ft, MLLW) could be transported back up to the ebb platform. Rather it is likely dredged during maintenance and disposal activities. Sediment transport leaving the Point's south facing shoreline is indicated by the reoccurring submerged shoal feature depicted in the photo chronology presented in Figure 4.21.

A net tidal flow circulation is suggested across the flood shoals by the applicant's modeling. Net counter-clockwise flow is indicated across the channel, whereby water moved northward along the Bald Head Island side of the channel (presumably on the flood tide) is suggested to be circulated southward along the Oak Island side of the channel (presumably on the ebb tide), in the net, and ultimately toward the Smith Island Range segment of the navigation channel, between the two islands.

4.14.2 Tidal Prism

The tidal prism of an inlet describes the volume of water exchanged from the ocean to the interior estuary throughout a tidal period. The tidal prism is a function of inlet and estuary geometries, tide range, river discharge, and frictional components of the inlet. The USACE has annually monitored the Cape Fear River Entrance as part of a physical monitoring program of the Wilmington Harbor Federal Navigation Project. Data collection has typically included computation of the inlet's tidal prism (USACE 2011a). Table 4.4 lists the tidal prism measured by USACE since October 2000. Values presented have been normalized across an inlet cross sectional area measured in January 2003 (raw monitoring data are not available). Comparison of the ebb and flood prism computations suggests that the Cape Fear River Entrance is ebb-dominated with average ebb and flood flows equal to about $1.79x10^8$ and $1.21x10^8$ m^3, respectively.

Table 4.4: Measured (Normalized) Tidal Prism Values 2000-2009 (adapted from USACE 2011a).

Date	Ebb Prism (m^3)	Flood Prism (m^3)	Total Prism (m^3)
Oct-00	1.90E+08	1.30E+08	3.20E+08
Apr-02	1.50E+08	1.10E+08	2.60E+08
Mar-03	1.70E+08	1.20E+08	2.90E+08
Jan-04	1.50E+08	9.00E+07	2.40E+08
Mar-05	2.30E+08	1.10E+08	3.40E+08
Feb-07	2.10E+08	1.50E+08	3.60E+08
Mar-08	1.50E+08	1.50E+08	3.00E+08
Apr-09	1.80E+08	1.10E+08	2.90E+08

4.14.3 River Discharge

Figure 4.22 plots the measured daily river discharge for the years 1969 to 2010, as reported by the USGS National Water Information System. The data suggest that, on historical average, the Cape Fear River discharge is approximately 268 m3/s (cms). Flows attributable to astronomical tides and waves are more significant in terms of the physical processes controlling inlet dynamics than those derived from river discharge.

4.14.4 Waves

Waves are the dominant forcing mechanism for most coastal processes. Factors affecting waves in the vicinity of the proposed project include transformation over ebb tide shoals as well as other shallow bottom habitats, filtering of wave energy by Frying Pan Shoals, wave generation by local winds, and wave/current interactions. Near Bald Head Island, dominant wave directions are south to southeast. Nearshore waters of Bald Head Island are sheltered to the east southeast by Frying Pan Shoals and, as such, wave movement from an easterly direction is virtually absent (Thompson et al. 1999). The offshore and nearshore wave climates are quantified by both measured data collected at several wave buoys, as well as numerically hindcasting offshore wave conditions completed by USACE.

A. Measured Wave Data

In addition to the offshore wave buoy maintained by NOAA and NOS (41013, see Figure 4.23), the USACE, maintains an array of offshore and nearshore ADCP wave gauges. The gauges of interest to the study: 11-mile ADCP (offshore), Bald Head ADCP (nearshore), and Oak Island ADCP (nearshore). The location of these gauges is shown in Figure 4.23 along with the location of the far offshore NOAA wave buoy number 41013.

Directional wave data from the Corps' ADCP gauges span the period September 2000 to the present. Directional wave and wind data are available from NOAA buoy 41013 from late 2003 to the present.

Figures 4.24 through 4.27 present wave roses and histograms describing the available wave data for each of the stations shown in Figure 4.23. Frying Pan Shoals is a large shoal feature extending towards the southeast from the southern tip of Bald Head Island. NOAA buoy 41013 is the only measurement station located outside of the influence of the shoals and within meaningful proximity to the area of interest. Comparison of the wave roses illustrates the sheltering capacity of Frying Pan Shoals to efficiently filter out wave energy from the northeast, east, and southeast. Outside of the shoals, at wave buoy 41013, the dominant wave direction is from the east southeast. Immediately inside the shoals, in relatively unprotected water, the 11-mile ADCP data suggest a dominant wave direction of south southeast. At the protected, nearshore ADCP gauges, the dominant wave direction is from the south with very little wave energy arriving from east of south.

B. WIS Data

The USACE maintains a database of coastal wave characteristics for the Atlantic Ocean. These wave characteristics are derived by numerically simulating past wave and wind conditions, a process called hindcasting. The most recent hindcast for the Atlantic Ocean basin result describes conditions for the twenty year period 1980 to 1999. The WIS dataset includes hourly time series output at selected coastal stations within the numerical model domain. The locations of WIS stations (both epochs) and the wave measurement arrays are plotted in Figure 4.28.

Figure 4.29 plots several wave roses in the vicinity of the study area. Also plotted, for comparison, are wave roses computed using measured ADCP and wave buoy data. Scaling and bin definitions are consistent for each rose plot in the figure. The mean wave direction at the peak frequency is presented. An analysis of the ability of most recent WIS data to accurately incorporate the effects of Frying Pan Shoals was conducted by Olsen (2012) which suggested that the numerical resolution of the WIS model (5 degrees or 5 nautical miles) is likely insufficient to fully resolve the bathymetry of the shoals. Given their availability, the study recommended the use of measured wave data or an alternative WIS Station located outside of the influence of Frying Pan Shoals (i.e., WIS Station 63510, not shown herein).

4.14.5 Analysis of Sediment Transport Pathways

A. Bald Head Island

A 1989 sediment transport study completed by Olsen Associates, Inc. described the sediment transport patterns along Bald Head Island. This analysis considered both wave and tidally driven currents. Figure 4.30 describes the potential sediment transport regime around Bald Head as described in the earliest Olsen report. This analysis utilized a relatively coarsely-resolved wave transformation model along with an empirical estimate of sediment transport potential derived from the wave transport results (i.e. CERC formula) and qualitative interpretation of tidal flows. The following describes the conceptual sediment transport patterns derived in the Olsen study.

The most notable sediment transport feature described by Olsen (1989) is a nodal point located between Starfish Trail and Sandspur Trail where the direction of sediment transport diverges. West of this divergence point, alongshore transport rapidly increases in magnitude westward, towards the inlet and navigation channel. Sand along this reach is expected to be removed from the beaches and nearshore seabed and either (a) stored within the west-point spit at the end of the island; (b) transported to the beaches along the west side of Bald Head; (c) and/or trimmed from the west-point spit by tidal currents and transported to the channel or nearshore shoals.

East of the nodal point, alongshore transport is directed towards the east, gradually increasing in magnitude. The 1989 study concluded that sediment was removed from the east end of the island and either deposited onto a spit formation or transported offshore onto Frying Pan Shoals. Sediment transport along East Beach was predicted to be southerly directed in the net.

B. Channel Shoaling

Figure 4.31 plots areas where the navigation channel shoals with beach compatible sand, indicated by shaded areas within the channel. Since March 2005 the USACE has undertaken bi-monthly surveys of the navigation channel immediately adjacent to the western end of Bald Head Island. Select monitoring surveys were digitized by the applicant's engineer and overlaid upon one another in order to visualize areas of chronic shoaling pressure within the channel and deduce the sediment transport pathways. Selected surveys were digitized from construction plans issued by the USACE prior to dredging of the navigation channel.

Figure 4.32 plots the approximate locations of the -44 ft, MLLW contour for the April 2003 (pre-2004 project), August 2008 (pre-2008/09 project) and September/November 2010

USACE condition surveys of the channel. For reference, the federal channel is currently maintained at a depth of -44+2 ft, MLLW. With the exception of the most recent survey (2010), the data were digitized from construction plans issued by USACE.

In the opinion of the applicant's engineer, the channel survey data suggest that there are specific, repeatable shoaling trends within these three reaches of the navigation channel. Bald Head Shoal Channel Reaches 1 and 2 chronically shoal from the east while the northern Smith Island Channel cut tends to recurrently shoal from the west. Alternatively stated, shoal material deposited into Bald Head Shoal Channel cuts 1 and 2 appears to be derived from Bald Head Island and the nearshore ebb shoal platform. Material deposited in the Smith Island cut appears to be principally from Jay Bird Shoals complex, Middle Ground Shoals complex, and/or Oak Island.

C. Transport Along Oak Island

Figure 4.33, plots a wave height rose for data collected at the Oak Island ADCP gauge, located in about 23 feet (7 m) of water off Oak Island. The western limit of U.S. Army Corps monitoring of the federal placement project is indicated for reference. This limit is approximately 1,000 feet west of the limits of federal fill. Figure 4.33 differs from that shown in Figure 4.26 only with respect to the increased density of directional sorting bins and the depiction of a common shoreline angle along the Oak Island project shoreline, which is indicated by the bold, red line oriented about 15 degrees north of west along with a shore-perpendicular dashed red line. The percent occurrence data shown in the plot, as well as, computation of the wave power (energy flux), H^2T, suggests a tendency towards a net westerly bias as waves approach the shore. Approximately 11 percent more wave power originates from the 105 to 195 degree directional bin (westerly directed) than from the 196 to 285 degree bin (easterly directed)[1].

[1] The azimuth ranges represent shore-normal directional bins corresponding with a 15 degree shoreline angle.

It is important to note there is marked variability in the shoreline along the project reach, which impairs the ability to make localized conclusions in the relative directionality of wave energy. While the approximate generalized shoreline angle away from the immediate effects of the inlet is closer to 15 degrees, the project shoreline appears to range in angle from around 13 to 15 degrees (+/-), with shallower angles predominate along the western reaches of the project. Usage of these angles alters the estimated directional distribution of energy flux. For example, at a shoreline angle of 14 degrees, there is approximately 5.1 percent more westerly-directed energy flux. As the shoreline approaches 13 degrees there is only about 0.4 percent more westerly-directed energy flux suggesting little net transport. Taken in total, these observations are supportive of a littoral climate which consists largely of bimodal transport with a relatively weak net westerly component. Given the proximity to the inlet, however, one would anticipate the existence of a point of divergence in net littoral transport (i.e., net easterly-directed) at some point along eastern Oak Island associated with tidal currents and the influence of inlet shoals – despite the higher incident shoreline angles nearest the inlet (~17 degrees). The measured wave data at the Oak Island ADCP, however, do not resolve the effects of local inlet shoals and currents on the wave climate and are better suited to a discussion of general patterns in transport potential.

Approximately 31,000 feet of the Oak Island/Caswell Beach shoreline is surveyed semi-annually by USACE as a part of the overall monitoring program for the Wilmington Harbor Navigation Project and associated beach disposal program. In comparison to the DCM shoreline data, USACE physical monitoring data also indicates that since July 2001, Oak Island has been stable to accretional -- excepting for an erosional "hot spot" located on Fort Caswell Beach not indicated in the DCM data. This "hot spot" occurs at two USACE monitoring profiles located at the east end of the island that have experienced consistent recession since the navigation channel was realigned and deepened in 2000 (USACE, 2011a).

The 2011 USACE monitoring report documents continuing erosion between COE survey stations 35 and 40. Figure 4.34 is adapted directly from the most recent USACE monitoring report and presents the historical (pre-2000) and recent (post-2000) shoreline response at stations 35 and 40, within the erosional "hot spot" (USACE, 2011a p. B-4). The data suggest that prior to August 2000, profiles 35 and 40 experienced persistent seaward shoreline growth at an average annual rate of about 29.9 ft/yr and 17.2 ft/yr, respectively. Since August 2000, the shorelines at stations 35 and 40 have experienced landward retreat at an average annual rate of about -8.8 ft/yr and -4.5 ft/yr, respectively.

D. Olsen Associates 2012 Study

Olsen Associates, Inc. utilized the process-based numerical model Delft3D in order to more accurately predict sediment transport and seabed morphology in the vicinity of the Inlet as a function of average annual wave conditions. Input wave conditions were derived from measured wave buoy data collected in deep water between November 2003 and December 2009 (NOAA Buoy 41013), located beyond the effects of Cape Fear Shoals. Schematization involved sorting the measured wave data into distinct bins based on wave height, direction, period, and contribution to morphological change, and accounting for gaps in the data, as described by Lesser (2009). For each resulting bin, a weighted mean wave condition and an annual probability of occurrence were computed. The numerical model was calibrated and verified using measured rates of beach profile change along Bald Head and Oak Islands, historically documented rates of shoaling within the navigation channel, and qualitative comparisons of measured morphological changes in the nearshore shoal systems. Figure 4.35 presents the model output in terms of the predicted net sediment transport pathways in the vicinity of the Inlet. The areas identified as chronically shoaling with beach compatible sediment are overlaid onto the plot.

In the opinion of the applicant's engineer, the numerical model analysis confirmed the accuracy of the aforementioned 1989 conceptual predictions of overall trends in average annual net sediment transport along Bald Head Island and allowed for a detailed analysis of inlet dynamics. For example, he states that the model correctly predicts the magnitude and extent of the severe erosional gradient along western Bald Head along with a reversal in net transport direction east of the existing tube groin field.

Olsen states that in addition to correctly describing alongshore sediment magnitudes and directions, the model proved capable of reasonably predicting the magnitude and spatial distribution of shoals within the navigation channel. Volumetric changes predicted by the model were computed within the limits of the Smith Island Cut, Bald Head Shoal 1, and Bald Head Shoal 2. The results suggest that these three channel cuts shoaled with a combined 963,500 cy during a two-year model simulation. Approximately 32 percent of this volume (about 311,900 cy) is deposited within the Smith Island Cut while the remaining 68 percent (about 651,600 cy) shoals both Bald Head Shoal Reaches. According to Olsen, these model predictions demonstrate good consistency with measured values and distributions of channel shoaling published by the USACE for the time period of model calibration and since the last harbor dredging project.

A 2011 reevaluation report of the Sand Management Plan for the Wilmington Harbor Navigation Project completed by the USACE, identified a total shoaling volume of about 1,176,000 cy over a typical two-year dredge cycle. This shoaling volume was based on the analysis of the first three maintenance dredging cycles following the 2001 channel deepening. The USACE analysis further shows that deposition within the Smith Island Cut comprises about 33 percent of this total volume with the remaining and 67 percent shoaling within both Bald Head Shoal cuts (USACE 2011b). The model's predicted two-year shoaling volume (963,500 cy) is within about 18%, slightly less, than the measured volumes. The model's predicted distribution of shoaling between the Smith Island Cut and Bald Head Shoal Reaches (32% and 68%, respectively) is nearly identical to the measured distribution (33% and 67%).

Perhaps of greater importance, the results of the USACE 2011 reevaluation report further supports the aforementioned sediment transport patterns which link the shoaling in the specific channel locations to the individual beaches. Specifically, sediment depositing within the Baldhead Shoal Channel Reaches 1 & 2, nearest to Bald Head Island comes from that island. Likewise, the shoaling within the Smith Island Range comes from Middle Ground Shoals and the Oak Island/Caswell Beaches. The report finds that in essence, these two littoral systems can be thought of as largely independent with little sand sharing between the islands. As noted in the prior paragraph, the shoaling rates within these two channel reaches have occurred in a one-third to two-third proportion reflecting the basic assumption of the original Sand Management Plan.

The gross sediment transport potential predicted for individual wave cases was additionally investigated by Olsen Associates via the real-time tracking of motion patterns of specific 'tracer' sediments inserted into the numerical model. The tracer code represents a special purpose addition to the Delft3D modeling suite[2] and describes computed sediment transport as opposed to traditional particle tracking models which describe only particle motion due to water movement and dispersion. The tracer model does not yield estimates of transport magnitude or the final destination of sediments, however. Rather, the tracer code predicts maximum movement rates (potential transport pathways) associated with previously calibrated hydrodynamics. This process revealed complex transport patterns which are not otherwise definable in the net, as well as stark differences in transport between Bald Head and Oak Islands beyond the aforementioned magnitudes in transport leaving the respective islands.

Under south southwest incident offshore waves, sediment off Oak Island is transported towards the lee of the Island on flood tides. The subsequent ebb tide forces material which is not trapped in the navigation channel out of the inlet and back into the littoral system of Oak Island – both onto Middle Grounds, Jay Bird Shoals, and the active beach profile off Oak

[2] Elias, E. (2011). "Predicting Sediment Transport Patterns at the Mouth of the Columbia River". Proceedings Coastal Sediments 2011 Conference. May 2-6, 2011. Miami, Florida. Pp.588-601

Island. Similar patterns exist under west-southwest storm waves. In contrast, material which enters the navigation channel from Bald Head Island under easterly-directly waves adds volume to the Point and/or shoals the navigation channel to be mobilized seaward by the next ebb tide. Either way material is lost from the littoral system along South Beach. The most commonly occurring east southeast incident waves tend to produce a similar, highly erosive trend on Bald Head Island, excepting that some material entering the navigation channel is transported into the Smith Island Channel cut on a flood tide, although the results suggest the subsequent ebb tide is capable of mobilizing these sediments further seaward. Unlike the south southwest condition, east southeast waves mobilize little-to-no sediment in the nearshore profile of Oak Island. Additional details and results from the tracer analysis are included in the Engineering Report prepared by Olsen Associates (2013).

4.14.6 Sea-Level Rise

Sea level, also known as eustatic sea level, is a measure of the average height of the ocean surface. Sea-level rise is an increase in eustatic sea level that is sustained over a long period of time. There are two types of sea level change over the long-term, relative sea level (RSL) and global mean sea level (GMSL). RSL, local sea level, fluctuates as the local land and sea floor move up and down as a result of tectonic plate collisions, glaciation, sediment compaction in large deltas or any other process that increases or decreases the weight of the Earth's crust. GMSL is a measure of the increase in water volume in the ocean expressed as a change in the height of the oceans. Several factors influence sea-level change at the local to regional level including global sea-level change, local vertical land movement, changes in tidal range, changes in coastal currents and/or water temperature and gravitational effects (NCCRC 2010b).

According to the NC Coastal Resource Commission Science Panel on Coastal Hazard's, historical tide gauge data and geologic evidence obtained over the last several centuries provide evidence that sea level is steadily rising in the state of North Carolina. Additionally, data collected from scientific studies within the state suggest that RSL change varies as a function of latitude along the North Carolina coast. RSL change is higher in the northern part of the state with lower documented rates in the south and varies from 2.04 mm/yr to 4.27 mm/yr (NCCRC 2010b).

NOAA maintains a detailed record of sea level trends at stations around the United States. The nearest such station to the study area is at Southport, immediately inside Cape Fear Inlet (Station 8659084). Figure 4.36 was taken directly from the NOAA data archives and plots the linear trend of sea level rise at the Southport station. The measured data at Southport cover the period between 1933 and 2006 and suggest that the local water level rises approximately 2.08 mm/year, or about 0.21 meters (0.69 feet) per 100 years, on average.

4.15 INFRASTRUCTURE

Bald Head Island is a well-recognized destination for both daily visitors (from the local region) and longer-term vacationers (visiting from the region, other states, and foreign countries). There are two bed and breakfasts and hundreds of rental homes, timeshares and fractional ownership dwellings. There are only approximately 220 full time residents, but there are approximately 5,000 or more visitors on a summer weekend day. The resident and visiting population is serviced by a network of roads (used by golf carts as well as emergency and construction motor vehicles) and utilities (including sub-grade water, sewer, power and communication lines). In addition, potable water is supplemented through the use of sixteen groundwater wells located in different areas of the Island. The Village has also constructed and maintained numerous beach accesses along West Beach, South Beach, and East Beach.

Bald Head Island was initially developed in the early 1970's by Bald Head Island Limited. The Island consists of approximately 2,000 single-family residential lots. The Island is accessible by boat only with daily ferry service providing access from Southport, NC. Transportation is primarily limited to golf cart, bicycle and pedestrian traffic, however, vehicular service is allowable to facilitate construction and for emergency purposes. Bald Head Island Marina is accessed from the Cape Fear River and offers 153 wet boat slips accommodating vessels up to 100 ft in length, gas and diesel fuel pumps and a marina pump-out. The Island also supports two clubhouses with associated amenities, restaurants, a market and additional shopping opportunities.

Existing infrastructure within the project study area includes a number of roadways and sub-grade utilities including sewer, water distribution, fire suppression, power, communications, and stormwater ponds (Figure 4.37). In addition, there are privately held infrastructure components associated with the facilities at the Bald Head Island (BHI) Club. While wastewater is primarily collected via sewer and treated by a package treatment system, there are few individual septic tanks for single-family residences that are still in existence. In particular, there are privately-owned and operated septic tanks and attendant lines for four homes on Cape Fear Trail (located within the permit study area and in close proximity to the Point). Additional privately-owned infrastructure associated with major habitable structures within the study area include, furnishings, pools, outbuildings, over-walks, pavilions, etc.

4.16 URBAN QUALITY

The location of the project study area is within the Cape Fear River estuary. There are no urban quality issues associated with the Village of Bald Head Island Shoreline Protection Project.

4.17 SOLID WASTE

The Village of Bald Head Island wastewater treatment facility operates in accordance with the provisions of Article 21 of Chapter 143, General Statutes of North Carolina as amended and other applicable Laws, Rules, and Regulations under permit numbers WQ0000193 and NC0085553. The collection system consists of approximately 180,000 feet of sewer mains with size ranging from 1.5" to 10" in diameter, and 38 lift stations, which collect and convey waste to the wastewater treatment facility for processing (Permit No. WQCS00276).

The wastewater treatment facility was originally constructed in 1996. An expansion to the wastewater treatment facility was brought online in June 2003 and increased the treatment capability to 400,000 gallons per day. The treatment facility is an Aqua-Aerobic System with sequencing batch reactors with tertiary treatment and UV disinfection.

The Village of Bald Head Island Public Works Department provides routine collection of yard debris and household waste. Additional trash receptacles are located throughout the island for public use. Recycling receptacles for private and public use are located at the Public Works Facility.

4.18 DRINKING WATER

Groundwater of the area is generally supplied from the shallow semi-confined water table aquifer and the deeper Castle Hayne limestone aquifer. Potable water is supplied to Bald Head Island through a combination of sources. The Village of Bald Head Island recently constructed a ten inch (10") water main from mainland Brunswick County to Bald Head Island (the subaqueous portion having an eight inch (8") diameter). This line is operated by the Brunswick County Utilities Department. Brunswick County water consists of ground water from the Castle Hayne Aquifer and surface water drawn from the Cape Fear River above Lock and Dam # 1. Peak water usage averages 270,000 gallons per day in July and August. The minimum water usage occurs in February, which averages 68,000 gallons per day.

Potable water is also supplied to Bald Head Island through a series of 16 state approved groundwater supply wells scattered across the inland portion of the island (Figure 4.37). The water supply wells are situated at an average depth of 55 feet below the ground surface in the shallow semi-confined aquifer. Individual groundwater wells can produce 40 GPM. Water from the production wells is piped to the Village water treatment facility located at 256 Edward Teach Extension and filtered by reverse osmosis.

4.19 NON-RELEVANT RESOURCES

4.19.1 Hazardous, Toxic and Radioactive Waste

In light of the substrate composition and the physical processes of the mouth of the Cape Fear River, it is unlikely that bottom sediments have accumulated any toxic or hazardous substances as regulated by CERCLA (1980) or RCRA (1976). Contaminants tend to bind more readily to the surfaces of fine-grained sediments uncharacteristic of the substrate of the project area. In addition, there have been no known sources of contamination (i.e. spillage, treatment, or storage of toxic substances) within or near the project area. Therefore, it is unlikely that a composite bottom sample would yield contaminant levels exceeding EPA standards.

4.19.2 Noise

Ambient noise levels within and adjacent to the project area are relatively low. No industrial properties are located near the project site. Some commercial properties are located adjacent to the Bald Head Island Marina. Short-term elevations in noise levels may be attributed to ferry and boat traffic near the marina basin and residential construction activity. In general, the predominant low-impact land use of the island equates to low ambient noise levels.