2.0 PROJECT IMPACT ASSESSMENT

Two study areas were identified in order to delineate and differentiate between areas anticipated to receive primary and secondary effects and areas that are used to analyze cumulative effects within the Bogue Inlet complex. The study area for primary and secondary effects is the Permit Area/Project Impact Zone; and the boundary limits for analyzing cumulative effects is known as the Project/Survey Area. For this particular document we will be referring to these two areas as Permit Area and Project Area. The basis for determining the Permit Area was identified from the hydrodynamic modeling results (Appendix B - Engineering Report [Appendix D - Hydrodynamic Model]), as well as from the sedimentation analysis conducted for Bogue Inlet (Appendix B - Engineering Report [Sections 5 and 6]). Based on these analyses, the area of effect was predicted to occur in the immediate vicinity of the Bogue Inlet complex and along the southern portions of the Western Channel and Main Ebb Channel. A buffer zone was added, which included known aquatic resources directly bordering the area of effect, to the predicted zone of influence by extending the Permit Area further up the reach of the Western and Main Ebb Channels, to the Atlantic Intracoastal Waterway. The Permit Area encompasses portions of Bear Island, approximately 3,000 feet offshore of Bogue Inlet, and approximately 4.5 miles of the Emerald Isle shoreline (from the intersection of Sea Breeze Road and South Windjammer to the Land's End Subdivision). The Project Area was developed for the purpose of evaluating each resource and how each resource relates to the proposed action, in terms of determining the significance of the cumulative impacts of the proposed actions on that particular resource. See Appendix A for Permit and Project Area maps.

Engineering and Geotechnical Studies developed for the project show that Islands No. 1 and 2 are eroding in response to the westward movement of the Eastern Channel, as a result of the growth of the Bogue Banks spit. Pre- and post-construction digital aerial imagery and field investigations of the low and high marsh will be utilized to assess cumulative effects associated with the project.

3.0 COMPONENTS OF CUMULATIVE EFFECTS ASSESSMENT

Pursuant to the Council of Environmental Quality's (CEQ) regulations (40 CFR §§ 1500-1508) with implementing procedural provisions of the National Environmental Policy Act (NEPA) of 1969 as amended (42 U.S.C. §§ 4321 et seq.) this document includes an assessment of cumulative effects from the proposed channel re-alignment of Bogue Inlet and the affects to resources from other projects. CEQ defines cumulative effects as *the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable actions regardless of what agency (Federal or non-Federal) or person undertakes such other action* (40 CFR 1508.7).

The development of the Cumulative Effects Assessment (CEA) utilized both the CEQs "Considering Cumulative Effects Under the National Environmental Policy Act" (1997) and comments from agencies. These provide a framework for the analysis, as well as recommendations for addressing cumulative effects.

This assessment will provide an analysis on cumulative effects from the proposed project, as well as affects from other projects. Cumulative impacts can result from individually minor, but collectively significant actions taking place over a period of time. The principle elements associated with the development of the CEA include: 1) identifying environmental resources, ecosystems and human communities; 2) assessment of baseline conditions in the project area; 3)

identifying a range of project alternatives and related actions; and 4) analyzing cumulative effects from other projects in the region from both a spatial and temporal scale.

The CEA process is based on three main components of an environmental impact assessment with eleven detailed steps to the analysis. The main components include: 1) scoping, 2) describing the affected environment, and 3) determining the environmental consequences. The eleven step method of the assessment is to assist in finalizing the project alternatives and developing a mitigation plan. Table 3.1 lists the three components and associated steps used to develop cumulative effects analysis.

Table 3.1 Steps in Cumulative Effects Analysis to be Addressed in each Component of the Environmental Impact Assessment (CEQ 1997)

Environmental Impact Assessment Components	**Cumulative Effects Analysis Steps**
Scoping	1. Identify the significant cumulative effects issues associated with the proposed action and define the assessment goals.
	2. Establish the geographic scope for the analysis.
	3. Establish the time frame for the analysis.
	4. Identify other actions affecting the resources, ecosystems, and human communities of concern.
Describing the Affected Environment	5. Characterize the resources, ecosystems, and human communities identified in scoping in terms of their response to change and capacity to withstand stresses.
	6. Characterize the stresses affecting these resources, ecosystems, and human communities and their relation to regulatory thresholds.
	7. Define a baseline condition for the resources, ecosystems, and human communities.
Determining the Environmental Consequences	8. Identify the important cause-and-effect relationships between human activities and resources, ecosystems, and human communities.
	9. Determine the magnitude and significance of cumulative effects.
	10. Modify or add alternatives to avoid, minimize, or mitigate significant cumulative effects.
	11. Monitor the cumulative effects of the selected alternative and adapt management.

The proposed project has been designed to meet the needs of the present without compromising the ability of future needs. This statement corresponds with the objectives of the World Commission on Environment and Development (1987) and the President's Council on Sustainable Development (1996) in planning for sustainable development.

4.0 CEA STEP 1 – IDENTIFYING CUMULATIVE EFFECTS ISSUES

Step 1 includes a description of potentially affected resources, ecosystems and human communities; identifying the direct and indirect effects of the proposed project; and identifying important effects on the resources from a cumulative effects perspective.

4.1 Potential Affected Resources, Ecosystems and Human Communities

The types of resources identified in the permit area are species and habitat that could be cumulatively affected by the project and associated work. These resources include: birds, both shorebirds and waterbirds, Federally protected species, piping plover, piping plover critical habitat, seabeach amaranth, and nesting sea turtles; Submerged Aquatic Vegetation (SAV); saltwater marsh ecosystem of Dudley Island, west end of Bogue Sound and Hammocks Beach State Park; shellfish and their habitats; food resources necessary for the sustainability of species (benthic community); finfish; and surface water quality.

4.2 Cumulative Effects Perspective

This section of the CEA discusses whether the proposed activities will have effects similar to other actions in the area and whether the resources within the project area have been historically affected by the cumulative actions of previous projects.

4.2.1 Cumulative Effects to Birds

The primary concerns regarding cumulative effects to shorebirds and waterbirds is habitat loss.

4.2.1.1 Cumulative Effects to Shorebirds

Habitat loss and degradation, disturbance by humans and pets, and increased predation can contribute significantly to the downward population trend of piping plovers (*Charadrius melodus*). According to the U.S. Fish and Wildlife Service (USFWS), the primary threats to piping plovers along the Atlantic coast are habitat modification, destruction, and human disturbance that has contributed greatly to the loss of piping plover nesting habitat. Additionally, the loss of wintering habitat can be attributed to coastal development, including inlet and shore stabilization activities. (USFWS, 2002)

The goals of the cumulative effects assessment are 1) to provide optimum breeding habitat for the maintenance and growth of priority species, 2) to provide high quality managed habitat for the support of species migrating through or spending the winter in the region, and 3) to restrict human disturbance of shorebirds to the greatest extent possible during the project term. Cumulative impact goals should maintain disturbance frequencies below tolerance levels than enable birds to obtain fat storage needed for long-distance migrations.

4.2.1.2 Cumulative Effects to Waterbirds

The greatest overall threat to waterbirds is a reduction in the quantity and quality of habitat.
Kushlan and Steinkamp (2002) found that adult mortality is the most critical demographic parameter in determining population stability. Cumulative effects must not decrease the quality or quantity of key habitats (intertidal flats and sand spits) for waterbirds.

4.2.2 Cumulative Effects to Shellfish

Water quality, disease, predation, over-harvesting and habitat destruction have contributed significantly to the decline of shellfish populations, especially oysters (*Crassostrea virginicus*), in recent years. A decrease in water quality can occur from river or stormwater runoff; and paired with solar heating can cause a reduction in dissolved oxygen in waters used by shellfish

(Lenihan and Peterson, 1998). Because some species of shellfish reside in submerged aquatic vegetative (SAV) habitats, persistently high turbidity levels that affect SAV's can also affect shellfish populations. Runoff can contribute to sediment loading, nutrient loading, fecal coliform contamination, and the presence of other contaminants that are funneled into areas utilized by shellfish.

Disease and parasites (e.g. *Perkinsus marinus*) can also contribute to an increase in environmental stresses. Environmental stress lowers the ability of the shellfish to resist disease and parasites and can cause mortality.

4.2.3 Cumulative Effects to the Benthic Community

Suffocation or loss of food sources and habitat can result in the reduction or elimination of benthic communities. Sustainability of benthic macroinvertebrates and infaunal species complex habitat can be significantly affected by sediment deposition (Waters, 1995). A lack of adequate tidal flushing and water flow can contribute to poor water quality conditions for benthic communities, possibly leading to cumulative effects. Hypoxic conditions can also contribute to detrimental effects to infaunal species, since oxygen and pore space of sediments are needed for their survival.

4.2.4 Cumulative Effects to Nesting Sea Turtles

Available beach habitat and compatibility of sand can cumulatively effect the nesting and hatching success of sea turtles. The environment of the nest is influenced by the type, size and sorting of the sand (Crain et al., 1995). Successful development of embryonic sea turtles is dependent upon the conditions found within the nest environment, including incubation temperatures that can be altered by the color of the sand. Nest cavity factors affecting embryonic development include water content, gas exchange and the temperature of the surrounding sand (Ackerman, 1997).

4.2.5 Cumulative Effects to Seabeach Amaranth

Cumulative effects to seabeach amaranth (*Amaranthus pumilus*) include beach stabilization structures, beach erosion and tidal inundation, beach grooming, herbivory by insects (webworm) and feral animals and off-road vehicles (USMC, 2003).

The construction of seawalls, groins, jetties and other hard structures on the beach has been found to disrupt the natural movement of sand, preventing the creation of new habitat. Available habitat for the plant has been lost due to the installation of these structures north of Cape Lookout. North Carolina state law prohibits the construction of hard structures, which may be why the plant is still found throughout the North Carolina coastline including the three island of the Cape Lookout National Seashore (NPS, 2001).

4.2.6 Cumulative Effects to Submerged Aquatic Vegetation (SAV)

Cumulative effects to submerged aquatic vegetation are most typically caused by excessive nutrient loading from non-point source pollution. Excessive nutrient loading can lead to and increase algal blooms resulting in a reduction in water clarity, the ultimate dying off of seagrass beds and the increase in sediment loads. Other contributing factors include light intensity, salinity levels, substrate, temperature, water currents and wave action. Each of these can influence the spatial and temporal distribution of SAV, however salinity is the primary influencing factor.

4.2.7 Cumulative Effects to Salt Marsh Ecosystems

The U.S. EPA (2000) has identified global warming and sea level rise as a major factor in the cumulative loss of wetlands in the State of North Carolina. North Carolina has 3,375-miles of tidally influenced shoreline, consisting of a long chain of barrier islands, including the Outer Banks, and extensive salt marshes and tidal freshwater marshes formed behind these barrier islands (EPA, 2000). The EPA has predicted that the effects of sea level rise will initially cause coastal marshes to expand by spreading onto low-lying terraces, particularly in and around Albemarle Sound. However, further changes in the extent of coastal wetlands will vary depending on location, although a significant loss of wetlands may be possible in some areas.

Generally, estuarine habitat is being lost or degraded in direct proportion to human population density in coastal areas. Much of the decline of salt marsh has been through alteration to the flow of water to these habitats, such as dams, levees, dikes, dredge and fill operations, drainage, and roadways (NOAA, 2001).

4.2.8 Cumulative Effects to Water Quality

Cumulative effects to water quality conditions in estuarine environments are influenced by changes in salinity regime; impacts from runoff (including nutrient, phosphate, bacteria and sediment loading); point source pollutants (including sewage and stormwater discharge); and tidal flushing. The distribution and survival of estuarine-dependent fish, shellfish and SAV are sensitive to the changes and fluctuations in saline conditions. Changes in salinity are most readily influenced by a change in flow volumes due to a constriction of flow in the waterway.

The White Oak River Basinwide Water Quality Plan indicates that "continued development, road building, wetland ditching and draining, and poor de-snagging practices have the potential to cause degradation of aquatic habitats and water quality in the White Oak River…"(NCDWQ, 2001).

5.0 CEA STEP 2 - GEOGRAPHIC SCOPE

The geographic boundary of the Bogue Inlet Channel Erosion Response Project includes the Project Area as shown in Appendix A.

6.0 CEA STEP 3 - TIMEFRAME FOR ANALYSIS

The timeframe for the cumulative effects analysis ranges from the earliest construction dates of shoreline and inlet stabilization projects, through the present, to 50 years into the future. The timeframe for analysis reflects the typical planning life of a federal shore protection project. Based on recommendations provided by the U.S. Fish and Wildlife Service, National Marine Fisheries Service and other members of the Project Delivery Team, the proposed monitoring efforts for the project were extended for three years post-construction to assess the positive and negative direct and indirect effects from the project within that timeframe.

7.0 CEA STEP 4 - OTHER ACTIONS AFFECTING THE RESOURCES

Table 7.2 lists 53 projects and their effect on the resources identified in the geographic scope of the proposed project. These projects were found applicable to this analysis based on their geographic location and type of activity, and were therefore included in this analysis (M. Sugg, pers. comm., 2003). These 54 selected projects were analyzed based on the guidelines provided in the CEQ Handbook for Considering Cumulative Effects (CEQ, 1997).

The projects listed in Table 7.2 were categorized to better associate similar activities involved in projects of the same type, where appropriate (see end of Section 7). This matrix assisted in determining the effects of other actions on a particular resource. The matrix assessment included assigning a type of effect (i.e., D [Direct], I [Indirect] or C [Cumulative]) to the resource based on the available history and nature of the project. The analysts' best professional judgments were used to assess the projects listed in Table 7.2 and the effects of these projects based on the information and resources available. This table takes into account the ability for the resources to respond to change or adapt to that particular activity. However, due to the age of some of these projects information was not always available to the analyst so a best professional judgment was used and based on similar projects to make a determination

The following is a description of 53 projects (Past, Present, RFFA) identified in the temporal and spatial scope of the Bogue Inlet Channel Erosion Response Project. The details provided for each project are based on available data which are presumed to be accurate for the purpose of this analysis.

7.1 Inlet Openings

The opening of Drum and Carolina Beach Inlets occurred early in the timeframe analysis associated with this project (1971 and 1952, respectively). Drum Inlet may still have a cumulative effect on the resources identified in this assessment, assuming that the opening of the inlet impacted environmental resources. Based on the information available, analysts have assumed an increase in tidal flows to the estuarine system resulting from each of these projects, which would allow for increased current and water flow to shellfish, SAV, and salt marsh habitat. These effects are considered to have positive cumulative effects to shellfish, SAV and salt marsh, unless otherwise noted. Negative effects to birds, infauna, sea turtles, and seabeach were assumed from dredging of intertidal, beach and dune habitat.

Since these projects were conducted over 30 years ago, environmental resources may not have been considered in the project design. Therefore, detrimental cumulative actions to the resources described in this analysis may have occurred but verification of those effects is not possible given the lack of data on the ecosystems present prior to project construction. These effects are considered to have a positive cumulative effect on shellfish, SAV and salt marsh, unless otherwise stated. Negative effects to birds, infauna, sea turtles and seabeach amaranth were assumed from dredging of the intertidal beach and dune habitat.

Drum Inlet Opening and Dredging

It is believed that the old Drum Inlet closed naturally in February 1971. In response to the natural closing of the old Drum Inlet, New Drum Inlet was opened 2.5 miles south on December 3, 1971 by the U.S. Army Corps of Engineers Navigation Branch. In 1997, maintenance dredging of the inlet was conducted. After one attempt to maintain the new Drum Inlet, the USACE suspended maintenance dredging. Future maintenance of the new Drum Inlet is highly unlikely. In 1999, after a major hurricane season, the high tides and winds produced by mainly Hurricane Dennis re-opened the old Drum Inlet.

Carolina Beach Inlet Opening

Carolina Beach Inlet was artificially opened in 1952 to improve water quality in the sound north of the inlet. In the early 1930's, the construction of the Atlantic Intracoastal Waterway (AIWW) included a land cut that connected the lower end of Myrtle Grove Sound to the Cape Fear River. At that time, the Cape Fear River was very polluted and when the waters from the Cape Fear

River entered the lower part of the sound, siltation and water quality problems resulted. The opening of Carolina Beach Inlet improved water quality conditions north of the inlet but did not improve conditions south of the inlet. The opening of Carolina Beach Inlet also caused significant erosion of the shoreline south of the inlet and the erosion zone migrated about 1.5 miles south of the inlet over a 15 year period with maximum erosion immediately south of the new inlet. Nearly 1,000 feet of shoreline recession was documented immediately south of the inlet over the period from 1952 to 1976. One positive effect of the inlet opening was that it improved water quality in Myrtle Grove Sound north of the inlet based on personal observations in the area.

7.2 Inlet Closures

The closing of an inlet can have significant cumulative effects on environmental resources located on the landward side of the inlet (i.e., estuarine system). It can be assumed that projects conducted before the 1970's may not have considered potential effects to environmental resources in the project design. The closure of Moore Inlet, in 1965, eliminated the established flow of water in the area. Since tidal flushing no longer occurred because of the closing of this inlet, water quality may have been negatively impacted by hypoxic or anoxic conditions. If water quality is negatively cumulatively affected, then cumulative negative effects to shellfish, SAV, and salt marsh habitats can result since these resources rely on good water quality conditions. Therefore, it can be assumed that cumulative effects of inlet closures can be negative. The Moore Inlet project did, however, create additional beach habitat, which was available to foraging, nesting, and roosting birds, as well as nesting turtles and for growth of seabeach amaranth.

Moore Inlet Closure

At the time of its closure, Moore Inlet was very shallow (people were able to walk across at low tide) and was not a significant factor with respect to circulation and water quality in the Wrightsville Beach area. The USACE Navigation Branch artificially closed Moore Inlet in 1965 using material dredged from the sound to extend Wrightsville Beach and connect it with Shell Island to form a single, continuous barrier island. The biggest impact of the inlet closure was the creation of a convex shoreline between Mason Inlet and Masonboro Inlet. The convex shoreline contributes to relatively high erosion rates along the middle sections of the Wrightsville Beach Storm Damage Protection Project which extends from Masonboro Inlet and extends 14,000 feet to the north. Prior to its relocation, Moore Inlet was located 7,000 feet north of the north end of the Wrightsville Beach project, i.e. 21,000 feet north of Masonboro Inlet.

7.3 Inlet Navigation Projects

Dredging of inlets, especially repetitive maintenance dredging can create stress to various resources in the inlet. Dredging activities stir up sediment in the inlet, which can impact water quality, and if significant, can affect SAV, shellfish, and salt marsh habitat. Depending on the silt content of the dredged material, the decrease in water quality is usually expected to be temporary and thus, not cumulative. In some cases, such as the dredging of Beaufort Inlet, continuous dredging activities may affect sediment transport over long periods of time, which may be considered as a cumulative effect.

For other resources, stress must not increase over the thresholds to which the resources have adapted. For example, to prevent loss to shellfish, SAV, and salt marsh, dredging projects should not drastically influence water quality which can result in cumulative impacts to these resources, such as impacts from siltation. The silt content of the dredged material in Bogue Inlet

is negligible, and therefore, turbidity levels will be temporarily increased during project construction.

Other dredging projects involve placing large amounts of sand onto surrounding beaches using ocean disposal methods. This can provide habitat for birds, nesting turtles, and seabeach amaranth, and can be considered a positive cumulative effect on these resources.

Some projects have had negative effects by creating alterations in shoaling habitat, such as the dredging of New River Inlet and New Topsail Inlet. The dredging of New River Inlet in the early 1960's created the formation of offshore shoals which, in turn, could have cumulatively affected shellfish in the area by affecting the flow of water in and out of the inlet. The alteration of tidal flow in an inlet can cause an increase in sedimentation that can then lead to the burial of shellfish beds. Dredging of New Topsail Inlet had the opposite effect on shoaling habitat compared to New River Inlet. The dredging of New Topsail Inlet cleared shoaling habitat which then resulted in the loss of habitat for shorebirds and waterbirds. This can be viewed as a negative cumulative effect for birds that utilize the areas near New Topsail Inlet. Based on the magnitude of positive and negative effects, Table 12.1 shows only a slight cumulative effect on environmental resources from the dredging of the inlets.

Oregon Inlet Dredging and Disposal

The Oregon Inlet navigation project, officially known as the Manteo (Shallowbag) Bay, NC Navigation Project, includes a channel 14 feet deep at MLW and 400 feet wide from the Atlantic Ocean through Oregon Inlet with connecting channels 12 feet deep at MLW and 100 feet wide to Pamlico Sound and Wanchese Harbor located on the southern end of Roanoke Island. The interior channel leading from Oregon Inlet to Wanchese Harbor is maintained by commercial pipeline dredges which dispose of the dredged material in confined disposal areas adjacent to the channel. The ocean bar channel was constructed in 1960 and maintained by a US Government hopper dredge until 1963 with the dredged material deposited offshore. From 1964 to 1972, the inlet channel was maintained by a combination of US Government hopper and sidecast dredges. Again, the hopper dredge material was deposited offshore while the sidecast dredge was deposited immediately adjacent to the channel. US Government sidecast dredges were used almost exclusively between 1973 and 1982. Due to rapid deteriorating channel conditions, a combination of commercial hopper dredges and US Government sidecast dredges were used to maintain the inlet channel between 1983 and 1990. The hopper dredge material was deposited off the north end of Pea Island in approximately 20 feet of water. Changes in the channel shoaling characteristics, particularly in the vicinity of the navigation span of the Bonner Bridge, resulted in the use of commercial ocean certified pipeline dredges to keep the channel open under the bridge. The pipeline dredges have been used on 9 separate occasions since 1993 with the dredged material deposited along the northern 2 to 3 miles of Pea Island. Maintenance of the ocean bar channel since 1993 has also involved the continued use of commercial and US Government hopper dredges as well as US Government sidecast dredges. The commercial hopper dredges deposit the dredged material in a shallow water (10 to 15 feet) disposal area located off the north end of Pea Island. The Table 7.1 summarizes the maintenance dredging history for the Oregon Inlet ocean bar channel.

Table 7.1
Maintenance Dredging History – Oregon Inlet, NC
Average Annual Dredge Quantities for Various Dredge Plant

Time Period	Government Hopper Dredge (CY/YR)	Commercial Hopper Dredge (CY/YR)	Government Sidecast Dredge (CY/YR)	Commercial Pipeline Dredge (CY/YR)
1960 - 1963	68,300	0	0	0
1964 - 1972	115,300	56,700	0	0
1973 - 1982	2,700	0	400,500	0
1983 - 1990	17,700	507,000	668,600	0
1991 - Present	0	189,600	565,900	249,000

Future maintenance of the Oregon Inlet ocean bar channel will probably continue to involve the combined use of US Government hopper and sidecast dredges and commercial hopper and pipeline dredges. The NC Department of Transportation is planning to replace the present Bonner Bridge with a bridge that will have a much wider navigation span which should eliminate shoaling problems in the vicinity of the bridge. This would possibly eliminate the future need to use ocean certified pipeline dredges.

Hatteras Inlet Dredging

Because Hatteras Inlet lies at a bend in the coast, it is subjected to strong erosion forces that are addressed through periodic maintenance dredge required to maintain safe harbor and inlet navigation conditions. Recent maintenance dredging of Hatteras Inlet occurred in late 1997 and from June 7, 2002 to June 18, 2002. The June 2002 project dredged the Hatteras Inlet Ferry Channel and removed 52,720 cubic yards of sand across the inlet from Cape Hatteras to Ocracoke Island (USACE, 2003).

Beaufort Inlet Dredging

Beaufort Inlet separates Shackelford and Bogue Banks. Between 1936 and 2000, 6,954,000 cy of material has been removed from Beaufort Inlet to construct deeper channels and another 32,717,000 cy has been removed to maintain the navigation and access channels. All of the material until 1997 was placed in ocean disposal areas and essentially removed from the littoral system. Beginning in 1997, approximately one-half of the material removed during maintenance dredging of both the inlet and access channels was placed in nearshore disposal areas located west of the entrance.

Beaufort Inlet is part of the Morehead City Harbor Federal Navigation Project, which involved deepening the harbor in 1961, 1978, and 1994. These dredging events have altered the normal inlet processes of Beaufort Inlet and has greatly modified the inlet morphology. Natural fluctuations in the channel alignment and position, which was a major mechanism that transported sediment across the inlet, no longer occurs. In addition, material removed to maintain the inner harbor is temporarily stored in an upland disposal area known as Brandt Island with material removed from this island every 8 to 10 years and deposited on the east end of Bogue Banks (Atlantic Beach and Fort Macon shorelines). The total length of the beach disposal area is 7 miles beginning at the west side of Beaufort Inlet, however, past disposals have only covered approximately 6 miles of shoreline. Brandt Island has been cleaned out two times, once in 1986 and again in 1994. A total of 8,833,000 cy has been removed from Brandt Island

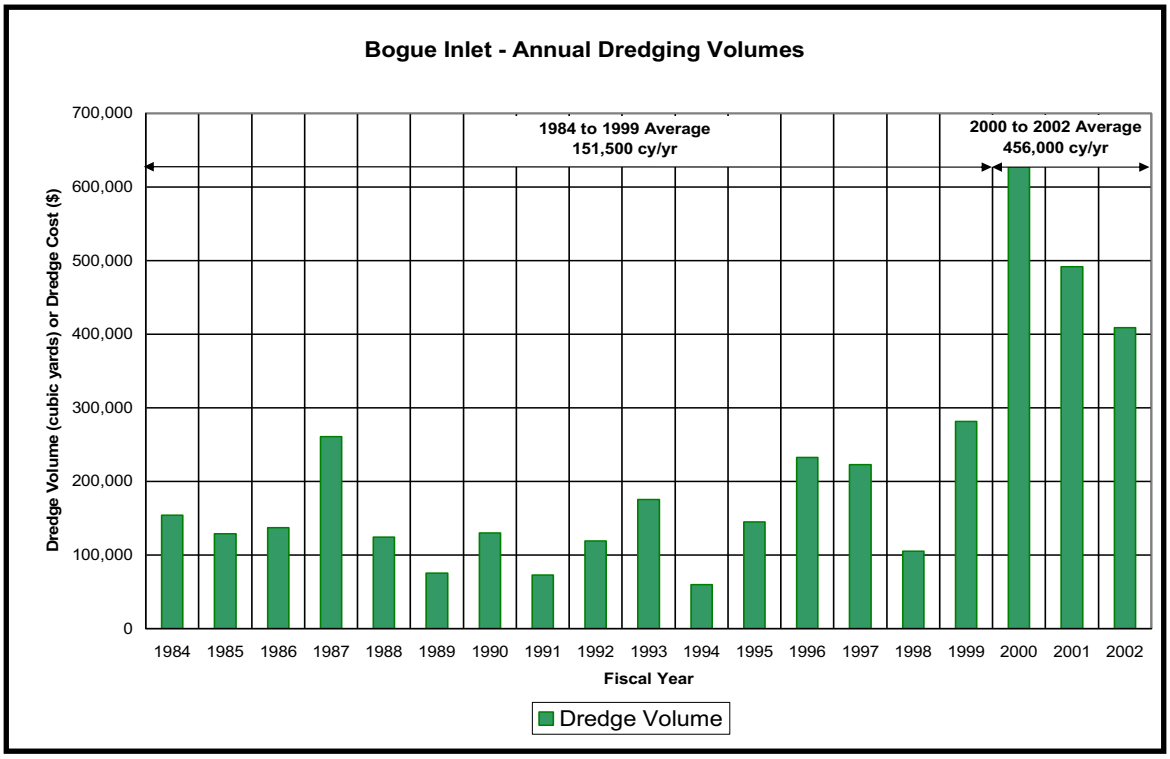
and the inner harbor and deposited on the east end of Bogue Banks. Brandt Island is scheduled to be pumped out again this fall providing sufficient funds are available. The local population is pushing to have all of the dredged material distributed along Bogue Banks from Atlantic Beach west to Indian Beach as part of a Section 933 project. However, Congress and the President have not included the necessary funds in the budget.

Bogue Inlet Dredging

The navigation channel through Bogue Inlet, which measures 150 feet wide at a depth of 8 feet below mean low water (mlw), was authorized on September 7, 1983 under authority of Section 107 of the Rivers and Harbors Act of 1960. A 90-foot wide by 6-foot mlw deep channel connecting the Atlantic Intracoastal Waterway with the Bogue Inlet gorge was authorized on November 29, 1963 also under authority of Section 107 of the Rivers and Harbors Act of 1960. Construction of the inlet bar channel was accomplished in 1984 and has been maintained annually primarily with U.S. Government Sidecast dredges MERRITT and FRY. Note that the U.S. Government mini-hopper dredge CURRITUCK was used in 1984, 1985, and 1987. Maintenance dredging of the connecting channel is accomplished by cutter-suction pipeline dredges on an annual basis generally as part of the AIWW inlet crossings contract. Material removed from the Bogue Inlet crossing and the connecting channel in deposited on the west end of Emerald Isle beginning at a point 1,500 feet east of the inlet shoulder.

The material removed from the inlet channel by the sidecast dredges is deposited in the open waters of the inlet between 90 and 100 feet to the side of the dredge. The total volume of material reportedly removed from the inlet channel each year is plotted on Figure 7.1.

Figure 7.1 Annual Maintenance Dredging – Bogue Inlet – 1984 to 2002



Between 1984 and 1999, maintenance dredging ranged from 60,000 cy/yr to 280,000 cy/yr and averaged 151,500 cubic yards/year. Recently, the amount of maintenance dredging in Bogue

Inlet has increased substantially, averaging 456,000 cy/yr between 2000 and 2002. Apparently, the increased dredging activity reflects attempts by the Corps of Engineers to move the channel to the west away from the Pointe shoreline. However, this increased effort has been unsuccessful in moving the channel as it still is positioned immediately adjacent to the Pointe shoreline.

The annual maintenance of the Bogue Inlet crossing and the connecting channel generally involves the removal of between 50,000 cubic yards and 100,000 cubic yards. The disposal of this material on the extreme west end of Emerald Isle is partially responsible for the accretion on this section of the shoreline, however, most of the accretion is due to the position and orientation of the inlet bar channel.

The historic dredging history for Bogue Inlet and the connecting channel provides the base environmental conditions on which to measure the impacts of the proposed Bogue Inlet Channel Relocation project. In this regard, the channel relocation will involve the removal of approximately 1,000,000 cubic yards with 200,000 cubic yards to be used to construct a sand dike across the exiting channel next to the Pointe shoreline and the balance of the material used to nourish 20,000 feet of Emerald Isle shoreline during Phase 3 of the Emerald Isle beach nourishment project. Construction of the sand dike will require direct disposal of the dredged material into the open waters of Bogue Inlet. However, the amount of material involved in the dike construction is less than one-half of the annual volume of dredge material that has been deposited in the inlet open waters between 2000 and 2002. The relocation of the inlet channel will also eliminate the need for annual maintenance dredging of the inlet channel for at least one year and perhaps longer. During the last 3 years (2000 to 2002) the Corps of Engineers has spent an average of $1,132,000/year maintaining the inlet channel.

New River Inlet Dredging

New River Inlet is located along the northern boundary of Topsail Island approximately 30 miles west of Bogue Inlet. The inlet is very shallow and has migrated within a three km wide zone over the past 40 years. Dredging of the inlet began in the 1940's and resulted in an alteration of the hydrodynamics of the inlet. Further dredging in the early 1960's caused the formation of ebb tidal shoals that controlled the shoreline change patterns on the adjacent beaches. The New River Inlet ocean bar channel has been maintained annually since 1965 using USACE Navigation Branch sidecast dredges or the mini-hopper dredge CURRITUCK. Between 1990 and 2000, the reported average amount of material removed from the New River Inlet entrance channel was approximately 335,000 cy. In addition to the entrance channel, the channel connecting the inlet to the AIWW is maintained by pipeline dredge with excavated material being deposited on the north end of North Topsail Beach. Maintenance of this connecting channel has been sporadic with maintenance performed six times between 1976 and 2002.

New Topsail Inlet Dredging

New Topsail Inlet (comprised of Topsail Creek and Banks Channel) has been dredged annually since 1969 with sidecast dredges and the mini-hopper CURRITUCK. The CURRITUCK is used to maintain the inlet channel and contract dredges are used to maintain channels in Topsail Creek and Banks Channel. Between 1992 and 2000, an average of 106,000 cy has been removed from Topsail Creek and Banks Channel and deposited on the south end of Topsail Beach. Topsail Creek and Banks Channel were scheduled for maintenance dredging by a USACE Navigation Branch dredge contractor in December 2002 or January 2003, if funding was available. According to the USACE, Topsail Creek was dredged this year (2003).

Rich Inlet Dredging

This relatively large inlet separates Figure 8 Island, a private residential island, from Hutaff Island, an undeveloped barrier island to the north. The flood tidal delta is highly asymmetric and is bordered by two large channels. Nixon channel, which borders the south side of the Rich Inlet delta, has been dredged periodically with the material used for nourishment of Figure 8 Island. However, the Nixon channel experiences repeated refilling due in part to the expansion of the adjacent flood tidal delta. Local municipalities have expressed interest in dredging Rich Inlet because of the large volumes of sand that may be used for nourishment of adjacent beaches. Figure 8 Island, like Emerald Isle, may seek State and Federal approvals to dredge the inlet channel and use the excavated material for beach nourishment.

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.

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.

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. 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 from this project assumed that the relocation of inlet had only temporary and minimal affects 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 salt marsh, but 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.

Tubbs Inlet Relocation

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.

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 direct (1.9 acres) salt marsh habitat loss in the area. However, approximately 8.7 acres of salt marsh were created as compensatory mitigation (preserving 19 acres). Recent monitoring has shown no indirect loss of salt marsh and some shoaling areas are becoming vegetated with salt marsh 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 to a defined beach system over a long period of time. Recent beach nourishment projects have required special measures to be 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 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 has not been identified. However, "most beach nourishment projects do not directly affect SAV or salt marsh habitat unless they are in the dredging area" (USACE, pers. comm.). Therefore, no direct impacts from beach nourishment or similar projects should result, however assigning an indirect or cumulative effect designation to the resource proved to be more difficult.

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. The winter of 2008-10 is currently planned for the start of construction. This Federal project is proposed to add storm protection along Bogue Banks for the listed 50 years.

Dare County Beaches North Beach Nourishment
Future nourishment of the beach from the northern boundary of Cape Hatteras National Seashore to Kitty Hawk is proposed as part of a 50-year Federal program to address erosion along this segment of the North Carolina shoreline. The project consists of two segments (totaling 14 miles), a southern segment and a northern segment. The southern segment begins at the north boundary of the Cape Hatteras seashore and extends about 10 miles to the north. The northern segment covers 4 miles of beach and includes portions of Kill Devil Hills and Kitty Hawk.

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.

Camp Lejune - Beach Nourishment
This 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 U.S. Marine Corps- Camp Lejeune has postponed the project for an undetermined time.

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.

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.

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.

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 designing 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.

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.

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 show signs of significant damage from 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.

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).

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.

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 4th, 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.

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 have provided habitat for birds, nesting turtles, and seabeach amaranth and resulted in minimal cumulative effects for these 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 involved nourishing Oak Island and Holden Beach, which may provide 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.

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.

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.

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.

Onslow Bay Dredge Disposal Islands

No Information available.

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 the 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.

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.

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.

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.

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.

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.

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.

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.

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 12.1).

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.

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.

Cape Lookout Jetty

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

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.

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.

Masonboro Inlet Jetties and Dredging

A rock jetty and a weir jetty were installed to 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 Oak Island Sea Turtle Habitat Restoration Project (May 2001) provided 8,900 feet of beach fill for sea turtle nesting habitat. The newly formed berm provided suitable habitat for sea turtle nesting.

Oak Island Sea Turtle Habitat Restoration Project

Dune and Berm construction on Oak Island Island was completed in May 2001. Approximately 8,900 feet of degraded sea turtle nesting habitat was restored.

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.

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), Irene (1999), and Isabel (2003). Of these seven 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.

Hurricanes can also clear densely vegetated areas, providing open sand areas and overwash fans along barrier islands. Open areas can provide new available nesting, roosting, and foraging habitat for shorebirds and waterbirds.

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.

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).

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.

Bogue Banks Beach Scraping

Until recently, CAMA allowed bulldozing of beach sand on Emerald Isle as a method of shoreline stabilization. This practice is viewed as a short-term response to shoreline recession. The Bogue Banks Beach Scraping Project is assumed to have only minimal effects on listed resources, since the sand is typically relocated to an adjacent habitat that may be more effective for flora and fauna usage.

NC Highway 12 Dune Maintenance – Hatteras Island

The NC Highway 12 dune maintenance project occurred on Hatteras Island, constructed and completed in December 2001. Approximately 56 miles of continuous dune line is maintained to protect State Highway 12. The dune system 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. The continuous dune habitat may provide the necessary habitat for the growth of seabeach amaranth. Therefore, the NC 12 Dune Maintenance project is assumed to have provided positive cumulative effects for seabeach amaranth.

Table 7.2

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 project type**

Table 7.2 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								
Bogue Inlet Sandbags	D+	U	D-	D-	C+	U	I-	U
Topsail Island 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
Other Actions								
Bogue Banks Beach Scraping	-D	U	-D	+I	-D/+I	U	U	-D
NC 12 Dune Maintenance - Hatteras Island	-C	U	U	U	+C	U	U	U
Cumulative Effects Determination	**Positive (33+/5-)**	**Negative (2+/2-)**	**Negative (0+/7-)**	**Positive (31+/4-)**	**Positive (31+/4-)**	**Negative (2+/2-)**	**Negative (1+/4-)**	**Positive (3+/1-)**

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

Note: The determination of cumulative effects takes 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.

8.0 CEA STEP 5 – RESOURCES RESPONSE TO CHANGE AND CAPACITY TO WITHSTAND STRESS

This section identifies the resource and how it responds to stresses. The goal of characterizing the stresses is to determine whether the resources of concern are approaching conditions where additional stresses could have an important cumulative effect.

8.1 Effects of Stress on Birds

Coastal development, human activities, and overall habitat loss can create stresses to migratory and resident birds. Many areas used by birds in Bogue Inlet are highly ephemeral, such as intertidal sand shoals. It is difficult to determine a bird's response to change and its capacity to withstand stress. However, it may be assumed that changes to habitat, or loss of habitat can decrease population numbers if the birds cannot obtain adequate prey resources needed for migration, nesting, and breeding.

8.1.1 Effects of Stress on Shorebirds

Shorebirds rely on wetlands, shoreline areas, and adjacent habitats in the Bogue Inlet area (i.e. intertidal shoals, beach areas, etc). Historically, these communities throughout the southeastern Atlantic Coast have been disturbed and are generally decreasing in size. According to the United States Shorebird Conservation Plan (Brown et al., 2001), the loss of bird migration habitats in the coastal zone has been extensive. Coastal development and human activities have reduced intertidal habitats used for foraging and roosting.

Determining the decline in shorebird habitat areas and how it affects shorebird populations can be difficult. Habitat loss poses a threat and, despite conservation efforts, many shorebird populations are declining. Thus, it can be assumed that a decrease in essential shorebird habitat used for breeding, migration stop-overs, wintering grounds, and foraging may cause declines in shorebird numbers.

Wetlands and their associated habitats provide high densities of food available at critical times during migration stop-overs. Shorebirds use these food resources to obtain fuel reserves for their migrations. If the prey resources are not present, and shorebirds are unsuccessful in gaining necessary fat reserves, low survival rates may occur. In addition, shorebirds have low rates of reproduction, with clutch sizes of most species consisting of four or fewer eggs; and very few species re-nest after a successful first nesting attempt.

Specific habitats are utilized by many species of shorebirds in the Bogue Inlet environment. Shorebirds have been surveyed on the south side of Dudley Island, the West beach area of Emerald Isle, Island No. 2, and the intertidal shoals in the inlet. These habitats are dynamic systems, characteristic of a migrating inlet. Intertidal shoals, Island No. 1 and Island No. 2 are particularly ephemeral areas that are used by many species of shorebirds for feeding and resting. It can be assumed that shorebirds may have an ability to adapt to changes in the intertidal habitats of Bogue Inlet due to their continued use of the area.

The west end of Emerald Isle is heavily influenced by the migration of the inlet. The erosion rate in this area is very high with roosting and foraging areas being altered by morphologic changes in the inlet complex. Of the four areas surveyed, the west end of Emerald Isle is the only area adjacent to a human community. Tourists and residents often use this area

recreationally, and the shorebirds are apparently accustomed to the presence of the people in these areas.

The beach habitat along the south side of Dudley Island is frequently used by nesting, foraging, resting, and migrating shorebirds. Dudley Island is minimally affected by boaters and sun-bathers. Shorebirds that utilize this area must adapt to the changing environment along the south side of the island. Therefore an assumption can be made that shorebirds have adapted to the physical changes on Dudley Island.

Bird surveys, conducted by CZR, Inc. for the Bogue Inlet Channel Relocation Project, report feeding, resting, and migrating shorebirds on Bear Island's intertidal and beach areas. Similar to Dudley Island, Bear Island is an undeveloped coastal environment. There is limited human activity on Bear Island due to its designation as a State Park protected by the North Carolina Division of Parks and Recreation (NCDPR). Bear Island's intertidal and beach areas are dynamic and are changing in response to natural forces to which shorebirds adapt.

It can be difficult to determine how the declines in any of the habitat areas in Bogue Inlet have affected the shorebirds that utilize the area. Although limited historic data exists, North Carolina Wildlife Resource Commission (NCWRC) surveys from previous years of Bogue Inlet's shorebird habitats have shown no significant declines in populations. Due to the natural dynamics of the wetlands and intertidal environments of Bogue Inlet, it can be assumed that shorebirds are well adapted to the dynamic environment, responding well to changing conditions.

8.1.2 Effects of Stress on Waterbirds

Animal and human disturbances, depending upon duration and proximity of perceived threat, may result in adults leaving eggs or chicks exposed to predators or inclement weather and may result in disruption of nesting, foraging, and loafing behaviors. Adult mortality has been identified as the key determinant in population trends, while decreases in nestling/juvenile mortality may not have as strong of an effect on populations. Although human disturbances may result in acclimation by birds to disturbances in some cases, abandonment of critical habitats often results.

Waterbirds are long-lived, have low annual reproductive output, high juvenile mortality, with high adult survivorship. As a result, reproductive success in any one year may not be as critical to population success as adult mortality because waterbirds are long-lived with delayed maturity.

The formation of colonies at feeding, nesting, and loafing sites results in an increased susceptibility of waterbirds to environmental disasters. Hydraulic changes in freshwater wetlands, degradation of coastal and marine habitats, and depletion of food resources can also adversely affect waterbirds and cause population declines. For this reason, the Cumulative Effects Assessment is performed as a tool to determine if habitats essential for foraging, resting, and nesting will be impacted by this and future actions. Inlet and shoreline stabilization projects have been identified as affecting sand and mud flat usage by birds (Federal Register Part II, 2001). These projects can limit the overwash processes that form the various dynamic shoals characteristic of inlets. Waterbirds, especially colonial species, can rapidly populate and alter ranges in response to changes in environmental conditions. Due to the waterbirds' ability to acclimate to a changing environment, the Bogue Inlet Channel Erosion Response Project is

expected to have minimal effects on waterbirds in the area. The project is not expected to cause the deaths of any adult waterbirds or nesting disturbances due to the winter timing of the project. These disturbances may cause birds to temporarily relocate, but adverse effects to nesting are not expected.

8.2 Effects of Stress on Shellfish

The eastern oyster (*Crassostrea virginicus*) is a very successful estuarine animal that can tolerate a wide variety of environmental conditions. Oysters can survive in waters with varying salinities, temperatures, currents, and turbidities. In fact, "intertidal oysters thrive in the most rigorous of habitats" (Lunz, 1960). Oysters do have certain requirements that, when available, account for higher concentrations in particular areas. The presence of suitable substrates, food, current velocities, acceptable levels of turbidity, and/or exclusion of some disease-causing organisms represents an optimal environment for oysters. Extreme changes in one or more of these factors may affect oysters.

Two of the most important requirements for successful oyster populations are suitable habitat and food availability. If oysters inhabit an area that does not receive adequate food sources via water currents, the oyster cannot survive, even if the habitat is optimal. Although preferred, firm substrate is not necessary for oyster reefs to become established. Oysters have the ability to build large reefs in soft mud habitats, beginning with a few oysters attaching to a bit of shell or wood in a mud flat. Other oysters then attach to them and push them into the mud which smothers the original oysters, however, it provides habitat for subsequent spat. This process continues until the first set of oysters sink deep enough into the mud to provide a sufficient basement that prevents further subsidence. Recent evidence shows that disturbances (marine fishing, shellfishing) can alter the physical structure of oyster reefs and negatively affect populations (Lenihan and Peterson, 1998). Research by Lenihan and Peterson (1998) indicate that reef habitat degradation by disturbance (fisheries) caused oyster mortality on natural reefs when paired with bottom-water hypoxic/anoxic conditions. Furthermore, Lenihan and Micheli (2000) showed that both oyster and clam harvesting using tongs and rakes affected oyster populations by disturbing and/or possibly killing oysters due to cracking/puncturing of shells or smothering individuals beneath sediments.

Even though oysters are highly tolerant of a variety of conditions, extreme stress can cause damage. The Bogue Inlet Channel Erosion Response Project is not expected to directly affect or cause significant stress to oysters. Construction machinery that could potentially damage oyster reefs will be located outside of areas where oysters are found in Bogue Inlet (See Appendix A - NCDMF C004 Shellfish Map). Turbidity, salinity, dissolved oxygen, current velocity, and food availability effects, if any, should be minimal and temporary.

8.2.1 Effects of Stress on Hard Clams

Hard clams (*Mercenaria mercenaria*) occur extensively in estuarine systems throughout North Carolina, and because of their wide distribution, may be exposed to various environmental impacts throughout their life cycle. The planktonic stage of hard clams is particularly sensitive to environmental changes while adult hard clams are less susceptible to changes. However, adults have been found to be particularly vulnerable to the effects of pollution and coastal development. Similar to oysters, hard clams rely on water currents to provide food and remove bio-deposits.

Hard clams are osmoconformers that are capable of altering their water balance as environmental conditions change; an adaptation that allows them to withstand extreme stresses. For example, clams have been found to withstand salinities from 4 ppt to over 35 ppt (Eversole, 1987). Furthermore, hard clams have the ability to close their shells tightly during periods of stress, and respire anaerobically. Clams also have the ability to move from their habitat or correct for displacement caused by disturbances (Eversole, 1987). Horizontal movement of adult clams is limited and distance traveled corresponds with the size of the clam (the smaller the clam, the farther it can travel). Adult clams can also avoid unfavorable conditions by rapidly burrowing into sediments.

Densities of hard clams have been positively correlated with seagrass cover in Bogue Sound. Research reveals that the presence of seagrass insulates hard clams from higher mortality rates (Peterson, 1982) by adding protection against decreases in water quality related to turbidity or variations in current speeds.

Mortality of hard clams in the absence of predation appears low and the larger the clam (>50 mm), the lower the natural mortality rate. Mortality is extremely high in juvenile stages until the clams reach a critical size greater than 50 mm when mortality drastically decreases (Eversole, 1987). Research conducted by Peterson (2002) reveals that hard clam numbers decreased from 1980-1997 within the fishing grounds of central North Carolina. Peterson contributes the declines in numbers to a decrease in hard clam recruitment which is, in part, due to overfishing. "The overfishing has lead to low recruitment in subsequent years and not even an initiation of recovery of historic abundance" (Peterson, 2002).

This project should not impact hard clams because these bivalves have not been documented in significant numbers in the area and have various adaptive methods to protect and shield themselves from changing environmental conditions. Clams can osmoconform to their environment, move to another habitat, close their shells, or bury into the sediment to avoid environmental stress. The project is not expected to cause significant disturbance to areas utilized by clams (seagrass beds, sand flats with shell, or Strata V and W) or affect future clam recruitment to the area.

8.2.2 Effects of Stress on Bay Scallops

Bay scallops (*Argopecten irradians*) are much more susceptible to environmental conditions than oysters and hard clams. From the autumn of 1987 to early winter of 1988, a red tide epidemic decreased the populations of bay scallops found in western Bogue Sound. Recruitment to the area by scallops in the subsequent years after the red tide event was significantly lower.

Bay scallops live up to 26 months and rely on the presence of seagrass for survival and growth. In the early stages of life, bay scallops attach to the blades of seagrass with a byssal thread. As the scallops mature, they fall to the bottom of the seagrass bed where they continue to grow. It has been hypothesized that feeding may be more efficient in seagrass beds due to slower currents (Eckman et al., 1989). Additionally, it has been shown that bay scallop densities decline with declining seagrass biomass (Peterson et al., 1982). Past research also reveals that fishing methods, such as clam kicking or dredging, destroys seagrass habitat and thus, could possibly lower the number of bay scallops in those areas (Peterson, 2002).

Adult bay scallops are efficient swimmers and can utilize voluntary movements, as well as shallow burrowing to escape from unfavorable environmental conditions (Fay et al., 1983). The movement of adult scallops results in a motion that appears zig-zag but is not directional. Directionality may result if movement is influenced by tidal flow (Fay et al., 1983; Moore and Marshall, 1967).

The project is not expected to disturb or affect seagrass habitat and any disturbances will be temporary and minimal. Scallops located in seagrass beds close to the permit area should gain protection from the seagrass if any decreases in water quality should occur.

8.3 Effects of Stress on the Benthic Community

A reduction in the population, abundance and diversity of infaunal species in the construction area are expected during and immediately after construction activities. The Coordination Act Report developed for Bogue Banks (USFWS, 2002) states that recovery rates of infaunal species and their ecosystem is dependent on the size of the sediment grains. Fine-grained (mud, silts and clays) were found to have similar levels of biodiversity in a dredge site within one year after construction. However, ecosystems associated with medium-grained size sands took one to three years to recover and coarse-grained deposits (>2 mm) required a five year recovery time. The recovery of an infaunal community was further defined as "a successional community of opportunistic species providing evidence of progression towards a community equivalent to that previously present, or at non-impacted reference sites" (USFWS, 2002). Therefore, if the abundance of the benthic community decreases, fish, birds, other aquatic organisms and terrestrial animals utilizing the fauna as a primary food source will be affected if adequate replacement opportunities are not present close to the disturbed site.

Studies have shown recovery in beach nourishment areas as well as at dredged areas and offshore borrow sites. Due to the medium sized grains of the inlet, recovery time for benthic infauna is expected to be 1 to 3 years. In addition, the frequency of large storms such as hurricanes and heavy wave actions suggests that benthic infauna are adapted and accustomed to change. Furthermore, populations are seasonally and thus, lower populations may be found during the winter.

8.4 Effects of Stress on Nesting Sea Turtles

Loss of nesting habitat is a significant stress for both sea turtles and the Carolina diamondback terrapin (*Malaclemys terrapin centrata*) (Lutcavage et al., 1997; Reshetiloff, 2001). While all six species discussed are aquatic turtles they must return to land to nest. Female sea turtles construct their nests on coastal beaches and the Carolina diamondback terrapin builds their nests on embankments found along salt marshes, impoundments, tidal creeks, lagoons and mud flats (Reshetiloff, 2001). The loss of these habitats affects the ability of females to nest and reproduce.

Sand grain size, composition, and sorting of fill material are critical elements of nourishment activities that affect sea turtle nesting ability. Many beach nourishment projects obtain sand from offshore borrow sites where sediment properties of the material may not be comparable to the nourishment area. Projects that utilize fill material that is similar in grain size and

composition to the nourishment area may prevent some of the adverse effects associated with some nourishment efforts (Crain et al., 1995).

The Bogue Inlet Channel Erosion Response Project is not expected to negatively affect the nesting habitat of sea turtles. Nourishment activities along Emerald Isle are expected to positively affect sea turtles by increasing the amount of available nesting habitat. Obtaining fill material from areas adjacent to the eroded beach may provide sediments that are similar to the sediments naturally occurring on the beach. Using sediment from Bogue Inlet, adjacent to the beach, will decrease the likelihood of adverse effects associated with non-compatible fill material.

Sea turtles are a group of highly migratory species (Lohmann et al., 1997). The activities associated with the Bogue Inlet plan will not affect juvenile or adult sea turtles because of the timing of the project. During the winter months the turtles migrate out of inland waters and into nearshore coastal waters; or they migrate further south into warmer coastal waters, until the spring time (Keinath et al., 1987; Epperly et al., 1995; Epperly et al., 1994).

8.5 Effects of Stress on Seabeach Amaranth

The stability of the frontal dune communities is important for the survival of the seabeach amaranth (*Amaranthus pumilus*). Seabeach amaranth, along with other dune plants act as dune stabilizers, securing the dune system with their roots and capturing wind-blown sand. However, these dune communities are frequently exposed to significant wind and wave actions and are susceptible to the erosive properties of these elements. The loss of these habitats can be detrimental to the survival of seabeach amaranth.

Nash (2002) reported that observations of the seabeach amaranth in Brunswick County and along Bogue Banks showed significant signs of recovery in 2002. Nash suggested two reasons for the recovery of the plant species: (1) beach renourishment activities have provided habitat for the plant; and (2) the North Carolina coastline has not suffered the effects of hurricanes since 1999, which can relocate seedlings during washover events. Nash also indicated that seabeach amaranth is a prolific seed producer, which may be one of the measures the plant has adopted to ensure its survival in the active frontal dune community.

The proposed beach nourishment activities are expected to have a positive indirect and cumulative effect on the seabeach amaranth population of North Carolina. The proposed beach nourishment activities will provide suitably sorted, beach-compatible material to the frontal dune system and high beach environment between mean high water and toe of dune. The supply of this material will provide the habitat needed for seabeach amaranth colonization. Natural recruitment from aeolian and wave actions to the nourished beach and dune area will assist in further recovery of the plant population.

8.6 Effects of Stress on Submerged Aquatic Vegetation

Three main contributing factors affect the sustainability of Submerged Aquatic Vegetation (SAV) habitat, these include: water quality, qualitative and quantitative light effects, and sedimentation (Livingston et al., 1998). Drastic influences to submerged aquatic vegetation can occur from the co-occurrence of changes in sediment and water quality characteristics and light restrictions (Stevenson, 1988; Livingston et al., 1998; Mallin et al., 2000).

Water quality factors that can affect SAV include: color levels, salinity, nutrient levels, turbidity, temperature, and pollution. Based on field data collected by Livingston et al. (1998), water quality factors were one of the best predictors of SAV distribution. For example, the quality and quantity of SAV habitats have been shown to increase with improvements in water quality and nutrient reductions (Carter and Rybicki, 1990).

Light is a major factor influencing the growth and distribution of seagrass (Stevenson, 1988; Grice et al., 1996; Mallin et al., 2000). Significant changes in the light regime of seagrass habitats have caused large scale losses of seagrass in the natural environment (Dennison et al, 1993 and Grice et al., 1996). Sufficient amounts of high-intensity sunlight can create more productive SAV species compared to species under low-intensity lights (Dennison et al, 1993 and Grice et al., 1996). In addition, reductions in SAV cover have been linked to reductions in "photosynthetically active radiation" (PAR) reaching the bottom of coastal waters (Onuf, 1994). Dennison et al. (1993) describes the minimum light requirement of SAV as 4-29% of incident light measured just below the water surface.

Extensive loss in seagrass cover in Laguna Madre, Texas from 1965 and 1974 was attributed to turbidity caused by maintenance dredging which then reduced the amount of light surrounding the seagrass habitat. A study by Onuf (1994) verified this hypothesis by assessing the influence of dredging on light and seagrass cover in Laguna Madre, Texas and found reduced light levels attributable from dredging in several areas of the study. Reduced light levels were evident in the seagrass meadow up to 10 months after dredging. Onuf (1994) did not attribute dredging as the sole contributor to increases in turbidity, reductions in light, and therefore, losses in seagrass cover. The dredging paired with "resuspension and dispersion events caused by wind-generated waves" were in part responsible for the long suspension time and large areal coverage of the dredge-related turbidity.

Sediment quality can also affect seagrass distribution (Livingston et al., 1998). Research conducted by Livingston et al. (1998) suggests that sediment characteristics are one of the best predictors of SAV distribution (along with water quality, photic depth and wavelength distribution). This study stated that sediment can contain nutrients which can then affect seagrass growth, morphology and abundance. One discussed effect of nutrient enrichment on eelgrass (*Zostera marina*) beds included increased growth.

Water quality, light, and sediments influence seagrass abundance and quality, which then influences predation where an increase in plant density yields an increase in predation (Irlandi, 1998). The theory for this stems from the increase in the amount of edge associated with small patches and fragmented habitats. The "greater amount of edge associated with small patches and fragmented habitats increases the accessibility of prey residing in patches to predators that forage from patch to patch" (Irlandi, 1998). The size of seagrass assemblages, density, composition, and fragmentation of these habitats can be critical to the diversity, abundance, composition, and biological interactions of faunal species that depend on these communities. The size of a seagrass patch is considered to be an important factor in supporting nursery habitat for commercially important fish species (Irlandi, 1998). Ultimately, the shape and areal coverage of these habitats are influenced by both abiotic and biotic factors.

Recovery time for an SAV habitat has additionally been found to vary based on the length, width and depth. The larger the size of the SAV patches, the quicker the recovery (SAV/DOT Advisory Panel Meeting December 2002).

8.7 Effects of Stress on Salt Marsh Ecosystems

Wetlands are often located on the receiving end for wastes from human and natural sources. The location of these habitats forces them to function as a sink to filter nutrients, phosphorous, metals, organic compounds and sediments prior to outletting into the ocean. The effects of these pollutants to the salt marsh system can be significant, although there are no studies to support this finding, the potential for detrimental effects to this system are evident. Pollutant loading to an estuarine system may interrupt the food web in the salt marsh by killing off some species and prompting other, potentially invasive species, to greatly increase in numbers (SCDNR, 2003).

Sea level rise may lead to flooding of low-lying property, loss of coastal wetlands, erosion of beaches, saltwater contamination of drinking water, and decreased longevity of low-lying roads, causeways, and bridges which have potential adverse effects to human and natural systems. In addition, sea level rise could increase the vulnerability of coastal areas to storms and associated flooding (EPA, 2000). Wetlands located in flood zones can restrict development and provide water storage areas to protect adjacent property from potential flood damage.

The inclusion of ditches for mosquito and can alter water flow and cause water loaded with vital nutrients to bypass the marsh. Many bird species rely on low, wet marsh systems, which could diminish along with the supply of nutrients and food sources once available in these fragile ecosystems. Canals designed for flood control can increase the surface water and stress and ultimately kill the grass species. (SCDNR, 2003)

It is estimated that three-quarters of the Nation's marine harvestable species are, at some point in their life cycle, dependent on estuarine habitats for food and shelter or as migratory routes and spawning grounds (NOAA, 2001). The loss of these habitats could be detrimental to many components of the food web.

8.8 Effects of Stress on Water Quality

Water quality is susceptible to impacts from point and non-point source pollution, tides, currents, dredging, boat traffic and recreational activities that may contribute to fluctuations in the water quality of an estuarine environment. Tidal exchange and groundwater flow continuously exchange water in Bogue Inlet by receiving freshwater from the White Oak River and oceanic water from the Atlantic. Freshwater from the White Oak River can contain agricultural runoff that may impair water quality. Saltwater from the ocean, which is less likely to contain pollutants, enters the inlet during flood tides which flushes the estuarine system. During ebb tide, estuarine water is flushed out of the sound and into the ocean.

Dissolved oxygen is an important aspect of water quality needed for floral and faunal species in the estuarine ecosystem. Tidal exchange within the inlet can minimize the effects of hypoxia by circulating water in the estuarine system.

Temperature, salinity, dissolved oxygen, and pH are not expected to change due to project related activities. Changes in the turbidity levels in Bogue Inlet are expected to be temporary

during dredging activities. No cumulative effects to water quality are expected to result from project implementation.

9.0 CEA STEP 6 - STRESSES IN RELATION TO REGULATORY THRESHOLDS

CEA Step 6 discusses the regulations, criteria and plans associated with each the resource.

9.1 Regulatory Thresholds of Birds

The waterbird and shorebird species that frequent Bogue Inlet are protected under the Migratory Bird Treaty Act of 1918 and are included in the following conservation plans: U.S. Shorebird Conservation Plan, Caribbean Regional Shorebird Plan, and the North American Waterbird Conservation Plan. These plans assign the various bird species with a high, moderate, low, or not at risk designation as a guide to further protect the resource. Higher designation suggests that an effect may have more influence on a species that is of higher concern. Piping plovers (*Charadrius melodus*), for example, are listed as Federally endangered species and a species of extremely high priority (Hunter, 2001). Effects on piping plovers, and other species of high concern, must be minimal due to the regulatory thresholds that govern the species conservation.

9.1.1 Regulatory Thresholds of Shorebirds

Specific shorebird species of concern range from species not at risk to species of extremely high priority. Species of extremely high priority are designated by the Southeastern Coastal Plan – Caribbean Regional Shorebird Plan (Hunter, 2001) and include the American oystercatcher (*Haematopus palliates*), the piping plover (*Charadrius melodus)*, and the red knot (*Calidris canutus*). Species of high priority include Wilson's plover (*Charadrius wildonia)* and the short-billed dowitcher (*Limnodromus griseus*). Species of moderate priority include the sanderling (*Calidris alba*), willet (*Catoptrophorus semipalmatus*), and dunlin (*Calidris alpine*). The red phalarope (*Phalaropus fulicarius*) is a species of high concentration and its populations are thought to be in decline. The U.S. Shorebird Conservation Plan (Brown et al., 2000) lists the red phalarope as a species of moderate concern because of its perceived population decline. According to the North American Waterbird Conservation Plan, the population status of Cory's shearwater (*Puffinus diomedea*) is apparently stable and the species is designated as moderate to low concern (Kushlan and Steinkamp, 2002). The North American Waterbird Conservation Plan also lists the northern gannet (*Morus bassanus*) as a species not at risk because biologically significant population increases have been documented.

Species in highest need of conservation, based on the above cited plans, include American oystercatchers, piping plovers, and red knots. The American oystercatcher is designated as a species of extremely high concern because existing information suggests that their populations are significantly declining and significant threats exist to the current populations. In addition, the Southeast region is extremely important for breeding and wintering for the species. The piping plover is listed as endangered under the Federal Endangered Species Act and the North Carolina Natural Heritage Program (LeGrand and Hall, 1999). The region is extremely important to piping plovers for wintering and very important for breeding and migration. Furthermore, piping plover habitat is listed as critical and requires protection under Federal regulations.

Red knots migrate to the Bogue Inlet area during their spring and fall migrations and may be sporadically found in the region during the winter. Wilson's Plover, a species of high priority is

also listed as significantly rare under the North Carolina Heritage Program (LeGrand and Hall, 1999) and the Bogue Inlet region is important to this species for breeding.

All shorebirds are protected under the Migratory Bird Treaty Act of 1918, which prohibits, pursuing, hunting, shooting, wounding, killing, trapping, capturing, collecting, or attempting such conduct without appropriate permits. As a Federally listed species, the piping plover is protected under the Endangered Species Act of 1973 (ESA). Federal actions are all subject to consultation so as not to jeopardize the continued survival and recovery of a species listed under the ESA. The ESA prohibits taking, and harming and harassing piping plovers, or significantly modifying or degrading critical habitat that may impair essential behavioral patterns including breeding, feeding, or sheltering (Federal Register Part II, 2001). The major goal for piping plover management is to protect wintering grounds where the plovers forage, roost, and shelter. Important regulatory thresholds are based on sustained wintering habitat constituents essential for the primary biological needs of foraging, sheltering, and roosting.

The stressors from the project will include noise, relocation of habitat, and a temporary increase in human activity in Bogue Inlet. These stressors should not be of sufficient duration or intensity to effect drastic changes to foraging, roosting, sheltering, or nesting shorebirds. No long-term habitat loss or human disturbance to critical habitat is expected to occur. Activities will be timed as to minimize the effects on piping plovers and other shorebirds in the area.

There are no identified stress thresholds regarding shorebirds in general, however, the areas of Bogue Inlet have been defined as Critical Habitat for Wintering Piping Plovers. Furthermore, it is unlikely that the cumulative impacts from the Inlet Channel Erosion Response Project and other known projects will cause population impacts to shorebird species due to the timing of the project outside the critical nesting period.

9.1.2 Regulatory Thresholds of Waterbirds

Waterbirds are also protected under the Migratory Bird Treaty Act of 1918 and harm or harassment of waterbirds is strictly forbidden without the appropriate Federal permits. This project is not expected to harm or harass any waterbirds.

Waterbird conservation and protection is addressed in the North American Waterbirds Conservation Plan (Kushlan and Steinkamp, 2002). This plan provides the framework for the conservation and management of 210 species of waterbirds, including seabirds, coastal waterbirds, wading birds, and marsh birds utilizing aquatic habitats throughout North America. Many of these waterbirds, seabirds, and wading birds may be found along North Carolina coasts, estuaries, and pelagic waters.

Waterbird species found in and around Bogue Inlet may be listed under the Conservation Plan as high, moderate, or low levels of concern. Species of high concern are those where threats to breeding are occurring and can be documented, and may have apparent population declines (Kushlan and Steinkamp, 2002). Moderate species of concern are waterbirds that may have declining populations with moderate threats or distributions; or may be stable with known or potential threats and moderate to restricted distributions; or may be represented by relatively small populations with relatively restricted distributions. Low species of concern have

populations that may be stable with moderate threats and increasing distributions; or of moderate population size with known or potential threats and moderate to restricted distributions.

Species of high concern in the Bogue Inlet include snowy egret (*Egretta thula*), tricolored heron (*Egretta tricolor*), little blue heron (*Egretta caerulea*), gull-billed tern (*Sterna nilotica*), black skimmer (*Rynchops niger*) and least tern (*Sterna antillarum*). These species have known threats to breeding that are occurring and can be documented, and they may have apparent population declines (Kushlan and Steinkamp, 2002). Moderate waterbird species of concern observed in the Bogue Inlet ecosystem include white ibis (*Eudocimus albus*), bonaparte's gull (*Larus philadelphia*), lesser black-billed gull (*Larus fuscus*), royal tern (*Sterna maxima*), black tern (*Chilidonias niger*), Forster's tern (*Sterna forsteri*) and brown pelican (*Pelecanus occidentalis*). Low species of concern include glossy ibis (*Plegadis falcinellus*), herring gull (*Larus argentatus*), caspian tern (*Sterna caspia*), and common tern (*Sterna hirundo*).

The gull-billed tern (*Sterna nilotica*) is listed by the State of North Carolina as threatened. The Natural Heritage Program (Le Grand and Hall, 1995) also lists various species as significantly rare and species of concern. The common tern (*Sterna hirundo*), least tern (*Sterna antilllarum*), and the black rail (*Laterallus jamaicensis*) are all listed as significantly rare under the North Carolina Natural Heritage Program. Also of importance to the State of North Carolina is the brown pelican (*Pelecanus occidentalis*), which was removed from the Federal listing in 1985.

9.2 Regulatory Thresholds of Shellfish

The North Carolina Marine Fisheries Commission (NCMFC) was created to "manage, restore, develop, cultivate, conserve, protect, and regulate the marine and estuarine resources of the State of North Carolina" (NCDMF, 2001a; NCDMF, 2001b). The NCMFC issues proclamations (public notices) to implement rules governing fishery practices in the State. In addition, shellfish are regulated under the Fisheries Reform Act (FRA) of 1997 that establishes a process for development of coastal fisheries management plans in North Carolina. The FRA states that "the goal of the plans shall ensure the long term viability of the State's commercially and recreationally significant species or fisheries". During the 1994 Session of the North Carolina General Assembly, a Blue Ribbon Advisory Council was appointed to study and make recommendations concerning policies and management of the State's oyster resources.

Laws and regulations exist to protect shellfish and to ensure a proper balance between fishermen, swimmers, boaters, and developers, along with providing adequate protection for the environment. These goals and management issues for shellfish include maintaining water quality, preventing increases in sedimentation, protecting habitat (SAV, primary nursery areas, oyster rock) that are necessary for shellfish growth and survival, and to prevent further habitat destruction, especially to wetlands, which can contribute significantly to the degradation of shellfish. The North Carolina Shellfish Sanitation and Recreational Water Quality Section of the Division of Environmental Health is responsible for monitoring and classifying coastal waters as to their suitability for shellfish harvesting for human consumption and inspection and certification of shellfish processing plants.

Both the oyster (*Crassostrea virginicus*) and the hard clam (*Mercenaria mercenaria*) fisheries are regulated under the Fishery Management Plan (FMP) developed for the State of North Carolina. The bay scallop (*Argopecten irradians*) is not covered by a FMP because the status of

the fishery in North Carolina is healthy. However, the depletion of grass beds in North Carolina's estuaries may create the need for a FMP for the bay scallop in the future. The Bogue Inlet Channel Erosion Response Project may result in minimal and/or temporary indirect effects to the seagrass beds in Bogue Inlet's estuaries with minimal effects on shellfish.

In 1998, the South Atlantic Fishery Management Council designated intertidal and subtidal shell bottom as Essential Fish Habitat. The hard structure that a shellfish species creates (i.e. oyster reefs) can be used by other species, as well as finfish and invertebrates. It has been documented that topography, morphology, and structural heterogeneity often control recruitment, persistence, and diversity in coral reefs, seagrass communities, and salt marshes. This finding has led to the development of measures to protect these areas from direct anthropogenic disturbances. Shellfish communities serve as fishery nursery habitats and provide natural water filtration that has beneficial effects on the surrounding marine environment. Shell bottom habitat also provides structure for attachment, cover from predators and food opportunities to the estuarine community (NCDMF, 2001). Studies have shown that the most critical areas for oyster populations are oyster beds or rocks, which the oysters themselves formed by accumulation of shells over time and the removal and degradation of oyster habitat has contributed to a decline in oyster landings (NCDMF, 2001). More importantly, shellfish are sensitive to changes in water quality and can be used as environmental indicators. Therefore, there have been many management activities and regulations implemented to assess impacts to shellfish populations from various anthropogenic activities and ensure survival of shellfish communities.

9.3 Regulatory Thresholds of the Benthic Community

There are no federal, state or local regulatory thresholds or guidelines associated with infaunal species in North Carolina. However the survival of these species and their habitat is crucial for the sustainability of fish, birds and marine mammals that feed on these species. Therefore, maintaining the biological integrity of this resource is crucial regardless of the lack of regulatory thresholds assigned to resident infaunal species.

9.4 Regulatory Thresholds of Sea Turtles

The Endangered Species Act of 1973 protects sea turtles in the United States (Pritchard, 1997) and lists declining species as either endangered (in danger of becoming extinct) or threatened (may soon face extinction unless measures are taken to protect it). Under the ESA, the loggerhead sea turtle (*Caretta caretta*) is designated as threatened throughout its entire range. Green sea turtles (*Chelonia mydas*) are also designated as threatened throughout its entire range, except for the State of Florida and Pacific coast of Mexico where it is listed as endangered. The hawksbill (*Eretmochelys imbricate*), Kemp's Ridley (*Lepidochelys kempi*) and leatherback (*Dermochelys coriacea*) sea turtles are all designated as endangered throughout their entire range (Ripple, 1996).

The ESA makes it illegal to import, sell or transport turtles or products derived from turtles for domestic or international commerce. Because sea turtles are found on beaches as well as in the surrounding water of the United States two Federal agencies have jurisdiction over sea turtles. The NMFS has jurisdiction over sea turtles in the water and the USFWS oversees activities that may affect them while on land. The Carolina diamondback terrapin (*Malaclemys terrapin centrata*) is listed by North Carolina state law (NCDMF, 2003) as a species of special concern.

The North Carolina Wildlife Resources Commission (NCWRC), through an agreement with the USFWS, established the State's Sea Turtle Protection Program under Section 6 of the Endangered Species Act (NCWRC, 1998). The Sea Turtle Protection Program monitors, manages, and protects sea turtle nests on North Carolina's beaches, with over 20 sea turtle nest-monitoring programs that currently exist. Individual program scopes vary in involvement from counting nests, emergences, and false crawls to full-scale management of nests and their success. The program also maintains records of sea turtle mortality, and strandings that occur in the State.

To protect turtles within the state waters of North Carolina, the NCWRC in cooperation with NMFS, enforces the use of Turtle Excluder Devices (TEDs) on fishing vessels year-round. TEDs allow sea turtles to escape trawling nets through an escape hatch at the cod end of the net. Before implementation of TEDs, a study conducted by the National Academy of Sciences, reported that incidental capture of sea turtles by shrimp trawlers accounted for more sea turtle deaths than all other human activities combined (National Research Council, 1990). Crowder (1995) found that the use of TEDs has reduced the bycatch of loggerhead sea turtles in South Carolina by 44%.

9.5 Regulatory Thresholds of Seabeach Amaranth

In 1993, the USFWS listed the seabeach amaranth (*Amaranthus pumilus*) as a threatened species throughout its range which includes the shorelines of Delaware, Maryland, North Carolina, New Jersey, New York, South Carolina, Virginia.

North Carolina established a seabeach amaranth conservation program in conjunction with the State's enactment of the Plant Protection and Conservation Act in 1979. The Plant Conservation Program mandates that the North Carolina Department of Agriculture and Consumer Services (NCDACS) list and protect threatened and endangered plant species. Management responsibilities of the Conservation Program include: 1) maintaining the list of endangered, threatened and special concern plant species, 2) enforcing regulations and issuing permits for activities that may affect listed plants, 3) monitoring and managing of plant populations, 4) educating the public, and 5) monitoring the trade of American ginseng (*Panax quinquefolius*).

The NCDACS defines a threatened species as any resident plant species that is "likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range, or one that is designated as threatened by the USFWS" (NCDACS, 2003). A permit is not anticipated for the project since the proposed activities will occur during the winter months when the plant will have died back and construction activities will not occur in the frontal dune community where the plant grows.

9.6 Regulatory Thresholds of Submerged Aquatic Vegetation

Submerged aquatic vegetation is managed by the National Marine Fisheries Service as an Essential Fish Habitat and Habitat Area of Particular Concern under the 1996 amendment to the Magnuson-Stevens Fishery Conservation and Management Act (NMFS, 2000). In response to NMFS regulation, every state that is located in the coastal zone and has seagrass communities is required to preserve, protect, and restore submerged aquatic vegetation.

The North Carolina Division of Marine Fisheries is in the process of developing Coastal Habitat Protection Plans (CHPPs) for the long-term enhancement of coastal fisheries through the

protection and heightened consideration of fish habitat in resource management areas. Plan development is part of a cooperative effort among scientists from state agencies with jurisdiction over marine fisheries, water quality and coastal management areas (NCDMF, 2003).

The first CHPP to be developed will apply to the entire coastal area of North Carolina. The overall CHPP will be based on the six basic habitats that support all of North Carolina's coastal fisheries resources: the water column, shell bottom, submerged aquatic vegetation, wetlands, soft bottoms, and ocean hard bottom. (NCDMF, 2003) This plan is not yet available.

9.7 Regulatory Thresholds of Salt Marsh Ecosystems

The Federal and State regulations have been implemented throughout North Carolina to protect and prevent a net loss of wetlands. Coastal and freshwater wetlands of North Carolina are protected and managed under Federal regulations pursuant to Section 404 of the Clean Water Act and North Carolina Division of Water Quality Section 401 Water Quality Certification Program administered by USACE. In addition to these regulations, the North Carolina Coastal Area Management Act of 1974 (CAMA) has specific management rules that apply to saltwater wetlands.

The protection of coastal wetlands includes twenty coastal counties in North Carolina, governed by two state laws:

(1) North Carolina Dredge and Fill Act (1969) which requires permits for excavation or filling in any estuarine waters, tidelands, marshlands, or state-owned lake. This law is currently administered with CAMA (1974).

(2) North Carolina CAMA (1974) attempts to control development pressures through coordinated management in order to preserve North Carolina's coastal features that make it economically, aesthetically and ecologically rich. The Coastal Resources Commission, a 15-member board appointed by the Governor that oversees CAMA implementations.

The Coastal Resources Commission, a State commission created under the Coastal Area Management Act of 1974, has identified four Areas of Environmental Concern (AEC), (estuarine system, ocean system, public fresh water supplies, and natural and cultural resource areas) within the twenty coastal counties of North Carolina. The estuarine system includes a broad network of brackish sounds, marshes, and surrounding shorelines. Except for an activity that is considered exempt, any development that occurs within an AEC must obtain a CAMA authorization (Cox et al., 1994).

9.8 Regulatory Thresholds of Water Quality

Bogue Inlet is listed as Class SA Outstanding Resource Waters (ORW) by the North Carolina Department Environment Natural Resources (NCDENR). Class SA waters are suitable for shellfishing for market purposes and important to aquatic life propagation, survival, fishing, as well as primary and secondary recreation (NCDENR, 2000). ORW are classified as pristine surface waters that are considered to be exceptional by the State, and have a national recreational or ecological significance that requires special protection to maintain existing uses (NCDENR 2000). The special protection measures that apply to North Carolina ORWs are set forth in 15A NCAC 2B .02225 (NCDENR, 2001).

Table 9.1
North Carolina Water Quality Standards
(NCDWQ, 2003)

Water Quality Physical Parameters	North Carolina Surface Water Standards
Dissolved Oxygen	5.0 mg/L
pH	6.8 – 8.5
Salinity	Changes should not result in removal of the functions of a Primary Nursery Area (PNA)
Temperature	Changes should not increase 2.2ºC (3.96ºF) during all months except June – August; in no case should temperature increase above 32ºC (89.6ºF) due to discharge of heated liquids
Turbidity	25 NTU

The North Carolina Administrative Code does not provide specific standards for Class SA ORW, however, SA waters are incorporated into the rules that apply to fishing and secondary recreational waters as provided in Table 9.1.

Turbidity is measured in Nephelometric Turbidity Units (NTU) that defines the light-scattering properties of the water. The state guideline for turbidity in North Carolina SA waters are not allowed to increase in turbidity levels above ambient conditions. Due to the low percentage of silt in the material to be excavated, the increase in NTU is expected to be minimal. Vibracores taken at Bogue Inlet in 2002 show that, on average, silt comprised only 1.25% of the material. Additionally, turbidity samples taken at Swansboro from 1994 to 1999 showed an average background turbidity level of approximately 5.2 NTUs (NCDENR, 2000). Thus, it is not expected that the project will cause large increases in turbidity values above the State standards. Turbidity levels will be monitored during construction activities and measured levels that exceed State standards will require modification of construction techniques or cessation of dredging activity until acceptable levels are reached.

Salinity is another important water quality parameter for estuarine environments. During the year, Bogue Inlet has natural fluctuations and periods of high, transitional and low salinity levels. No changes to ambient salinity levels are expected either during or post-construction activities.

10.0 CEA STEP 7 – BASELINE CONDITIONS

Baseline conditions for the below listed resources can be found in the Environmental Impact Statement on the associated page.

Section 4…. Pg 56-58,76-81	Bird Resources
Section 4…..Pg. 64-67	Shellfish
Section 4…..Pg. 59-64	Benthic Infaunal Community
Section 4…..Pg. 49-55,75-76	Sea Turtles
Section 4…..Pg. 58-59	Seabeach Amaranth
Section 4…..Pg. 48-49	SAV
Section 4…..Pg. 46-48	Salt Marsh Ecosystem
Section 4…..Pg. 81-83	Water Quality
Section 4…..Pg. 67-71	Finfish

11.0 CEA STEP 8 - CAUSE AND EFFECT RELATIONSHIPS

This section of the CEA provides a conceptual model of the cause and effect relationships between resources and a changing environment. Two models were developed for each identified resource within the project area to show (1) the pathway of the resource response from non-project specific cumulative effects and (2) the pathway of the resource response from project specific effects. A project related flowchart for some of the resources was not created because the project was not expected to have high direct, indirect, or cumulative effects on that resource. Attachment B provides the general and project specific flow charts developed for the project.

12.0 CEA STEP 9 - MAGNITUDE AND SIGNIFICANCE OF CUMULATIVE EFFECTS

Step nine of the CEA assesses the effects of other projects that have occurred within the last 50 years, are presently occurring, or are going to occur in the near future along the North Carolina coastline. Table 12.1 lists 53 other significant projects (M. Sugg, pers. comm., 2003), their associated occurrence, magnitude and significance of cumulative effects on the environment.

Table 7.2 (Section 7.0) was used to assist in determining the magnitude and significance identified in Table 12.1. The magnitude column indicates positive cumulative effects versus negative cumulative effects associated with each project based on the findings provided in Table 7.2. The significance column is based on the total number of cumulative effects (positive and negative) and assigns a degree of effect to that project (Very Low = 1, Low = 2-4, High = 5-7, and Very High = 8-9).

The realignment of the Bogue Inlet channel will involve 1) dredging of the subtidal habitat; 2) placing the dredged material in the existing channel to form a dike (providing new inter- and supratidal habitat); 3) reformation of the Bogue Inlet spit from the ocean shoreline to the existing channel (providing additional intertidal habitat); 4) erosion of the ocean shoreline along the west end of Emerald Isle; and 5) erosion of the inlet shoreline along the east end of Bear Island.

Section 4.0 describes the contributing factors that can have a negative cumulative effect on each of the associated resources. The following describes the potential effects of the project on the associated resource.