### 7.3.8 Carolina Beach Inlet Dredging

The Carolina Beach Inlet sediment trap, a constructed feature, is used to collect sediment for nourishment of the Carolina Beach storm damage reduction project. The sediment trap is dredged every three years with an average of approximately 1,000,000 cy being removed and placed on 14,000 feet of shoreline south of the inlet during each cycle.

### 7.3.9 Tubbs Inlet Dredging

The present-day Tubbs Inlet was relocated in 1970 by the developer of Sunset Beach. The inlet relocation project subsequently caused considerable erosion on the southwest end of Ocean Isle. Local interests have developed a plan to remove material from Old Sound Creek and Eastern Channel and place the material on adjacent beaches.

### 7.3.10 Shallotte Inlet Dredging

In 2001, dredging of Shallotte Inlet involved removing approximately 1.7 million cubic yards of material from the inlet and depositing it on the Ocean Isle Beach shoreline to construct a beach berm and dune project.

### 7.3.11 Lockwood's Folly Inlet Dredging

Lockwood's Folly Inlet connects Lockwood's Folly River to the Atlantic Ocean. In 1993, the Lockwood's Folly River Channel was dredged, 2-1/2 miles up the river, in a major project that placed significant amounts of dredge material on Long Beach strand. The inlet was dredged from October 1, 2001 to October 8, 2001 and during this time, 19,245 cubic yards of sand was removed. Approximately 165,390 cubic yards of material was again removed from the inlet from October 12, 2001 to November 14, 2001 and maintenance dredging of the inlet in 2002 (August 20 to September 4) removed 76,190 cubic yards of sand.

## 7.4 Inlet Relocations

Relocations of inlets can minimally, slightly, or significantly affect environmental resources (Table 7.1). Tubbs Inlet was relocated in 1966 and no reports of changes to water flow, shoaling, or sediment transport were documented. Therefore, the analysis of the effects of this project assumed that the relocation of inlet had only temporary and minimal effects on the surrounding resources.

The Mason Inlet relocation directly impacted salt marsh habitat in the area, although the project mitigated for the impacts. Continual monitoring has shown no indirect loss of saltmarsh. In fact, some shoaling areas are becoming vegetated with salt marsh grasses (USACE, pers. comm.).

The relocation of Mason Inlet through Figure 8 Island (March 2002), may have altered the hydrodynamics of the project area. A change in hydrodynamics can negatively affect SAV habitat and shellfish. Relocation projects, such as Mason and Bogue Inlets provide beach habitat for birds, nesting sea turtles, and seabeach amaranth. This additional habitat can be assumed to be cumulatively positive for the respective resources.

### 7.4.1 Mason Inlet Relocation

Mason Inlet is a tidal inlet connecting the Atlantic Ocean and Banks Channel between Wrightsville Beach and Figure 8 Island. The relocation project involved the excavation of a new inlet through Figure 8 Island and the maintenance of the new location for 30 years in order to protect threatened properties. The relocation of the inlet was completed on March 7, 2002 and

repositioned the channel approximately 3,500 feet to the northeast and the old channel was closed on March 14, 2002. In addition to channel relocation, the project also involved nourishing Figure 8 Island and Wrightsville Beaches and opening up Mason Creek for increased tidal flushing. The relocation of the inlet and creation of the tidal creek resulted in saltmarsh habitat loss in the area and a mitigation plan for saltmarsh impacts was accepted by the State and Federal resource protection agencies. Recent monitoring has shown no indirect loss of salt marsh and some shoaling areas are becoming vegetated with saltmarsh grasses (USACE, pers. comm.). Inlet maintenance is scheduled every three years and includes dredging and placing the material along the beaches of Figure 8 Island or further south along the north end of Wrightsville Beach.

### 7.5 Beach Nourishment Projects

Beach nourishment projects are designed to add sand to a sand-starved or under-nourished beach. Two nourishment projects included in the assessment are the Carteret County Bogue Banks Beach Restoration Project (expected to occur in 2008-2010) and Wrightsville Beach Nourishment Project (since 1965). Both of these projects include repetitive nourishment activities of a defined beach system over a long period of time. Recent beach nourishment projects have required that special measures are implemented to ensure that the sand is suitable for sea turtles (i.e., sand size, color, and shell content, as well as slope profile) as well as for the benthos community. Because of the current regulations in place for beach nourishment projects, equal quality beach habitat is provided for shorebirds, waterbirds, sea turtles, and seabeach amaranth compared to the native beach. Therefore, nourishment projects are not recognized to have long term cumulative effects to these resources. In some projects, nourished beaches have project provided positive cumulative effects. Other resources can be affected, but these effects are usually temporary and minimal. Information on the influence of a particular beach nourishment project on SAV and salt marsh habitats outside of the project area is not available. However, “most beach nourishment projects do not affect SAV or saltmarsh habitat unless it is in the dredging area” (USACE, pers. comm.). Therefore, no direct impacts from beach nourishment or similar projects should result but assigning an indirect or cumulative effect designation to the resource is more difficult.

#### 7.5.1 Carteret County Bogue Banks Beach Restoration Project

The Carteret County Bogue Banks Beach Restoration Project is a 50-year initiative to nourish all 25 miles of the Bogue Banks shoreline. The project is currently still in review and design and winter of 2008-10 is the earliest time that the construction phase would be initiated and completed for Bogue Banks beaches. This federal project is established to add storm protection along Bogue Banks for the listed 50 years.

#### 7.5.2 Dare County Beaches North Beach Nourishment

Future nourishment of the beach from the northern boundary of Cape Hatteras National Seashore to Kill Devil Hills-Nags Head line is proposed as part of a 50-year Federal program to address erosion along this segment of the North Carolina shoreline.

#### 7.5.3 Bogue Banks - Beach Nourishment

The project consists of a one-time 3-phased beach nourishment along approximately 16.8 miles of Bogue Banks extending from the Atlantic Beach/Pine Knoll Shores town boundary westward to a point approximately one mile east of the present location of Bogue Inlet. Phase 1 was constructed in 2001-2002 as the Pine Knoll Shores/Indian Beach Restoration Project and

included the placement of approximately 1.76 million cubic yards of sand along 7.4 miles of beach in Pine Knoll Shores and Indian Beach.

Phase 2 of the Bogue Banks beach nourishment project included the eastern Emerald Isle project area and was constructed in 2002-2003. Phase 3 includes the western section of Emerald Isle and proposes to utilize sand from the Bogue Inlet Channel Erosion Response Project.

### 7.5.4 Camp Lejune - Beach Nourishment

The project encompassed nourishing approximately one mile of Onslow Beach with approximately 710,300 cubic yards of material. Material used for the project could come from two dredge disposal islands and the dredging of New River Inlet. USACE Regulatory Division authorized the work on September 13, 2003, but USACE has postponed the project for an undetermined time.

### 7.5.5 Topsail Island - Beach Nourishment

The originally authorized project for the Town of Topsail Beach (south end of the island) was in the design stage during the early 1990's when the Town opted not to support the project. A revised project is presently being reevaluated by the USACE to include all of Topsail Island, Surf City, and a portion of North Topsail Beach. The remainder of North Topsail Beach (approximately seven miles of its eleven miles of shoreline) is not eligible for Federal assistance due to the presence of Coastal Barrier Resource Act (CBRA) designated lands in the project area. A separate locally-sponsored initiative is underway to evaluate the feasibility of renourishing these beaches.

### 7.5.6 Topsail Beach/West Onslow Beach Nourishment & Terminal Groin

The original Topsail Beach project described above included a terminal groin near New Topsail Inlet to control losses from the south end of the beach fill. The State of North Carolina would not approve the groin construction as proposed. Since the shore protection plan with the structure was deemed to be the least costly alternative, and hence the Federal NED plan, Federal assistance for the project was based on the structure only alternative which increased the non-Federal cost for periodic beach nourishment to an amount that was unacceptable to the local sponsor. The USACE is reevaluating the project to include all of the Town's shoreline. The new evaluation requires that the USACE must analyze the groin alternative again and the changed shoreline conditions (primarily as a result of the continued southward migration of New Topsail Inlet) may result in project re-formulation to show that the project without the groin is the least costly.

### 7.5.7 Figure 8 Island - Beach Nourishment

Figure 8 Island has received material for beach nourishment from inlet maintenance dredging of Rich Inlet and Banks Channel. Furthermore, the Mason Inlet Relocation Project in 2002 provided nourishment material for Figure 8 Island Beach; and future periodic dredging of Mason Inlet will be a source of nourishment material.

### 7.5.8 Wrightsville Beach - Beach Nourishment

The Wrightsville Beach nourishment is one of the oldest beach nourishment projects in North Carolina, having first been nourished in 1965. The first nourishment in 1965 involved the USACE building separate 2.6-mile nourishment projects for Wrightsville Beach and Carolina Beach. The plans of this original project called for beach maintenance by adding sand to the lower beach every two to four years to offset the pre-existing long-term erosion in the project

areas. Since 1965 approximately 10.2 million cubic yards of material has been placed along the Wrightsville Beach project area.

### 7.5.9 Kure Beach - Beach Nourishment

The USACE-administered Kure Beach program was designed and implemented in 1998 to provide wider beaches, dunes, public walkover access, and the extension of storm water outfalls. The primary borrow areas for the Kure Beach program is immediately offshore of Kure Beach (Horseshoe Shoal) and has enough material to accomplish two to three nourishment projects. The most recent renourishment of Kure Beach began in mid-February 2001 and was completed in April, 2001. Approximately 1.2 million cubic yards of sand were removed and placed along approximately 3.5 miles (18,000 ft) of Kure Beach ocean shoreline. Kure Beach received sand for the 2001 project as part of the deepening of Wilmington Harbor and future nourishment will likely come from a borrow area located farther north.

### 7.5.10 Fort Fisher Revetment

Revetment construction at Fort Fisher is comprised of a 926.6 m (3,040 ft) long seawall constructed of 3-ton granite boulders and 5-ton cast concrete stapods. Construction of the revetment was completed in 1996 and a 50-foot extension was added in 2001, following the 1996 hurricane season. The revetment performed well and did not experience any significant damage during the 1996 hurricane season. A monitoring program is in place to document shoreline changes north and south of the revetment. Pre-established erosion thresholds were required by the State of North Carolina to determine if measures should be implemented to mitigate for excessive erosion. There is no record, to date, that mitigation has been required.

### 7.5.11 Bald Head Island - Beach Nourishment

Bald Head Island received sand from the Wilmington Harbor entrance channel under a Section 933 navigation project from November through December of 1991. The Village of Bald Head Island used the channel material to nourish its beach in 1996 in conjunction with construction of a series of sandbag groins. While a Section 933 project was approved, the USACE did not have the necessary funds and the Village of Bald Head Island was therefore required to pay all the project costs. During 2001-2002, the USACE Wilmington Harbor project deepened and realigned the navigational entrance channel to the Cape Fear River. About 5.6 million cubic yards of sandy material from the Cape Fear River was used to renourish four Brunswick County beaches (Oak Island/Caswell Beach/Holden Beach/Bald Head Island).

### 7.5.12 Oak Island - Beach Nourishment

Material placed on a 25,000 foot segment of Caswell Beach and the eastern part of the Town of Oak Island was accomplished in 2002 as part of the Wilmington Harbor deepening project as the least cost disposal measure. Harbor deepening material was also placed on the western 25,500 feet of Oak Island and the east end of Holden Beach as part of a Section 933 project in 2002. The sand management plan for Wilmington Harbor will place approximately 1 million cy of maintenance material on the eastern 25,000 feet of Oak Island (Caswell Beach-east Oak Island) every six years. Maintenance performed during years two and four following initial deepening will be placed on Bald Head Island under the sand management plan.

### 7.5.13 Holden Beach - Beach Nourishment

Completed in February 2002, the first phase of the Holden Beach Project placed 660,000 cubic yards of sand that came from the Wilmington Harbor Deepening Project under Section 933 on the beach. The second phase, from March 4$^{th}$, 2002 to April 30, 2002, was associated with a

truck-hauling project funded by the town to extend the east and west limits of the first phase, placed a total of 160,000 cubic yards on the shoreline. The 160,000 cubic yards of sand included placing 150,000 cubic yards on the beach, extending the first phase of the project both to the east and west, and placing 10,000 cubic yards to fill the "gap area' in high ponding areas. The remaining gap area of the project is expected to receive sand sometime in 2003. Holden Beach is also part of the 50-year Wilmington Harbor project which is in the final evaluation / planning stages, and will be constructed in 2005 (see section C15).

### 7.5.14 Ocean Isle - Beach Nourishment

Dredging material from Shallotte Inlet (located at the east end of Ocean Isle Beach) was placed on Ocean Isle Beach to construct a beach berm and dune project in 2001. Approximately 1.7 million cubic yards of material was initially dredged from the inlet as part of a 50-year program that will provide beach nourishment material to Ocean Isle Beach.

## 7.6 Maintenance Dredging Projects

Maintenance dredging projects are typically short-term and impacts are usually temporary and restricted to the project area. The Nags Head/Kitty Hawk, North Carolina (January 2000) dredging disposal project provided a large volume of sand to beaches along Nags Head. These projects provided essential habitat for birds, nesting turtles, and seabeach amaranth and resulted in positive cumulative effects for the resources.

The Wilmington Harbor Dredging Project (currently ongoing, expected completion in March 2005) is a large project that involved various smaller projects and is expected to occur over a period of 20 years. One part of the project involves deepening the ocean bar and entrance channel, which may provide easier access to inshore waters for marine mammals. The project also involves increasing the elevation of flood control dikes, which may add to the restriction of water flow in the area. The effects of the continuous dredging and dike expansion can have negative cumulative affects on infauna, SAV, and salt marsh habitat. Another aspect of the Wilmington Harbor project involves nourishing Oak Island and Holden Beach, which provides positive cumulative effects for nesting turtles, birds, and seabeach amaranth. It can be assumed that the Wilmington Harbor project has a high magnitude and significance for resources.

### 7.6.1 Nags Head/Kitty Hawk Dredge Disposal

In January of 2000, dredging of the North Channel, which runs from Shallowbag Bay north around the end of Roanoke Island, provided approximately 125,000 cubic yards of material to nourish the beaches in the Town of Nags Head. Dredging of a section of the Manteo to Wanchese Channel, south of Baum Bridge, placed another 75,000 cubic yards of material on Nags Head beach in 2001. The material from the North Channel and the Manteo to Wanchese Channel contained a considerable percentage of silt, which is not likely to be allowed in the future.

The USACE received $500,000 to begin construction on a long-term beach replenishment project in Kitty Hawk, Kill Devil Hills, Nags Head, and South Nags Head in 2003. Congress authorized the project in 2000 with passage of the Water Resources Development Act. The project is expected to begin in November 2004 and is scheduled to be completed in 2007. The project involves 50 years of beach renourishment on a three-year schedule.

### 7.6.2 Beaufort Inlet Nearshore and Offshore Disposal Sites

The material removed from the outer parts of Morehead City Harbor prior to 1996 has been disposed of in an offshore dredge material disposal site. In 1993, the North Carolina Division of Coastal Management proposed that the USACE modify the project to include alternatives that would preferably dispose dredged material on the ocean beach or shallow active nearshore area rather than in offshore disposal sites. In order to comply with the State's request, the USACE constructed a nearshore berm complex located along the 25-foot bathymetric contour that allows the beach-quality sand from maintenance dredging to be incorporated into the littoral cell feeding Bogue Banks. The nearshore berm was initially constructed in 1996 and has been used for dredge disposal in all subsequent projects.

### 7.6.3 Emerald Isle Dredge Disposal

In 2001/2002 and 2002/2003 periodic sand disposal on Emerald Isle was obtained from the Morehead City Harbor Project. Future disposals on Emerald Isle area expected in 2003/2004.

### 7.6.4 Onslow Bay Dredge Disposal Islands

No Information available.

### 7.6.5 Cape Fear River (Wilmington Harbor) Dredging

The Wilmington Harbor Project deepened 37 miles of channel in the Cape Fear River to the State Port of Wilmington, and into the Northeast Cape Fear River. Project completion is scheduled for March 2005 and involves various improvements including sand placement on Caswell Beach, Oak Island, and Holden Beach as part of the Section 933 project; raising dikes on Eagle Island to an elevation of 12.1 m (40 ft) over a 20-year period; and deepening the ocean bar and entrance channels (Cape Fear River) from 12.1 m (40 ft) to 13.4 m (44 ft). The beach disposal operations for Caswell Beach, Oak Island and Holden Beach were completed in 2002 and the USACE is presently planning the first maintenance dredging of the deepened entrance channel with disposal occurring on Bald Head Island.

## 7.7 Soft Structure Projects

The initial use of sandbags for shore protection occurred in the early 1970's when the State sponsored construction of numerous sandbag groins along Atlantic Beach, Bogue Inlet, Oak Island, and Lockwoods Folly Inlet. With the State's ban on hard structures, individual property owners have turned to sandbags to provide "temporary" protection to their property. While sandbags are permitted for two years for individual buildings and five years for major structures including roads, extensions are granted on a case-by-case basis.

Studies of soft structures and their impacts on resources have not been published for large-scale projects in North Carolina. Therefore, it is not known how sandbags and sandbag revetments cumulatively affect birds, shellfish, infauna, marine mammals, sea turtles, or seabeach amaranth. These structures are designed to aid in erosion control and help prevent the loss of beach habitat. By reducing the effects of erosion, sandbags may temporarily increase water quality by preventing turbidity in the water column. Therefore, water quality, SAV, and salt marsh habitat can be assumed to be indirectly affected in a positive manner.

Minimal cumulative effects are assumed to result from soft structure stabilization projects due to the limited time placement. However, the North Carolina Coastal Resource Commission (CRC) adopted a rule that allows oceanfront property owners in towns pursuing beach nourishment to keep sandbags in place until May 1, 2008. The effects of long-term sandbag placement on environmental resources are unknown and may need to be considered in future projects.

### 7.7.1 Bogue Inlet Sandbags

Presently, seven homeowners and the Town of Emerald Isle have responded to the erosion threat along the ebb channel in Bogue Inlet by constructing temporary sandbag revetments to protect threatened homes and infrastructure. The existing sandbag revetment covers approximately 700 feet of the inlet shoreline and has been effective in protecting the threatened homes and roads albeit not without some maintenance.

### 7.7.2 Topsail Island Sandbags

Sandbags were placed by private property owners on North Topsail Island's ocean shoreline to protect against severe erosion and to provide protection of property from large storms and hurricanes.

### 7.7.3 Figure 8 Island Sandbags

A sandbag wall was constructed on the northern end of the island to protect the Figure 8 shoreline from erosion resulting from the migration of Mason Inlet. The relocation of Mason Inlet is expected to eliminate the need for sandbags.

### 7.7.4 Mason Inlet Sandbag Revetment

Shell Island Resort sits along the southern side of Mason Inlet. In 1997, a temporary sandbag installation was constructed to prevent Mason Inlet from completely eroding that portion of the barrier island occupied by the hotel. The revetment is 6 m (20 ft) high, 130 m (425 ft) long and formed of geotextile material. With relocation of Mason Inlet in 2002, the need for sandbags to protect the hotel has been eliminated.

### 7.7.5 Holden Beach Sandbags

Property owners of Holden Beach have installed and maintained sandbags to protect threatened structures within the Town. The effects of Tropical Storm Dennis in 1999, increased the need for shore protection in the area.

### 7.7.6 Ocean Isle Sandbags

Sandbags were placed along Ocean Isle in 1994 to slow erosion and protect waterside property. The Ocean Isle installation is permitted until May 1, 2008, in recognition of the local sponsor's efforts to implement a beach nourishment project. The Coastal Resource Commission (CRC) adopted a rule in 2002 that allows oceanfront property owners in towns pursuing beach nourishment projects to keep their protective sandbags in place until May 1, 2008.

## 7.8 Dredge Disposal Projects

Each year, the USACE contracts to remove shoal material from inlet crossings with this material placed on the ocean shorelines near the inlets. The inlet crossings maintained and the designated disposal areas include: Shallotte Inlet/east end of Ocean Isle; Lockwoods Folly Inlet/east end of Holden Beach and west end of Oak Island on alternate years; Carolina Beach Inlet/north end of Carolina Beach near the inlet; New Topsail Inlet/southwest end of Topsail Beach; New River Inlet/North Topsail Beach, and Bogue Inlet/west end of Emerald Isle. The amount of material removed from each inlet crossing ranges from 50,000 to 100,000 cy with the material distributed along approximately 1,500 ft to 2,000 ft of shoreline.

### 7.8.1 Atlantic Beach Dredge Disposal

USACE Dredge Disposal to Eastern Bogue Banks occurred in 1978, 1986, and 1994. As discussed previously, sediment dredged from the inner harbor is stockpiled on Brandt Island where it is subsequently discharged (pump out) to the beaches of Fort Macon and Atlantic Beach every eight to ten years. The next pumpout of Brandt Island is scheduled for the winter of 2003-04.

### 7.8.2 Pine Knoll Shores Dredge Disposal

Dredge material from the channel adjacent to Indian Beach and Pine Knoll Shores is taken to an offshore disposal site, as of April 2002 or to a nearshore berm located in about 25 feet of water west of the Beaufort Inlet entrance channel. Suggestions have been made to use this sand which is inexpensive and of high quality to nourish beaches instead of the Corps depositing the material at an offshore site. Previous disposal operations for material from Brandt Island and the Beaufort Inlet entrance channel under the Section 933 project is supposed to include about 1 mile of Pine Knoll Shores shoreline. However, the two previous disposal operations did not extend past the west town limits of Atlantic Beach, and thus, no material was placed on Pine Knoll Shores.

## 7.9 Hard Structure Projects

Hard structures such as jetties and groins can provide both positive and negative impacts to flora and fauna. For example, these structures can sometimes cause erosion or create accretion along surrounding areas. The Oregon Inlet jetties were determined to cause erosion along Cape Hatteras, North Carolina and Pea Island, and since Pea Island is a National Wildlife Refuge, it was determined that there may be negative cumulative affects to important wildlife in the area. The White House Council on Environmental Quality, the USACE, and the Commerce Department in May 2003 decided not to build the jetties and to find alternatives to aid in the prevention of erosion along the inlet.

Other hardened inlet stabilization projects, such as the Masonboro Inlet Jetties, function as sediment traps that retain sand for use in future beach nourishment activities. This activity can be cumulatively positive for birds, nesting turtles, and seabeach amaranth by providing habitat for these resources. Cumulative effects to infauna may result from the construction of jetties, such as in Masonboro Inlet, where the structures were constructed on top of infaunal habitat.

Studies of the effects of beach nourishment activities on benthic communities suggest that direct mortality to infauna results from the placement of the dredged material onto a dry beach. However, recruitment and repopulation of the infauna to the dredge and fill sites can occur rather quickly (one to three years), and the net result is a slight change in community diversity. Therefore, negative cumulative effects to the benthic community are not expected to result from beach nourishment projects. Overall the effects and significance of hard shoreline and inlet stabilization structures on environmental resources is low (Table 7.1).

### 7.9.1 Oregon Inlet Jetties

The construction of jetties along Oregon Inlet has been repeatedly proposed since 1970. In May 2003, the White House Council on Environmental Quality, the USACE, and the Department of the Interior and Department of Commerce reached an agreement to find alternatives to aid in the prevention of erosion and provide safe navigation through the inlet.

### 7.9.2 Oregon Inlet Terminal Groin

Because of the ongoing migration of Oregon Inlet, the construction of a terminal groin in 1991 was completed to prevent the highway from being cut off from the south side of the Herbert Bonner Bridge. The groin was placed at the northern end of Pea Island to reinforce the tip of Pea Island and protect the base of the Bonner Bridge. The groin is responsible for accretion on the northern tip of Pea Island and a monitoring program is in place to document shoreline changes north and south of Oregon Inlet.

### 7.9.3 Cape Lookout Jetty

Cape Lookout jetty is the remnant of an early 1900s breakwater project that was never completed. The jetty is not trapping sediment on its updrift side, but, through sediment bypassing, allows the formation of extensive spit growth on its downdrift side.

### 7.9.4 Shackleford Banks Jetty

The jetties at Shackleford Banks are internal jetties, located about a mile east of the western end of the Banks. Most of the jetty is submerged and water moves over and around the rocks.

### 7.9.5 Fort Macon Jetty & Groins

As part of a Federal/local cooperative beach erosion control project, the State of North Carolina constructed a project to protect Fort Macon in the early to mid 1960's. The project included construction of a revetment along the west shore of Beaufort Inlet that is attached to a terminal groin. The project was modified in 1966 by the State to include a radial groin just inside the terminal groin.

### 7.9.6 Masonboro Inlet Jetties and Dredging

A rock jetty and a weir jetty stabilize Masonboro Inlet, located at the south end of Wrightsville Beach. The USACE constructed the Masonboro Inlet north jetty with weir in 1965 and 1966. A deposition basin was dredged in 1965 adjacent to the weir north of Masonboro Inlet with the material placed on Wrightsville Beach. Between 1966 and 1970, the inlet channel migrated north and assumed a position immediately adjacent to the north jetty, which rendered the sediment trap ineffective and caused numerous problems with undermining of the rubble structure and concrete sheet pile weir. The south jetty, completed in 1981, allowed for relocation of the channel and controlled sediment entrapment within the inlet. Since 1981, material has been routinely removed from the inlet and bypassed to both Wrightsville Beach and Masonboro Island.

## 7.10 Habitat Restoration Projects

Habitat restoration projects are constructed to aesthetically and environmentally improve an area typically degraded by human activity. The Bogue Banks Beach Scraping Project is assumed to have only minimal effects on listed resources, since the sand is relocated to another location, and may be more efficient or effective for flora and fauna usage.

The NC 12 Dune Maintenance Project on Hatteras Island (December 2001) provided 56 miles of continuous dune habitat that is used by birds and seabeach amaranth. Burger (1994) stated that birds will utilize dune habitat to forage since it is secluded from human activity. The NC 12 Dune Maintenance project can be assumed to have positive cumulative affects on birds and seabeach amaranth since it provides a place for birds to forage and roost, as well as, habitat for the growth of seabeach amaranth.

### 7.10.1 Bogue Banks Beach Scraping
Until recently, CAMA allowed bulldozing of beach sand on Emerald Isle as a method of shoreline stabilization. The practice is viewed as a short-term response to shoreline recession.

### 7.10.2 NC Highway 12 Dune Maintenance – Hatteras Island
Dune construction on Hatteras Island was completed in December 2001. Approximately 56 miles of continuous dune line is maintained to protect State Highway 12, which runs the length of the island, through Cape Hatteras National Seashore and Pea Island National Wildlife Refuge and is the only highway on the islands of Hatteras and Ocracoke.

## 7.11 Other Actions
Other non-project related impacts can have an affect on the environmental resources of Bogue Inlet. The following actions were included in this assessment because of the potential overwhelming effect these actions could have on the resources identified in the geographic range of this analysis. The considered actions are both natural and human induced activities that are not directly related to the proposed channel relocation project.

### 7.11.1 Hurricanes
The Bogue Inlet area is periodically subjected to hurricanes and tropical storms. Five major hurricanes of Category 2 or greater (Safford-Simpson Scale) have affected the area between 1996 and 1999, including Hurricanes Fran (1996), Bertha (1996), Dennis (1999), Floyd (1999), and Irene (1999). Of these six hurricanes, the strongest was Fran (Category 3). Hurricane Fran created a storm surge of 2.4 to 3 meters (8-12 feet) above mean tide and 6.1 meter (20 foot) waves impacted the coast.

Hurricane floodwaters can impact the hydrologic and chemical characteristics of an estuarine system. Impacts include changes to salinity from rainfall and freshwater runoff, increases in organic matter, and decreases in dissolved oxygen levels. These impacts have been shown to have direct, short-term, physiological effects on estuarine macrofauna and greatly reduce the habitable area for residential fish and shellfish species in the system (Paerl et al., 2001). Many motile species are able to move out of affected estuaries, but sessile benthic invertebrates can become stressed or killed by exposure to low salinity, hypoxic waters. Additionally, hurricanes can move large quantities of sediment within the barrier island and inlet complex, which can lead to changes in the dynamics of a shoal system thereby affecting birds. Water quality can recover from the extensive flooding that results from these storms; however, human activities paired with hurricane events can increase the extent, duration, and severity of water quality impacts.

### 7.11.2 Population Increase
An increase in human population on Bogue Banks, coupled with increased tourism to the area can also affect the resources of Bogue Inlet. Significant population and tourism increases in Carteret and Onlsow counties have occurred for the past twenty-five years. The population of Emerald Isle has increased by 43.3% in the past ten years to approximately 3,500 (in 2002) (NCDENR, 2001; U.S. Census Bureau, 2003). Seasonal population of Emerald Isle is approximately 16,000 during peak tourist season. Increases in population create pressure to find more available recreational areas to satisfy the growing communities which makes preservation and conservation of natural areas difficult to manage. With increases in human population,

increases in pollution and demands on natural resources result. These activities can directly affect the environment and the resources associated with natural communities.

### 7.11.3 Shellfish Harvesting

Oyster (*Crassostrea virginicus*) harvesting in North Carolina was the most valuable shellfishery in the state until the 1970's (NCDMF, 2001). Currently, oyster (and other shellfish) stocks are in a decline due to overharvesting and are considered depleted.

In the past, harvesting shellfish in North Carolina waters included the use of mechanical dredging methods. However, mechanical fishing gear dislodges or removes critical shellfish habitat and physically destroys the shellfish. Mechanical harvesting was ultimately banned for use in the shallow areas behind the Outer Banks from Oregon Inlet to Core Sound and its tributaries; North Bay, The Straits, Back Sound, North River, Newport River, Bogue Sound, White Oak River; and all of the coastal waters of Onslow, Pender, New Hanover, and Brunswick Counties. Oyster reefs and other shellfish beds are significant biological and physical entities in North Carolina, providing hard substrate and habitat for other marine organisms such as fishes and invertebrates. Under the current regulations, only rakes and tongs or the un-aided hand can be used to collect shellfish, although rakes and tongs can also disturb shellfish habitat.

Oyster harvesting is the most obvious factor affecting the condition of oyster rock (NCDMF, 2001). Negative ecological effects of fishing result from over-harvesting of target species, incidental mortality of nontarget species, and fishery-related disturbances to marine habitats. Oyster reefs that have been fished heavily lose vertical profile and are more likely to be affected by sedimentation, which can smother live oysters and inhibit oyster recruitment. The complexity of oyster beds is important in estuaries as they provide suitable habitat for hard clam (*Mercenaria mercenaria*) settlement and growth in areas where salinity regimes and water flow are suitable for clam survival. Eastern oysters can form large reefs that provide habitat to many species of fishes, invertebrates, and algae (Lenihan and Peterson, 1998). Research shows that shellfish harvesting has obvious negative effects on populations where there is a significant decrease in the number of live oysters on clam-harvested and oyster-harvested reefs compared with non-harvested, control reefs (Lenihan and Micheli, 2000). The tongs and rakes used in clam fishing kills oysters by either cracking or puncturing their shells, or indirectly when buried or smothered below sediments that are disturbed in the process of digging for buried clams (Lenihan and Micheli, 2000). Clams are motile so the effect of oyster and clam harvesting on naturally occurring population of hard clams is less clear. However, clam harvesting, both along and in combination with oyster harvesting decrease densities of live clams by 50-90% compared with non-harvested areas. Oyster harvesting alone may have a negative effect on clams by direct removal of clams as bycatch and enhanced clam mortality through the same mechanisms previously hypothesized for oysters.

Shellfish can also be affected by diseases from a variety of sources, including upland runoff. *Perkinsus marinus*, also known as Dermo, is a parasite that attacks the stomach and intestine of oysters and causes death within three years. The impact from Dermo and another parasite called MSX resulted in a decrease in landings of oysters in North Carolina (mainly Pamlico Sound) from 1988 to 2001 (NCCF, 2002).

The first documented red tide event (*Gymnodinium breve*) in North Carolina was recorded in October 1987 and lasted until January 1988 and resulted in the closure of 98% of shellfish harvesting areas in the state. *G. breve* produces a neurotoxin that accumulates in filter feeders

and this red tide event killed an estimated 21% of adult scallops (*Argopecten irradians concentricus*) (Summerson and Peterson, 1990).

### 7.11.4 Agricultural Impacts

Agricultural pollution is a significant water quality concern in North Carolina. Swine waste, fertilizers, pesticides, and other fecal bacteria contribute to the decline in water quality in North Carolina's riverine systems. These pollutants can be transported to coastal estuaries and affect water quality in the bays and sounds.

**Table 7.1**

**Resource Effect Assessment from Past, Present, and Reasonably Foreseeable Future (RFFA) Projects (50 years)**

| PROJECT TYPES | RESOURCES | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Inlet Projects** | **Birds** | **Shellfish** | **Infauna** | **Nesting Sea Turtles** | **Seabeach Amaranth** | **SAV** | **Salt Marsh** | **Water Quality** |
| **Inlet Openings** | | | | | | | | |
| Drum Inlet Opening & Dredging | -D/-C | -D/-C | -D/-C | -C | -C | -I | -D/-C | +C |
| Carolina Beach Inlet Opening | -D/-C | -I/+C | -D/-C | -C | -C | -I/+C | -I/+C | -D/+C |
| **Inlet Closures** | | | | | | | | |
| Moore Inlet Closure | -D/+C | -D | -D/-C | +C | +C | -D | -D | -D |
| **Inlet Navigation Projects** | | | | | | | | |
| Oregon Inlet Dredging & Disposal | -D/+C | -I | -D | +C | +C | -I | -I | -D |
| Hatteras Inlet Dredging | -D | -I | -D | U | U | -I | -I | -D |
| Beaufort Inlet Dredging | -D | -I | -D | U | U | -I | -I | -D/-C |
| Bogue Inlet Dredging | -D | -I | -D/-C | U | U | -I/-C | -I/-C | -D |
| New River Inlet Dredging | -D/+C | -C | -D | -C | -C | -I | -I | -D |
| New Topsail Inlet Dredging | -D/-C | -I | -D | U | U | -I | -I | -D |
| Rich Inlet Dredging | -D/+C | -D/-I | -D/-C | +C | +C | -D/-I | -D/-I | -D |
| Carolina Beach Inlet Dredging | -D | -I | -D | U | U | -I | -I | -D |
| Tubbs Inlet Dredging | -D/+C | -I | -D | +C | +C | -I | -I | -D |
| Shallotte Inlet Dredging | -D/+C | -I | -D | +C | +C | -I | -I | -D |
| Lockwood's Folly Inlet Dredging | -D | -D/-I | -D | U | U | -D/-I | -D/-I | -D |
| **Inlet Relocations** | | | | | | | | |
| Bogue Inlet Relocation | -D/+C | U | -D | +C | +C | U | U | -D |
| Mason Inlet Relocation | -D/+C | -I/+C | -D | +C | +C | -I/+C | -I/-C | -D/+C |
| Tubbs Inlet Relocation | -D | -I | -D | U | U | -I | -I | -D |
| **Beach Nourishment Projects** | | | | | | | | |
| Carteret Co. Bogue Banks Beach Restoration Project | -D/+C | U | -D | +C | +C | U | U | -D |
| Dare County Beaches North Beach Nourishment | -D/+C | U | -D | +C | +C | U | U | -D |
| Bogue Banks Beach Nourishment | -D/+C | U | -D | -D/+C | +C | U | U | -D |
| * Camp Lejune Beach Nourishment | -D/+C | U | -D | +C | +C | U | U | -D |
| Topsail Island Beach Nourishment | -D/+C | U | -D | +C | +C | U | U | -D |
| Topsail Beach/West Onslow Beach Nourishment& Terminal Groin | -D/+C | U | -D | +C | +C | U | U | -D |
| Figure 8 Island Beach Nourishment | -D/+C | U | -D | +C | +C | U | U | -D |
| Wrightsville Beach Beach Nourishment | -D/+C | U | -D | +C | +C | U | U | -D |
| Carolina Beach Beach Nourishment | -D/+C | U | -D | +C | +C | U | U | -D |
| Kure Beach Beach Nourishment | -D/+C | U | -D | +C | +C | U | U | -D |
| Fort Fisher Revetment | -D/+C | U | -D | +C | +C | U | U | -D |
| Bald Head Island Beach Nourishment | -D/+C | U | -D | +C | +C | U | U | -D |
| Oak Island Beach Nourishment | -D/+C | U | -D | +C | +C | U | U | -D |
| Holden Beach Beach Nourishment | -D/+C | U | -D | +C | +C | U | U | -D |
| Ocean Isle Beach Nourishment | -D/+C | U | -D | +C | +C | U | U | -D |

**D = Direct Effect**
**I = Indirect Effect**
**C = Cumulative Effect**
**U = Unknown Effect**
**Negative = - Effects**
**Positive = + Effects**

*** Assessment based on similar type project**

**Table 7.1 Cont'd**

**Resource Effect Assessment from Past, Present, and Reasonably Forseeable Future (RFFA) Projects (50 years)**

| PROJECT TYPES | RESOURCES | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Maintenance Dredging Projects** | **Birds** | **Shellfish** | **Infauna** | **Sea Turtles** | **Seabeach Amaranth** | **SAV** | **Salt Marsh** | **Water Quality** |
| Nags Head/Kitty Hawk Dredge Disposal | **-D/+C** | **-D** | **-D** | **+C** | **+C** | **-D** | **-D** | **-D** |
| Beaufort Inlet Nearshore & Offshore Disposal Sites | **U** | **U** | **-D** | **U** | **U** | **U** | **U** | **-D** |
| Emerald Isle Dredge Disposal | **+C** | **U** | **U** | **+C** | **+C** | **U** | **U** | **U** |
| Onslow Bay Dredge Disposal Islands | **+C** | **U** | **U** | **U** | **U** | **U** | **U** | **U** |
| Cape Fear River (Wilmington Harbor) Dredging | **-D/+C** | **-D/-I** | **-D/-C** | **-D/+C** | **+C** | **-D/-C** | **-D/-C** | **-D** |
| **Soft Structure Projects** | | | | | | | | |
| Topsail lsland Sand Bags | **U** | **U** | **U** | **U** | **U** | **+I** | **+I** | **+I** |
| Figure 8 Island Sandbags | **U** | **U** | **U** | **U** | **U** | **+I** | **+I** | **+I** |
| Mason Inlet Sandbag Revetment | **U** | **U** | **U** | **U** | **U** | **+I** | **+I** | **+I** |
| Holden Beach Sandbags | **U** | **U** | **U** | **U** | **U** | **+I** | **+I** | **+I** |
| Ocean Isle Sandbags | **U** | **U** | **U** | **U** | **U** | **+I** | **+I** | **+I** |
| **Dredge Disposal Projects** | | | | | | | | |
| Atlantic Beach Dredge Disposal | **-D/+C** | **U** | **-D** | **-I** | **-I** | **U** | **U** | **U** |
| Pine Knoll Shores Dredge Disposal | **-D/+C** | **U** | **-D** | **-I** | **-I** | **U** | **U** | **U** |
| **Hard Structure Projects** | | | | | | | | |
| Oregon Inlet Jetties | **-C** | **U** | **-D** | **-C** | **-C** | **U** | **U** | **-D** |
| Oregon Inlet Terminal Groin | **+C** | **U** | **-D** | **+C** | **+C** | **U** | **U** | **-D** |
| Cape Lookout Jetty | **+C** | **U** | **U** | **+C** | **+C** | **U** | **U** | **U** |
| Shackleford Banks Jetty | **+C** | **U** | **U** | **+C** | **U** | **U** | **U** | **U** |
| Fort Macon Jetty & Groins | **+C** | **U** | **U** | **+C** | **+C** | **U** | **U** | **U** |
| Masonboro Inlet Jetties & Dredging | **-D/+C** | **U** | **-D/-C** | **-I/+C** | **-I/+C** | **U** | **U** | **-D** |
| **Habitat Restoration Projects** | | | | | | | | |
| Bogue Banks Beach Scraping | **-D** | **U** | **-D** | **+I** | **-D/+I** | **U** | **U** | **-D** |
| NC 12 Dune Maintenance - Hatteras Island | **-D/+C** | **U** | **U** | **U** | **+C** | **U** | **U** | **U** |

| **Cumulative Effects Determination** | **Positive (35+/4-)** | **Negative (2+/3-)** | **Negative (0+/7-)** | **Positive (29+/4-)** | **Positive (30+/4-)** | **Negative (2+/3-)** | **Negative (1+/5-)** | **Positive (3+/2-)** |
|---|---|---|---|---|---|---|---|---|

**D = Direct Effect**
**I = Indirect Effect**
**C = Cumulative Effect**
**U = Unknown Effect**
**Negative = - Effects**
**Positive = + Effects**

Note: The determination of cumulative effects took into account the ability of the resource to resond to changes in their environment, as well as the geographic scope and timeframe of the analysis.