INTEGRATED
FEASIBILITY REPORT
AND
ENVIRONMENTAL IMPACT STATEMENT

COASTAL STORM DAMAGE REDUCTION

SURF CITY AND NORTH TOPSAIL BEACH

NORTH CAROLINA

DECEMBER 2010

US Army Corps
of Engineers
Wilmington District

INTEGRATED

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EXECUTIVE SUMMARY, JUNE 2010

The purpose of this study is to evaluate coastal storm damage reduction for the towns of Surf City and North Topsail Beach, North Carolina, and develop the most suitable plan of damage reduction for the present and future conditions for a 50-year period of analysis. Topsail Island is on the southeastern North Carolina coast. From south to north, the three towns on the island are Topsail Beach, Surf City, and North Topsail Beach. The primary study area for this report includes the towns of Surf City and North Topsail Beach and associated nearby borrow sites. Two Transportation and Infrastructure Committee resolutions dated February 16, 2000, and April 11, 2000, authorized this report. A *General Reevaluation Report* has been completed for the town of Topsail Beach under a separate authority.

The study team integrated representatives of federal, state, and local governments, in the effort to identify cost-effective and environmentally and technically sound alternatives to reduce damages within the two towns and to the adjacent shoreline. The process integrated the U.S. Army Corps of Engineers' (Corps') Campaign Plan in all aspects of the study process. In particular, the study meets Goal 2 of the Campaign Plan, which is to deliver enduring and essential water resource solutions through collaboration with partners and stakeholders. The study effort identified a *National Economic Development* (NED) plan, which would maximize net benefits to the nation through reduction of future storm damages. The recommended plan of action is construction of the NED Plan.

This study discloses that the most practicable plan of damage reduction for the primary study area is a berm and dune project along approximately 10 miles of the oceanfront. The southern limit of the project is the boundary between Topsail Beach and Surf City. The northern limit is within North Topsail Beach at the southern edge of the Coastal Barrier Resources System (Topsail Unit, L06).

The principal project purpose is coastal storm damage reduction. The primary damages reduced are those resulting from beach erosion. In addition, if implemented the project would enhance the beach strand available for recreation use and provide habitat for a variety of plants and animals.

The selected NED Plan consists of a sand dune constructed to an elevation of 15 feet (ft.) above the National Geodetic Vertical Datum (NGVD), fronted by a 50-foot-wide beach berm constructed to an elevation of 7 ft. above NGVD. The berm and dune project extends along a reach of 52,150 ft. That plan is identified among the other alternatives as *Plan 1550*. No Locally Preferred Plan was suggested. The NED Plan is the recommended plan of improvement. The project plan is shown schematically in Figure i. Details of geographic scope, project features, and source borrow area are summarized in Table i. At the project ends, the cross sections would begin transitions to terminate gradually according to conditions existing at construction.

Figure i. Surf City and North Topsail Beach, plan view.

Table i. Plan quantities

Dune, topwidth	25 feet
Dune, elevation, NGVD	15 feet
Dune, landward slope	5H:1V
Dune, seaward slope	10H:1V
Berm, width	50 feet
Berm, elevation, NGVD	7 feet
Berm, seaward slope	15H:1V
Dune and berm fill, length	52,150 feet
North transition section, length (if required)	Variable
South transition section, length (if required)	Variable
Total Length	52,150 feet
Volume, initial, borrow, cubic yards	11,855,000
Volume, renourishment, average, borrow, cubic yards	2,642,000
Renourishment interval	6 years
Borrow source	Offshore

The recommended plan was evaluated using a discount rate of 4.125 percent at October 2010 price levels. First costs of the project are estimated at $123,135,000. Renourishment costs at 6-year intervals are estimated at $27,724,000. Expected annual costs are estimated at $10,702,000, with expected annual benefits estimated at $40,129,000 of which $16,820,000 are coastal storm damage reduction benefits, $20,505,000 are recreation benefits, and $2,804,000 are benefits during construction. The project benefit-cost ratio is 3.7 to 1. The baseline cost estimate for construction in fiscal year (FY) 2015 is $132,648,000. Details of first costs, annual costs, annual and net benefits, and benefit-cost ratios made at October 2010 price levels are shown in Table ii.

Table ii. Economic analysis, October 2010 price levels, 4.125% interest rate

Item	Amount
Total First Cost	$123,135,000
Interest During Construction	$9,513,000
Total Investment Cost	$132,648,000
Renourishments, every 6 years (total cost)	$205,539,000
Present Value, TIC & Renourishments.	$213,344,000
Annual Costs	
Interest and Amortization	$10,145,000
Monitoring	$505,000
OMRR&R	$52,000
Total	$10,702,000
Average Annual Benefits	
CSDR Benefits (incl. $1,277,000 BDC)	$18,097,000
Net Benefits (CSDR only)	$7,395,000
BCR (CSDR only)	1.7 to 1
Recreation Benefits (incl. $1,527,000 BDC)	$22,032,000
Total Benefits (all)	$40,129,000
Net Benefits (all)	$29,427,000
BCR (all)	3.7 to 1

On the basis of the recommendation using public funds for the reduction of damages along this shoreline, the Sponsors (towns of Surf City and North Topsail Beach) would provide public access and parking in accordance with Corps guidelines, at intervals of no more than one-half mile, throughout Surf City and the reach of North Topsail Beach benefitted by the cost-shared project.

The NED Plan of improvement is considered to be environmentally acceptable. However, piping plover were documented to feed along the primary study area. That species is most common as a winter resident of the state and frequently uses the surf zone. The project may affect piping plover foraging distribution on the beach because beach food resources may be affected by beachfill operations. The green sea turtle, loggerhead sea turtle, Kemp's ridley sea turtle, and leatherback sea turtle are known to nest in North Carolina and could nest in the project area. For that reason, they could be affected by initial project construction and periodic nourishment. The sea turtles occur in offshore waters and may also be affected by hopper dredges. Initial construction and periodic nourishment activities would be timed, to the extent practicable, to avoid the sea turtle nesting season and avoid hopper dredging during months when water temperatures are warm and turtles may be present. The project combined Feasibility Report and Environmental Impact Statement includes a biological assessment of project impacts as Appendix I. The U.S. Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) have reviewed this biological assessment pursuant to section 7 of the Endangered Species Act of 1973 and have concurred with the Corps findings. The USFWS concurrence is for initial construction only and re-consultation will be initiated prior to the first renourishment. The requirements of section 404(r) of P.L. (P.L.) 92-500, as amended, have been met. The town of North Topsail Beach is developing a nonfederal coastal storm damage reduction project for the parts of town that lie within the Coastal Barrier Resources System (Topsail Unit, L06). There is no conflict between the federal and nonfederal project, either on the shoreline or in the borrow areas. If the nonfederal project is not in place when the federal project begins, the northern 2,000 ft. of the dune and berm would be replaced with a transition section.

Agency Technical Review (ATR) on both the draft and final versions of this report was conducted in accordance with the Corps' *Peer Review of Decision Documents* process. The report has been reviewed by Corps staff outside the originating office, with the review being conducted by a regional and national team of experts in the field, and coordinated by the National Planning Center of Expertise in Coastal Storm Damage Reduction, North Atlantic Division, and the Corps comments and responses will accompany the report to the Assistant Secretary of the Army for Civil Works (ASA(CW)) and the Office of Management and Budget (OMB). Documentation of ATR certification will accompany the final report.

An Independent External Peer Review (IEPR) was conducted following the ATR of the draft report. The IEPR was conducted by a non-Corps national team of experts in the field and coordinated by the National Planning Center of Expertise in Coastal Storm Damage Reduction, North Atlantic Division, and the Corps comments and responses from the IEPR will accompany the report to the ASA(CW) and the OMB. Documentation of IEPR certification will accompany the final report.

In analyzing potential measures, the study team considered, in all cases where technically sound and environmentally feasible, both structural and nonstructural measures. Nonstructural measures, such as removal and relocation, were found to have greater cost than benefits, and therefore, were not recommended for the purposes of storm damage reduction. However, the recommendations of the study team that accompany all structural recommendations for dune and berm construction is that of continued and vigilant attention to the need for proactive hurricane and coastal storm threat education, coastal storm and hurricane warning and evacuation planning procedures, floodplain management, and other nonstructural activities directed at both damage reduction and preservation of life and safety. Those activities are provided as recommended actions, although many do not fall within current Corps implementation authorities.

The analyses and design of the recommendations contained in this report comply with the National Environmental Policy Act (NEPA). A separate Environmental Impact Statement (EIS) will not be provided because the final document is a fully integrated report that complies with both NEPA requirements and the Corps (and federal) water resources planning process and its requirements. The report complies with all applicable environmental statutes.

The final report fully discusses areas of risk, uncertainty, and consequences, where that information is appropriate, and describes them with sufficient detail that decisions can be made with knowledge of the degree of reliability of the estimated benefits and costs and of the effectiveness of alternative plans. All recommendations made in the report are capable of being adaptively managed, if such capability is needed. For instance, renourishment may be needed more often or less often, depending on the occurrence of large storms and accompanying erosion.

Substantial, long-term federal investments would be required to implement the current project proposal. The total first cost of the project, at Oct 2010 price levels, is $123,135,000. The federal share of the total first project cost is estimated at $80,038,000 (65 percent). The nonfederal share of the total first project cost is estimated at $43,097,000 (35 percent). The total cost of all renourishments is $205,539,000. The Federal share of the total renourishment cost would be about $102,769,500 (50 percent) and the non-Federal share would be about $102,769,500 (50 percent). As previously indicated, the total project benefit-cost ratio is 3.7 to 1, which means that for every dollar spent for the project, 3 dollars and 70 cents are realized in NED benefits from the project.

Recommendations

Hurricane Risk Education

Numerous people die each year as a result of hurricanes, primarily because of the failure to evacuate to an area of safety. Any loss of life is tragic, and any number of those deaths may have been prevented. Even one death prevented is sufficient reason to improve our methods of educating the public on hurricane and storm threats and to ensure that all is done to warn all those residents or visitors to the coastline of North Carolina as to the dual hazards of wind and surge/waves. It is particularly vital to inform the public as to the potential for hurricane occurrence, particularly within the dangerous hurricane season, so that they pay continued attention to media reports on weather. Education needs to include articulation of effects related to the potential magnitude of the threat, the urgency to heed potential calls to evacuate, and providing the means by which to make wise choices on evacuation methods and route (see recommendations given below under Hurricane Evacuation Planning). The following are suggested guidelines for implementation by state and local government, in the interests of good education on hurricane storm threats:

- Provide good science and information to the residents and visitors to coastal North Carolina, so they can understand the nature of the threat and its possibility of happening at any time within the hurricane season. That information should be provided in both written form and as an initial *page* on televisions provided in visitor's housing, and in a variety of venues, including the following:
    - Posted and televised education in supermarkets, libraries, and public buildings
    - Teacher-provided, posted, and televised education in schools and at public meetings and gatherings, at intervals not to exceed 1 year
    - Publicly posted and visitor-housing-posted information on evacuation routes, and procedures, on publicly accessible Web sites, updated regularly (minimum once a year)

There is nothing humanly possible to maintain the lives and safety of coastal North Carolina residents and visitors during hurricanes if they do not have sufficient warning, and if they then do not use that knowledge to evacuate in a timely manner.

Education of hurricane risks is an ongoing effort of multiple agencies and educational institutions and not a funded program under existing Corps authorities. Updating Web sites containing evacuation routes and procedures should be done under existing programs implemented by the state and local governments.

Hurricane and Storm Warning

Residents and visitors to the coast of North Carolina need to recognize that they live in, or visit, a high-hazard area. Although certain times of the year pose less risk than others, each year's hurricane season provides a strong possibility of hurricane impact somewhere along the coast of North Carolina. All residents and visitors need to be made aware of the current hurricane threat; but first, meteorological conditions must be evaluated, and any threat must be assessed and characterized by experts with the National Oceanic and Atmospheric Administration's (NOAA's) National Weather Service, and that interpretation must be passed to national and local media for dissemination. Continued support of NOAA's program, and the following supportive activities is critical to an adequate warning process:

- Ongoing efforts to upgrade the existing system of NOAA buoys, transmission capabilities, and advanced warning measures that provide data on the location and nature of weather conditions.
- Efforts directed at the interpretation of that data and its dissemination to the media and public, through the National Weather Service.
- Public appreciation for the need to be aware at all times of, and the need to listen to weather reports and advice given on various media. Television weather reports, radio, and the Internet all provide excellent, up-to-date information on weather conditions and the development of threatening situations. Simply living in or visiting the barrier islands of North Carolina should be sufficient to create a consistent and ongoing process of being exceptionally aware of the weather and its potential consequences.
- The vital importance of heeding the advice of experts. One should know what needs to be done if a storm is approaching. Family members should conduct evacuation drills, keep needed phone numbers and travel supplies on hand, and be prepared to leave on short notice. One should be aware of evacuation routes, keeping a full tank of gas during the hurricane season, and having a plan for where one should go, how to maintain contact with other family members, and where one will relocate temporarily, particularly if the event is longer than expected.

Hurricane Evacuation Planning Upgrading

The critical need for adequate evacuation planning was borne out by hurricanes Bertha, Fran, and Floyd, of the late 1990s and brought even more to the forefront by the monumental impacts of Hurricane Katrina in 2005. An evacuation plan is an essential component of a comprehensive plan for ensuring the safety of residents of and visitors to the coast of North Carolina. The preservation of life is the single most important goal and objective of the recommendations. Joint Federal Emergency Management Agency (FEMA)/NOAA/Corps/North Carolina studies of evacuation routes and populations along the coastline have provided a tremendous amount of value to-date in aiding local government and individual and family readiness in the face of approaching events. Support for this program is a critical element of the recommendations for the towns of Surf City and North Topsail Beach, in support of its residents and visitors. The towns of Surf City and North Topsail Beach both have evacuation and emergency response plans already in place. Important facets of these plans include:

- Annual review of hurricane evacuation plans
- State evacuation route signage
- Reverse 911 phone systems
- Low frequency AM Station

- NIMMS (emergency response command and control) training for all emergency personnel
- WEBEOC.org – a website for coordinating communication during emergencies
- Mutual aid agreements with inland emergency agencies
- Coordination of evacuation and emergency shelters with Onslow/Pender County Emergency Management
- Active re-entry pass system, for safe re-entry after an event

The following are important additional recommendations in support of efforts to support Hurricane Evacuation Planning:

- There is still much that can be done to update this ongoing effort, and to provide new, and more widely disseminated data and tools for evacuation planning by the state and the towns of Surf City and North Topsail Beach, and also for use by individuals and families in their preparation for an impending event.
- Evacuation route signage is an important part of a successful evacuation campaign. Maintenance of hurricane evacuation route signage is viewed as a vital link in ensuring the safety of residents and visitors alike.
- The provision of additional signage illustrating surge height achieved during past events would be an added and continual link to ongoing education efforts. That could take the form of signs placed in locations in which there is significant traffic, such as major thoroughfares, where pedestrians walk, and particularly in those highest hazard zones according to elevation/depth data.

Evacuation Planning is an ongoing effort of multiple agencies, including the Corps, but its implementation is not a funded program under existing Corps authorities. Periodic updating of Web sites containing evacuation routes and procedures should be conducted under existing programs implemented by North Carolina.

Floodplain Management

Management of the floodplain is a nonfederal responsibility, yet it is considered a key component of all plans for coastal storm damage reduction. The towns of Surf City and North Topsail Beach participate in the National Flood Insurance Program, which requires the towns to engage in active and responsible floodplain management. Within Surf City, property owners have 2,148 flood insurance policies composed of nearly $480 million insurance in force. North Topsail Beach property owners possess 1,384 flood insurance policies providing approximately $240 million insurance in force. Because so much of the towns of Surf City and North Topsail Beach are within a recognized floodplain, the towns continue to engage in activities that reduce threats to existing and potential future development, including structure setbacks, building code and construction monitoring, and flood zone management. The towns are encouraged to continue to update building codes, and encourage strong pursuit of activities such as first-floor elevation and building code upgrading, in the effort to reduce the potential for future structural and content damage.

Building Codes

Surf City and North Topsail Beach have adopted the International Building Code (IBC) to guide the design and construction of residential and commercial structures in the study area. To ensure that the latest design and construction techniques are being used that apply to hurricane-resistant construction, all future construction should to follow the latest version of the IBC (2007) and enforcement of the codes should occur through diligent building permit processing and on-site inspections of construction. Annual training classes on the use and enforcement of the new IBC should be conducted. In addition, Surf City and North Topsail Beach should consider adopting the document *FEMA 550 Recommended Residential Construction for Coastal Areas* (FEMA 2009) as a part of their updated building codes for construction, because of the possibility of surge inundation associated with hurricane events.

Long-term Critical Infrastructure and Services Upgrading

Upgrading critical infrastructure and services, such as Fire and Police services, is considered a vital recommendation in the reduction of threats to lives and property. The need to bring the services up to immediate restoration in the wake of a hurricane is of vital importance to the community. The methodical upgrading of the towns' Fire and Police services facilities as part of their Capital Improvement Programs would provide long-term savings in capital outlay, and potentially save lives and residential and commercial property damage. As funds become available, such a program may be instituted under a modified Capital Improvement Program, where structures reaching the end of their economic life are successively replaced by upgraded structures, locating vital communications and power supplies above the elevation of a Maximum Probable Surge event, and capable of surviving the ravages of wind and/or surge.

Upgrading or replacing services is primarily a local charge, implemented through capital improvement plans, with funding from a variety of federal, state, and local resources, and would take many years to accomplish, because of the varying age and condition of each facility.

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APPENDICES

FEASIBILITY REPORT
AND ENVIRONMENTAL IMPACT STATEMENT

COASTAL STORM DAMAGE REDUCTION

SURF CITY AND NORTH TOPSAIL BEACH

NORTH CAROLINA

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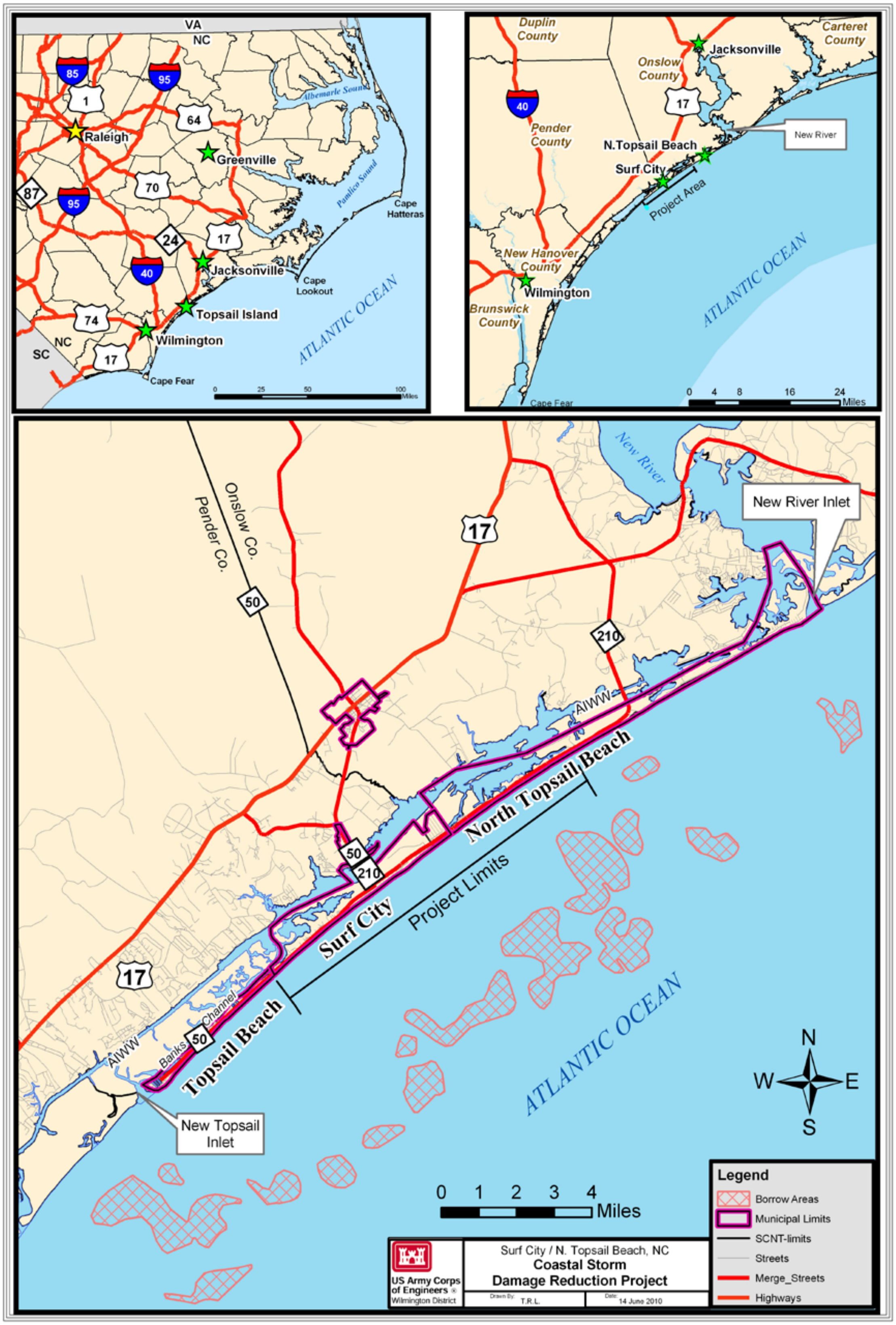
1. STUDY OVERVIEW

This Feasibility Report and Environmental Impact Statement (FEIS) presents the results of studies to reexamine the feasibility of federal coastal storm damage risk reduction for the towns of Surf City and North Topsail Beach, which are on Topsail Island. The third of three towns on the island, Topsail Beach, comprises the southern 5 miles of the island. Topsail Island lies in Pender and Onslow counties, North Carolina, as indicated in Figure 1.1, Location and Vicinity Map. Surf City and North Topsail Beach are the project sponsors. The study evaluated alternative plans for reducing damages to the commercial and residential structures and infrastructure of Surf City and North Topsail Beach. The study has resulted in a recommendation to construct a berm and dune project with continuing renourishment. The scale and costs of the project have been optimized to produce the maximum net economic benefits, or National Economic Development (NED) Plan, as directed by federal planning guidelines.



Note: The left inset is the North Carolina coast; the right inset is the region.

Figure 1.1. Location and vicinity map.

1.01 Report Organization

This report is a combined Feasibility Study and Environmental Impact Statement (FEIS), meaning it contains elements that are required for both a U.S. Army Corps of Engineers (Corps) planning feasibility report as well as an EIS per the National Environmental Policy Act (NEPA). Chapter 1 of the report is an overview of the feasibility study. Chapter 2 contains background information on the environment that could be affected by a Corps project resulting from the study. Chapters 3 to 6 discuss the plan formulation process that led to the selection of the final plan recommended in this report. Chapter 7 is a detailed description of the selected plan. Chapter 8 contains more expansive discussions on the resources that are discussed in Chapter 2 and describes in detail the environmental effects the selected plan would have on those resources. The chapter also contains briefer descriptions of the environmental effects of other major categories of alternatives (No Action and Nonstructural) that were considered during the formulation process. Chapter 9 contains information on plan implementation such as schedule and cost-sharing. Chapter 10 lists the study's compliance with all applicable environmental laws and Executive Orders. Chapter 11 is a summary of agency and public involvement that has been undertaken throughout the course of the study. Chapters 12 to 16 contain, respectively, the report's conclusions, recommendations, main point of contact, literature references, and a list of report preparers.

1.02 Study Authority

Four congressional resolutions lead up to the initiation of this project. The most applicable text is underlined.

- Resolution adopted June 24, 1970 by the United States Senate

  Resolved by the Committee on Public Works of the United States Senate, that the Board of Engineers for Rivers and Harbors, created under Section 3 of the River and Harbor Act, approved June 13, 1902, be, and is hereby, requested to review the reports of the Chief of Engineers on the Inland Waterway from Beaufort to Jacksonville, N.C., and New River to Jacksonville, published as House Document Numbered 421, Eightieth Congress, on Bogue Inlet to Moore Inlet, North Carolina, published as House Document Numbered 480, Eighty-ninth Congress, and other pertinent reports with a view to determining whether any modification of the existing project is advisable at the present time, particularly for the stabilization and deepening of New River Inlet.

- Resolution adopted 2 December 1970 by the United States House of Representatives

  Resolved by the Committee on Public Works of the House of Representatives, United States, that the Board of Engineers for Rivers and Harbors is hereby requested to review the reports of the Chief of Engineers on the Intracoastal waterway from Beaufort, North Carolina, to the Cape Fear River, published as House Document Numbered 450, 69th Congress, on the Inland Waterway from Beaufort to Jacksonville, North Carolina, and New River to Jacksonville, published as House Document Numbered 421, 80th Congress, on Bogue Inlet to Moore Inlet, North Carolina, published as House Document 480, 89th Congress, and other pertinent reports with a view to determining whether any modification of the existing project is advisable at the present time, particularly for the stabilization and deepening of New River Inlet and Bogue Inlet.

- Resolution adopted 23 June 1971 by the United States House of Representatives

  Resolved by the Committee on Public Works of the House of Representatives, United States, that, in accordance with Section 110 of the River and Harbor Act of 1962, the Secretary of the Army is hereby requested to direct the Chief of Engineers to make a survey of the shores of West Onslow Beach, Onslow County, North Carolina, and such adjacent shores as may be necessary in the interest of beach erosion control, hurricane protection, and related purposes.

- Resolution adopted 14 November 1979 by the United States House of Representatives

  Resolved by the Committee on Public Works and Transportation of the House of Representatives, United States, that, in accordance with Section 110 of the River and Harbor Act of 1962, the Secretary of the Army is hereby requested to direct the Chief of Engineers to make a survey of Topsail Beach and Surf City, North Carolina, and adjacent beaches and inlets, in the interest of beach erosion control, hurricane protection, and related purposes.

The four study resolutions between 1970 and 1979 were combined and used to initiate studies separated by function and location. Studies for navigation improvement at Bogue Inlet were combined with other congressional authorities related to Bogue Banks. Navigation needs at New River Inlet were later investigated under the Chief of Engineers Section 107 Continuing Authority program. The remaining study resolutions, pertaining to West Onslow Beach (North Topsail Beach), New River Inlet, Topsail Beach, and Surf City, were combined in 1980 at the direction of the Chief of Engineers, and designated the *West Onslow Beach and New River Inlet, North Carolina* general investigation study. That study was therefore a coastal storm damage reduction study and did not include navigation.

The study area originally included all Topsail Island, including the towns of Topsail Beach and Surf City, the community of West Onslow Beach, the community of New Topsail Shores, and New River Inlet. In 1990 West Onslow Beach and New Topsail Shores were incorporated as the town of North Topsail Beach. The recommended plan, authorized in 1992, consisted of a beachfill for the southern portion of Topsail Beach.

Storm damage reduction was not found economically feasible for the rest of the island at that time.

Following a series of hurricanes that damaged Topsail Island between 1996 and 1999, interest in a coastal storm damage reduction project was renewed. This feasibility study is in response to the two following resolutions adopted February 16, 2000, and April 11, 2000, respectively:

- Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That the Secretary of the Army is requested to review the report of the Chief of Engineers on West Onslow Beach and New River Inlet, North Carolina, published as House Document 393, 102nd Congress, 2nd Session, dated September 23, 1992, and other pertinent reports, to determine whether any modifications of the recommendations contained therein are advisable at the present time in the interest of shore protection and related purposes for Surf City, North Carolina.

- Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That the Secretary of the Army is requested to review the report of the Chief of Engineers on West Onslow Beach and New River Inlet, North Carolina, published as House Document 393, 102nd Congress, 2nd Session, dated September 23, 1992, and other pertinent reports, to determine whether any modifications of the recommendations contained therein are advisable at the present time in the interest of shore protection and related purposes for North Topsail Beach, North Carolina.

1.03 Study Area

Topsail Island is a 22-mile-long and 0.5-mile-wide barrier island approximately 40 miles northeast of Wilmington, North Carolina. Because of the northeast-southwest orientation of the coastline, the island faces the Atlantic Ocean on the southeast. Other waterbodies in the vicinity consist of the New River Inlet immediately to the northeast, Banks Channel and the Atlantic Intracoastal Waterway (AIWW) to the northwest, and New Topsail Inlet at the far southwestern end of the island.

The study area is uniformly developed with few undeveloped lots and a wide range of structures consisting mostly of single-family dwellings, some multi-unit apartment and condominium buildings, about 30 various commercial buildings, and a few hotels. Most of the developable land in the study area is already occupied with structures. Roadway access to the mainland is provided via North Carolina (N.C.) Highway 50 to Surf City and then by bridges on N.C. Highway 50/210 at Surf City and N.C. Highway 210 at North Topsail Beach. Public access to the beach is provided by numerous parking areas and dune walkovers.

Over the past 35 years, the study area has developed rapidly as a family ocean resort community for outdoor recreation. On summer weekends the population can be in the tens of thousands. In the off-season, the population drops to about 2,200 residents. During the summer months, a large portion of the homes within the study area are available as summer rentals to vacationers primarily from inland North Carolina and other locations around the Eastern United States. Two fishing piers are in the study area.

The sponsors' interest is in developing a plan of storm damage reduction for 17 miles of shoreline extending from the Topsail Beach/Surf City town limits to the northern end of Topsail Island. From the shoreline, the study area extends landward approximately 500 feet (ft.). Seaward, the study area extends from the shoreline approximately 1 mile. The study area also includes offshore borrow areas lying 1 to 6 miles from the shoreline and borrow areas in New River Inlet. For purpose of incremental analysis, the shoreline has been divided into study reaches approximately 1,000 ft. in length. The study area, consisting of town limits, bodies of water, Coastal Barriers Resources Act (CBRA) zone, and reaches, is shown in Figure 1.1.

1.04 Purpose and Need for Action

The purpose and need for coastal storm damage reduction is to reduce damages resulting from beach erosion and waves along the ocean shoreline of the study area. A wide variety of possible measures would reduce the impacts of erosion, flooding and waves on commercial and residential structures and infrastructure of the island. Some of the measures would provide incidental environmental and recreational benefits. The purpose of this action is to authorize the use of OCS sand (or other sediment) resources in beach nourishment and coastal restoration projects undertaken by federal, state or local government agencies, and/or in other federally authorized construction projects. Beach nourishment measures, which include dredging of sediment from offshore borrow areas on the Outer Continental Shelf (OCS) may require authorization by the Minerals Management Service (MMS) for use during initial or maintenance construction or both (see Section 10.11). The MMS Leasing Division is charged with environmentally responsible management of federal OCS sand and gravel resources. P.L. 102-426 [43 United States Code (U.S.C.) 1337(k)(2)], enacted October 31, 1994, gave MMS the authority to negotiate, on a noncompetitive basis, the rights to OCS sand, gravel, and shell resources for coastal storm damage reduction projects; beach or wetlands restoration projects; or for use in construction projects funded in whole or part by or authorized by the federal government. The MMS, as a cooperating federal agency, may undertake a connected action (i.e., authorize use of the OCS borrow area) that is related to, but unique from the Corps' proposed action. The MMS's proposed action is to issue a negotiated agreement pursuant to its authority under the Outer Continental Shelf Lands Act.

1.05 Scope of Study

This study consists of the analysis of measures and plans to select the plan with the highest net benefits, or determine that no plan of improvement is justified under current planning criteria and policies.

1.06 Study Process

The Corps studies for water and related land resources follow detailed guidance provided in the *Planning Guidance Notebook* (Engineer Regulation 1105-2-100). This guidance is based on the *Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies* that were developed pursuant to section 103 of the Water Resources Planning Act (P.L. 89-80) and Executive Order 11747, which were approved by the U.S. Water Resources Council in 1982 and by the President in 1983. A defined six-step process is used to identify and respond to problems and opportunities associated with the federal objective and specific state and local concerns. The process involves an orderly and systematic approach to making evaluations and decisions at each step so that the public and the decision makers can be informed of basic assumptions made, the data and information analyzed, risk and uncertainty, the reasons and rationales used, and the significant implications of each alternative plan. The process concludes with the selection of a recommended plan. Specific aspects of the process are described in more detail in other sections of this document.

1.07 National Objective

The federal objective of water and related land resources project planning is to contribute to national economic development in a manner consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other federal planning requirements. If the projected benefits of coastal storm damage reduction measures exceed their estimated costs and are judged environmentally acceptable, their construction as a federal project would contribute to this objective and be in the federal interest.

1.08 Prior Studies and Reports

The USACE has conducted a number of prior studies regarding the Topsail Island area and has prepared a number of related engineering, planning, and environmental reports. These studies have addressed coastal storm damage reduction as well as navigation needs. Reports particularly pertinent to the present study are briefly described below. Other reports related to the study area are cited in the Section 15, References.

Coastal Storm Damage Reduction

- House Document No. 480, 89th Congress, *Topsail Beach and Surf City, North Carolina*. This report, approved by Congress in 1966, presents the results of an investigation of Topsail Island conducted during the period 1963 – 1965 as part of a comprehensive study of coastal storm damage reduction needs for the segment of the North Carolina coast extending between Bogue and Moore Inlets. With approval of this report, Congress authorized coastal storm damage reduction projects for the towns of Topsail Beach and Surf City. Improvements along the northernmost 11.7 miles of Topsail Island, referred to as West Onslow Beach, were determined to be economically infeasible. The improvements authorized by this report were not constructed, and the project was deauthorized August 5, 1977. The reason for this deauthorization was that there was no apparent nonfederal interest in the project following authorization.

- House Document No. 393, 102nd Congress, 2nd Session, *West Onslow Beach and New River Inlet, North Carolina*. This report (HD 393/102/2) was conducted pursuant to four congressional resolutions adopted between 1970 and 1979. The resolutions addressed beaches, channels and inlets in the greater vicinity of Topsail Island. Studies for navigation purpose were conducted separately. The recommendation of the Final Feasibility Report and Environmental Impact Statement on Hurricane Protection and Beach Erosion Control was a dune and berm system at Topsail Beach as described below in Section 1.09, Authorized Project.

Navigation

- House Document No. 450, 69th Congress, *Inland Waterway, Beaufort – Cape Fear River*. This house document, approved by Congress in 1927, authorized construction of the AIWW from Beaufort to the Cape Fear River, with dimensions of 12 ft. deep by 90 ft. wide.

- House Document No. 421, 80th Congress, *Inland Waterway from Beaufort to Jacksonville, NC and New River to Jacksonville*. The natural river channel is considered adequate for existing river traffic and no improvements are being considered.

- House Document No. 691, 75th Congress, *Channel to New River Inlet*. This house document, approved by Congress June 20, 1938, authorized construction of a 6-foot deep by 90-foot wide channel from the AIWW through New River Inlet to the Atlantic Ocean.

- *Detailed Project Report on Improvement of Navigation, New Topsail Inlet and Connecting Channels*. This July 1965 report, approved by the Chief of Engineers April 7, 1966, authorized construction of a channel 8 ft. deep by 150 ft. wide through New Topsail Inlet. A connecting channel through Banks Channel to the AIWW was also authorized under Continuing Authorities Program, Section 107 of the River and Harbor Act of July 14, 1960.

- *Detailed Project Report on Improvement of Navigation, New River Inlet, December 1987*. This report by the Wilmington District addresses that portion of the study authority concerning navigation at New River Inlet. The report recommends deepening of the authorized navigation channel from 6 to 8 ft. and widening from 90 to 150 ft.

1.09 Existing Federal and Nonfederal Projects

The nearest existing federal coastal storm damage reduction project is at Wrightsville Beach, which is 16 miles to the southwest and beyond this study area. There is authorization for a federal coastal storm damage reduction project at the southern half of the Town of Topsail Beach. The sponsor did not execute the Project Partnership Agreement (PPA), and no project was built. A General Reevaluation Report (GRR) for Topsail Beach (formally known as the West Onslow and New River Inlet GRR) was completed in 2008, and a record of decision (ROD) was issued in April 2010. The report proposes a berm and dune plan along approximately 5 miles of shoreline in the town of Topsail Beach Appendix D (Coastal Engineering) contains additional information on the size of these and other federal coastal storm damage reduction projects in the state of NC.

Construction of both the Topsail Beach and Surf City/North Topsail Beach projects would potentially have cumulative environmental effects in the study area. Potential cumulative effects include effects on benthic organisms in borrow areas (both projects would use some of the same borrow areas) and beach impacts resulting from beach maintenance activities. Of specific concern are macroinvertebrate, fisheries, shorebird, and sea turtle species that use or occur on or adjacent to ocean beaches. A detailed discussion of the cumulative effects of the projects (and other federal and nonfederal projects in the area and in the state) is in Appendix J. Although the potential for cumulative effects does exist, the federal projects include environmental and monitoring commitments (described in sections 7.03.6 and 10.06.1 of this report) that would either minimize or avoid such effects.

A number of federal navigation projects are in this study area. They are listed and briefly described below.

- **Atlantic Intracoastal Waterway (AIWW)—**The AIWW provides an important inland navigation route from Norfolk, Virginia, to the St. Johns River, Florida. The 308-mile-long North Carolina portion is the state's only north-south commercial navigation thoroughfare. The authorized project includes a navigation channel with a depth of 12 ft. and widths varying from 90 ft. in land cuts to 300 ft. in open waters; side channels and basins at a number of locations; and five highway bridges. The Beaufort to Cape Fear River section was authorized by House Document No. 450, 69th Congress, *Inland Waterway, Beaufort – Cape Fear River*. The main channel of the AIWW in North Carolina was completed in 1940, and it has since been maintained by dredging to remove shoals that develop periodically. Some of the dredged material removed during maintenance activities is beach-quality sand. That material is placed directly on nearby ocean beaches, when practicable; otherwise, it is stockpiled in confined disposal areas near the shoreline of the AIWW. The sand can serve as a viable source of beachfill where it exists in sufficiently large volumes and in proximity to beaches.

- **New Topsail Inlet and Connecting Channels—**These consist of a channel 8 ft. deep and 150 ft. wide through New Topsail Inlet, with connecting channels 7 ft.

deep and 80 ft. wide to the AIWW. The connecting channels are through Old Topsail Creek (1.42 miles) and Banks Channel (6.27 miles), both between the AIWW and New Topsail Inlet.

- **New River Inlet—**This consists of a channel 6 ft. deep and 90 ft. wide through New River Inlet to the AIWW, a length of 2.3 miles. The channel continues another 18.8 miles from the AIWW to U.S. highway 17 at Jacksonville, North Carolina, but has not been maintained.

Additionally, over the past 25 to 30 years, material resulting from maintenance dredging of New River, the AIWW, and connecting channels has been placed on the northernmost mile of the study area in the vicinity of New River Inlet. Records from FY 1998 through FY 2007 show that this total placement of 680,000 cubic yards has occurred on an irregular basis, generally every 1 to 3 years, with dredging quantities varying from 70,000 to 170,000 cubic yards and averaging about 110,000 cubic yards per event.

The towns of North Topsail Beach and Topsail Beach are also proposing nonfederally funded beach renourishment actions. North Topsail Beach has proposed putting 4 million cubic yards of material in the CBRA zone, which is outside the federal project study area. Topsail Beach has proposed putting about 1.3 million cubic yards of material as an interim renourishment plan that would occur before construction of a federal plan.

Also of note, North Carolina has begun creating a Beach and Inlet Management Plan (BIMP). The long-term goal of that plan is implementing a consensus-based regional strategy for the state, federal, and local governments to manage beach and inlet projects across the entire state.

2. AFFECTED ENVIRONMENT

The project is in Pender and Onslow counties in the towns of Surf City and North Topsail Beach, North Carolina. Topsail Island is a 22-mile-long barrier island on North Carolina's south-central coast consisting of three communities, from south to north—Topsail Beach, Surf City, and North Topsail Beach. The footprint of the proposed action includes the sub-aerial beaches of Surf City and North Topsail Beach as well as the marine environment offshore of the barrier island. Significant resources found within the vicinity of the project area, in both the marine and terrestrial environment, are described below. Physical resources, socioeconomic resources, recreation and aesthetic resources, cultural resources, Section 122, P.L. 91-611 Resources, and water quality conditions are also discussed in this section. Vertical datum for this report is NGVD29.

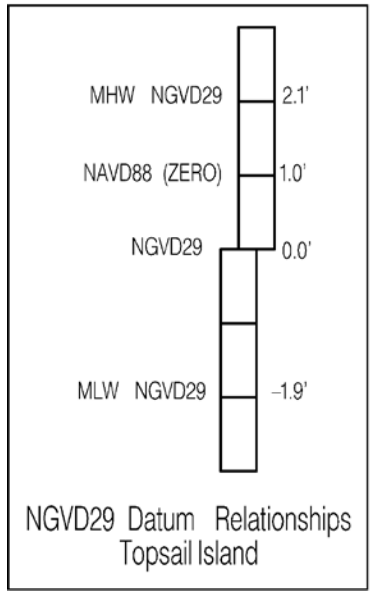


Figure 1.2, Datum relationships

2.01 Marine Environment

Marine waters in the vicinity of the beach nourishment area and offshore borrow sites provide habitat for a variety of ocean fish and are important commercial and recreational fishing grounds (Appendix A, Figure A-1). Kingfish, spot, bluefish, weakfish, spotted sea trout, flounder, red drum, king mackerel, and Spanish mackerel are actively fished from boats, the beach, and local piers. According to the North Carolina Division of Marine Fisheries (NCDMF) commercial and recreational harvest statistics, those species compose approximately 18 and 37 percent, respectively, of the total pounds of fish landed in North Carolina in 2007 (http://www.ncfisheries.net/statistics/index.html). The surf zone typically exhibits a high diversity of fish fauna. According to data collected from surf zone seine sampling along the South Atlantic Bight, 130 species of fishes are known from the surf zone between North Carolina and southern Georgia of which 47 species have been recorded from North Carolina beaches. The major recruitment period for juvenile fishes to surf zone nurseries is late spring through early summer. The waters also accumulate juvenile, ocean spawning, and estuarine-dependent fish and invertebrates in the late winter and early spring before their transport through New Topsail and New River Inlets (Hackney et al., 1996).

The intertidal zone in the proposed beach nourishment area serves as habitat for invertebrates including mole crabs, coquina clams, amphipods, isopods, and polychaetes, which are adapted to the high-energy, sandy-beach environment. The species are not commercially important; however, they provide an important food source for surf-feeding fish and shore birds. Offshore bottoms also provide habitat for benthic-oriented organisms. Special concerns are hard-bottom areas, which generally support a diversity of soft corals, anemones and sponges and provide habitat for reef fish such as black sea bass, red porgy, and groupers. Hard bottoms are also attractive to pelagic species such as king mackerel, amberjack, and cobia.

Sargassum is an abundant seaweed that occurs near the surface in warm waters of the western North Atlantic. With an exceptionally fast growth rate, floating rafts of Sargassum represent a highly renewable natural resource that can be harvested for various uses. Sargassum supports a wide range of marine organisms that include micro- and macro-epiphytes, fungi, more than 100 species of invertebrates, more than 100 species of fishes, and four species of sea turtles. The South Atlantic Fishery Management Council (SAFMC) previously designated Sargassum as essential fish habitat (EFH) for snappers, groupers, and coastal migratory pelagic fishes of the South Atlantic region (Coston-Clements et al., 1991)

2.01.1 Wetlands and Flood Plains

Coastal wetlands of the project vicinity include tidal salt marshes, which occur along the shorelines and island fringes along the backside of Topsail Island (Appendix A, Figure A-2). Intertidal wetlands of the area are very important ecologically because of their high primary productivity, their role as nursery areas for larvae and juveniles of many marine species, and their refuge/forage value to wildlife. In addition, they provide aesthetically valuable natural areas. Many types of wetland communities are present in the project area including smooth cordgrass marsh, needlerush marsh, saltmeadows, and high marsh. All are important primary producers of organic matter and, therefore, serve as part of the base of the aquatic food chain. Smooth cordgrass (*Spartina alterniflora*) marshes occur within the intertidal zone along the sounds and tidal creeks and provide valuable nursery habitat for many commercially valuable species of marine and estuarine organisms. The frequent removal of organic material and the daily tidal sedimentation processes make salt marsh communities very productive (Schafale and Weakley 1990). Needlerush marsh is dominated by black needlerush (*Juncus romerianus*) and occurs in areas that are irregularly flooded. Saltmeadows are essentially pure stands of salt meadow cordgrass (*Spartina patens*), which can occur between 3.5–5.0 ft. above mean sea level. Salt grass (*Distichlis spicata*), sea lavender (*Limonium carolinianum*), glasswort (*Salicornia* spp.), and sea ox-eye (*Borrichia frutescens*) are also prominent plants in this community. High marsh is a transitional community between high ground areas and wetlands and, depending on location and frequency of flooding, may have characteristics of either. It is important in stabilizing the shifting sands of the barrier island. Given time and protection, it will eventually become vegetated with dominant shrub species such as marsh elder (*Iva frutescens*), wax myrtle (*Myrica cerifera*), and yaupon (*Ilex vomitoria*) (Wilson 1981).

North Carolina defines Primary Nursery Areas (PNAs) as tidal saltwaters, which provide essential habitat for the early development of commercially important fish and shellfish (Appendix A, Figure A-3). It is in such estuarine areas that many fish species undergo initial post-larval development. PNAs are designated by the North Carolina Marine Fisheries Commission and total 80,144 acres statewide. With the exception of navigation channels, they include most estuarine waters of the project vicinity, including those bounded by New River (north), New Topsail Inlet (south), AIWW (west), and the landward side of Topsail Island. Protection of juvenile fish is provided in those areas through prohibition of many commercial fishing activities, including the use of trawls, seines, dredges, or any mechanical methods of harvesting clams or oysters (http://www.ncfisheries.net/rules.htm; 15 NC Administrative Code 3B .1405).

2.01.2 Inlet, Flats, and Sounds

New Topsail Inlet separates Topsail Beach to the northeast from Lea Island to the southwest and serves as the major ocean outlet for the waters of the AIWW through Howard's Creek, Topsail Creek, and Banks Channel (see Figure 1.1). The mean minimum inlet width for the past 60 years has been 480 meters (1,575 ft.) and over the past decade, the average rate of migration has been southwest 30 meters (98 ft.) per year. New River Inlet separates North Topsail Beach to the southwest from military-controlled Onslow Beach to the northeast and serves as an ocean outlet for New River (see Figure 1.1). In recent history, the width of New River inlet has varied considerably and has been influenced by dredging activities. Since the initiation of maintenance dredging activities in 1963, inlet migration rates have altered and the average inlet width has been 225 meters. North Topsail Beach is experiencing oceanfront erosion trends related the changing shape of the ebb-tidal delta, which in turn is primarily governed by the ebb-channel orientation (Cleary and Marden, 1999). Ebb channel orientation and subsequent inlet migration response at New Topsail inlet and New River inlets has a dramatic effect on the accretion and erosion patterns experienced at Topsail Beach and North Topsail Beach, respectively. As New Topsail inlet migrates southwest toward Lea Island, the southern spit of Topsail Beach continues to accrete; whereas, North Topsail Beach continues to erode under the current ebb-channel alignment of New River inlet. Portions of the sound around New Topsail Inlet and the mouth of New River inlet may contain large intertidal shoals and mud flats, which are very important to migrating and wintering waterbirds, including the Piping Plover; however, the quantity and quality of that habitat is dependent on the inlet dynamics and subsequent shape of the ebb tidal delta and ebb-channel orientation at any time. Both inlets are a critical migratory pathway for many organisms entering and exiting the sounds and river, including larval fishes and crustaceans (Section 2.01.5), and anadromous and catadromous fishes.

An estuary is a partly enclosed body of water where freshwater from rivers mixes with saltwater from the sea. North Carolina has the largest estuarine system of any state on the Atlantic Coast with estuarine-dependent species composing 90 percent of commercial landings and 60 percent of recreational landings (by weight) (Street et al. 2004). The large estuarine system within the vicinity of Surf City and North Topsail Beach, including the sounds (i.e., Topsail and Stump sounds) and bays (i.e., Chadwick and Alligator bays), are separated from the ocean by Topsail Island. Many variables influence the character of the estuary including wind direction and force, inlet flows, river discharge, and such. Salinity near New Topsail and New River inlets varies depending on tides and freshwater discharge and could range between 10 and 32 parts per thousand (ppt) (Hettler and Barker 1993). Tides near those inlets normally follow those of the sea; however, at times, the combined forces of freshwater discharge and wind overwhelm incoming tides and force water out of the inlet throughout the tidal cycle. Below the surface of the estuarine environment around the inlets is a mosaic of shifting sand habitats. Small areas of submerged aquatic vegetation (SAV) habitat have been observed in the past few years by biologists from NCDMF Topsail Sound (NCDENR 2005). The

Carolina diamondback terrapin is a state-listed species of concern for Pender County, North Carolina, and may be found on the sound side of Topsail Island in brackish water areas and feeds mostly feed on clams, shrimp, crabs, snails, and small fish. They have been known to eat some vegetation, but they are primarily carnivores (http://www.chelonia.org/).

2.01.3 Nearshore Ocean

Sand excavation and material disposal for beach and berm construction would occur in the nearshore ocean in an area described by Day et al. (1971) as the *turbulent zone*. The turbulent zone includes ocean waters from below low tide to a depth of about 60 ft. NGVD (National Geodetic Vertical Datum). Identified sediment borrow areas proposed for project construction and periodic nourishment are approximately 1 to 6 miles offshore between –35 foot to –50 foot Mean Lower Low Water (MLLW) (Appendix A, Figure A-6). Those borrow sites beyond 3 nautical miles offshore are subject to federal mining requirements imposed by the MMS. Beach nourishment would introduce fill into nearshore waters with a depth of closure of –23 ft. NGVD. Benthic organisms, phytoplankton, and seaweeds are the major primary producers in this community with species of *Ulva* (sea lettuce), *Fucus*, and *Cladocera* (water fleas) being fairly common where suitable habitat occurs. Many species of fish-eating birds are typically found in that area including gulls, terns, cormorants, loons, and grebes (Section 2.02.3). Marine mammals and sea turtles also are frequently seen in the area (See Appendix I). Fishes and benthic resources of the area are discussed in Sections 2.01.7 and 2.01.9, respectively.

2.01.4 Surf Zone Fishes

The surf zone along the area beaches provides important fishery habitat on which some species are dependent. Surf zone fisheries are typically diverse, and 47 species have been identified from North Carolina; however, the actual species richness of fishes using the North Carolina surf area for at least part of their life history is much higher (Ross, 1996; Ross and Lancaster, 1996). According to Ross (1996), the most common species in the South Atlantic Bight surf zone are Atlantic menhaden (*Brevoortia tyrannus*), striped anchovy (*Anchoa hepsetus*), bay anchovy (*A. mitchilli*), rough silverside (*Membras martinica*), Atlantic silverside (*Menidia menidia*), Florida pompano (*Trachinotus carolinus*), spot (*Leiostomus xanthurus*), Gulf kingfish (*Menticirrhus littoralis*), and striped mullet (*Mugil cephalus*). Two species in particular, the Florida pompano and gulf kingfish (*M. littoralis*) seem to use the surf zone exclusively as a juvenile nursery area and are rarely found elsewhere. The major recruitment time for juvenile fishes to surf zone nurseries is late spring through early summer (Hackney et al., 1996). Recent studies by Ross and Lancaster (1996) indicate that the Florida pompano and gulf kingfish may have high site fidelity to small areas of the beach and extended residence time in the surf zone, suggesting its function as a nursery area. Major surf zone species consume a variety of benthic and planktonic invertebrates, with most of the prey coming from the water column. The dominant benthic prey are coquina clams; however, that is not the dominant food item throughout the South Atlantic Bight. Furthermore, many surf zone fishes exhibit prey switching in relation to prey availability, which could mitigate effects of beach nourishment (Ross, 1996).

2.01.5 Larval Fishes

New Topsail and New River Inlets are important passageways for the larvae of many species of commercially or ecologically important fish. Spawning grounds for many marine fishes are believed to occur on the continental shelf with immigration to estuaries during the juvenile stage. The shelter provided by the marsh and creek systems in the sound serves as nursery habitat where young fish undergo rapid growth before returning to the offshore environment.

Transport from offshore shelves to estuarine nursery habitats occurs in three stages: offshore spawning grounds to nearshore, nearshore to the locality of an inlet or estuary mouth, and from the mouth into the estuary (Boehlert and Mundy, 1988). Hettler et al. (1997) documented, through analysis of larvae otoliths, that a large number of young Atlantic menhaden (*B. tyrannus*) larvae averaging 55 days post hatch arrived in mid-March on the date of maximum observed daily concentration (160 larvae per 100 cubic meters (m^3)(3,531 cubic feet [ft^3]). For all species recorded in this study, abundance varied as much as an order of magnitude from night to night. The methods the larvae use to traverse large distances over the open ocean and find inlets are uncertain. Various studies have hypothesized such mechanisms as passive wind and depth-varying current dispersal and active horizontal swimming transport. However, little is known regarding larval distribution in the nearshore area.

Little research has been conducted within the New Topsail and New River Inlet systems regarding larval species composition and abundance. However, the Beaufort Inlet system about 40 miles north/northeast of New River Inlet has been extensively studied, and significant amounts of data have been collected regarding larval transport of commercially and ecologically important fish. Considering the close proximity of the inlet systems, it can be expected that species composition would be similar (Larry Settle, personal communication, June 27, 2002; Thomas Lankford, personal communication, August 12, 2004). During the winters of 1992–1993 and 1993–1994, Hettler and Hare (1998) conducted an experiment at Beaufort Inlet, North Carolina, to further understand the estuarine ingress of offshore spawning species. A complex lateral structure in estuarine circulation, independent of the inlet opening size, was found in regards to larval concentration with significant interactions among inlet side, distance offshore, and date of ichthyoplankton tows. Length of species caught varied by cruise, inlet side, and distance offshore. The differences in larval concentration offshore and inshore and the species differences in length suggest species-specific rates controlling the net number of larvae entering the nearshore from offshore, the net number of larvae entering the inlet mouth from nearshore, and the larval mortality in the nearshore zone. Results from the study suggest two bottlenecks for offshore-spawning fishes with estuarine juveniles: the transport of larvae into the nearshore zone and the transport of larvae into the estuary from the nearshore zone (Hettler and Hare, 1998).

Egg and larval transport from offshore spawning grounds to the inshore environment of Beaufort Inlet was studied by Hettler and Hare (1998) in seven estuarine-dependent species, including Atlantic menhaden (*B. tyrannus*), spot (*L. xanthurus*), Atlantic croaker

(*Micropogonias undulatus*), pinfish (*Lagodon rhomboides*), summer flounder (*Paralichthys dentatus*), southern flounder (*P. lethostigma*) and Gulf flounder *(P. albigutta*). Research conducted by the NMFS Beaufort Laboratory through June 2002 collected a total of 120 species of larval fish fauna off the Beaufort Inlet and adjacent waters. According to Hettler and Hare (1998), average weekly concentration (number per 100 m^3 (3,531 ft^3)) for all of the above estuarine dependent species, with the exception of Gulf flounder, was calculated during the October 1994 to April 1995 immigration season. Concentrations were 22.9, 4.8, 25.7, 12.4, 0.3, and 0.8 larvae/100m^3 (3,531 ft^3) respectively (Hettler, 1998). According to the spring tide flow calculated by Jarret (1976) and the calculated daily larval concentration within the water column, approximately 32.5, 6.8, 36.5, 17.6, 0.43, and 1.1 million larvae pass through the inlet during a single spring tide for each respective species. Concentrations for all species combined (Appendix Q) entering the inlet during a single tidal prism range from 0.5 to 5 larvae/m^3. Therefore, daily calculated larval concentration at Beaufort Inlet for all species within the tidal prism ranges between 66 to 710 million (Larry Settle, personal communication, June 27, 2002).

2.01.6 Anadromous Fishes

A number of anadromous fish species occur in ocean waters along the North Carolina coast (within ~3 miles) and migrate into rivers and their tributaries to spawn in freshwater. These include the striped bass (*Morone saxatilis*), Atlantic sturgeon (*Acipenser oxyrhynchus*) and shortnosed sturgeon (*Acipenser brevirostrum*), and several members of the herring family (Clupeidae) such as the American shad *(Alosa sapidissima*), hickory shad (*Alosa mediocris*), alewife (*Alosa pseudoharengus*), and blueback herring (*Alosa aestivalis*). Historically, the species used most accessible coastal streams in North Carolina, and the highest use occurred from mid-winter to mid-spring during the spawning runs. Sampling in the New River in 1974 and 1975 by NCDMF identified the presence of blueback herring, alewife, American shad, and Atlantic sturgeon, although egg-netting results indicated very poor spawning success for all anadromous species. That 1975 study concluded that anadromous fish stocks in New River were very low and that, as a result, there was little or no use of the fishery (Sholar, 1975) and no recent anadromous fish studies have been completed in New River since then (Fritz Rhode, personal communication, August 9, 2008). Recent reports from the NCDMF indicate the presence of juvenile Atlantic sturgeon in the lower New River and inlet vicinity; however, no recent records exist of shortnose sturgeon in the project area (Fritz Rhode, personal communication, August 9, 2008) (see Appendix I, Biological Assessment). Because of the lack of suitable freshwater spawning areas in the project area and the requirement of low salinity waters by juveniles, any shortnose sturgeons present would most likely be non-spawning adults (NMFS, 1998).

2.01.7 Nekton

Nekton collectively refers to aquatic organisms capable of controlling their location through active movement rather than depending on water currents or gravity for passive movement. Nekton of the nearshore Atlantic Ocean along Topsail Island, North Carolina, can be grouped into three categories: estuarine dependent species, permanent resident species, and seasonal migrant species. The most abundant nekton of these waters are the estuarine-dependent species, which inhabit the estuary as larvae and the ocean as juveniles or adults. That group includes species that spawn offshore, such as the Atlantic croaker (*Micropogon undulatus*), spot (*L. xanthurus*), Atlantic menhaden (*B. tyrannus*), star drum (*Stellifer lanceolatus*), southern kingfish (*Menticirrhus americanus*), flounders (*Paralichthys* spp.), mullets (*Mugil* spp.), anchovies (*Anchoa* spp.), blue crab (*Callinectes sapidus*), and penaeid shrimp (*Farfantepenaeus* spp. and *Lilopenaeus* sp.), as well as species that spawn in the estuary, such as red drum (*Sciaenops ocellatus*) and weakfish (*Cynoscion regalis*). Species that are permanent residents of the nearshore marine waters include the black sea bass (*Centropristis striata*), longspine porgy (*Stenotomus caprinus*), Atlantic bumper (*Chloroscombrus chrysurus*), inshore lizardfish (*Synodus foetens*), and searobins (*Prionotus* spp.). Common warm water migrant species include the bluefish (*Pomatomus saltatrix*), Spanish mackerel (*Scomberomorus maculatus*), king mackerel (*Scomberomorus cavalla*), cobia (*Rachycentron canadum*), Florida pompano (*T. carolinus*), and spiny dogfish (*Squalus acanthias*). Oceanic large nekton offshore of Topsail Island are composed of a wide variety of bony fishes, sharks, and rays, as well as fewer numbers of marine mammals and reptiles.

All marine mammals are protected by the Marine Mammal Protection Act (MMPA) of 1972, as amended, but the West Indian manatee and six large whales are also listed as endangered and, therefore, are afforded additional protection under the Endangered Species Act (ESA). The MMPA prohibits, with certain exceptions, the *take* of marine mammals in U.S. waters and by U.S. citizens on the high seas, and the importation of marine mammals and marine mammal products into the United States. All marine mammals and reptiles that may be present within the project area and are federally listed as threatened or endangered under the ESA are addressed in the biological assessment (see Appendix I).

Several marine mammal species occur in the project, which are not federally listed but are protected under the MMPA. The Navy uses the Marine Resource Assessment program to develop a comprehensive data and literature compilation of protected and managed marine resources within its various operating areas. The document is used for planning purposes and for various types of environmental documentation, such as biological and environmental assessments, that must be prepared in accordance with NEPA, MMPA, ESA, and Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA). Thirty-eight marine mammal species have been recorded in or adjacent to the Surf City and North Topsail Beach project area. Those species include 33 cetaceans (whales, dolphins, and porpoises), 4 pinnipeds (seals, sea lions, and fur seals), and 1 sirenian. Only 24 of those species are expected to regularly occur in the region (Table 2.1). Some cetacean species occur in the project area year-round (e.g., bottlenose dolphin, beaked whales), while others (e.g., right whale, humpback whale) occur seasonally as they migrate through the area. Only rare occurrences of the West Indian manatee are anticipated. Although bottlenose dolphins are common in the project area, the Corps has never documented a direct effect on bottlenose dolphins from dredging activities during its numerous dredging projects throughout the United States; therefore, an Incidental Harassment Authorization in accordance with the MMPA is not anticipated for this project. In the April 25, 2005, notice in the *Federal Register* for the issuance of an Incidental Harassment Authorization for blasting at the Port of Miami, NMFS concluded, “According to the Corps, bottlenose dolphins and other marine mammals have not been documented as being directly affected by dredging activities and, therefore, the Corps does not anticipate any incidental harassment of bottlenose dolphins. NMFS concurs” (Geo-Marine, 2005). Therefore, no further coordination under the MMPA is anticipated for this project.

Table 2.1. Marine mammal species found in the project area.

Order Cetacea
Suborder Mysticeti (baleen whales)
Family Balaenidae
North Atlantic right whale *Eubalaena glacialis* ENDANGERED
Family Balaenopteridae (rorquals)
Humpback whale *Megaptera novaeangliae* ENDANGERED
Minke whale *Balaenoptera acutorostrata*
Bryde’s whale *Balaenoptera edeni*
Sei whale *Balaenoptera borealis* ENDANGERED
Fin whale *Balaenoptera physalus* ENDANGERED
Blue whale *Balaenoptera musculus* ENDANGERED
Suborder Odontoceti (toothed whales)
Family Physeteridae
Sperm whale *Physeter macrocephalus* ENDANGERED
Family Kogiidae
Pygmy sperm whale *Kogia breviceps*
Dwarf sperm whale *Kogia sima*
Family Ziphiidae (beaked whales)
Cuvier’s beaked whale *Ziphius cavirostris*
True’s beaked whale *Mesoplodon mirus*
Gervais’ beaked whale *Mesoplodon europaeus*
Blainville’s beaked whale *Mesoplodon densirostris*
Sowerby’s beaked whale *Mesoplodon bidens*
Northern bottlenose whale *Hyperoodon ampullatus*
Family Delphinidae (dolphins)
Rough-toothed dolphin *Steno bredanensi*s
Bottlenose dolphin *Tursiops truncatus*
Pantropical spotted dolphin *Stenella attenuata*
Atlantic spotted dolphin *Stenella frontalis*
Spinner dolphin *Stenella longirostris*
Striped dolphin *Stenella coeruleoalba*
Clymene dolphin *Stenella clymene*
Short-beaked common dolphin *Delphinus delphis*
Fraser’s dolphin *Lagenodelphis hosei*
Risso’s dolphin *Grampus griseus*
Melon-headed whale *Peponocephala electra*
Pygmy killer whale *Feresa attenuate*
False killer whale *Pseudorca crassidens*
Killer whale *Orcinus orca*
Long-finned pilot whale *Globicephala melas*
Short-finned pilot whale *Globicephala macrorhynchus*
Family Phocoenidae
Harbor porpoise *Phocoena phocoena*

Order Carnivora
Suborder Pinnipedia (seals, sea lions, walruses)
Family Phocidae (true seals)
Harbor seal *Phoca vitulina*
Gray seal *Halichoerus grypus*
Harp seal *Pagophilus groenlandicus*
Hooded seal *Cystophora cristata*

Order Sirenia
Family Trichechidae
West Indian manatee *Trichechus manatus*

Source: Geo-Marine, 2008

Note: Those species identified as endangered under the ESA are addressed in the biological assessment (Appendix I).

2.01.8 Benthic Resources—Beach and Surf Zone

The intertidal zone of the beach shoreface is extremely dynamic and is characterized as the area from mean low tide landward to the high tide mark. The area serves as habitat for invertebrate communities adapted to the high-energy, sandy-beach environment. Important invertebrates of the surf zone and beach/dune community include the mole crab (*Emerita talpoida*), coquina clams (*Donax variabilis*), polychaete worms, amphipods, and ghost crabs (*Ocypode quadrata*). Mole crabs and coquinas represent the largest component of the total macrofaunal biomass of North Carolina intertidal beaches, and they are consumed in large numbers by important fish species such as flounders, pompanos, silversides, mullets, and kingfish (Reilly and Bellis, 1978; Leber, 1982; Johnson, 1994). Beach intertidal macrofauna are also a seasonally important food source for numerous shorebird species.

Through recent studies supported by the U.S. Fish and Wildlife Service (USFWS) and the Corps, the distributions and abundance of these animals on nearby beaches is fairly well documented. Extensive sampling of the intertidal and nearshore beach environment was performed and documented in the Corps New York District's biological monitoring report titled, *Final Report for The Army Corps of Engineers New York District's Biological Monitoring Program for the Atlantic Coast of New Jersey, Sea Bright to Manasquan Inlet, Beach Erosion Project* (2001). Results of that study indicate that the intertidal infaunal assemblage was dominated by rhynchocoels; the polychaetes *Scolelepis squamata*, *Protodriloides (LPIL)*, and *Microphthalmus* spp.; oligochaetes; the mole crab *E. talpoida*; and a number of haustoriid amphipods. The nearshore infaunal assemblage included many of the same taxa but was dominated by the wedge clam, *D. variabilis*, the polychaete *Magelona papillicornis*, the clams *Spisula solidissim*a and *Tellina agilis*, and the amphipods *Acanthohaustorius millsi* and *Psammonyx nobilis*, and the polychaete *Asabellides oculata*. Those documented infaunal assemblages are consistent with other studies throughout the Atlantic Coast (USACE, 2001). In North Carolina, along Bogue Banks and Topsail Island, infaunal assemblages are dominated by *D. variabilis*, *D. parvula*, and *E. talpoida*, which function as an important first link in the flow of energy in the intertidal system (Leber, 1982; Reilly and Bellis, 1978). Other organisms occurring less frequently are Amphipods (*Haustorius canadensis*, *Talorchestia megalopthalma*, and *Amphiporia virginiana*) and Polychaetes (*S. squamata* and *Nephtys picta*) (Lindquist and Manning, 2001; Nelson, 1989; Leber, 1982; Reilly and Bellis, 1978).

2.01.9 Benthic Resources—Nearshore Ocean

Aquatic organisms that live in close association with the bottom, or substrate, of a body of water, are collectively called the benthos. Benthos communities provide a link between planktonic and benthic production and commercially important fish species (Posey, 1991). Benthic communities of the project area exhibit a wide range of organism composition and density, and community structure may vary considerably depending on substrate type, salinity regime, proximity to structural habitat, and the like. Benthic substrate type and structural habitat within the project area range between fine- to coarse-grained sand; gravel and shell hash; and low-, moderate-, and high-relief hard bottom. Specifically, the nearshore *soft bottom* environment just offshore of the beach face consists of transitioning regions of coarse gravel and shell hash and sand. Those features, common to North Carolina, are defined in the literature as, rippled scour depressions (RSD), rippled channel depressions (RCD), or sorted bed forms. They are thought to be the result of a feedback mechanism whereby an existing deposit of coarse-shell hash and gravel material is built on and segregated from fine material due to wave motion interacting with the enhanced roughness of the seafloor bed around patches of coarse material (Cacchione et al., 1984; Thieler et al., 1999, 2001; Murray and Thieler, 2004) (see Section 8.01.8.2). The specific biological functions of those features have not been heavily studied; however, the benthic species composition, population, and community structure likely shift depending on the substrate type. Most nearshore benthic invertebrates in soft-bottom substrates tend to be r-strategists, which are characteristically small-bodied, short-lived, and have high fecundity, efficient dispersal mechanisms, and rapid growth rates. Thus, recolonization of a disturbed area is generally initiated by r-strategists (Bowen and Marsh, 1988).

As discussed in Section 2.01.10, *hard-bottom* communities are in the offshore environment of the project area and are found within the proposed borrow areas and consist of low-, moderate-, and high-relief features (Moser and Taylor, 1995; Moser et al., 1995). Benthic organisms and community structure associated with hard-bottom features are unique from other soft-bottom, benthic communities. Section 2.01.10 and Appendix R4 discuss the specific organisms identified within representative hard-bottom communities found in the study area. In summary, moderate- to high-relief, hard-bottom communities were more diverse and supported predominantly *Oculina* sp. colonies, tunicates, sponges, macro-algae (i.e., benthic sargassum), bryozoans, and hydrozoans; whereas, low-relief communities were characterized by lower stony coral cover and higher cover by fast-growing octocorals.

A myriad of benthic surveys of representative soft-bottom, nearshore ocean sites have been conducted throughout the Mid-Atlantic and South Atlantic regions, including within the vicinity of the proposed project area. Three nearshore ocean sites off Virginia Beach were conducted for the U.S. Department of Interior’s MMS in 1996 and 1997 by Cutter and Diaz (1998). They collected a total of 119 taxa from 13 Smith-Macintyre grabs collected in 1996. Half of the top 14 taxa (occurrence and abundance) were polychaetes. The remainder included representatives from the amphipods, decapods, bivalves, nemerteans, tanaids, echinoderms, and chordates. They found the overall community composition to be typical for sandy, shallow, continental shelf habitats and with similar species composition for similar depths and sediment types reported by Day et al. (1971) for North Carolina (Table 2.2). Day et al. (1971) define the nearshore ocean as the *turbulent zone*, which includes ocean waters from below low tide to a depth of about 60 ft. According to Day et al., polychaete species are highly represented in this zone with pelecypods, decapods, amphipods, echinoderms, and cephalochordates also present. Biological characterization results from field surveys performed by MMS of offshore shallow shelf habitats in the Outer Banks, North Carolina, identified members of the major invertebrate and vertebrate groups commonly found in the general area. Dominant infaunal groups consisted of crustaceans, echinoderms, mollusks, and polychaetes, while epifaunal taxa consisted primarily of decapods, sea stars, and squid. Dominant demersal fish species included clearnose skate (*Raja eglanteria*), flounder (*Paralichthys* sp.), scup (*Stenotomus chrysops*), and sea robin (*Prionotus scitulus*) (Byrnes et al., 2003). Posey and Alphin (2000), collected offshore benthic infaunal samples at depths of 30–40 ft. from pre-borrow sites of Kure Beach, North Carolina. Results indicate that the benthic community was very diverse, with more than 600 species, and largely dominated by polychaetes, with crustaceans and bivalves composing most of the remaining taxa.

Benthic infaunal samples were collected by Dial Cordy and Associates Inc. within six borrow sites offshore of Topsail Beach in 2007 (USACE, 2009, 2007a). Benthic invertebrate abundance, species composition, and biomass were calculated and qualitative comparisons of the data were made to the results of other pertinent benthic studies in the Mid- and South-Atlantic regions. Results indicate that the benthic resources in the sampled borrow areas off of Topsail Beach are similar in composition and taxa dominance to those described in other studies along the North Carolina and South Carolina coasts (Table 2.2) (Byrnes et al., 2003; Van Dolah et al., 1984; Versar, 2002 and 2006; and Posey and Alphin 2000 and 2002). However, the benthic community found offshore of Topsail Beach was less diverse and abundant than baseline sampling performed for the Kure Beach restoration project (Posey and Alphin, 2000 and 2002) and for the Dare County beach coastal storm damage reduction project (Versar, 2006). It is likely that the differences between the benthic community off Topsail Beach and the two referenced studies are due to the more extensive sampling effort associated with baseline monitoring programs as compared to a less intensive sampling regime for a general characterization study (i.e., 10 sampling stations per site off Dare County as compared to three to five stations per site for the Topsail Beach benthic characterization study). Of the 104 total taxa collected for the one-time sampling performed off Topsail Beach, polychaetes also dominated the community, composing over 30 percent of the relative abundance at four of the six borrow sites (USACE, 2009, 2007a).

Table 2.2. Most abundant benthic species within the Topsail Island offshore borrow sites

Group	Species
Polychaeta	*Mediomastus* sp. *Onuphidae* sp. *Armandia maculate* *Bhawania heteroseta* *Glyceridae* sp. *Goniada littorea* *Goniadides carolinae* *Caulleriella* sp. *J* *Magelona papillicornis* *Spionidae* sp.
Malacostraca	*Rhepoxynius hudsoni* *Eudevenopus honduranus*
Ostracoda	*Eusarsiella texana*
Leptocardia	*Branchiostoma* sp.
Ophiuroidea	*Ophiuroidea* sp.
Bivalvia	*Crassinella dupliniana* *Crassinella lunulata* *Lucinidae* sp. *Tellina* sp.
Gastropoda	*Acteocina canaliculata* *Cylichna alba* *Caecum pulchellum*
Turbellaria	*Turbellaria* sp.
Rhynchocoela	*Rhynchocoela* sp.

Source: USACE, 2007a

Though specific borrow areas identified for the Surf City and North Topsail Beach Coastal Storm Damage Reduction Project have not been sampled, considering (1) the similarities in species composition and taxa dominance throughout all previously conducted benthic studies offshore of Virginia, North Carolina, and South Carolina, (2) the nearness of the Topsail Island sampled borrow areas (USACE, 2009, 2007a) to the proposed Surf City North Topsail Beach (SCNTB) project borrow areas, and (3) the similarity in sediment characteristics among the previous studies, it is expected that the benthic infaunal communities within the borrow areas offshore of SCNTB would be similar to previous studies.

2.01.10 Hard Bottoms

Historical Database

Hard bottoms are defined as localized areas not covered by unconsolidated sediments, where the ocean floor consists of hard substrate. In the South Atlantic Bight, such hard bottoms vary in relief from high (higher than 2.0 m (6.6 ft) to low (lower than 0.5 m (1.6 ft) profile and range nearshore (within the states' 3-nautical-mile territorial sea limit) to beyond the continental shelf edge (more than 200 m [656 ft] [Moser et al. 1995]). Hard bottoms are also called *live bottoms* because they support a rich diversity of invertebrates such as corals, anemones, and sponges, which are refuges and food sources for fish and other marine life. They provide valuable habitat for reef fish such as black sea bass, red porgy, and groupers. Hard bottoms are also attractive to pelagic species such as king mackerel, amberjack, and cobia. While hard bottoms are most abundant in southern portions of North Carolina, they are along the entire coast. Storms play a major role in distributing hard-bottom, benthic communities as they remove sediments accumulated from bioerosion and redistribute the ephemeral bottom sediments, exposing or burying hard-bottom surfaces (Riggs et al., 1998). The surficial sand sheet on the upper, flat, hard bottom is generally very thin, has an irregular distribution, and is highly mobile (Riggs et al., 1996). According to Cleary (2003), the environment offshore of the proposed Surf City and North Topsail Beach (SCNTB) project area is characterized by undulating, relatively flat, hard-bottom platform punctuated by scattered, low-relief, hard-bottom scarps (moldic limestone and siltstone) and sediment-filled depressions.

Existing databases of hard-bottom habitat throughout North Carolina, including offshore of Topsail Island, are fairly limited. In 1985 the Southeast Area Monitoring and Assessment Program (SEAMAP–South Atlantic) established a bottom-mapping workgroup to develop a regional database that describes the location and characteristics of bottom habitats throughout the South Atlantic Bight. The primary focus of the effort was to identify the location and quantify the extent of hard-bottom reef habitats for state and federal resource agencies to adequately assess reef-fish populations and the effects of changes in fishing pressure as well as to provide protection of the habitats from adverse effects related to various anthropogenic stresses. The three major objectives of SEAMAP were to (1) conduct an extensive search of existing databases to classify the presence of hard-bottom reef habitats, (2) use standardized protocols to analyze whether hard-bottom habitat is present, possibly present, or absent, and to identify the location of artificial reef habitats, and (3) summarize the data into easy-to-use databases for researchers and mangers.

As a component of the SEAMAP database, Moser et al. (1995) and Moser and Taylor (1995) provided a summary of the distribution and aerial extent of hard-bottom habitats on the continental shelf of North Carolina. Existing hard-bottom data (i.e., fisheries, in-situ observations, core data, artificial reef data, and geophysical data) were compiled and evaluated to map bottom types on the continental shelf. Bottom-type classifications for North Carolina were based primarily on geophysical and fish trawl surveys. A total of 11,890 observations were added to the SEAMAP hard-bottom database. The location of the hard-bottom communities offshore of Surf City, North Topsail Beach, and Onslow Beach, as identified in this study, are in Table 2.3 and shown in Figure A-1 in Appendix A.

Table 2.3. Hard-bottom locations within waters off Surf City, North Topsail Beach, and Onslow Beach, North Carolina, according to Moser and Taylor (1995)

Location # According to Moser and Taylor (1995)	Nearest Town	Nearest Inlet Access	Vertical Distances		Reef Site Location		
			Approximate Water Depth (Ft)	* Relief High (H), Medium (M), Low (L)	Latitude	Longitude	Type of Location
24	Surf City	New River	25-40	M	3422.59	7732.87	Point
25	Surf City	New River	25-40	M	3422.67	7732.83	Point
26	Surf City	New River	25-40	M	3422.98	7733.12	Point
27	Surf City	New River	25-40	M	3423.13	7733.21	Point
28	Surf City	New River	25-40	NA	3423.46	7732.64	Point
29	Surf City	New River	25-40	M	3422.69	7732.31	Point
30	Surf City	New River	25-40	NA	3422.97	7732.04	Point
31	Surf City	New River	25-40	NA	3423.25	7732.11	Point
32	Surf City	New River	25-40	NA	3423.6	7731.95	Point
33	Surf City	New River	25-40	M	3424.47	7731.26	Point
34	Surf City	New River	25-40	NA	3424.7	7731.26	Point
35	Surf City	New River	25-40	M	3424.66	7731.07	Point
36	Surf City	New River	25-40	H	3425.51	7729.71	Point
37	Surf City	New River	25-40	H	3423.63	7730.62	Point
38	Surf City	New River	25-40	H	3424.04	7730.53	Point
94	N. Topsail	New River	30	NA	3428.32	7722.25	Point
95	N. Topsail	New River	30	NA	3429.08	7721.02	Point
110	N. Topsail	New River	40	NA	3425.68	7724.17	Point
117	N. Topsail	New River	35-40	NA	3429.45	7721.1	Line
					3429.45	7722.2	Line
145	Surf City	New River	35-40	NA	3421.73	7730.71	Point
146	Surf City	New River	35-40	NA	3423.24	7729.56	Point
151	Surf City	New River	45	NA	3422	7736	Line
					3424	7734	Line
155	Surf City	New River	25	NA	3426.1	7727.8	Line
					3426.5	7728.2	Line
156	Onslow	New River	25	NA	3430.3	7717.9	Line
					3429.8	7718.5	Line

Table 2.3. (*continued*)

Location # According To Moser And Taylor (1995)	Nearest Town	Nearest Inlet Access	Vertical Distances Ft		Reef Site Location		
			Approximate Water Depth (Ft)	* Relief High (H), Medium (M), Low (L)	Latitude	Longitude	Type Of Location
171	N. Topsail	New River	35-40	H	3428.1	7723.1	Polygon
					3427.2	7722.3	Polygon
					3427	7722.5	Polygon
					3427.9	7723.4	Polygon
180	N. Topsail	New River	25-35	NA	3427.6	7722.7	Point
181	N. Topsail	New River	25-35	NA	3427.9	7723	Point
182	N. Topsail	New River	25-35	NA	3428.1	7723.1	Point
183	N. Topsail	New River	25-35	NA	3429.4	7723.9	Point
184	N. Topsail	New River	25-35	NA	3429.7	7723.2	Point
185	N. Topsail	New River	25-35	NA	3429.9	7722.6	Point
186	N. Topsail	New River	25-35	L	3430.2	7722.3	Line
					3430.5	7721.6	Line
187	N. Topsail	New River	25-35	L	3430.7	7721.3	Point
188	N. Topsail	New River	25-35	L	3430.7	7720.9	Point
189	N. Topsail	New River	25-35	H	3430	7721.3	Polygon
					3430.7	7722.2	Polygon
					3428.6	7723.8	Polygon
					3429.3	7724.2	Polygon
190	Onslow	New River	25-35	H	3431.2	7719.3	Polygon
					3432.4	7717.9	Polygon
					3431.5	7717.5	Polygon

* Low relief (L) was defined as < 0.5m (1.6 ft), Moderate relief (M) was defined as 0.5–2.0 m (1.6–6.6 ft), and High relief (H) was defined as profiles > 2 m (> 6.6 ft) (Moser and Taylor, 1995).

Summary of Corps Sand Resource and Hard-Bottom Investigations Contracts

To identify and delineate the most economical and environmentally acceptable borrow areas in the offshore environment (more than –7 m [–23 ft.]) NGVD) that could provide a sufficient volume of sediment for the SCNTB Coastal Storm Damage Reduction project, the Corps contracted with multiple engineering and environmental companies. The objectives of the contracts were to provide an assessment of the availability of beachfill-quality sand offshore and an assessment of underlying geology and exposed, offshore, hard-bottom features. Furthermore, to assess the potential effects of the proposed project on: (1) nearshore, hard-bottom habitat as a result of burial or sedimentation from the beachfill equilibration process and (2) offshore habitat from hopper-dredging activities, the Corps contracted side-scan sonar, multibeam, and diver ground truth data collection. The following paragraphs summarize, in chronological order, the hard-bottom data-collection components of both the offshore and nearshore survey contracts.

Offshore (more than –7 m (–23 ft.) MLLW)

(1) USACE. 2003. *An Assessment of the Availability of Beachfill Quality Sand Offshore North Topsail Beach and Surf City, North Carolina*. HDR Engineering Inc. of the Carolinas in association with William J. Cleary, PhD, PG (Appendix R; Attachment 1).

The goals of this study were to: (1) investigate the area offshore of North Topsail Beach and Surf City using published reports and available unpublished data, (2) summarize existing vibracore, fathometer, seismic, and side-scan sonar data, (3) ground truthing of side-scan sonar seafloor mosaic—SCUBA based diver mapping and seafloor sampling surveys, and (4) identify and delineate the most economical and environmentally acceptable borrows sites that could support the proposed projects on Topsail Island while avoiding environmentally sensitive hard bottoms.

Results of the report indicated an extremely complex exposure pattern of hard bottom throughout the study area, extending from the –9.1 m (–30 ft.) contour seaward to a distance of ~8 kilometers (km) (5.0 miles) offshore between Surf City through the southern end of Onslow Beach. Throughout the offshore environment, surface sediments are easily reworked during storms, exposing hard-bottom platforms and low-relief scarps in areas where the sediment cover is thin. As identified in the side-scan imagery, a patchy veneer of silty sand and gravel produces a *pock-marked* or *patchwork* appearance on the surface of the underlying flat hard-bottom areas. The southern portion of North Topsail Beach and Surf City was characterized by undulating, relatively flat hard-bottom platform punctuated by scattered low-relief hard-bottom scarps (moldic limestone and siltstone) and sediment filled depressions; whereas, high-relief hard-bottom locations dominate the North Topsail Beach vicinity (Alligator Bay to New River Inlet [Onslow Beach]). Two notable areas of high-relief hard-bottom were located (1) offshore of Mile Hammock Bay on the Onslow Beach portion of the shoreface and (2) between Alligator Bay and New River Inlet. Furthermore, several linear, shore-normal depressions that were interpreted to be channel remnants or RSD features were identified through the study area.

Using the information collected by HDR Engineering, Inc., the Corps was able to refine the locations of potential borrow site locations and implement a detailed vibracore plan to adequately assess the compatibility of sediments within the target borrow areas. Additional recommendations for future work in the proposed borrow areas included: (1) geophysical analysis to better interpolate potential sediment quantities relative to underlying geology, and (2) high-resolution side-scan sonargraph surveys of the borrow sites to assess the presence of exposed hard-bottom resources.

(2) USACE. 2004a. *Marine Geophysical Investigation for the Evaluation of Sand Resource Areas Offshore Topsail Island North Carolina*. Final Report. Contract DACW54-02-D-0006, Delivery Order 0002. Prepared by Greenhorne and O'Mara, Inc., with consultant Ocean Surveys, Inc., (OSI) (Appendix C; Attachment 1).

Using *Chirp* and *boomer* profiles, Corps Core Samples (412), hydrographic survey, and previous studies (HDR 2002 and 2003), OSI was able to further delineate limits of suitable borrow material for the proposed project. Specific goals of the study were to: (1) determine water depths and general morphology, (2) map aerial extent and thickness of available unconsolidated sediment, (3) delineate the extent of bedrock units on and below the seafloor, and (4) use data to evaluate proximity of sand borrow areas to hard-bottom outcrops.

The OSI investigation further confirmed that Onslow Bay is a sediment-starved system consisting mostly of a thin, patchy veneer (less than 0.9–1.8 m [3–6 ft.]) of modern sediments covering the low-relief Oligocene limestone and siltstone. Consistent with HDR, OSI also identified numerous quaternary channel fill sequences or RSD features. Wave and current action move the surface material periodically exposing the rock units just below the seafloor. The moldic sandy limestone protrudes above the seafloor as scarps exhibiting relief of 0.6–4.6 m (2–15 ft.) in some areas with areas of relatively flat low-lying hard-bottom in between; however, the siltstone unit rarely identified outcropping. The thicker sediment deposits (~3 m [10 ft.]) have filled in the broad depressions of the rock surface.

Though this study further refined the limits of the proposed offshore borrow areas, and the extent of the exposed offshore hard bottom, the spacing of the hydrographic survey data was still too wide; thus, small-scale features could not be identified. High-resolution side-scan sonar was necessary to identify and define hard bottom within the refined borrow areas.

(3) USACE. 2005. *An Archaeological Remote Sensing Survey of Surf City – North Topsail Beaches Offshore Borrow Areas*. Contract Number DACW 54-03-D-0002, Delivery Order 0005. Submitted by Mid-Atlantic Technology and Environmental Research (MATER), Principal Investigator Wes Hall (Appendix U).

Within the limits of the refined borrow areas identified by HDR, OSI, and the Corps, MATER implemented high-resolution side-scan sonar to identify and delineate hard bottom within the proposed borrow areas. Side scan sonar is a marine geophysical technique used to map underwater topography and for identifying features on the surface of waterbody bottoms. Generally, hard materials provide high-amplitude echoes and soft, fine-grained materials provide weak signals. As a result, side-scan sonar provides a visual representation of the change in density of the surface material of a waterbody bottom. Data were collected along parallel lines spaced at 20-m (65-ft.) intervals using a Marine Sonic 600-kilohertz (kHz) side-scan sonar. Relief was classified in accordance with Moser and Taylor (1995) and Moser et al. (1995:): (1) **Low-relief—**the majority of the area less than 0.5 m (1.6 ft.) above the bottom, (2) **Moderate-relief—**the majority of the area between 0.5 m (1.6 ft.) and 2.0 m (6.6 ft.) above the bottom, and (3) **High-relief—**the majority of the area more than 2 m (6.6 ft.) above the bottom.

On the basis of the interpretation of the acoustic signatures from the side-scan sonar data, hard bottom was identified and delineated within all proposed borrow areas as follows:

Borrow Area G	2% hard bottom all low relief.
Borrow Area I	73% hard bottom with mix of low, moderate, and high relief.
Borrow Area H, J, L, N, O, P	13% hard bottom with mix of low, moderate, and high relief.
Borrow Area K, M	48% hard bottom with mix of low, moderate and high relief.
Borrow Area S	19% hard bottom all low relief.
Borrow Area Q, R	20% hard bottom with mix of low and moderate relief.
Borrow Area T	46% hard bottom with mix of low to moderate relief.

The extensive hard bottom plus the remaining low volume of beach compatible material identified in borrow areas I, K, and M, resulted in their removal from consideration for borrow material. Borrow area T has enough accessible, beach-compatible material for continued consideration. Delineation of hard-bottom resources within each borrow area allowed for further refining of the proposed borrow areas to avoid potential impacts to hard-bottom resources from hopper dredging activities.

Nearshore (less than –7 m (–23 ft.) NGVD)

(1) USACE. 2006. *High-Resolution Remote Sensing of Potential Hard Bottom Habitats: Topsail Island, NC*. July 2006 Contract DACW54-02-D-0006. Submitted by: : Greenhorne and O'Mara Consulting Engineers with sub-consultant Geodynamics (Appendix R; Attachment 2).

To assess potential project impacts to nearshore hard-bottom resources, as a result of the equilibration process associated with the constructed beach template, surveys for hard-bottom resources within the calculated depth of closure (i.e., –7 m [–23 ft.] NGVD) for this project were necessary. As a component of the Corps scope of work for identifying nearshore (less than 9.1 m [30 ft.]) hard-bottom resources off SCNTB, the Corps requested a two-phased effort to (1) locate and quantify *potential hard bottom* sites within the project impact area using side-scan sonar and, if targets were identified, (2) use multibeam survey techniques to assess the bathymetry (i.e., relief). The scope of work was coordinated with and received approvals from the environmental resource agencies. Nearshore survey data outside the scope of the contract in North Topsail Beach were collected by Coastal Planning and Engineering, Inc., (CPE) as a component of the EIS for the local, nonfederal *North Topsail Beach Shoreline Protection Project*. CPE's procedural steps for identifying hard-bottom communities were consistent with the Corps' procedures and entailed: (1) side-scan sonar data collection and interpretation, (2) identifying and delineating potential hard-bottom features, and (3) diver ground truthing and biological characterization of representative sites. Details of the CPE investigation of the nearshore environment of North Topsail Beach are in the November 2007 Draft Environmental Impact Statement for the *North Topsail Beach Shoreline Protection Project* (USACE, 2007b).

The Corps nearshore side-scan sonar survey (phase 1) began in July 2006 and was composed of six planned survey lines spaced 100 m apart (320 ft.) in depths ranging from ~1.5 m (5 ft.) MLLW to ~9.1 m (30 ft.) MLLW. The distance between survey lines was calculated in separate zones of relatively equal depths using 42 times the water depth for multibeam and 120-m swaths (394 ft.) for side-scan as indicated on the NOAA digital nautical chart 11541_4.kap. Interpretation of the side-scan sonar data identified several areas in SCNTB that had higher density material than the adjacent area. Those high backscatter features were located cross-shore throughout the survey area. On the basis of those density differences, the areas of high backscatter were considered *potential hard bottom* anomalies and were delineated. Generally, the potential hard-bottom targets identified started approximately 244 m (800 ft) offshore (2004 wet/dry line) and extended to the end of the survey, approximately 545 m (1,800 ft.) offshore (2004 wet/dry line).

(2) USACE. 2007c. *High-Resolution 3D Bathymetric Assessment of Potential Hard Bottom Habitats: Topsail Island, Surf City and North Topsail Island, NC*. January / February 2007. Contract DACW54-02-D-0006. Submitted by: Greenhorne and O'Mara Consulting Engineers with sub-consultant Geodynamics (Appendix R; Attachment 3).

Using information gained from the Corps 2006 side-scan sonar survey, the Corps implemented a multibeam survey contract to further investigate the bathymetry of the target potential hard-bottom areas. The multibeam survey was composed of 18 planned survey lines (6 lines per survey area) spaced 21 m (70 ft.) to 27 m (90 ft.) apart to obtain 100 percent seafloor coverage. The total area of the survey encompassed 0.85 square mile with a total of 57 line miles and employed a Simrad EM3002 shallow-water multibeam sonar system to collect spatially dense bathymetric data for developing an accurate surface model. Data interpretation of seafloor bathymetry indicated that areas of high backscatter with cross-shore orientation identified in the phase one side-scan sonar survey were areas of gradual seafloor depressions with approximately 0.5-m (1.5-ft.) vertical relief per 101 m (330 ft.) horizontal distance. Additional ground-truth investigations of potential hard-bottom features were necessary to confirm the absence or presence of hard bottom to better interpolate the features from the acoustic signatures.

(3) USACE. 2008. *Surf City/North Topsail Beach, NC Shore Protection Project, Hard Bottom Resource Confirmation and Characterization Study*. Contract W912HN-08-C-

0009. Submitted by ANAMAR Environmental Consulting Inc. and Coastal Planning and Engineering, Inc. (Appendix R; Attachment 4).

During a Project Delivery Team (PDT) meeting with environmental resource agencies held on August 8, 2007, a summary of all nearshore and offshore hard-bottom data collection contracts conducted off of Topsail Island were presented to the resource agencies. Furthermore, details of the North Carolina hard-bottom buffer rule language (NCAC 07H. 0208(b) (12)(A)(iv)) were discussed. Specifically, the rule states that, "Mining activities shall not be conducted on or within 500 meters of significant biological communities, such as high relief hard bottom areas. High relief is defined for this standard as relief greater than or equal to one-half meter per five meters of horizontal distance." In accordance with the state's definition of *high relief* hard bottom, the Corps created a buffer around all identified high-relief, hard bottom delineated by MATER in 2005. However, the Corps questioned the interpretation of the 500-m (1,640-ft.) buffer rule with respect to hard-bottom relief that is less than the defined characteristics of high-relief hard-bottom identified in the state rule language. Adherence to a 500-m (1,640-ft.) buffer for all identified hard bottom (i.e., low, medium, and high relief) would result in a reduction of available sediment to a volume that is less than that required for the 50-year life of the project. To provide sufficient compatible sand resources for the 50-year project, the Corps proposed to implement a 122-m (400-ft.) dredging buffer around the low-relief hard bottom (less than 0.5 m [1.6 ft.]) identified by MATER in the offshore borrow sites while still adhering to the 500-m buffer for high-relief hard bottom as defined in the state rule language. Implementing a 122-m (400-ft.) buffer is consistent with the recommended buffer distances in Florida, which recommends a 122-m (400-ft.) dredging buffer around hard bottom communities, including coral reefs, in their state dredging permit conditions. Additionally, the NMFS recommends a 122-m (400-ft.) dredging buffer in its *Gulf Regional Biological Opinion* (GRBO) for dredging activities in the Gulf of Mexico to avoid impacts to hard-bottom foraging grounds for sea turtles. The buffer recommendation is based on lessons learned from a history of sedimentation and turbidity monitoring data collected in association with dredging projects in the vicinity of coral reefs throughout Florida. Though the Florida does include a 122-m (400-ft.) buffer in its state permit conditions, site-specific circumstances are considered for individual projects that may warrant a decrease or increase in the buffer guideline (for additional information pertaining to Florida monitoring reports, see Section 8.01.8.2).

Recognizing the room for interpretation of the North Carolina rule pertaining to *low-relief* hard bottom and the Corps' subsequent request to dredge closer to low-relief hard-bottom resources than outlined in the state rule language, on the basis of limited sediment availability, the PDT requested additional in-situ biological characterization of identified low-relief hard bottoms using divers. Furthermore, to assess potential beach nourishment effects as a result of beach profile equilibration process, the PDT requested in-situ diver ground truthing of the nearshore side-scan sonar survey data. The purpose of that investigation was to confirm the presence or absence of hard bottom in high-backscatter areas identified by Geodynamics as *potential hard bottom*. As identified in the contract scope of work, which was approved by the environmental resource agencies, the Corps required a phased approach in the nearshore environment to (1) confirm the presence or absence of *potential* hard-bottom resources identified by Geodynamics and, if necessary, (2) biologically characterize the identified hard-bottom habitat including fish species observation and identification. The nearshore investigation sites are approximately 335 m (1,100 ft.) from the shore between the –5.5 m (–18 ft.) and the –9.1 m (–30 ft.) NGVD contours from the Surf City/Topsail Beach town border and extending through the southern end of North Topsail Beach and consisted of eight bounce dives. The ground-truth investigation of offshore sites identified by MATER consisted of biological characterization of the delineated hard-bottom community and observation and identification of fish species. Confirmation and characterization of hard bottom was conducted at five borrow sites for a total of 12 transects (G=2, J=2, L=2, O=3, and T=3). The borrow sites are approximately 1 to 6 miles from the coast in water depths of between –9.1 m (–30 ft.) to –14.3 m (–47 ft.) MLLW. All dives included in–water, digital video documentation of the site.

To refine sampling locations and maximize site diversity, previously collected remote sensing data conducted by Geodynamics and MATER were thoroughly evaluated before transect site selection. That analysis of the remote-sensing data helped determine if previously identified potential hard-bottom anomalies could be further classified as unconsolidated sediments, shell hash, or rubble before in-situ dive efforts. Furthermore, transect site locations, relative to distance offshore and cross-shore, were considered to optimize the data collection to ensure that the diversity of habitat type and area were captured. The following paragraphs summarize the data collected from the nearshore and offshore dives.

Nearshore

Diver ground truth confirmation of the eight selected areas previously identified as potential hard bottom, in conjunction with the side-scan interpretation, support the conclusion that no hard bottom was identified landward of the calculated –7 m (–23 ft.) depth of closure. Additional refined analyses of the remote sensing data coupled with the (1) diver ground truth transects, (2) collected sediment samples, and (3) digital video, identified the previously defined *high-backscatter anomalies* to be regions of coarse gravel and shell hash. Careful selection of dive sites enabled divers to traverse backscatter transitional areas identified in the remote-sensing data. Diver confirmation and corresponding sediment samples identified the transitional areas to be a sorting of sediment characteristics from fine-grained to course-grained sediments. Those features identified in the nearshore environment off Surf City and North Topsail Beach are consistent with previously identified RSD (Cacchione et al., 1984; Thieler et al., 1999, 2001), RCD (McQuarrie, 1998), or *sorted bedform* (Murray and Thieler, 2004) features identified throughout the coast of North Carolina (Wrightsville Beach, Figure Eight Island, Topsail Island, and such). The features are thought to be the result of a feedback mechanism whereby an existing deposit of coarse shell hash and gravel material is built on and segregated from fine material due to wave motion interacting with the enhanced roughness of the seafloor bed around the patches of coarse material (Murray and Thieler, 2004). The interaction between wave motion and seafloor roughness results in near-bed turbulence that is greatly enhanced relative to other areas of the seafloor. The increase in near-bed turbulence enhances entrainment and inhibits settling of fine material, thereby further expanding and maintaining the coarse patches of material.

After the eight nearshore dives were completed and the confirmation was made that no hard-bottom resources are in the –7 m (–23 ft.) contour, the Corps requested the contractor ground truth two additional features located approximately 183 m (600 ft.) offshore of the –7 m (–23 ft.) contour. On the basis of preliminary side-scan data interpretation, ANAMAR documented that the sites closely resembled exposed rock outcrops. Using diver ground-truth data from the previous dives, a more refined analysis and interpolation of side-scan imagery for hard-bottom resources was possible. Diver confirmation of hard bottom in areas that, in the side-scan interpretation, appeared to more closely resemble exposed rock outcrops on the seafloor than any of the seafloor features landward of the depth of closure, added further confidence to the side-scan data interpretation for presence/absence of hard bottom. Divers verified the presence of low-relief ephemeral hard-bottom features at both sites with a maximum vertical relief of approximately 15 centimeters (cm).

Offshore
A total of 12 temporary transects were established among the five borrow areas (T=3, O=3, L=2, J=2, and G=2) identified for biological characterization of hard bottoms. Hard bottom of varying low (lower than 0.5 m [1.6 ft.]) to moderate (0.5 m [1.6 ft.] to 2.0 m [6.6 ft.]) relief (i.e., large, contiguous, hard bottom; patchy outcroppings; or distinct ledges) and total area were confirmed and characterized for all sites, with the exception of one transect in borrow area J (J1) in which no hard bottom was identified. Remote-sensing data was carefully analyzed before selecting transect locations to maximize diversity of habitat covered within a transect line by traversing areas of relief transition. Furthermore, transects were also distributed among borrow areas to capture the potential differences associated with the distance offshore and the location alongshore, as well as potential association with nearness to New River Inlet. According to the data collected, the hard–bottom, benthic community did not differ relative to nearness to New River inlet or distance offshore. The surveyed borrow areas contained intermittent areas of well-developed benthic cover and areas of frequent burial. Some of the sites contained small, hard-bottom patches interspersed with sand and had relatively undeveloped benthic communities; whereas other sites contained more extensive communities. Furthermore, there was evidence of periodic burial or sand scouring in areas with less rugosity and site relief was not correlated with diversity or amount of benthic growth. Vertical surfaces (i.e., outcroppings/ledges) had an increased diversity of organisms (i.e., bryozoans, tunicates, hydrozoans) as well as adult *Oculina* sp. colonies, thus, indicating a more stable environment along the vertical faces. The horizontal surfaces of the hard-bottom outcrops were predominantly covered with macro-algae. About 80 percent of the transects were low-relief hard bottom that contained little biotic diversity dominated by emergent octocorals and sponges. However, borrow area G represented a unique area of low-relief hard bottom that contained diverse and persistent benthic communities. The following contains brief summaries of the data for each borrow area investigated:

Borrow area G: : Sites investigated in borrow area G were indicative of a more persistent low-relief, hard-bottom community as evidenced by the mature colonies of *Oculina* sp. and highest percent stony coral cover and density (i.e., transect G1).

Borrow area J: : The sites contained the least amount of confirmed hard bottom of any of the investigated borrow areas. Specifically, no hard bottom was identified in transect J1, an area previously delineated as potential hard bottom on the basis of side-scan sonar interpretation provided by MATER. Furthermore, transect J2 was confirmed to be an extremely ephemeral system on the basis of the observation of *L. virgulata* colonies attached to buried hard bottom and protruding through a thin veneer of sand.

Borrow area L: Transects L1 and L2 were placed along previously identified transition areas of moderate- and high-relief hard bottom, on the basis of side-scan sonar data. As expected, those transects contained the highest maximum relief of all sites. The myriad relief patterns, crevices, ledges, and such, resulted in the highest diversity index identified for L1. However, although those transects had the highest maximum relief of .50 m (1.6 ft.) and .55 m (1.8 ft.), respectively, according to in-situ dive investigations, they were previously mapped as *moderate* and *high* relief on the basis of side-scan sonar interpretation. The confirmed in-situ maximum relief of the sites is on the low end of the moderate-relief classification as defined by Moser and Taylor (1995) and Moser et al. (1995). Furthermore, the average relief of the sites was 0.16 m (0.5 ft.) and 0.07 m (.23 ft.), respectively, indicating that the areas of moderate relief were isolated peaks rather than a continuous moderate relief shelf.

Borrow area O: Three transects were placed throughout borrow area O to capture previously determined areas of low, moderate, and high relief. Although two transects were placed along areas of moderate and high-relief transitions on the basis of side-scan sonar interpretation and mapping, the in-situ dive confirmation indicated only areas of intermittent, varying, low-relief hard bottom with interspersed patches of sand. Although the side-scan sonar interpretation and subsequent mapping indicated differing relief patterns between the three transects (i.e., O1, O2, and O3), the in-situ dive confirmation did not support the preliminary delineation of hard bottom.

Borrow area T: : Transect locations throughout borrow area T were specifically located to capture site diversity. Transect T1 was unique in that it traversed a distinct moderate relief ledge (i.e., maximum relief of 0.47 m [1.5 ft.]) and extended into a low relief ledge with an average relief of 0.05 m (0.16 ft.). Transects T3 and T4 were generally low relief (i.e., maximum relief of 0.14 m [0.5 ft.] and 0.22 m [0.7 ft.]), respectively) and ephemeral in nature as evidenced by sediment cover and less site diversity. However, *Oculina* sp. were identified in areas with higher relief.

Although the study was limited to the winter months during limited biological activity, similar work has been conducted by CPE in the project area vicinity in June, August, and October of 2005 (USACE, 2007). Field investigations with similar methodologies were performed to ground truth potential hard-bottom resources and characterize the benthic community of representative locations. Sessile benthos observed along the hard bottom were dominated by macroalgae, octocorals, encrusting red algae, sessile worms, and stony corals and were consistent with those identified during the Corps March 2008 investigation (Table 2.4). Therefore, the offshore hard bottom habitats of borrow areas have been characterized during the spring, summer, fall, and winter and there does not appear to be significant differences in species composition and diversity for each sampling period. However, as expected, the finfish species observed during the warm water sampling periods were more diverse than the cold water sampling period.

Table 2.4. Consolidated species list for all 12 transects investigated throughout borrow areas T, O, L, J, and G in March 2008.

	Species	Common Name
INVERTEBRATES		
SPONGES	*Cliona celata**	Boring sponge
	Unidentified gray sponge (Possibly *Ircinia* sp.)*	
	Several unidentified species*	
HYDROIDS	Several unidentified species	
BRYOZOANS	*Bugula turrita**	Spiral-tufted bryozoan
	Hippopodina feegeensis	Pearly orange encrusting bryozoan
	Unidentified fan bryozoans*	
ANEMONES	Cerianthid anemone*	Tube-dwelling anemone
	Several unidentified species*	
SCLERACTINIAN CORAL	*Oculina sp.**	Ivory tree coral
OCTOCORAL	*Leptogorgia hebes**	Regal sea fan
	*Leptogorgia virgulata**	Colorful sea whip
	Telestaceans (*Carijoa riisei* and/or *Telesto sp.)**	Telestos
	*Titanideum frauenfeldii**	Brilliant sea fingers
MOLLUSCS	*Fasciolaria tulipa*	Tulip snail
	Simnia sp.*	Simnia
ECHINODERMS		
Urchins	*Arbacia punctulata**	Common Arbacia urchin
	*Lytechinus variegatus**	Variegated urchin
Sea Stars	*Astropecten articulatus**	Beaded sea star
	*Asterias forbesii**	Forbe's sea star
	*Echinaster sp.**	Orange-ridged sea star
	*Luidia alternata**	Banded sea star
Sea Cucumbers	Unidentified sea cucumber*	
ARTHROPODS	*Anoplodactylus lentus*	Lentel sea spider
	Various hermit crabs	
	Balanus sp.	Barnacles
TUNICATES	*Botryllus/Botrylloides* spp.*	Flat/row/geometric encrusting tunicates
	*Distaplia corolla**	Button tunicate
	Eudistoma spp.	Condominium tunicates
	Several unidentified species*	
VERTEBRATES		
FISH	*Archosargus probatocephalus**	Sheepshead
	*Centropristis striatus**	Black sea bass
	*Diplodon holbrookii**	Spottail pinfish
PLANTS		
MACROALGAE	*Caulerpa*	green alga
	*Codium**	Dead man's fingers
	Cryptonemia	red alga
	*Dasya**	red alga
	Gelidiella	red alga
	Gelidium	red alga
	*Halymenia**	red alga
	*Lobophora**	Encrusting fan-leaf alga
	*Sargassum**	Sargassum weed
	Wrangelia	red alga
	Encrusting Red Algae	

Source: USACE 2008b

Artificial Reef

North Carolina Department of Environment and Natural Resources, NCDMF Artificial Reef Program manages six reefs that are off Topsail Island. They are AR 355, AR 360, AR 362, AR 364, AR 366, and AR 368. Of those managed reefs, AR360 *Topsail Reef* is in close proximity of the proposed offshore borrow areas and is at 34° 20'59" N and

77° 36'11" W (Table 2.5). It was deployed in 1984 and modified in 1992 and consists of about 49,000 tires and 850 4’x8’ pieces of concrete pipe. The reef no longer exists in its confined location but is broken up and spread out well beyond its original footprint and is exposed or buried at different locations. The location of the hard-bottom habitats and artificial reef sites, in relation to project features, is shown in Appendix A, Figure A-1.

Table 2.5. Artificial reefs

NC Reef Site No.	Nearest Inlet Access and Distance	Approx. Water Depth (ft.)	LORAN Position Coordinates	Latitude and Longitude	Comment
355	New River 9.7 miles	60	27210.0 39324.4	34°21'11" 77°20'00"	230’ Bridge span
360	New Topsail 2.5 miles	44	27256.9 39252.5	34° 20'59" 77°36'11"	Concrete pieces
362	New Topsail 8.7 miles	54	27233.1 39244.5	34°15'43" 77°30'27"	Concrete pieces
364	New Topsail 6.0 miles	44	27267.4 39169.6	34°14'50" 77°42'50"	174’ JELL II Boat mold
366	New Topsail 13.9 miles	66	27214.6 39255.0	34°12'57" 77°25'15"	Concrete pieces
368	New Topsail 15.5 miles	66	27211.7 39195.0	34°09'34" 77°25'50"	Small vessel

Source: NCDMF, http://www.ncfisheries.net/download/ReefGuide2005.pdf

Since the placement of tire-based artificial reefs throughout North Carolina, many tires have broken loose from their original footprint and wash up consistently throughout the North Carolina beaches. In 2001 (December–April), during Phase I of the Bogue Banks Beach Nourishment project in Bogue Banks, North Carolina, the dredging contractor encountered about 5,000 tires in the borrow sites that had broken free from an artificial reef site. On the basis of that history, the NCDMF has identified concerns that, although the historical placement of tire-based artificial reefs are outside the identified borrow sites, a potential exists for loose tires to be in the borrow sites. The NCDCM’s Artificial Reef Program has a team to document and pick up tires that wash up on the local beaches (Appendix A, Figure A-1).

2.01.11 Essential Fish Habitat

The 1996 congressional amendments to the MSFCMA (P.L. 94-265) set forth new requirements for the NMFS, regional fishery management councils (FMC), and other federal agencies to identify and protect important marine and anadromous fish habitat. Those amendments established procedures for identifying EFH and a requirement for interagency coordination to further the conservation of federally managed fisheries. Table 2.6 lists the federally managed fish species of North Carolina for which Fishery

Management Plans (FMPs) have been developed by the SAFMC, Mid-Atlantic Fishery Management Council (MAFMC), and NMFS. In addition, the table shows EFH by fish life stage and ecosystem type for those species that have designated EFH. Table 2.7 shows the categories of EFH and Habitat Areas of Particular Concern (HAPC) for managed species that were identified in the FMP Amendments affecting the South Atlantic area. A description of specific HAPC resources (i.e., hard bottom, coral, artificial reef, and *sargassum*) in the project area is in Sections 2.01.9, 2.01.10, and Appendix R (Attachment 4). The fish species and habitats shown in those tables require special consideration to promote their viability and sustainability. The potential effects of the proposed action on those fish and habitats are discussed in Section 8.01.8 of this report.

Table 2.6. EFH species for coastal North Carolina[a]

Management Plan Agency[b]	Management Plan Species Group	Common Name of Species	Scientific Name of Species	EFH for Life Stages by Ecosystem[c]		Geographically Defined Habitat Areas of Particular Concern (HAPC) (North Carolina Locations Only)
				Marine	Estuarine	
SAFMC	Calico Scallop	Calico scallop	*Argopecten gibbus*	A		
SAFMC	Coastal Migratory Pelagics	Cobia	*Rachycentron canadum*	E L P J A	L P J A	Capes Fear, Lookout, & Hatteras sandy shoals; The Point; Ten Fathom Ledge; Big Rock; Bogue Sound; New River; hardbottom
SAFMC	Coastal Migratory Pelagics	Dolphin	*Coryphaena hippurus*	L P J A		Capes Fear, Lookout, & Hatteras sandy shoals; The Point; Ten Fathom Ledge; Big Rock; Bogue Sound; New River; hardbottom
SAFMC	Coastal Migratory Pelagics	King mackerel	*Scomberomorus cavalla*	J A		Capes Fear, Lookout, & Hatteras sandy shoals; The Point; Ten Fathom Ledge; Big Rock; Bogue Sound; New River; hardbottom
SAFMC	Coastal Migratory Pelagics	Spanish mackerel	*Scomberomorus maculatus*	L J A	J	Capes Fear, Lookout, & Hatteras sandy shoals; The Point; Ten Fathom Ledge; Big Rock; Bogue Sound; New River; hardbottom
SAFMC	Coral & Coral Reef	Corals	100s of species	Florida only		Big Rock; Ten Fathom Ledge; The Point
SAFMC	Golden Crab	Golden crab	*Chaceon fenneri*	A		
SAFMC	Red Drum	Red drum	*Sciaenops ocellatus*	E L A	P J S A	tidal inlets, state nursery, spawning sites, SAV
SAFMC	Shrimp	Brown shrimp	*Farfantepenaeus aztecus*	E L A	P J S	tidal inlets, state nursery, overwintering habitats

Table 2.6. (*continued*)

Management Plan Agency[b]	Management Plan Species Group	Common Name of Species	Scientific Name of Species	EFH for Life Stages by Ecosystem[c]		Geographically Defined Habitat Areas of Particular Concern (HAPC) (North Carolina Locations Only)
				Marine	Estuarine	
SAFMC	Shrimp	Pink shrimp	*Farfantepenaeus duorarum*	E L A	P J S	tidal inlets, state nursery, overwintering habitats
SAFMC	Shrimp	Rock shrimp	*Sicyonia brevirostris*	A		
SAFMC	Shrimp	Royal red shrimp	*Pleoticus robustus*	A		
SAFMC	Shrimp	White shrimp	*Lilopenaeus setiferus*	E L A	P J S	tidal inlets, state nursery, overwintering habitats
SAFMC	Snapper Grouper	Blackfin snapper	*Lutjanus buccanella*	J A		hardbottom, SAV, oyster/shell, inlets, state nursery, The Point, Ten Fathom Ledge, Big Rock, Hoyt Hills
SAFMC	Snapper Grouper	Blueline tilefish	*Caulolatilus microps*	E A		hardbottom, SAV, oyster/shell, inlets, state nursery, The Point, Ten Fathom Ledge, Big Rock, Hoyt Hills
SAFMC	Snapper Grouper	Golden tilefish	*Lopholatilus chamaeleonticeps*	A		hardbottom, SAV, oyster/shell, inlets, state nursery, The Point, Ten Fathom Ledge, Big Rock, Hoyt Hills
SAFMC	Snapper Grouper	Gray snapper	*Lutjanus griseus*	L A	P J A	hardbottom, SAV, oyster/shell, inlets, state nursery, The Point, Ten Fathom Ledge, Big Rock, Hoyt Hills
SAFMC	Snapper Grouper	Greater amberjack	*Seriola dumerili*	J A		hardbottom, SAV, oyster/shell, inlets, state nursery, The Point, Ten Fathom Ledge, Big Rock, Hoyt Hills

Table 2.6. (*continued*)

Management Plan Agency[b]	Management Plan Species Group	Common Name of Species	Scientific Name of Species	EFH for Life Stages by Ecosystem[c]		Geographically Defined Habitat Areas of Particular Concern (HAPC) (North Carolina Locations Only)
				Marine	Estuarine	
SAFMC	Snapper Grouper	Goliath Grouper	*Epinephelus itajara*	Florida only	Florida only	hardbottom, SAV, oyster/shell, inlets, state nursery, The Point, Ten Fathom Ledge, Big Rock, Hoyt Hills
SAFMC	Snapper Grouper	Mutton snapper	*Lutjanus analis*	Florida only	Florida only	hardbottom, SAV, oyster/shell, inlets, state nursery, The Point, Ten Fathom Ledge, Big Rock, Hoyt Hills
SAFMC	Snapper Grouper	Red snapper	*Lutjanus campechanus*	L P J A		hardbottom, SAV, oyster/shell, inlets, state nursery, The Point, Ten Fathom Ledge, Big Rock, Hoyt Hills
SAFMC	Snapper Grouper	Scamp	*Mycteroperca phenax*	A		hardbottom, SAV, oyster/shell, inlets, state nursery, The Point, Ten Fathom Ledge, Big Rock, Hoyt Hills
SAFMC	Snapper Grouper	Silk snapper	*Lutjanus vivanus*	J A		hardbottom, SAV, oyster/shell, inlets, state nursery, The Point, Ten Fathom Ledge, Big Rock, Hoyt Hills
SAFMC	Snapper Grouper	Snowy grouper	*Epinephelus niveatus*	E L A		hardbottom, SAV, oyster/shell, inlets, state nursery, The Point, Ten Fathom Ledge, Big Rock, Hoyt Hills
SAFMC	Snapper Grouper	Speckled hind	*Epinephelus drummondhayi*	A		hardbottom, SAV, oyster/shell, inlets, state nursery, The Point, Ten Fathom Ledge, Big Rock, Hoyt Hills

Table 2.6. (*continued*)

Management Plan Agency[b]	Management Plan Species Group	Common Name of Species	Scientific Name of Species	EFH for Life Stages by Ecosystem[c]		Geographically Defined Habitat Areas of Particular Concern (HAPC) (North Carolina Locations Only)
				Marine	Estuarine	
SAFMC	Snapper Grouper	Red snapper	*Lutjanus campechanus*	L P J A		hardbottom, SAV, oyster/shell, inlets, state nursery, The Point, Ten Fathom Ledge, Big Rock, Hoyt Hills
SAFMC	Snapper Grouper	Scamp	*Mycteroperca phenax*	A		hardbottom, SAV, oyster/shell, inlets, state nursery, The Point, Ten Fathom Ledge, Big Rock, Hoyt Hills
SAFMC	Snapper Grouper	Silk snapper	*Lutjanus vivanus*	J A		hardbottom, SAV, oyster/shell, inlets, state nursery, The Point, Ten Fathom Ledge, Big Rock, Hoyt Hills
SAFMC	Snapper Grouper	Snowy grouper	*Epinephelus niveatus*	E L A		hardbottom, SAV, oyster/shell, inlets, state nursery, The Point, Ten Fathom Ledge, Big Rock, Hoyt Hills
SAFMC	Snapper Grouper	Speckled hind	*Epinephelus drummondhayi*	A		hardbottom, SAV, oyster/shell, inlets, state nursery, The Point, Ten Fathom Ledge, Big Rock, Hoyt Hills
SAFMC	Snapper Grouper	Vermillion snapper	*Rhomboplites aurorubens*	J A		hardbottom, SAV, oyster/shell, inlets, state nursery, The Point, Ten Fathom Ledge, Big Rock, Hoyt Hills
SAFMC	Snapper Grouper	Warsaw grouper	*Epinephelus nigritus*	E A		hardbottom, SAV, oyster/shell, inlets, state nursery, The Point, Ten Fathom Ledge, Big Rock, Hoyt Hills
SAFMC	Snapper Grouper	White grunt	*Haemulon plumieri*	E L A		hardbottom, SAV, oyster/shell, inlets, state nursery, The Point, Ten Fathom Ledge, Big Rock, Hoyt Hills

Table 2.6. (*continued*)

Management Plan Agency[b]	Management Plan Species Group	Common Name of Species	Scientific Name of Species	EFH for Life Stages by Ecosystem[c]		Geographically Defined Habitat Areas of Particular Concern (HAPC) (North Carolina Locations Only)
				Marine	Estuarine	
SAFMC	Snapper Grouper	Wreckfish	*Polyprion americanus*	A		hardbottom, SAV, oyster/shell, inlets, state nursery, The Point, Ten Fathom Ledge, Big Rock, Hoyt Hills
SAFMC	Spiny Lobster	Spiny Lobster	*Panulirus argus*	L J A	L J A	Spiny lobster EFH and HAPC located only in Florida
SAFMC	Dolphin-Wahoo	Common Dolphin	*Coryphaena hippurus*	ELPJSA		The Point, Ten Fathom Ledge, and Big Rock, Pelagic Sargassum
SAFMC	Dolphin-Wahoo	Pompano Dolphin	*C. equiselis*	ELPJSA		The Point, Ten Fathom Ledge, and Big Rock, Pelagic Sargassum
SAFMC	Dolphin-Wahoo	Wahoo	*Acanthocybium solanderi*	ELPJSA		The Point, Ten Fathom Ledge, and Big Rock, Pelagic Sargassum
SAFMC	Sargassum	Sargassum	*Sargassum* sp.			
MAFMC	Atlantic Mackerel, Squid, Butterfish	Atlantic butterfish	*Peprilus triacanthus*			
MAFMC	Atlantic Mackerel, Squid, Butterfish	Atlantic mackerel	*Scomber scombrus*			
MAFMC	Atlantic Mackerel, Squid, Butterfish	Long finned squid	*Loligo pealei*			
MAFMC	Atlantic Mackerel, Squid, Butterfish	Short finned squid	*Illex illecebrosus*			
MAFMC	Atlantic Surfclam & Ocean Quahog	Ocean quahog	*Artica islandica*			
MAFMC	Atlantic Surfclam & Ocean Quahog	Surfclam	*Spisula solidissima*			

Table 2.6. (*continued*)

Management Plan Agency[b]	Management Plan Species Group	Common Name of Species	Scientific Name of Species	EFH for Life Stages by Ecosystem[c]		Geographically Defined Habitat Areas of Particular Concern (HAPC) (North Carolina Locations Only)
				Marine	Estuarine	
MAFMC	Bluefish	Bluefish	*Pomatomus saltatrix*	L J A	J A	
MAFMC	Spiny Dogfish	Spiny dogfish	*Squalus acanthias*	J A		
MAFMC	Summer Flounder, Scup, Black Sea Bass	Scup	*Stenotomus chrysops*			
MAFMC	Summer Flounder, Scup, Black Sea Bass	Scup	*Stenotomus chrysops*			
MAFMC	Summer Flounder, Scup, Black Sea Bass	Summer flounder	*Paralichthys dentatus*	L J A	L J A	SAV for larvae and juveniles
MAFMC	Summer Flounder, Scup, Black Sea Bass	Black sea bass	*Centropristis striata*			
MAFMC	Atlantic Mackerel, Squid, Butterfish	Atlantic butterfish	*Peprilus triacanthus*			
MAFMC	Summer Flounder, Scup, Black Sea Bass	Scup	*Stenotomus chrysops*			
MAFMC	Summer Flounder, Scup, Black Sea Bass	Summer flounder	*Paralichthys dentatus*	L J A	L J A	SAV for larvae and juveniles

Table 2.6. (*continued*)

Management Plan Agency[b]	Management Plan Species Group	Common Name of Species	Scientific Name of Species	EFH for Life Stages by Ecosystem[c]		Geographically Defined Habitat Areas of Particular Concern (HAPC) (North Carolina Locations Only)
				Marine	Estuarine	
NMFS	Billfish	Blue marlin	*Makaira nigricans*	E L J A		
NMFS	Billfish	Longbill spearfish	*Tetrapturus pfluegeri*	J A		
NMFS	Billfish	Sailfish	*Istiophorus platypterus*	E L J A		
NMFS	Billfish	White marlin	*Tetrapturus albidus*	J A		
NMFS	Sharks	Atlantic angel shark	*Squatina dumerili*			
NMFS	Sharks	Atlantic sharpnose shark	*Rhizoprionodon terraenovae*	J A	J	
NMFS	Sharks	Basking shark	*Cetorhinos maximus*			
NMFS	Sharks	Big nose shark	*Carcharhinus altimus*	J		
NMFS	Sharks	Bigeye sand tiger shark	*Odontaspis noronhai*			
NMFS	Sharks	Bigeye sixgill shark	*Hexanchus vitulus*			
NMFS	Sharks	Bigeye thresher shark	*Alopias superciliosus*	E L P J S A		
NMFS	Sharks	Blacknose shark	*Carcharhinus acronotus*	J A		
NMFS	Sharks	Blacktip shark	*Carcharhinus limbatus*	J A		
NMFS	Sharks	Blue shark	*Prionace glauca*	J S A		
NMFS	Sharks	Bonnethead	*Sphyrna tiburo*	J A	J A	
NMFS	Sharks	Bull shark	*Carcharhinus leucas*	J	J	
NMFS	Sharks	Caribbean reef shark	*Carcharhinus perezi*	Florida only		
NMFS	Sharks	Carribean sharpnose shark	*Rhizoprionodon porosus*			
NMFS	Sharks	Dusky shark	*Carcharhinus obscurus*	A	J A	

Table 2.6. (*continued*)

Management Plan Agency[b]	Management Plan Species Group	Common Name of Species	Scientific Name of Species	EFH for Life Stages by Ecosystem[c]		Geographically Defined Habitat Areas of Particular Concern (HAPC) (North Carolina Locations Only)
				Marine	Estuarine	
NMFS	Sharks	Finetooth shark	*Carcharhinus isodon*	E L P J S A		
NMFS	Sharks	Longfin mako shark	*Isurus paucus*	E L P J S A		
NMFS	Sharks	Narrowtooth shark	*Carcharhinus brachyurus*			
NMFS	Sharks	Night shark	*Carcharhinus signatus*	J A		
NMFS	Sharks	Nurse shark	*Ginglymostoma cirratum*	J A		
NMFS	Sharks	Oceanic whitetip shark	*Carcharhinus longimanus*	J S A		
NMFS	Sharks	Porbeagle shark	*Lamna nasus*			
NMFS	Sharks	Sand tiger shark	*Odontaspis taurus*	J A		
NMFS	Sharks	Sandbar shark	*Carcharhinus plumbeus*	J A	J A	Pamlico Sound adjacent to Hatteras and Ocracoke Islands and offshore
NMFS	Sharks	Scalloped hammerhead	*Sphyrna lewini*	J A		
NMFS	Sharks	Sharpnose sevengill shark	*Heptranchias perlo*			
NMFS	Sharks	Shortfin mako shark	*Isurus oxyrinchus*	E L P J S A		
NMFS	Sharks	Silky shark	*Carcharhinus falciformis*	J		
NMFS	Sharks	Sixgill shark	*Hexanchus griseus*			
NMFS	Sharks	Smalltail shark	*Carcharhinus porosus*			
NMFS	Sharks	Smooth hamerhead	*Sphyrna zygaena*			
NMFS	Sharks	Spinner shark	*Carcharhinus brevipinna*	J A		
NMFS	Sharks	Thresher shark, common	*Alopias vulpinus*			
NMFS	Sharks	Tiger shark	*Galeocerdo cuvieri*	J S A		
NMFS	Sharks	White shark	*Carcharodon carcharias*	J		

Table 2.6. (*continued*)

Management Plan Agency[b]	Management Plan Species Group	Common Name of Species	Scientific Name of Species	EFH for Life Stages by Ecosystem[c]		Geographically Defined Habitat Areas of Particular Concern (HAPC) (North Carolina Locations Only)
				Marine	Estuarine	
NMFS	Swordfish	Swordfish	*Xiphias gladius*	E L J S A		
NMFS	Tuna	Albacore	*Thunnus alalunga*	A		
NMFS	Tuna	Atlantic bigeye tuna	*Thunnus obesus*	J A		
NMFS	Tuna	Atlantic Yellowfin tuna	*Thunnus albacares*	E L J S A		
NMFS	Tuna	Skipjack tuna	*Katsuwonus pelamis*	E L J S A		
NMFS	Tuna	Western Atlantic bluefin tuna	*Thunnus thynnus*	E L J S A		

Notes:

a. These EFH species were compiled from *Essential Fish Habitat: A Marine Fish Habitat Conservation Mandate for Federal Agencies*. February 1999 (Revised 08/2004) (Appendices 2, 3, 6, 7, and 8). Although 46 species are listed in Appendix 3 under NMFS management, only 35 of the species have EFH listed in Appendix 8.

b. Organizations responsible for FMPs consist of: SAFMC = South Atlantic Fishery Management Council; MAFMC = Mid-Atlantic Fishery Management Council; NMFS = National Marine Fisheries Service.

c. Life stages include E = Eggs, L = Larvae, P = PostLarvae, J = Juveniles, S = SubAdults, A = Adults

(End of Table 2.6)

Table 2.7. Categories of EFH and HAPC identified in FMP Amendments affecting the South Atlantic Area.[a, b]

EFH	GEOGRAPHICALLY DEFINED HAPC
Estuarine Areas	**Area-wide**
Estuarine Emergent Wetlands	Council-designated Artificial Reef Special Management Zones
Estuarine Scrub/Shrub Mangroves	Hermatypic (reef-forming) Coral Habitat & Reefs
Submerged Aquatic Vegetation (SAV)	Hard Bottoms
Oyster Reefs & Shell Banks	Hoyt Hills
Intertidal Flats	*Sargassum* Habitat
Palustrine Emergent & Forested Wetlands	State-designated Areas of Importance of Managed Species
Aquatic Beds	Submerged Aquatic Vegetation
Estuarine Water Column[2]	
Seagrass	
Creeks	
Mud Bottom	
Marine Areas	**North Carolina**
Live/Hard Bottoms	Big Rock
Coral and Coral Reefs	Bogue Sound
Artificial/Man-made Reefs	Pamlico Sound at Hatteras/Ocracoke Islands
Sargassum	Capes Fear, Lookout, & Hatteras (sandy shoals)
Water Column[2]	New River
	The Ten Fathom Ledge
	The Point

Notes:

a.EFH areas are identified in FMP Amendments for the South Atlantic and Mid-Atlantic Fishery Management Councils. Geographically Defined HAPC are identified in FMP Amendments affecting the South Atlantic Area. Information in this table was derived from *Essential Fish Habitat: A Marine Fish Habitat Conservation Mandate for Federal Agencies*. February 1999 (Revised 08/2004) (Appendices 4 and 5).

b. EFH for species managed under NMFS Billfish and Highly Migratory Species generally falls within the marine and estuarine water column habitats designated by the Fishery Management Councils.

2.01.12 Shellfish

The commercial fishing industry is a very important economic component to North Carolina. According to Burgess and Bianchi (2004), shellfish (i.e., bivalves, crustaceans, and other species that do not have fins) as a whole are more economically important than finfish in North Carolina. The commercial shell fishing industry in North Carolina consists of Eastern oysters, hard clams, bay scallops, blue crabs, and shrimp. Between 1972 and 2002, the total shellfish composition of North Carolina commercial landings has varied, total shellfish landings have exhibited an overall increase, and the value for shellfish landed exhibited an overall increase. From 1994 to 2002, the majority of shellfish landings and revenue was attributable to hard blue crabs and shrimp (Burgess and Bianchi, 2004).

Eastern Oyster

Eastern oysters (*Crassostrea virginica*) are managed under the North Carolina Oyster FMP dated June 2008, as amended (NCDMF, 2008b). The Eastern oyster is designated by the NCDMF as a species of concern. It is a very successful estuarine bivalve and can tolerate a wide variety of salinities, temperatures, currents, and turbidities. The preferred habitat for Eastern oysters is from just below mean low water to one meter (3.28 ft.) above mean low water (Burrel, 1986). Vast intertidal reefs formed by oysters are significant biological and physical formations in the estuaries of North Carolina. Fish, crabs, and shrimp use oyster beds as refuge and as a source of food. The intertidal oyster beds also provide habitat for various infaunal and epifaunal species. Although traditionally harvested from Pamlico Sound in the northern part of the state, disease has caused the stock to decline in this area. Consequently, landing trends indicate that the Eastern oyster is primarily harvested from the southern part of the state including Topsail Sound, Lockwood Folly, Masonboro Sound, the New River, the Newport River, and the Shallotte River (Burgess and Bianchi, 2004).

Oysters are the primary component of shell bottom habitat and the North Carolina Marine Fisheries Commission, SAFMC, and Atlantic States Marine Fisheries Commission all recognize the importance of this habitat. The SAFMC defines this shell bottom habitat as, "the natural structures found between (intertidal) and beneath (subtidal) tide lines, that are composed of oyster shell, live oysters and other organisms that are discrete, contiguous and clearly distinguishable from scattered oysters in marshes and mudflats, and from wave-formed shell windrows" and has designated oyster reefs as EFH for red drum (SAFMC, 1998). Additionally, shell bottom is federally designated as an HAPC for estuarine–dependent, snapper-grouper species. Shell bottom provides critical fisheries habitat for oysters and for recreationally and commercially important finfish, other mollusks, and crustaceans. Several studies have found higher abundance and diversity of fish on shell bottom than adjacent soft bottom, particularly pinfish, blue crabs (*Callinectes sapidus*), and grass shrimp (Street et al., 2005).

The action area of the proposed project is within the marine environment and would not be expected to directly or indirectly affect Eastern oysters or shell bottom habitat or any associated EFH or HAPCs.

Hard Clams

Hard clams (*Mercenaria mercenaria*) are managed under the North Carolina hard clam FMP dated June 2008 (NCDMF, 2008a). Hard clams are an estuarine-dependent mollusk found primarily in sandy and vegetated bottoms. Juvenile and adult habitats for hard clams include intertidal sand flats, shell bottom, and SAV (Street et al., 2005). Increased fishing, poor water quality, and habitat loss have affected this fishery. The NCDMF shellfish habitat and abundance mapping program has documented the current distribution of clam habitat. Survey data through January 2007 (including Carolina Beach north to Core Sound, west to Clubfoot Creek on the lower Neuse River, and north to Pungo River) indicate that approximately 2 percent (6,736 acres) of the bottom was classified as intertidal soft bottom, 75 percent (309,814 acres) was classified as subtidal soft bottom, and 4 percent (14,600 acres) was classified as shell bottom. The EFH for the hard clam, as designated by the SAFMC, is subtidal and intertidal flats, oyster reefs and shell banks, and SAV. In North Carolina, hard clams are commonly harvested from Core Sound, the New River, and the Newport River (Burgess and Bianchi, 2004).

The action area of the proposed project is within the marine environment and is not expected to directly or indirectly affect hard clams or any associated EFH or HAPs.

Bay Scallop

Bay scallops (*Argopecten irradians*) are managed under the North Carolina bay scallop FMP, which was adopted in November 2007 (NCDMF, 2007). The bay scallop is an estuarine dependent bivalve found in seagrass beds. They have a short life span, and their populations are mainly affected by environmental conditions such as temperature, salinity, habitat, and water quality (NCDMF, 2007). Bay scallops are rarely found attached, although they do have the ability to attach by byssal threads mainly as juveniles but as they mature, scallops sink to the bottom and continue to grow. Adult scallops prefer calm waters, secluded from high winds, storms, with tides and depths of 0.3 to 10 m (98 to 32.8 ft). In North Carolina, the majority of bay scallops are harvested from Core and Bogue sounds (Burgess and Bianchi, 2004).

The action area of the proposed project is within the marine environment and is not expected to directly or indirectly affect bay scallops or any associated EFH or HAPCs.

Blue Crabs

Blue crabs (*Callinectes sapidus*) are managed under the North Carolina blue crab FMP dated December 2004 (NCDMF, 2004). Increased concern for the health of the stock and fishery is due to reduced landings of hard blue crabs during 2000–2002 and 2004–2007, following record-high landings observed during 1996–1999. With increasing concerns over fluctuating blue crab landings and increasing fishing effort, numerous requests have been made to further protect the spawning stock of blue crabs in North Carolina. The blue crab life cycle consists of an offshore phase and an estuarine phase and uses a wide range of habitats depending on its life stage, sex, maturity, and associated salinity preferences (NCDMF, 2004). After mating, females migrate to high-salinity waters in lower estuaries, sounds, and nearshore spawning areas. They over-winter before spawning by burrowing in the mud. Most females spawn for the first time 2 to 9 months after mating, usually from May through August the following season. Juveniles (i.e., typically 2.5 millimeters [mm] wide) gradually migrate into shallower, less-saline waters in upper estuaries and rivers where they grow and mature. When air temperatures drop below 50 degrees Fahrenheit (°F) (10 °Celsius [C]), adult crabs leave shallow, inshore waters and seek deeper areas where they bury themselves and remain in a state of torpor throughout the winter (Zinski, 2006). Crab spawning sanctuaries are at Oregon Inlet, Hatteras Inlet, Ocracoke Inlet, Drum Inlet and Bardens Inlet; however, no spawning sanctuaries have been established south of Cape Lookout, North Carolina. The majority of blue crabs are harvested from the Albemarle-Pamlico estuarine system (Burgess and Bianchi, 2004).

The action area of the proposed project is within the marine environment and is not expected to directly or indirectly affect blue crabs and associated critical habitat, spawning sanctuaries, or designated EFH and HAPCs.

Shrimp

Shrimp are managed under the North Carolina shrimp FMP dated April 2006 (NCDMF, 2006). The most common commercially important species in North Carolina are the Penaeid shrimp (white shrimp (*Litopenaues setiferus*), pink shrimp (*Farfantepenaeus duorarum*), and brown shrimp (*F. aztecus*)). Penaeid shrimp are spawned in the ocean and carried by tides and wind driven currents into the estuaries. As the shrimp increase in size, they migrate from the upper reaches of small creeks to deeper, saltier rivers and sounds. By late summer and fall, they return to the ocean to spawn (NCDMF, 2009). The most significant threat to shrimp stocks is loss or degradation of habitat from pollution or physical alteration. Critical habitat types that support juvenile shrimp nursery areas include salt marsh and inshore seagrass habitat (NCDMF, 2006). In North Carolina, the majority of shrimp landings occur in Pamlico Sound, Core Sound, and the Atlantic Ocean fewer than 3 miles offshore (Burgess and Bianchi, 2004). Inshore waters account for 76 percent and ocean waters 24 percent of the total harvest. In the southern portion of the state, the fishery is characterized by a large number of small boats fishing internal waters (primarily the Intracoastal Waterway, New and Cape Fear rivers) and larger craft fishing the Atlantic Ocean primarily off New River, Carolina Beach, and Brunswick County (NCDMF, 2006).

The action area of the proposed project is within the marine environment and is not expected to directly or indirectly affect penaeid shrimp species or any associated EFH or HAPCs.

2.02 Terrestrial Environment

2.02.1 Maritime Shrub Thickets

The maritime shrub thicket community normally occurs landward of the dune where it is protected from salt spray and the full force of ocean winds. Maritime shrub thicket occurs sporadically throughout Surf City and North Topsail Beach—on the backside of the island, west of the highway, and interspersed with marsh areas that border the sound. Dominant shrubs and trees in the community are wax myrtle (*M. cerifera*), yaupon (*I. vomitoria*), red cedar (*Juniperus virginica*), live oak (*Quercus virginiana*), and loblolly pine (*Pinus taeda*). Vines are also common with greenbriar (*Smilax bonanox*), pepper-vine (*Ampelopsis arbore*a) and grape (*Vitus rotundifolia*) being particularly abundant. The community type offers excellent cover for neotropical, migrating songbirds. Other important species that may be found in the maritime thicket include the seaside sparrow, painted bunting, saltmarsh sharp-tailed sparrow, Nelson’s sharp-tailed sparrow, and marsh and sedge wrens. Raptors may also be common during migration (e.g., American kestrel, merlin, peregrine falcon, bald eagle, northern harrier) (Sue Cameron, personal communication, September 8, 2004).

2.02.2 Beach and Dune

Terrestrial areas that may be influenced by the proposed actions include a 9.9-mile area that includes all Surf City (reaches 27–58) and the southern 3.8 miles of North Topsail Beach (reaches 58–78). Terrestrial habitat types within the areas include sandy or sparsely vegetated beaches and vegetated dune communities. The first line of stable vegetation is outside or landward of the proposed project limits. Utility corridors may have herbaceous or shrub cover. Barren areas are also widespread because of the disturbed nature of the utility corridors. Mammals occurring in this environment are opossums, cottontails, red foxes, gray foxes, raccoons, feral house cats, shrews, moles, voles, and house mice.

Among North Carolina's upland habitats, the beach and dune community could be considered depauperate in both plants and animals. The beach environment is severe because of constant exposure to salt spray, shifting sands, wind, and sterile soils with low water retention capacity. Common vegetation of the upper beach includes beach spurge (*Euphorbia polygonifolia*), sea rocket (*Cakile edentula*) and pennywort (*Hydrocotyle bonariensis*). The dunes are more heavily vegetated, and common species are American beach grass (*Ammophila breviligulata*), panic grass (*Panicum amarum*), sea oats (*Uniola paniculata*), broom straw (*Andropogon virginicus*), seashore elder (*Iva imbricata*), and salt meadow hay (*Spartina patens*) (Nash and Rogers, 2003). Seabeach amaranth is present throughout Surf City and North Topsail Beach and is addressed in Appendix I. Important macroinvertebrates of the beach/dune community are the mole crab (*E. talpoida*), coquina clams (*D. variabilis*) (see Section 2.01.8), and ghost crabs (*O. quadrata*).

Ghost crabs occupy the upper zone of the beach environment and function as an important predator in the beach community. Up to 60 percent of their diet consists of mole crabs; up to 25 percent consists of coquina clams (Wolcott, 1978). During the sea turtle nesting season, ghost crabs are also known to prey on incubating sea turtle eggs and newly hatched sea turtle hatchlings. *O. quadrata* is the only ghost crab occurring in the southeastern United States and, though little is known regarding its life history aspects, their various reproductive and larval components most likely reflect that of other decapods. Although timing of recruitment is poorly understood, it most likely occurs between late spring and early fall (Hackney et al., 1996).

2.02.3 Birds

Birds common to the nearshore ocean in the project area are loons, grebes, gannets, cormorants, scoters, red-breasted mergansers, gulls, and terns (LeGrand, 1983; USACE 2007b; Sauer et al., 2008). The habitat and food source of such seabirds is the marine environment, whether coastal, offshore or pelagic. They can be divided into four groups by their feeding strategies, which are reflected in their anatomy, physiology, and habitat niche: surface feeders, surface swimmers/pursuit divers, plunge-divers, and scavengers and pirates (i.e., steal from other birds). The waters off of Topsail Island are very important to migrating and wintering northern gannets, loons, and grebes because of the abundant hard-bottom habitat offshore of Surf City and North Topsail Beach (see Section

2.01.10) (Sue Cameron, personal communication, September 8, 2004). Those hard-bottom communities support a rich diversity of invertebrates, which are refuges and food sources for fish and other marine life. The diverse communities support a variety of reef and pelagic fish species that, in-turn, provide a forage base for migrating and wintering sea birds. The USFWS indicates that sea ducks raft in large numbers in the nearshore ocean waters of the project area during spring and fall migrations. Ducks, geese, and many kinds of shorebirds may also be found here during the spring and fall (Sauer et al., 2008).

The beaches and inlets of the project vicinity are heavily used by migrating shorebirds. However, dense development and high public use of project area ocean front beaches may reduce their value to shorebirds. Along the ocean beach, black-bellied plovers, ruddy turnstones, whimbrels, willets, red knots, semi-palmated sandpipers, and sanderlings may be found (LeGrand, 1983; USACE 2007b; Sauer et al., 2008). Table 2.8 provides a more complete list of waterbirds found in the project area. The dunes of the project area support fewer numbers of birds but can be very important habitats for resident species and for other species of songbirds during periods of migration. The maritime forest along Topsail Island is important for painted buntings and in the herbaceous dune areas, the American kestrel, merlin, bald eagle, peregrine falcon, northern harrier, and other raptors may be found during migration. Other birds occurring in the area are mourning doves, swallows, fish crows, starlings, meadowlarks, redwinged blackbirds, boat tailed grackles, and savannah sparrows (Douglas and Dechant-Shaffer, 2002; Sauer et al., 2008).

The black skimmer, least tern, and common tern are state-listed species of concern for Pender and Onslow counties, North Carolina, and are found on Topsail Island year round during both the breeding season and during migration, with peak abundance occurring in the summer months. Terns feed by diving from the air on insects and small fish, and the black skimmer feeds on shrimp or small fish by flying just above the water with the tip of the long lower mandible shearing the surface. All these bird species may use Topsail Island for roosting, foraging, breeding, and nesting (Potter et al., 1980).

Table 2.8. List of waterbirds that occur in the Surf City and North Topsail Beach project area and their status

Common name	Scientific name	Season[a]	NC status[b]
Red-throated loon	*Gavia stellata*	M, W	
Common loon	*Gavia immer*	M, W	
Horned Grebe	*Podiceps auritus*	M, W	
Brown pelican	*Pelecanus occidentalis*	B, M, W	SR
Double-crested cormorant	*Phalacrocorax auritus*	B, M, W	SR
Northern Gannet	*Morus bassanus*	M, W	
Great blue heron	*Ardea herodias*	B, M, W	
Great egret	*Ardea albus*	B, M, W	
Snowy egret	*Egretta thula*	B, M	SC
Reddish egret	*Egretta rufescens*	M	
Tricolored heron	*Egretta tricolor*	B, M	SC
Little blue heron	*Egretta caerulea*	B. M. W	SC
Black-crowned night heron	*Nycticorax nycticorax*	B, M, W	
White ibis	*Eudocimus albus*	B, M, W	
Glossy ibis	*Plegadis falcinellus*	B, M	SC
Osprey	*Pandion haliaetus*	B, M	
Clapper rail	*Rallus longirostris*	B, M, W	
Black-bellied plover	*Pluvialis squatarola*	M, W	
Wilsons plover	*Charadrius wilsonia*	B, M	SC
Semipalmated plover	*Charadrius semipalmatus*	M	
Piping plover	*Charadrius melodus*	B, M, W	T (T)
Killdeer	*Charadrius vociferus*	B, M, W	
American oystercatcher	*Haematopus palliatus*	B, M, W	SC
American avocet	*Recurvirostra americana*	M	
Black-necked stilt	*Himantopus mexicanus*	B, M	SR
Greater yellowlegs	*Tringa melanoleuca*	M, W	
Lesser yellowlegs	*Tringa flavipes*	M, W	
Willet	*Catoptrophorus semipalmatus*	B, M, W	
Spotted sandpiper	*Actitis macularia*	M	
Whimbrel	*Numenius phaeopus*	M	
Marbled godwit	*Limosa fedoa*	M, W	
Ruddy turnstone	*Arenaria interpres*	M, W	
Sanderling	*Calidris alba*	M, W	
Semipalmated sandpiper	*Calidris pusilla*	M	
Western sandpiper	*Calidris mauri*	M, W	
Least sandpiper	*Calidris minutilla*	M, W	
Red Knot	*Calidris canutus*	M, W	
Dunlin	*Calidris alpina*	M, W	

Table 2.8. (*continued*)

Common name	Scientific name	Season[a]	NC status[b]
Short-billed dowitcher	*Limnodromus griseus*	M, W	
Bonaparte's gull	*Larus philadelphia*	M, W	
Laughing gull	*Larus atricilla*	B, M	
Ring-billed gull	*Larus delawarensis*	M, W	
Herring gull	*Larus argentatus*	B, M, W	
Great black-backed gull	*Larus marinus*	B, M, W	
Gull-billed tern	*Sterna nilotica*	B, M	T
Caspian tern	*Sterna caspia*	B, M, W	SR
Royal tern	*Sterna maxima*	B, M, W	
Sandwich tern	*Sterna sandvicensis*	B, M	
Common tern	*Sterna hirundo*	B, M	SC
Forster's tern	*Sterna forsteri*	B, M, W	
Least tern	*Sterna antillarum*	B, M	SC
Black tern	*Chlidonias nigra*	M	
Black skimmer	*Rynchops niger*	B, M	SC

Source: LeGrand, 1983

a. Season: B = Breeding; M = Migrating; W = Wintering

b. North Carolina Status: Endangered (E); Threatened (T); Special Concern (SC); Significantly Rare (SR).

E, T, and SC status species are given legal protection status by the North Carolina Wildlife Resources Commission. SR status is defined as any species which has not been listed by the North Carolina Wildlife Resources Commission as E, T, or SC species, but which exists in the state in small numbers and has been determined by the North Carolina Natural Heritage Program to need monitoring. federal status is indicated in parentheses.

Annual shorebird surveys conducted by the North Carolina Wildlife Resources Commission (NCWRC) in the project vicinity are limited, and complete surveys for American oystercatchers and Wilson's plovers have been conducted only in 2004 and 2007. However, annual surveys for nesting piping plovers in appropriate habitat have been conducted since 1989, and complete coast-wide wintering surveys were conducted most recently in 1996, 2001, and 2006. Table 2.9 summarizes the Topsail Island vicinity annual shorebird surveys and database provided by NCWRC. Surveys encompassed the wintering, breeding, and spring and fall migration periods.

Table 2.9. Summary of annual shorebird surveys

Species	Site	Birds	Breeding pairs
American Oystercatcher	AIWW Bogue Inlet south to North Topsail	14	6
	AIWW North Topsail south to S. Figure Eight	32	14
	AIWW South Topsail	21	10
	New River Inlet	23	10
	Topsail Beach North	2	1
	UNI, New River Channel 1	2	1
	UNI, New River Channel 2	4	2
	UNI, New River Channel 3	10	5
	UNI, New River Channel 4	2	1
	TOTAL	**110**	**50**
Black-necked Stilt	Surf City, AIWW 1	1	
	TOTAL	**1**	**0**
Killdeer	AIWW Bogue Inlet south to North Topsail	4	2
	AIWW North Topsail south to S. Figure Eight	4	2
	AIWW South Topsail	2	1
	North Topsail Overwash	2	1
	Topsail Beach North	4	2
	UNI, New River Channel 2	4	2
	UNI, New River Channel 3	4	2
	TOTAL	**24**	**12**
Piping Plover*	North Topsail Overwash	0	0
	Topsail Beach North	10	2
	TOTAL	**10**	**2**
Willet	AIWW Bogue Inlet south to North Topsail	20	10
	AIWW North Topsail south to S. Figure Eight	22	11
	AIWW South Topsail	1	1
	New River Inlet	24	12
	North Topsail Overwash	2	1
	Topsail Beach North	20	10
	UNI, New River Channel 2	4	2
	UNI, New River Channel 3	20	10
	UNI, New River Channel 4	6	3
	TOTAL	**119**	**60**
Wilsons Plover	AIWW Bogue Inlet south to North Topsail	22	11
	North Topsail Overwash	40	19
	Topsail Beach North	41	18
	UNI, New River Channel 1	4	2
	UNI, New River Channel 2	14	7
	UNI, New River Channel 3	4	2
	TOTAL	**125**	**59**

Note: *Piping plover surveys conducted during the winter did not identify any birds. (AIWW – Atlantic Intracoastal Waterway; UNI – Un-named Island). Source: NCWRC 2009.

Colonially nesting waterbirds are an important part of the project area ecosystem. The species formerly nested primarily on the barrier islands of the region, but development or recreational activities have usurped the nesting sites. With the loss of their traditional nesting areas, the species have retreated to the relatively undisturbed dredged material disposal islands that border the navigation channels throughout the state. Those islands often offer ideal nesting areas because they are close to food sources, well removed from human activities, and are isolated from mammalian egg and nesting predators. Other species also use the islands for loafing or roosting during migratory periods or the winter months including painted buntings. Surveys conducted by the NCWRC for American oystercatchers and Wilson's plovers indicate that the dredge islands, natural islands, and shell rakes behind Topsail Island are very important nesting areas for the species. However, dredged material islands in the immediate vicinity of the project area that are diked are used by only a small number of nesting waterbirds. Since 1972, coast-wide breeding colonial waterbird surveys have been conducted every 2–3 years with the most recent completed survey conducted in 2007. Seven of the survey sites are in the project vicinity and, between 1972 and 2007, have supported a total of 978 nests from 9 different species of colonial nesting waterbirds (Table 2.10).

Table 2.10. Summary of colonial nesting waterbird data (1972–2007) conducted by NCWRC in the SCNTB vicinity

Site	Colonial nesting waterbirds (# of nests from 1972 through 2007)								
	Green heron	Least tern	Black skimmer	Common tern	Gull billed tern	Cattle egret	Little blue heron	Snowy egret	Tri-colored heron
UNI, New River Channel 1	2	66							
UNI, New River Channel 2	65	297	25	6					
UNI, New River Channel 3	64	18	5	14	4				
UNI, New River Channel 4	13								
UNI, Alligator Bay 1	33					75	49	10	11
ICW, Dredge Island South of Surf City		29							
New Chadwick Bay Inlet		192							
TOTAL	177	602	30	20	4	75	49	10	11

Note: AIWW = Atlantic Intracoastal Waterway; UNI = Unnamed Island; shaded areas represent 0 documented nesting records.

Though most of the project area is heavily developed, the southern end of Topsail island the north end of North Topsail Beach, and nearby Lea and Hutaff islands and Onslow beaches provide important and unique, undeveloped habitat for breeding birds including terns, skimmers, piping plovers, Wilson's plovers, and American oystercatchers. The undeveloped barrier island areas are rare in the project vicinity and are very important breeding habitats for those species. The north end of North Topsail Beach is important for many shorebird and water bird species and secretive marsh birds such as sharp-tailed sparrows. Though historically the north end of North Topsail Island had not been roped off for nesting shorebirds, in 2008 NCWRC was permitted to post a section of the north end for nesting birds, and a colony of least terns (~40 pairs) attempted to nest. Furthermore, a single migrant piping plover was identified using an area on the north end. Information on birds using the north end of North Topsail Beach and the ocean-facing beaches of the project area during the nonbreeding season are limited. However, as a component of the ongoing shorebird monitoring plan for the nonfederal North Topsail Beach coastal storm damage reduction project, CPE has been conducting regular surveys of the North Topsail Beach and New River Inlet vicinity. Specifically, CPE has surveyed seven bird-monitoring transect areas in the New River Inlet complex since November 19, 2007. As identified in the preconstruction bird-monitoring plan of the November 2007 *Draft Environmental Impact Statement* (USACE, 2007b), the transect sites include: transect No. 1 - Riverside of North Topsail Beach inlet shoreline beginning at River Road; transect No. 2 - Oceanside of North Topsail Beach inlet shoreline beginning at the southeastern end of Topsail Reefs Condominiums and ending at River Road; transect No. 3 - Onslow Beach inlet shoreline extending approximately 1,060 m (3,500 ft.) to the northeast; transect No. 4 - shoal formations approximately 609 m (2,000 ft.) north of inlet mouth; and transect No. 5 - subtidal habitat of New River Inlet and oceanfront surf zones of transects 2 and 3. CPE has not yet completed the pre-project data collection component of the monitoring plan and a detailed analysis and summary of the data. However, to provide a preliminary assessment of key species in the proposed federal project vicinity that use habitat on the north end of North Topsail Beach, a summary of the current data within transects 1 and 2 (on the north end of North Topsail Beach) is provided in Table 2.11. Of particular importance are the state-listed species: the black skimmer (*Rynchops niger*) (n=2) (species of concern), least tern (*Sterna antillarum*) (n=197) (species of concern), and common tern (*Sterna hirundo*) (n=57) (species of concern), Wilsons plover (*Charadrius wilsonia*) (n=38) (species of concern), American oystercatcher (*Haematopus palliates*) (n=61) (species of concern), and the federally listed Piping plover (threatened) (n=1).

Table 2.11. Summary of key waterbird species identified along the inlet and ocean facing shorelines of North Topsail Beach based on ongoing pre-construction monitoring performed by CPE as a component of the bird monitoring plan for the Nonfederal North Topsail Beach Shoreline Protection Project (USACE, 2007b)

Species	Survey period				Total
	Winter (Nov–Feb)	Spring (Mar–Jun)	Summer (Jul–Aug)	Fall (Sept–Oct)	
Common loon	7	1	0	0	**8**
Brown pelican	84	73	22	42	**221**
Double-crested cormorant	112	22	3	1	**138**
Great Blue heron	1	0	5	4	**10**
Great egret	0	0	77	46	**123**
Snowy egret	0	0	17	19	**36**
Little Blue heron	0	0	11	5	**16**
Tricolored heron	0	0	1	1	**2**
White ibis	13	0	12	35	**60**
Glossy ibis	0	0	0	0	**0**
Black-bellied plover	22	16	17	38	**93**
Wilson's plover	0	3	30	5	**38**
Semipalmated plover	0	0	61	66	**127**
Piping plover	0	0	1	0	**1**
Killdeer	0	2	3	0	**5**
American oystercatcher	0	2	28	31	**61**
Greater yellowlegs	9	3	6	10	**28**
Solitary sandpiper	0	0	0	0	**0**
Willet	6	11	31	15	**63**
Spotted sandpiper	0	0	2	1	**3**
Whimbrel	0	0	0	0	**0**
Marbled godwit	0	0	1	0	**1**

Table 2.11. (*continued*)

Species	Survey period Winter (Nov–Feb)	Spring (Mar–Jun)	Summer (Jul–Aug)	Fall (Sept–Oct)	Total
Ruddy turnstone	15	3	9	24	**51**
Red knot	59	0	4	0	**63**
Sanderling	22	7	101	114	**244**
Semipalmated sandpiper	0	0	29	29	**58**
Western sandpiper	17	22	4	28	**71**
Least sandpiper	0	0	31	44	**75**
Pectoral sandpiper	0	0	0	0	**0**
Dunlin	309	87	0	12	**408**
Short-billed dowitcher	39	0	104	95	**238**
Long-billed dowitcher	0	0	0	1	**1**
Laughing gull	432	30	479	1174	**2115**
Bonaparte’s gull	167	104	0	0	**271**
Ring-billed gull	658	147	88	138	**1031**
Herring gull	256	12	68	184	**520**
Lesser black-backed gull	0	0	0	2	**2**
Great black-backed gull	129	2	18	51	**200**
Gull-billed tern	0	0	0	0	**0**
Caspian tern	0	0	16	186	**202**
Royal tern	0	2	147	232	**381**
Sandwich tern	1	1	96	148	**246**
Common tern	0	0	7	50	**57**
Forster’s tern	14	5	0	147	**166**
Least tern	0	76	121	0	**197**
Black tern	0	0	1	0	**1**
Black skimmer	0	0	2	93	**95**
TOTAL	**2,372**	**631**	**1,653**	**3,071**	**7,727**

2.02.4 Endangered and Threatened Species

The ESA of 1973, as amended (16 U.S.C. 1531–1543), provides a program for the conservation of threatened and endangered (T&E) plants and animals and the habitats in which they are found. The lead federal agencies for implementing the ESA are the USFWS (http://www.fws.gov/) and the NOAA Fisheries Service (http://www.nmfs.noaa.gov/). The USFWS has primary responsibility for terrestrial and freshwater organisms, while the responsibilities of NMFS are mainly marine wildlife such as whales and anadromous fish such as salmon. Section 7 of the ESA requires federal agencies to use their legal authorities to promote the conservation purposes of the ESA and to consult with the USFWS and NMFS, as appropriate, to ensure that effects of actions they authorize, fund, or carry out will not jeopardize the continued existence of listed species or result in the destruction or adverse modification of designated critical habitat of such species. The law also prohibits any action that causes a *taking* of any listed species of endangered fish or wildlife without a permit. Take is defined as, “to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect or attempt to engage in any such conduct.” Through regulations, the term *harm* is defined as, “an act

[that] actually kills or injures wildlife. Such an act may include significant habitat modification or degradation where it actually kills or injures wildlife by significantly impairing essential behavioral patterns, including breeding, feeding, or sheltering." Likewise, import, export, interstate, and foreign commerce of listed species are all generally prohibited. In accordance with section 7 (a)(2) of the ESA, the Corps has been in consultation with the USFWS and NMFS since beginning this study to ensure that effects of the proposed project would not jeopardize the continued existence of listed species or result in the destruction or adverse modification of designated critical habitat of such species.

Updated lists of federally listed T&E species for the project area (Pender and Onslow counties, North Carolina) were obtained from the NMFS (Southeast Regional Office, St. Petersburg, Florida) (http://sero.nmfs.noaa.gov/pr/pdf/North%20Carolina.pdf) and the USFWS (Field Office, Raleigh, North Carolina) (http://www.fws.gov/raleigh/es_tes.html) Web sites. Those were combined to develop a composite list of T&E species that could be present in the area according to their historical occurrence or potential geographic range (Table 2.12). However, the actual occurrence of a species in the area depends on the availability of suitable habitat, the season of the year relative to a species' temperature tolerance, migratory habits, and other factors. The likelihood of occurrence and potential project effects regarding T&E species are provided in the Biological Assessment (Appendix I.)

Chapter 113 (Conservation and Development), Subchapter IV (Conservation of Marine and Estuarine and Wildlife Resources), and Article 25 (Endangered and Threatened Wildlife and Wildlife Species of Special Concern) of the North Carolina General Statute comprises the state's endangered species provisions. Under that North Carolina statutory section, endangered species is defined as any native or once-native species of wild animal whose continued existence as a viable component of the state's fauna is determined by the Wildlife Resources Commission to be in jeopardy or any species of wild animal determined to be an *endangered species* pursuant to the ESA. Species are listed by the North Carolina Wildlife Resources Commission under specific criteria as defined by the statute. Under the act, it is unlawful to take, possess, transport, sell, barter, trade, exchange, export, or offer for sale, barter, trade, exchange or export, or give away for any purpose including advertising or other promotional purpose any animal on a protected wild animal list.

Table 2.12. Federally listed T&E species for the project area (Pender and Onslow counties, North Carolina)

Species common names	Scientific name	Federal status
Mammals		
West Indian Manatee	*Trichechus manatus*	Endangered
North Atlantic Right whale	*Eubaleana glacialis*	Endangered
Sei whale	*Balaenoptera borealis*	Endangered
Sperm whale	*Physeter macrocephalus*	Endangered
Finback whale	*Balaenoptera physalus*	Endangered
Humpback whale	*Megaptera novaeangliae*	Endangered
Blue Whale	*Balaenoptera musculus*	Endangered
Birds		
Piping Plover	*Charadrius melodus*	Threatened
Red-cockaded woodpecker	*Picoides borealis*	Endangered
Reptiles		
American alligator	*Alligator mississippiensis*	T(S/A)
Green sea turtle	*Chelonia mydas*	Threatened[1]
Hawksbill turtle	*Eretmochelys imbricata*	Endangered
Kemp's ridley sea turtle	*Lepidochelys kempii*	Endangered
Leatherback sea turtle	*Dermochelys coriacea*	Endangered
Loggerhead sea turtle	*Caretta caretta*	Threatened
Fish		
Shortnose sturgeon	*Acipenser brevirostrum*	Endangered
Smalltooth sawfish	*Pristis pectinata*	Endangered
Vascular Plants		
Golden sedge	*Carex lutea*	Endangered
Chaffseed	*Schwalbea Americana*	Endangered
Cooley's meadowrue	*Thalictrum cooleyi*	Endangered
Rough-leaved loosestrife	*Lysimachia asperulaefolia*	Endangered
Seabeach amaranth	*Amaranthus pumilus*	Threatened

Status	Definition
Endangered	A taxon "in danger of extinction throughout all or a significant portion of its range."
Threatened	A taxon "likely to become endangered within the foreseeable future throughout all or a significant portion of its range."
T(S/A)	Threatened due to similarity of appearance (e.g., American alligator)--a species that is threatened due to similarity of appearance with other rare species and is listed for its protection. These species are not biologically endangered or threatened and are not subject to Section 7 consultation.

An updated list of state-listed species for Pender and Onslow counties, North Carolina, was obtained from the North Carolina Natural Heritage Program Web site, http://www.ncnhp.org. (Table 2.13). Bird species are addressed in Sections 2.02.3 and 8.02.3, and the Carolina diamondback terrapin is addressed in Sections 2.01.2 and 8.01.2 of this FEIS.

Table 2.13. Summary of state-listed species for Pender and Onslow counties, North Carolina, that are not already federally listed as defined in Table 2.12

Species common name	Scientific name	State status
Birds		
Wilsons plover	*Charadrius wilsonia*	SC
American oystercatcher	*Haematopus palliatus*	SC
Bald Eagle	*Haliaeetus leucocephalus*	T
Least bittern	*Ixobrychus exilis*	SC
Eastern painted bunting	*Passerina ciris ciris*	SC
Black skimmer	*Rynchops niger*	SC
Common tern	*Sterna hirundo*	SC
Least tern	*Sternula antillarum*	SC
Gull-billed tern	*Gelochelidon nilotica*	T
Black necked stilt	*Himantopus mexicanus*	SR
Black rail	*Laterallus jamaicensis*	SC
Brown pelican	*Pelecanus occidentalis*	SR
Double-crested cormorant	*Phalacrocorax auritus*	SR
Snowy egret	*Egretta thula*	SC
Tricolored heron	*Egretta tricolor*	SC
Little blue heron	*Egretta caerulea*	SC
Glossy ibis	*Plegadis falcinellus*	SC
Caspian tern	*Sterna caspia*	SR
Reptiles		
Carolina diamondback terrapin	*Malaclemys terrapin centrata*	SC

Endangered (E); Threatened (T); Special Concern (SC); Significantly Rare (SR). E, T, and SC status species are given legal protection status by the NC Wildlife Resources Commission. SR status is defined as any species which has not been listed by the NC Wildlife Resources Commission as E, T, or SC species, but which exists in the state in small numbers and has been determined by the NC Natural Heritage Program to need monitoring.

Bald eagles were removed from the federal endangered species list in June 2007 because their populations recovered sufficiently, although they are still listed in North Carolina as threatened (Table 2.13) and their protection under the Bald and Golden Eagle Protection Act continue to apply. When the bald eagle was delisted, the USFWS proposed regulations to create a permit program to authorize limited take of bald eagles and golden eagles where take is associated with otherwise lawful activities. The Bald and Golden Eagle Protection Act (16 U.S.C. 668–668c), enacted in 1940, and amended several times since, prohibits anyone, without a permit issued by the Secretary of the Interior, from *taking* bald eagles, including their parts, nests, or eggs. The act provides criminal penalties for persons who, "take, possess, sell, purchase, barter, offer to sell, purchase or barter, transport, export or import, at any time or any manner, any bald eagle...[or any golden eagle], alive or dead, or any part, nest, or egg thereof." The act defines take as, "pursue, shoot, shoot at, poison, wound, kill, capture, trap, collect, molest or disturb." The bald eagle is found throughout North America including Pender and Onslow counties; however, the proposed action is not expected to affect specific habitat requirements of the bald eagle.

2.03 Physical Resources

2.03.1 Wave Conditions

Waves selected as input for the study were taken from the Corps' Coastal and Hydraulics Laboratory Wave Information Study. Updated wave hindcast data for station 292, about 10 miles offshore of Topsail Island for 1990 to 1999 were used. On the basis of the data, waves commonly approach the southeast-facing study area from east through south directions (nearly two-thirds of the time), with east-southeast and southeast approaching waves occurring most frequently (nearly one-third of the time). Annually, the most frequently occurring wave heights range from 1.6 to 3.2 ft., with a mean wave height of about 3.3 ft. In winter, the most frequently occurring wave heights range from 1.6 up to 4.9 ft. because of storms, with easterly to northeasterly approaching waves increasing in frequency. Summer wave conditions have more of a southeasterly component and are commonly in the 1- to 3-foot range, except for tropical systems that can generate the infrequent, but extreme waves of 15 ft. or more.

2.03.2 Shoreline and Sand Transport

The contiguous 9.9 miles of the study area consisting of Surf City and the southern portion of North Topsail Beach were divided into 52 reaches (27–78), each of which is about 1,000 ft. wide, except for the southernmost reach (27), which is 1,300 ft. wide. The two separate, smaller non-CBRA sections were each divided into 2 smaller reaches of varying lengths (reaches 107–108 and 114–115). The 1,000-foot-long study reaches are visible in Section 7, Figure 7.2 and in Appendix A, Figures A-7 and A-8.

Aside from the two small non-CBRA sections, the study area is more than 7 miles south of New River Inlet and more than 5 miles north of New Topsail Inlet—well out of the direct influence of the inlet complex. The authorized depth of those channels is relatively shallow (8 ft for New River and 7 ft for New Topsail). Both navigation channels are laid out to follow naturally deep water, and any maintenance dredging of these channels occurs along the unfixed channels. Dredging of those ocean bar channels has historically occurred predominately using sidecast dredging vessels, and the sediment remains in the inlet complex. External to this feasibility report effort, additional steps related to sediment allocation are being taken. The Corps' Regional Sediment Management program is analyzing the North Carolina coast and will include development of a sediment budget for the Topsail Island area. Some preliminary results are briefly presented in Appendix D. A grosser scale sediment budget for the island has been calculated for a previous report and showed a gross sediment rate of about 1,289,000 cubic yards per year and a net sediment transport rate of about 200,000 cubic yards per year to the north. For additional details, see Appendix D.

Long-term shoreline changes were determined by comparing Mean High Water (MHW) shoreline positions for each reach. Between 1963 and 2002, erosion rates were relatively low (less than one foot per year) in the southern half of the main study area (reaches 27–43); however, erosion rates in the northern half of the main study area (reaches 44–78) averaged nearly 2 ft. per year. This change in erosion rates may indicate the presence of a sediment transport reversal in this area. Appendix D discusses ongoing regional sediment management studies which, when completed, will help clarify the sediment transport processes and the presence of transport reversals. Erosion rates increased significantly to more than 5 ft. per year in portions of the non-study CBRA area (reaches 79-106), but they decreased to 2 to 3 ft. per year in reaches 107–108 study segment. Shoreline changes in reaches 114–115 study segment begin to be significantly influenced by inlet processes as erosion precipitously changed to minor accretion and then back to significant erosion in a span of only a few reaches approaching New River Inlet.

2.03.3 Geology and Sediments

The study area is in the Atlantic Coastal Plain Physiographic Province bordering Onslow Bay. The geomorphology of the area is characterized by beaches, dunes, and marshes typical of a barrier island complex. The Atlantic Coastal Plain and Onslow Bay are both underlain by relatively flat-lying sedimentary units that gently dip and thicken to the southeast. That large sedimentary wedge includes both sediments that have not been indurated or cemented and rock units. The sedimentary units range in age from Cretaceous to Quaternary and overlie crystalline basement rock. A patchy veneer of Holocene sands and gravels overlies the Quaternary strata. The sand soils found on the Topsail Island beaches are classified as fine- to medium-grained, poorly graded sands (SP) according to the Unified Soils Classification System.

The small rivers and streams entering Onslow Bay contribute small sediment loads as a significant fraction is deposited in the estuaries. That, in turn, contributes to the sand-starved nature of the coast in the area.

2.03.4 Climate

The climate of Surf City and North Topsail beaches is typically seasonal and generally mild. Temperatures are moderated by the ocean temperature, which ranges between 65 °F to 80 °F in the spring and summer and 50 °F to 65 °F in the fall and winter. The summers are warm and humid with highs averaging between 80 °F to 90 °F and winters are short and mild averaging around 55 °F. Predominant winds in the winter are from the north and northeast, whereas in the summer the winds are predominantly out of the south to southeast. Average monthly precipitation ranges from 3 to 8 inches throughout the year. October through December are the driest months, averaging 2–3 inches of precipitation, and July through September are the wettest months, averaging between 6–7 inches of precipitation.

Surf City and North Topsail Beach are low elevation and narrow barrier islands, and the orientation of the coastal communities on the Atlantic coastline lend them particularly vulnerable to tropical systems, including a long history of hurricanes. Though a significant number of historic hurricanes have approached the vicinity of Topsail Island, Hurricane Bertha, in 1996, was the first direct hit on it since Hurricane Donna in 1960. In the same year Hurricane Fran, a category 3 hurricane, struck the same area hit by Bertha with sustained winds of about 115 miles per hour and gusts to at least 125 miles per hour with significant coastal property loss extending from Cape Fear northward to Topsail Island.

Northeasters occur far more frequently than hurricanes and are much larger and longer lasting. The North Carolina coastline is vulnerable to large, persistent northeasters because of its orientation to the winter track of the polar jet stream. Significant coastal storm damage can result from these storm events. The most memorable coastal northeasters of the 20th century include the 1962 Ash Wednesday Storm and the 1993 Storm of the Century which caused extensive damage on Topsail Island and the rest of coastal North Carolina.

2.03.5 Physical Oceanography

The coastline of Surf City and North Topsail Beach is controlled by tidal and wind driven currents and experiences semi-diurnal tides with an average tidal range of about 3 ft. The longshore current is predominantly toward the northeast in the summer and toward the southwest in the winter. The predominant wave direction is from the south to southeast in the spring and summer and from the north to northeast in the fall and winter (see Section 2.03.1).

2.04 Socioeconomic Resources

The local economic impact area includes all Topsail Island and the nearby areas of both Pender and Onslow Counties, North Carolina. Topsail Island includes Surf City and North Topsail Beach on the north end of the island and Topsail Beach on the south end of Topsail Island. Highways 50 and 210 connect the island to the mainland portion of the two counties.

2.04.1 Demographics

Demographics for the existing economic conditions for the two-county study area, which includes census data for population, housing, and personal income are shown in Table 2.14. The total population of the two-county area was more than 190,000 in 2000. The study area had 2,236 permanent residents in 2000. According to the towns of Surf City and North Topsail Beach officials, the estimated peak summer time population of the two towns is greater than 30,000.

Table 2.14. Socioeconomic conditions of Pender and Onslow counties, North Carolina

Category	Pender County	Onslow County	Surf City	North Topsail Beach
Population year-round (2007 estimate)	50,430	169,302	1,766	898
Population year-round (2000 census)	41,082	150,355	1,393	843
Population peak season (Estimated)			15,438	15,000–20,000
Households				
Ave. household size	2.49	2.72	2.02	1.87
Housing units	20,798	55,726	2,578	2,085
Occupied year-round	16,054	48,122	689	451
Seasonal or vacant	4,744	7,604	1,889	1,634
Employment				
In labor force	19,087	85,054	754	545
Civilian	18,972	52,670		
Unemployed	1,076	3,650		
Armed Forces	115	32,384		
Employment by leading industry				
Construction	2,468	5,022		
Manufacturing	2,632	2,682		
Retail trade	2,367	7,496		
Education, health & social services	2,704	10,865		
Per capita and household income				
Per capita money income	$17,882	$14,853	$25,242	$33,972
Median household income 1999	$35,902	$33,756	$40,521	$45,982

Source: U.S. Census Bureau (http://factfinder.census.gov) and U.S. Department of Commerce, Bureau of Economic Analysis (http://bea.doc.gov/bea)

Office of State Budget and Management (2007 population estimates)

The population of Pender County grew from 28,855 in 1990 to 41,082 in 2000, an increase of 42 percent. Onslow County population was virtually unchanged during the same period. North Carolina grew by 21 percent during that same period. Figure 2.1 shows both historical population from 1920 to 2000 and population projections by the North Carolina State Demographer for Pender and Onslow counties through 2029. Personal per capita income for Pender and Onslow counties was reported to be $27,720 and $25,317, respectively. Personal per capita income for North Carolina was $20,307.

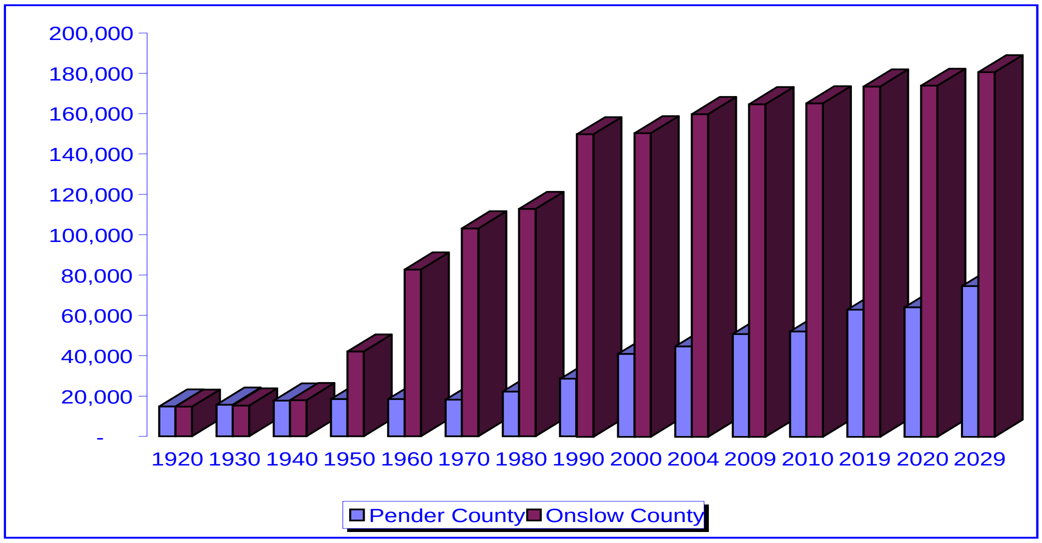


Figure 2.1, Population history and projections.

2.04.2 Aesthetic and Recreational Resources

The towns of Surf City and North Topsail Beach are urbanized beach communities characterized by paved streets, bridges, parking lots, hotels, single-family dwellings, hotels, and low-rise condominiums. Land use is primarily recreational and residential with few commercial properties. A scenic setting is provided by waters of the Atlantic Ocean, New River Inlet, the AIWW and Stump Sound, and the numerous vessels common to those waters. The marine environment provides opportunities for boating and fishing, as well as an escape from the faster pace of land-based activities. Beaches generally offer extensive recreational opportunities for activities such as swimming, sunbathing, walking, surfing, bird watching, and fishing. In addition, two ocean fishing piers are in the study area (one in the project area) and are considered important recreational facilities at Topsail Island. Although Surf City and North Topsail Beach have lost some of their visual appeal because of severe erosion caused by the hurricanes of 1996–1999 and 2003, the enduring aesthetic value of the beach community is evidenced by the popularity of the area for family oriented use and tourism. During the summer months, many of the homes in the study area are available as summer rentals to vacationers primarily from inland North Carolina and other locations around the eastern United States. Table B-2 (Appendix B), shows that the number of housing units at Surf City and North Topsail Beach is 2,578 and 2,085, respectively. Of those units, 689 at Surf City and 451 at North Topsail Beach are occupied year-round. The remaining units are designated as seasonal or vacant. The estimated peak seasonal populations for Surf City and North Topsail Beach are 15,438 and 15,000–20,000, respectively. In the off-season, the populations drop to about 1,400 residents at Surf City and 840 residents at North Topsail Beach.

2.04.3 Commercial and Recreational Fishing

According to the North Carolina commercial fish landings report produced annually by the NCDMF, the commercial finfish harvest was up 17 percent from 2008 to 2009.

However, the commercial shellfish harvest was down 7.3 million pounds in 2009 mostly because of a 43 percent decrease in shrimp harvest from 2009. Total commercial landings in 2009 were 68.6 million pounds, which is about 2.5 million pounds lower than in 2008 (NCDMF, 2009). NCDMF reported approximately 136,000 pounds of commercial reported approximately 136,000 pounds of commercial finfish and shellfish landings in the vicinity of Stump Sound in 2006 and nearly 162,000 pounds in 2007 (NCDMF, 2008a,b). The top five species included blue crabs (hard), oysters, white shrimp, southern flounder and clams (hard). Total commercial seafood landings by county for 2006 and 2007 were as follows: —Pender: 635,549 pounds in 2006, valued at $754,742 and 695,051 pounds in 2007, valued at $1,083,330; Onslow: 2,549,223 pounds in 2006 valued at $5,060,902 and 2,550,206 pounds in 2007, valued at $5,542,501 (NCDMF, 2008a,b). Areas in the vicinity of the study area that are closed to shellfishing are shown in Appendix A, Figure A-4.

Recreational fishing includes fishing from head boats, charter boats, private boats, piers, and the surf. Fishing from head boats is best in the winter months for snapper and grouper. Fishing from charter boats is excellent for king mackerel and bottomfish during the winter. Offshore, gulfstream species, like yellowfin tuna and wahoo are available. Inside fishing has been successful for inshore species such as red drum, speckled trout, and flounder.

Private boat anglers can find bluefin tuna in the nearshore area, king mackerel, and other bottomfish species in the offshore, and other species such as speckled trout, red drum, and flounder can be found in the inside areas of the creeks and AIWW.

2.05 Cultural Resources

Recent archaeological findings in the mid-Atlantic and southeastern regions demonstrate that coastal areas were being exploited soon after human occupations began in North America. The most complete regional evidence of these early Americans comes from the Cactus Hill site, on the coastal plain of the Nottaway River in Sussex County, Virginia. The site has abundant evidence of a Clovis occupation, which is so named after the distinctive fluted Clovis projectile point. This point is a marker for this nationally widespread horizon. The Clovis occupation at Cactus Hill is firmly dated and supports other dates from throughout North America, which place Clovis occupations around 13,000 B.P. (McAvoy 1997). Research at this and other sites throughout the mid-Atlantic and southeastern coasts of Virginia and North and South Carolina demonstrate that Paleoindian occupation of the coastal plain was widespread during those times of much lower sea level and cooler climate.

Glaciation during the late Pleistocene (circa 18,000 to 14,000 B.P.) may have lowered sea level south of Cape Hatteras, North Carolina, 60 or more meters below present level, exposing the entire continental shelf for settlement and exploitation (Boss and Hoffman 2001; Science Applications, Inc. 1981). Some exposed areas, however, lacked stabled land surfaces and mature estuaries because of downcutting and other fluvial dynamics associated with lower stream base level (Sassaman 1996). Some research, particularly at

Cactus Hill, suggests a pre-Clovis occupation going back to 18,000 B.P. Both archaeological and geological research suggest that the Paleoindians and the megafauna they hunted disappeared or became very scant in the archaeological record around 12,900 B.P., presumably as a result of a catastrophic event (Goodyear 2006).

Warming trends produced a major rise in sea level from water released from melting glaciers after 14,000 B.P. (Faught 2004). The rise in sea level was interrupted during the Younger Dryas (circa 11.000 to 10,000 B.P.) as the climate returned to near glacial conditions. Sea levels were within a few meters of present levels by 9,000 B.P. and reached present sea level circa 2,000 to 5,000 B.P. (Anderson et al. 1996; Haynes 2002; Lewis 2000).

After the demise of post-Pleistocene mega-fauna, Native Americans adapted with a new lifestyle and associated tool kit. Those people, referred to by archaeologists as Archaic, focused on plant gathering and the hunting of modern game animals. Their tool kit remained limited but elegant, including a variety of projectile points, ground stone tools, and basketry. Archaic populations appear in the archaeological record around 10,000 years ago and persist until the advent of agriculture around 3,000 years ago. Social organization probably still centered on extended families and bands, with possible larger seasonal gatherings; however, Russo (1996) proposes, on the basis of analyses at a number of mid-Holocene coastal deposits, estuarine environments at that time were capable of supporting year-round occupation. The Archaic period was an extremely important foundation on which later, more complex societies would grow. The early Woodland period, in particular, probably inhabited the same riverside locations and followed much the same lifestyle as their Archaic predecessors. However, regional subsistence specialization and incipient agriculture allowed for the development of a more settled lifestyle, support of larger permanent populations, and the establishment of defended territories.

While many scattered coastal Archaic and Early Woodland period sites and artifact finds exist, the most significant occupations tend to occur during Middle- and Late-Woodland periods (Ward and Davis 1999). Those are times of increasing reliance of agriculture, more settled village life, the development of pottery, and especially sophisticated political organization. Through time, many regional cultures appear along the coast with several cultural and language affiliations with groups to the north, west, and south (Phelps 1983; Ward and Davis 1999). Seasonal exploitation of sound-side resources is now full blown, and some villages persisted long enough to establish large settlement, complete with ossuary pits (mass burials). The Colington phase of the Woodland Period is equated with the Carolina Algonkian culture, who greeted the first English explorers (Phelps 1983).

To date, few indications exist that Native American populations made significant use of oceanside resources. Littoral zones, especially intertidal areas, appear to have been more important extractive locales than ocean-facing beaches (Phelps 1981; Science Applications, Inc. 1981). Inner and outer coast populations of North Carolina during the Middle Woodland period shared similar settlement and foraging strategies, with fish, shellfish, deer, rabbit, and raccoon being important food resources (Hargrove 1983; Hutchinson 2002). Indeed, the intensive use of the sounds may indicate that resources there were so plentiful that an interest in exploiting the open-ocean never developed.

The proposed borrow areas are 1 to 5.5 miles offshore of the towns of Topsail Beach, Surf City and North Topsail Beach and stretch from the New Topsail Inlet to the New River Inlet. The area has seen significant maritime activity since at least the early eighteenth century when permanent settlement began. One of the earliest land grants included the inlet and area surrounding the sound, and by 1755 New Topsail Sound was designated as an official inspection point for export commodities in New Hanover County, along with counties Brunswick, Wilmington, and New Exeter (Angley 1984). Inspections were conducted for export commodities of fish, flour, butter, flax seed, beef, pork, rice, tar, pitch and turpentine, staves and headings, sawed lumber and shingles.

Throughout the Colonial Period, the inlet was relatively stable and was suitable for passage by schooners and small sloops. During the latter part of the eighteenth century and throughout most of the nineteenth century, New Topsail Inlet migrated significantly to the north. According to Wilson Anglely's (1984) analysis, the Mouzon Map of 1775 and the Price-Strother Map of 1808, the inlet migrated northward some 2 miles. While the Mac Rae-Brazier Map of 1833 indicates no significant change, the U.S. Coast Survey Map of 1865 shows that an additional migration of 2 miles occurred during that period. The migration appears to have abated during the end of that century, as is suggested by review of the Kerr-Cain Map of 1882 and the Post Route Map of 1896. A detailed U.S. Coast Survey Map of 1885 indicates that the New Topsail Inlet was approximately 3,000 ft. wide at that time.

Five miles northeast of North Topsail Beach lies New River, another important waterway in coastal North Carolina history. In 1705 three Englishmen established a settlement at Town Point, the first in Onslow County. Within 20 years, the population had grown to approximately 35 families with English, German, and French Huguenot ancestry. The Moseley map of 1733 indicates that settlement spread along the coast and up the rivers and streams, a pattern typical of the southern colonies. A county seat was platted at Mittam's Point on New River in 1742. The town, called Johnston, was struck by a hurricane in 1752 that devastated much of the coastal southeast. In response to the destruction of the storm, the county seat was moved inland. Land was acquired from James Wantland, who operated a ferry and tavern at the site where the Boston–Charleston Post Road crossed the New River. That road was the precursor to U.S. Highway 17, following nearly the same route as the present-day road. In 1775 a bill officially established a town at the ferry to be known as Onslow Courthouse, but in 1842 the name of the town was changed to Jacksonville in honor of Andrew Jackson.

Production of turpentine and naval stores (tar and pitch) represented the primary occupation of small and large landholders in Onslow County. Substantial acres were planted in corn, with smaller investments in wheat, flax, and rice. In 1860 several military companies were formed. Hostilities were concentrated along the lower New River and Bear Inlet. Union raids, intended to quash blockade running and to demolish the coastal saltworks, occurred from 1862 to 1864. As was the case elsewhere in the South, the Civil War resulted in poverty, economic stagnation, and strained relations in Onslow County. Share-cropping and tenancy replaced plantation agriculture. In response to the gradual decline of the naval stores industry in southeastern North Carolina, local people turned to crop and livestock farming, mostly on relatively small-scale farms. Cotton began to emerge as a prominent market crop in the first postbellum decade, followed by tobacco in the 1890s, though neither became a dominant factor in the county's economy.

Eleven vessels are reported or believed to have been lost in the area of Topsail Inlet (Table 2.15) and an additional 19 recorded in the vicinity of New River Inlet. That number includes one of four vessels lost in 1750 as part of the Spanish Plate Fleet. That ship, the packet boat, *El Salvador*, was lost in the vicinity of Topsail Inlet on August 18, 1750. Because of the shifting sands, the surviving remains were buried in a matter of days, making salvaging operations difficult.

Table 2.15. North Carolina Division of Archives and History, Underwater Archaeology Section shipwreck files

1737	UNK, wrecked at mouth of New River with 10 lives lost
1750	EL SALVADOR, wrecked at Topsail Inlet
1765	UNK, sloop lost in vicinity of New River
1769	UNK, brigantine lost below Topsail Inlet
1771	BETSY, merchant ship lost at Old Topsail Inlet
1799	SALLY, schooner lost east of New River Inlet bar channel
1815	UNK, vessel and cargo and crew (?) lost at mouth of New River
1837	SEAMAN, lost in or near New River Inlet
1838	PULASKI, wrecked off-shore of New River with 141 lives lost
1841	SUPERIOR, schooner driven ashore near Topsail Inlet
1858	ALBION, lost inside New River Inlet bar
1862	ADELAIDE, schooner wreck at mouth of New Topsail Inlet
1863	ALEXANDER COOPER, schooner wrecked at New Topsail
1863	INDUSTRY, schooner lost 5 miles north of Topsail Inlet
1863	PHANTOM, steamer sunk 200 yards off Topsail Inlet in 30 ft. of water
1863	UNK, schooner lost west of Stump Inlet
1864	NUTFIELD, blockade runner, run ashore at New River Inlet
1867	ELLIS, federal gun boat lost 5 miles above New River Inlet, possibly salvaged
1871	HERTFORD, steamer aground inside New River Inlet bar, may have gotten off
1879	MARION GAGE, schooner lost in New River, total loss
1880	UNK, lost at mouth of New River
1881	N.W. DREW, schooner disabled and ashore 3 miles south of New River Inlet
1881	UNK, shipwreck at mouth of New River
1881	MARY BEAR, schooner wrecked 4 miles south of New River Inlet
1884	UNK, shipwreck at mouth of New River
1890	CHARLES, schooner aground on New River inlet bar, total loss
1892	LORENZO, schooner wrecked in New River Inlet, total loss
1894	UNK, lost in New River Inlet
1895	UNK, sharpie sunk at its mooring near Jacksonville
1919	WILLIAM H. SUMNER

Before the Civil War, the following vessels were lost in the vicinity: schooner *Superior*, driven ashore November 24, 1841; an unknown brig in September 1769, run ashore below Topsail Inlet; and English merchantman *Betsy* in 1771 at Old Topsail Inlet. The Civil War also resulted in a number of wrecks, including the schooner *Adelaide* of Halifax, an unidentified schooner west of Stump Inlet, the iron-hulled steamer *Phantom*, and the schooner *Industry*. During the late-nineteenth and early-twentieth centuries the following losses are recorded: the schooner *Mary Bear* on September 9, 1881, at New Topsail Inlet; and schooner *William H. Sumner* on September 7, 1919, grounded at Topsail Inlet.

As indicated by the vessels seized, the inlet was active in salt production. An 1864 military map shows at least two Confederate salt works on either side of Holmes Landing. The presence of the salt works is further substantiated in a letter from

November 1, 1862, written by USS Lieutenant William Cushing to his superior (Angley 1984).

In 1932 a 12-ft.-deep and 90-ft.-wide segment of the AIWW between Beaufort and the Cape Fear south of Wilmington was completed (USACE 1961). The channel allowed for an increase in vessel traffic from 33,710 tons in 1932 to 243,000 tons in 1939. As reported the previous year, the character of the vessel traffic—of around 9,000 vessel trips—consisted of approximately 8,500 motor vessels, 300 tugs, 200 barges, and a smattering of pleasure craft. Cargo vessels transported agricultural commodities, lumber, petroleum products, seafood, fertilizer, and general merchandise.

2.06 Water Resources

This section describes water resources, including the availability and quality of both freshwater and saltwater.

2.06.1 Hydrology

Tides in the area are semidiurnal, and the mean tidal range is about 3.0 ft. at New River Inlet and at New Topsail Inlet. Regular reversals of flow occur with each tidal cycle except during periods of high freshwater flow. The salinity of the area varies because of many factors including freshwater inflow, tidal action, and wind. From 2002 to 2004, average salinities in the Topsail Island vicinity range from an average of 14.2 ppt near New River Inlet, to 23.9 ppt in the AIWW behind Topsail Island, to 35.9 ppt in the nearshore ocean at the Surf City Pier (Stan Sherman, personal communication).

2.06.2 Water Quality Classification

All surface waters in North Carolina are assigned a primary classification by the North Carolina Division of Water Quality (NCDWQ) (15A NC Administrative Code 02B .0301 to .0317). Waters in the vicinity of Topsail Island fall into three classifications. Waters of the Atlantic Ocean between Drum Inlet and Baldhead Island are classified as *SB* and are suitable for primary recreation, including frequent or organized swimming and all *SC* uses (secondary recreation such as fishing, boating, and other activities involving minimal skin contact; aquatic life propagation and survival; and wildlife). Stormwater controls are required under the Coastal Area Management Act (CAMA), and there are no categorical restrictions on discharges.

All other surface waters of the vicinity, including the New River, AIWW, Topsail Sound, and Banks Channel, meet the *SA HQW* classification and are suitable for shellfishing for marketing purposes as well as all *SB* and *SC* uses (see Appendix A, Figure A-5). All *SA* waters are *HQW* (High Quality Waters) by definition, and stormwater controls are required, and domestic discharges are prohibited. Waters of the AIWW from Daybeacon # 17 (between Chadwick Bay and Alligator Bay) to Morris Landing (south of Spicer Bay) and waters of Topsail Sound southward from approximately New Topsail Inlet to Middle Sound are classified as *SA ORW*. The ORW (Outstanding Resource Waters) designation is a supplemental classification intended to protect unique and special waters having excellent water quality and an exceptional state or national ecological or recreational significance. Waters of that classification must have one of the following outstanding resource values:

- Outstanding fish habitat or fisheries
- Unusually high level of water-based recreation
- Some special designation such as North Carolina or National Wild/Scenic/Natural/Recreational River, National Wildlife Refuge
- Important component of state or national park or forest
- Special ecological or scientific significance (rare or endangered species habitat, research, or educational areas)

No new or expanded wastewater discharges are allowed in these waters. ORW are HQW by definition.

2.06.3 Groundwater

The sole source of water supply for both public and private systems in Pender and Onslow counties is groundwater. A vast aquifer system from which potable water can be drawn lies below the counties. The cretaceous aquifer is used as the water source for the various communities on Topsail Island. Pender County does not have a countywide water system, and the system is concentrated in the southern part of the county in the Rocky Point area (Pender County, 2006). In Surf City, water is supplied through two wells on the mainland. A third well has been constructed but is not fully operational yet (Town of Surf City, 2005). Water is supplied to North Topsail Beach by the Onslow County water system and is initiated at the Sneads Ferry elevated storage tank near the intersection of Highway 210 and Highway 172. A 12-inch water main carries the water from the tank to the intersection of Highway 210 and SR 1568 where it intercepts a water main that extends into the Town of North Topsail Beach where it is further distributed (Holland Consulting Planners, Inc, 1996).

Regionally, the horizontal groundwater movement is eastward with some southeast movement. The resultant groundwater movement is toward the coast.

2.07 Other Significant Resources (P.L. 91-611, Section 122)

Section 122 of P.L. 91-611 identifies other significant resources that must be considered during project development. Such resources and their occurrence in the study area are described in the following subsections.

2.07.1 Air, Noise, and Water Pollution

Areas of the country where air pollution levels persistently exceed the national ambient air quality standards may be designated *nonattainment*. All Topsail Island is in an attainment area. No known air quality problems are in the study area.

Noise is a prominent feature in the study area because of the sound of the breakers and at times, tourists and traffic on the beach. The sounds of breakers are tranquil and add to the pleasure experienced by visitors. Complaints of municipal residents concerning noise in the downtown area of Surf City are normal. However, the town does not experience a problem to the extent that maximum densities for residential dwellings have been established nor have noise level reduction standards (outdoor to indoor or indoor to outdoor) been established. No large manufacturing, industrial, or mining-type operations are in town. No airports or other area establishments or entities are affecting unbearable noise levels on the community (Town of Surf City, 2005). North Topsail Beach has a Noise Ordinance Code (Article VII) that is enforced 24 hours a day (Town of North Topsail Beach, 1998).

Any harbor or open-water coastal environment has a number of underwater ambient noise sources such as commercial and recreational vessel traffic, dredges, wharf/dock construction (e.g., pile driving), natural sounds (e.g., storms, biological), and so on. To better assess potential species effects (i.e., disturbance of communication among marine mammals) associated with dredge specific noise from navigation maintenance, deepening, or borrow area dredging operations, Clarke et al. (2002) performed underwater field investigations to characterize sounds emitted by bucket, hydraulic cutterhead, and hopper dredge operations. A summary of results from the study are presented below and are a first step toward developing a dredge sounds database that will encompass a range of dredge plant sizes and operational features:

Cutterhead Suction Dredge

Noise generated by a cutterhead suction dredge is continuous and muted and results from the cutterhead rotating within the bottom sediment and from the pumps used to transport the effluent to the placement area. The majority of the sound generated was from 70 to 1,000 hertz (Hz) and peaked at 100 to 110 decibel (dB) range. Although attenuation calculations were not completed, reported field observations indicate that the cutterhead suction dredge became almost inaudible at about 500 meters (Clarke et al., 2002).

Hopper Dredge

The noise generated from a hopper dredge is similar to a cutterhead suction dredge except there is no rotating cutterhead. The majority of the noise is generated from the dragarm sliding along the bottom, the pumps filling the hopper, and operation of the ship engine/propeller. Similar to the cutterhead suction dredge, most of the produced sound energy fell within the 70- to 1,000-Hz range; however peak pressure levels were at 120 to 140 dB (Clarke et al., 2002).

Bucket Dredge

Bucket dredges are relatively stationary and produce a repetitive sequence of sounds generated by winches, bucket impact with the substrate, bucket closing, and bucket emptying. The noise generated from a mechanical dredge entails lowering the open bucket through the water column, closing the bucket after impact on the bottom, lifting the closed bucket up through the water column, and emptying the bucket into an adjacent barge. On the basis of the data collected for this study, which included dredging of coarse sands and gravel, the maximum noise spike occurs when the bucket hits the bottom (120 dB peak amplitude). A reduction of 30 dB re 1 µPa/m occurred between the 150 m and 5,000 m listening stations with faintly audible sounds at 7 km. All other noises from the operation (i.e., winch motor, spuds) were relatively insignificant (Clarke et al., 2002).

Water quality is discussed in Section 2.06.2 and in the section 404(b)(1) (P.L. 95-217) evaluation that is included as Appendix G of this document.

2.07.2 Man-made and Natural Resources, Aesthetic Values, Community Cohesion, and the Availability of Public Facilities and Services

Only one pier, the Surf City Ocean Pier, is within the proposed beachfill area. The pier complex includes a bait and tackle shop, restaurant facilities with a screened dining area and a game room. The 937-ft.-long ocean pier is open from March through November. Aesthetic values are discussed in Section 2.04.2.

In regard to wastewater disposal, nearly all of Surf City's residential and commercial structures are connected to the town's wastewater collection and treatment system. The wastewater collection and treatment system discharge is pumped to a land-application treatment facility off of North Carolina Highway 50 between Surf City and Holly Ridge. The system includes 30 pump stations. No private wastewater systems are operating in Surf City (Town of Surf City, 2005). North Topsail Beach sewer services are provided by a private utility under state regulatory authority.

Water supply is discussed in Section 2.06.3, Groundwater. No private water supply systems are operating in the planning jurisdiction of Surf City or North Topsail Beach.

Topsail Island—including Topsail Beach, Surf City, and North Topsail Beach—is served by two bridges. Surf City has a system of well-maintained roads, and accident rates in Surf City's jurisdiction are low because of a well-designed traffic system (Town of Surf City, 2005). In the southern end of Surf City, Highway 50 is very vulnerable to ocean erosion and required repair after Hurricane Fran in 1996. That section of road is the only access by land to the entire town of Topsail Beach to the south. Highway 210 from the high-rise bridge south to the Pender County line is the only primary roadway in North Topsail Beach. The most serious transportation issue at North Topsail Beach continues to be the overwash of the road (SR 1568) at Galleon Bay (Holland Consulting Planners, Inc, 1996).

The Surf City Volunteer Emergency Medical Services and Pender Emergency Medical Services provide emergency services to Surf City. Other emergency services at Surf City are provided by the town's Fire and Police departments. Emergency services at North Topsail Beach are provided by the North Topsail Beach Police Department, Fire Department, and Rescue and Emergency Medical Services. Electricity is provided by Jones-Onslow Electric Membership Corporation. Sprint provides telecommunications service in the town limits, and the cable television franchise is operated by Charter Communications.

Details regarding beach access and parking are in Section 3.04 and in Appendix O.

2.07.3 Hazardous, Toxic and Radioactive Wastes (HTRW)

Because of past military activities in the project area, the presence of Hazardous, Toxic and Radiological Wastes (HTRW) warrants discussion. The potential for encountering HTRW in the project area is discussed below as documented in the *Defense*

Environmental Restoration Program For Formerly Used Defense Sites (DERP-FUDS), Ordnance And Explosive Waste, Archives Search Report, Findings For The Former Camp Davis, Holly Ridge, North Carolina, Project Number 104nc001702, May 1994.

In 1941 Camp Davis was established as an Anti-Aircraft Training Center at Holly Ridge, North Carolina. Acquisition of land for Camp Davis took place from 1941 to 1943. Approximately 46,682 acres were acquired by lease from numerous individuals, corporations, and governmental agencies by the War Department for a World War II Army Air Corps training facility. The Training Center was later used as a convalescent hospital and rehabilitation center and became home to various military units. Coast Artillery Anti-Aircraft Regiments were the dominant groups, moving thousands of recruits through basic training and anti-aircraft weaponry. Although the main part of Camp Davis was on the mainland, northwest of Topsail Island, the Coastal Gunnery Range Emplacement Area was on Topsail Island near the Surf City bridge and the Coastal Gunnery Potential Range Impact Area was offshore of Topsail Island (Appendix A, Figure A-1).

The Gunnery Emplacement area was 4.5 miles southeast of the main portion of the former Camp Davis. The site was known as the Sears Landing and occupied a narrow strip of land between the inland waterway and the ocean. As a gun emplacement, the ordnance used on-site would have been fired or returned to the point of issue; therefore, the possibility of ordnance residue is extremely remote. The inspection team did not observe any Ordnance or Explosive Wastes (OEW) in the area, and there are no reports of OEW within the gun emplacement area.

The Coastal Gunnery Range Impact Area, which was offshore of Topsail Island, was viewed by inspectors from the beach (no offshore survey was conducted). The AA coastal gunnery range impact area has potential ordnance contamination because of its use when it was active; however, no evidence of residual OEW contamination has been found or documented since the anti-aircraft gunnery range was closed. No records or documentation were located as to the exact types of ordnance used, although it is presumed that mostly practice rounds were used because gunners fired at a target that was pulled/towed behind an aircraft. Practice round sizes would have varied but are presumed to consist of : 37 mm (1.46 inches), 40 mm (1.57 inches), 3-inch, 90 mm (3.54 inches), 105 mm (4.13 inches), and 155 mm (6.10 inches).

After World War II, Camp Davis was assumed by the Navy for its secret guided missile testing program, code named Operation Bumblebee. Topsail Island was the third of three widespread test sites established along the Atlantic seaboard in the closing years of World War II and the first permanent ground for missile testing. The Topsail Island site, placed in operation in March 1947, incorporated rigid structures that were designed and built for specific uses related to the assembly, firing, monitoring and perfecting of experimental ramjet missiles. The Navy used only a small portion of Camp Davis for testing rocket motor propulsion systems. An arsenal center for assembling and storing rockets was built on the sound-side of the island, and launching pads were constructed on the oceanfront. Concrete observation towers were built throughout the island to monitor the experimental launchings, and many of the military structures remain today. During the 18 months that Operation Bumblebee was active at Topsail Island, an estimated 200 experimental rockets, each measuring 6 inches in diameter and between 3 and 13 ft. in length, were fabricated at the Assembly Building, dispatched to the launch site, and fired along a northeasterly angular deflection of 15 degrees to the shoreline for a maximum clear distance of 40 miles. Despite the initial success of the U.S. Naval Ordnance Testing facility at Topsail Island, its location did not fulfill completely the needs of a permanent base because weather conditions and increased sea traffic interfered with testing, and Navy abandoned the facility and moved its equipment to other sites (http://www.cr.nps.gov/nr/travel/aviation/usn.htm).

Although, more than 200 rocket launchings took place on the island between 1946 and 1948, no OEW was associated with the testing procedures, and all leased land was returned to the original landowners. Most of the former Camp Davis lands are being used for state wildlife game lands (Holly Shelter) and for producing forestry products.

Several databases were reviewed to obtain information pertaining to releases, treatment, storage, and disposal of hazardous substances in the project area. On the basis of that review and the review of the Camp Davis Archives Search Report, referenced above, no documented active or inactive hazardous waste sites are on Topsail Island.

3. PROBLEMS, NEEDS, AND OPPORTUNITIES

The main public concerns identified in the study area are economic losses resulting from (1) damages to structures and their contents due to hurricane and storm activity, and (2) the loss of beachfront land due to progressive shoreline erosion. In addition, periods of severe shoreline recession have adversely affected nesting habitat for endangered and threatened sea turtles. The economic losses and environmental concerns are discussed below.

3.01 Hurricane and Storm Damage

Being between Cape Lookout and Cape Fear, Topsail Island is a frequent target for hurricanes and tropical storms tracking along the mid-Atlantic coast. Table 3.1 is excerpted from hurricane history information on the State Climate Office of North Carolina Web site and shows the frequency and severity of hurricanes and tropical storms directly affecting southeastern North Carolina since 1800. In addition to the direct landfalling storms, many storms that have passed offshore without making landfall have also affected the study area. Local effects on the study area varied depending on the landfall location and strength of the storm. However, hurricanes Bertha and Fran in 1996 and Floyd in 1999 were among the most damaging and costly storms ever to hit North Carolina.

3.02 Beach Erosion

Between 1963 and 2002, erosion rates were relatively low (less than one foot per year) in the southern half of the main study area (reaches 27–43); however, erosion rates in the northern half of the main study area (reaches 44–78) averaged nearly 2 ft. per year. Erosion rates increased significantly to more than 5 ft. per year in portions of the non-study CBRA area (reaches 79–106) but decreased to 2 to 3 ft. per year in reaches 107–108 study segment. Shoreline changes in reaches 114–115 study segment begin to be significantly influenced by inlet processes as erosion precipitously changed to minor accretion and then back to significant erosion within a span of only a few reaches approaching New River Inlet. Major storms in the late 1990s caused significant erosion and decimated the island’s natural dunes, resulting in major property damage.

Table 3.1. Direct landfalling hurricanes and tropical storms in southeastern North Carolina since 1800

Approximate date of landfall	Storm name	Saffir-Simpson intensity at landfall	Approximate location of landfall	Estimated wind speed (knots)	Storm surge (ft.)
9/16/1999	Floyd	2	Topsail Island	95	9–10
8/26/1998	Bonnie	3	Cape Fear	100	6–8
9/6/1996	Fran	3	Cape Fear	100	8–12
7/13/1996	Bertha	2	Topsail Beach	90	5
9/9/1984	Diana	1	Long Beach	80	5–6
9/11/1960	Donna	2	East of Wilmington	95	6–8
8/17/1955	Diane	1	Carolina Beach	75	5–9
10/15/1954	Hazel	4	NC/SC border	125	10–20
7/6/1946		Tropical Storm	Wilmington	60	
8/1/1944		1	Southport	80	
12/2/1925		1	Wilmington/Hatteras	65	
9/22/1920		1	Topsail Beach	65	
9/6/1916		Tropical Storm	Southport	35	
10/31/1899		1	Wrightsville Beach	80	8
9/11/1883		1	Southport	85	
9/9/1881		NA	Wilmington/Wrightsville		
08/18/1879		4	Wilmington/Cape Lookout	120	
9/17/1876		Tropical Storm	NC/SC border	60	
11/10/1875		NA	Long Beach		
9/28/1874		NA	Southport	60	
8/19/1871		NA	Southport		
9/4/1856		NA	Wrightsville Beach		
8/18/1837		NA	Cape Fear		
9/4/1834		NA	NC/SC border		
9/3/1815		NA	Wilmington/New Bern		10

3.03 Beach Recreation

All reaches in the study area are available for typical beach recreation activities—swimming, surfing, wading, walking, sightseeing, picnicking, sunbathing, surf fishing, jogging, and so on. As the state population increases, the number of visitors to North Topsail Beach and Surf City is expected to increase as well. The concern regarding beach recreation is that shore erosion will continue, resulting in a narrowing of the width between the surf, especially at high tide, and the landward limits of recreational use. Such landward limits are the toe of the dune, streets, or existing structures. As the available width decreases, some of those activities are hindered and eventually prevented. For example, the recreation benefits analysis conducted (Appendix O) indicates that a 50-ft. decrease in berm width would decrease average annual recreation value at the two beaches by almost $8 million.

3.04 Public Access

Many public beach access points and parking areas are in the limits of the study area. Surf City has 33 public beach access points in the allowable project limits, and North Topsail has 22. The access sites are shown in Figures 3.1 and 3.2. The access points generally consist of small parking areas and wooden walkways to the beach. Only three areas of the study area do not have access points within one-quarter mile. Those areas are indicated in red on the access site figures. One such area in Surf City near Elizabeth Street in reaches 34 and 35 is 900 ft. long. Two sites are in North Topsail Beach. One site between Sloan and Lincoln streets in reaches 62 and 63 is 900 ft. long. Another site north of 2nd Street in reaches 76 and 77 is 1,000 ft. long. The total length without adequate public access is 2,800 ft. Additional access points would be necessary to meet the requirements for federal cost sharing.

In addition to direct access pathways to the beach, nearby public parking would be necessary to provide public access to the shoreline. A wide variety of public parking spaces are throughout Surf City and North Topsail Beach. They are at the access sites, on nearby street right-of-ways, and at four large parking lots. In 2003 and in 2008 parking space counts were conducted on site visits by the Wilmington District and town officials. All right-of-way areas were considered eligible for parking with the exception of areas that met designated restrictions (e.g., driveways, fire hydrants, intersection, physical barriers). For North Topsail Beach, only the reaches south of the CBRA zone were included in the count. The combined total from the 2008 count was 1,992 spaces, with 785 at Surf City and 1,207 at North Topsail. Those numbers are included in Tables 3.2 and 3.3. The distribution of parking spaces is uneven, with some areas not meeting a minimum of 10 publicly available parking spaces within one-quarter mile. Areas having access, but needing parking, are indicated in yellow in the access site figures. One area in the southern part of Surf City is 7,600 ft. long. Another area in North Topsail Beach is 600 ft. long. The total length of study area with access but without minimum parking requirements is 8,200 ft. A total of 37 additional parking spaces would needed in the southern portion of the project limits in Surf City and a minimum of 20 in North Topsail Beach would be needed to satisfy the 10-space minimum requirements.

Table 3.2. Public access and parking, Surf City, July 2008

Access points	Parking spaces			Access points	Parking spaces		
	Lot	Row	Total		Lot	ROW	Total
2111 N. Shore	8	0	8	Roland/Central	15	8	23
9th St.	0	10	10	Kinston	15	20	35
2001 N. Shore	9	9	18	High Point	8	3	11
5th St.	9	9	18	Raleigh	6	2	8
1719 N. Shore	5	28	33	Durham	9	8	17
Broadway	43	7	50	Charlotte	20	19	39
Pender	6	40	46	Quarterhorse	0	37	37
Lenior	8	32	40	1140 S. Shore	0	33	33
Jones	2	34	36	Windward	0	35	35
Craven	12	42	54	Oceanair Estates	0	39	39
Mecklenburg	0	11	11	Elizabeth St.	0	6	6
Dolphin	17	34	51	Roberts St.	0	1	1
508 N. Shore	15	5	20	Pirates Cove	0	0	0
Wilmington	10	16	26	Abigail Place	0	4	4
New Bern	12	15	27	Bland Shores	0	2	2
Goldsboro	10	12	22	Hispanola	0	6	6
Greensboro	6	13	19				
Total							785

Table 3.3. Public access and parking, North Topsail Beach, July 2008

Access points	Parking spaces			Access points	Parking spaces		
	Lot	row	Total		Lot	Row	Total
Myrtle	32	67	99	14th Ave	0	27	27
2nd Ave	0	39	39	15th Ave	0	34	34
4th Ave	0	32	32	18th Ave	0	41	41
5th Ave	0	19	19	20th Ave	0	13	13
6th Ave	0	23	23	21st Ave	12	51	63
7th Ave	0	15	15	OCBA #4	400	34	434
9th Ave	0	43	43	Chestnut St	12	30	42
10th Ave	0	27	27	Gray St	12	23	35
11th Ave	0	16	16	Green St	6	0	6
12th Ave	0	23	23	Reeves	0	83	83
13th Ave	0	22	22	Sea Shore Dr	6	65	71
Total							1,207

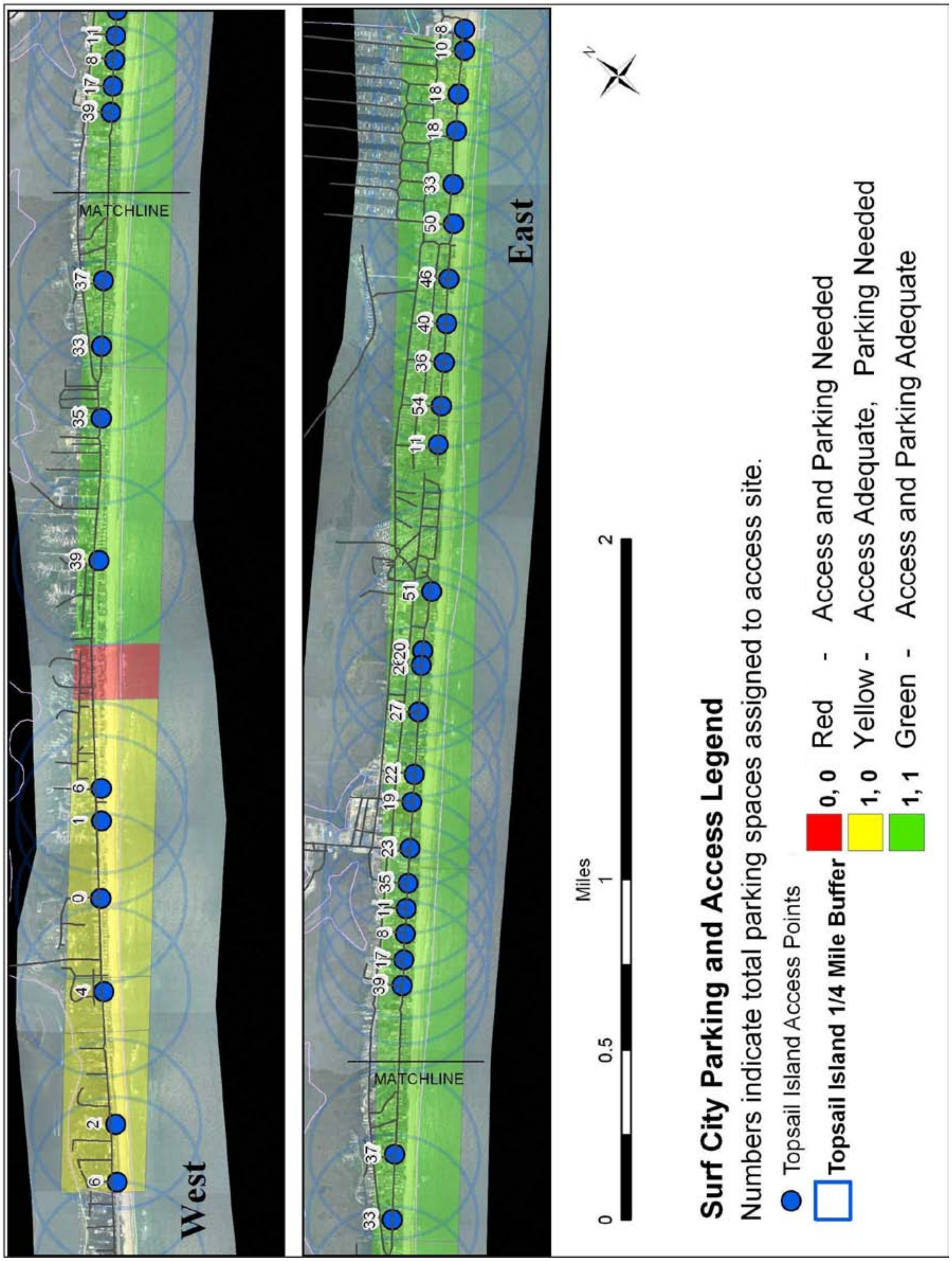


Figure 3.1. Public access and parking, Surf City.

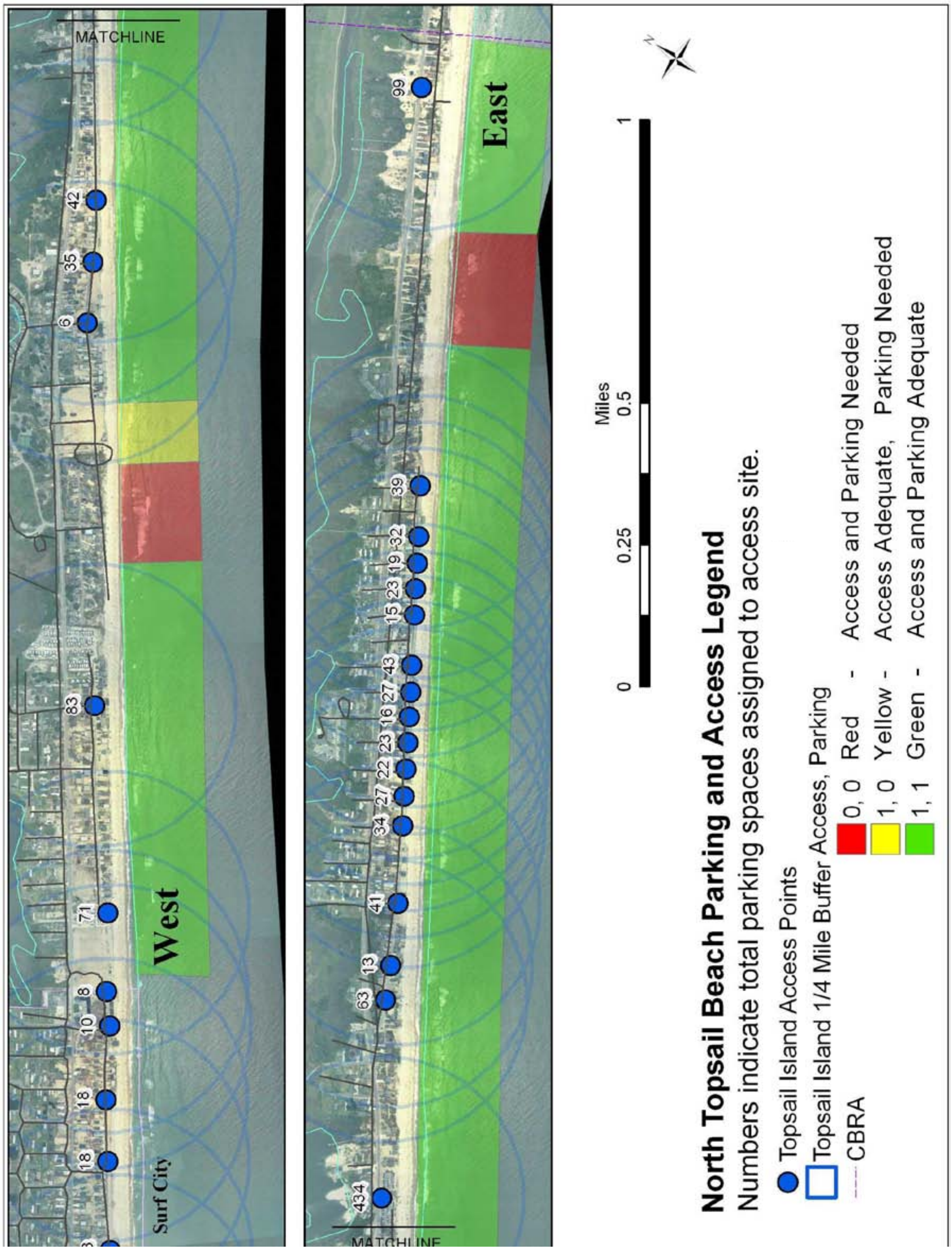


Figure 3.2. Public access and parking, North Topsail Beach.

3.05 Loss of Sea Turtle Nesting Habitat

A shoreface composed of beach, berm, and dune components can provide valuable nesting habitat for sea turtles. The loggerhead and green sea turtles, which are on the federal list of T&E species, have been documented to nest in the study area on Topsail Island. However, long-term shoreline erosion processes coupled with historical short-term hurricane events have led to significant sediment losses from the shoreface. As a result of those existing erosional activities, substantial portions of the berm and dune system have been lost as the shoreline is being squeezed between the ocean and adjacent development. That puts nesting sea turtles at risk because limited, high-quality nesting habitat remains in the eroded areas. Turtle monitoring efforts from 1990 to 2008 show significant declines over the previous year in nesting numbers following hurricanes in the 1990s: 91 to 53 from 1992 to 1993 (Hurricane Emily), 102 to 61 from 1996-97 (hurricanes Bertha and Fran) and 152 to 87 from 1999 to 2000 (Hurricane Floyd). Also, a comparison between the average number of annual turtle nests between 1990–1999 and 2000–2008 indicates a decline from 88 to 65 nests per year. In some cases, nests laid in high-erosion areas where available nesting habitat is lost need to be relocated to avoid tidal inundation (Jean Beasley, personal communication, 2004) (see Appendix I). Without beach renourishment activities, the number of nest relocations would be expected to increase. Persistent erosion along the towns of Surf City and North Topsail Beach could lead to site-specific loss of nesting habitat. Additionally, as short-term erosional processes scour the existing shoreface and the nesting beach environment slowly erodes away, large scarps may form at the toe of the primary dune, thus, preventing a turtle from encountering suitable nesting habitat above the mean high tide line. Reestablishing a berm and dune system with a gradual slope can enhance nesting success of sea turtles by providing suitable nest sites without escarpment obstacles and away from tidal inundation.

3.06 Existing Shore Condition

In March 2002, beach profile surveys were taken along Topsail Island at 1,000-ft. intervals to determine existing conditions of the project shoreline. Of the 56 shoreline profiles in the study area, 16 were selected as representative of the existing condition and used for analysis. The selection of the representative profiles was based on important features such as dune height, berm and nearshore profile. The typical profiles are shown in Figures 3.3 and 3.4 and in Appendix D.

The existing condition includes a fairly substantial constructed dune that was rebuilt following the decimation of the existing dune by Hurricane Fran in 1996. The dune was rebuilt using sand recovered from the landward side of the beach (from roads and drives) that was sifted and used for dune repair. The existing dune varies in height from 15 to 20 ft. along most of the study area; however, the dune has very little crest width, if any, and very steep side slopes. At the time of the surveys, the dry beach width from the base of the dune (at about elevation 7 ft. NGVD) out to the MHW line (at elevation 2.1 ft. NGVD) was rather narrow, generally averaging only about 60 ft. No well-defined berm feature existed either, with the beachface generally sloping directly from the base of the dune seaward. It is believed that the profiles are continuing to show effects from the active storm seasons in the 1990’s.

Over the past 25 to 30 years, material resulting from maintenance dredging of New River, the AIWW, and connecting channels has been placed on the northernmost mile of the study area in the vicinity of New River Inlet. Records from FY1998 through FY2007 show that the total placement of 680,000 cubic yards has occurred on an irregular basis, generally every 1 to 3 years, with dredging quantities varying from 70,000 to 170,000 cubic yards and averaging about 110,000 cubic yards per event.

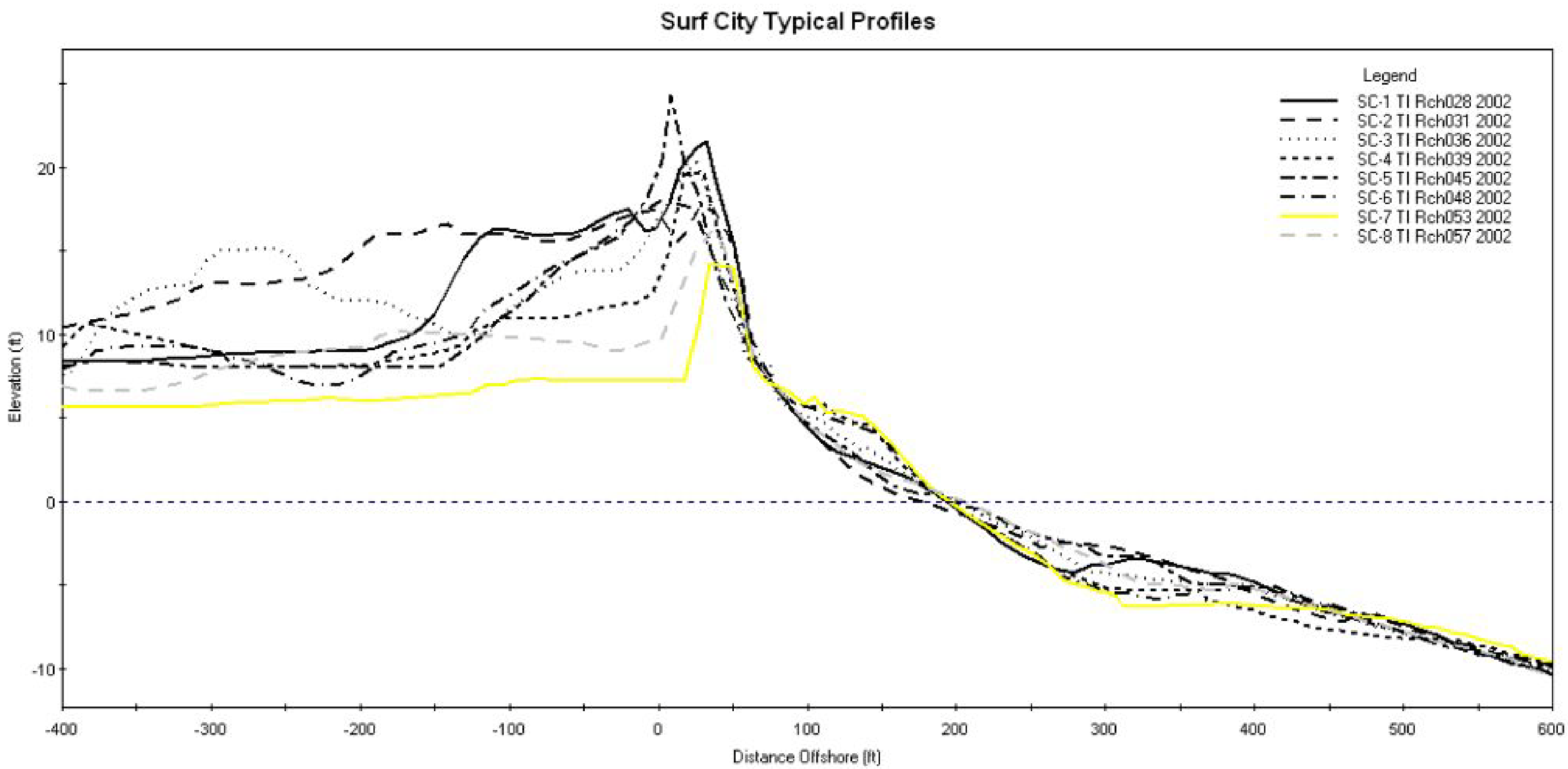


Figure 3.3. Surf City, typical profiles.

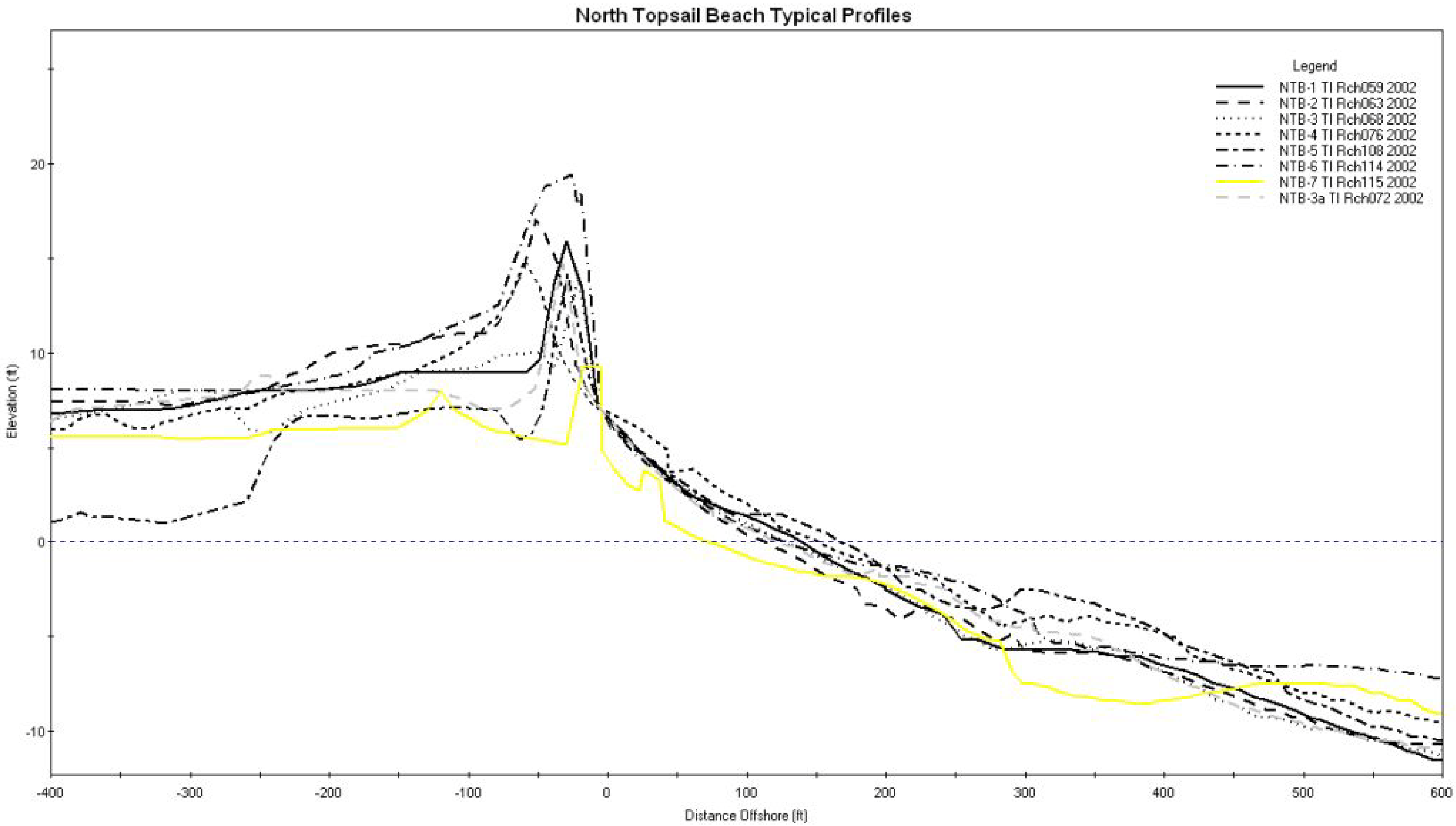


Figure 3.4. North Topsail Beach, typical profiles.

3.07 Without-Project Hydraulic Analysis

The without-project condition was analyzed using the Generalized Risk AND Uncertainty—Coastal (GRANDUC) model to establish the base condition for alternative evaluation. A range of storm responses (e.g., erosion distance, water level, volume lost) was determined for each of the typical existing profiles. The study area was subdivided into reaches of approximately 1,000 ft. each. Reach 27 is located near the Topsail Beach–Surf City town boundary and reach 117 is near New River Inlet. On the basis of 1,000 different 50-year storm simulations, in conjunction with existing long-term erosion rates, average land losses and structure damages for each reach were computed to allow for comparative economic analysis of alternatives. No allowance was made for future placement of maintenance dredging material because of the sporadic and variable nature of such work.

3.08 Without-Project Economic Analysis

The without-project condition displays the implication of storm damage and erosion if a federal project is not constructed in the study area. The base year for the without-project condition is the same year that construction of an authorized federal project would be completed. Construction is estimated to begin in December 2014 with completion 4 years later in March 2018, making the base year 2018.

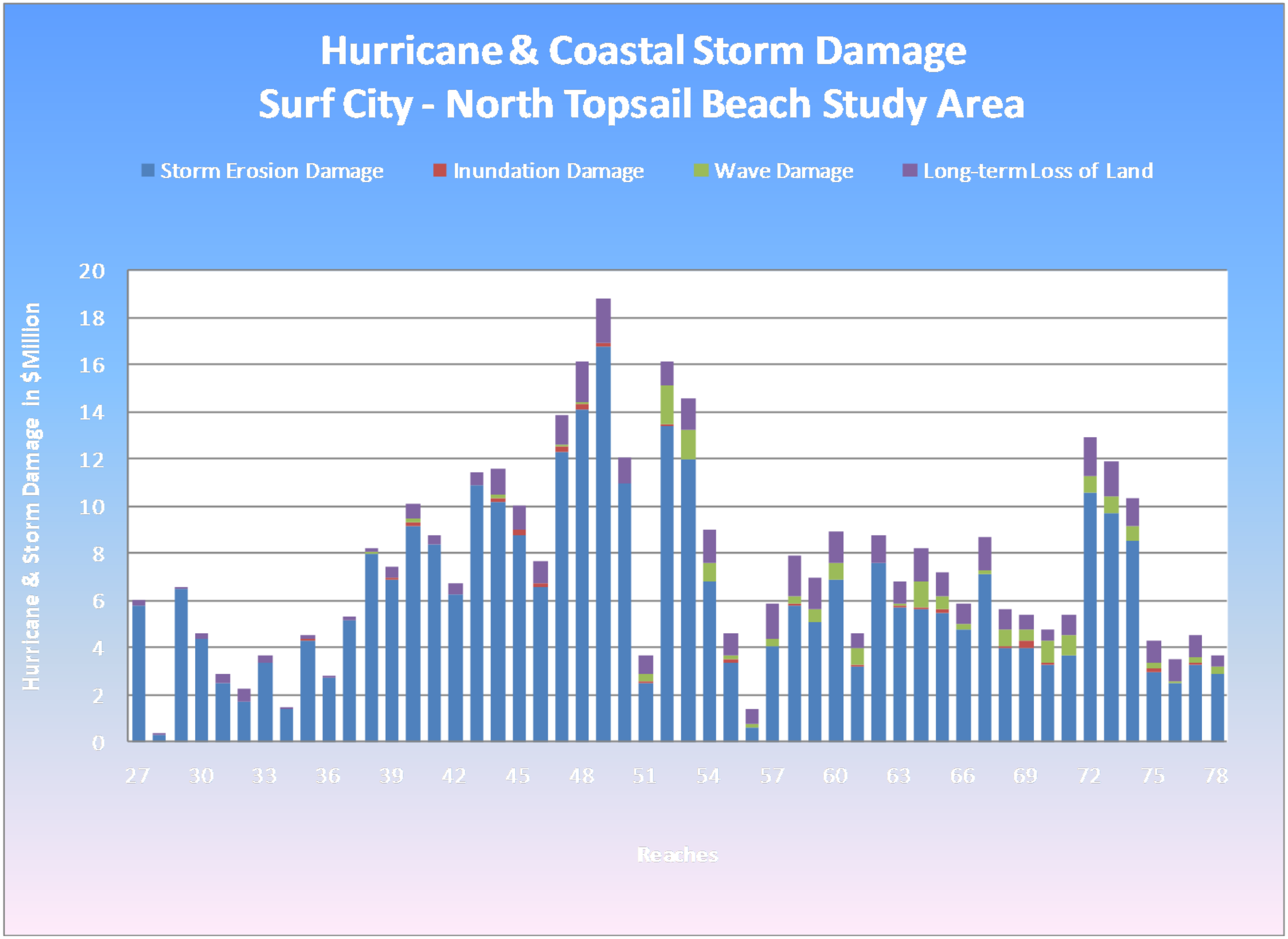
On the basis of historical building patterns, it is assumed that the study area will be fully developed by the base year. Although vacant lots exist, it is assumed that those lots will be built on by the base year, because the infrastructure (electricity, sewer, and such) is already available. Growth has occurred rapidly in the past, especially when the economy has been robust. For instance, in 2004, 174 building permits were issued in the two towns, and in 2006, more than 200 permits were issued. New structures built on vacant lots or replacing existing structures would be required to meet certain building codes for reducing storm damages. A horizontal setback is 60 ft. landward from the established line of stable vegetation. Vertically, the first living floor would be elevated on pilings, above the minimum Federal Flood Insurance elevation. Additionally, pilings for all first row replacement structures would be 16 ft. below grade or 5 ft. below mean sea level. Even with those building codes applied to new structures, the potential for hurricane-wave damage would increase without a project because of the weakened natural dune system in the area. Unlike long-term erosion, which can be predicted to some extent, on the basis of past trends and observed shore processes, damages from hurricane wave attack can occur in any year and can be predicted only as a mathematical probability.

Coastal storm damages in the study area include damages to structures and contents and to transportation infrastructure. Average annual coastal storm damages for the study area were computed using the Corps Wilmington District's computer models. The models integrate coastal engineering data—including storm frequency, storm surge, and long-term erosion rates—with economic data, including the values of structures that could be damaged or destroyed and the value of land that could be lost to erosion. That subject is addressed in greater detail in Appendix D, Coastal Engineering.

When evaluated at an interest rate of 4.125 percent over the 50-year period of analysis, the present worth (October 2010 price levels) of the expected damages totals $442.2 million; equivalent average annual damages are $21.0 million. For the continuous group of reaches 27 through 78, the present worth of the expected damages totals $400.9 million; equivalent average annual damages are $19.1 million. The storm and erosion damages calculated for the without-project condition are presented in Table 3.4 and illustrated in Figure 3.5. The vast majority of damage is categorized as storm erosion, which is the loss of structures from undermining as the supporting ground is eroded away during hurricanes and severe tropical storms. Flood damages are limited because most structures in the study area are now elevated. Wave damages are caused by the impact of waves on the structures. Finally, land damages are losses in the acreage of land.

Table 3.4. Estimated value of damages, without-project conditions, October 2010 price levels, 4.125% interest rate

Reach	Damages					
	Present Value					
	Erosion	Flood	Wave	Land	Total Damage	Annual Total
27	$ 5,952,000	$ 2,000	$ -	$ 220,000	$ 6,174,000	$ 294,000
28	$ 282,000	$ -	$ -	$ 110,000	$ 392,000	$ 19,000
29	$ 6,688,000	$ 2,000	$ -	$ 134,000	$ 6,823,000	$ 324,000
30	$ 4,531,000	$ 6,000	$ -	$ 223,000	$ 4,760,000	$ 226,000
31	$ 2,627,000	$ 1,000	$ -	$ 410,000	$ 3,038,000	$ 144,000
32	$ 1,827,000	$ 28,000	$ -	$ 671,000	$ 2,526,000	$ 120,000
33	$ 3,539,000	$ 25,000	$ -	$ 315,000	$ 3,880,000	$ 184,000
34	$ 1,473,000	$ 32,000	$ -	$ 118,000	$ 1,624,000	$ 77,000
35	$ 4,431,000	$ 58,000	$ -	$ 118,000	$ 4,607,000	$ 219,000
36	$ 2,784,000	$ 28,000	$ 1,000	$ 118,000	$ 2,931,000	$ 139,000
37	$ 5,341,000	$ 22,000	$ -	$ 126,000	$ 5,489,000	$ 261,000
38	$ 8,291,000	$ 27,000	$ 83,000	$ 137,000	$ 8,539,000	$ 406,000
39	$ 7,195,000	$ 74,000	$ 32,000	$ 402,000	$ 7,703,000	$ 366,000
40	$ 9,579,000	$ 64,000	$ 196,000	$ 581,000	$ 10,419,000	$ 495,000
41	$ 8,679,000	$ 18,000	$ 10,000	$ 402,000	$ 9,109,000	$ 433,000
42	$ 6,479,000	$ 7,000	$ 4,000	$ 406,000	$ 6,896,000	$ 328,000
43	$ 11,281,000	$ 16,000	$ 39,000	$ 477,000	$ 11,814,000	$ 562,000
44	$ 10,592,000	$ 112,000	$ 225,000	$ 1,181,000	$ 12,110,000	$ 576,000
45	$ 9,217,000	$ 171,000	$ 1,000	$ 1,065,000	$ 10,454,000	$ 497,000
46	$ 6,893,000	$ 154,000	$ 5,000	$ 1,071,000	$ 8,124,000	$ 386,000
47	$ 12,860,000	$ 179,000	$ 129,000	$ 1,411,000	$ 14,578,000	$ 693,000
48	$ 14,691,000	$ 170,000	$ 78,000	$ 1,785,000	$ 16,724,000	$ 795,000
49	$ 17,408,000	$ 51,000	$ 18,000	$ 1,995,000	$ 19,472,000	$ 926,000
50	$ 11,500,000	$ 41,000	$ -	$ 1,142,000	$ 12,683,000	$ 603,000
51	$ 2,563,000	$ 144,000	$ 260,000	$ 848,000	$ 3,815,000	$ 181,000
52	$ 13,934,000	$ 73,000	$ 1,632,000	$ 1,007,000	$ 16,646,000	$ 792,000
53	$ 12,409,000	$ 38,000	$ 1,250,000	$ 1,461,000	$ 15,157,000	$ 721,000
54	$ 7,088,000	$ 11,000	$ 858,000	$ 1,421,000	$ 9,377,000	$ 446,000
55	$ 3,554,000	$ 65,000	$ 170,000	$ 913,000	$ 4,702,000	$ 224,000
56	$ 669,000	$ 50,000	$ 216,000	$ 626,000	$ 1,561,000	$ 74,000
57	$ 4,216,000	$ 46,000	$ 266,000	$ 1,556,000	$ 6,083,000	$ 289,000
58	$ 6,044,000	$ 54,000	$ 282,000	$ 1,750,000	$ 8,131,000	$ 387,000
59	$ 5,261,000	$ 41,000	$ 542,000	$ 1,511,000	$ 7,355,000	$ 350,000
60	$ 7,129,000	$ 28,000	$ 723,000	$ 1,327,000	$ 9,207,000	$ 438,000
61	$ 3,374,000	$ 70,000	$ 710,000	$ 673,000	$ 4,827,000	$ 230,000
62	$ 7,823,000	$ 13,000	$ 34,000	$ 1,254,000	$ 9,123,000	$ 434,000
63	$ 6,000,000	$ 72,000	$ 131,000	$ 939,000	$ 7,141,000	$ 340,000
64	$ 5,880,000	$ 108,000	$ 1,115,000	$ 1,425,000	$ 8,528,000	$ 406,000
65	$ 5,728,000	$ 97,000	$ 596,000	$ 1,080,000	$ 7,501,000	$ 357,000
66	$ 5,092,000	$ 46,000	$ 241,000	$ 884,000	$ 6,262,000	$ 298,000
67	$ 7,372,000	$ 9,000	$ 218,000	$ 1,482,000	$ 9,082,000	$ 432,000
68	$ 4,133,000	$ 138,000	$ 685,000	$ 854,000	$ 5,811,000	$ 276,000
69	$ 4,181,000	$ 343,000	$ 544,000	$ 645,000	$ 5,714,000	$ 272,000
70	$ 3,384,000	$ 136,000	$ 893,000	$ 565,000	$ 4,978,000	$ 237,000
71	$ 3,826,000	$ 15,000	$ 816,000	$ 914,000	$ 5,570,000	$ 265,000
72	$ 11,061,000	$ 1,000	$ 769,000	$ 1,640,000	$ 13,470,000	$ 641,000
73	$ 10,119,000	$ 1,000	$ 757,000	$ 1,522,000	$ 12,398,000	$ 590,000
74	$ 8,862,000	$ 4,000	$ 705,000	$ 1,141,000	$ 10,712,000	$ 509,000
75	$ 3,145,000	$ 76,000	$ 307,000	$ 987,000	$ 4,514,000	$ 215,000
76	$ 2,626,000	$ 36,000	$ 144,000	$ 962,000	$ 3,767,000	$ 179,000
77	$ 3,418,000	$ 119,000	$ 223,000	$ 922,000	$ 4,682,000	$ 223,000
78	$ 3,031,000	$ 38,000	$ 267,000	$ 531,000	$ 3,867,000	$ 184,000
Subtotal	$ 336,062,000	$ 3,160,000	$ 16,175,000	$ 45,458,000	$ 400,850,000	$ 19,061,000
107	$ 3,743,000	$ 15,000	$ 802,000	$ 900,000	$ 5,460,000	$ 260,000
108	$ 10,867,000	$ 1,000	$ 748,000	$ 1,614,000	$ 13,230,000	$ 629,000
114	$ 9,920,000	$ 1,000	$ 738,000	$ 1,495,000	$ 12,154,000	$ 578,000
115	$ 8,704,000	$ 3,000	$ 686,000	$ 1,125,000	$ 10,518,000	$ 500,000
Total	$ 369,296,000	$ 3,180,000	$ 19,149,000	$ 50,592,000	$ 442,212,000	$ 21,028,000



Note: 106 & 107 combined, 115 & 116 combined

Figure 3.5 Estimated damages by reach, present value.

3.09 Without-Project Environmental Analysis

Only those resources that have the potential to be affected by the No Action Alternative are included in the analysis, below.

Sea Turtles. No nesting attempts of hawksbill, leatherback, and Kemp's ridley sea turtles are documented on Topsail Island. However, in regard to loggerhead and green sea turtles, Topsail Island is considered to be one of the more heavily nested areas along the North Carolina coast. Without implementing the proposed project, continued erosion of the beach would be expected to result in losses of sea turtle nesting habitat and possible poor nest site selection by females. That would put nesting sea turtles at risk because limited, high-quality nesting habitat remains in the eroded areas. Turtle monitoring efforts from 1990 to 2008 show declines over the previous year in nesting numbers following hurricanes in the 1990s: 91 to 53 from 1992 to 1993 (Hurricane Emily), 102 to 61 from 1996-97 (hurricanes Bertha and Fran) and 152 to 87 from 1999 to 2000 (Hurricane Floyd). Also, a comparison between the average number of annual turtle nests between 1990–1999 and 2000–2008 indicates a decline from 88 to 65 nests per year. In some cases, nests laid in high-erosion areas where available nesting habitat is lost must be relocated to avoid tidal inundation (Jean Beasley, personal communication, 2004) (see Appendix I). Without beach renourishment activities, the number of nest relocations would be expected to increase.

Seabeach Amaranth. Since 1992 the Corps has surveyed Topsail Island for seabeach amaranth. From 1992 to 2008, the average number of plants found on Topsail Island during any given year was 1,433. However, the number of plants varies along the project area and by year. In the Surf City and North Topsail Beach project area, the number of plants declined immediately following hurricane events as evidenced by the fluctuating numbers between 1996 and 2001 (Appendix I, Table 4). The maximum number of plants was 11,129 in 1995, and the minimum was 13 in 2006. When separated into incremental averages, it is apparent that the total number of plants from 1992 to 2008 have declined considerably. From 1992 to 1997 the average number of plants was 2,854; from 1998 to 2003 the average number of plants was 1,042; and from 2004 to 2008 the average number was 207. Although hurricane events result in a reduction in plant numbers immediately following the event, long-term beach erosion is probably the primary threat to the continued presence of seabeach amaranth in the area as evidenced by the consistent decline in plant numbers since 2001. Failure to construct the proposed project could result in continued loss of seabeach amaranth habitat. In the event that the beach and dune erode back to the infrastructure, it is possible that no seabeach amaranth habitat would be available in the developed portion of the project area.

Water Resources. Natural sedimentation and turbidity rates would continue to vary depending on storm activity, rainfall, currents, and other natural phenomenon. As the beach and dune erodes back under into the infrastructure, there is a potential for significant amount of debris and associated water pollution (i.e., septic tanks, sewer) from the compromised structures.

Aesthetic and Recreational Resources. Continued erosion of the beach would result in a continually narrowing beach front that is squeezed between the ocean and existing development, thus adversely affecting the recreation experience and aesthetics of the study area on Topsail Island.

Community Cohesion, public facilities and services. Ongoing erosion of the beach and degradation of the dune system by erosion and storms could result in damage to public facilities, such as roads and utilities, and threats to human lives, all of which would adversely affect services and community cohesion. Highway 50 is especially important because it is the only road to Topsail Beach to the south.

Beach and Dune. The Surf City and North Topsail Beach shoreline change rates average between 2–5 ft. per year depending on location in the study area (Appendix D; Figure D-5). Therefore, the beach would continue to erode from the existing condition back into the dune. Once the beach has eroded back into the dune, escarpments would likely occur resulting in wave reflection off the escarpment with subsequent increased erosion, scouring, and loss of intertidal beach habitat. As the beach and dune complex erode back, public infrastructure, public and private property, human lives, and important habitat for a variety of plants and animals would be endangered including loss of the dune grasses and associated fauna. The intertidal beach habitat and benthic invertebrate community is a significant resource for feeding shorebirds and surf zone fishes. Additionally, beach habitat for loafing and nesting shorebirds as well as nesting sea turtles would be degraded or lost as the beach and dune are eroded into the coastal infrastructure.

Floodplains. The floodplain in the study area is being adversely affected by erosion and the continued deterioration of the beach and dune complex. Those effects would become more pronounced as the beach continues to erode and future storms encroach on the area.

4. PLANNING OBJECTIVES

4.01 Goals and Objectives

The overall goal of the study is to reduce the adverse economic effects of coastal storms at Surf City and North Topsail Beach. Identifying and considering the problems, needs, and opportunities of the study area in the context of federal authorities, policies, and guidelines resulted in the establishment of the following specific objective:

Objective: Over a 50-year period of analysis, provide coastal storm damage reduction (as measured by increases in NED benefits) to the shoreline in Surf City and North Topsail Beach, while minimizing or avoiding impacts to natural resources.

Although achieving that objective would likely also have positive environmental effects and benefits to recreation, those benefits are considered incidental to the objective of providing coastal storm damage reduction benefits.

4.02 Constraints

The planning process is subject to the limitations imposed by the following constraints:

a. Geographic limits of the study authority but including the affected area of the environment

b. Applicable federal and state laws

c. Current limits of knowledge, information, and predictive ability

d. The CBRA zone in North Topsail Beach would be excluded from any proposed federal project

5. PLAN FORMULATION AND EVALUATION OF ALTERNATIVES

After identifying existing conditions, problems, needs, opportunities, planning goals, and planning constraints, this section describes the plan formulation process. A number of alternatives are usually identified early in the planning process, and their number is reduced by screening, evaluation, and comparison in an iterative sequence in increasing levels of detail to finally identify the selected plan.

Plan formulation for this study consisted of the following: (1) establishing criteria by which alternatives would be evaluated; (2) identifying, analyzing, and screening of measures; (3) identifying alternative plans; (4) screening of alternative plans; and (5) evaluating alternative plans. Each of those steps is discussed below.

5.01 Formulation and Evaluation Criteria

Alternative plans are evaluated by applying numerous, rigorous criteria. Those include basic, general criteria and four categories of technical criteria, including (1) engineering, (2) economic, (3) environmental, and (4) institutional items. They are as follows:

<u>General Criteria</u>

- The plan must comply with applicable federal laws and regulations.
- The plan must comply with applicable state and local laws and regulations, to the maximum extent practicable.
- The plan must comply with Corps regulations.

<u>Engineering Criteria</u>

- The plan must represent a sound, acceptable, and safe engineering solution.

<u>Economic Criteria</u>

- The plan must contribute benefits to NED.
- Tangible benefits of a plan must exceed economic costs.
- Each separable unit of improvement must provide benefits at least equal to costs.
- Recreation benefits may not be more than 50 percent of the total benefits required for economic justification.
- Plan implementation may not preclude development of more economical means of accomplishing the same purpose.

<u>Environmental Criteria</u>

- The plan would fully comply with all relevant environmental laws, regulations, policies, executive orders.
- The plan would represent an appropriate balance between economic benefits and environmental sustainability.
- The plan would be developed in a manner that is consistent with the Corps' Environmental Operating Principles (EOPs).
- Adverse impacts to the environment would be avoided. In cases where adverse effects cannot be avoided, mitigation must be provided to minimize impacts to at least a level of insignificance.

<u>Institutional Criteria</u>

- The plan must satisfactorily address the identified needs and concerns of the public.
- The plan must be implementable with respect to financial and institutional capabilities.
- The plan must be implementable with regard to public support.

5.02 Identification, Examination, and Screening of Measures

An extremely large variety of potential measures can be considered and combined when formulating plans. The measures generally are categorized as either structural or nonstructural. Structural measures are those that directly affect conditions that cause storm damage and erosion. The nonstructural measures are those taken to reduce damages without directly affecting those conditions. Finally, there is the No Action Alternative where no institutional or structural measure is applied.

A wide variety of structural measures are possible, such as beachfills, breakwaters, seawalls, and groins.

- Beachfill measures consist of berms, dunes, and terminal sections. The beachfill measures are considered some of the most appropriate, because they mimic the natural environment and can be shaped to maximize net storm damage reduction benefits.
- Groins can be a terminal groin near an inlet or can be installed as a repetitive groin field throughout the project length. Groin fields can be used to prolong the life of a beach nourishment project. However, groin fields create the risk of potential adverse effects on adjacent shorelines because of trapping or shunting sand offshore. Groin fields have high initial costs, do not provide storm damage reduction, have the potential to negatively affect turtles seeking beach nesting sites, and would require an extensive monitoring program with triggers that would initiate remediation. Some situations warrant the acceptance of the risk that accompanies the use of a groin field. Those situations include short beachfills, hot spots, areas adjacent to sediment sinks, and offset or convex shorelines. The study area does not include any of the situations that warrant the use of a groin field.
- Seawalls, bulkheads, and revetments are appropriate for reducing structural damage; however, they do not meet the goal of preserving the

environmental value of the beach and would reduce the usable recreation area of the beach at high tide.

- Breakwaters can be used in erosional hotspots where it is difficult to maintain a beachfill; however, no such condition appropriate for breakwaters was found in the project area. Moreover, while offshore breakwaters may reduce erosion in their lee, the benefits may be offset by accelerated erosion of the downdrift shoreline because of interruption of the littoral drift.
- Vegetation and sand fencing help retain windblown sand but do not provide adequate storm damage reduction for moderate to severe storms.

Nonstructural measures considered are changes in regulations and physical modifications to reduce damages.

- *Regulatory measures*. Some regulatory measures are coastal building codes, building construction setbacks, and floodplain regulations. Most regulatory measures are no longer considered in the alternative plans because these measures have already been implemented, they do not affect older structures, and there are few buildable, vacant lots remaining that would benefit. These measures are considered as part of the existing conditions. They have reduced damages from past events, and as older structures are replaced, would help to reduce future damages.
- *Removal*. Another category of nonstructural measures is reduction of the damage threat by removing beachfront structures from the threat. The three removal measures are retreat, relocation, and demolition. Retreat is moving an existing structure away from the shoreline a short distance within the same property parcel. Relocation is moving an existing structure away from the shoreline a longer distance to a vacant property. Acquisition of the property and demolition of the structure is a third measure where retreat or relocation is not feasible. Those three removal measures were retained for consideration in the nonstructural alternative.

The selected structural measure for detailed evaluation and consideration is beachfill. The selected nonstructural measures for detailed evaluation and consideration are retreat, relocation, and demolition. The measures can be applied independently and in combinations with each other to develop alternative plans.

5.03 Identification of Initial Alternative Plans

Beachfill plans were initially developed to extend the entire study area, including the two, separate, short groups of reaches in the non-CBRA area in the north end of North Topsail Beach. The two basic types of beachfills are a berm only and a berm and dune together. For all plans the berm elevation is 7 ft., the locally natural berm elevation for this coast. That selection of 7 ft-NGVD was made because of concerns that the artificially high berm would result in persistent scarping along the beach face.

The ends of typical beachfill plans have tapered transition sections. For Surf City and North Topsail Beach, the ends of the project would abut other beachfill projects planned to the south and north of the study area. Either the transition section would not be needed or would be a smaller transition between the two projects' cross sections. Plan formulation was conducted assuming a full cross section for each reach.

The nonstructural plans consist of retreats, relocations, and demolitions applied to threatened structures on an individual case basis.

The No Action Alternative remains in the list of alternative plans.

5.04 Screening of Alternative Plans

All but one of the initial alternative plans developed using the selected measures were considered to have sufficient potential for feasibility to be continued into economic evaluations of costs and benefits. The No Action Alternative did not undergo further economic evaluation because both costs and benefits of the plan are zero.

5.05 Evaluation of Alternative Plans

The remaining alternative plans were evaluated on the basis of costs, benefits, and net benefits. Benefits of all the plans were evaluated using the GRANDUC program. The program estimates the present worth of storm damages for the without project condition and the various alternative plans, including the nonstructural plan. Sea-level rise is factored into the analysis of both structural and non-structural alternatives, as GRANDUC is able to incorporate sea-level rise into its life cycle analysis. The analysis of alternatives was based on a historical sea level rise rate of 0.008 ft/yr, which is factored into both the future with- and without project conditions

5.05.1 Nonstructural Evaluation

The structures included in the analysis are those in the first row from the ocean. Those structures further landward from the shoreline are not likely to be severely threatened for a few decades and, therefore, are not included in the plan. Of the 1,815 structures in the study area, 904 were considered for the nonstructural alternative. Costs for moving structures are very specific and vary greatly depending on site conditions, travel route, and on structure size and construction. Several broad assumptions were necessary to make a manageable evaluation of the plan. Structures were categorized as one of three general relocation types, plus large, commercial structures such as hotels. Because of the rapid rate of development on Topsail Island, only one-third of the existing vacant lots were assumed available for relocation. Costs for each relocation type of structure were estimated for each of the three measures—retreat, relocation, and demolition. Costs were based solely on construction and acquisition costs for each measure. The costs for each structure were subtotaled by project reach and for the entire project area. More detailed discussion of the nonstructural plan is in Appendix P, Nonstructural Alternatives.

The GRANDUC program was also used to evaluate benefits of the nonstructural plan. The structure database was modified to delete all first row structures, whether actually planned for retreat or for removal. The without-project condition damages were recomputed on the basis of the revised database to estimate residual damages for the nonstructural plan. The difference in residual damages represented the present worth of average annual storm damage reduction benefits. Recreation benefits were not calculated for the nonstructural plan. There could be an increase in recreational benefits from the nonstructural alternative over the No Action Alternative because the nonstructural alternative can lead to an improved beach condition that users might value more (Daniel 2001; Kriesel, et al. 2005; Landry, et al. 2003). However, those benefits would likely be less than those accruing from a beachfill alternative, and recreation benefits from a nonstructural alternative would decrease as the beach continues to erode. The nonstructural plan does not benefit highway 50 where it is threatened by erosion at the south end of Surf City.

The present value economics of the nonstructural plan are given in Table 5.1. The overall net benefits are less than zero with a benefit to cost ratio of 0.26 and is not economically feasible. Combination plans of nonstructural measures in some reaches with beachfill in other reaches were also considered, but no applicable reach was found in the project area. On the basis of the nonstructural analysis that was performed, two reaches were found to have positive net benefits from a nonstructural plan. One of those, reach 44, had average annual net benefits of about $11,000. However, because beach fill is being proposed for reaches on either side, a transitional zone beach fill would still need to be placed through the nonstructural reach. The cost of the transitional zone was not determined; however, it would far exceed $11,000 per year. Therefore, that reach would not end up being economically feasible for a nonstructural plan. Another reach, reach 107 at the northern end of the study area, was found to have positive net average annual benefits of about $44,000 (benefit to cost ratio of 1.1). Beach fill is not being proposed for the adjacent reaches, so the cost of a transitional zone is not an issue. However, because of the coarser nature of the nonstructural analysis (i.e., costs were based on structure type, rather than a detailed assessment of the particular structure) and the benefit to cost ratio being barely over 1.0, it could be very likely that the reach was in fact not economically feasible from a nonstructural standpoint if a more detailed analysis was performed. Additionally, the benefits are assuming a 100 percent compliance rate by property owners. That is very highly unlikely because property owners would more than likely want to keep their beachfront property. Therefore, any combination plans were screened from further consideration. Because the nonstructural plan is not economically feasible, it was not further evaluated for technical feasibility or for acceptability.

Table 5.1. Nonstructural plan economics, present worth, October 2004 levels, 5.375% interest rate

Items	Amount
Cost, Demolition cost and value lost, 615 structures	$96,200,000
Cost, Relocation and retreat, 289 structures	$34,500,000
Cost, Purchase of lots, demolition and relocation, 739 lots	$389,500,000
Cost, Total, Nonstructural Plan	$520,200,000
Benefits, Total, Nonstructural Plan	$135,000,000
Net Benefits, Total, Nonstructural Plan	($385,000,000)

5.05.2 Beachfill Evaluations

As explained previously, the GRANDUC program is used to estimate benefits of alternative plans. To evaluate alternative plan storm damage reduction benefits, a comparison was made of without-project damages with the with-project, residual damages. That difference defines the storm damage reduction benefits. The benefits were determined for each reach and for each alternative. Recreation benefits were not included at this level of plan evaluation.

GRANDUC also estimates present worth costs for the alternative beachfill plans on the basis of initial sand volumes and renourishment sand volumes needed to replenish sand lost because of long-term and storm erosion. GRANDUC applies unit costs for dredging such sand volumes and applies mobilization and demobilization costs for each job. Other estimated costs included are engineering and design costs and contract supervision and administration. Other minor costs for tilling, vegetation, and walkover structures were omitted from the beachfill formulation process because the incremental differences between plans are negligible. Those costs would later be included in the evaluation of the final plans.

A common assumption of all beachfill plans was regarding borrow material. While geotechnical, environmental, and cultural resource surveys of the borrow sites were conducted, beachfill plans were being simultaneously evaluated. It was assumed that sufficient quantity of offshore sand was available for the project within 6 miles and that both initial construction and following renourishments would be performed by hopper dredges. Costs for all beachfill alternatives used the same mobilization costs and unit costs per cubic yard of dredging. A common loss factor between volume dredged and volume placed was used for all beachfill plans.

To assist in incremental analysis of the beachfill plans, costs and benefits of the beachfill plans were estimated for each reach. The process of identifying potentially feasible reaches was called scoping. A mid-range dune and berm cross section was selected as being representative for reach scoping. For the project, the representative cross section selected had a dune with a 25-ft. top width at elevation 13 ft. NGVD fronted by a 50-ft.-wide berm at elevation 7 ft. NGVD.

The results of the scoping showed most reaches had relatively good net benefits, some had very high net benefits, and a few had negative net benefits. The set of continuous reaches, 27–78, in Surf City and the non-CBRA portions of North Topsail Beach were all found to be economically feasible for beachfill. From a coastal morphodynamic perspective (difference in erosion rates, potential for a sediment transport reversal point – discussed in more detail in Appendix D), these reaches could be divided into segments A (reaches 27-44) and B (45-78). However, these erosion rates and their effects on the associated economic features were used in the alternative analysis on the 1,000 ft economic reaches, and consideration for differences in these segments was accounted for in this manner. Therefore, this difference in segments would not affect the scope of the overall plan. The two separate, short groups of reaches, 104–106 and 115–117, in the non-CBRA areas in the north end of North Topsail Beach were not found to be economically feasible for beachfill. Those were the only reaches excluded by the scoping analysis.

5.06 Optimization and Comparison of Beachfill Alternative Plans

Evaluation of plans at this point has narrowed the alternatives to beachfills in reaches 27 through 78. Cost estimates were developed using construction quantities produced from the GRANDUC evaluations. Additional information regarding surveyed profiles and nearshore bathymetry is in Appendix D.

5.06.1 Cross Sections

Plans were designated in the format, Plan DDBB, where DD represents the dune elevation in ft. NGVD datum, and BB represent the berm width from the seaward toe of dune to the top of the foreshore slope. For example, a plan with a 12-ft elevation dune and a 25-ft-wide berm is named Plan 1225. Table 5.2 presents the beachfill plan naming system.

Table 5.2 Beachfill plan names

Dune elevation (ft. NGVD)	Berm widths (ft.)				
	25	50	75	100	150
11	1125	1150	1175	--	--
13	1325	1350	1375	--	--
14	--	1450	--	--	--
15	1525	1550	1575	--	--
16	--	1650	--	--	--
17	--	1750	--	--	--
No dune, berm only	--	750	--	7100	7150

Higher storm dunes and wider berms result in both higher benefits and higher costs. Initially, dune elevations of 11, 13, and 15 ft. were evaluated for berm widths of 25, 50, and 75 ft. That analysis was based on using identical unit construction costs across all plans. Although the initial analysis indicated that 25-ft. plans on average had the highest net benefits (about 2 percent higher on average than 50-ft. plans), it was determined that borrow unit costs for implementing a 25-ft. plan were underestimated by at least 8 percent as compared to 50-ft. and greater width plans. One of the primary reasons for the greater unit cost with a 25-ft. plan is the additional equipment that would be needed to move pipe along the beach as the dredge is pumping, because the narrow berm width does not allow pumping at one location for as long. Therefore, on the basis of that reassessment of unit costs, the 50–ft. berm plans had the highest net benefits. Next, various dune elevations were evaluated with the preferred 50-ft. berm width. Dune elevations between 11 and 17 ft. were all found to be economically feasible. Plan 1550 was found to have the maximum net benefits.

5.06.1.1 Berm-Only Cross Sections

The berm-only plan is a fill extending seaward from the existing profile, with an elevation of 7 ft. NGVD, approximately the elevation of the existing berm along the study area beaches. Berm width is measured seaward along the top of the berm from the point where the top of proposed berm intersects the natural profile. Seaward of the designed berm width, the with-project profile parallels the existing profile out to the closure depth of –23 ft. NGVD. The widths included in preliminary plan screening of berm-only plans were 50, 100, and 150 ft. Berm-only plans with widths less than 50 ft. were not analyzed because they were not considered constructible or maintainable, particularly because no advance maintenance is added to the design berm width. Beach berm construction requires a sufficient width platform to construct the required longitudinal dikes, stage and advance pipeline, shape the pipeline effluent (both before and after dewatering) and minimize loss of material during construction. For 25-ft., berm-only plans, that becomes an issue particularly during the renourishment cycles. Also, because there is no advance maintenance, a 0-ft. hold the line, berm-only alternative is not considered constructible because in many areas, there is minimal existing berm width. In spite of a fairly substantial existing dune, the 50-, 100- and 150-ft. berm-only plans did not provide the level of coastal storm damage risk reduction as did the dune-and-berm plans, resulting in significantly lower total net benefits. Therefore, they did not warrant further consideration.

5.06.1.2 Dune and Berm Combination Cross Sections

Existing dunes were assumed to remain in place, with the designed dunes abutting them. Designed dune templates were tied to a construction line, which is based on both the existing shoreline and the existing development. The construction line is landward of the 7-ft. contour of the existing profile. The landward slope of the dune template is 5 horizontal to 1 vertical, the top of the dune is 25-ft. wide, and the seaward slope is 10 horizontal to 1 vertical. The berm elevation is 7 ft. NGVD, with berm width measured from the toe of the constructed dune. Seaward of the designed berm width, the with-project profile parallels the existing profile out to a closure depth of –23 ft. NGVD. Historical projects in place along the North Carolina coast have dune heights of about 13-ft. above NGVD with a berm width of about 50 ft. Therefore, in addition to the 13-ft dune with a 50-ft. berm, a higher 15-ft. and lower 11-ft. dune, each with a 25-, 50-, and 75-ft. berm at 7 ft-NGVD, were selected for initial screening.

5.06.2 Economic Comparisons

Table 5.3 presents the economic comparisons of the plans as described in Section 5.06.1 and subsections 5.06.1.1 and 5.06.1.2. All values are shown as average annual equivalent value discounted at the FY2005 federal water resources interest rate of 5.375 percent over a 50-year project life. More detailed evaluations of the selected plan are given later at current interest rates and price levels. The GRANDUC model estimates damages in three categories and selects the greatest of the three for both the with-project and without-project conditions, preventing the double counting of benefits in the analysis. Recreation benefits would be included as incidental benefits in the total benefit accounting, but they are not included in Table 5.3 in the formulation of the project with respect to size and scope.

All beachfill plan cross sections have average annual Storm Damage Reduction net benefits of more than $7 million, indicating economic feasibility. Of those plans, the plan with the greatest net benefits is defined as the NED plan. The NED plan is Plan 1550.

No specific modification to the NED plan is proposed. Any recommended plan would include a complete dune and berm section for the entire project length. During Pre-Construction Engineering and Design (PED) phase of the project, the endpoints of the project may be modified to transition to conditions outside of the project limits.

Table 5.3 Dune and berm plans, alternative screening, reaches 27 to 78*

Plan	Annual costs	Annual CSDR benefits	Annual net CSDR benefits
750 (berm only)	$4.3	$11.2	$6.9
7100 (berm only)	$4.8	$12.7	$7.9
7150 (berm only)	$5.0	$13.2	$8.2
1150	$5.7	$13.5	$7.8
1350	$6.1	$15.3	$9.2
1450	$6.5	$15.8	$9.3
1550	$6.7	$16.2	$9.6
1650	$7.0	$16.3	$9.2
1750	$7.3	$16.6	$9.3
1575	$7.3	$16.5	$9.2
Nonstructural	$30.2	$7.8	($22.4)

* Net annual benefits, without recreation, in millions. October 2004 cost levels, FY2005 interest rate 5.375%

5.06.3 Borrow Site Comparisons

The preliminary identification of borrow areas for the project included New River Inlet and ocean waters off Topsail Island in water depths greater than 30 ft. below NGVD. The results of a geophysical investigation conducted by OSI were used to define the boundaries of the offshore borrow areas. The AIWW was ruled out as borrow source because the compatible material obtained from maintenance dredging is already designated for another area, is relatively small, and its distance from the project would not make it a cost-effective source

As identified in Section 2 (b) of the Coastal Barrier Resources Act CBRA, P.L. 97-348 (96 Stat. 1653; 16 U.S.C. 3501 *et seq*.), the purpose of CBRA is to, “minimize the loss of human life, wasteful expenditure of federal revenues, and the damage to fish, wildlife, and other natural resources associated with the coastal barriers along the Atlantic and Gulf coasts by restricting future federal expenditures and financial assistance which have the effect of encouraging development of coastal barriers, by establishing a Coastal Barrier Resources System, and by considering the means and measures by which the long-term conservation of these fish, wildlife, and other natural resources may be achieved.”

The CBRA designates various undeveloped coastal barrier islands, depicted by specific maps, for inclusion in the Coastal Barrier Resources System (CBRS). Areas so designated were made ineligible for direct or indirect federal financial assistance that might support development, including flood insurance, except for emergency life-saving activities. Those areas included in the system are to be reviewed by the Secretary of the Interior, “at least once every five years in order to make minor and technical modifications to the boundaries of system units as are necessary solely to reflect changes that have occurred in the size or location of any system units as a result of natural forces." The last such boundary modification occurred in 1990, and at the time included New River Inlet. New reviews of the CBRS boundaries are underway; however, it is unclear how those boundaries would be adjusted.

In general, no federal funding may be used for physical or planning activities conducted in a CBRS area. However, exceptions for certain activities identified in Section 6 of the CBRA allow federal expenditures or financial assistance within the CBRS. Specifically, "the maintenance of existing channel improvements and related structures, such as jetties, and including the disposal of dredge materials related to such improvements…scientific research, including but not limited to aeronautical, atmospheric, space, geologic, marine, fish and wildlife and other research, development, and applications…[and] nonstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore natural stabilization systems" are exempt from CBRA restrictions. As such, Corps geological studies of the area are authorized, as is maintenance dredging of the existing navigational channel within New Topsail Inlet and New River Inlet. The Department of the Interior, however, reads CBRA to prohibit the transfer of sand from within a CBRS to a location outside the CBRS. Wilmington District does not necessarily agree with that interpretation, and indeed, material from the navigation channels has been used as borrow in other projects. However, the amount of borrow material available from New Topsail Inlet/Banks Channel is relatively small (< 94,000 cubic yards available) compared to what would be needed for a renourishment cycle (2.6 million cubic yards). A study of borrow volume available at New River Inlet was not conducted; however, it is expected that the available amount from maintenance dredging would be less than that in New Topsail Inlet. A qualitative assessment also indicates that it would not be cost-effective to use material from the inlets, on the basis of the distance required to move the material from the channels to the project area. Although a nonfederal project by the town of North Topsail Beach is proposing to use additional material that would be made available from a New River Inlet realignment, it would be inconsistent with the CBRA to use this new material on the federal project. Those factors, in addition to the availability of offshore borrow material, and other environmental factors that include the constituent elements of piping plover habitat and other estuarine resources, led to the screening out of the navigational channels as a potential borrow area for the project.

After completing the archeological resources survey, 10 offshore borrow areas were identified for the further evaluation as potential borrow sources for Surf City and North Topsail Beach. On the basis of the results of the compatibility analysis, the total estimated volume in those 10 borrow areas is insufficient to meet the required project volume over a 50-year project life. As a result, the excess amount of material identified in six offshore borrow areas for the Topsail Beach Federal Coastal Storm Damage Reduction project (USACE, 2009) have been included with the aforementioned 10 borrow areas to meet the project requirements for the Surf City/North Topsail Beach project. The offshore borrow areas were assumed to be the source of material in evaluation of the alternative plans. The borrow areas are discussed in more detail in Section 7.04.

5.06.4 Environmental Comparisons of Plans

In addition to the economic comparison, the effects of the major categories of plans on the resources described in Section 2.00 are considered. Table 5.4 presents the comparative effects on those resources. Only effects on areas that are of greater concern are listed in the table. The No Action Alternative is defined as no action by the federal government on this proposed coastal storm damage reduction project. It should be noted that categories of plans were not screened out on the basis of environmental effects. As mentioned earlier in the report, the No Action Alternative was screened out because it does not provide any NED benefits, and the nonstructural alternative was screened out because the benefit to cost ratio was < 1. However, an environmental comparison of plans was still done to show if categories of plans are consistent with protecting the nation's environment.

Table 5.4. Comparative impacts of the proposed plan to the Nonstructural and No Action alternatives, (part 1 of 5)

Resource Alternative →	Beachfill Alternatives[a]	Nonstructural Alternative	No Action
Socioeconomic Resources	1. Improved recreational quality on expanded beach 2. Greater damage reduction of oceanfront land, roads/utilities, structures, and personal property 3. Economically justified	1. More remote, undisturbed beach 2. Eliminates need for future damage reduction of structures, land loss continues 3. Displaces beachfront homeowners and businesses. Reduced tax base. Expected cost exceeds benefits	1. Continued deterioration of the existing beach 2. Continued threat to oceanfront land, roads/utilities, structures, and personal property 3. NED benefits foregone
Recreational and Aesthetic Resources	1. Improved appearance of beach would enhance recreational experience. Wider berm would increase recreation area. 2. Temporary inconvenience to beach users during initial construction and future maintenance.	1. More natural appearance along the beach that may be valued more by users. Recreation capacity would decrease as the beach erodes. 2. Temporary inconvenience to beach users during demolition or removal of structures.	1. Continued deterioration of beach appearance and berm width 2. Status quo maintained

Table 5.4. (continued) part 2 of 5

Resource Alternative	Beachfill Alternatives[a]	Nonstructural Alternative	No Action
Marine Resources	1. Benthic organisms in borrow areas would be removed but would be recolonized by opportunistic species 2. Temporary effects on intertidal microfauna in the immediate vicinity of the beach nourishment 3. Reduces needs for bulldozing, beach scraping, and sand bags 4. Short-term, recurring impacts to fishing areas 5. Temporary impacts to adult, larval, and juvenile fish because of turbidity and reduced benthic food in dredging and renourishment areas.	1. Status quo maintained 2. Status quo maintained 3. Eliminates needs for bulldozing, beach scraping, and sand bags. Eliminates reoccurring loss of invertebrates along beach. 4. Temporary inconvenience to beach fishermen during demolition or removal of structures. Status quo maintained in nearshore waters. 5. Status quo maintained.	1 to 5 Status quo maintained
Natural Communities	1. The berm would be reestablished, resulting in an extended shoreline. In the case of a dune and berm plan, the dune would also be revegetated. 2. Bottom substrate and bathymetry within 4,210 acres of nearshore ocean would be modified.	1. The beach would continue to erode, existing overwash areas would expand and new overwash areas would form. 2. Status quo maintained	1. The beach would continue to erode, existing overwash areas would expand and new overwash areas would form. 2. Status quo maintained

Table 5.4. (continued) part 3 of 5

Resource Alternative	Beachfill Alternatives[a]	Nonstructural Alternative	No Action
Threatened and Endangered Species	1. Placement of fill would increase nesting habitat for sea turtles. 2. Placement of fill may increase beach hardness and alter other physical characteristics of the beach that may affect the nesting environment of sea turtles. 3. May adversely affect loggerhead, green, and Kemp's Ridley sea turtle species through lethal entrainment within hopper dredge dragheads. 4. May affect piping plover foraging, sheltering, and roosting areas. 5. Placement of fill would increase seabeach amaranth habitat. 6. Minimal threat of collision with whales during dredging operations.	1. Conditions for loggerhead and green sea turtle nesting would be improved by reduced disturbance and artificial lighting 2. Status quo maintained 3. Status quo maintained 4. Conditions for piping plover may be improved by reduced disturbance and new overwash areas. 5. Conditions for seabeach amaranth may be improved by reduced disturbance 6. Status quo maintained	1. Continued erosion of the beach would result in losses of sea turtle nesting habitat and possible poor site selection by females. 2. Status quo maintained 3. Status quo maintained 4. Status quo maintained 5. Continued erosion of beaches would result in loss of seabeach amaranth habitat 6. Status quo maintained
Water Quality	1. Temporary elevated turbidities over existing conditions during initial construction and nourishment in nearshore areas and offshore borrow areas.	1. Status quo maintained	1. Status quo maintained

Table 5.4 . (continued) part 4 of 5

Resource Alternative	Beachfill Alternatives[a]	Nonstructural Alternative	No Action
Cultural Resources	1. No effects	1. Potential resource affected by natural processes or storms. Relocation could affect any historic structures.	1. Potential resource affected by natural processes or storms.
Contaminated Sediments	1. Remote possibility exists that OEW (anti-aircraft ammunition) could be present in the material to be dredged from offshore borrow areas and placed on the beach. The only ordnance that would be expected to be encountered would be spent shells from anti-aircraft target practice. In 1994, inspectors surveyed the beach area to the water's edge and did not find evidence of ordnance. Offshore areas were not surveyed. 2. Remote possibility that dredging in offshore borrow areas could encounter a missile (no OEW) and place it on beach. The missiles that were tested during Operation Bumblebee contained no OEW and were fired approximately 40 miles offshore, well beyond the project area, so the likelihood of encountering them in an offshore borrow area is remote.	1. Status quo maintained 2. Status quo maintained	1. Status quo maintained 2. Status quo maintained

Table 5.4. (continued) part 5 of 5.

Resource Alternative →	Beachfill Alternatives[z]	Nonstructural Alternative	No Action
Other significant resources	1. Temporary noise increases during construction and maintenance events 2. Minor, short-term increases in boat/floating plant traffic 3. Beneficial effects of the storm damage reduction project on community cohesion, public facilities (including roads and utilities) and services.	1. Temporary noise increases during demolition or removal of structures 2. Status quo maintained 3. Initially detrimental to community cohesion, public facilities (near beach) and some services.	1 and 2 Status quo maintained 3. Continued erosion of beaches would be detrimental to community cohesion and public facilities.

[a].This column addresses the effects that are generally relevant to any beachfill alternative. There may be some differences in effects with regard to different beachfill plans (i.e., berm and dune vs. berm-only alternatives, different berm widths); however, those differences are minor and would not affect plan selection.

6. PLAN SELECTION

6.01 National Economic Development Plan

The NED Plan is the alternative among plans with the greatest net economic benefits. The dune and berm plan, named Plan 1550, having the greatest net economic benefits, is the NED plan. Plan 1550 consists of a 52,150-ft-long dune and berm system to be constructed to a height of 15 ft. NGVD fronted by a 7-foot NGVD (50-ft-wide) beach berm.

6.02 Locally Preferred Plan (LPP)

Surf City and North Topsail Beach have indicated that they approve of the NED Plan. There is no Locally Preferred Plan.

6.03 Other Plans

No other plan has been proposed as being the selected plan.

6.04 Selected Plan

The NED Plan, Plan 1550, is the plan recommended for federal action. Average annual storm damage reduction benefits as shown in Table 5.3 are $16.2 million for the NED Plan. Average annual costs of shown in Table 5.3 are $6.7 million for the NED Plan. Annual Net CSDR Benefits for Plan 1550 are $9.6 million. The costs and benefits described in this section and in Table 5.3 were developed during FY2005 and use October 2004 costs and prices and the Federal Water Resources FY2005 interest rate of 5.375 percent. This concludes comparative evaluations of the alternatives. From this point forward in the Feasibility Report, costs and benefits for the NED Plan are reported at October 2010 costs and prices and the FY2011 interest rate of 4.125 percent.

7. THE SELECTED PLAN

The purpose of this report section is to centralize information concerning the Selected Plan. The Selected Plan is discussed in terms of features, construction, maintenance, real estate requirements, accomplishments, and economic feasibility.

7.01 Plan Description and Components

The Selected Plan is Plan 1550, which is the NED Plan. Plan 1550 consists of a 52,150-foot long dune and berm system. Sand for the beachfill would be delivered from offshore borrow areas by dredge. A cross section is shown in Figure 7.1, and a plan view is shown in Figure 7.2, and in more detail in Appendix A, Project Maps.

7.01.1 Main fill

The plan has a main fill length of 52,150 ft., from the Surf City town boundary in reach 27 to reach 78 in North Topsail Beach at the CBRA zone boundary. The two essential features of the selected plan are the dune and the berm.

The plan has a dune at an elevation of 15 ft. NGVD and with a crest width of 25 ft. The side slopes of the dune are 5H:1V on the landward side and 10H:1V on the seaward side to the berm.

The plan includes a berm seaward of the dune. The berm has a flat, level section with an elevation of 7 ft. NGVD and an optimum width of 50 ft. The seaward slope of the berm extends the beachfill approximately another 100 ft. at a slope of approximately 15H:1V down to mean low water elevation (-1.9 ft. NGVD), below which the with-project profile parallels the existing profile out to a closure depth of 23 ft.. A construction berm at elevation 7 ft. NGVD and varying width supplies sufficient volume to allow for the redistribution of material within the active profile while maintaining the optimum NED Plan berm width of 50 ft.

The landward construction line for the project is placed to minimize effects on existing structures, to parallel the existing shoreline, to allow the Perpetual Beach Storm Damage Reduction Easement to extend about 20 ft. landward of the dune toe, and to tie the fill into a minimum elevation of 7 ft. NGVD.

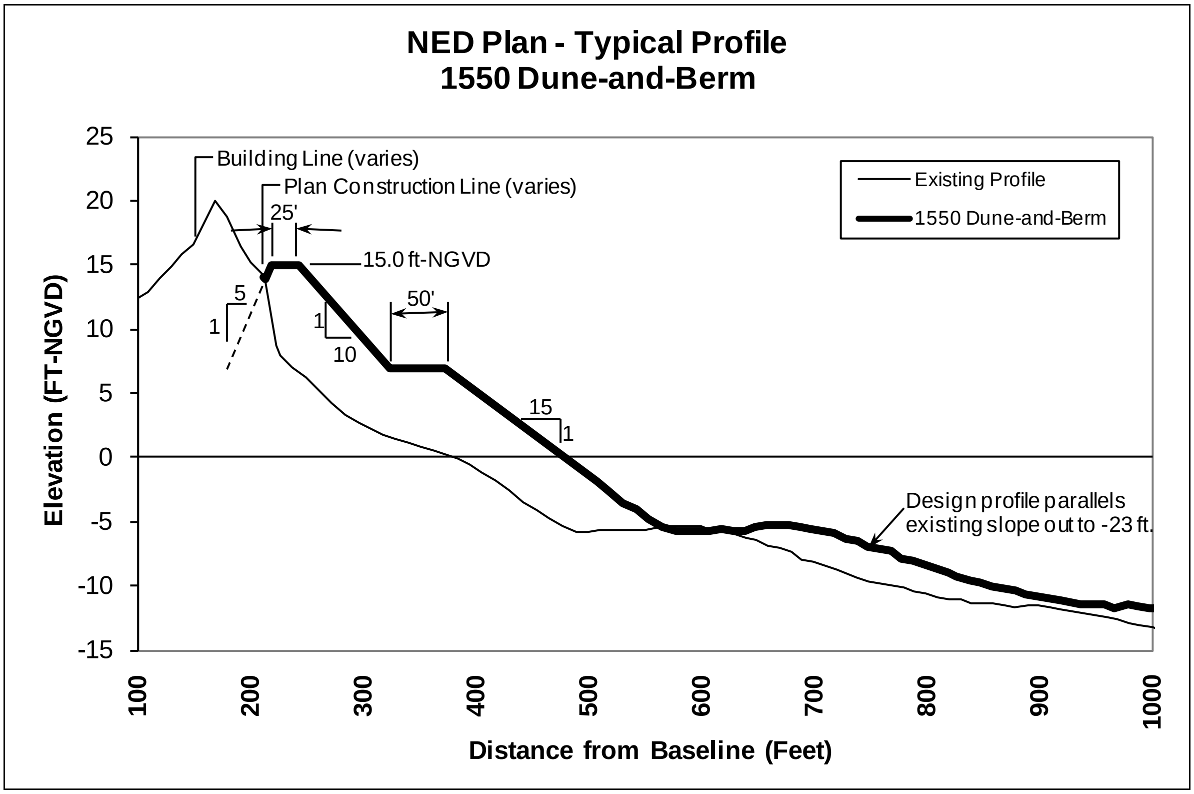


Figure 7.1. Plan 1550, NED Plan, cross section.

7.01.2 Transition Sections

The Selected Plan includes the complete berm and dune cross section for the entire project length. Depending on endpoint conditions found at construction, up to 2,000 ft. of each of the project endpoints may be replaced with transitions sections. The transition sections at both ends of the main fill are necessary to improve project stability and reduce end losses. If no adjacent beachfill project occurs, the plan would include a transition consisting of a tapered berm only, starting with a transition berm width of 200 ft. that uniformly tapers to zero. If an adjacent beachfill project occurs, any transition would be shorter and designed to fit the adjacent project.

Figure 7.2. Plan 1550, NED Plan, plan view.

7.02 Rationale for Support of the Locally Preferred Plan

Surf City and North Topsail Beach have indicated that they approve of the NED plan. There is no Locally Preferred Plan.

7.03 Design and Construction Considerations

7.03.1 Initial Construction and Renourishment

The selected plan requires about 11.86 million cubic yards of borrow material during initial construction, averaging 197 cubic yard per linear ft (in place). Project renourishment requirements for the 6-year renourishment cycle are about 2.64 million cubic yards of borrow material. In total, about 32.3 million cubic yards of borrow material would be required for the 50-year project. Those borrow volume quantities are actually 15 percent greater for initial construction and 21 percent greater for renourishment than the desired volumes to account for placement losses during construction, which equates to an average loss factor of 1.15 and 1.21. Placement losses are defined as the extra volume of material that must be removed from the borrow area to realize the required in-place volume of material on the beach.

The material would be pumped to the beach from hopper dredges and shaped on the beach by earth-moving equipment. The initial construction profile would extend seaward of the final design berm profile a variable distance to cover anticipated sand movement during and immediately after construction. This variable distance would generally range from 100 to 200 ft. along the project depending on foreshore slopes established by the fill material. Once sand redistribution along the foreshore occurs, the adjusted profile should resemble the design berm profile. The anticipated construction plan is to use two hopper dredges during four separate construction seasons to complete the initial project. Environmental windows limit the construction season to mostly the winter months from December 1 to March 31.

Renourishment is estimated to require 2,642,000 cubic yards of sand by two hopper dredges in one construction season. Renourishment would be repeated on a 6-year cycle. Because of the long initial construction period, the first renourishment would occur only two years after the most recently completed construction and 6 years after the sections of the project completed first. Therefore, the first renourishment volume would be estimated to be 75 percent of the volume compared to a project completed all within one year. The estimated volume for the first renourishment is 1,982,000 cubic yards. The seventh and last renourishment will occur at year 42 of the project and is estimated to require 3,523,000 cubic yards.

Delivery of sand could occur by hauling filled scows to a pumping station buoy or by hopper dredge hauling sand to the pipeline buoy. In both initial construction and during renourishment, material between the toe of dune and mean high water line would be tilled to prevent compaction.

7.03.2 Dune Vegetation

The dune portion of the project would be stabilized against wind losses by planting appropriate native beach grasses. Dune stabilization would be accomplished by planting vegetation on the dune during the optimum planting seasons and following the berm and dune construction. Planting stocks would consist of a variety of native dune plants including sea oats (*Uniola paniculata*), American beachgrass (*Ammophila breviligulata*), panic grass (*Panicum amarum*), and seaside little bluestem (*Littoralis variety*). The vegetative cover would extend from the landward toe of the dune to the seaward intersection with the storm berm for the length of the dune. Plant spacing guidelines would follow the recommendations provided by the North Carolina Sea Grant publication, *The Dune Book* (Nash and Rogers, 2003). Sea oats would be the predominant plant with American beach grass and panic grass as a supplemental plant. Seaside little bluestem would be planted on the backside of the dune away from the most extreme environment. The total area for dune plantings is estimated to be 165 acres.

7.03.3 Construction Access and Public Access

Surf City has 33 public beach access points in the project limits, and North Topsail has 22. Most access sites have wooden dune walkovers. Both Surf City and North Topsail Beach each have a vehicle crossover in the project limits for beach maintenance and emergency access. The drive-over sites would provide access during construction of the beachfill for delivery and removal of the dredge pipeline and for other construction equipment.

Most of the existing public dune walkovers would be totally or partially removed before beachfill construction. After the beachfill is completed, new walkovers would be built, and remaining walkovers would be extended over the dune. Including 5 new proposed public access sites, the total number of walkovers required is estimated to be 60. Of those, approximately 12 would be constructed to allow wheelchairs to cross the dune. The walkovers are to be constructed as a shared project construction cost. The real estate cost of providing the public access locations is not part of the project cost and is not creditable.

7.03.4 Renourishment Interval

An analysis of various renourishment intervals from 2 to 7 years was conducted in the GRANDUC model. Longer renourishment intervals increase the risks between renourishment events of allowing accumulated erosion to create escarpments (for instance, it is projected that the escarpment would be nearly two miles longer under a 7 versus a 4 year renourishment cycle), narrow the non-dune portion of the beachfill, erode the toe of the dune, and damage dune vegetation, resulting in an unnatural beach profile. Large scarps also create potential safety hazards (Figure 7.3). For renourishment cycles beyond 4 years, an additional hopper dredge would be needed in order to complete dredging during the environmental hopper dredging window of December 1 to March 31.

Net benefits increase as a function of renourishment interval from 2 to 4 years (Table 7.1). Beyond 4 years, the differences in benefits are insignificant. Therefore, the 6 year renourishment interval, which had the lowest cost, was selected.

Figure 7.3. Example of escarped dune and eroded berm.

Table 7.1. Summary of total costs and net benefits used for the selection of the project renourishment interval.

Renourishment interval (years)	Total cost ($)	Total net benefit ($)
2	129,594,587	158,481,504
3	115,058,012	165,298,498
4	111,479,241	168,712,045
5	111,931,664	167,731,332
6	109,549,340	169,771,051
7	109,637,064	169,032,905

7.03.5 Beachfill Monitoring

A comprehensive monitoring program in accordance with Corps guidance (CEM Part V, Chapter 4 and CHETN II-35) is planned for the Surf City and North Topsail Beach project to assess and ensure project functionality throughout its design lifetime. Such monitoring supports the design efforts for periodic renourishment and is cost shared 50 percent federal and 50 percent nonfederal. Estimated annual costs for beachfill monitoring are $483,000. The annual monitoring plan would consist of (1) semiannual beach profile surveys, $362,000, (2) New River Inlet monitoring, $6,000, (3) annual aerial photography of New River Inlet and the beach (cost included in the inlet hydrographic survey), (4) an annual monitoring report, $100,000, and (5) monitoring program coordination, $15,000. Beach profile surveys would allow assessment of anticipated beachfill performance and determination of renourishment volume requirements. An aerial photographic record of the beach would further facilitate assessment of the beachfill performance. An annual monitoring report would be prepared that presents the data collected and the corresponding analysis of project performance, including recommendations on renourishment requirements.

7.03.6 Environmental Monitoring and Other Commitments.

The environmental goal of the project is to avoid and minimize adverse impacts to the maximum extent practicable. Table 7.2 is a summary of environmental commitments to protect species and habitat types related to the construction and maintenance of the proposed project. This summary includes commitments to federally listed T&E species as identified in Appendix I. The table also lists other commitments to support coastal management plans and floodplain management.

Environmental monitoring costs associated with hopper dredging and beach tilling are estimated to be $31,050 for initial construction and $10,000 for each periodic nourishment. The environmental monitoring costs are included in the construction management costs and include only costs that are known at this time. It is anticipated that post-construction monitoring would be required, described as follows. Monitoring of sea turtle nesting activities in beach nourishment areas, item (10) is estimated to have an effective average cost of about $68,000 per year. That is an item occurring as part of the without-project condition and is not included as part of the project OMRR&R costs. Monitoring sea turtle nest temperature on the nourished beach, item (16) is estimated to cost about $10,000 during the nesting season following initial construction. Satellite tracking of sea turtle distribution in the project area, item (17) is estimated to cost about $25,000. Seabeach amaranth survey, item (18) is estimated to cost about $6,000 during the growing season following initial construction. Benthic Invertebrate Monitoring, part of item (19), of initial construction is estimated to cost $120,000. Physical monitoring of potential sedimentation impacts to hard bottom from initial construction dredging activities, item (23) is estimated to cost $300,000. When evaluated over the 50-year project life at 4.125 percent discount rate, the present value equivalent of environmental monitoring is estimated at $461,000 with an equivalent annual value of $22,000.

Table 7.2. Project commitments

Species, habitat, other	**Commitments to reduce environmental impacts and other impacts**
Sediment Compatibility	(1) Only beach compatible sediment (i.e., in accordance with North Carolina Sediment Criteria Rule Language) would be placed on the beach as a component of this project (Sections 10.06.1 and 11.02) (2) During the PED phase of this project, additional borings or geophysical surveys or both would be performed to better delineate the borrow area boundaries and material types (Section 7.04.3). (3) If the dredging operations encounter sand deemed non-compatible with native grain size or sorting characteristics of the native beach, the Wilmington District would make the decision on a suitable contingency measure that may include moving the dredge to another site in the borrow area or to another borrow area and would notify the NCDCM and other resource agencies of such a contingency measure (Section 7.04.4).
Piping Plover and Other Shorebirds	(4) The Corps would adhere to appropriate environmental windows to the maximum extent practicable (Appendix I and Section 10.06.1). (5) All staging areas, pipeline routes, and associated construction activities would avoid high value piping plover and shorebird habitat, located within the vicinity of New River Inlet, to the maximum extent practicable (Appendix I and Sections 10.06.1 and 11.02).
Manatee	(6) The Corps would implement precautionary measures for avoiding impacts to manatees during construction activities as detailed in the *Guidelines for Avoiding Impacts to the West Indian Manatee in North Carolina Waters* established by the USFWS (Appendix I and Section 10.06.1).

Table 7.2. (*continued*)

Species, habitat, other	**Commitments to reduce environmental impacts and other impacts**
Large Whales	(7) Endangered species observers would be on board all hopper dredges and would record all large whale sightings and note any potential behavioral effects. The Corps and the contractor would keep the date, time, and approximate location of all marine mammal sightings. They would take care not to closely approach (within 300 ft.) any whales, manatees, or other marine mammals during dredging operations or transport of dredged material. An observer would serve as a lookout to alert the dredge operator or vessel pilot or both of the occurrence of such animals. If any marine mammals are observed during other dredging operations, including vessel movements and transit to the dredged material disposal site, collisions would be avoided either through reduced vessel speed, course alteration, or both.
Sea Turtles	(8) The Corps would strictly adhere to all conditions outlined in the most current NMFS Regional Biological Opinion (RBO) for dredging of channels and borrow areas in the southeastern United States. Furthermore, as a component of this project, hopper dredging activities for both initial construction and each nourishment interval would adhere, to the maximum extent practicable, to a dredging window of December 1 to March 31 to avoid periods of peak sea turtle abundance. Turtle-deflecting dragheads, inflow or overflow screening, or both would be used, and NMFS-certified turtle and whale observers would also be implemented (Appendix I and Section 10.06.1). (9) To determine the potential taking of whales, turtles, and other species by hopper dredges, NMFS-certified observers would be on board during all hopper dredging activities. Recording and reporting procedures would be followed in accordance with the conditions of the current NMFS RBO (Appendix I and Section 10.06.1). (10) The Corps would avoid the sea turtle nesting season during initial construction and each nourishment interval. If, because of unforeseen circumstances, construction extends into the nesting season, the Corps would implement a sea turtle nest monitoring and avoidance/relocation plan through coordination with USFWS and NCWRC (Appendix I and Section 10.06.1).

Table 7.2. (*continued*)

Species, habitat, other	**Commitments to reduce environmental impacts and other impacts**
Sea Turtles (continued)	(11) Sea turtle nesting monitoring activities in beach nourishment areas would be required to assess post-nourishment nesting activity. That would include daily surveys beginning at sunrise from May 1 until September 15. Information on false crawl location, nest location, and hatching success of all nests would be recorded and provided to NCWRC (Appendix I and Section 10.06.1). (12) The beach would be monitored for escarpment formation by the contractor before completion of beach construction activities associated with initial construction and each nourishment interval. Additionally, the local sponsor would monitor the beach for escarpment formation before each turtle nesting season every year between nourishment events. Escarpments that exceed 18 inches in height for a distance of 100 ft. would be leveled by the contractor or the local sponsor accordingly. If it is determined that escarpment leveling is required during the nesting or hatching season, leveling actions should be directed by the USFWS (Appendix I and Section 10.06.1). (13) Only beach-compatible sediment would be placed on the beach as a component of the project. The Corps would, in coordination with the NCWRC and USFWS, evaluate post-nourishment beach compaction (hardness)would using qualitative assessment techniques to assure that impacts to nesting and incubating sea turtles are minimized and, if necessary, identify appropriate mitigation responses (Appendix I and Section 10.06.1). (14) Local lighting ordinances would be encouraged to the maximum extent practicable to reduce lighting impacts to nesting females and hatchlings. The local sponsors would be encouraged to work with the USFWS, local monitoring groups, and other concerned organizations to develop the best plan for Surf City and North Topsail Beach (Appendix I and Section 10.06.1).

Table 7.2. (*continued*)

Species, habitat, other	**Commitments to reduce environmental impacts and other impacts**
Sea Turtles (continued)	(15) Throughout the duration of each nourishment event, both initial construction and periodic nourishment, the contractor would be required to monitor for the presence of stranded sea turtles, live or dead. If a stranded sea turtle is identified, the contractor would immediately notify the NCWRC of the stranding and implement the appropriate measures, as directed by the NCWRC. Construction activities would be modified appropriately as not to interfere with stranded animals, live or dead (Appendix I and Section 10.06.1). (16) To better understand the threshold of sediment color change and resultant heat conduction from nourishment on temperature-dependent sex determination of sea turtles, the Corps would monitor nest temperatures in the project area during the nesting season following initial construction. That data would be compared to non-nourished native sediment temperatures to support development of management criteria for sediment color guidelines (Appendix I and Section 10.06.1). (17) To assess the abundance of sea turtles, and potential risk of hopper dredge take, within the proposed borrow areas for the project, the Corps would participate in the NCWRC's current satellite telemetry efforts to track the distribution and habitat usage of sea turtles in North Carolina offshore waters (Appendix I and Section 10.06.1).

Table 7.2. (*continued*)

Species, habitat, other	**Commitments to reduce environmental impacts and other impacts**
Seabeach Amaranth	(18) Monitoring for seabeach amaranth on Surf City and North Topsail Beaches would be implemented in the growing season following initial construction to assess the post-nourishment presence of plants. The survey would be broken down into survey reaches for each town in accordance with the designated Corps sea beach amaranth survey reaches from 1991 to 2008 to maintain consistent data and survey techniques over time, and results would be provided to USFWS (Appendix I and Section 10.06.1).
Benthic Invertebrates	(19) The anticipated construction time frame for initial and periodic nourishment events would avoid peak recruitment and abundance time period for surf zone fishes and benthic invertebrates (Section 8.01.6 and NCDCM consistency condition). (20) Before initiating any land disturbing activities related to the initial construction period, the Corps would develop Monitoring Plan, in coordination with the resource agencies, to assess project impacts on fisheries and fish prey habitat that outlines: (1) the methodologies for evaluating for hard bottom and intertidal beach habitat impacts, (2) the criteria for determining whether significant, adverse impacts to these habitats have occurred, (3) implementation of the monitoring plan. Though unlikely, based on the avoidance measures incorporated in the study design, should the Monitoring Plan document that a significant adverse impact to habitat has occurred, a Mitigation Plan would be developed outlining the appropriate actions that would be implemented in cooperation with state and federal agencies to rectify the adverse impacts to a level of insignificance. (Section 8.01.6 and NCDCM consistency condition). (21) Initial construction would be completed over the course of four construction stages, each stage entailing a full constructed template. Such a staged initial construction approach would increase the speed of benthic invertebrate recovery for affected areas by allowing for recruitment from adjacent unaffected areas of the beach (Section 8.01.6 and NCDCM consistency condition).

Table 7.2. (*continued*)

Species, habitat, other	Commitments to reduce environmental impacts and other impacts
Hard Bottom Monitoring	(22) To (1) ensure that required buffer distances are adhered to, (2) avoid physical impacts to hard-bottom resources, and (3) monitor the potential for leakage of sediment, the Corps would require all dredges to implement the Silent Inspector automated dredge plant monitoring system (Section 8.01.8.2). (23) Considering the ephemeral nature of the low-relief, hard-bottom features in the nearshore environment and the potential for low-lying outcrops to occur in the pipeline corridor distance requirements and associated dredge and pipeline anchor points, the Corps intends to survey all areas associated with potential pumpout and pipeline corridor requirements before construction to avoid potential impacts to hard-bottom features. All information associated with the surveys, data analysis, identification and mapping of pipeline corridors, appropriate buffers, and such, and subsequent measures developed to avoid resource impacts would be coordinated with the resource agencies before construction (Section 8.01.8.2) (24) If a physical impact by the hopper dredge dragheads to previously unexposed hard-bottom occurs, the incident would be thoroughly documented and coordinated with the appropriate state and federal resource agencies. On the basis of the outcome of such coordination, appropriate action would be taken to investigate and mitigate potential effects (Section 8.01.8.2). (25) Project monitoring of sedimentation effects from dredging activities in the proposed 122-m (400-ft.) buffer would be implemented when appropriate. Sediment monitoring at select offshore transects, including controls, would occur before, during, and, if necessary, after construction and would include installing sediment traps (collectors) and in-situ sediment depth measurements. If sediment accumulation at the compliance transects is > 10% of the sediment accumulated on average per day at the three control sites, the Corps would direct the contractor to stop dredging operations within the 122-m (400-ft.) buffer and move to another area 500-m (1,640-ft.) from the identified hard-bottom sites (Section 8.01.8.2).
Shellfishing	(26) The Corps would contact the North Carolina Shellfish Sanitation and Recreational Water Quality Section before start of work, so the project area may be posted as required.

Table 7.2. (*continued*)

Species, habitat, other	**Commitments to reduce environmental impacts and other impacts**
Erosion/Sediment Control	(27) Before initiating any land-disturbing activities, the Corps would obtain the approval of the North Carolina Division of Land Resources of an erosion and sedimentation control plan. The Corps would comply with the requirements of the approved erosion and sedimentation control plan. A copy of the plan approval will be forwarded to NCDCM (NCDCM consistency condition).
Water Quality	(28) Before construction, the Corps would obtain a Section 401 Water Quality Certification from the NCDWQ for the proposed project. The Corps would comply with the requirements of the Section 401 Water Quality Certification. A copy of the certification would be forwarded to NCDCM (NCDCM consistency condition). (29) Temporary dikes would be used to retain and direct flow of material parallel to the shoreline to minimize surf zone turbidities. The temporary dikes would be removed and the beach graded in accordance with approved profiles on completion of pumping activities in that section of beach (NCDCM consistency condition).
Terrestrial Impacts	(30) Land-based equipment necessary for beach nourishment work would be brought to the site through existing accesses. If the work results in any damage to existing accesses, the accesses would be restored to pre-project conditions immediately on project completion (NCDCM consistency condition). (31) Dune disturbance would be kept to a minimum. Any alteration of existing dunes would be coordinated with NCDCM and the appropriate property owner(s). All disturbed areas would be restored to original contours and configuration with reference to the surveyed normal high water line and would be revegetated immediately after project completion in that area (NCDCM consistency condition). (32) To prevent leakage, dredge pipes would be routinely inspected. If leakage is found and repairs cannot be made immediately, pumping of material must stop until such leaks are fixed (NCDCM consistency condition).

Table 7.2. (*continued*)

Species, habitat, other	**Commitments to reduce environmental impacts and other impacts**
Other Commitments	(33) Before construction the existing MHW line would be surveyed, and a copy provided to the NCDCM. If construction is not initiated within 60 days or there is a major shoreline change before beginning beach nourishment (or both), a new survey would be conducted (NCDCM consistency condition). (34) Before initiating any beach nourishment activity, the Corps would coordinate with NCDCM to determine the static vegetation line to be used as the reference point for measuring future oceanfront setbacks. That static vegetation line would then be marked, and a survey depicting the static vegetation line would be submitted to NCDCM before any beach nourishment activities (NCDCM consistency condition). (35) After the post-construction beach profile surveys are completed, the Corps would coordinate with the North Carolina Floodplain Mapping Program to support revisions to the Digital Flood Insurance Rate Maps (DFIRMs). As part of such coordination, the Corps would provide a Letter of Map Revision. (36) No sand would be placed on any sandbags that have been determined by NCDCM to be subject to removal under 15A NCAC 07H .0308(a)(2). To ensure compliance with that condition, NCDCM would be contacted before project initiation so that NCDCM staff may meet on-site with the Corps or the contractor or both (NCDCM consistency condition). (37) To mitigate the very remote chance of encountering ordnance, the beach would be inspected daily, and any ordnance discovered would be handled in accordance with the Military Munitions Rule, Title 40 of the *Code of Federal Regulations* (CFR) Parts 260-270. The Marine Corps Base Explosive Ordnance Disposal Team would be available (on call) during the dredging process. Additionally, the contract specifications for the proposed project would direct the contractor to immediately stop dredging or disposal. Additional measures would then be implemented, as necessary, including inspection of dredged material on the beach and installing outflow screens on the dredge pipeline. Any unexploded ordnance found on the beach would be promptly removed (Section 8.08.3).

Table 7.2. (*continued*)

Species, habitat, other	**Commitments to reduce environmental impacts and other impacts**
Other Commitments (continued)	(38) To assure the risk of potential impacts to cultural resources within inshore areas subject to pumpout activities are avoided, specific pumpout locations would identified, surveyed, and investigated for cultural resources in conjunction with hard-bottom surveys before beginning nourishment activities (Section 8.06). (39) If, during dredging activities, any previously unidentified or unanticipated historical, archaeological, and cultural resources are discovered in the inflow screening of the dredge or in the beach placement area, all activities that could damage or alter such resources would be temporarily suspended. If such a discovery or find is made, the Corps’ Contracting Officer would be immediately notified so that the appropriate authorities, including the MMS, may be notified in accordance with Corps policy and 30 CFR 250.194(c) and a determination made as to their significance and what, if any, special disposition of the finds should be made (Section 8.06).

7.04 Borrow Areas

Sixteen borrow areas have been identified for the Surf City/North Topsail Beach Coastal Storm Damage Reduction Project. Those borrow areas include 10 identified for the Surf City/North Topsail Beach project and the excess amount from 6 borrow areas identified for the Topsail Beach Federal project (USACE, 2009). Those areas are typically between 1 and 6 miles offshore and have pre-dredge bottom depths between 35 and 50 ft. Material from the borrow areas were classified in accordance with the Unified Soil Classification System. The material classification (EM 1110-1-1906) types for the material identified as compatible from the borrow areas consisted of poorly graded clean sand (SP) or gravelly sand (SP-SM). Borrow areas in the project area were identified on the basis of material characteristics and depth of suitable material. For more information on the borrow areas, see Appendices C and E. Borrow area characteristics are summarized in Table 7.3.

Table 7.3. Topsail Island borrow area characteristics

Borrow area	Mean grain size	Estimated volume (million cubic yards)	Distance offshore (miles)	Surface elevation (ft. MLLW)
A	2.36 phi (0.20 mm)	*	1 to 3	–38.5 to –49.0
B	2.17 phi (0.22 mm)	*	1.5 to 2.5	–42.2 to –43.2
C	2.32 phi (0.20 mm)	*	4 to 5.5	–45.5 to –47.7
D	2.13 phi (0.23 mm)	*	3.5 to 4.5	–43.5 to –46.9
E	2.15 phi (0.23 mm)	*	4.5 to 5.5	–49 to –50
F	1.09 phi (0.47 mm)	*	4.5 to 5.5	–47.2 to –48
G	2.05 phi (0.24 mm)	2.41	4 to 5.5	–46.5 to –49
H	2.21 phi (0.22 mm)	0.72	3.5 to 4.5	–44.4 to –45.2
J	2.12 phi (0.23 mm)	3.67	3 to 4.5	–42 to –47.4
L	2.05 phi (0.24 mm)	6.13	3 to 5.5	–42.3 to –47
N	1.86 phi (0.28 mm)	5.64	4 to 6	–43.6 to –46.7
O	2.12 phi (0.23 mm)	3.85	1.5 to 4	–40.6 to –43.9
P	2.01 phi (0.25 mm)	2.73	2 to 3.5	–39.5 to –40.5
Q	2.30 phi (0.20 mm)	0.73	1 to 1.5	–35.2 to –35.4
S	1.62 phi (0.32 mm)	1.46	3.5 to 4.5	–43.8 to –44.8
T	1.78 phi (0.29 mm)	0.25	2 to 4	–37.2 to –42

* These borrow areas are planned to be used for the Topsail Beach federal and nonfederal projects (USACE, 2009). The excess material not used for those projects would be expected to be available for the Surf City/North Topsail Beach project. That amount is approximately 9.68 million cubic yards.

As discussed in Section 2.01.10, an extensive geophysical investigation was conducted to identify hard bottom presence and delineate hard bottom that was identified in and near several borrow areas. Hard-bottom buffers of 500 meters (1,640 ft.) were established for high- and moderate-relief hard bottom and 122 meters (400 ft.) were established for low-relief hard bottom. The Corps, Wilmington District, proposed such buffers, and several state and federal resource agencies concurred. For more specific information regarding impacts to hard bottoms, see section 8.01.8.2 f.

7.04.1 Borrow Area Material Compatibility

The compatibility analysis compares the grain size of the *native beach* or the *reference beach* with the material in the proposed borrow material. The overfill ratio is the primary indicator of the compatibility of the borrow material to the beach material, with a value of 1.00 indicating that one cubic yard of borrow material is needed to match one cubic yard of beach material. An overfill ratio of up to 1.5 is generally considered acceptable as a match of compatibility. Table 7.4 illustrates the overfill ratios for potential borrow areas for the Surf City/North Topsail Beach project. The overfill ratios for the borrow areas are all below 1.5 with the exception of borrow area C, which is 1.56. Because the overfill ratio for borrow area C was only slightly above 1.5, it has been retained for further evaluation when additional characterization is conducted during the design phase.

North Carolina implemented new beachfill standards in 2007, which require compatibility of the native beach with borrow sources in regards to the percentage of silt (< 0.062 mm), granular sediment, (< 4.76 mm and $\geq$ 2.0 mm), gravel ($\geq$ 4.76 mm), and calcium carbonate. The state still needs to gain approval from NOAA to add the new standards to their Coastal Zone Management Program. If NOAA approves the changes, then the new criteria would need to be met in order for the project to be consistent with the Coastal Zone Management Act. A visual estimate of shell content can be used in lieu of carbonate weight percent for samples collected before the effective date of beachfill rules that applies to the Surf City/North Topsail Beach project. The standards require that percent silt, granular sediment, and gravel in borrow material not exceed the amount found in the native beach plus 5 percent, and the percent carbonate in borrow material not exceed the amount found in the native beach plus 15 percent. Those characteristics for the native beach and borrow material are given in Table 7.4. The analysis for the native beach material indicates the silt, granular sediment, and gravel content are 1.2, 1.1, and 0.5 percent, respectively. The visual shell content for the native beach is 9 percent. After incorporating the tolerance permitted by the beachfill standards, the silt, granular sediment, gravel, and shell content permitted for borrow areas to be used for Surf City/North Topsail Beach are 6.2, 6.1, 5.5, and 24 percent, respectively.

As shown in Table 7.4, all the borrow areas comply with the beachfill standards regarding the percentage of silt with the exception of borrow areas A (6.6 percent) and L (6.3 percent). Both of those borrow areas exceed the standard slightly by 0.4 and 0.1 percent, respectively. All the borrow areas comply with the beachfill standards regarding the percentage of granular sediment with the exception of borrow areas F (7.0 percent) and S (6.6 percent), which exceed the standard by 0.9 and 0.5 percent, respectively. All the borrow areas comply with the beachfill standards regarding the percentage of gravel sediment with the exception of borrow areas F (8.5 percent) and P (6.6 percent), which exceed the standard by 3.0 and 1.1 percent, respectively. All the borrow areas comply with the beachfill standards regarding the percentage of shell content (carbonate). The borrow areas in which the standards are exceeded for the various characteristic (A, F, L, S, and P) have been retained because all borrow areas would be further characterized during the design phase of the project. Additional vibracores would be performed to comply with the beachfill standards of 1 core/acre or 1,000 foot spacing. Vibracores would be performed to produce a density of 1,000 foot spacing in a borrow area before its use as a borrow source. For more information on borrow material compatibility, see Appendix E.

Table 7.4. Surf City/North Topsail Beach compatibility table

Native Beach	Mean (phi)	Mean (mm)	Std Dev (phi)	Std Dev (mm)	% Silt (0.062 mm)	% Granular (2 - 4.76 mm)	% Gravel (4.76 mm)	% Shell
Surf City/North Topsail Beach	**2.15**	**0.23**	**0.71**	**0.61**	**1.2**	**1.1**	**0.5**	**9**

Borrow Site	Mean (phi)	Mean (mm)	Std Dev (phi)	Std Dev (mm)	% Silt (0.062 mm)	% Granular (2 - 4.76 mm)	% Gravel (4.76 mm)	% Shell	Overfill Ratio	Silt Correction Factor	Final Overfill Ratios Corrected for Silt Content[1]
A ^	2.36	0.20	0.88	0.54	6.6	3.4	2.2	11	1.29	1.07	1.38
B ^	2.17	0.22	0.99	0.50	4.0	1.7	0.8	13	1.18	1.04	1.23
C ^	2.32	0.20	0.63	0.64	3.9	1.7	2.6	9	1.50	1.04	1.56
D ^	2.13	0.23	0.99	0.50	5.2	4.6	2.2	10	1.15	1.06	1.21
E ^	2.15	0.23	0.69	0.62	3.2	0.9	1.2	5	1.02	1.03	1.15
F ^	1.09	0.47	1.78	0.23	3.8	7.0	8.5	10	1.14	1.04	1.19
G	2.05	0.24	0.98	0.51	5.2	2.7	5.2	10	1.11	1.05	1.17
H	2.21	0.22	0.65	0.64	2.6	1.6	2.0	7	1.16	1.03	1.19
J	2.12	0.23	0.75	0.60	4.5	2.3	1.1	10	1.01	1.05	1.15
L	2.05	0.24	0.94	0.52	6.3	2.8	3.1	10	1.09	1.07	1.16
N	1.86	0.28	0.96	0.51	3.6	3.2	4.8	9	1.05	1.04	1.15
O	2.12	0.23	0.86	0.55	6.2	2.0	4.7	9	1.08	1.07	1.15
P	2.01	0.25	0.96	0.52	5.5	2.4	6.6	7	1.09	1.06	1.15
Q	2.30	0.20	0.66	0.63	5.9	2.4	2.3	10	1.37	1.06	1.46
S	1.62	0.32	1.12	0.46	3.3	6.6	4.1	21	1.06	1.03	1.15
T	1.78	0.29	0.95	0.52	2.8	3.0	3.9	17	1.03	1.03	1.15

^ These borrow areas have been identified for the Topsail Beach Federal project. The excess material not used for these projects is planned to be available for the Surf City/North Topsail Beach Federal project. This amount is approximately 9.68 million cubic yards.

[1] In order to account for placement losses, borrow areas were assigned a minimum overfill ratio of 1.15

7.04.2 Regional Sand Requirements

Four beachfill projects are planned or being planned for Topsail Island as shown in Figure 7.4. Those projects consist of the Surf City/North Topsail Beach Federal Coastal Storm Damage Reduction Project, the North Topsail Beach non-Federal Project, the West Onslow Beach and New River Inlet (Topsail Beach) Federal Coastal Storm Damage Reduction Project, and the Topsail Beach non-Federal Project. The two federal projects and the North Topsail Beach non-Federal project are planning to use material from offshore borrow areas identified for the federal projects. However, the Topsail Beach nonfederal project is not proposing to use material from those borrow areas. The estimated volume requirements for 50-year period of analysis of the projects are shown in Table 7.5.

By evaluating all Topsail Island offshore borrow areas together, the 16 borrow areas contain approximately 50.5 million cubic yards of borrow material. The four Topsail Island project volume requirements from these areas are approximately 46.2 million cubic yards or about 91 percent of the available borrow material in all the borrow areas evaluated for the federal projects.

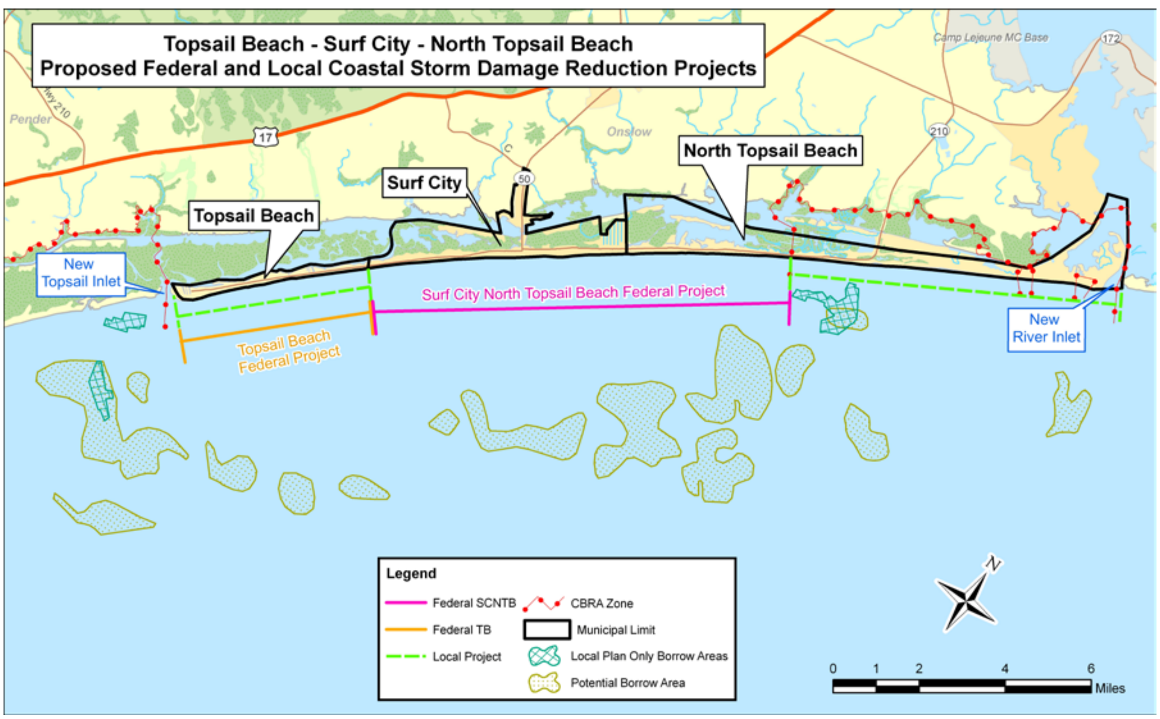


Figure 7.4 Topsail Island proposed federal and nonfederal coastal storm damage reduction projects.

Table 7.5. Lifetime borrow requirements, Topsail Island

Project	Volume (million cubic yards)
Surf City/North Topsail Beach federal[a]	32.3
North Topsail Beach nonfederal	0.34[b]
Topsail Beach federal	13.6
Topsail Beach nonfederal	0[c]
Total, required	46.2
Total, available	50.5

[a] brought back from NED plan identification.

[b] The amount estimated for the project is approximately 4 million cubic yards. However, only 340,000 cubic yards would be required from the borrow areas identified for the federal project.

[c]The amount estimated for the project is approximately 1.3 million cubic yards. However, none of this material is coming from the borrow areas identified for the federal project.

7.04.3 Borrow Area Use Plan

Many possible sequences and methods can be used for placing available material on the beach for the project. The purpose of this plan is to discuss the subjects of borrow area characteristics, dredging specifics, project construction plan, project sand requirements, and borrow area use. The economic optimization of using the borrow areas for the life of the project would be further evaluated when the final borrow area data has been collected and fully analyzed during the PED phase. Additional vibracore boring data would be collected and made a part of the final borrow area use plan, but for now, the defined borrow areas would be used. In addition to borrow area parameters (material quantities and location), the dredging production rates and dredging window are critical to selecting optimum borrow use plan.

The offshore borrow areas beyond 3 nautical miles offshore would be subject to federal mining requirements of the MMS. The borrow areas have been configured on the basis of a geotechnical evaluation (Appendix C, Geotechnical Analysis) and results of the compatibility analysis (Appendix E, Sand Compatibility Analysis).

Areas to be used for borrow would be further defined during the PED phase of the project. Additional borings or geophysical surveys or both would be performed to better delineate the borrow area boundaries and material types. Vibracore borings would be performed in a grid pattern, on a 500-ft to 1,000-ft spacing, in any area before its use as a borrow source.

7.04.4 Borrow Area Contingency Plan

Borrow area compatibility is determined on the basis of grain size analyses from borings taken before construction, during both the feasibility study and PED phase. The borings conducted during the PED phase would provide any additional data necessary to help further refine the borrow area to comply with the North Carolina beachfill standard of 1 core/acre or 1,000-ft spacing when combined with the borings conducted during the feasibility study. Such additional characterization of the borrow material would increase the level of confidence for borrow material compatibility and decrease the degree of interpolation between boring locations. Qualitative visual characterizations of the in-place material would be made by representatives of the Corps construction and environmental offices throughout the project construction.

Furthermore, dredging production rates are specific to each dredge and its operation and can be quantified. The recommended construction plan identified in Section 7.04.1.4 discusses the use of hopper dredges during initial construction and each periodic nourishment event. Hopper dredges would use pumpout facilities for each dredged hopper load. Because hopper dredges have a maximum capacity per load and are self-propelled, the Corps can feasibly manage potential incompatible material.

Federal and state environmental agencies would be notified if, and how much, potentially incompatible material is encountered during dredging operations. If necessary, the Wilmington District would make the decision on a suitable contingency measure that could include moving the dredge to another site in the borrow area or to another borrow area, depending on availability of sediment, and would notify the agencies of the contingency measure.

7.05 Dredging and Material Shaping

The following discussion describes the dredging and construction plan.

7.05.1 Dredging Production

Dredging production refers to the average volume transported per day and relates to factors such as plant, material, distance, and weather. This information is used to estimate project cost and construction time. Production rates are estimated to average 14,000 cubic yards/day for each hopper dredge for initial construction and for periodic nourishment.

7.05.2 Dredging Window

In determining the optimum borrow use plan, the hopper dredging window restriction was evaluated, with respect to sea turtles, using a December 1 to March 31 dredging window. The plan considers that to work within the hopper dredging window, the initial construction would take four seasons to complete.

A 6-year periodic nourishment cycle using hopper dredges is considered for the 50-year life of the project. Hopper dredging operations for the project would work in accordance with the *1997 National Marine Fisheries Service (NMFS) South Atlantic Regional Biological Opinion (SARBO) for the continued hopper dredging of channels and borrow areas in the Southeastern United States* or any superseding SARBO that is prepared by NMFS. Although, under the 1997 SARBO, the NMFS does not cover window hopper dredging operations from Pawley's Island, South Carolina, through North Carolina, both the Corps South Atlantic Division (SAD) office and South Atlantic Wilmington (SAW) District office recommend implementing a December 1 to March 31 dredging window, to the extent practicable, to minimize impacts to sea turtles in the offshore environment. A summary for the recommended construction plan follows with a brief discussion of start-stop times, number of contracts required, type and number of dredges required, and dredging presence in the project area during the life of the project.

7.05.3 Recommended Construction Plan

Initial construction would begin after December 1 of project year 1. The initial construction would consist of hopper dredging one or more of the offshore borrow areas and proceed until sea turtle activity resumes about March 31 of the following year. The process would continue each winter for 4 years until the full project length is completed in project year 4. To meet that schedule, two hopper dredges would be used in each season. Because of the relatively thin sand layer in the borrow areas, a cutterhead-pipeline dredge is unlikely to be effective.

Periodic nourishment would begin in project year 7 and consist of hopper dredging because of limited thickness of available material in the borrow areas and long haul distances. Periodic nourishment for the project would use a combination of offshore borrow areas. Renourishment would adhere to the hopper-dredging window and begin December 1 for each cycle and proceed until completion before March 31 of the following year. In summary, every 6 years two hopper dredges would be expected to complete the renourishment within the designated hopper-dredging window. The plan would require separate contracts for initial construction and for each periodic nourishment cycle. The first renourishment would apply the most material in reaches constructed in project year 1 and smaller volumes in reaches constructed in project year 4. The overall volume to be placed in the first renourishment would therefore be only about 75 percent of the volume required in each following renourishment.

7.06 Real Estate Considerations

Real estate requirements for the Selected Plan include lands, easements, rights-of-way and relocations, and disposal/borrow areas, which are referred to as LERRD. Real estate requirements in each of those categories are discussed and followed by a summary of estimated real estate costs. There would be no utility relocations. No existing federal project is within the acquisition area. Further details are provided in the Real Estate Appendix (Appendix M).

7.06.1 Borrow Areas

Proposed borrow areas are offshore. On final selection of borrow areas to be used for the project, coordination and concurrence for the sand removal from the offshore borrow areas would be required from appropriate state or federal agencies or both.

7.06.2 Pipeline

Material for initial project construction and beach nourishment would be dredged by hopper dredge from the offshore borrow areas, and then moved by pipeline to the beach. The pipeline would be routed along the ocean shoreline, where it would be placed either below Mean High Water or in the acquired Perpetual Beach Storm Damage Reduction Easements.

7.06.3 Construction Area

The project limits extend along the shoreline of Surf City and North Topsail Beach northward to reach 78, a total length of 52,150 ft. The estate to be acquired for the project would be a Perpetual Beach Storm Damage Reduction Easement for approximately 828 easements. According to project maps and ground examination, three parcels have structures so far seaward that it would be necessary to acquire the parcel and structures in fee. Another two parcels would be used temporarily as construction staging areas. No relocation of landowners would occur. Improvements (other than the pier) within the project include walkover structures that allow beach access from private and public property. The easement specifies that construction of walkover structures must not violate the integrity of the constructed dune. Approval of PED for construction of new walkover structures must be obtained from the project sponsor.

7.06.4 Real Estate Costs

Estimated real estate costs for the Selected Plan of Improvement are shown in Table 7.6. The land value for the Perpetual Beach Storm Damage Reduction Easements is $0. As *offsetting benefits* applies, a determination is made that the project would not reduce the value of the land. Rather, it would remain the same or increase after construction of the project.

Table 7.6. Real estate estimate (2010 price level), beachfill plan

a. Lands (two temporary staging areas)	$58,000
b. Improvements (three residences)	$1,158,300
c. Mineral rights	$0
d. Damages	$0
e. P.L. 91-646 Relocation costs	$4,000
f. Acquisition administrative costs (three parcels in fee, 828 easements)	$2,825,400
Federal	$332,400
Nonfederal	$2,493,000
Subtotal	$4,182,888
Contingencies, 25%	$1,045,722
Total, rounded	$5,229,000

7.07 Operation and Maintenance Considerations

Operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) requirements of the sponsors would consist of project inspections and maintenance. The beachfill monitoring actions are different from the nonfederal sponsors' OMRR&R project inspections and surveillance, which consist of assessing dune vegetation, access facilities, dune crest erosion, trash and debris, and unusual conditions such as escarpment formation or excessive erosion. Periodic renourishment and beachfill monitoring (including the semiannual beach profile surveys) are classified as continuing construction, not as OMRR&R. Dune vegetation maintenance includes watering, fertilizing, and replacing dune plantings as needed. Other maintenance is reshaping of any minor dune damage, repairs to walkover structures and vehicle accesses, and grading any large escarpments. Estimated OMRR&R annual costs are $52,000.

7.08 Plan Accomplishments

The Selected Plan would significantly reduce expected annual damages to structures and roads from coastal storm damages along the project reaches 27 though 78. It also would significantly reduce damages from long-term progressive erosion.

The Selected Plan would reduce, but not entirely eliminate, damages due to short term erosion, inundation, and wave overwash during storms. Although the Selected Plan would substantially reduce damages due to hurricane-wave overwash, note that the plan provides for storm damage reduction only in terms of reducing damage to development from the action of ocean storm surge and wave action. No provisions are in the project to reduce damages to the area against storm-tide flooding occurring from increased water levels in the sounds landward of Topsail Island.

The Selected Plan would reduce emergency costs and other damages and would increase the width of beach available for recreation and for beach habitat, providing incidental benefits. Topsail Island was included in a study of recreation demand and benefits to four barrier islands on the North Carolina coast. Details of the analysis are in the Recreation Appendix (Appendix O). To summarize, the study reports willingness to pay for a beach day for the average visitor within a travel cost method (TCM) framework. The TCM makes use of the basic idea that the time and money that households expend in traveling to beaches provide a signal of the value of such resources. The TCM relies on the assumption that, although access to a recreational site has a minimal price or no explicit price, an individual's travel cost, including transportation, accommodation, and lost wages, can be used as surrogate prices to approximate the nonexplicit prices for their recreational experiences. The basic premise is that visitors perceive and respond to changes in travel cost to the site in the same way they would respond to changes in an entry fee, so the number of trips to a recreation site should decrease with increases in distance traveled and other factors increasing the total travel cost.

Socioeconomic characteristics of the individuals and information concerning substitute sites and environmental quality indicators can also be included. On-site visitation data for 17 North Carolina beaches were collected between July and August 2003. A telephone survey was conducted in May 2004, with a target population based on the results of the on-site survey conducted in 2003. Results from the TCM measure the incremental value of having access to a beach when other substitute beaches are available, and the value of changes in beach characteristics, such as beach width. Additionally, the data were used to predict annual and peak visitation at the subject beaches and parking and access requirements to handle projected visitation. Finally, the NED benefits for the with-project conditions for the subject beaches were estimated. The expected average annual benefit for Surf City and North Topsail beaches for increases in beach width resulting from the selected 1550 alternative plan are approximately $12,709,000 and $7,796,000, respectively, for a total of $20,505,000 in average annual benefits for the entire project. Note that average annual recreation benefits for all North Topsail Beach actually amounts to $23,376,000; however, benefits were applied only for the portion of beach that is in the project area, which is approximately one-third of the total. The 1550 plan would add an additional beach width of 65 and 73 ft. for Surf City and North Topsail beaches, respectively. Table 7.7 summarizes expected peak visitation and the amount of parking required to satisfy peak visitation on 95 percent of peak days with a project in place. Peak visitation was defined as the average estimated number of visitors in the project area beaches at 1 p.m. on July 4, 5, 12, 13 and Aug 2, 3, 9, 10, 30, and 31. On the basis of a 2008 count, more than enough parking spaces exist (1,992) to accommodate peak visitation; however, the current distribution of parking spaces is inadequate, as is discussed in section 3.04.

Table 7.7. Peak visitation and parking required and available at the SCNTB project area

Peak visitors[a]	Parking spaces required[a]	Parking spaces available[b]
3,358	1,679	1,992

a. Projected 2012 peak visitation and parking requirements, with project

b. 2008 count of spaces

7.09 Economics of the Selected Plan

Many suitable plans were identified that have benefits that exceed costs. The Selected Plan is the NED Plan, having the greatest net benefits. Benefits and costs of the Selected Plan are presented in this section at October 2010 price levels. The Water Resources Interest Rate for FY 2011 of 4.125 percent is used to develop present values and annual values for benefits, costs, and net benefits.

7.09.1 Selected Plan—Benefits

The total expected annual benefits for the Selected Plan are estimated at $40,129,000. An itemized listing of expected annual benefits is presented in Table 7.8. Regarding the increase in flood damages, as storm erosion and long-term land losses are reduced, flood damages begin to become the dominant category. Also, structures that might have otherwise been taken out by storm and wave damage without a project would then be subject to residual flood damages.

Table 7.8. Expected annual benefits, October 2010 levels, 4.125% interest rate

Benefit category	Expected annual benefit
	Selected Plan, NED
Hurricane and Storm Damage Reduction	
Storm Erosion	$14,352,000
Flood	$(98,000)
Wave	$404,000
Land and Long-Term Erosion	$2,162,000
Subtotal, rounded	$16,820,000
Recreation	$ 20,505,000
Benefits During Construction	$ 2,804,000
Total expected annual benefits	$40,129,000

7.09.2 Selected Plan—Costs

Determining the economic costs of the Selected Plan consists of four basic steps. First, project First Costs are computed. First Costs include expenditures for project design and initial construction and related costs of supervision and administration. First Costs also include the lands, easements, and rights-of-way for initial project construction and periodic nourishment. Total First Costs are estimated to be $123,135,000 at October 2010 price levels as presented in Table 7.9.

Table 7.9. Project first costs, Plan 1550 NED (October 2010 price levels)

FIRST COST							
ACCT. CODE	ITEM	QUANTITY	UNIT	UNIT PRICE	AMOUNT	CONTIN-GENCY	TOTAL COST
1	LANDS AND DAMAGES						
	Lands				$1,216,00	$305,00	$1,521,00
	Improvement				$137,00	$34,00	$171,00
	PL 91-646				$4,00	$1,00	$5,000
	Acquisition Cost, Federal				$332,00	$83,00	$415,00
	Acquisition Cost, Non-				$2,493,00	$624,00	$3,117,00
	Subtota				$4,182,00	$1,047,00	$5,228,00
17	BEACH REPLENISHMENT						
	Mobilizati n Demobili atio	1	JOB	LS	$7,600,00	$1,596,00	$9,196,00
	Dredging and Fill	11,855,17	CY	$6.9	$82,102,00	$17,241,00	$99,344,00
	Dune Vegetatio	165	AC	$10,00	$1,650,00	$347,00	$1,997,00
	Beac Tillin	150	AC	$750	$113,00	$24,00	$137,00
	Public Walkovers	35	EA	$48,16	$1,866,00	$392,00	$2,258,00
	Subtota				$93,331,00	$19,600,00	$112,932,00
30	PLANNING, ENGINEERING, AND DESIGN				$2,454,00	$614,00	$3,068,00
31	CONSTRUCTION MANAGEMENT				$1,527,00	$382,00	$1,909,00
	TOTAL FIRST COST				$101,494,00	$21,640,00	$123,135,00

Second, Interest during Construction is added to the project First Cost. Interest during Construction is computed from the start of PED through the 4-year initial construction period. Interest during Construction for the Selected Plan is estimated to be $9,513,000. The project First Cost plus Interest during Construction represents the Total Investment Cost required to place the project into operation. Total Investment Cost for the Selected Plan is estimated to be $132,648,000 as shown in Table 7.10.

Table 7.10. Total investment cost, Plan 1550 NED (October 2010 price levels)

Item	Amount
Total First Cost	$123,135,000
Interest During Construction	$9,513,000
Total Investment Cost	$132,648,000

Third, Scheduled Renourishment Costs are computed. Those costs are incurred in the future for each renourishment. Neither discounting to present value, nor escalation for anticipated inflation is included.

Renourishments would be repeated on a 6-year cycle. There are three different renourishment volumes and costs. As explained in Section 7.03.1, the first renourishment would require less volume and the last renourishment would require additional volume. At October 2010 price levels the renourishment costs including non-contract costs, and other support costs are estimated to be $20,866,000 for the first event, $27,724,000 for events two through six, and $46,053,000 for the final renourishment. Details are shown in Tables 7.11, 7.12, and 7.13.

Table 7.11. Project renourishment costs, Plan 1550 NED (October 2010 price levels): First event

Acct. code	Item	Quantity	Unit	Unit price	Amount	Contingency	Total cost
17	Beach Replenishment						
	Mobilization and Demobilization	1	JOB		$1,900,000	$399,000	$2,299,000
	Dredging and Beachfill	1,981,670	CY	$7.17	$14,202,000	$2,982,000	$17,184,000
	Beach Tilling	66	AC	$753	$50,000	$10,000	$60,000
	Subtotal				$16,152,000	$3,391,000	$19,543,000
30	Planning, Engineering, And Design				$658,000	$165,000	$823,000
31	Construction Management				$400,000	$100,000	$500,000
	Total First Cost				$17,210,000	$3,656,000	$20,866,000

Table 7.12. Project renourishment costs, Plan 1550 NED (October 2010 price levels): Second through sixth events

Acct. code	Item	Quantity	Unit	Unit price	Amount	Contingency	Total cost
17	Beach Replenishment						
	Mobilization and Demobilization	1	JOB	LS	$1,901,000	$399,000	$2,300,000
	Dredging and Beachfill	2,642,225	CY	$7.57	19,870,000	$4,173,000	$24,042,000
	Beach Tilling	66	AC	$792	$50,000	$10,000	$60,000
	Subtotal				$21,820,000	$4,582,000	$26,402,000
30	Planning, Engineering, And Design				$658,000	$165,000	$823,000
31	Construction Management				$400,000	$100,000	$500,000
	Total First Cost				$22,878,000	$4,857,000	$27,724,000

Table 7.13. Project renourishment costs, Plan 1550 NED (October 2010 price levels): Final (seventh) event.

Acct. code	Item	Quantity	Unit	Unit price	Amount	Contingency	Total cost
17	Beach Replenishment						
	Mobilization and Demobilization	1	JOB	LS	$2,728,000	$573,000	$3,301,000
	Dredging and Beachfill	3,523,000	CY	$9.70	34,173,000	$7,176,000	$41,349,000
	Beach Tilling	66	AC	$792	$66,000	$13,000	$79,000
	Subtotal				$36,967,000	$7,762,000	$44,729,000
30	Planning, Engineering, And Design				$658,000	$165,000	$823,000
31	Construction Management				$400,000	$100,000	$500,000
	Total First Cost				$38,025,000	$8,027,000	$46,053,000

Fourth, Expected Annual Costs are computed. Those costs consist of interest and amortization of the Total Investment Cost and the equivalent annual cost of project OMRR&R. The Expected Annual Costs provide a basis for comparing project costs to expected annual benefits. Expected Annual Costs for the Selected Plan are estimated to be $10,702,000. A summary of the computations involved in each of these four steps is presented in Table 7.14.

Table 7.14. Project annual costs, Plan 1550 NED (October 2010 price levels)

interest rate =	4.125%	years of analysis =	50
ITEM	**YEAR**	**AMOUNT**	**PRESENT**
			VALUE, 2014
Total Investment Cost	2014	$132,648,000	$132,648,000
Renourishment	2020	$20,866,000	$16,372,000
Renourishment	2026	$27,724,000	$17,069,000
Renourishment	2032	$27,724,000	$13,393,000
Renourishment	2038	$27,724,000	$10,508,000
Renourishment	2044	$27,724,000	$8,245,000
Renourishment	2050	$27,724,000	$6,470,000
Renourishment	2056	$46,053,000	$8,639,000
Total Investment Cost, Present Value			$213,344,000
Annual Costs			
Interest & Amortization @ 4-1/8%			$10,145,000
Monitoring			$505,000
OMRR&R			$52,000
Total Annual Cost			$10,702,000
Cost level	Oct-10		

7.09.3 Benefit to Cost Ratio

With expected annual benefits of $40,129,000 and average annual costs of $10,702,000, the benefit to cost ratio for the Selected Plan, Plan 1550, is 3.7 to 1. The annual net benefits are $29,427,000. Because the project is justified solely on the basis of coastal storm damage reduction benefits, all incidental recreation benefits are being claimed in the benefit cost ratio.

7.09.4 Incremental Analysis

Incremental costs and benefits by reach are shown in Table 7.15 and graphically in Figure 7.5. For the incremental feasibility test, allowable recreation benefits cannot exceed hurricane and storm damage reduction benefits. Four reaches are shown with negative net benefits—reaches 28, 31, 34 and 56. Those reaches are included within the selected plan because a transition across the reaches would be required if they were omitted. The costs of the transitions would be close to the costs of the full dune and berm cross section. Therefore, omitting those sections does not actually omit the full cost of that reach as indicated in the table.

Table 7.15. Incremental analysis

Incremental Analysis of Typical Plan, 1550, by Reach, Annual Value 2010 Costs and Benefits, 4.125% interest rate

REACH	1550 CSDR Benefits	1550 Costs	1550 Net CSDR Benefits	1550 Recreation Benefits	1550 Allowable Recreation Benefits	1550 Total Benefits	1550 Total Net Benefits
27	$282,000	$262,000	$20,000	$387,500	$282,000	$564,000	$302,000
28	$17,000	$217,000	($200,000)	$387,500	$17,000	$34,000	($183,000)
29	$302,000	$247,000	$55,000	$387,500	$302,000	$604,000	$357,000
30	$153,000	$196,000	($43,000)	$387,500	$153,000	$306,000	$110,000
31	$62,000	$196,000	($135,000)	$387,500	$62,000	$124,000	($72,000)
32	$93,000	$197,000	($104,000)	$387,500	$93,000	$186,000	($11,000)
33	$136,000	$194,000	($58,000)	$387,500	$136,000	$272,000	$78,000
34	$30,000	$193,000	($163,000)	$387,500	$30,000	$60,000	($133,000)
35	$198,000	$184,000	$14,000	$387,500	$198,000	$396,000	$212,000
36	$123,000	$184,000	($61,000)	$387,500	$123,000	$246,000	$62,000
37	$237,000	$185,000	$53,000	$387,500	$237,000	$474,000	$289,000
38	$375,000	$217,000	$158,000	$387,500	$375,000	$750,000	$533,000
39	$336,000	$215,000	$121,000	$387,500	$336,000	$672,000	$457,000
40	$467,000	$215,000	$252,000	$387,500	$387,500	$854,500	$639,500
41	$388,000	$215,000	$173,000	$387,500	$387,500	$775,500	$560,500
42	$267,000	$215,000	$53,000	$387,500	$267,000	$534,000	$319,000
43	$499,000	$215,000	$284,000	$387,500	$387,500	$886,500	$671,500
44	$522,000	$215,000	$308,000	$387,500	$387,500	$909,500	$694,500
45	$476,000	$157,000	$319,000	$387,500	$387,500	$863,500	$706,500
46	$368,000	$158,000	$210,000	$387,500	$368,000	$736,000	$578,000
47	$649,000	$202,000	$447,000	$387,500	$387,500	$1,036,500	$834,500
48	$739,000	$202,000	$537,000	$387,500	$387,500	$1,126,500	$924,500
49	$886,000	$202,000	$684,000	$387,500	$387,500	$1,273,500	$1,071,500
50	$590,000	$157,000	$432,000	$387,500	$387,500	$977,500	$820,500
51	$150,000	$234,000	($84,000)	$387,500	$150,000	$300,000	$66,000
52	$648,000	$267,000	$381,000	$387,500	$387,500	$1,035,500	$768,500
53	$636,000	$268,000	$368,000	$387,500	$387,500	$1,023,500	$755,500
54	$390,000	$267,000	$123,000	$387,500	$387,500	$777,500	$510,500
55	$201,000	$234,000	($33,000)	$387,500	$201,000	$402,000	$168,000
56	$61,000	$234,000	($173,000)	$387,500	$61,000	$122,000	($112,000)
57	$254,000	$208,000	$46,000	$387,500	$254,000	$508,000	$300,000
58	$348,000	$208,000	$140,000	$387,500	$348,000	$696,000	$488,000
59	$315,000	$188,000	$127,000	$380,000	$315,000	$630,000	$442,000
60	$384,000	$188,000	$196,000	$380,000	$380,000	$764,000	$576,000
61	$198,000	$188,000	$10,000	$380,000	$198,000	$396,000	$208,000
62	$383,000	$175,000	$208,000	$380,000	$380,000	$763,000	$588,000
63	$316,000	$191,000	$125,000	$380,000	$316,000	$632,000	$441,000
64	$358,000	$208,000	$149,000	$380,000	$358,000	$716,000	$508,000
65	$307,000	$208,000	$99,000	$380,000	$307,000	$614,000	$406,000
66	$258,000	$208,000	$50,000	$380,000	$258,000	$516,000	$308,000
67	$345,000	$208,000	$138,000	$380,000	$345,000	$690,000	$482,000
68	$235,000	$207,000	$28,000	$380,000	$235,000	$470,000	$263,000
69	$201,000	$192,000	$9,000	$380,000	$201,000	$402,000	$210,000
70	$186,000	$192,000	($6,000)	$380,000	$186,000	$372,000	$180,000
71	$215,000	$203,000	$13,000	$380,000	$215,000	$430,000	$227,000
72	$576,000	$191,000	$385,000	$380,000	$380,000	$956,000	$765,000
73	$531,000	$191,000	$339,000	$380,000	$380,000	$911,000	$720,000
74	$462,000	$191,000	$270,000	$380,000	$380,000	$842,000	$651,000
75	$197,000	$190,000	$7,000	$380,000	$197,000	$394,000	$204,000
76	$162,000	$190,000	($28,000)	$380,000	$162,000	$324,000	$134,000
77	$194,000	$191,000	$3,000	$380,000	$194,000	$388,000	$197,000
78	$146,000	$163,000	($17,000)	$380,000	$146,000	$292,000	$129,000
27 to 78	$17,275,000	$11,025,000	$6,250,000	$20,505,000	$14,602,000	$35,107,000	$24,082,000

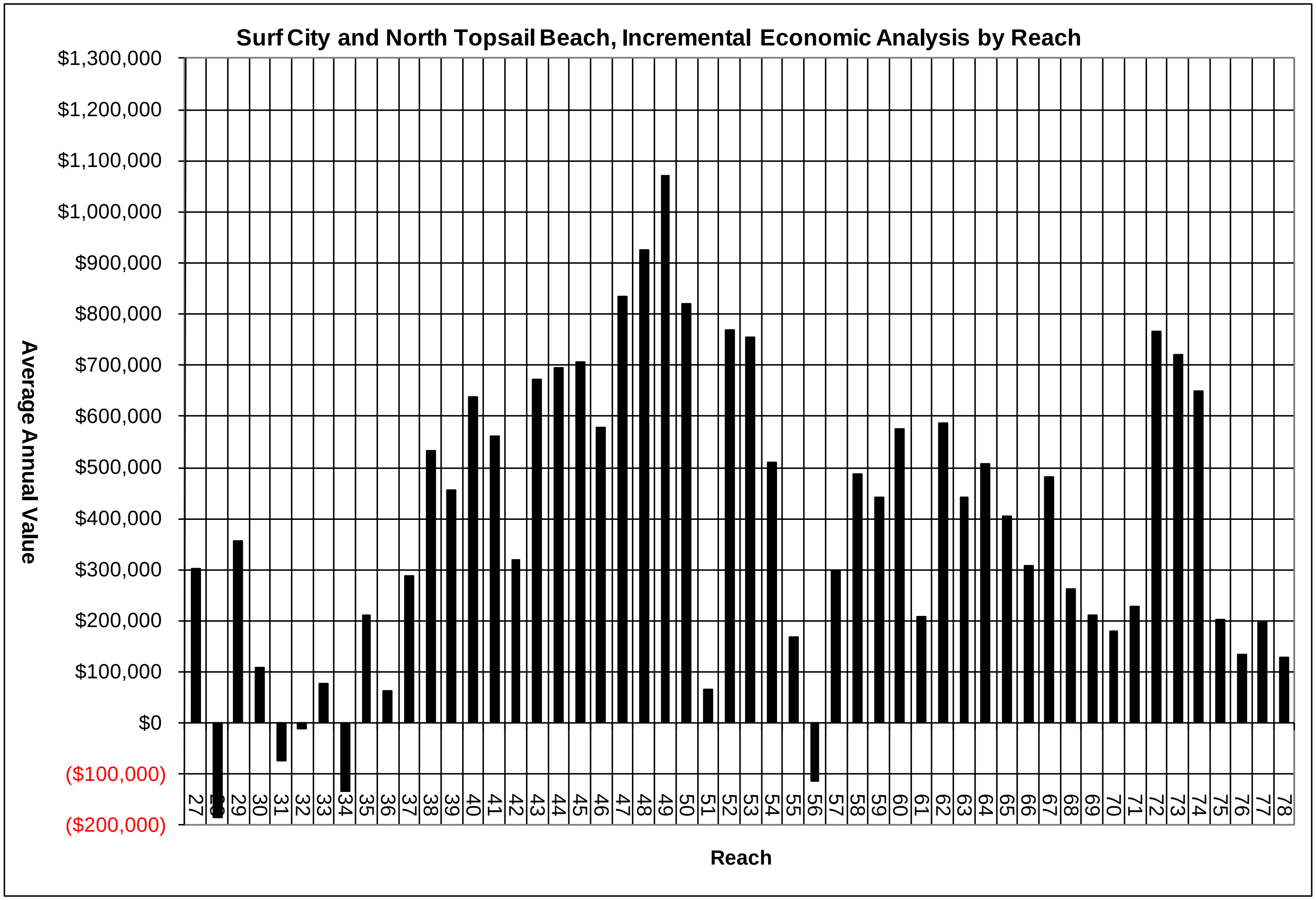


Figure 7.5. Net benefits by project reach.

7.10 Evaluation of Risk and Uncertainty

7.10.1 Residual Risks

The proposed beachfill plan would greatly reduce average annual storm damages. The selected plan, Plan 1550 would reduce combined wave and erosion damages by 88 percent. Some wave and erosion damages would still occur, estimated to average $2,241,000 per year over the 50-year period of analysis (Table 7.16). The project is designed to reduce damages mainly from storm waves and storm-induced erosion, two major categories of storm damage. The project would not prevent any damage from back bay flooding; therefore, any ground-level floors of structures, ground-level floor contents, vehicles, landscaping, and property stored outdoors on the ground would still be subject to saltwater flooding that flows in through New Topsail Inlet and New River Inlet and the back bay channels. However, flooding is a relatively minor issue in the first three rows of the island, which is where the benefits of the project are being measured. Flooding from all sources (back bay and ocean side) accounts for less than 1 percent of total expected damages to the first three rows in the without-project condition. Because the project is not claiming any benefits beyond the third row of the island, damages from flooding to structures past the third row have not been calculated. However, in major storm events, those structures could be subject to back bay flooding. Structures would also continue to be subject to damage from hurricane winds and windblown debris. Damages from flooding and winds would decrease as older structures are replaced with those meeting floodplain ordinances and wind hazard building construction standards. But even new construction is not immune to damage, especially from severe storm events. Also, the condition of the CSDR project at the time of storm occurrence can affect the performance of the project for that event.

The proposed beachfill would reduce damages but does not have a specific design level. In other words, the project is not designed to fully withstand a certain category of hurricane or a certain frequency storm event. The project purpose is storm damage reduction, and the berm-and-dune is not designed to prevent loss of life. Loss of life is prevented by the existing procedures of evacuating the barrier island completely, well before expected hurricane landfall and removing the residents from harm’s way. The erratic nature and unpredictability of hurricane path and intensity require early and safe evacuation. That policy should be continued both with and without the storm damage reduction project.

Table 7.16. Residual risks, average annual values, 50-year period of analysis, 4.125% interest rate, October 2010 price level

Plan	Residual damages	CSDR benefits
No Action	$19,061,000	$0
Plan 1550, NED	$2,241,000	$16,820,000

7.10.2 Risk and Uncertainty in Economics

GRANDUC's life cycle approach to plan formulation explicitly incorporates risk and uncertainty into the formulation process. Three significant variables in GRANDUC are programmed to incorporate uncertainty, namely the following:

- erosion distance – plus or minus 5.0 ft.
- structure distance – plus or minus 2.0 ft.
- structure elevation – plus or minus 0.1 ft.

Given the probabilistic nature of the analysis, the dune-and-berm alternatives were evaluated to determine the percent chance that the alternative would have positive net benefits, or conversely, the risk of having negative net benefits. On the basis of analysis of 1,000 life cycles, the Selected Plan (15-ft. dune elevation with 50-ft. berm) has a 99.8 percent chance of having positive net benefits (i.e., less than a 0.2 percent risk of negative net benefits in any given year).

7.10.3 Risk and Uncertainty in Borrow Availability

Enough material has been identified in the borrow areas to supply the initial construction and periodic renourishments over the 50-year life of the project, although the measured surplus of material is a relatively low percentage of the estimated total. However, a risk exists that during the latter renourishment cycles of the project, no more material would be available in the designated borrow areas. For example, factors such as accelerated rates of sea level rise (SLR) and higher storm frequencies could lead to a more than anticipated volume of borrow material being required during the renourishment cycles. Also, refining the borrow area boundaries during the PED stage of the study could indicate that less volume is available in the areas then originally estimated. If borrow material from the designated areas were to run out, additional borrow material would need to come from a different site or sites, at a potentially higher cost. If that scenario begins to develop, a Limited Reevaluation Report on borrow sources would be initiated. The scope of the Limited Reevaluation Report would be to identify additional suitable borrow sources and to conduct a feasibility analysis of remaining costs and remaining benefits over the expected life of the project. A strong possibility exists that additional borrow material is available and accessible both in the designated sites and further offshore. For example, in the current sites, beach quality material may be available at greater volume than anticipated from the investigation because of densification of sand material during the vibracore sampling process. Also, because borrow area boundaries were interpolated on the basis of a limited amount of vibracores, a possibility exists that during the PED phase when additional vibracores are taken additional borrow material might be available adjacent to the defined boundaries. One specific area of note is borrow area C, where the ancestral New Topsail River channel (fluvial paleochannel) cuts as deep as 60 ft. into the underlying lithology (Greenhorne and O'Mara 2004) and extends throughout the 1- to 5-mile investigation boundary, intersecting borrow areas A, B, and C. The cores conducted in the paleochannel (TI-V-132, 185, 186, 187, 188, 189, 197) indicate beach quality material is present at varying thickness (4 to 9 ft.) throughout the paleochannel.

For economic purposes in calculating project benefits, investigating the identified borrow areas was limited to about a 5.5 miles offshore boundary. No data exist as to the availability of borrow material beyond 5.5 miles; however, existing data from within the investigation boundaries indicate that the potential for additional sand resources exists beyond the 5.5 mile boundary. For example, cores that were taken in borrow areas C, E, F, G, and N that coincide with the 5.5-mile boundary indicate beach quality material. The cores include the following:

Borrow Area C

- TI-V-03-186: 3.3 ft. thick with an average silt content below 3.5 percent. 6.2 ft. thick with an average silt content of 5.5 percent
- TI-V-03-198: 3 ft. thick with an average silt content of 1.7 percent
- TI-V-03-199: 3 ft. thick with an average silt content of 1.4 percent

Between Borrow Area C and E

- TI-V-03-212A: 1.5 ft. thick with an average silt content of 1.8 percent
- TI-V-03-232: 1.8 ft. thick with an average silt content of 2.7 percent
- TI-V-03-239: 1.5 ft. thick with an average silt content of 3.6 percent

Borrow Area E

- TI-V-03-240: 2.8 ft. thick with an average silt content of 2.3 percent

Borrow Area F

- TI-V-03-245: 2.5 ft. thick with an average silt content of 1.6 percent
- TI-V-03-369: 3 ft. thick with an average silt content of 5.6 percent

Outside and within Borrow Area G

- TI-V-03-248: 1.4 ft. thick with an average silt content of 1.5 percent
- TI-V-03-255: 1.2 ft. thick with an average silt content of 0.7 percent
- TI-V-03-256: 2 ft. thick with an average silt content of 1.1 percent

Outside and within Borrow Area N

- TI-V-03-64: 1.5 ft. thick with an average silt content of 0.4 percent
- TI-V-03-63: 3 ft. thick with an average silt content of 1.2 percent

As illustrated by the data, the potential for additional beach quality material exists beyond the boundaries of the investigation. In terms of costs, going an additional mile offshore is estimated to increase unit costs by 4 percent, going 2 extra miles would increase costs by 9.7 percent, and going 3 extra miles would increase costs by 15.5 percent. The benefit-cost ratio of the project is high enough that going to an additional borrow area several miles further offshore should not affect the economic feasibility of the plan.

The towns of Topsail Beach and North Topsail Beach have also identified other offshore borrow areas, containing approximately 8 million cubic yards of sand, that they intend to use for their own, nonfederally funded beachfill projects. They are known borrow areas from which remaining material could be used, if necessary, for the federal projects.

On the basis of all the factors outlined above, it is unlikely that the project would encounter a situation where no more sand could be reasonably obtained. Therefore, the risk to the project from potentially not having enough suitable material in the defined borrow areas is considered to be minimal.

7.10.4 Risk and Uncertainty in Sea Level Rise Assumptions

Sea-level change can cause a number of effects on coastal in estuarine zones, including changes in shoreline erosion and changes in storm and flood damages. SLR rates over time are the subject of many predictions. Historical trends in Mean Sea Level (MSL) are determined using measurement data from tide gauge records. Tidal records from nearby National Ocean Service tidal station in Wilmington, North Carolina (No. 865810) show a historical trend of 0.008 ft. per year from 1953 to 1993. This feasibility study uses that historical SLR rate to formulate the NED plan. Climate research has documented global warming during the 20th Century and has predicted continued or accelerated global warming ultimately resulting in continued or accelerated rise in sea level. Corps, Engineering Circular EC 1165-2-211 provides the guidance for considerations of accelerated SLR for federal civil works projects. The guidance uses the updated National Research Council projections (updated from 1987) as well as using the Intergovernmental Panel on Climate Change (IPCC 2007b) Fourth Assessment Report guidelines. The guidelines were used to bracket a range of possible SLR for the Surf City and North Topsail Beach area. The modified National Research Council SLR projections include three scenarios resulting in three curves of SLR thru 2100. The curves represent global eustatic sea-level rise values of 0.5 m and 1.5 m over the next 125 years. To investigate the sensitivity of the NED Plan to SLR, Curves 1 and 3 were used to bracket estimates in SLR. The Curve 1 projection indicates an SLR of 0.8 ft. 50 years after construction (year 2064), while Curve 3 indicates 2.2 ft. of SLR in 2064. For comparison, the historic SLR rate projects about 0.4 ft. of SLR in 2064 (see Figure 7.6).

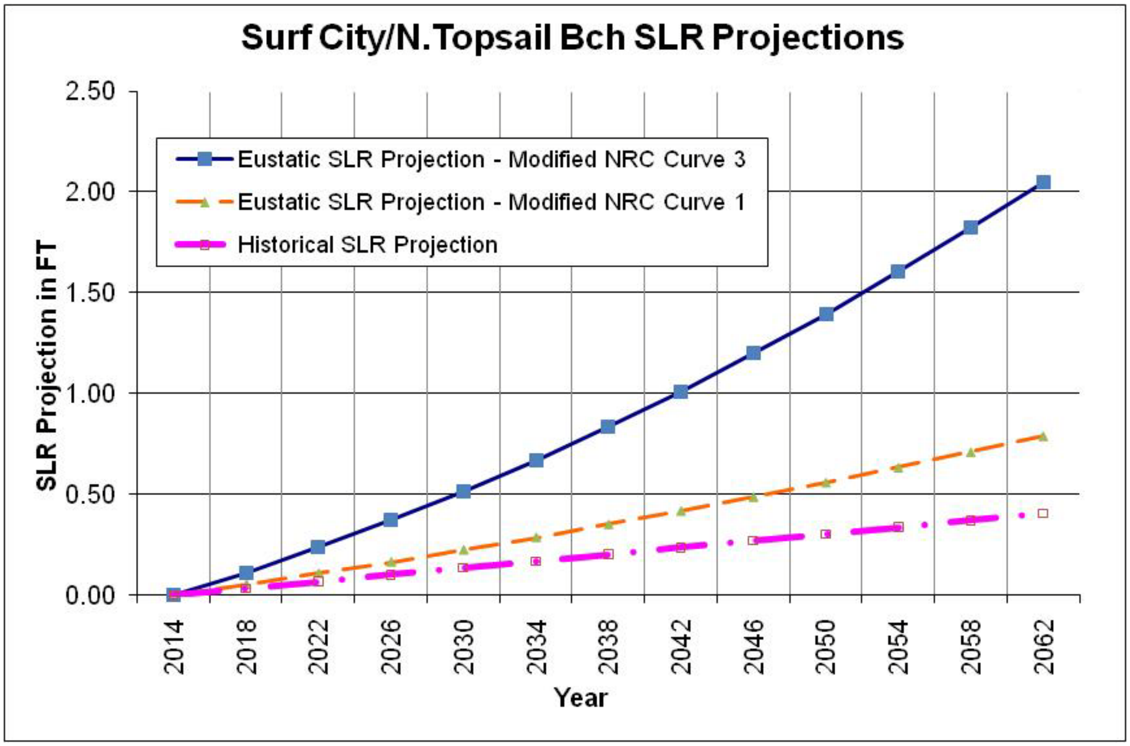


Figure 7.6. SLR projections

A sensitivity analysis of SLR effects on the NED Plan was conducted to estimate the with-project and without-project damages, benefits, and costs. The purpose of the sensitivity analysis was to determine if the project would still be economically feasible (greater benefits then costs) under higher rates of SLR, and not to provide project equivalent costs and benefits under the different scenarios. Note that the GRANDUC life cycle model does not allow a gradually occurring SLR, and therefore the sensitivity analysis represents a worst-case scenario in which total projected SLR over 50 years is immediately applied at year 1 of the modeling process. Full details of the analysis are included in Appendix D, Coastal Engineering. In summary, with accelerated SLR scenarios, the without-project damages are about six times greater than the with-project damages. Total project costs would increase 24 percent from additional erosion (using the most extreme estimate of 2.2 ft. of SLR over 50 years [NRC Curve 3] and worst case modeling scenario of it being applied all at the start of the project), but the project provides an additional 115 percent of damage reduction benefits. Realistically, since an immediate SLR of 2.2 ft is not possible, the actual increase in project costs would be much less than 24 percent, and therefore the chance of the project exceeding section 902 limits on the basis of accelerated sea level rise is extremely unlikely. A summary graph of the SLR scenarios analyzed and resulting modeling output is provided in Figure 7.7.

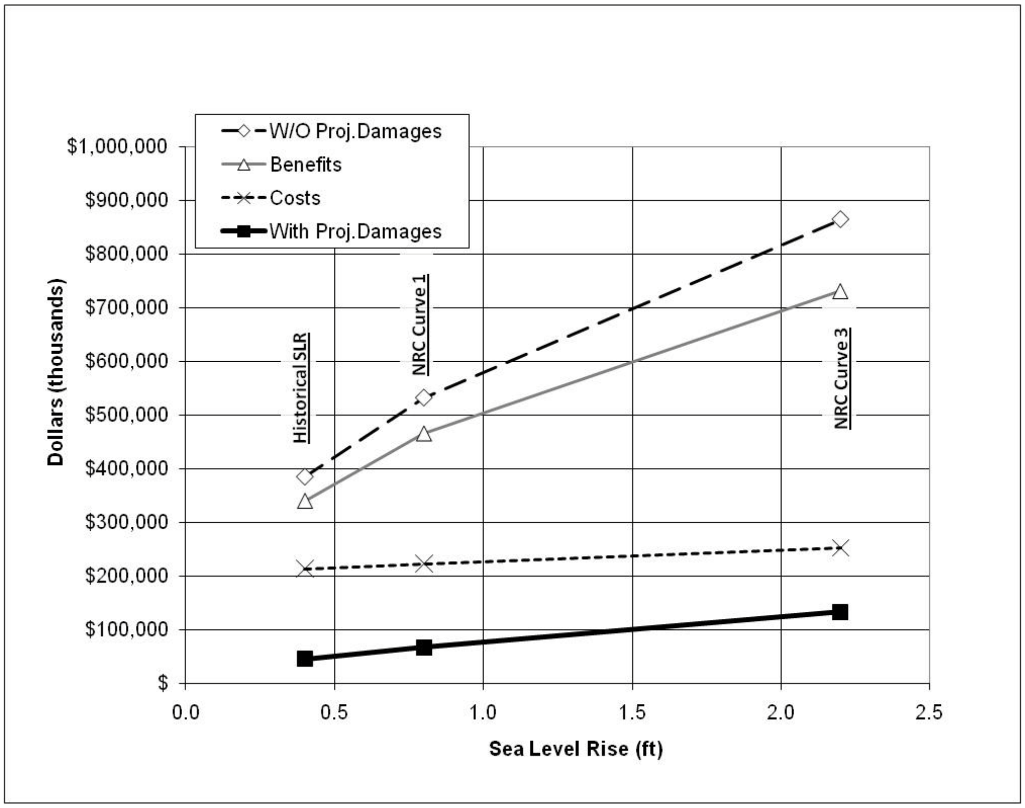


Figure 7.7. SLR effects on project economics.

The proposed beach nourishment project is not a hard structure and adjusts to natural forces. Regardless of the rate of SLR, the beach fill project would be monitored annually and renourished every 6 years. Monitoring data provides input to determining the details of each renourishment of the beach. If an accelerated SLR occurs, erosion volumes increase and renourishment volumes would increase, shortening the life of designated borrow areas. Under SLR Curves 1 and 3, approximately 1.4 million and 5.5 million extra cubic yards of material would be needed, respectively, over the life of the project (for more detail see Appendix D). If necessary, a Limited Reevaluation Report on borrow sources would be conducted to investigate additional borrow sources (see Section 7.10.3). All alternative plans contain a 7-ft. elevation berm, and all would be affected similarly by accelerated SLR. Therefore, no change to the Selected Plan by accelerated SLR would be expected other than minor modification of the berm elevation and possibly the dune elevation. There is no expectation that accelerated SLR would result in selection of other major categories of alternative plans such as the nonstructural plan or hard structure plans.

7.11 System of Accounts Evaluation

The plan selected for recommendation, Plan 1550, was based on the NED account alone. The plan is compared to the Nonstructural Plan and the No Action Alternative in Table 7.17. The plans are compared quantitatively in the NED account and qualitatively in the other three accounts—Regional Economic Development, Environmental Quality and Other Social Effects, as well in terms of risk.

Table 7.17. (1 of 7). System of Accounts, NED

Item	Beachfill	Nonstructural	No Action
Plan Description	Vegetated dune (elevation varies) fronted by nonvegetated, sandy beach berm at elevation 7 ft. NGVD, with beach then sloping to approximate natural slope. Includes NED Plan 15-ft elevation dune with 50-ft-wide berm. Specific amounts are shown for Plan 1550 at Oct. 2010 level of 4.125%.	Combinations of relocating existing beach structures either demolition, removal to new tract, or moving in same tract away from shoreline. Allow natural revegetation to occur on vacated lands on and landward of existing dune. Amounts for nonstructural plan shown for Oct. 2004 level at 5.375%.	No federal action, nor significant changes to existing nonfederal actions.
a. Damages Prevented (see Figure 7.8)	$16,820,000	$7,800,000	$0
b. Recreation Benefits	$20,505,000	$0	$0
c. Ben. During Construction	$2,804,000	$0	$0
d. Total Benefits	$40,129,000	$7,800,000	$0
e. Costs	$10,702,000	$30,200,000	$0
f. Net Benefits	$29,427,000	($22,400,000)	$0
g. Residual Damages	$2,241,000	$11,400,000	$19,061,000

Table 7.17. (*continued*) 2 of 7. System of Accounts, Regional Economic Development

Item	Beachfill Alternatives	Nonstructural Alternative	No Action
a. Sales Volume	Preserves rental sales and tourism markets.	Reduces rental market and tourism market.	Occasionally changes from tourism to reconstruction.
b. Income	Increased recreation visitation may improve the income of service industries.	Decreased recreation visitation may reduce the income of service industries.	Occasional loss of tourism income.
c. Employment	Preserves seasonal employment. Project construction employment increases during winter dredging months and when walkovers and dune vegetation are installed.	Minor reduction in employment related to maintaining structures and serving tourists. Increase in project construction employment during relocations and demolition.	Occasionally changes from tourism services to reconstruction.
d. Tax Changes	Tax base and property values preserved.	Moderate loss to tax base as front row structures and property are removed from property tax base and rental market.	Continued occasional storm losses to revenues, tax base and buildable lots.

Table 7.17. (*continued*) 3 of 7. System of Accounts, Other Social Effects, Part 1

Item	Beachfill Alternatives	Nonstructural Alternative	No Action
a. Security of Life, Health and Safety	Significant reduction in stress related to concern of amount of damage and recovery. Significant reduction in hazards associated with post-storm recovery and reconstruction.	Moderate reduction in stress related to concern of amount of damage and recovery. Moderate reduction in hazards associated with post-storm recovery and reconstruction.	No change. Continued stress during damaging storms.
b. Preservation of Life	No change. Evacuation required before storm landfall.	No change. Evacuation required before storm landfall.	No change. Evacuation required before storm landfall.
c. Community Cohesion	Reduces displacements of all permanent residents.	Permanently displaces oceanfront residents/visitors. Periodic displacement of other residents. Continued threat to Highway 50.	Occasional displacement of all permanent residents. Continued threat to Highway 50.
d. Community Growth	Growth trends in population and recreation visitation would continue.	No significant net change.	Occasional reductions in population and recreation visitation trends.

Table 7.17. (*continued*) 4 of 7. System of Accounts, Other Social Effects, Part 2

Item	Beachfill Alternatives	Nonstructural Alternative	No Action
e. Man-made Resources	Reduces risks to buildings, houses, and other structures.	Eliminates erosion risks to structures relocated. Demolishes those not suitable for relocation.	Continued erosion risks to buildings, houses, and other structures. Occasional replacement of heavily damaged structures.
f. Public Facilities	Reduces erosion and wave damages to streets and utilities nearest the shoreline.	Continued threat to streets and utilities near shoreline.	Continued threat to streets and utilities near shoreline.
g. Displacement of business	Reduces displacement of business.	Continued occasional disruption.	Continued occasional disruption.
h. Recreation and public access.	Improved appearance and utility of beach for recreation and requirement to maintain access for public. Infrequent storm litter.	Reduced lodging available for visitors. Continued narrowing of beach width. Infrequent storm litter.	Continued narrowing of beach width. Occasional littering of beach with storm debris.
i. Traffic and transportation	Prevents damage to streets and sole highway to Topsail Beach.	Continued risk to streets and highways. Major disruptions during house relocations.	Continued risk to streets and highways.

Table 7.17. (*continued*) 5 of 7. System of Accounts, Risk Evaluation

Item	Beachfill Alternatives	Nonstructural Alternative	No Action
a. Risk of Failure (risk that the project would not provide stated benefits)	Low. If renourishments occur on schedule, a beachfill plan should continue to provide reduction in damages. The selected plan has a 99.8% chance of having positive net benefits. There is also risk that borrow material from identified sources would run out in the future; however, additional nearby sources could be identified and used.	High. The benefits for this plan assume a high compliance rate, which is unlikely for beachfront properties.	N/A
b. Residual Risk (risk to structures and population once the plan is implemented)	Damages to structures would still occur from soundside flooding. In storms of greater intensity. Some wave and erosion damage would still occur. Structures are not protected from wind or windblown debris. There is still risk to loss of life if hurricane evacuation procedures are not followed.	Damages would still occur to structures from soundside flooding. Remaining structures would still be subject to wave and erosion damage, as well as wind damage. There is still risk to loss of life if hurricane evacuation procedures are not followed.	Damages to structures would not be reduced. There is still risk to loss of life if hurricane evacuation procedures are not followed.
c. Risk from accelerated SLR	Accelerated rates of SLR would increase project costs, but also increase project net benefits. Material running out in the identified borrow areas would be more likely to occur.	Accelerated rates of SLR would increase damages to remaining structures from waves, and erosion.	Accelerated rates of SLR would increase damages to all structures from waves and erosion.

Table 7.17. (*continued*) 6 of 7. System of Accounts, Environmental Quality, Part 1

Item	Beachfill Alternatives	Nonstructural Alternative	No Action
a. Ecosystem Restoration	Indirectly only, not an authorized project purpose.	Indirectly only, not an authorized project purpose.	No change.
b. Natural Resources	Increase in vegetated primary dune and upper beach habitat area.	Increase in undeveloped natural primary dune habitat.	Reduction of upper beach, dune, and upland habitat areas.
c. Biological Resources	Bottom substrate and bathymetry of nearshore ocean would be modified. Benthic organisms in borrow areas during dredging would be temporarily lost; however, recovery would be expectedwould be expected to occur within 1–2 years. Beach bulldozing very infrequently.	Occasional beach bulldozing and scraping would result in temporary losses to intertidal habitat and biota.	Occasional beach bulldozing and scraping would result in temporary losses to intertidal habitat and biota.
d. Threatened and Endangered Species	Reestablishment of beach and dune would benefit sea turtle nesting suitability and seabeach amaranth habitat. Hopper dredging offshore may increase risk of sea turtle take. Temporary loss to piping plover foraging habitat during construction.	Sea turtle nesting suitability would be reduced by continued erosion of beach, but improved by reduction of artificial lighting. No risk of incidental sea turtle take from hopper dredging. Improved piping plover conditions from reduced disturbance.	Continued erosion of beach would impact suitability and success of sea turtle nesting. No risk of incidental sea turtle take from hopper dredging. Continued loss of seabeach amaranth habitat. Piping plover foraging reduced occasionally by beach bulldozing.

Table 7.17. (*continued*) 7 of 7. System of Accounts, Environmental Quality, Part 2

Item	Beachfill Alternatives	Nonstructural Alternative	No Action
e. Water Quality	Temporary elevated turbidity during construction and renourishment in nearshore area and in off-shore borrow areas. Temporary impacts to benthic invertebrates feeding activities of shorebird and surf zone fish species.	No change.	No change.
f. Air Quality	Reduction offshore from dredging operations and onshore from earthmoving equipment.	Reduction during relocation and during demolition and hauling.	Occasional reduction during hauling of debris and reconstruction.
g. Noise Level Changes	Noise from mobilization/de-mobilization of equipment and pipeline. Noise from earthmoving equipment.	Noise during relocations, demolitions, and hauling.	Occasional noise from storm recovery and reconstruction.
h. Aesthetic Values	Improve appearance of beach and enhanced recreational quality. Temporary inconvenience during construction and renourishments, winter only.	More natural appearance of landscape immediately landward of dune on vacated properties. Continued deterioration of dune and beach appearance.	Continued deterioration of dune and beach appearance.
i. Cultural and Historical Preservation	No change, no such objects found in beach construction or borrow sites.	No change.	No change.
j. Total Quality of the Environment	Improvement of beach and dune. Temporary reduction during construction.	Short-term and long-term degradation of the beach and dune would continue. Increase habitat areas created landward of dune.	Short-term and long-term degradation of the beach and dune would continue.

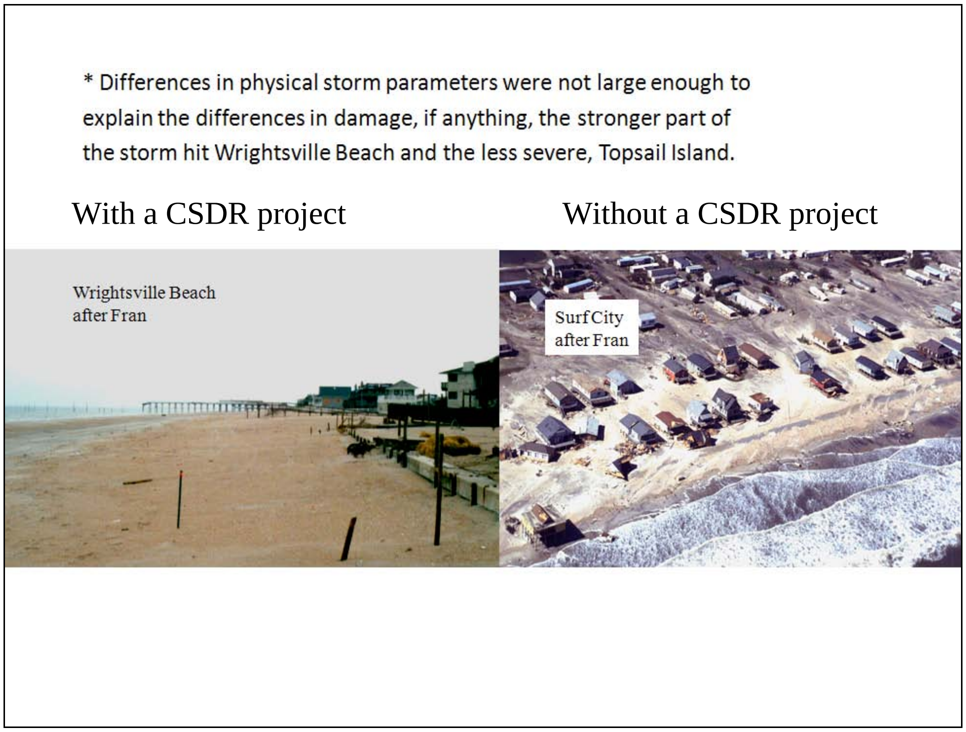


Figure 7.8. Example of differences in damages sustained in an area with and without a storm damage reduction project in place. (From USACE 2000).

8. ENVIRONMENTAL EFFECTS

The selected plan consists of a sand dune constructed to an elevation of 15 ft. NGVD, fronted by a 50-ft-wide beach berm constructed to an elevation of 7 ft. NGVD. The berm and dune project extends along a reach of 52,150 ft. Depending on endpoint conditions at the time of construction, up to 2,000 ft. of the berm and dune on the ends of the project could be replaced with a tapered transition section.

The proposed borrow sites are between 1 and 6 miles offshore at depths of 35 to 50 ft. MLLW. Initial construction would require 11.86 million cubic yards of borrow material. Renourishment would require 2.64 million cubic yards of borrow material at 6-year intervals. In total, about 32.3 million cubic yards of borrow material would be required for the 50-year project.

This section describes the probable consequences (impacts and effects) of the selected alternative on significant environmental resources in the project area. Natural communities that would be affected by the proposed action include the beach and dune and nearshore ocean as described below. Effects on wetlands and floodplains, inlets, flats, sounds and maritime shrub habitat would not be expected.

8.01 Marine Environment

8.01.1 Wetlands and Floodplains

The proposed borrow areas for the project are between 1 and 6 miles offshore; therefore, dredging operations would not be expected to adversely affect wetlands and floodplains of Surf City or North Topsail Beach. Nourishment operations would not be expected to adversely affect wetlands and floodplains. Section 10 includes additional discussion of wetlands and floodplains pursuant to Executive Order 11988 (Floodplain Management) and Executive Order 11990 (Protection of Wetlands).

8.01.2 Inlet, Flats, and Sounds

The proposed borrow areas for the project are between 1 and 6 miles offshore and would not be expected to adversely affect the inlet, flats, and sound of Surf City or North Topsail Beach. Because no sediment would be removed from the inlet complex for beach nourishment, impacts to inlet dynamics would not be expected. Although large quantities of sediment would be added to Surf City and North Topsail Beach to construct and maintain the project, the total volume of sediment added to the littoral system would not be expected to be significantly more than pre-project conditions. Furthermore, the southern and northern limits of the project are approximately 5 and 7 miles from New Topsail and New River inlets, respectively. Therefore, placing additional sediment on the beach would not significantly affect sand flat and shoal development in the inlet systems. The additional material would only accentuate the natural dynamics of the sand sharing system that exists. Therefore, nourishment operations would not be expected to adversely affect the inlet, flats, and sounds.

8.01.3 Surf Zone Fishes

The surf zone is a dynamic environment, and the community structure of organisms that inhabit it (e.g., surf zone fishes and invertebrates) is complex. Representative organisms of both finfish and the invertebrate inhabitants they consume exhibit similar recruitment periods. In North Carolina, the majority of invertebrate species recruit between May and September (Hackney et al., 1996; Diaz, 1980; Reilly and Bellis, 1978), and surf zone fish species recruit from March through September (Hackney et al., 1996). The anticipated construction time frame for the project is from December 1 to March 31 and would avoid a majority of the peak recruitment and abundance periods of surf zone fishes and their benthic invertebrate prey source.

The surf zone represents HAPC for some species, including adult bluefish and red drum, which feed extensively in that portion of the ocean. The surf zone is suggested to be an important migratory area for larval/juvenile fish moving in and out of inlets and estuarine nurseries (Hackney et al., 1996). Disposal operations along the beach can result in increased turbidity and mortality of intertidal macrofauna, which serves as food sources for those and other species. Therefore, feeding activities of the species could be interrupted in the immediate area of beach sand placement. Those mobile species are expected to temporarily relocate to other areas as the project proceeds along the beach. However, some species like Florida pompano and Gulf kingfish exhibit strong site fidelity during the middle portion (summer) of the nursery period (Ross and Lancaster, 2002) and might not avoid secondary effects (turbidity) of disposal. Because the project would avoid impacts to the surf zone during the summer months, it is expected that the project would not affect this period of strong site fidelity. Although a short-term reduction in prey availability could occur in the immediate disposal area, only a small area is affected at a time, and once complete, organisms can recruit into the nourished area. Such a recovery would begin immediately after disposal activity if the material is similar to the native beach (see Benthic Resources—Beach and Surf Zone Section 8.01.6).

According to Ross (1996) some surf zone fishes exhibit prey switching in relation to prey availability. Therefore, during periods of low prey availability, as a result of short-term impacts to the benthic invertebrate population during beach disposal activities, surf zone fishes may temporarily use alternative food sources. Considering the dynamic nature of the surf zone, such opportunistic behavior of avoidance and prey switching might enable some surf zone fishes to adapt to disturbances such as beach nourishment. A combination of short-term prey switching and temporary relocation capabilities may help mitigate short-term prey reductions during beach disposal operations. Once the placement operation is finished, physical conditions in the impact zone quickly recover and biological recovery soon follows. Surf-feeding fish can then resume their normal activities in the areas. That is supported in Ross and Lancaster's (2002) study in which Florida pompano and Gulf kingfish appeared to remain as long near a recently nourished beach as a beach that was not recently nourished.

Disposal and subsequent turbidity increases may have short-term effects on surf zone fishes and prey availability. However, the opportunistic behavior of the organisms within the dynamic surf zone environment enables them to adapt to short-term disturbances. Because of the adaptive ability of representative organisms in the area and the avoidance of peak recruitment and abundance time frames with a December 1 to March 31 construction time frame, such effects would be expected to be temporary and minor.

8.01.4 Larval Entrainment

For many marine fishes, spawning grounds are believed to occur on the continental shelf with immigration to estuaries during the juvenile stage through active or passive transport. According to Hettler and Hare (1998), research suggests two bottlenecks that occur for offshore-spawning fishes with estuarine juveniles: the transport of larvae into the nearshore zone and the transport of larvae into the estuary from the nearshore zone. During that immigration period from offshore to inshore environments, the highest concentration of larvae generally occurs in the inlets as the larvae approach the second bottleneck into the estuary. Once through the inlet, the shelter provided by the marsh and creek systems in the sound serve as nursery habitat where young fish undergo rapid growth before returning to the offshore environment.

Those free floating planktonic larvae lack efficient swimming abilities and are, therefore, susceptible to entrainment by an operating hydraulic or hopper dredge as they immigrate from offshore to inshore waters. However, all the proposed borrow areas are between 1 and 6 miles offshore, and none of the borrow areas are in the vicinity of the New River Inlet or New Topsail Inlet complexes. Therefore, though concentrations of larvae would likely be present within offshore borrow areas, dredging activities would not occur in the highest concentration *inlet bottleneck* areas.

Susceptibility to this effect of entrainment is largely dependent on proximity to the cutter-head or drag-head and the pumping rate of the dredge. Those larvae present near the bottom would be closer to the dredge area and would, therefore, be subject to higher risk of entrainment. Assessment of the significance of the entrainment is difficult. Assuming the very small volumes of water pumped by dredges relative to the total amount of water in the dredging vicinity, a small proportion of organisms are presumed to be affected. Potential reasons for low levels of impact include the extremely large numbers of larvae produced by most estuarine-dependent species and the extremely high natural mortality rate for early life stages of many fish species. Because natural larval mortalities might approach 99 percent (Dew and Hecht, 1994; Cushing, 1988), entrainment by a hydraulic dredge would not be expected to pose a significant additional risk in most circumstances.

An assessment of potential entrainment effects of the proposed dredging action may be viewed in a more site-specific context by comparing the pumping rate of a dredge with the amount of water present in the affected waterbody. For the purposes of this assessment, assumptions would be made that inlet bottlenecks would have the highest concentrations of larvae as they are transported into the estuarine environment from the nearshore zone. Larval effects of dredging in this *high-concentration* system would be significantly greater than the entrainment risk of dredging in offshore borrow areas. The larval fish distribution, abundance seasonality, transport, and ingress at Beaufort Inlet, North Carolina, has been extensively studied (Blanton et al., 1999; Churchill et al., 1999; Hettler and Barker, 1993; Hettler and Chester, 1990; Hettler and Hare, 1998). Therefore, it represents a good case study site for assessing larval entrainment of a hydraulic dredge. The largest hydraulic dredge likely to work in offshore borrow areas would have a discharge pipe about 30 inches in diameter and would be capable of transporting about 30,600 m^3 of sand per day if operated 24 hours (because of breakdown, weather, and the like, dredges generally do not work 24 hours a day, 7 days a week). The dredged sediment would be pumped as slurry containing about 15 percent sand and about 85 percent water by volume. The volume of water discharged would, thus, be about 173,000 m^3 per day, or about 2.0 m^3 per second. In contrast, the calculated spring tide flow through Beaufort Inlet (a representative North Carolina inlet) is approximately 142,000,000 $m^3 \times 2$ = 284,000,000 m^3 (i.e., two tides a day) of water and 264,000,000 m^3 during neap tide. Thus, the dredge would entrain only 0.06 to 0.07 percent of the daily volume flux through the inlet. According to Larry Settle (2002), the percentage of the daily flux of larvae entrained during a spring and neap tide is very low regardless of larval concentration and the distribution of larvae within the channel. Under the worst-case scenario with the highest concentrations of larvae possible based on spatial and temporal distribution patterns, the maximum percentage entrained barely exceeds 0.1 percent per day (for a more detailed analysis conducted by Larry Settle, see Appendix Q). Although any larvae entrained (calculations indicate 914 to 1.8 million depending on the initial concentration in the tidal prism) would likely be killed, the effect at the population level would be expected to be insignificant. On the basis of those calculations indicating an *insignificant* larval entrainment impact, at the population level, from hydraulic dredging activities within a representative high concentration *inlet bottleneck* at Beaufort Inlet, North Carolina, the risk of larval entrainment from dredging activities in the offshore borrow areas associated with this project would likely be even less and would not be expected to adversely affect marine fish larvae.

8.01.5 Nekton

Oceanic nekton are active swimmers, not at the mercy of the currents, and are distributed in the relatively shallow oceanic zone. They are composed of three phyla-chordates, mollusks, and arthropods, with chordates (i.e., fish species) forming the largest portion. Any entrainment of adult fish, and other motile animals in the vicinity of the borrow area during dredging would be expected to be minor because of their ability to actively avoid the disturbed areas. Fish species are expected to leave the area temporarily during the dredging operations and return when dredging ceases (Pullen and Naqvi, 1983). Larvae and early juvenile stages of many species pose a greater concern than adults because their powers of mobility are either absent or poorly developed, leaving them subject to transport by tides and currents. That physical limitation makes them potentially more susceptible to entrainment by an operating hydraulic dredge (see Section 8.01.4, Larval Entrainment). Benthic-oriented organisms close to the dredge draghead could be captured by the effects of its suction field and entrained in the flow of dredged sediment and water. As a worst-case, it could be assumed that entrained animals experience 100 percent mortality, although some small number might survive. Susceptibility to this effect depends on avoidance reactions of the organism, the efficiency of its swimming ability, its proximity to the draghead, the pumping rate of the dredge, and possibly other factors.

Behavioral characteristics of different species in response to factors such as salinity, current, and diurnal phase (daylight versus darkness) are also believed to affect their concentrations in particular locations or strata of the water column. Any benthic oriented organisms present near the ocean bottom (i.e., calico scallops and spiney dogfish (SAFMC-managed species) would be closer to the dredge draghead and, therefore, subject to higher risk of entrainment.

The biological effect of hydraulic entrainment has been a subject of concern for more than a decade, and numerous studies have been conducted nationwide to assess its effect on early life stages of marine resources, including larval oysters (Carriker et al., 1986), post-larval brown shrimp (Van Dolah et al., 1994), striped bass eggs and larvae (Burton et al., 1992), juvenile salmonid fishes (Buell, 1992), and Dungeness crabs (Armstrong et al., 1982). The studies indicate that the primary organisms subject to entrainment by hydraulic dredges are bottom-oriented fishes and shellfishes. The significance of entrainment effects depends on the species present; the number of organisms entrained; the relationship of the number entrained to local, regional, and total population numbers; and the natural mortality rate for the various life stages of a species. Assessing the significance of entrainment is difficult, but most studies indicate that the significance of impact is low. Effects of dredging activities on marine mammals and sea turtles are addressed in the biological assessment (Appendix I). Although entrainment of benthic oriented organisms would be expected from the proposed dredging activities, a hydraulic dredge operating in the open ocean would pump such a small amount of water in proportion to the surrounding water volume that any entrainment effects associated with dredging of borrow material for the project are not expected to adversely affect species at the population level. In accordance with T&E species observer requirements for hopper dredging activities (See appendix I), inflow screening, as well as observation of dredged material is required to assure accountability of species entrained by the draghead. As a component of hopper dredge observer requirements, all other biota (i.e., fish, bivalves) captured by the inflow screening are recorded and submitted to the Corps for incorporation into a historic entrainment database.

8.01.6 Benthic Resources—Beach and Surf Zone

Beach nourishment may have negative effects on intertidal macrofauna through direct burial, increased turbidity in the surf zone, or changes in the sand grain size or beach profile. Literature dating back to the early 1970s along the southeast coast indicate that opportunistic infauna species (e.g., *Emerita* and *Donax*) found in the nourished areas are subject to direct mortality from burial; however, recovery often occurs within one year (Hayden and Dolan, 1974; Saloman, 1984; Van Dolah et al., 1992; Van Dolah et al., 1993; Jutte et al., 1999) especially if compatible material is placed on the beach (Hayden and Dolan, 1974; Reilly and Bellis, 1978; Saloman, 1984; Nelson, 1989; Van Dolah et al., 1992; Van Dolah et al., 1993; Hackney et al., 1996; Jutte, P.C. et al., 1999; Peterson et al., 2000). In North Carolina, post-nourishment studies have documented similar reductions in abundance of coquina clams (*Donax* spp.), mole crabs (*E. talpoida*), and amphipods (*Haustoriid* spp.) immediately following disposal with recovery times persisting between one and three seasons after project construction depending on sediment compatibility (Reilly and Bellis 1983; Peterson et al., 2000; and Coastal Science Associates, Inc., 2002).

Reilly and Bellis (1978) state, "Beach nourishment virtually destroys existing intertidal macrofauna; however, recovery is rapid once the pumping operation ceases. In most cases, recovery should occur within one or two seasons following the project completion." Similar findings were reached by Van Dolah (1992) in a study of the effects of a beach nourishment project in South Carolina. A study by Dolan et al. (1992) of the effects of beachfill activities on mole crabs at the Pea Island National Wildlife Refuge, Dare County, North Carolina, indicates that while nourishment has a dramatic effect on mole crabs in the area where beachfill is placed, mole crabs returned to the beach areas that were nourished soon after pumping stopped.

While beach nourishment may produce negative effects on intertidal macrofauna, they would be localized in the vicinity of the nourishment operation. Beach nourishment conducted as a component of the proposed action would be expected to move along the beach at a relatively slow rate (i.e., about a mile per month or about 200 ft. per day). Such a rate of progress is slow enough that surf-feeding fishes and shorebirds can move to other areas that are not affected by the nourishment operation. As the dredging operation passes by a section of beach, that area is soon available for recolonization by invertebrates.

In a 1999 Environmental Report on the use of federal offshore sand resources for beach and coastal restoration, U.S. Department of Interior, MMS provided the following assessment of potential effects on beach fauna from beach nourishment.

> Because benthic organisms living in beach habitats are adapted to living in high energy environments, they are able to quickly recover to original levels following beach nourishment events; sometimes in as little as three months (Van Dolah et al. 1994; Levisen and Van Dolah, 1996). This is again attributed to the fact that intertidal organisms are living in high energy habitats where disturbances are more common. Because of a lower diversity of species compared to other intertidal and shallow subtidal habitats (Hackney et al. 1996), the vast majority of beach habitats are re-colonized by the same species that existed before nourishment (Van Dolah et al. 1992; Nelson 1985; Levisen and Van Dolah, 1996; Hackney et al. 1996).

As a component of their review of the potential effects of beach nourishment on surf zone fishes and invertebrates in the South Atlantic Bight, Hackney et al. (1996) identified nine fish species and five invertebrate species/groups that are important inhabitants of the intertidal and subtidal beach environment. According to their literature review of associated impacts to these species and how best to protect the natural resources associated with beach nourishment, they identified four management questions to address for each nourishment project: (1) project timing, (2) sediment compatibility, (3) nourishment duration, and (4) innovative ways to minimize effects (i.e., staging nourishment events). Those questions were considered during planning efforts associated with the proposed dredging and beach construction efforts for this project. The proposed dredging window of December 1 through March 31 for initial construction and each nourishment event avoids the identified peak recruitment periods for surf zone fish (March through September [Hackney et al., 1996]) and invertebrate species (May through September [Hackney et al., 1996; Diaz, 1980; Reilly and Bellis, 1978]) in North Carolina. Beach nourishment would therefore be completed before the onshore recruitment of most surf zone fishes and invertebrate species. Furthermore, to complete the full initial construction template, while adhering to the December 1 to March 31 dredging window, the construction effort would occur over a 4-year period. Therefore, the duration of each initial construction effort and each subsequent renourishment effort would be limited so that it does not preclude recruitment for any species during its entire recruitment period. Additionally, in accordance with recommendations provided by Hackney et al. (1996), the four initial construction events would occur in stages along the beach, with the full template being constructed for each stage, instead of the entire beach being affected within each construction event. This approach would also increase the speed of recovery for affected areas by allowing for recruitment from adjacent unaffected areas of the beach. To assure compatibility of nourishment material with native sediment characteristics and minimize impacts to benthic invertebrates from the placement of *incompatible* sediment, all sediment identified for use for the project would meet the *Technical Standards for Beachfill Projects* (15A NCAC 07H.0312) identified in the NCDCM rule language. During each renourishment interval, any loss of intertidal organisms would be temporary, as repopulation would be expected to begin as soon as the renourishment operation ends with recolonization of the beach by organisms from adjacent unaffected areas and offshore.

In summary, temporary effects on intertidal macrofauna in the immediate vicinity of the beach nourishment project would be expected as a result of discharges of nourishment material on the beach. While the proposed beach nourishment may adversely affect intertidal macrofauna, with the implementation of environmental measures discussed above, such effects would be expected to be localized, short-term, and reversible. Any reduction in the numbers or biomass (or both) of intertidal macrofauna present immediately after beach nourishment may have localized limiting effects on surf-feeding fishes and shorebirds because of a reduced food supply. In such instances, those animals may be temporarily displaced to other locations.

8.01.7 Benthic Resources—Nearshore Ocean

Individual borrow areas, or a combination of borrow areas, could be used for each construction event throughout the 50-year duration of the project. All the borrow areas are offshore of Topsail Island between 1 and 6 miles offshore. The offshore borrow areas beyond 3 nautical miles offshore would be subject to federal mining requirements of the MMS. Multiple dredging areas within a given borrow site may be used to reduce material transport or allow for concurrent operation of more than one dredge in an area. Considering the distance offshore and the shallow volumes of sediment within the borrow areas, it is anticipated that all dredging activities associated with initial construction and each renourishment interval would be conducted using a hopper dredge. Hopper dredges are mobile and are most productive dredging smaller depths of cut of approximately 3 ft. over larger areas rather than dredging to larger depths of cut over smaller areas, as is the case with hydraulic cutterhead dredges. The depth of hopper dredge cut would vary depending on the availability of suitable sandy material within each borrow area and dredge plant capabilities. On the basis of existing vibracore data, the anticipated average dredging depths for all borrow areas off of Topsail Island are provided in Table 8.1.

Table 8.1. Anticipated dredge cut depths and subsequent post-dredge surface elevations for borrow areas located offshore of Topsail Island based on vibracore data

Borrow area	Pre-dredge surface elevation (MLLW)	Post-dredge surface elevation (MLLW)	Thickness range	Average thickness
A	–38.5 to –49	–40.5 to –54.8	2 to 9.3	4.4
B	–42.2 to –43.2	–45.2 to –47.6	2 to 5.4	3.7
C	–45.5 to –47.7	–48 to –51	2 to 4.5	2.8
D	–43.5 to –46.9	–46.5 to –53.6	2 to 6.7	3.9
E	–49 to –50	–52.8 to –53	2.8 to 4	3.4
F	–47.2 to –48	–49.7 to –51	2.5 to 3	2.8
G	–46.5 to –49	–49.3 to –54	2 to 5.5	3.7
H	–44.4 to –45.2	–46.6 to –50	2.2 to 4.8	3.5
J	–42 to –47.4	–45.6 to –55	2 to 8.3	3.7
L	–42.3 to –47	–45.3 to –60.8	2 to 13.8	4.2
N	–43.6 to –46.7	–46.4 to –59.1	2.3 to 14.8	5.1
O	–40.6 to –43.9	–44.7 to –55	2 to 12.7	6.4
P	–39.5 to –40.5	–42.5 to –51	2 to 10.5	5.7
Q	–35.2 to –35.4	–39.6 to –41.2	4.2 to 6	5.1
S	–43.8 to –44.8	–46.1 to –47.7	2.2 to 3.5	2.6
T	–37.2 to –42	–40.4 to –49.2	2.2 to 8.6	4.2

A few outlier vibracores with compatible sediment thicknesses of 10.5, 12.7, 14.8, and 13.8 ft. were identified in borrow areas P, O, N, and L, respectively; however, insufficient vibracore data exists to assume that dredging depths significantly greater than the identified averages would be achieved. According to the existing pre-dredge depths and the anticipated average depths of material removed, post-project borrow area depressions would likely not exceed about 50 to 60 ft. of depth.

Because all proposed offshore borrow areas are beyond the –35-ft. contour and the proposed depth of closure for this project is –23 ft, significant infilling of the borrow areas as a result of longshore sediment transport processes would not be expected to occur. However, considering the shallow dredge volumes of material to be removed from the borrow areas, some infilling of sediments could still occur from other storm- and current-driven processes. Monitoring studies of post-construction borrow areas in the southeast indicated that borrow areas can fill in and return to near pre-dredging conditions when there is adequate transport of sediment under the influence of strong currents in the area (Bowen and Marsh, 1988). Although, some infilling of the borrow areas is anticipated from sedimentation and side sloughing, as well as wind- and tidal-driven currents, the bathymetric feature of the post-dredging borrow area would be expected to persist.

The post-dredge infilling rate and quality and type of the material are contributing factors to the recovery of the area dredged. Data collected by Saloman (1974) indicate that low densities and diversities of benthic fauna within the borrow area compared to control sites can be attributed to thick deposits of gelatinous, organic-rich sediments that lead to low dissolved oxygen concentrations. The MMS (1999) indicates that the bottom substrate at and near a borrow area can be modified in several ways. A change in bottom contour could be evident throughout the project life and post-construction populations can differ from pre-construction conditions. A change in the hydrologic regime as a consequence of altered bathymetry may result in the deposition or scour of fine sediments, which may result in a layer of sediment that differs from the existing substrate. Also, once material in the borrow areas is dredged, it is possible that different post-dredging underlying sediment types would be exposed and would be different from pre-dredging sediment types.

Benthic organisms within the defined borrow areas dredged for construction and periodic nourishment would be lost. However, recolonization by opportunistic species would be expected to begin soon after the dredging activity stops. Because of the opportunistic nature of the species that inhabit the soft-bottom benthic habitats, recovery would be expected to occur within 1–2 years. Rapid recovery would be expected from recolonization from the migration of benthic organisms from adjacent areas and by larval transport. Monitoring studies of post-dredging effects and recovery rates of borrow areas indicates that most borrow areas usually show significant recovery by benthic organisms approximately 1 to 2 years after dredging (Naqvi and Pullen, 1982; Bowen and Marsh, 1988; Johnson and Nelson, 1985; Saloman et al., 1982; Van Dolah et al., 1984; and Van Dolah et al. 1992). According to Posey and Alphin (2000), benthic fauna associated with sediment removal from borrow areas off of Carolina Beach recovered quickly with greater inter-annual variability than differences from the effects of direct sediment removal. However, a potential change in species composition, population, and community structure may occur from the initial sediment removal impact and the change in surficial sediment characteristics, resulting in the potential for longer recovery times (2–3 years) (Johnson and Nelson, 1985; Van Dolah et al., 1984). Differences in community structure may occur that may last 2–3 years after initial density and diversity levels recover (Wilber and Stern, 1992). Specifically, large, deeper-burrowing infauna can require as long as 3 years to reach pre-disturbance abundance. According to Turbeville and Marsh (1982), long-term effects of a borrow site at Hillsboro Beach, Florida, indicated that species diversity was higher at the borrow site than at the control site. Jutte et al. (1999 and 2001) evaluated recovery rates of post-hopper dredged borrow areas and found that hopper dredging creates a series of ridges and furrows, with the ridges representing areas missed by the hopper dredge. Rapid recolonization rates were documented because of the dredge’s inability to completely remove all the sediment. Furthermore, Jutte et al. (2002) documented that dredging to shallower depths is less likely to modify wave energy and currents at a borrow site; thus, reducing the likelihood of infilling of fine-grained sediment.

According to Cahoon et al. (1990 and 1992), primary production in Onslow Bay is characterized as being dominated by benthic microalgae, rather than phytoplankton. Therefore, Onslow Bay food web interactions with demersal zooplankton grazers are significant. However, on the basis of existing depths of the proposed borrow areas, the maximum post-dredging depth would likely not exceed about 60 ft. According to Dr. Cahoon (Larry Cahoon, personal communication, October 24, 2006), although a direct, short-term dredging impact would occur, benthic microalgae are very adaptable to disturbance, and the effects of dredging would likely be no more significant than large storm events. The chlorophyll *a* concentrations decrease as depth increases; however, solar irradiance at 60 ft. is not a limiting factor, and recruitment of benthic microalgae at the proposed post-dredging depths (maximum of ~60 ft.) would be expected to occur fairly quickly (about 4–6 weeks). Furthermore, microalgae biomass is less in the winter; thus, because the dredging window for initial construction and each nourishment interval is December 1 through March 31, biomass would be low during periods of impact and when the dredging window ends, spring time recruitment would begin (Larry Cahoon, personal communication, October 24, 2006)).

As identified in Section 8.01.8.2, dredging in the selected borrow areas would not be expected to have an adverse physical effect on any hard bottom in the area. Though secondary sedimentation effects could occur from dredging operations, they would likely not exceed natural sedimentation and burial levels, provided strict adherence to buffer requirements for all offshore activities. However, strong trophic linkages exist between hard-bottom communities and adjacent soft-bottom habitat. Though hard-bottom communities have been considered highly productive, self-sustaining habitats, the primary food resource of reef associated fishes is not solely supported by attached or associated motile benthic organisms. Data collected off North Carolina's Onslow Bay hard-bottom communities suggest that benthic microalgae are an important source of soft-bottom primary production supporting reef fishes (Lindquist et al., 1994). Benthic microalgae are concentrated at the sediment-water interface and are grazed by demersal zooplankton, meiobenthos, and many macrofaunal sand-bottom animals (Cahoon et al., 1990). According to Lindquist et al. (1994), gut content analysis of reef fishes indicated that an important benthic food chain connection between benthic microalgae concentrations, associated demersal zooplankton, and infaunal macroinvertebrates from sand substrata adjacent to hard-bottom communities are important to the diet of reef fishes. Therefore, rather than hard bottoms being self-sustaining communities, reef-associated predators depend adjacent soft-bottom communities for food. According to Posey and Ambrose (1994), benthic macrofaunal abundances near a rock ledge near Wrightsville Beach, North Carolina, indicated significantly higher abundances of total infauna, and of polychaetes, bivalves, isopods, and scaphopods, at a distance of 75 m (225 ft) from the rock ledge. Those data, suggesting a zone of decreased prey abundance (i.e., *halo*) adjacent to predator refugia, provide support for a trophic link between hard bottom ledges and soft bottom communities. On the basis of the proposed hard-bottom dredging buffer distances discussed in Section 8.01.8.2, dredging of sediment within the vicinity of hard-bottom resources (moderate and high relief – 500 m (1,640 ft.) buffer; low relief – 400 ft. (122 m)) would not be expected to directly affect this documented tropic link within the 75-m (225-ft) halo from the hard-bottom ledge.

Effects on estuarine-dependent organisms are not expected to be significant because construction-related activities in the offshore borrow areas and on beaches proposed for nourishment would be localized. A study of nearshore borrow areas after dredging offshore of South Carolina revealed no long-term effects on fishery and planktonic organisms, as a result of the dredging (Van Dolah et al., 1992). In a 1999 Environmental Report on the use of federal offshore sand resources for beach and coastal restoration, the U.S. Department of Interior MMS provided the following assessment of potential turbidity impacts.

> The impacts from turbidity on benthic organisms during dredging operations were reviewed in detail by Pequegnat et al. (1978) and Stern and Stickle (1978). Both studies concluded that impacts to the benthic populations of the marine ecosystem from turbidity are local and temporary but not permanent. Similarly, recent studies show that benthic impacts may be limited to the immediate vicinity of dredging operations (e.g., Hitchcock et al. 1998; MMS 1996).

8.01.8 Essential Fish Habitat

The FMP amendments of the SAFMC identify more than 30 categories of EFH and HAPC, which are listed in Table 8.2. Fish species managed by the SAFMC and their association with those categories of EFH and HAPC are identified in Table 8.2. While all those habitat categories occur in waters of the southeastern United States, only a few occur in the immediate project vicinity or the project impact zone. The proposed project would avoid direct effects on estuarine areas; therefore, only identified EFH and HAPC in marine areas might be directly affected. Effects on habitat categories potentially present in the project vicinity are discussed in the following subsections.

Table 8.2. Categories of EFH and HAPC and potential impacts

Essential Fish Habitat	**Potential presence**		**Potential impacts**	
Estuarine areas	**In/near project vicinity**	**Project impact area**	**Dredge plant operation**	**Sediment disposal activities**
Estuarine Emergent Wetlands	no	no	no	no
Estuarine Scrub/Shrub Mangroves	no	no	no	no
Submerged Aquatic Vegetation (SAV)	no	no	no	no
Oyster Reefs & Shell Banks	no	no	no	no
Intertidal Flats	no	no	no	no
Palustrine Emergent & Forested Wetlands	no	no	no	no
Aquatic Beds	no	no	no	no
Estuarine Water Column	Yes	no	no	no
Seagrass	no	no	no	no
Creeks	no	no	no	no
Mud Bottom	no	no	no	no
Marine areas				
Live/Hard Bottoms	Yes	Yes	W/in Acceptable Limits	no
Coral and Coral Reefs	no	no	no	no
Artificial/Man-made Reefs	Yes	no	no	no
Sargassum	offshore	no	no	no
Water Column	Yes	yes	W/in Acceptable Limits	W/in Acceptable Limits

Table 8.2. (*continued*)

<u>Geographically Defined HAPC</u>

Area-wide				
Council-designated Artificial Reef Special Management Zones	no	no	no	no
Hermatypic (reef-forming) Coral Habitat and Reefs	offshore	no	no	no
Hard Bottoms	Yes	Yes	W/in Acceptable Limits	no
Hoyt Hills	no	no	no	no
Sargassum Habitat	offshore	no	W/in Acceptable Limits	no
State-designated Areas of Importance of Managed Species (PNAs)	yes	no	no	W/in Acceptable Limits
Submerged Aquatic Vegetation (SAV)	no	no	no	no
North Carolina				
Big Rock	distant offshore	no	no	no
Bogue Sound	no	no	no	no
Pamlico Sound at Hatteras/Ocracoke islands	no	no	no	no
Cape Fear sandy shoals	No	no	no	no
Cape Hatteras sandy shoals	No	no	no	no
Cape Lookout sandy shoals	No	no	no	no
New River	Yes	no	no	no
The Ten Fathom Ledge	distant offshore	no	no	no
The Point	distant offshore	no	no	no

8.01.8.1 Effects on the Estuarine Water Column

All proposed borrow areas are approximately 1 to 6 miles offshore beyond 35-ft. MLLW; thus, dredging operations would not be expected to directly affect the estuarine water column, and therefore, would not be expected to directly affect estuarine life cycle requirements of managed species in the South Atlantic Region. However, the selected 1550 beach nourishment plan consists of a berm and dune project along a reach of 52,150 ft. Short-term, elevated turbidity levels could occur during the nourishment operation and could be transported outside the immediate disposal area via longshore and tidal currents. However, the nearest inlet (New River Inlet) is more than 7 miles to the north of the northern terminus of the project. Therefore, turbidity associated with the beach nourishment operation could extend into the New River Inlet vicinity and the estuarine water column from longshore currents and tidal influx; however, the associated effects would not be expected to be significant.

8.01.8.2 Effects on Hard Bottoms

Background

Hard-bottom communities are within state waters throughout the North Carolina coast, including the vicinity of the proposed SCNTB coastal storm damage reduction project. Depending on the location of these hard-bottom communities to the proposed project site, they could be vulnerable to shoreline alterations or dredging operations or both (Moser and Taylor, 1995). However, as discussed in Section 2.01.10 to develop a detailed understanding of the existing hard-bottom resources both in the nearshore and offshore environments of the project area, multiple contracts including remote sensing and in-situ ground-truth dive operations were implemented. That detailed hard-bottom resource data provided a better understanding of location and characterization of the sites relative to available sand resources. Thus, they enable the Corps to refine the limits of the identified borrow areas to avoid effects on the resources. To guide the decision process for collecting hard-bottom resource data, a PDT was developed to specifically discuss hard-bottom issues as a component of the project. The PDT consisted of state and federal resource agency representatives with an interest or expertise in hard-bottom communities. Also, concurrent with the resource evaluations being developed for the project, the town of North Topsail Beach and its consultant CPE were performing hard-bottom resource evaluations as a component of a separate nonfederal coastal storm damage reduction project for North Topsail Beach. To ensure consistency in the collection of resource data and avoid duplication of data-collection efforts, representatives of CPE were also included in the PDT. Members of the team provided comment on the development of scopes of work for each field investigation contract to ensure that all concerns for the data-collection procedures were addressed before task completion. On completion of each consecutive contract, the PDT was briefed of the results, and comments were solicited to identify what data gaps still existed and what actions were still necessary to assure avoidance of hard-bottom resource effects in both the nearshore and offshore environment as a component of the beach profile equilibration and dredging processes, respectively. The consistent coordination of hard-bottom resource evaluations among the PDT throughout the planning process of the project ensured team concurrence on what steps were necessary to fulfill critical data gaps and resulted in a detailed understanding of hard-bottom resource location and characterization throughout the project area.

On the basis of the hard-bottom resource evaluations completed in both the nearshore and offshore areas of Surf City and North Topsail Beach, actions associated with both the nearshore beachfill template construction (including hopper dredge pumpout stations and associated pipeline routes), and the associated offshore dredging operations, were refined to avoid effects on identified hard-bottom communities. Therefore, no direct effects associated with the physical dredging operation or associated construction activities (i.e., pipeline route) would be expected to occur. Potential project effects relative to the beachfill construction and associated equilibration process in the nearshore environment and the dredging and associated sedimentation and turbidity in the offshore environment are discussed below.

Nearshore (< –7 m [–23 ft.] NGVD)

The long-term and short-term limits of cross-shore sediment transport are important in engineering and environmental considerations of beach profile response. Significant quantities of sand-sized sediments can be transported and deposited seaward as a result of short-term erosional events and the equilibration of a constructed beach profile. Over time, the evolving profile advances seaward into deeper water until it approaches equilibrium; however, sediment particles can be in motion at greater depths than those at which profile readjustment occurs. The seaward limit of effective profile fluctuation over long-term time scales is referred to the *closure depth*. On the basis of calculations derived from the Corps Coastal Engineering Manual (2002), the calculated Depth of Closure for this study is –7 m (–23 ft.) NGVD. On the basis of the remote sensing data collected in the –7 m (–23 ft.) contour and the in-situ diver ground-truth investigations of identified anomalies from the remote sensing data, no hard-bottom features were identified in the calculated depth of closure for the study. The anomalies identified from the side-scan and multibeam survey results were not hard-bottom resources but regions of course gravel and shell hash that extend as shallow, depressional features perpendicular to shore. Ground truth dive investigation transects were specifically in traverse transitional areas identified in the side-scan sonar data. Divers were able to capture video of the transitional regions of sediment grain size, and sediment samples were gathered both in and outside the features to confirm that the side-scan sonar acoustic signature documented a transition from fine- to course-grained sediment, not consolidated, hard-bottom features. Such RSDs, RCDs, and sorted bedform features are common throughout North Carolina and are thought to be the result of a feedback mechanism whereby an existing deposit of coarse shell hash and gravel material is built on and segregated from fine material because of wave motion interacting with the enhanced roughness of the seafloor bed around those patches of coarse material (Cacchione et al., 1984; Thieler et al., 1999; Thieler et al., 2001; Murray and Thieler, 2004).

On the Pacific Coast, Cacchione et al. (1984) identified surficial sedimentary features of the shoreface and inner shelf environments with slight topographic expressions (~1 m (3.28 ft.) total relief) about 100–200 m (328–656 ft.) wide and extending hundreds to thousands of meters in the cross-shore direction. Those features were composed of course sand (in some cases shell hash and gravel) and arranged into large wave-generated ripples. Termed, RSDs the features are attributed to areas of intensified cross-shore flow that preferentially winnow fine material, leaving a course lag parallel to flow. Similar geologic features were later identified throughout the Atlantic Coast, including off the coast of North Carolina and South Carolina (McQuarrie, 1998; Thieler et al., 1999; Thieler et al., 2001).

According to McQuarrie (1998), an approximately 102 square km area was surveyed using side-scan sonar, high-resolution seismic, and vibracores on the shoreface and inner shelf of Onslow Bay. The study characterized the inner shelf off Topsail Island as Tertiary and Pleistocene outcrops with a thin, discontinuous, loose surficial sheet of sediment. In addition to continuous quaternary fluvial channels traced shore perpendicular across the shore face, wave and current action on the shoreface generates RCDs on the shoreface. Vibracore and surface sediment samples in and outside the features were consistent with RSD sediment data identified in other studies (Cacchionne et al., 1984; Thieler et al., 1999; Thieler et al., 2001).

Side scan imagery from Theiler et al. (1999) identified subtle shore oblique bathymetric expressions of high acoustic reflectivity dominating the shoreface and inner shelf of Wrightsville Beach, North Carolina, and Folly Beach, South Carolina. The depressional features had 1-m (3.28-ft.) vertical relief across widths of hundreds of meters and were associated with RSDs as defined by Cacchione et al. (1984). According to Thieler (1999), individual RSDs were approximately 40–100 m (131–328 ft.) wide on Wrightsville Beach, North Carolina, and Folly Beach, South Carolina, and are up to 1-m (3.28-ft.) deep on the upper shoreface, but have a much more subdued (~50 cm (~1.6 ft.)) bathymetric expression further offshore. Most depressions develop just outside the surf zone at 3–4 m (9.8–13.1 ft.) water depth and extend into the inner shelf at 15 m (49.2 ft.). Vibracore data from Thieler et al. (2001) indicate that these RSD features are floored by course sand, shell hash, and quartz gravel and are surrounded by areas of fine sand. The study sites appear to be relatively stable or represent a recurring, preferential morphologic state to which the seafloor returns after storm-induced perturbations. The apparent stability is interpreted to be the result of interactions at several scales that contribute to a repeating, self-reinforcing pattern of forcing and sedimentary response that ultimately causes the RSDs to be maintained as bedforms responding to both along and across shore flows. According to Dr. Bill Cleary (personal communication), the presence of RSDs/RCDs/sorted bedforms as identified through side-scan imagery off Topsail Beach are ubiquitous from Topsail Beach through Wrightsville Beach. Side-scan sonar imagery identifying the same features exists for Figure Eight Island and Lee/Hutaff Island.

Murray and Thieler (2004) reviewed data within Wrightsville Beach, North Carolina, RSDs and did not find any significant offshore-directed currents as identified by Cacchione et al. (1984), suggesting the dominance of along-shelf transport rather than cross-shelf flow. The depressional features are independent of geologic factors and are a result of oceanographic process such as the interaction of waves, mean currents, and poorly sorted bed material in a moderately high-energy environment. Because their observations suggested the dominance of along-shelf transport rather than cross-shelf flow and transport, Murray and Thieler (2004) adopted the term *sorted bedforms* to describe the features off Wrightsville Beach and elsewhere.

The North Carolina Marine Fisheries, Environmental Management, and Coastal Resources Commissions adopted the *North Carolina Coastal Habitat Protection Plan* (CHPP) was adopted by in December 2004. The CHPP identifies six types of habitats that produce North Carolina's coastal fisheries resources consisting of shell bottom, sea grasses, wetlands, hard bottoms, soft bottoms, and the water column. RSDs are identified as soft-bottom habitat in chapter 6 of the CHPP under the subsection titled Ocean Intertidal Beaches and Subtidal bottom:

> The surf zone is the shallow subtidal area of breaking waves seaward of the intertidal beach. Within the surf zone, longshore sandbars frequently develop and shift seasonally in response to wave energy. Seaward of the surf zone, the subtidal bottom consists of a series of minor ridges and swales. Ripple scour depressions, ranging from 40–100 m (130–330 ft) in width and up to 1 m (3 ft) in depth, occur along the southern portion of the coast and are perpendicularly oriented to the beach, extending to the base of the shoreface (Thieler et al. 1995; Reed and Wells 2000). These features are located adjacent to areas experiencing chronic severe beach erosion, and may be indicative of rapid offshore transport of sand during storms (Thieler et al. 1995).

According to the CHPP, RSDs are not considered EFH, HAPC, PNA or Strategic Habitat Area. Though soft-bottom habitat is probably the most resilient to physical alterations because of its lack of structure and dynamic nature, it plays a vital role as nursery and foraging grounds for fish and invertebrate species. During the equilibration process, nourished sediment from the constructed berm could gradually move within the RSD/RCD/Sorted Bedform features; however, it is likely that the features would be maintained as a preferential morphologic state through the repeating, self-reinforcing pattern of forcing and sedimentary response, which causes the features to be maintained as sediment starved bedforms responding to both along- and across-shore flows (Thieler et al., 2001). Therefore, it is expected that benthic organisms normally associated with soft- and coarse-grained sediments in the nearshore environment would not be significantly altered by the project. The RSD/RCD/Sorted Bedform data collected off of Wrightsville Beach, North Carolina, a beach with a long nourishment history, further suggests that those features are self-reinforcing, independent of beach construction activities. Additionally, a significant amount of historic side-scan data has been collected offshore of Topsail Island (1992, 1994, and 1996) (Rob Thieler, personal communication, March 1, 2007; McQuarrie, 1998). This historic data matches well with the 2006 side-scan data collected by Geodynamics, providing some additional insight to the offshore extent and stability of these features. Because the data are spread over a 15-year time frame and imagery still matches well, it appears that the features are fairly stable, at least over a decadal time frame (Rob Thieler; personal communication, March 1, 2007); thus, further suggesting that the features are maintained by the localized interaction of oceanographic processes and poorly sorted bed material.

Though, according to Thieler et al. (1999) it is possible that sedimentation occurs beyond the –7-m (–23-ft.) depth of closure calculated for SCNTB, the available information of hard bottom off the coast of Topsail Island indicate that the hard-bottom areas of influence are low lying and ephemeral (USACE, 2008, 2004a, 2003; Moser and Taylor, 1995) and associated sedimentation would not affect high-relief, significant hard bottom. Biological characterization of low-relief, hard-bottom habitats in the nearshore and offshore environment of SCNTB confirmed that the species associated with low-lying features are more adapted to sediment loading associated with the ephemeral nature of such systems, and, therefore, would not experience effects greater than existing natural conditions. Therefore, no burial of exposed hard bottom features would be expected to occur in the nearshore environment as a result of the constructed beachfill template and associated beach profile equilibration process. Though surveys and diver ground truth efforts did not identify hard bottom within the –23-ft. depth contour, it is anticipated that any selected pipeline corridor and associated pumpout anchor point features could extend approximately 2,500 to 3,000 ft. offshore into areas that were not surveyed. Therefore, because of ephemeral nature of the low-relief, hard bottom features in the nearshore environment and that pipeline corridors and pumpout stations may be outside the surveyed areas, the Corps intends to survey all potential pipeline corridor routes before construction to avoid potential hard-bottom features.

Offshore (> –7 m (–23 ft.) NGVD)

As identified in Section 2.01.10, preliminary investigations of hard-bottom communities throughout each proposed borrow area were identified using high-resolution, side-scan sonar and delineated as *low*-, *moderate*-, and *high*-relief, in accordance with Moser and Taylor (1995) and Moser et al. (1995). Follow-up diver ground-truth efforts confirmed their presence and characterized the associated biota. To ensure protection of the hard-bottom resources from the physical dredging operation and the associated sedimentation and turbidity, the contractor applied a conservative approach when delineating hard-bottom features from the side-scan sonar acoustic signature data. For example, areas where hard bottom was interspersed with large areas of sediment, a line was drawn around the entire area to define the limits of the hard-bottom feature instead of delineating each individual feature. It is important for reviewers of those hard-bottom data to be aware of that conservative methodology and not assume that all the delineated features are large, consistently exposed hard-bottom platforms. In some instances, the delineated limits of a hard bottom area could consist of several very small pinnacles of low-relief and highly ephemeral outcroppings rather than a persistent hard-bottom platform. Furthermore, although the delineation of hard-bottom resources from the acoustic signature data incorporated high-, medium-, and low-relief classification, ground truth diver verification of the sites confirmed that no high-relief hard bottom was identified, and most of the mapped areas consist of low-relief hard bottom. As a component of the ground-truth effort, transect locations were specifically placed to traverse predefined areas of medium and high relief; however, divers confirmed that the areas were predominantly low-relief systems.

Biological characterization data of offshore hard-bottom resources were evaluated using the Benthic Ecological Assessment for Marginal Reefs (BEAMR) model developed by CPE. That methodology for characterizing benthic communities has been implemented throughout Florida and for the nonfederal North Topsail Beach coastal storm damage reduction project. The BEAMR methodology samples three core characteristics in each sample quadrant: (1) physical characteristics (including maximum sediment depth), (2) abiotic and biotic percent cover, (3) and coral density. During BEAMR surveys, biologists look for indications of natural sediment movement stress. Visual inspections include indentifying whether benthic organisms are being, or have recently been, stressed. Visual inspections include observations and evaluation of stress indicators such as standing sediment not removed by normal currents or wave actions. As identified in Table 8.3, sediment loading was evident in all sampled transects.

Table 8.3. Physical characteristics of hard bottom at each transect

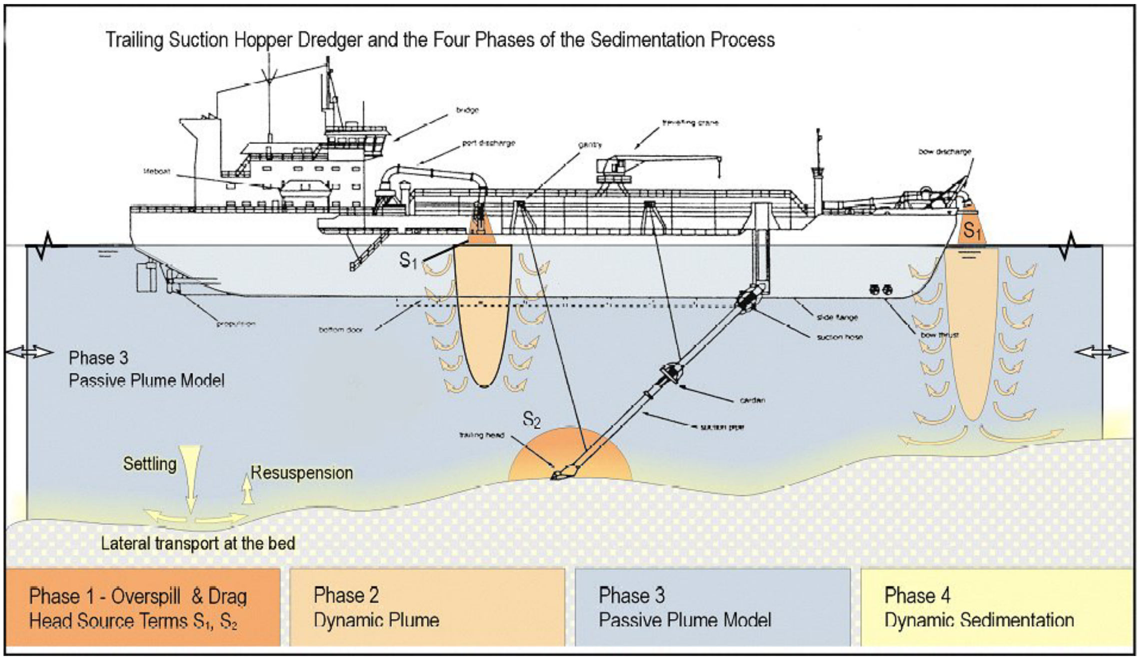
	Transect										
Physical Parameters	**G1**	**G3**	**J2**	**L1**	**L2**	**O1**	**O3**	**O4**	**T1**	**T3**	**T4**
Number of Quadrants Surveyed	10	10	9	10	10	10	10	10	14	10	10
Number of 100% Sediment Quadrants	0	5	6	1	2	4	3	7	0	2	4
Percent Sediment Cover	27.4	60	90	33	35	43	46	30	46	55	48
Average Sediment Depth (cm)	4.7	6.8	8.3	3.3	2.1	4.5	4.3	6	2	4.5	6.2

Overall, most hard-bottom areas investigated in the proposed borrow areas of the study were characterized by a combination of moderate- and low-relief habitats. Most areas included some regions of relatively moderate-relief rock outcroppings or ledges that were able to support adult *Oculina* sp. colonies and high cover by tunicates and sponges, and other areas of lower relief that were subject to more frequent burial and were characterized by low stony coral cover and higher cover by fast growing corals. The lower relief areas identified in each borrow area appeared to be more ephemeral. The increased benthic diversity and high numbers of adult *Oculina* sp. found on ledges and crevices are likely the result of protection from ambient sedimentation offered by the vertical and overhanging surfaces. The persistent growth of organisms on those protected surfaces compared to the flat surfaces suggests a natural environment with high sedimentation. Details of the results are in Attachment 4 of Appendix R.

Additional benthic characterization data of the nearshore and offshore environment collected by CPE in 2005 and 2006, for the adjacent non-Federal North Topsail Beach Coastal Storm Damage Reduction Project, also suggest a high-sedimentation environment. In some instances, heavy sediment and particulate loading observed in the water column during summer and fall sampling periods prevented divers from completing flora and fauna surveys. Furthermore, in June 2005 CPE marine biologists confirmed hard bottom at two sites that were later found covered with more than 60 cm (1.9 ft.) of mud during subsequent October 2005 dives. The ephemeral nature of many of the sites was also confirmed through a comparison of side-scan sonar, hard-bottom edge digitization from 2005 to 2006, which indicated a change in exposed hard bottom by as much as 3 acres.

Hopper Dredge—Sedimentation and Turbidity

During dredging operations, hard bottom within the vicinity of offshore borrow areas can be affected by turbidity and sediment plumes generated from filling and overflow of the hopper dredge depending on the characteristics and suspension time of the sediment being dredged. Because of the distance offshore and the limited thickness of available sediment in the proposed borrow areas for the project, all dredging activities are expected to be performed using hopper dredge. Hopper dredge suction dragheads hydraulically remove sediment from the sand bottom and discharge the material into the storage hoppers on the dredge. The screened sandy material fills the hopper until an economic load is achieved for transit and subsequent pumpout to the beach placement location. As illustrated in Figure 8.1, the operation has two types of sedimentation and turbidity sources: S1 from the overflow (which for most U.S. dredges now is through the bottom of the hull) and S2 associated with suspension of sediment at the draghead. During filling of the hopper, any fine sediments (primarily silt, clays, and fine-sands) are washed overboard through *overflow* ports (i.e., S1) either over the side of the vessel or through *weirs* that release the slurry through the hull of the vessel. Such *washing* of the dredged material is the predominant source of turbidity plumes and sedimentation generated by the hopper dredge. Some turbidity would be expected from the physical interaction of the draghead with the bottom substrate (i.e., S2) during the dredging operation; however, it would not be expected to be significant considering most of the disturbed sediments would be confined to the suction field of the hopper dredge dragheads and would be dredged and disposed into the hopper. Sediment discharged overboard from the hopper overflow moves faster than would be anticipated from simple Gaussian models because of the settlement velocity of component particles. That is because of high sediment concentration and discharge rate of the overflowed material, factors that lead to the development of a density current that moves through the water column in a *dynamic phase* of settlement, at least initially. Sediment is stripped away as the dynamic plume moves through the water column forming a passive plume that is advected and dispersed by ambient currents, with the particles settling according to Gaussian models (MMS, 2004).



Source: MMS, 2004

Note: This figure shows two S1 sources at overflows from a screening operation; in almost all U.S. dredges, the S1 source is through the bottom of the hull.

Figure 8.1. Hopper dredge sedimentation processes..

Hitchcock and Drucker (1996) summarized values for material lost through the overflow process on a typical 4,500 ton hopper dredge operating in U.K. waters. Results from the study indicate that during an average loading time of 290 minutes, 4,185 tons of dry solids are retained as cargo, while 7,973 tons of dry solids are returned overboard from overflow. Sand-sized particles fall directly to the seabed and are reduced to background levels over a distance of 200–500 m (656–1,640 ft.) and smaller, silt-sized particles have a typical settling velocity of 0.1 to 1.0 mm/s and are reduced to background values of 2–5 milligrams per liter (mg/L) over a similar distance. According to Neff (1981, 1985), concentrations of 1,000 mg/L immediately after discharge decreased to 10 mg/L within one hour. The minimal effect of settling particles from hopper dredge turbidity plumes was further supported by a study from Poopetch (1982), which found that the initial hopper dredge overflow concentrations of 3,500 mg/L were reduced to 500 mg/L within 50 m (164 ft.).

The distance that sediment plumes can extend depends on the type of dredge, how it is operated, currents, and the nature of the sediments in the dredged area. As discussed in Section 7.03.6, only beach-compatible, sandy sediments would be used for this project in accordance with the North Carolina sediment compatibility rules. Dredging of sandy sediments would minimize the amount of turbidity and sedimentation associated with the dredging operation and would reduce the suspension time and advection distance of overflow sediments. A study performed by Newell and Siederer (2003) in the U.K. (high-current velocities) showed that, in most cases, coarse material up to sand-size particles settles within 200 m (656 ft.) to 600 m (1,968 ft.) of the point source of discharge, depending on depth of water, tidal velocity, and the velocity of flow from the discharge pipe. During hopper dredging operations in the Baltics, Gajewski and Uscinowicz (1993) noted that the main deposition of sand from hopper dredge overflow was confined to distances within 150 m (492 ft.) on each side of the dredge. The study further supported that the initial sedimentation associated with overflow material behaves like a density current where particles are held together by cohesion during the initial phase of the sedimentation process and are mainly confined to a zone of a few hundred meters from the discharge chutes. According to a plume dispersion model developed by Whiteside et al. (1995) (based on field study measurements obtained while hopper dredging in Hong Kong waters), the contours for sediment deposition remain as a narrow band extending for approximately 100 m (328 ft.) on each side of the vessel, consistent with that recorded by Gajewski and Uscinowicz. As a component of the sedimentation associated impacts to hard bottom from hopper dredging in adjacent borrow areas offshore of Bal Harbor, Florida, Blair et al. (1990) recorded elevated sediment levels at about 335 m (1,100 ft) from the borrow area when dredged sediment had a higher silt/clay composition.

Though elevated turbidity levels could occur from hopper dredging overflow, the overflow process occurs only during the physical dredging operation. Because maximum load efficiency would be attained before transit to the pumpout location, overflow of material would not be expected to occur once the dredging process is complete. Therefore, although the hopper dredge might transit over hard-bottom locations in route to the beach, no significant turbidity or sedimentation would be expected to occur during the process. Once at the pumpout location, all turbid water generated by the hopper dredge slurry for pumpout would be retained in the hopper.

Hard-Bottom Buffer

As discussed in Section 2.01.10, the North Carolina hard-bottom buffer rule language (NCAC 07H. 0208(b) (12)(A)(iv)) states, “Mining activities shall not be conducted on or within 500 meters of significant biological communities, such as high relief hard bottom areas. High relief is defined for this standard as relief greater than or equal to one-half meter per five meters of horizontal distance.” Adherence to a 500-m (1,640-ft.) buffer for high-relief hard bottom, as defined in the North Carolina state rule language (NCAC 07H. 0208(b) (12)(A)(iv)), would be adhered to. However, implementing a 500-m (1,640-ft.) buffer for all delineated hard bottom (i.e., including low and medium relief) would result in a reduction of available sediment to a volume that is less than that required for the 50-year life of the project. To provide sufficient compatible sand resources for the 50-year project while minimizing impacts to hard bottom resources, a 122 m (400 ft.) dredging buffer around the low relief hard bottom (< 0.5 m [1.6 ft.]) in the offshore borrow sites would be implemented; while still adhering to the 500-m (1,640-ft.) buffer for moderate- and high-relief hard bottom (as defined by MATER report [Appendix U]). State and federal resource agency representatives from the NCWRC, NCDMF, and NMFS concurred with that dredging buffer proposal on the basis of an evaluation of all the Surf City and North Topsail Beach hard-bottom resource data collected by the Corps. Furthermore, implementing a 122-m (400-ft.) buffer around low relief is consistent with the recommended buffer distances in Florida, which recommends a 122-m (400-ft.) dredging buffer around all hard bottom, including coral reefs, in its state dredging permit conditions. Additionally, that buffer recommendation is consistent with the decision made by the PDT for the non-federal North Topsail Beach Coastal Storm Damage Reduction project, which allowed dredging within 122 m (400 ft.) of all identified hard-bottom resources. A discussion of Florida's buffer recommendation and associated project specific monitoring results are provided below:

Florida's 122-m (400-ft.) Dredging Buffer
Beach nourishment in southeast Florida is commonly accomplished by dredging sand deposits from between offshore coral reefs and moving the sand to shore. As a component of Florida Department of Environmental Protection (FLDEP) permit process for coastal storm damage reduction and dredging projects, a 122 m (400 ft.) buffer distance for hopper dredging in the vicinity of coral reef and hard-bottom communities is recommended as a guideline in the permit conditions for dredging projects. However, site-specific and project specific circumstances are considered for each permit request and expansions of the recommended buffer distances are considered on the basis of the site context (i.e., 183-m (600-ft.) buffer recommendation for projects with high silt content). The establishment of that buffer distance recommendation by FLDEP is based on a history of lessons learned from previous projects with myriad different buffer distances and associated monitoring of sedimentation impacts. Historically, 46-m (150-ft.) dredging buffer distances from hard bottom were considered adequate for cutterhead dredging operations. However, for hopper dredge operations, buffer recommendations ranged from 46 m (150 ft.) to 76 m (250 ft.) with site-specific effects ranging from no effect to significant effect depending on the site and the project. In 1998 significant effects were documented for the Bal Harbor (Miami-Dade county) dredging project, which resulted in a reconsideration of the recommended buffer distance and the development of improved techniques for monitoring coral sedimentation stress by developing a visual stress index (Vargas-Angel et al., 2006). On the basis of lessons learned from previous projects, FLDEP later implemented a 122-m (400-ft.) dredging buffer distance from hard-bottom communities, and the state monitoring of coral stress now incorporates histological and visual investigations of coral response to dredging associated sedimentation. Modifications to that buffer recommendation are pursued for individual projects depending on habitat quality and site- and project-specific conditions (i.e., currents, sediment quality) of the project area.

As a component of the Town of Reach 7, Phipps Ocean Park Beach Restoration project (Lybolt and Tate, 2003; Delaney et al., 2006)), pre-, during-, and post-construction biological monitoring was required to assess dredging impacts to adjacent coral reef. Project permits mandated to Palm Beach implement a program to monitor sedimentation rates, baseline biological conditions of live organisms, and coral stress associated with hopper dredging within 122 m (400 ft.) of barrier coral reef formations. Analysis of the collected data demonstrated that project associated turbidity, sedimentation, and coral stress did not exceed previously defined threshold criteria used to assess impacts to offshore hard-bottom resources (Delaney et al., 2006). In 2005 Broward County, Florida, constructed 10.9 km of beach using a hopper-dredge and moving 1.9 million cubic yards of sand from five different sand borrow areas as close as 122 m (400 ft.) from offshore coral reefs. A visual stress index was developed for three coral species to monitor a real-time response of stony corals to potentially increased sediment-induced stress environment during the dredging process. An average stress index threshold was developed to allow for cessation of dredging at specific borrow areas if the stress threshold is exceeded. However, the threshold shutdown criteria were not exceeded throughout the project (Lou Fisher, personal communication, July 24, 2008). As a component of the Boca Raton Beach Restoration Project conducted in 1988, a 3-year environmental monitoring program was implemented to monitor potential impacts to the surrounding hard-bottom habitats. On the basis of the data collected, the environmental conditions at the offshore hard-bottom monitoring stations did not appear to be affected by the dredging efforts associated with the restoration project. The borrow areas were between two offshore hard-bottom zones and associated dredging was separated from the patch hard-bottom zone by a minimum of 122 m (400 ft.) and from the barrier hard-bottom zone by 305 m (1,000 ft.) The average sedimentation rates recorded during the construction and post-construction phases were less than the background, or pre-construction sedimentation rate.

Summary

As identified through the myriad investigative studies discussed in Section 2.01.10 to identify and avoid nearshore and offshore hard-bottom resources, the Corps has demonstrated a commitment to avoidance and minimization of impacts to hard-bottom communities. Early in the planning process, a PDT composed of state and federal resource agency representatives was developed to identify and discuss key concerns specific to hard-bottom resource concerns and develop appropriate avoidance and minimization guidelines. These avoidance efforts include eliminating three borrow areas, I, K, and M, from the project design because of the discovery of significant hard-bottom resources within and adjacent to the proposed borrow areas. Furthermore, in coordination with the PDT, specific dredging buffer guidelines were developed and incorporated into the borrow area design providing appropriate buffer distances from the dredging and associated overflow activities to the varying hard-bottom resource areas. Specific buffer requirements include adherence to a 500-meter, hard-bottom buffer around high- and moderate-relief hard bottom, as defined in NCAC 07H. 0208(b)(12)(A)(iv)), while implementing a 122-m (400-ft.) buffer around low-relief hard bottom (based on hard-bottom mapping data provided by MATER [Appendix U]).

Recognizing that it is too costly to ground truth, delineate, and map all hard-bottom resources throughout each borrow area, the Corps requested mapping of low-, moderate-, and high-relief hard bottom from the side-scan sonar data collected by the MATER contract. A conservative approach to mapping the resources was used to limit the amount of dredging activities in and around patchy hard-bottom resources. For example, if multiple anomalies were identified to be hard bottom throughout an area, the entire feature was identified instead of separating each individual anomaly. Furthermore, although the best effort was made to differentiate low-, moderate-, and high-relief hard bottom from the remote sensing data, the exact relief patterns were not revealed until ground-truth efforts were pursued. As a component of the ground-truth effort, transect locations were carefully selected to traverse the transition areas of previously identified by MATER as low-, moderate-, and high-relief hard bottom. In some instances, the ground-truth efforts did not support the moderate- to high-relief classifications defined by

MATER, but rather site-specific maximum relief points of low to moderate relief with an average of low-relief features throughout the study area. Therefore, when adding the additional data from the ground-truth efforts of the offshore hard-bottom communities to the previously mapped hard-bottom features on the basis of side-scan interpretation, it becomes apparent that the hard-bottom mapping provided by MATER using side-scan sonar is a very conservative effort.

Although in-situ dive efforts confirmed that areas previously defined as high-relief hard bottom were actually moderate or low relief, for those areas that have not been ground truthed, the North Carolina 500-m (1,640-ft.) buffer requirement is still included to offer sufficient protection of potentially more stable hard-bottom resources associated with higher relief systems. However, a buffer distance of 122 m (400 ft.) for hopper dredging within the vicinity of lower relief systems throughout all borrow areas associated with this project would be implemented. The plan is consistent with that developed by the PDT, and addressed in the EIS, for the adjacent nonfederal coastal storm damage reduction project proposed for North Topsail Beach, North Carolina (USACE, 2007). The rationale for establishing a buffer zone limit of 122 m (400 ft.) for low–relief, hard-bottom resources in the project area instead of the state standard of 500 m (1,640 ft.) (15A NCAC 07H.0208(b)(12)(A)(iv)) is based on lessons learned from 40 years of dredging experience in less turbid south-Florida waters adjacent to sensitive coral reef systems where site-specific borrow area buffer zones ranging from 76 m (250 ft.) to 122 m (400 ft.) have proven effective in protecting hard bottom and coral reef habitats. On the basis of the species list provided from the in-situ dive investigations offshore of Surf City and North Topsail Beach, North Carolina, and the natural sediment loaded nature of this hard bottom system, it is apparent that the species are more adapted to sedimentation than the reef-building coral species of Florida. The potential turbidity and sedimentation effects associated with proposed activities are not expected to significantly different than those associated with disturbances from natural storm events.

On the basis of the available information pertaining to the dredged sediments, hopper dredge overflow activities, and associated potential turbidity plumes, and implementing a 122-m (400-ft.) to 500-m. (1,640-ft.) buffer distance depending on relief, no significant impacts would be expected from the sedimentation and turbidity associated with the proposed dredging activities. The potential impacts to the hard-bottom communities would not be expected to exceed the natural sedimentation and turbidity conditions of the project area.

Monitoring

Silent Inspector (SI)—Automated Dredge Plant Monitoring System

To ensure that the dredgers adhere to the required buffer distance and to avoid physical impacts to hard-bottom resources, the Corps would require all dredges to implement the SI automated dredge plant monitoring system. The SI Program is a Corps-dredging industry partnership for automated dredging monitoring of Corps dredging projects. Onboard sensors monitor dredge activities, operations, and efficiency. Data are routed to the SI Support Center for data retrieval and storage; contract managers, dredge inspectors, biologists, and others can use Corps-provided software to monitor performance and ensure environmental compliance. SI produces many different reports including dredge location history, volume history, disposal location history, and operational status. It also helps monitor all aspects of dredge operations from contract compliance to assurance that the operation is being performed in an environmentally safe manner. In addition to providing detailed tracking information of dredge location, SI also tracks the hopper dredge displacement status throughout the entire dredging operation, including hopper filling, transit, and pumpout. Therefore, the potential for any leakage of sediment through the hopper during transit can be tracked to assure accountability of any misplaced material. If material is misplaced, the Corps would take appropriate coordination and mitigative action. Additional information and specifications regarding the SI is at: http://si.wes.army.mil/.

Although it is unlikely, if a physical impact by the hopper dredge dragheads on previously unexposed hard bottom occurs, the exact location of impact would be recorded using SI. The Corps would direct the dredge to move to a new borrow area or different portion of the existing borrow area to avoid additional risk of impact. The incident would be thoroughly documented and coordinated with the appropriate state and federal resource agencies. On the basis of the outcome of such coordination, appropriate action would be taken to investigate and mitigate potential impacts.

Nearshore Hard Bottom Monitoring—Pipeline Corridor

As discussed in Section 8.01.8.2 and Appendix R, Attachments 2-4, significant of remote sensing and ground truth diver survey efforts were conducted between the shoreface and –23 ft., and no hard-bottom resources were identified. It is anticipated that any selected pipeline corridor for hopper dredge pumpout during construction could extend from the shoreface to approximately 2,500 to 3,000 ft. offshore. Considering the ephemeral nature of the low-relief, hard-bottom features in the nearshore environment and the potential for low-lying outcrops to occur within the pipeline corridor distance requirements and associated dredge and pipeline anchor points, the Corps intends to survey all areas associated with potential pumpout and pipeline corridor requirements before construction to avoid impacts to hard-bottom features. All existing remote-sensing and ground-truth data would be used in combination with the new survey data. All information associated with the surveys, data analysis, identification and mapping of pipeline corridors, appropriate buffers, and such, and subsequent measures developed to avoid resource impacts would be coordinated with the resource agencies before construction.

Offshore Hard-Bottom Sedimentation Monitoring

As a component of the November 2007 EIS for the permitted non-federal North Topsail Beach Coastal Storm Damage Reduction Project, prepared by CPE for North Topsail Beach, an agency-approved sedimentation monitoring plan was provided. Detailed methodologies for documenting potential sedimentation impacts from the dredging operation on offshore hard bottom were discussed. As a component of the agency coordination for the federal coastal storm damage reduction project (August 28, 2008, PDT meeting), agency representatives requested that similar sedimentation monitoring methodologies be applied for the federal project in the event that monitoring for the nonfederal project is not completed before beginning the federal project. If monitoring for the nonfederal project is completed before beginning the federal project and no sedimentation impacts are documented from dredging with a 122 m (400 ft.) buffer, no additional monitoring as a component of the federal project would be implemented. Because multiple borrow areas would be used throughout the 50-year project and dredging would not occur within the vicinity of hard-bottom communities at all times, during-project monitoring of sedimentation impacts from dredging activities would not occur until dredging within the proposed 122-m (400-ft.) buffer would be required. Details of the proposed sedimentation monitoring plan, based on methodologies developed by CPE (USACE, 2007b), are provided below. Specific contract monitoring requirements and subsequent scope of work would be circulated for agency concurrence before implementation.

Marine resource investigations of the offshore communities conducted by ANAMAR and CPE in March 2007 included establishing 12 temporary transects throughout five borrow areas (G=2; J=2; L=2; O=3; and T=3). A representative sample of those 12 sites would be established as permanent transects before construction. Additional control transects would be established before construction for comparison purposes to determine changes in community cover or possible sedimentation effects from dredging activities on proximate hard bottom. Monitoring stations would include stainless steel pins that would be installed into the hard bottom using a hammer or drill at 5.0 m (16.4 ft) spacing along each of the permanent transects.

Sediment monitoring at the offshore transects would occur before, during, and, if necessary, after construction and would include (1) installing sediment traps (collectors) (Figure 8.2) and (2) in-situ sediment depth measurements. Sediment collectors would be installed on both ends of the transects and could consist of a replaceable 2–liter, high-density polypropylene (HDPE) bottle with a triple PVC tube lid, installed in a permanent housing. The three-tube lid is screwed onto the top of the bottle for collecting settling particles. The collector design allows sediment from the water column to enter through the open tubes and accumulate in the collector.


Figure 8.2. Sediment trap permanently installed at each end of a monitoring transect.

During each monitoring event, the HDPE bottle is removed and replaced with empty bottles, and the lid is checked for biofouling and replaced or cleaned if blocked. The contents in each of the sediment bottles would be combined to produce a composite sample in the lab. Each composite sample would be dried and mechanically sieved to determine both the dry weight of the sample (in milligrams) and the silt/clay fraction (the material that passed through a No. 200 U.S. standard sieve). The resulting weights are divided by the area of the tubes open to the water column and the number of days the trap was in place. The area of the tubes used to calculate the sedimentation rates would be adjusted if one or more of the sediment traps is lost or if debris/organism growth is observed in the collector tubes preventing unrestricted access to the collection jar. The offshore monitoring transects adjacent to the borrow area would be installed and sampled for sedimentation biweekly for 2 months before construction (weather and sea state conditions permitting) and once every 2 weeks for the initial 2 months of construction. If sediment accumulation at the compliance transects is > 10 percent of the sediment accumulated on average per day at the three control sites, the Corps would direct the contractor to stop dredging operations within the 122-m (400-ft.) buffer and move to another area 500-m (1,640-ft.) from the identified hard-bottom sites. Dredging would not be allowed to resume within the 500-m (1,640-ft.) buffer until measures can be implemented to reduce sedimentation impacts to adjacent hard bottom resources, such as no hopper dredge overflow within 500 m (1,640 ft.) from hard bottom. All monitoring data would be coordinated with appropriate state and federal resource agencies throughout the construction process, and all proposed modifications of the dredging operation to minimize sedimentation impacts would be coordinated before implementation.

8.01.8.3 Effects on Reef-forming Corals

Hermatypic, or reef-forming, corals consist of anemone-like polyps occurring in colonies united by calcium encrustations. Reef-forming corals are characterized by the presence of symbiotic, unicellular algae called zooxanthellae, which impart a greenish or brown color. Because those corals derive a very large percentage of their energy from the algae, they require strong sunlight and are, therefore, generally found in depths of less than 150 ft. They require warm water temperatures (68 °F to 82 °F) and generally occur between 30° N and 30° S latitudes. Off the East Coast of the United States, that northern limit roughly coincides with northern Florida; however, they can occur off the North Carolina coast. As identified in Section 2.01.10, extensive limestone and siltstone hard-bottom communities have been identified in the offshore borrow areas of the proposed action. As a component of the in-water diver benthic characterization of the communities, *Oculina* sp. were identified in each surveyed transect. However, the percentage of *Oculina* sp. relative to other functional groups identified along the transects ranged from 0.3 to 3.7 percent. *Oculina* colonies identified were predominantly small recruits (1 cm); however, some of the higher-relief outcroppings or ledges supported larger adult colonies.

Oculina sp. range from Cape Hatteras, North Carolina, through the Gulf of Mexico and Caribbean. Oculina Banks, off east-central Florida, are the area of main concern and have been identified as an HAPC. Colonies are semi-isolated, patchy, and low growing in shallow water; however, they form larger, massive coalescing aggregates with substantial topographic relief in 160 to 330 ft. (50-100 m) depth (http://www.nmfs.noaa.gov/pr/pdfs/species/ivorytreecoral_detailed.pdf). Though *Oculina* colonies were identified in the project area, as discussed in section 8.01.8.2, buffers would be incorporated to avoid sedimentation and turbidity effects associated with hopper dredging activities. Therefore, though *Oculina* sp. are present in the project vicinity, appropriate buffers have been incorporated into the project design to avoid impacts to the species.

8.01.8.4 Effects on Artificial/Manmade Reefs

North Carolina, Department of Environment and Natural Resources, NCDMF Artificial Reef Program manages six reefs that are offshore of Topsail Island. They are AR 355, AR 360, AR 362, AR 364, AR 366, and AR 368. With the exception of AR 360, which is offshore of Topsail Beach about 2.5 nautical miles from the New Topsail Inlet sea buoy, all those sites are offshore of the proposed borrow sites and are not within the immediate project area. Therefore, dredging and placement of material associated with the Surf City and North Topsail Beach Coastal Storm Damage Reduction Project would not be expected to adversely affect artificial reef sites managed by the Artificial Reef Program.

8.01.8.5 Effects on Sargassum

Benthic and pelagic *Sargassum* sp. are found within the vicinity of the proposed project area. *Sargassum filipendula* is a benthic species of *Sargassum* and is often the predominant macrophyte in nearshore areas where *Sargassum* beds grow subtidally in moderately exposed or sheltered rocky or pebble areas near hard bottom or coral reef communities (Schneider et al., 1991). Pelagic *Sargassum* sp. occur in large floating mats on the continental shelf, in the Sargasso Sea, and in the Gulf Stream. Most pelagic *Sargassum* circulates between 20° N and 40° N latitudes and 30° W longitude and the western edge of the Florida Current/Gulf Stream and forms a dynamic structural habitat with a diverse assemblage of marine organisms including fungi, micro- and macro-epiphytes, at least 145 species of invertebrates, 100 species of fishes, four species of sea turtle, and numerous marine birds. It is a major source of productivity in a nutrient-poor part of the ocean. Unregulated commercial harvest of *Sargassum* for fertilizer and livestock feed has prompted concerns over the potential loss of this important resource.

As discussed in Section 2.01.10, in-water benthic characterization surveys (i.e., BEAMR) of offshore, hard-bottom communities were completed by ANAMAR Environmental Consulting, Inc., and CPE in March 2008. In-situ dives were conducted along 12 representative transects throughout the proposed offshore borrow areas. Benthic *Sargassum* sp. were identified as a dominant macroalgae in almost all surveyed transects. Though benthic *Sargassum* sp. are dominant macroalgal species in vicinity of the dredging operation, their presence is associated with the hard-bottom attachment substrate. Because dredging buffers have been incorporated into the project plan to avoid impacts to hard-bottom communities, dredging operations would be expected to avoid direct and indirect impacts to benthic *Sargassum* sp.

Pelagic *Sargassum* is positively buoyant and, depending on the prevailing surface currents, would remain on the continental shelf for extended periods or be cast ashore. Therefore, pelagic *Sargassum* species could be transported inshore from the Gulfstream and drift through the vicinity of the dredge plant operation. Because it occurs in the upper few feet of the water column, it is not subject to effects from dredging or sediment disposal activities associated with the proposed action (SAFMC, 1998.); thus, effects from the dredging or disposal operations would not be expected to be significant.

8.01.8.6 Effects on the Marine Water Column

The potential water quality effects of dredging and beachfill placement are addressed in Section 8.07.2. Dredging and beachfill placement conducted during project construction and periodic nourishment could create effects in the marine water column in the immediate vicinity of the activity potentially affecting the surf zone and nearshore ocean. Such effects could include minor and short-term suspended sediment plumes and related turbidity, and the release of soluble trace constituents from the sediment. In the case of overflowing hopper dredges or scows to obtain economic loading, sediment that is more than 90 percent sand is not likely to produce significant turbidity or other water quality impacts (USACE, 1997) (for sedimentation and turbidity associated with hopper dredges, see section 8.01.8.2). Overall water quality impacts of the proposed action would be expected to be short-term and minor. The various life stages of fish species associated with marine and estuarine resources dependent on good water quality would not be expected to experience significant adverse effects from water quality changes.

Scientific data are very limited with regard to the effects of beach nourishment on fishery resources. The effects could be similar, on a smaller scale, to the effects of storms; storm effects could include increased turbidity and sediment load in the water column and, in some cases, changes in fish community structure (Hackney et al., 1996). Storms of great severity, such as hurricanes, have been documented to create conditions resulting in fish kills, but such situations are not usually associated with beach nourishment.

In a 1999 Environmental Report on the use of federal offshore sand resources for beach and coastal restoration, the U.S. Department of Interior MMS provided the following assessment.

> In order to assess if turbidity causes an impact to the ecosystem, it is essential that the predicted turbidity levels be evaluated in light of conditions such as during storms. Storms on the Mid-Atlantic shelf may generate suspended matter concentrations of several hundred mg/L (e.g., Styles and Glenn 1999). Concentrations in plumes decrease rapidly during dispersion. Neff (1981, 1985) reported that solids concentrations of 1000 ppm two minutes after discharge decreased to 10 ppm within one hour. Poopetch (1982) showed that the initial concentration in the hopper overflow of 3,500 mg/L decreased rapidly to 500 mg/L within 50 m. For this reason, the impact of the settling particles from the turbidity plume are expected to be minimal beyond the immediate zone of dredging.

Beach nourishment can affect fishery resources and EFH through increases in turbidity and sedimentation that, in turn, can create localized stressful habitat conditions, and can result in temporary displacement of fish and other biota. However, the sediment proposed for beach placement on Surf City and North Topsail Beach would average 90 percent or more sand (see Appendix C, Geotechnical Analysis). Because of the low silt/clay content, water column effects would be expected to be localized, short-term, and minor. Furthermore, the beach nourishment operation would be expected to proceed at a slow rate. Mobile biota, including juvenile and adult fish, should be able to relocate outside the more stressful conditions of the immediate nourishment operation. Cumulative effects of multiple, simultaneous beach nourishment operations could be harmful to fishes of the surf zone. Because of the high quality of the sediment selected for beachfill and the small amount of beach affected at any time, the proposed activity would not be expected to pose a significant threat.

8.01.8.7 Effects on State-Designated Areas Important for Managed Species

PNAs are designated by the North Carolina Marine Fisheries Commission and are defined by North Carolina as tidal saltwaters that provide essential habitat for the early development of commercially important fish and shellfish (http://www.ncfisheries.net/rules.htm; 15 NC Administrative Code 3B .1405). Many fish species undergo initial post-larval development in the areas. PNAs would not be expected to be directly affected by implementing the proposed project. However, PNAs adjacent to the New River Inlet vicinity could experience indirect and short-term elevated turbidity levels from the nourishment operation on the shoreface. Such turbidity effects are dependent on the location of the outflow pipe and the direction of longshore and tidal currents. Because the elevated turbidity levels would be short-term and within the range of elevated turbidity from natural storm events, the impacts to state-designated PNAs would be expected to be insignificant.

8.01.8.8 Effects on New River

New River Inlet is approximately 7 miles north of the northern terminus of the project. No direct impacts associated with dredging or beach placement of sediment would be expected to occur within New River Inlet. However, short-term elevated turbidity levels could occur during the nourishment operation and could be transported outside the immediate disposal area via longshore and tidal currents. Such elevated turbidity levels could extend into the New River Inlet vicinity; however, the associated effects would not be expected to be significant and likely would not affect HAPC for managed fish species.

8.01.8.9 Effects on Big Rock and Ten Fathom Ledge

Big Rock and the Ten Fathom Ledge are south of Cape Lookout, North Carolina. Ten Fathom Ledge is at 95–120 m (312–394 ft.) depth on the Continental Shelf in Onslow Bay, North Carolina, and consists of 136 square miles of ocean floor containing patch reefs and rock outcroppings. Big Rock is approximately 36 miles south of Cape Lookout at about 50–100 m (164–328 ft.) of water. Hard substrate consists of algal limestone and calcareous sandstone. Both sites are offshore of the proposed borrow areas and would not be expected to be affected by implementing the proposed project (SAFMC, 1998).

8.01.8.10 Effects on The Point

The Point is near Cape Hatteras near the 200-m (656-ft.) contour and is a confluence zone of six major water masses including the Gulf Stream, Western Boundary Under Current (WBUC), Mid-Atlantic Shelf Water (MASW), Slope Sea Water (SSW), Carolina Capes Water (CCW), and the Virginia Coastal water. A result of the convergence of the currents is a dynamic and highly productive environment. The area is well offshore of the proposed project, and no effects would be expected (SAFMC, 1998).

8.01.8.11 Impact Summary for Essential Fish Habitat

The proposed action would not be expected to cause any significant adverse impacts to EFH or HAPC for those species managed by the SAFMC and MAFMC. Effects would be expected to be minor on an individual and cumulative effects basis.

8.02 Terrestrial Environment

8.02.1 Maritime Shrub Thicket

The maritime shrub thicket community occurs sporadically throughout Surf City and North Topsail Beach, occurring on the backside of the island, west of the highway, and interspersed with marsh areas, which border the sound. Because the community is landward of the proposed project construction limits, no significant effects would be expected.

8.02.2 Beach and Dune

Under the proposed plan, approximately 52,150 ft. of beach berm and dune would be constructed. Constructed dunes would be waterward of the first line of stable vegetation, would tie into existing dunes where practical, and be revegetated with native dune grasses to minimize effects. That would result in a seaward movement of the shoreline.

Project construction and periodic nourishment would not be expected to have an adverse effect on wildlife found along the beach or that uses the dune areas. However, short-term transient effects could occur to mammalian species using the dune and fore-dune habitat, but those species are mobile and would be expected to move to other, undisturbed areas of habitat during construction and periodic nourishment events. Revegetation of dune areas would be expected to increase the amount and quality of habitat available to mammal and avian species dependent on those areas.

Project construction would result in disturbance and removal of some of the existing vegetation along the seaward side of the existing dune. However, construction would be followed by measures designed to stabilize the constructed dunes. Dune stabilization would be accomplished by planting vegetation on the dune during the optimum planting seasons and after the berm and dune construction. Planting stocks would consist of sea oats (*Uniola paniculata*), American beachgrass (*Ammophila breviligulata*), panic grass (*Panicum amarum*), and seaside little bluestem (*Littoralis* variety). The vegetative cover would extend from the landward toe of the dune to the seaward intersection with the storm berm for the length of the dune. Sea oats would be the predominant plant with American beach grass and panic grass as a supplemental plant. Seaside little bluestem would be planted on the backside of the dune away from the most extreme environment. Planting would be accomplished during the season best suited for the particular plant. Periodic nourishment of the project would involve placing material along the berm. Therefore, minimal impacts to dune vegetation would be expected from implementing the project.

Nourishment operation at Surf City and North Topsail Beach would be expected to directly affect ghost crabs through burial (USACE, 2004b; Lindquist and Manning, 2001; Peterson et al., 2000; Reilly and Bellis, 1983). Because ghost crabs are vulnerable to changes in sand compaction, short-term effects could occur from changes in sediment compaction and grain size. According to Hackney et al. (1996), management strategies are recommended to enhance recovery after beach nourishment are (1) timing activities so that they occur before recruitment and, (2) providing beach sediment that favors prey species and burrow construction. Ghost crabs are present on the project beach year-round (Hackney et al., 1996); therefore, direct effects from burial could occur during the proposed construction time frame of December 1 to March 31. However, the peak larval recruitment time frame would be avoided and, because only compatible borrow material would be used, it is expected that ghost crab populations would recover within one year post-construction (USACE, 2004b; Lindquist and Manning, 2001; Peterson et al., 2000;

Reilly and Bellis, 1983). Because ghost crabs recover from short-term effects and because recommended management strategies to avoid long-term effects would be followed, no significant long-term impacts to the ghost crab population would be expected.

8.02.3 Birds

The waters off of Topsail Island and Onslow Beach are very important to migrating and wintering northern gannets, loons, and grebes because of the abundant hard-bottom habitat. It has been suggested that migrating and wintering birds key on the hard-bottom areas (Sue Cameron, personal communication, September 8, 2004) because such habitat supports significant prey species for the birds. However, appropriate dredging buffers have been incorporated into the project design so disturbance of birds using those areas for feeding would be expected to be minimal. Nonetheless, distribution patterns of sea ducks or other birds using the offshore environment in the project vicinity could be affected during dredging operations for construction and periodic nourishment. Congregation or rafting of sea ducks in the areas is primarily for loafing. Because of the depth in the areas (greater than 30 ft.), they would not be expected to provide a benthic food source for sea ducks. Because the area of ocean disturbed is small when compared to available loafing or foraging areas, it is expected that any effects would be minor.

The identified project limits avoid important shorebird habitat in the New River and New Topsail Inlet complexes. Although the project area is heavily developed and sustains heavy recreational use, migratory shorebirds could still use the project area for foraging and roosting habitat. As mentioned in Section 2.02.3 of this report, beach nourishment activities could temporarily affect the roosting and intertidal macro-fauna foraging habitat; however, recovery often occurs within one year if nourishment material is compatible with native sediments. A recent 2-year study in Brunswick County, North Carolina (USACE, 2004b) indicated that beach nourishment had no measurable impact to shorebird use. Additionally, to complete the full initial construction template while still adhering to the December 1 to March 31 dredging window, initial construction would be staged in four intervals. Although temporary impacts to the shorebird prey base could occur in the affected areas, the staggering of the initial construction effort would allow for availability of adjacent unaffected foraging habitat. Because (1) areas of diminished prey base are temporary and isolated, (2) recovery occurs within one year if material is compatible, and (3) adjacent unaffected foraging and roosting habitat would be available throughout the project, it would not be expected that foraging and roosting habitat would be significantly affected by implementing the proposed action.

Although it is possible that shorebird nesting could occur in the project area during the spring and summer months (April 1–August 31), most of the bird species have been displaced by development pressures and heavy recreational use along the beach; thus, traditional nesting areas on the project beach have been lost. Many of the bird species have retreated to the relatively undisturbed dredged material disposal islands that border the navigation channels in the area. Nonetheless, it is possible that shorebird species would still attempt to nest in the project area (Sue Cameron, personal communication, September 8, 2004). To protect bird nesting, the NCWRC discourages beach work between April 1 and August 31. All work is proposed to be accomplished by hopper dredges within the hopper dredging window of December 1 to March 31, thus avoiding the bird nesting window. Additionally, as discussed in Section 2.02.3, a significant amount of shorebird activity occurs year-round on the north end of North Topsail Beach and in the New River Inlet complex. To avoid disturbance to this important shorebird habitat, all associated construction activities for this project would avoid those areas to the maximum extent practicable.

Undeveloped and undisturbed barrier island systems with associated saltmarsh, beach, and adjacent sand flats offer ideal migratory shorebird and waterbird microhabitats. Specifically, the undeveloped islands are dominated by overwash processes and the formation of bare sand habitats that offer prime nesting habitat for some shorebird species. Undeveloped barrier islands to the north (Onslow Beach and Bear Island) and south (Lea Island) of the project area are overwash-dominated systems and support thousands of shorebirds during migration and during winter, hundreds of beach-nesting seabirds and shorebirds, wading birds, waterfowl and marsh birds. However, the project limits in Surf City and North Topsail Beach are heavily developed on both the ocean and sound sides of the island; thus, limiting the opportunity for overwash fan formation. The Corps recognizes that natural barrier island overwash processes are an important factor in the creating and maintaining shorebird nesting habitat and that creating a constructed dune as a component of the project would further inhibit natural overwash processes. However, the without-project condition in the project area is not an undisturbed barrier system that is supportive of those habitat features. Rather, it is a continued developed shoreline. As identified in Section 3.08 of the report, the Corps' without-project future economic condition assumes that all structures affected by hurricane and storm erosion damages would be replaced to a level similar to the existing distribution of residential and commercial use. Thus, if an existing structure is replaced by an overwash fan as a result of a significant storm event, the home would likely be rebuilt on top of the overwash fan. That process of structural loss and redevelopment on top of overwash features was experienced in North Topsail Beach in the years after Hurricane Fran in 1996. Furthermore, it is assumed that residential structures removed by long-term erosion would not be replaced during the 50-year period of analysis; however, the second row structures would become first row structures. Therefore, in regards to the Corps evaluation of without-project conditions relative to economics, post-storm structural losses would be replaced and any washover fan formation that occurs within property limits that are deemed rebuildable by the state would have a new structure rather than offering new bird habitat. The project area is, and would continue to be, a highly developed beach whose residential and commercial development practices have led to the degradation of available washover habitat before the construction of a coastal storm damage reduction project.

On the basis of the following considerations, the proposed construction activities would not be expected to significantly affect breeding and nesting shorebirds or colonial waterbirds in the project area: (1) contractors would adhere to the April 1 to August 31 bird-nesting window when timing the initial construction activities and periodic renourishments, (2) beach nourishment and construction activities would not occur in the

New River and New Topsail Inlet complexes, which most likely support foraging, loafing, roosting, and nesting shorebirds, and (3) project construction timing and planning would allow for rapid recovery of intertidal foraging habitat in the project area.

8.02.4 Endangered and Threatened Species

In accordance with section 7 (a)(2) of the ESA of 1973, as amended, the Corps initiated consultation with both the USFWS and NMFS for the proposed project. A biological assessment (Appendix I) was prepared to evaluate effects of the proposed action on listed T&E species and their designated critical habitat in the project area. A summary of effect determinations for all listed species identified in the project area relative to both the beach placement and in-water related activities for the project are provided in Table 8.4. All commitments to reduce impacts to listed species are provided in Section 5.0 of Appendix I and Table 7.2 and Section 10.06.1 of the main report.

Table 8.4. T&E species effects determination for beach placement and dredging activities associated with the proposed project area

Listed species w/in the project area		Effects determination	
		Beach placement activities (USFWS)	**In-water dredging activities (NMFS)**
Sea turtles	***Leatherback***	MANLAA	MANLAA
	Loggerhead	MANLAA	MALAA
	Green	MANLAA	MALAA
	Kemp's Ridley	NE	MALAA
	Hawksbill	NE	MALAA
Large whales	***Blue, finback, sei, and sperm***	NE	NE
	NARW	NE	MANLAA
	Humpback	NE	MANLAA
West Indian manatee		NE	MANLAA
American alligator		NE	NE
Piping plover		MANLAA	NE
Red-cockaded woodpecker		NE	NE
Shortnose sturgeon		NE	NE
Smalltooth sawfish		NE	NE
Seabeach amaranth		MANLAA	NE
Golden sedge		NE	NE
Chaffseed		NE	NE
Cooley's meadowrue		NE	NE
Rough-leaved loosestrife		NE	NE

Notes: No Effect (NE = green); May Affect Not Likely to Adversely Affect (MANLAA = orange); and May Affect Likely to Adversely Affect (MALAA = red)

Summary of Effects Determinations

American Alligator, Red-cockaded Woodpecker, Golden Sedge, Chaffseed, Cooley's Meadowrue, and Rough-leaved Loosestrife.

These are all terrestrial, freshwater, woodland, or savanna species. Because the habitat type is not present in the areas that would be affected by the proposed action, those species are unlikely to occur. Therefore, implementing the proposed action would not be expected to adversely affect any of those species or their habitat.

Large Whales—Blue Whale, Finback Whale, Humpback Whale, North Atlantic Right Whale (NARW), Sei Whale, and Sperm Whale

Of the six species of whales being considered, only the NARW and humpback whale would normally be expected to occur in the project area during the project construction period. Therefore, the proposed project would not be expected to adversely affect the blue whale, finback whale, sei whale, and sperm whale. Conditions outlined in previous NMFS consultations to reduce the potential for accidental collision (i.e., contractor pre-project briefings, large whale observers, slow down and course alteration procedures) would be implemented as a component of the project. Because of such implementation measures, dredging activities associated with the proposed project may affect but are not likely to adversely affect the NARW and humpback whale species.

West Indian Manatee

Since the habitat and food supply of the manatee would not be significantly impacted, overall occurrence of manatees in the project vicinity is infrequent, all hopper dredging would occur in the offshore environment, and precautionary measures for avoiding impacts to manatees, as established by USFWS, would be implemented for transiting vessels associated with the project, the proposed action may affect by is not likely to adversely affect the manatee.

Sea Turtles—Loggerhead, Hawksbill, Kemp's Ridley, Green, and Leatherback

All five species are known to occur within oceanic waters of the proposed project borrow areas; however, only the loggerhead, green, and leatherback sea turtles are known to nest within the limits of the project beach placement area. Therefore, species-specific impacts could occur from both the beach placement and dredging operations. Considering the proposed dredging window to avoid the sea turtle nesting season to the maximum extent practicable, the proposed project may affect but is not likely to adversely affect nesting loggerhead, green, and leatherback sea turtles by altering nesting habitat. Though significant alterations in beach substrate properties may occur with the input of sediment types from other sources, reestablishing a berm and dune system with a gradual slope can enhance nesting success of sea turtles by expanding the available nesting habitat beyond erosion- and inundation-prone areas. As previously stated, in regards to suitability for nesting, turtles continue to nest on disposal beaches of Topsail Island with hatch rate successes similar to non-disposal beaches (Jean Beasley, personal communication, 2004).

The proposed hopper dredging activities for initial construction, and each nourishment interval, could occur in areas used by migrating turtles. Hopper dredges pose risk to benthic-oriented sea turtles through physical injury or death by entrainment. Although the December 1 to March 31 dredging window would avoid periods of peak turtle abundance during the warm water months, the risk of lethal effects still exist because some sea turtle species can be found year-round in the offshore area. Therefore, the proposed hopper dredging activities would be expected to adversely affect loggerhead, green, hawksbill, and Kemp's ridley sea turtles. On the basis of historic hopper dredging take data, leatherback sea turtles are not known to be impacted by hopper dredging operations.

Shortnose Sturgeon
Although hopper dredges have been known to affect shortnose sturgeons, dredging for the project would occur in offshore environments, outside its habitat range. Therefore, impacts from dredges would not be expected. Because of the unlikelihood of shortnose sturgeon being present in the project area (Fritz Rhode, personal communication, August 9, 2008) and because dredging would occur in the offshore environment, the actions of the proposed project are not likely to adversely affect the shortnose sturgeon.

Seabeach Amaranth
Beach nourishment would restore much of the existing habitat lost to erosion and would be expected to provide long-term benefits to seabeach amaranth; however, construction and deep burial of seeds on a portion of the beaches during project construction could slow germination and population recovery over the short term. Therefore, the project may affect, but is not likely to adversely affect seabeach amaranth.

Piping Plover
The long-term effects of the project may restore lost roosting and nesting habitat through the addition of beachfill; however, short-term impacts to foraging, sheltering, roosting habitat may occur during project construction. Therefore, it has been determined that the project may affect, but is not likely to adversely affect the piping plover.

Smalltooth Sawfish
On the basis of the South Atlantic distribution of smalltooth sawfish and only one sighting in North Carolina since 1999, hopper dredge impacts to smalltooth sawfish in the project area are unlikely. Additionally, the take of a smalltooth sawfish by a hopper dredge is unlikely considering the smalltooth sawfishes affinity for shallow, estuarine systems as well as the fact that there has never been a reported take of a smalltooth sawfish by a hopper dredge. Therefore, hopper dredge activities associated with this project are not likely to adversely affect smalltooth sawfish.

Consultation Summary—NMFS
On April 30, 2007, the Corps formally reinitiated consultation under section7 of the ESA in regard to the NMFS South Atlantic Regional Biological Opinion (SARBO), dated September 25, 1997. The SARBO was issued to the Corps' South Atlantic Division for "the continued hopper dredging of channels and borrow areas in the Southeastern United States." On September 12, 2008, SAD provided NMFS with the Corps' South Atlantic Regional Biological Assessment (SARBA). The SARBA addresses federal, federally permitted, or federally sponsored (funded or partially funded) dredging activities (i.e.,

hopper, cutterhead, mechanical, bed leveling, and side cast) in the coastal waters, navigation channels (including designated Ocean Dredged Material Disposal Sites), and sand mining areas in the South Atlantic Ocean (including OCS sand resources under MMS jurisdiction) from the North Carolina/Virginia Border through and including Key West, Florida and the Islands of Puerto Rico and the U.S. Virgin Islands. As noted in the September 12, 2008, transmittal letter, the U.S. Department of Interior, MMS, has agreed to a joint consultation with the Corps as the lead agency. In May 2007 during a SARBA scoping meeting at the NMFS Southeast Regional Office in St. Petersburg, Florida, Corps and NMFS representatives agreed that all dredging activities in the South Atlantic would continue to work under the 1997 SARBO until the new SARBO was developed and finalized. Therefore, all dredging actions associated with the proposed project would work under the Reasonable and Prudent Measures (RPMs), Terms and Conditions (T&Cs), and Incidental Take Statement (ITS) of the 1997 SARBO until a superseding SARBO is completed. When the NMFS completes the new SARBO, all new RPMs, T&Cs, and ITS would be adhered to as a component of this project.

On January 13, 2010, the Corps provided a letter to the NMFS requesting concurrence that operating under the 1997 and superseding SARBO, for the purposes of this project, would satisfy section 7 requirements of the ESA. In an e-mail from Erick Hawk (NMFS-SERO) dated January 19, 2010, NMFS provided the following determination:

> NMFS agrees with the [Corps'] determination that the proposed beach renourishment action, consisting (in part) of utilizing hopper dredges to mine offshore sand sources for deposition of sand onto North Carolina beaches (a 17-mile section extending from Topsail Beach/Surf City town limits to the northern end of Topsail Island) falls under the authority of the current NMFS South Atlantic regional biological opinion on hopper dredging of navigation channels and borrow areas in the southeastern United States, dated September 25, 1997 (i.e., SARBO). The SARBO is in the process of being revised and will eventually supersede the current opinion. The [Corps] will abide by the revised SARBO when it is ultimately issued. Sea turtle or shortnose sturgeon takes resulting from the proposed dredging action when conducted under the RPMs and T&Cs of the SARBO are authorized and would be counted against the ITS take limit as set forth in the SARBO.

Consultation Summary—USFWS

On January 13, 2010 the Corps provided a letter to the USFWS requesting review and concurrence of the Corps effect determination of project related impacts to listed species in the project area. Specifically, the letter states that proposed project could affect but would not be likely to adversely affect the West Indian manatee (*Trichechus manatus)*, seabeach amaranth (*Amaranthus pumilus)*, piping plover *(Charadrius melodus)*, and nesting loggerhead (*Caretta caretta*), green (*Chelonia mydas*), and leatherback (*Dermochelys coriacea*) sea turtles.

In a letter dated April 30, 2010, the USFWS provided the following determination:

> The USFWS believes that the proposed action is not likely to adversely affect federally listed species or their critical habitat as defined by the Endangered Species Act (ESA) of 1973, as amended (16 U.S.C. 1531-1543). Therefore, the requirements of section 7 (a)(2) of the ESA have been satisfied for this project. However, the Corps' obligations under the ESA must be reconsidered if: (1) new information identifies impacts of this action that may affect listed species or critical habitat in a manner not previously considered; (2) this action is modified in a manner that was not considered in this review; or, (3) a new species is listed or critical habitat determined that may be affected by the identified action.

Upon further consultation following modifications made to monitoring commitments, the USFWS established that their concurrence is for initial construction only and consultation will need to be re-initiated prior to the first renourishment. A USFWS letter in regards to this is contained in Appendix L.

8.03 Physical Resources

8.03.1 Wave Conditions

Localized deepening of offshore borrow areas is the only potential source of effects on wave conditions, however, those changes would not be expected to be significant. The borrow area use plan identifies 16 borrow areas 1.2 to 5.5 miles offshore scattered across approximately 24 miles in water depths of 35 to 50 ft. MLLW, which should have less impact on wave conditions than dredging a large, contiguous area. The anticipated average dredging depths for the majority of the borrow areas range from 2.8 to 4.4 ft. with the exception of borrow areas N, O, P, and Q, where the average dredging depth ranges from approximately 5.1 to 6.4 ft. Specific locations in borrow areas A, J, L, N, O, P, and T indicate isolated locations of compatible material at depths ranging from 8.3 to almost 15 ft. The potential to dredge those borrow areas to the deeper depths would be dependent on additional investigation conducted during the design phase to comply with the North Carolina beachfill standards. Simplified, irregular wave transformation calculations were made to look at the sensitivity of deepening the ocean floor by 5 ft. (to simulate excavating borrow) on wave heights. Findings indicate absolute wave height differences of less than 0.1 ft. because of deepening for a range of the most commonly occurring wave heights and periods. Even considering the greater depths up to 15 ft. in the borrow areas, negligible changes in wave conditions would be expected along the project shoreline because of pre-dredge water depths at the borrow areas ranging from 38 to 48 ft. MLLW.

8.03.2 Shoreline and Sand Transport

Existing water depths in the borrow areas range from 35 to 50 ft. MLLW, which is substantially deeper than the estimated active profile depth of 23 ft. NGVD. Therefore no impacts to the active profile would be expected as a result of borrow area dredging.

Planform evolution indicates that without-project erosion rates of 0 to 3 ft. per year would increase to 2 to 13 ft. per year with a beachfill project in place, with rates increasing toward the ends of the project. Renourishment would take place every 6 years to replenish the losses, unless project monitoring indicates that renourishment could be reasonably delayed. Net movement of the material would be predominantly to the north on the basis of transport analysis, with northerly sediment transport being roughly twice that of southerly transport on average.

8.03.3 Geology and Sediments

8.03.3.1 Borrow Area Dredging

About 11.5 square miles of sandy ocean bottom would be affected over the 50-year economic life of the project. Within the borrow areas (Figures A-1 and A-6, in Appendix A) existing water depths (greater than –35-foot MLLW) would be deepened, and recolonization of affected areas would be expected within 1–3 years. As discussed in Section 2.01.10, an extensive geophysical investigation was conducted to identify hard bottom presence and delineate hard bottom that was identified in and near several borrow areas. Hard-bottom buffers of 500 meters (1,640 ft.) were established for high- and moderate-relief hard bottom, and 122 meters (400 ft.) were established for low-relief hard bottom. The buffers were proposed by the Corps, Wilmington District and agreed to by several state and federal resource agencies. For more specific information regarding impacts to hard bottoms, see Section 8.01.8.2.

8.03.3.2 Beachfill Construction

Hopper dredging would be the anticipated method used during the construction and renourishment phases. Adverse effects during the construction phase would be minor and temporary. Potential effects associated with this type of operation include the following:

- Increased turbidity in the surf zone
- Sedimentation of nearshore and offshore hard bottoms

Impacts should be insignificant considering turbidity and sedimentation plumes would be confined to the offshore borrow areas during hopper dredging operations, and hard bottoms were identified within only the vicinity of eight of the offshore borrow areas. For more information, see Section 8.01.8.2.

During nourishment operations, there would be an increase in the turbidity in the surf zone in the immediate area of sand deposition. Deposition and subsequent turbidity increases may have short-term effects on surf zone fishes and prey availability. The anticipated hopper dredging time frame for the project is from December 1 to March 31 and avoids the peak recruitment and abundance timeframe of the surf zone fishes. Because of the construction time frame and the adaptive availability of representative organisms, the impacts should be temporary and minor. For more information, see Section 8.01.3.

8.03.3.3 Sediment Compatibility

The compatibility analysis compared the grain size of the *native beach* or the *reference beach* with the material in the proposed borrow areas. The overfill ratio is the primary indicator of the compatibility of the borrow material to the beach material, with a value of 1.00 indicating that one cubic yard of borrow material is needed to match one cubic yard of beach material. The procedure for calculating the overfill ratio for borrow areas in relation to the reference beach was performed in accordance with the Corps Coastal and Hydraulics Laboratory Automated Coastal Engineering System (ACES) software version 4.01. That procedure is discussed in section V-4-1.e.(2)i. of the Corps' Engineer Manual (EM) 1110-2-1100, part V, titled *Coastal Engineering Manual*. An overfill ratio of up to 1.5 is generally considered acceptable as a match of compatibility. Although no studies have been conducted concerning overfill ratios and post-project water quality, post-construction studies conducted for beach erosion control projects have concluded the effects of beachfill operations on short-term turbidity appeared to be limited to the immediate area of the operation. Total suspended sediment concentrations outside the swash zone seldom exceed 25 mg/L, a value comparable to concentrations many species experience in estuaries or during storms (USACE New York District, 2001). Because the project borrow area sediment generally consists of a low percentage of silt, post-project impacts to water quality would be expected to be minimal.

Table 7.4 illustrates the overfill ratios for potential borrow areas for the Surf City/North Topsail Beach project. The overfill ratios for the borrow areas are all below 1.5 with the exception of borrow area C, which is 1.56. Because the overfill ratio for borrow area C is only slightly above 1.5, it has been retained for further evaluation when additional characterization is conducted during the design phase.

As stated in Section 7.04.1, North Carolina implemented new beachfill standards in 2007, which require compatibility of the native beach with borrow sources in regards to the percentage of silt, granular sediment, gravel, and calcium carbonate (or shell content for projects initiated before implementation of the rules). The standards require that percent silt, granular sediment, and gravel in borrow material not exceed the amount found in the native beach plus 5 percent and the percent carbonate in borrow material not exceed the amount found in the native beach plus 15 percent. As illustrated in Table 7.3, the silt, granular sediment, gravel content, and visual shell content for the Surf City/North Topsail Beach project are 1.2, 1.1, 0.5, and 9 percent respectively. Incorporating the tolerance permitted by the beachfill standards results in the following criteria silt (6.2 percent), granular sediment (6.1 percent), gravel (5.5 percent), and calcium carbonate (24 percent).

As shown in Table 7.4, all the borrow areas comply with the beachfill standards in regards to the percentage of silt with the exception of borrow areas A (6.6 percent) and L (6.3 percent). Both of these borrow areas exceed the standard slightly by 0.4 and 0.1 percent respectively. All the borrow areas comply with the beachfill standards in regards to the percentage of granular sediment with the exception of borrow areas F (7.0 percent) and S (6.6 percent), which exceed the standard by 0.9 and 0.5 percent respectively. All the borrow areas comply with the beachfill standards in regards to the percentage of gravel sediment with the exception of borrow areas F (8.5 percent) and P (6.6 percent), which exceed the standard by 3.0 and 1.1 percent respectively. All the borrow areas comply with the beachfill standards in regards to the percentage of shell content (carbonate). The borrow areas in which the standards were exceeded for the various characteristic (A, F, L, S, and P) have been retained because all borrow areas would be further characterized during the design phase of the project. Additional vibracores would be performed to comply with the beachfill standards of 1 core/acre or 1,000-ft spacing. Vibracores would be performed to produce a density of 1,000-ft spacing in a borrow area before its use as a borrow source. For more information on borrow material and sediment compatibility, see Appendix E.

8.04 Socioeconomic Resources

8.04.1 Commercial and Recreational Fisheries

The economic effects of the NED plan or other nourishment plans during construction would not be expected to be significant. Effects on shore fishing would be limited to the area where material is being placed on the beach. Such localized temporary impact can easily be avoided by anglers in the area. Nearshore fishing boats can operate around the dredging equipment operating in the area. The beach nourishment plan would not be expected to affect inside fishing or the operation of commercial fishing boats operating in or going through New Topsail Inlet or New River Inlet. Unless there is extreme weather, the ocean going dredge would operate continuously. Therefore, the economic impact of commercial and recreational fishing would not be expected to change with the project construction.

8.05 Recreation and Aesthetic Resources

Overall, short-term minor adverse and long-term minor beneficial effects would be expected on aesthetic and recreational resources. Implementing the proposed action could cause temporary reduction of aesthetic appeal and interference with recreational activities in the areas of project construction. However, because project construction would be conducted in relatively small areas at a time, recreational and aesthetic impacts would be localized. Also, construction and maintenance would be done between December 1 and March 31, thereby avoiding the peak summer tourist season. When work activities in any area are completed, aesthetic values and recreational opportunities would be restored or enhanced as construction equipment is moved away.

The ocean and navigable waters in the vicinity of Surf City and North Topsail Beach would be affected to only a minor extent in that dredges, barges, and other watercraft associated with the work would be on-site for several months during construction and during renourishment events. However, that is judged to be an insignificant effect.

Placement of beachfill would result in temporary use of dredge pipeline, bulldozers, and other equipment on the beach, and these objects would detract from the normal appearance of the beach. Also, recreational activities on beaches may experience some interruption or interference during work periods, but the degenerated, eroded conditions of the beaches already present recreational constraints. After work is completed on a beach and the heavy equipment is removed, the resulting wider beach would be expected to represent an aesthetic enhancement and an improvement for recreation.

One ocean pier, the Surf City Ocean Pier, is within the construction area. The placement of beachfill under this pier could temporarily reduce the area available for fishing. Beach nourishment during the fishing season could also affect the recreational catch. During past projects at Wrightsville Beach and Carolina Beach, no special provisions were made during placement of beach-fill around the piers and no major objections were raised during the process. However, for Atlantic Beach, during the pumpout of Brandt Island, the beachfill was wider than usual, thus raising concerns from fishing interests. The Surf City and North Topsail Beach project is similar to the Wrightsville and Carolina Beach projects. In the vicinity of the pier, immediately after construction, the shoreline could extend out approximately 300 ft. from its present position. However, natural forces would reshape the beach area and within a few months, beachfill material would be more evenly distributed throughout the nearshore zone. After that redistribution of material, it is expected that the new beach profile would extend out approximately 150 ft. beyond its current position, thus having minimal impact on the 937-foot pier. Any turbidity that would occur during placement would be dissipated during several tidal cycles and should have no significant long-term impact on fishing from either the piers or the surf zone. Such impacts are not expected to significantly reduce public use at the pier.

8.06 Cultural Resources

The Coastal Plain remains the least known archaeological region in North Carolina (Phelps, 1983; Science Applications, Inc., 1981; Ward and Davis, 1999). While there has been some success developing upland-offshore site location correlations in Florida and perhaps elsewhere, the methodology is not very well developed for sites in the Carolinas region. There are not a significant number of known upland locations that could be used to model settlement in now inundated areas (Ward and Davis, 1999). Scientific Applications, Inc. (1981) noted the paucity of archaeological data in its study area along the Atlantic coast from North Carolina to Florida, and its need to use data from outside the study area to develop a model for predicting the location of archaeological sites on the submerged continental shelf. Anderson (1996) also found a low site incidence for Early, Middle, and Late Archaic Period sites for the coastal area of North Carolina when examining Archaic settlement in the Southeast.

Five chronological cultural units, Pre-Paleoindian, Paleindian to Early Archaic (early), Early Archaic (late) to Middle Archaic, Late Archaic to Woodland, and Woodland were used for assembling the data for modeling. Pre-Paleoindian sites are assumed to date before 11,500 B.P. and represent transient camps of a low density population (Scientific Applications, Inc., 1981). Paleoindian and Early Archaic sites tend to be clustered along major drainages and sources of knappable stone (Anderson and Faught, 2000; Ward and Davis, 1999). These sites are likely to be associated with paleochannels; however, these sites are very rare in the North Carolina coastal region and consist only of single point (Science Applications, Inc., 1981). Terminal Early through Middle Archaic sites are also associated with riverine settings and upland swamps, with base camps located on terraces of major rivers, and specialized sites occurring in throughout interfluvial areas (Blanton, 1996; Sassaman, 1996; Scientific Applications, Inc., 1981; Ward and Davis, 1999). Settlement during the Late Archaic and Early Woodland appears to have shifted to the mouths of major rivers, and by the Woodland period, sites are in most estuarine settings (Scientific Applications, Inc., 1981; Ward and Davis, 1999). Base camps, especially shell middens, tend to be in the most productive estuaries and adjacent landforms (Scientific Applications, Inc., 1981). However, Anderson (1996) noted the lower Coastal Plain and coastal areas of North Carolina appear to have been of limited use during the Late Archaic.

The Science Applications, Inc., model uses three sensitivity zones, with zone 1 having the highest probability of containing archaeological sites, and zone 3 having the least probability. Zone 1 includes areas from the present day shoreline to the 8,000 B.P. shoreline (circa the 39-foot-depth contour). Zone 2 extends outward from the 8,000 B.P. shoreline to the 12,000 B.P. shoreline (circa the 75-foot-depth contour). Zone 3 continues outward from the 12,000 B.P. shoreline to the 16,000 B.P. shoreline (circa 200-foot-depth contour). The paleoshorelines for the above zones are based on the sea level curve proposed in the same study (Science Applications, Inc., 1981).

The proposed borrow areas are in water depths ranging from 28 to 52 ft. Those depths would correlate to roughly the 9,000 B.P. to 6,000 B.P. shorelines proposed by Science Applications, Inc. (1981). Early- to Middle-Archaic base camps could exist along major inundated channels, with specialized sites in most riverine settings. Pump-out locations closer to shore could contain Late Archaic and Woodland period sites. Significant sites of those periods tend to be larger than earlier base camps and contain shell middens in estuarine environments. The proposed project is also within zone 1, the highest probability zone; however, the North Carolina coastline is considered a high-energy, wave-dominated zone because of the narrow and steep nature of the continental shelf. Most of the North Carolina continental shelf is believed to have been dominated by erosional transgression and have a low preservation potential (Scientific Applications, Inc., 1981).

In its reviews of this project, the Underwater Archaeology Branch (UAB) of the North Carolina Office of State Archaeology has not mentioned prehistoric sites or impacts to other types of sites; shipwrecks have been the major concern. The North Carolina State Historic Preservation Officer (NC SHPO) letter accepting the final report of investigations is dated March 1, 2005, and is included in Appendix H of the FEIS. Although all literature reviews, surveys, coordination efforts, and the like, have not identified any cultural resource concerns to date, to further minimize the risk of resource impacts before and during construction, the following commitments would be implemented: (1) To assure the risk of potential impacts to cultural resources within inshore areas subject to pump-out activities are avoided, specific pump-out locations would identified, surveyed, and investigated for cultural resources in conjunction with hard bottom surveys before commencement of nourishment activities. (2) If, during dredging activities, any previously unidentified or unanticipated historical, archaeological, and cultural resources are discovered or found within the inflow screening of the dredge or within the beach placement area, all activities that may damage or alter such resources would be temporarily suspended. Resources of interest include any human skeletal remains or burials; artifacts; shell, midden, bone, charcoal, or other deposits; shipwrecks; rock or coral alignments, pavings, wall or other constructed features; and any indication of agricultural or other human activities. If such a discovery or find is made, the Corps' Contracting Officer would be immediately notified so that the appropriate authorities, including the MMS, can be notified in accordance with Corps policy and 30 CFR 250.194(c) and a determination made as to their significance and what, if any, special disposition of the finds should be made. All activities that could result in effects on or the destruction of those resources would cease. The area would be secured to prevent employees or other persons from trespassing on, removing, or otherwise disturbing such resources until the sites potential historic significance can be assessed and protected.

Whereas the Topsail Island vicinity is known to have had an active historical maritime trade, the Corps Wilmington District, in consultation with the North Carolina Division of Archives and History, undertook contracted remote sensing survey designed to meet the intent of the National Historic Preservation Act and the Abandoned Shipwreck Act. During summer and fall of 2004, Mid-Atlantic Technology and Environmental Research, Inc., conducted a magnetometer and side-scan sonar survey of the 10 proposed borrow areas. The results of that survey are reported in *Archaeological Remote Sensing Survey of Topsail and West Onslow Beaches Offshore Borrow Areas (*Contract DACW54-03-D-0002, Order 0003, Wes Hall, Principal Investigator, December 2004). Data were collected along parallel lines spaced at 65-ft (20-m) intervals. Magnetic data, along with corresponding positioning data, were recorded at one-second sample intervals (or approximately every 8 ft. along a track line at 5 knots).

Note that seven potential offshore borrow areas (extending from the Topsail Beach/Surf City town limit to New River Inlet) were originally identified at the time the cultural resources survey was conducted. After completion of the survey, hard bottom was identified in several borrow areas, which required modification to the boundaries of several borrow areas and elimination of three borrow areas (now identified as I, K, and M). Consequently, the remaining viable borrow areas were renamed and reconfigured into 10 borrow areas. The boundaries of those reconfigured borrow areas are completely contained within the boundaries of the original seven borrow areas.

No single, isolated magnetic anomalies or acoustic targets were identified during the survey of the 10 borrow areas. A low potential exists for encountering submerged prehistoric sites according to proposed borrow areas and material type, preservation potential, and current data on North Carolina prehistoric sites in coastal/submerged settings. No further cultural resources studies are anticipated for the project within the proposed borrow areas. By letter of November 2, 2004, the NC SHPO concurred with the reported findings. The Corps must, pursuant to 36 CFR 800.13(b), immediately secure the jobsite, suspend work in the vicinity of the affected resource, and consult with the NC SHPO and MMS if previously unidentified culture resources are discovered during the execution of the project.

8.07 Water Resources

8.07.1 Hydrology

Marine waters of the project area display considerable daily variation in current and salinity conditions due to fresh water inflow, tides, and wind. Within the ocean environment, any project-induced changes in the vicinity of the proposed work would be very small (if any) in comparison and would, therefore, considered to be insignificant.

8.07.2 Water Quality

Dredging in the selected borrow areas would involve mechanical disturbance of the bottom substrate and subsequent redeposition of suspended sediment and turbidity generated during dredging. Factors that are known to influence sediment spread and turbidities are grain size, water currents and depths. Monitoring studies done on the impacts of offshore dredging indicate that sediments suspended during offshore are generally localized and rapidly dissipate when dredging ceases (Naqvi and Pullen, 1983; Bowen and Marsh, 1988; Van Dolah et al., 1992). Some infilling of the borrow area after dredging would be expected from side sloughing of native bottom sediments, which consist of predominately sandy material with a small amount of fine or organic material.

During construction, there would be elevated turbidity and suspended solids in the immediate area of sand deposition when compared to the existing non-storm conditions of the surf zone. Significant increases in turbidity are not expected to occur outside the immediate construction/maintenance area (turbidity increases of 25 nephelometric turbidity units [NTUs]) or less are not considered significant). Turbid waters (increased turbidity relative to background levels but not necessarily above 25 NTUs) would hug the shore and be transported with waves either northeast or southwest depending on wind conditions. Because of the low percentage of silt and clay in the borrow areas (less than 10 percent), turbidity impacts would not be expected to be greater than the natural increase in turbidity and suspended material that occurs during storm events. Any increases in turbidity in the borrow areas during project construction and maintenance would be expected to be temporary and limited to the area surrounding the dredging. Turbidity levels would be expected to return to background levels in the surf zone when dredging ends.

Overall water quality impacts of the proposed action would be expected to be short-term and minor. Living marine resources dependent on good water quality should not experience significant adverse effects from water quality changes.

A section 401 Water Quality Certificate under the Clean Water Act of 1977 (P.L. 95-217), as amended, is required for the proposed project and would be obtained from the NCDWQ before construction begins.

Pursuant to section 404 of the Clean Water Act, the impacts associated with the discharge of fill material into waters of the United States are discussed in the Section 404(b)(1) (P.L. 95-217) Guidelines Analysis in Appendix G. Discharges associated with dredging in the offshore borrow areas are considered incidental to the dredging operation, and therefore, are not being considered as being a discharge addressed under the *Section 404(b)(1) Guidelines Analysis*.

8.07.3 Groundwater

Dredging with beach placement of material would not be expected to adversely affect groundwater of the area. Groundwater in the area moves generally east and southeast along a regional gradient of about 8 ft. per mile. The potential for saltwater intrusion into groundwater does not exist unless a reversal of hydrologic gradient occurs from excessive groundwater pumping. Water supplies of nearby communities would not be expected to be affected by the proposed action.

8.08 Other Significant Resources (P.L. 91-611, Section 122)

8.08.1 Air, Noise, and Water Pollution

Temporary increases in exhaust emissions from construction equipment are expected during the construction and periodic renourishment of the SCNTB project; however, the pollution produced would be similar to that produced by other large pieces of machinery and should be readily dispersed. All dredges must comply with the applicable EPA standards. Additionally, ozone is North Carolina's most widespread air quality problem, particularly during the warmer months. High ozone levels generally occur on hot sunny days with little wind, when pollutants such as nitrogen oxides and hydrocarbons react in the air. High levels of fine particles are more of a problem in the western Piedmont region but can occur throughout the year, particularly during episodes of stagnant air and wildfires. The project would be constructed outside the ozone season. The air quality in Pender and Onslow counties, North Carolina, is designated as an attainment area. North Carolina has a State Implementation Plan (SIP) approved or promulgated under section 110 of the Clean Air Act (CAA), however, for the following reasons; a conformity determination is not required.

a. 40 CFR 93.153 (b), "For Federal actions not covered by paragraph (a) of this section, a conformity determination is required for each pollutant where the total of direct and indirect emissions in a nonattainment or maintenance area caused by a federal action would equal or exceed any of the rates in paragraphs (b) (1) or (2) of this section." North Carolina has designated Pender and Onslow counties as an attainment area.

b. The direct and indirect emissions from the project fall below the prescribed deminimus levels (58 *Fed. Reg.* 93.153(c)(1)) and, therefore, no conformity determination would be required.

c. The project is within the jurisdiction for air quality of the Wilmington Regional Office of the NCDENR. The ambient air quality for Pender and Onslow counties has been determined to be in compliance with the National Ambient Air Quality Standards. Furthermore, Table 8.5 includes an analysis of total emissions for the proposed dredging and land-based operations associated with the project as well as a comparison of the project calculated emissions to EPA's NEI data for Onslow County.

To provide additional verification that the proposed project would not adversely impact air quality in these attainment areas, air emissions of the various pieces of equipment used in beach nourishment project were estimated. The following assumptions were made when calculating the emissions outputs for the dredging and beach placement equipment:

1. Hopper Dredge emissions calculations were based on representative hopper dredge (i.e., RN Weeks) emissions calculated by MMS for the Sandbridge Beach Restoration project in Virginia. MMS made the following assumptions:

a. Hopper Dredge (with pump ashore capability) is working 120 days and pumps 2,000,000 cubic yards of material to the beach.

b. The following equipment is part of the in-water dredging operation:
1) 2 tender tugs
2) 1 derrick barge
3) 2 work barges
4) 1 bulldozer

c. The following equipment is part of the beach placement operation:
1) 2 bull dozers (215 horsepower)
2) 1 flat bed truck

2. Initial SCNTB Project Construction Requirements: Two hopper dredges would be working for about 120 days each year or from December 1 to March 31 for 4 years. The two hopper dredges would pump about 3,000,000 cubic yards each year for a total of about 12,000,000 cubic yards of material (after 4 years).

a. The following equipment is part of the in-water dredging operation:
1) 2 tender tugs
2) 1 derrick barge
3) 2 work barges
4) 1 bulldozer

b. The following equipment is part of the beach placement operation:
1) 2 bull dozers (215 horsepower)
2) 1 flat bed truck

3. Renourishment Maintenance Interval for the SCNTB project: Once every 6 years after initial construction, two hopper dredges working about 120 days or from December 1 to March 31 and would place about 2.6 million cubic yards of material on the beach.

a. The following equipment is part of the in-water dredging operation:
1) 2 tender tugs
2) 1 derrick barge
3) 2 work barges

4) 1 bulldozer

b. The following equipment is part of the beach placement operation:
1) 2 bull dozers (215 horsepower)
2) 1 flat bed truck

3. Equation used: From EPA: VOC= 1.005 × HC.

Table 8.5 below indicates that the percentage of the monthly emission rate (tons/month) for all construction equipment (i.e., hoppers, tugs, barges, bulldozers, and trucks) for the SCNTB project compared to the monthly emissions (tons/month) in EPA's NEI Data for Onslow County is 3.3 percent for NO_2, 0.08 percent for CO, 0.08 percent for HC, 0.17 percent for PM_{10}, and 1.20 percent for SO_2.

On the basis of the analysis provided in Table 8.5, the project would not be expected to create any adverse effects on the air quality in the attainment area, and the project would be in compliance with section 176 (c) of the Clean Air Act, as amended. Additionally, the analysis provided in Table 8.5 is considered conservative for the following reason: vessels powered by Category 2 engines (i.e., hopper dredges, tugs, crew boats) use non-road diesel fuel, which is subject to a 500 ppm (0.05 percent) sulfur level. Starting in 2012, the diesel fuel sulfur limit for locomotive and marine diesel fuel will be reduced to 15 ppm (0.0015 percent) (Penny Carey, personal communication, EPA, March 23, 2010).

Table 8.5. Project emissions analysis

Initial Construction	NOX	CO	HC	PM10	SO2
Two Hopper Dredges	113.10	30.04	3.17	3.53	10.71
2 Tender Tugs	0.72	0.17	0.02	0.02	0.10
1 Derrick Barge	1.80	0.41	0.05	0.05	0.24
2 Work Barges	1.44	0.33	0.04	0.04	0.19
Dozer	0.14	0.03	0.01	0.01	0.01
Sub-Total	117.20	30.98	3.29	3.66	11.25
*Land Based Equipment					
Sub-Total	19.24	4.20	1.56	1.37	1.28
TOTALS	136.44	35.18	4.85	5.03	12.54
Emissions (tons/month)	11.37	2.93	0.40	0.42	1.04
** Initial Construction Total	545.75	140.72	19.40	20.13	50.14
Maintenance Interval (Every 6 years)***					
Two Hopper Dredge	113.10	30.04	3.17	3.53	10.71
2 Tender Tugs	0.72	0.17	0.02	0.02	0.10
1 Derrick Barge	1.80	0.41	0.05	0.05	0.24
2 Work Barges	1.44	0.33	0.04	0.04	0.19
Dozer	0.14	0.03	0.01	0.01	0.01
Sub-Total	117.20	30.98	3.29	3.66	11.25
*Land Based Equipment					
Sub-Total	19.24	4.20	1.56	1.37	1.28
Renourishment Total	136.44	35.18	4.85	5.03	12.54

* Land based Equipment includes 2 dozers and 1 flatbed truck
** Initial Construction takes 2 Hoppers (includes land based equipment) for 4 years. Total of about 12 million yards for initial construction.
*** Maintenance Interval is every 6 years at about 3 million yards

Water quality impacts are discussed in Section 8.07.2 and in the Section 404(b)(1) (P.L. 95-217) evaluation included with this document as Appendix G. Noise in the outside environment associated with beach construction activities would be expected to minimally exceed normal ambient noise in the project area; however, construction noise would be attenuated by background sounds from wind and surf. In-water noise would be expected in association with the dredging activities for this project. Specifically, noise associated with dredging could occur from (1) ship/machinery noise—noise associated with onboard machinery and propeller and thruster noise, (2) pump noise—noise associated with pump driving the suction through the pipe, (3) collection noise—noise associated with the operation and collection of material on the sea floor, (4) deposition noise—noise associated with the placement of the material within the barge or hopper, and (5) transport noise—noise associated with transport of material up the suction pipe. The limited available data indicate that dredging is not as noisy as seismic surveys, pile driving and sonar; but it is louder than for example most shipping, operating offshore wind turbines and drilling (Thomsen et al., 2009).

Dredging produces broadband and continuous, low-frequency sound (below 1 kHz) and estimated source sound pressure levels range between 168 and 186 dB re 1 µPa at 1 m, which can trigger avoidance reaction in marine mammals and marine fish. In some instances, physical auditory damage can occur. Auditory damage is the physical reduction in hearing sensitivity due to exposure to high-intensity sound and can be either temporary (temporary threshold shift) or permanent (permanent threshold Shift) depending on the exposure level and duration. Other than physical damage, the key auditory effect is the increase in background noise levels, such that the ability of an animal to detect a relevant sound signal is diminished, which is known as *auditory masking*. Masking marine mammal vocalizations used for finding prey, navigation and social cohesion could compromise the ecological fitness of populations (Compton et al., 2008).

According to Richardson et al. (1995) the following noise levels could be detrimental to marine mammals:

Prolonged exposure of 140 dB re 1 µPa/m (continuous man-made noise), at 1 km can cause permanent hearing loss.

Prolonged exposure of 195 to 225 dB re 1 µPa/m (intermittent noise), at a few meters or tens of meters, can cause immediate hearing damage.

According to Richardson et al. (1995), "Many marine mammals would avoid these noisy locations, although it is not certain that all would do so." In a study evaluating specific reaction of bowhead whales to underwater drilling and dredge noise, Richardson et al. (1990) also noted that bowhead whales often move away when exposed to drillship and dredge sound; however, the reactions are quite variable and can be dependent on habituation and sensitivity of individual animals. According to Richardson et al (1995), received noise levels diminish by about 60 dB between the noise source and a radius of 1 km. For marine mammals to be exposed to a received level of 140 dB at 1-km radius, the source level would have to be about 200 dB re 1 µPa/m. Furthermore, few human activities emit continuous sounds at source levels greater than or equal to 200 dB re 1 µPa/m; however, supertankers and icebreakers can exceed the 195 dB noise levels.

According to Clarke et al. (2002), hopper dredge operations had the highest sustained pressure levels of 120–140 dB among the three measured dredge types; however, the measurement was taken at 40 m from the operating vessel and would likely attenuate significantly with increased distance from the dredge. On the basis of (1) the predicted noise effect thresholds noted by Richardson et al. (1995), (2) the background noise that already exists in the marine environment, and (3) the ability of marine mammals to move away from the immediate noise source, noise generated by bucket, cutterhead, and hopper dredge activities would not be expected to affect the migration, nursing/breeding, feeding/sheltering or communication of large whales. Although behavioral effects are possible (i.e., a whale changing course to move away from a vessel), the number and frequency of vessels present in a given project area is would be small, and any behavioral impacts would be expected to be minor. Furthermore, for hopper dredging activities, endangered species observers would be on board and would record all large whale sightings and note any potential behavioral impacts. Per the standard Corps specifications for all dredging projects, the Corps and the contractor would keep the date, time, and approximate location of all marine mammal sightings. Care would be taken not to closely approach (within 300 ft.) any whales, manatees, or other marine mammals during dredging operations or transportation of dredged material. An observer would serve as a lookout to alert the dredge operator or vessel pilot or both of the occurrence of the animals. If any marine mammals are observed during other dredging operations, including vessel movements and transit to the dredged material disposal site, collisions must be avoided either through reduced vessel speed, course alteration, or both. During the evening hours, when there is limited visibility from fog, or when there are sea states of greater than Beaufort 3, the dredge must slow down to 5 knots or less when transiting between areas if whales have been spotted within 15 nautical miles of the vessel's path in the previous 24 hours. Sightings of whales or manatees (alive, injured, or dead) in the work area must be reported to NMFS Whale Stranding Network.

Similar to conclusions made regarding effects of sound on marine mammals, non-injurious impacts to sea turtles may also occur because of acoustic annoyance or discomfort. It has been hypothesized, on the basis of anatomical studies that sea turtle hearing range centers around low-frequency sounds. Ridgeway et al. (1969, 1970) evaluated the frequency sensitivity of green sea turtles and found that green turtles detect limited sound frequencies (200–700 Hz) and display high level of sensitivity at the low-tone region (approx 400 Hz). According to Bartol et al. (1999), the most sensitive threshold for loggerhead sea turtles is 250–750 Hz with the most sensitive threshold at 250 Hz. Though noise generated from dredging equipment is within the hearing range of sea turtles, no injurious effects would be expected because sea turtles can move from the area, and the significance of the noise generated by the dredging equipment dissipates with an increasing distance from the noise source.

8.08.2 Man-made and Natural Resources, Aesthetic Values, Community Cohesion, and the Availability of Public Facilities and Services

Beach nourishment would require the extension of dune crossover structures along the beach. Dredging in the offshore borrow areas would not be expected to cause significant interference with commercial and recreational boat traffic. The mobility of a hopper dredge would preclude any interference with regular commercial ship traffic as a result of travel to and from the borrow areas.

Impacts to aesthetic values are discussed in Section 8.05. Impacts to natural resources are discussed previously throughout Sections 8.01 and 8.02. Impacts to cultural resources are discussed in Section 8.06. Coastal storm damage risk reduction would benefit numerous roads, business, and residences. Implementing the NED alternative would be expected to have beneficial effects on community cohesion and would reduce damages to many public facilities and services (i.e., roads and utilities) from storm events.

8.08.3 Hazardous, Toxic and Radioactive Wastes (HTRW)

The Corps' standard tiered approach for analyzing the potential for encountering contaminated sediments in the potential borrow areas was used to assess the potential borrow areas for HTRW. According to that analysis, before any chemical or physical testing of sediments would be conducted, a reason to believe that the sediments could be contaminated must be established. The sources of the sediments in the selected borrow areas are derived from sediment transport and deposition by ocean currents. The probability of the areas being contaminated by pollutants is low; however, the beach front (potential nourishment area) and the potential borrow areas are in areas that were affected by the operations of Camp Davis and the Navy's Operation Bumblebee.

Because of the project area's location relative to Camp Davis operations, a very remote possibility exists that OEW could be present in the material to be dredged from offshore borrow areas. However, the only ordnance that would be expected to be encountered would be spent shells from anti-aircraft target practice. The missiles that were tested during Operation Bumblebee contained no OEW and were fired approximately 40 miles offshore, well beyond the project area, and the likelihood of encountering them in an offshore borrow area would be remote.

As described in Section 2.07, the anti-aircraft shells that were fired from the beach during WWII were presumed to range in size from 37 mm (1.46 inches) to 155 mm (6.10 inches). A cultural resources survey, which used magnetometer and side-scan sonar, was completed for all proposed offshore borrow areas. Survey line spacing was 20 meters, and no anomalies were found in the areas surveyed (for a cultural resources summary, see Section 8.06). Although the cultural resources survey would have identified large anomalies, it was not intended to identify, nor was it capable of identifying, smaller anomalies, such as anti-aircraft shells. Because the survey did not identify any anomalies, it is presumed that any materials found offshore would be small and therefore would not impede the dredging and disposal operations and would not present a safety hazard to workers on the dredge or to anyone on the beach. However, to mitigate the very remote chance of encountering ordnance, the beach would be inspected daily, and any ordnance discovered would be handled in accordance with the Military Munitions Rule, 40 CFR 260-270. The Marine Corps Base Explosive Ordnance Disposal Team would be available (on call) during the dredging process. Additionally, the contract specifications for the proposed project would direct the contractor to immediately stop work and inform the contracting officer if unexploded ordnance is encountered during dredging or disposal. At that time, additional measures would be implemented, as necessary, including inspecting dredged material on the beach and installing outflow screens on the dredge pipeline. Any unexploded ordnance found on the beach would be promptly removed.

The bottom sediments that would be dredged from the borrow areas and placed on the beach would consist of predominately fine- to medium-grain size with some shell. Therefore, no further analyses or physical and chemical testing of the sediments is recommended. It would not be expected that any hazardous and toxic waste sites would be encountered during construction or periodic nourishment. However, if any hazardous and toxic waste sites are identified, response plans and remedial actions would be the responsibility of the local sponsor.

8.09 Summary of Cumulative Effects

The detailed analysis of cumulative effects is included as Appendix J. The assessment of cumulative effects focused on effects of dredging from the proposed ocean borrow sites, and effects of placing sand material on the beach (whether for beach nourishment or disposal of dredge maintenance material) on significant coastal shoreline resources In completing the cumulative effects analysis, the Corps reviewed two Environmental Reports prepared for and published by the U.S. Department of the Interior, MMS, titled *Use of Federal Offshore Sand Resources for Beach and Coastal Restoration in New Jersey, Maryland, Delaware, and Virginia*, dated November 1999 (DOI 1999) and *Collection of Environmental Data Within Sand Resource Areas Offshore North Carolina and the Environmental Implications of Sand Removal for Coastal and Beach Restoration*, dated 2003 (Byrnes et al. 2003); the *U.S. Army Corps of Engineers Dare County Beaches (Bodie Island Portion) Final Feasibility Report and EIS on Hurricane Protection*, dated September 2000; the Corps' *Draft Evaluation Report and Environmental Assessment*, Morehead City Harbor Section 933, dated May 2003, and the *Final Integrated General Reevaluation Report and Environmental Impact Statement, Shore Protection, West Onslow Beach and New River Inlet (Topsail Beach)*, dated March 2008, the last three of which include comprehensive assessments of statewide cumulative effects. In discussing the potential cumulative effects of offshore borrow area dredging and beach nourishment, time-crowded perturbations, and space-crowded perturbations, as defined below, were considered to be pertinent to the action.

> **Time-crowded perturbations—**repeated occurrence of one type of impact in the same area
> **Space-crowded perturbations—**a concentration of a number of different impacts in the same area

For instance, as a result of dredging borrow areas for beach nourishment sand, there is concern for potential cumulative effects from repeated dredging in a borrow area within short periods of time such that the benthic community might not have time to recover. Dredging in subsequent areas close to one another could result in impacts to potential adult organism recruitment to the dredged areas, further lengthening the time for recovery in an area. However, as noted in Section 8.01.7 of the report, considering the distance offshore and the shallow volumes of sediment in the borrow areas, it is anticipated that all dredging activities associated with initial construction and each re-nourishment interval would be conducted using a hopper dredge. Recognizing the thin volumes of sediment within each borrow area, it is anticipated that all available sediment within each dredged portion of a borrow site would be fully used. Therefore, reoccurring impacts to an individual portion of a borrow area are not anticipated and full recovery of each

Relatively small portions of North Carolina beaches (approximately 12 percent) are affected by time/space crowded perturbations. With the proposed action, the impact area would not increase significantly because portions of the areas proposed for fill have previously had sand deposition. On a statewide scale, the existing and approved disposal sites are well distributed in northern, central, and southern parts of the state with undeveloped protected beaches (i.e., national/federal and state parks and estuarine reserves) in between. It is unlikely that cumulative effects from space-crowded perturbation are occurring or would occur because of the construction of this project. The analysis suggests that the potential impact area from the proposed and existing actions is small relative to the area of available similar habitat on a vicinity and statewide basis. Also, for some species such as sea turtles and seabeach amaranth, beach projects would improve habitat by replacing beach material lost to erosion. Last, all affected areas would be expected to recover invertebrates, which should continue to be available as food resources.

9. PLAN IMPLEMENTATION

9.01 Project Schedule

Table 9.1 shows the schedule through initial construction for the Selected Plan. The schedule assumes expeditious review and approval of the project through all steps, including authorization and funding. Actual project implementation could take longer. The schedule is subject to availability of funds.

Table 9.1. Project schedule

Study Authority	February 16, 2000
Reconnaissance Report, HQ Approval	June 12, 2001
Execute FCSA	February 13, 2002
Initiate Feasibility Study	February 2002
Alternative Formulation Briefing	December 2006
Complete Draft Feasibility Report & EIS	August 2009
Begin 45-day Public Review	January 2010
Begin Independent External Peer Review (IEPR)	February 2010
IEPR Certified	June 2010
Complete Final Feasibility Report & EIS	July 2010
Civil Works Review Board	August 2010
Begin 30-day Public Review	October 2010
Sign Record of Decision (ROD)	May 2011
Execute Design Agreement	October 2010
Initiate Initial Plans & Specifications	October 2010
Project Authorization (WRDA)	December 2010
Complete Initial Plans & Specifications	September 2012
Initiate Real Estate Acquisition	October 2012
Execute Project Partnership Agreement	March 2013
Initiate Final Plans & Specifications	October 2013
Complete Real Estate Acquisition	March 2014
Complete Final Plans & Specifications	June 2014
Advertise Initial Construction Contract	July 2014
Open Bids	August 2014
Award Initial Construction Contract	September 2014
Begin Initial Construction, Season 1 of 4	November 2014
Begin Initial Construction, Season 2 of 4	November 2015
Begin Initial Construction, Season 3 of 4	November 2016
Begin Initial Construction, Season 4 of 4	November 2017
Complete Initial Beachfill Construction	April 2018
Complete Remaining Construction Items	June 2018
Begin First Renourishment	November 2020
Complete First Renourishment	February 2021
Begin Second Renourishment	November 2026
Complete Second Renourishment	April 2027

9.02 Division of Plan Responsibilities

9.02.1 General

Federal policy requires that costs for water resources projects be assigned to the various purposes served by the project. These costs are then apportioned between the federal government and the nonfederal sponsor according to percentages specified in section 103 of the Water Resources Development Act (WRDA) of 1986 (P.L. 99-662). For projects that provide damage reduction to publicly owned shores, the purposes are usually (1) coastal storm damage reduction and (2) separable recreation. For the Surf City and North Topsail Beach project, there is no separable recreation component.

9.02.2 Cost Sharing

Cost sharing for initial construction of the Selected Plan would be consistent with that specified in section 103(c)(5) of WRDA 1986 as amended by WRDA 1996 (generally 65 percent federal and 35 percent nonfederal). Nonfederal interests are required to provide all lands, easements, rights-of-way, and dredged material disposal areas and perform all necessary relocations (LERRD) necessary for the project. The value of the nonfederal portion of the LERRD is $4,814,000 and is included in the nonfederal share of initial project construction costs. The remainder of the nonfederal share of initial project construction costs consists of $38,283,000 cash contribution.

Cost sharing for periodic nourishment (continuing construction) would be consistent with Section 215 of WRDA 99, which requires that such costs be shared 50 percent federal and 50 percent nonfederal.

Annual OMRR&R costs, such as inspection costs and dune vegetation maintenance costs, are 100 percent nonfederal responsibility. The federal government is responsible for preparing and providing an OMRR&R manual to the sponsor.

As noted previously, current federal policy requires that, unless there are other, overriding considerations, the plan that produces the maximum net benefits, the (NED) plan, would be the selected plan recommended for implementation. In this case, the selected plan recommended for implementation is the NED plan. Cost sharing for the selected plan is shown in Table 9.2 at October 2010 price levels.

The sponsor is in the process of obtaining the required public access sites and public parking to meet the definition of a public shoreline. The cost apportionment is computed to assume that 100 percent of the project would be a public shoreline by the time the PPA is executed. All project costs are allocated to the purpose of hurricane and storm damage reduction.

Table 9.2. Cost allocation and apportionment, October 2010 price levels

Initial project construction costs					
Project purpose	Project first cost	Apportionment %		Apportionment $	
		Nonfederal	Federal	Nonfederal	Federal
Coastal storm damage reduction	$123,135,000	35%	65%	$43,097,000	$80,038,000
LERRD credit				$4,814,000	
Cash portion				$38,283,000	$80,038,000
Total financial initial project construction costs					
Project purpose	Project first cost	Apportionment %		Apportionment $	
		Nonfederal	Federal	Nonfederal	Federal
Coastal storm damage reduction	$123,135,000	35%	65%	$43,097,000	$80,038,000
sunk feasibility phase costs	$4,240,000	50%	50%	$2,120,000	$2,120,000
Total financial cost	$127,375,000	35%	65%	$45,217,000	$82,158,000
Total renourishment costs					
Project purpose	Total Cost (7 renourishments)	Apportionment %		Apportionment $	
		Nonfederal	Federal	Nonfederal	Federal
Coastal storm damage reduction	$205,539,000	50%	50%	$102,769,500	$102,769,500
	Cost per Year	Apportionment %		Apportionment $	
		Nonfederal	Federal	Nonfederal	Federal
Monitoring	$505,000	50%	50%	$252,500	$252,500
Annual OMRR&R costs					
	Cost per year	Apportionment %		Apportionment $	
		Nonfederal	Federal	Nonfederal	Federal
General repair, maintenance, inspection	$52,000	100%	0%	$52,000	$0

If parking and access minimums are not met, public use requirements for those areas would not be met and they would not be eligible for federal cost sharing. As described in Section 3.04, there are three areas totaling 2,800 ft. that do not meet shoreline access requirements to be considered as a public use shoreline. Two adjacent areas, totaling 8,200 ft., although having access, do not meet the criterion of having at least 10 public parking spaces within one-quarter mile, and so do not meet requirements. Those areas have a total length of 11,000 ft. and include both the 2,800 ft. without access and the 8,200 ft. lacking sufficient parking. Those reaches not meeting federal cost-sharing requirements represent 21 percent of the 52,150-ft total project length. The cost sharing percentage effects of the present categorization of the project shorelines are shown in Table 9.3. Table 9.3 is based on Appendix C, of ER 1165-2-130, *Federal Participation in Shore Protection*. Without the required access, the federal cost sharing decreases from 65 to 61.5 percent for initial construction and decreases from 50 to 47.3 percent for renourishment. Without both the required access and parking, the federal cost sharing decreases from 65 to 51.3 percent for initial construction and decreases from 50 to 39.5

percent for renourishment. As stated previously the towns of Surf City and North Topsail Beach intend to provide access and parking along the entire shoreline.

Table 9.3. Cost sharing based on shoreline category

Shore ownership	Public or private shores		Private shores	
	Developed public use	Developed no public use	Not developed	Total project requirements
Federal participation, construction	65%	0%	0%	
Length, ft (based on access)	49,350	2,800	0	52,150
Federal Cost Share	61.5%	0.0%	0.0%	61.5%
Federal participation, renourishment	50%	0%	0%	
Length, ft (based on access)	49,350	2,800	0	52,150
Federal cost share	47.3%	0.0%	0.0%	47.3%
Federal participation, construction	65%	0%	0%	
Length, ft (based on parking)	41,150	11,000	0	52,150
Federal cost share	51.3%	0.0%	0.0%	51.3%
Federal participation, renourishment	50%	0%	0%	
Length, ft (based on parking)	41,150	11,000	0	52,150
Federal cost share	39.5%	0.0%	0.0%	39.5%

The given cost sharing percentages assume that there would be no vacant first-row lots when construction begins. Vacant lots would be considered undeveloped, and the cost allocation for these lots would be 100 percent nonfederal. The number of undeveloped first-row lots would be reassessed before the signing of the PPA, and the cost sharing would be recalculated at that time to reflect any remaining undeveloped lots.

9.02.3 Financial Analysis

The nonfederal sponsors have submitted financial plans and statements of financial capability and have requested a letter from North Carolina, which declares the state's financial capability and financing plan relative to a Surf City and North Topsail Beach, North Carolina, Coastal Storm Damage Reduction project. Preliminary documentation of the sponsors' financial capability is to be provided in Appendix H.

9.02.4 Project Partnership Agreement

The model Project Partnership Agreement (PPA), based on the selected plan, was fully discussed with the nonfederal sponsors. The nonfederal sponsors have a clear understanding of the type of agreement that must be signed before the start of project construction. The terms of local cooperation to be required in the PPA are described in Section 13.0, Recommendations. Letters of intent from the nonfederal sponsors are to be provided in Appendix H.

Federal commitments regarding a construction schedule or specific provisions of the PPA cannot be made to the nonfederal sponsors on any aspect of the recommended plan or separable element until the following are true:

- The recommended plan is authorized by Congress
- Construction funds are provided by Congress, apportioned by the OMB, and their allocation is approved by the Assistant Secretary of the Army for Civil Works (ASA [CW])
- The draft PPA has been reviewed and approved by the ASA (CW)

The PPA would not be executed nor would construction be initiated on the project or any separable element until compliance requirements have been met for applicable federal and state statutes. Compliance is met once the Final EIS has been fully coordinated and a Record of Decision has been signed.

After this report is approved and the project budgeted for construction, Wilmington District can conduct negotiations with the nonfederal sponsors regarding the PPA, and submit a draft PPA package to higher authority for review and approval by the ASA (CW). The PPA would be executed only after approval of this report and enactment into law of an Appropriations Bill providing funds for the project. Federal construction funds for the project would not allocated by the Chief of Engineers until the ASA (CW) approves the nonfederal sponsors' financing plans and the PPA has been executed.

9.03 Views of the Nonfederal Sponsor

The Selected Plan of Improvement is acceptable to the nonfederal sponsors. Letters of support from the towns of Surf City and North Topsail Beach are to be provided in Appendix H.

9.04 Views of North Carolina

North Carolina, Department of Environment and Natural Resources, Division of Water Resources has indicated support for implementation of the Selected Plan.

9.05 Views of the U.S. Fish & Wildlife Service

Views of the USFWS are provided in the attached Fish and Wildlife Coordination Act Report in Appendix L. The recommendations of the USFWS and responses by Corps are presented in Section 11.02, Fish & Wildlife Coordination, of this report.

10. COMPLIANCE WITH ENVIRONMENTAL REQUIREMENTS

10.01 General

The following paragraphs summarize the relationship of the proposed action to the most pertinent federal, state, and local requirements. Table 10.1 lists the compliance status of all federal laws and policies that were considered for the proposed Surf City and North Topsail Beach project.

10.02 Water Quality

10.02.1 Section 401 of Clean Water Act of 1977

A section 401 Water Quality Certificate under the Clean Water Act of 1977 (P.L. 95-217), as amended, would be required for the proposed project and would be obtained from the NCDWQ before construction begins. Work would not proceed until the certificate is received.

10.02.2 Section 404 of Clean Water Act of 1977

Pursuant to section 404 of the Clean Water Act, the effects associated with the discharge of fill material into waters of the United States are discussed in the section 404(b)(1) (P.L. 95-217) evaluation in Appendix G. Discharges associated with dredging in the offshore borrow areas are considered incidental to the dredging operation, and therefore, are not being considered as being a discharge addressed under the section 404 (b)(1) Guidelines Analysis.

10.03 Marine, Protection, Research, and Sanctuaries Act

In 1972 Congress enacted the Marine Protection, Research and Sanctuaries Act, declaring that it is the policy of the United States to regulate the dumping of all types of materials into ocean waters. The act is designed to prevent or strictly limit the dumping into ocean waters of any material that would adversely affect human health, welfare, or amenities, or the marine environment, ecological systems, or economic potentialities. The proposed coastal storm damage reduction project does not involve ocean disposal of dredged material. Therefore, the project would be considered to be in compliance with the requirements of the Marine Protection, Research and Sanctuaries Act.

10.04 Essential Fish Habitat

Potential project effects on EFH species and their habitats have been evaluated and are addressed in Section 8.01.8 of this document. It has been determined that the proposed action would not have a significant adverse effect on such resources. By coordination of this document with the NMFS, consultation is officially initiated and concurrence with the Corps findings is requested. Compliance obligations related to EFH provisions of the 1996 congressional amendments to the MSFCMA (P.L. 94-265) would be fulfilled before initiation of the proposed action.

10.05 Fish and Wildlife Resources

The Fish and Wildlife Coordination Act, as amended (16 U.S.C. 661, *et seq*), requires that the Corps coordinate and obtain comments from the USFWS, the NMFS, where applicable, and appropriate state fish and wildlife agencies, including the NCDMF and the North Carolina Wildlife Resources Commission. A Fish and Wildlife Coordination Act Report (Appendix L) has been provided by the USFWS under the Fish and Wildlife Coordination Act.

10.06 Endangered and Threatened Species

A biological assessment evaluating the potential effects of the proposed action on T&E species has been prepared (Appendix I) and is being coordinated with the USFWS (jurisdiction over the Florida manatee, nesting sea turtles, piping plovers, and seabeach amaranth) and NMFS (jurisdiction over other protected marine and aquatic species which can occur in the project vicinity) pursuant to section 7 of the ESA of 1973 (P.L. 93-205), as amended. All compliance obligations under section 7 would be satisfied before the proposed action is implemented.

10.06.1 Commitments to Reduce Impacts to Listed Species

The following list is a summary of environmental commitments to protect listed species related to the construction and maintenance of the proposed project. The commitments address agreements with agencies, mitigation measures, and construction practices and should be considered preliminary. The list of commitments may be modified pending new information acquired through the public and agency review process.

1. The Corps will strictly adhere to all conditions outlined in the most current National Marine Fisheries Service RBO for dredging of channels and borrow areas in the southeastern United States. Furthermore, as a component of this project, hopper dredging activities for both initial construction and each nourishment interval will adhere, to the maximum extent practicable, to a dredging window of 1 December to 31 March in order to avoid periods of peak sea turtle abundance. The use of turtle deflecting dragheads, inflow and/or overflow screening, and NMFS certified turtle and whale observers will also be implemented.

2. In order to determine the potential taking of whales, turtles and other species by hopper dredges, NMFS certified observers will be on board during all hopper dredging activities. Recording and reporting procedures will be in accordance with the conditions of the current NMFS RBO.

3. Endangered species observers (ESOs) will be on board all hopper dredges and will record all large whale sightings and note any potential behavioral impacts. The Corps and the Contractor will keep the date, time, and approximate location of all marine mammal sightings. Care will be taken not to closely approach (within 300 feet) any whales, manatees, or other marine mammals during dredging operations or transportation of dredged material. An observer will serve as a lookout to alert the dredge operator and/or vessel pilot of the occurrence of these animals. If any marine mammals are

observed during other dredging operations, including vessel movements and transit to the dredged material disposal site, collisions shall be avoided either through reduced vessel speed, course alteration, or both.

4. The Corps will avoid the sea turtle nesting season during initial construction and each nourishment interval. If, due to unforeseen circumstances, construction extends into the nesting season, the Corps will implement a sea turtle nest monitoring and avoidance/relocation plan through coordination with USFWS and NCWRC.

5. Monitoring of sea turtle nesting activities in beach nourishment areas will be required to assess post nourishment nesting activity. This will include daily surveys beginning at sunrise from May 1 until September 15. Information on false crawl location, nest location, and hatching success of all nests will be recorded and provided to NCWRC.

6. The beach will be monitored for escarpment formation by the Contractor prior to completion of beach construction activities associated with initial construction and each nourishment interval. Additionally, the beach will be monitored by the local sponsor for escarpment formation prior to each turtle nesting season every year between nourishment events. Escarpments which exceed 18 inches in height for a distance of 100 ft. will be leveled by the Contractor or local sponsor accordingly. If it is determined that escarpment leveling is required during the nesting or hatching season, leveling actions should be directed by the USFWS

7. Only beach compatible sediment will be placed on the beach as a component of this project. Post nourishment beach compaction (hardness) will be evaluated by the Corps, in coordination with the NCWRC and USFWS, using qualitative assessment techniques to assure that impacts to nesting and incubating sea turtles are minimized and, if necessary, identify appropriate mitigation responses.

8. Local lighting ordinances will be encouraged to the maximum extent practicable in order to reduce lighting impacts to nesting females and hatchlings. The local sponsors will be encouraged to work with the USFWS, local monitoring groups, and other concerned organizations to develop the best plan for the Towns of Surf City and North Topsail Beach.

9. Throughout the duration of each nourishment event, both initial construction and periodic nourishment, the Contractor will be required to monitor for the presence of stranded sea turtles, live or dead. If a stranded sea turtle is identified, the Contractor will immediately notify the NCWRC of the stranding and implement the appropriate measures, as directed by the NCWRC. Construction activities will be modified appropriately as not to interfere with stranded animals, live or dead.

10. In order to better understand the threshold of sediment color change and resultant heat conduction from nourishment on temperature dependent sex determination of sea turtles, the Corps will monitor nest temperatures in the project area during the nesting

season following initial construction. This data will be compared to non-nourished native sediment temperatures in order to support development of management criteria for sediment color guidelines.

11. In order to assess the abundance of sea turtles, and potential risk of hopper dredge take, within the proposed borrow areas for this project, the Corps will participate in the NCWRC's current satellite telemetry efforts to track the distribution and habitat usage of sea turtles in NC offshore waters.

12. Monitoring for seabeach amaranth on Surf City and North Topsail Beaches will be implemented in the growing season following initial construction to assess the post nourishment presence of plants. This survey will broken down into survey reaches for each town in accordance with the designated USACE sea beach amaranth survey reaches from 1991-2008 in order to maintain consistent data and survey techniques over time and results will be provided to USFWS.

13. The Corps will implement precautionary measures for avoiding impacts to manatees during construction activities as detailed in the "Guidelines for Avoiding Impacts to the West Indian Manatee in North Carolina Waters" established by the USFWS.

14. The Corps will adhere to appropriate environmental windows for piping plovers and other shorebirds to the maximum extent practicable.

15. All staging areas, pipeline routes, and associated construction activities will avoid high value piping plover and shorebird habitat, located within the vicinity of New River Inlet, to the maximum extent practicable.

10.07 Cultural Resources

Significant impacts to known archaeological or historic resources are not anticipated due to the proposed work. No cultural resources were identified in the study area. Project-specific historic survey data have been coordinated with the NC SHPO, and concurrence has been obtained that the proposed action would not cause significant adverse impacts to submerged cultural resources.

The SHPO letter accepting the final report of investigations is dated March 1, 2005, and is included in Appendix H.

10.08 Executive Order 11988 (Flood Plain Management)

Executive Order 11988 requires federal agencies to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of flood plains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. In accomplishing this objective, "each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by flood plains in carrying out its responsibilities." The Water Resources Council Floodplain Management Guidelines for implementation of EO 11988, as referenced in the Corps' ER 1165-2-26, require an eight-step process that agencies should carry out as part of their decision-making on projects that have potential impacts to or within the floodplain. The eight steps reflect the decision-making process required in Section 2(a) of the Order. The eight steps and responses to them are summarized below.

1. Determine if the proposed action is in the base flood plain.

Yes, the project is a Coastal Storm Damage Reduction project located on portions of the ocean shoreline of the communities of Surf City and North Topsail Beaches, which are within the 100-year floodplain.

2. If the action is in the base flood plain, identify and evaluate practicable alternatives to the action or to location of the action in the base flood plain.

Chapter 5 of this document has an analysis of practicable alternatives and Chapter 8 evaluates the environmental impacts of the selected alternative.

3. If the action must be in the flood plain, advise the general public in the affected area and obtain their views and comments.

The general public and other interested stakeholder's including State, Federal, and Non-Governmental (NGO) resource agencies have been a part of the planning process for this study. Specifically, the integrated Feasbility Report and EIS was circulated for a 45 day Public review in January 2010. All comments have been reviewed and integrated into the report where appropriate. Also, the towns of Surf City and North Topsail Beach, as the non-federal sponsors, have been engaged throughout the planning process.

4. Identify beneficial and adverse impacts due to the action and any expected losses of natural and beneficial flood plain values. Where actions proposed to be located outside the base flood plain will affect the base flood plain, impacts resulting from these actions should also be identified.

Potential impacts associated with the proposed alternative are identified in Chapter 8, "Environmental Effects," of the report. No project components would be located outside of the base flood plain.

5. If the action is likely to induce development in the base flood plain, determine if apracticable non-flood plain alternative for the development exists.

In their Draft Fish and Wildlife Coordination Act report, the USFWS suggested that most of Topsail Island is in the 100-year floodplain and a large portion of the Surf City and North Topsail Beach project area is subject to hurricane storm surge flooding (Section

11.03). Furthermore, the USFWS has suggested that the existing structures and subsequent additional growth would be supported by the proposed federal action; thus, representing unwise development in a hazardous floodplain and incompliance with EO 11988. The Corps disagrees and believes that the proposed Coastal Storm Damage Reduction project is in full compliance with the requirements of Executive Order 11988. Specifically, IWR Report 96-PS-1, Final Report, *An Analysis of the U.S. Army Corps of Engineers Shore Protection Program,* June 1996 states the following:

> The presence of a Corps project has little effect on new housing production. The econometric results presented imply that general economic growth of inland communities is sufficient by itself to drive residential development of beachfront areas at a rapid pace. The statistical evidence indicates that the effect of the Corps on induced development is, at most, insignificant, compared to the general forces of economic growth which are stimulating development in these areas, many of which are induced through other municipal infrastructure developments such as roads, wastewater treatment facilities, etc. The results presented for beachfront housing price appreciation are consistent with the findings from the more general econometric model of real estate development in beachfront communities. The increasing demand for beachfront development can be directed related to the economic growth occurring in inland areas. There is no observable significant effect on the differential between price appreciation in inland and beachfront areas due to Corps activity. The housing price study could not demonstrate that Corps shore protection projects influence development. Corps activity typically follows significant development.

In fact, the requirements for federal participation in coastal storm damage reduction projects essentially dictate that these projects be constructed along areas that have a high degree of development. Additionally, part of the conceptual framework of the Unified National Program for Floodplain Management consists of a series of strategies and tools that can be used to manage floodplains to reduce losses to both human and natural resources. As part of the broader, national vision of floodplain management, the Water Resources Council submitted the Unified National Program for Floodplain Management to the President in 1976. That report, which updates the 1966 Unified National Program for Managing Flood Losses, reflects a shift in focus from flood damage reduction to floodplain management. Through Executive Orders and Interagency Task Forces, the 1976 report was revised and strengthened during the 1980s and 1990s and continues to serve as the focus of the national need to evaluate flood damages within the context of floodplain management. In the 1994 Unified National Program Report, four strategies for managing floodplains wisely were developed (FEMA, 1994). One of the four strategies, which is also a purpose of Executive Order 11988, is to preserve and restore the natural resources and functions of floodplains. The 1994 report further identifies beach nourishment and building sand dunes as tools to support this strategy. Clearly, beach nourishment has been accepted as a valuable tool in moderating flooding and protecting floodplains. Placement of beachfill would occur in the floodplain of area beaches. That placement would be conducted specifically for its beneficial effect in offsetting erosion and restoring damaged beaches, and therefore would be judged acceptable. The action would be expected to have an insignificant effect on the floodplain; therefore, the proposed action is in compliance with the requirements of Executive Order 11988 and with state/local floodplain protection standards.

6. As part of the planning process under the Principles and Guidelines, determine viable methods to minimize any adverse impacts of the action including any likely induced development for which there is no practicable alternative and methods to restore and preserve the natural and beneficial flood plain values. This should include reevaluation of the “no action” alternative.

Specific “Commitments to Reduce Environmental Impacts” were identified as a part of the project planning process and are listed in Table 7.2. These identified commitments will be implemented as part of the project to minimize the project’s potentially adverse impacts. The project includes some incidental environmental benefits associated with the expansion of beach habitat. The No-Action Alternative is discussed in Chapter 5 of the report, and is not considered a practicable alternative. Furthermore, the nature of the recommended project and the associated floodplain is such that the project and floodplain are able to naturally adapt and equilibrate to changes in sea level rise, and are thus sustainable during the 50 year project life.

7. If the final determination is made that no practicable alternative exists to locating the action in the flood plain, advise the general public in the affected area of the findings.

As per item 3 above, the report has been circulated for public review and directly provided to the towns of Surf City and North Topsail Beach.

8. Recommend the plan most responsive to the planning objectives established by the study and consistent with the requirements of the Executive Order.

The objective of the project is to reduce risks to public health, safety, and property on Surf City and North Topsail Beaches. The project is responsive to the EO 11988 objective of “avoidance, to the extent possible, of long- and short-term adverse impacts associated with the occupancy and modification of the base flood plain and the avoidance of direct and indirect support of development in the base flood plain wherever there is a practicable alternative” because it would not induce development in the floodplain, would reduce the hazard and risk associated with floods thereby minimizing the impacts of floods on human safety, health, and welfare, and would restore and preserve the natural and beneficial values of the base floodplain.

10.09 Executive Order 11990 (Protection of Wetlands)

Executive Order 11990 directs all federal agencies to issue or amend existing procedures to ensure consideration of wetlands protection in decision making and to ensure the evaluation of the potential effects of any new construction proposed in a wetland. The proposed action would not require filling any wetlands and would not be expected to produce significant changes in hydrology or salinity affecting wetlands. The proposed action is in compliance with Executive Order 11990.

10.10 Executive Order 13186 (Responsibilities of Federal Agencies to Protect Migratory Birds)

Executive Order 13186 directs departments and agencies to take certain actions to further implement the Migratory Bird Treaty Act. Specifically, the executive order directs federal agencies, whose direct activities would likely result in the take of migratory birds, to develop and implement a Memorandum of Understanding with the USFWS that must promote the conservation of bird populations. As discussed in Section 8.02.3, the proposed project would not be expected to adversely affect migratory birds and therefore, is in compliance with Executive Order 13186.

10.11 Outer Continental Shelf Lands Act

The OCS law provides the Secretary of the Interior, on behalf of the federal government, with authority to manage the mineral resources, including oil and gas, on the OCS. The MMS Leasing Division is charged with environmentally responsible management of federal OCS sand and gravel resources. The OCS is a zone that generally extends from 3 nautical miles seaward of the coastal state boundaries out to 200 nautical miles. For the Surf City and North Topsail Beach project 9 of the 16 potential borrow sites are within the OCS. P.L. 102-426 (43 U.S.C. 1337(k)(2)), enacted October 31, 1994, gave MMS the authority to negotiate, on a noncompetitive basis, the rights to OCS sand, gravel, and shell resources for coastal storm damage reduction, beach or wetlands restoration projects, or for use in construction projects funded in whole or part by or authorized by the federal government.

The MMS is a cooperating agency with the Corps on the project (see correspondence in Appendix H) and coordination with MMS is ongoing. Pursuant to P.L. 103-426, which authorizes the Secretary of the Interior to negotiate agreements for the use of OCS sand, gravel, and shell resources, any federal agency that proposes to make use of sand, gravel and shell resources must enter into a Memorandum of Agreement (MOA) with the MMS concerning the potential use of those resources. Previous procedures for obtaining a noncompetitive lease for OCS sand from the MMS included execution of a MOA between the MMS and the Corps' district office making the request. Later in the process, the MMS would then complete a lease agreement with the local government entity receiving the sand. However, the MMS has changed that part of the procedure; instead of the two separate agreements, MMS now requires only one MOA signed by the local sponsor, the Corps, and the MMS. Under the new procedure, the three-party MOA becomes the lease instrument. It is developed as the required NEPA steps are completed and terms and conditions identified by the NEPA consultations with other agencies are incorporated into the MOA. The required MOA would be signed before beginning construction. The MMS would not issue a lease until all applicable federal requirements have been appropriately satisfied.

10.12 North Carolina Coastal Management Program

The proposed action would be conducted in the designated coastal zone of North Carolina. Pursuant to the federal Coastal Zone Management Act of 1972, as amended (P.L. 92-583), federal activities are required to be consistent, to the maximum extent practicable, with the federally approved coastal management program of the state in which their activities will occur. The components of the proposed action have been evaluated and determined to be consistent with the North Carolina Coastal Management Program and local land use plans. Concurrence with this determination is being requested from the North Carolina Division of Coastal Management.

10.12.1 Areas of Environmental Concern (15A NCAC 07H .0204)

The selected plan would take place in areas under the North Carolina Coastal Management Program designated as an Area of Environmental Concern (AEC) (15A NCAC 07H). Specifically, the activities could affect the following AECs: Coastal Wetlands, Estuarine Waters, Public Trust Areas, Coastal Shorelines, and Ocean Hazard Areas. The following determination has been made regarding the consistency of the proposed project with the state's management objective for each AEC affected:

Coastal Wetlands. Coastal wetlands are defined as any salt marsh or other marsh subject to regular or occasional flooding by tides, including wind tides (whether or not the tide waters reach the marshland areas through natural or artificial watercourses), provided this will not include hurricane or tropical storm tides. The highest priority of use will be allocated to the conservation of existing coastal wetlands. Second priority of coastal wetland use will be given to those types of development activities that require water access and cannot function elsewhere. Unacceptable land uses may include the following examples: restaurants and businesses; residences, apartments, motels, hotels, and trailer parks; parking lots and private roads and highways; and factories. Examples of acceptable land uses may include utility easements, fishing piers, docks, and agricultural uses, such as farming and forestry drainage, as permitted under North Carolina's Dredge and Fill Act or other applicable laws. The management objective is to conserve and manage coastal wetlands so as to safeguard and perpetuate their biological, social, economic and aesthetic values; to coordinate and establish a management system capable of conserving and using coastal wetlands as a natural resource essential to the functioning of the entire estuarine system. No dredge pipelines would cross coastal wetlands during project construction or renourishment events, therefore no impacts would be incurred, making the project consistent with the management objective for this AEC.

Estuarine Waters. Estuarine waters are defined in G.S. 113A-113(b)(2) to include all the waters of the Atlantic Ocean within the boundary of North Carolina and all the waters of the bays, sounds, rivers, and tributaries thereto seaward of the dividing line between coastal fishing waters and inland fishing waters. The highest priority of use will be allocated to the conservation of estuarine waters and their vital components. Second priority of estuarine waters use will be given to those types of development activities that require water access and use which cannot function elsewhere such as simple access channels; structures to reduce erosion; navigation channels; boat docks, marinas, piers, wharfs, and mooring pilings. The management objective is to conserve and manage the important features of estuarine waters so as to safeguard and perpetuate their biological, social, aesthetic, and economic values; to coordinate and establish a management system capable of conserving and using estuarine waters so as to maximize their benefits to man and the estuarine and ocean system. The selected plan would not involve estuarine waters and therefore would not be detrimental to estuarine waters.

Public Trust Areas. These areas include (1) waters of the Atlantic Ocean and the lands thereunder from the mean high water mark to the 3 nautical mile limit of state jurisdiction, (2) all natural bodies of water subject to measurable lunar tides, and all lands thereunder, to the mean high water mark, and (3) all navigable natural bodies of water, and all lands thereunder, except privately owned lakes to which the public has no right of access. Acceptable uses include those that are consistent with protection of the public rights for navigation and recreation, as well as conservation and management to safeguard and perpetuate the biological, economic, and aesthetic value of these areas. The management objective is to protect public rights for navigation and recreation and to conserve and manage the public trust areas so as to safeguard and perpetuate their biological, economic and aesthetic value. Placement of beach compatible material on Surf City and North Topsail Beach would result in a wider, more stable beach, thus enhancing recreational opportunities, biological habitat and economic and aesthetic values. For a more thorough discussion of project impacts, please see Section 8 Environmental Effects, of the FEIS, specifically Sections 8.05 Recreational and Aesthetic Resources, 8.04 Socioeconomic Resources, 8.01 Marine Environment, and 8.02 Terrestrial Environment. The selected plan is an acceptable use within public trust areas and would not be detrimental to the biological and physical functions of Public Trust Areas.

Coastal Shorelines. The Coastal Shorelines category includes estuarine shorelines and public trust shorelines. Estuarine shorelines AEC are those non-ocean shorelines extending from the normal high water level or normal water level along the estuarine waters, estuaries, sounds, bays, fresh and brackish waters, and public trust areas. Acceptable uses will be limited to those types of development activities that would not be detrimental to the public trust rights and the biological and physical functions of the estuarine and ocean system. The management objective is to ensure that shoreline development is compatible with both the dynamic nature of coastal shorelines as well as the values and the management objectives of the estuarine and ocean system. Other objectives are to conserve and manage the important natural features of the estuarine and ocean system so as to safeguard and perpetuate their biological, social, aesthetic, and economic values; to coordinate and establish a management system capable of conserving and using these shorelines so as to maximize their benefits to the estuarine and ocean system and the people of North Carolina. The selected plan would not involve estuarine shorelines and therefore would not be detrimental to these areas. Please see the paragraph above regarding Public Trust Areas and the references to pertinent sections of the FEIS for information regarding public trust shorelines. Additionally, as discussed in Appendix J (Cumulative Effects) of the FEIS, on a regional basis, renourishment projects add material to the longshore transport system, thus providing positive impacts. Although a regional sediment budget analysis has not been completed, it is expected that the proposed action and the combined effects of all other existing and proposed beach projects would have a minimal effect on shoreline and sand transport. Therefore, the proposed project would not be expected to negatively impact coastal shorelines.

Ocean Hazard Areas. These areas are considered natural hazard areas along the Atlantic Ocean shoreline where, because of their special vulnerability to erosion or other adverse effects of sand, winds, and water, uncontrolled or incompatible development could unreasonably endanger life or property. Ocean hazard areas include beaches, frontal dunes, inlet lands, and other areas in which geologic, vegetative and soil conditions indicate a substantial possibility of excessive erosion or flood damage. The specific Ocean Hazard Areas and potential project impacts are described below.

Ocean Erodible Area. This is the area in which there exists a substantial possibility of excessive erosion and significant shoreline fluctuation. The seaward boundary of this area is the mean low water line. The landward extent of this area is determined as follows:

(a) a distance landward from the first line of stable natural vegetation to the recession line that would be established by multiplying the long-term annual erosion rate times 60, provided that, where there has been no long-term erosion or the rate is less than two ft. per year, this distance will be set at 120 ft. landward from the first line of stable natural vegetation. For the purposes of this Rule, the erosion rates will be the long-term average based on available historical data. The current long-term average erosion rate data for each segment of the North Carolina coast is depicted on maps titled *Long Term Annual Shoreline Change Rates* updated through 1998 and approved by the Coastal Resources Commission on January 29th, 2004 (except as such rates may be varied in individual contested cases, declaratory or interpretive rulings). Erosion rates are variable along Surf City and North Topsail Beach. See Appendix D (Figure D-5) for a comparison of the shoreline rate change, referenced above, to recently computed erosion rates at subject beaches.

(b) a distance landward from the recession line established in Sub-Item (1)(a), above, to the recession line that would be generated by a storm having a one percent chance of being equaled or exceeded in any given year.

Construction of the proposed beach template, which consists of 15-ft elevation dune (NGVD) and 50-ft-wide berm, would result in a wider, more stable beach, thus providing significant benefits to the ocean erodible area. Beach-related work, including the discharge of dredged material, the associated temporary operation of heavy equipment, and placement of dredge pipeline, would not cause any significant adverse effects to the ocean erodible area.

High Hazard Flood Area. This is the area subject to high velocity waters (including, but not limited to, hurricane wave wash) in a storm having a one percent chance of being equaled or exceeded in any given year, as identified as zone V1-30 on the flood insurance rate maps of the Federal Insurance Administration, U.S. Department of Housing and Urban Development. Placement of beach nourishment on the beach would provide short-term damage reduction benefits for high hazard flood areas.

Inlet Hazard Area. The inlet hazard areas are natural-hazard areas that are especially vulnerable to erosion, flooding and other adverse effects of sand, wind, and water because of their proximity to dynamic ocean inlets. This area will extend landward from the mean low water line a distance sufficient to encompass that area within which the inlet would, on the basis of statistical analysis, migrate, and will consider such factors as previous inlet territory, structurally weak areas near the inlet (such as an unusually narrow barrier island, an unusually long channel feeding the inlet, or an overwash area), and external influences such as jetties and channelization. In all cases, this area will be an extension of the adjacent ocean erodible area and in no case will the width of the inlet hazard area be less than the width of the adjacent ocean erodible area. While components of the proposed action may involve the movement of equipment across these areas, no construction or periodic nourishment activities are proposed for these areas, and no adverse impacts are anticipated.

10.12.2 Use Standards (15A NCAC 07H .0208)

Primary Nursery Areas. With the exception of navigation channels, these include most estuarine waters of the project vicinity, including those bounded by New River (north), Mason Inlet (south), AIWW (west), and the landward side of Topsail Island. Protection of juvenile fish is provided in those areas through prohibition of many commercial fishing activities, including the use of trawls, seines, dredges, or any mechanical methods of harvesting clams or oysters (http://www.ncfisheries.netirules.htm; 15 NC Administrative Code 3B .1405). PNAs (Figure A-3) would not be directly affected by the project. However, PNAs adjacent to the project area may experience indirect and short-term elevated turbidity levels from the nourishment operation on the shoreface. Such turbidity effects are dependent on the location of the outflow pipe and the direction of longshore and tidal currents. Because the elevated turbidity levels would be short-term and within the range of elevated turbidity from natural storm events, the impacts to state-designated PNAs would be expected to be insignificant (FEIS Section 8.01.8.7).

Outstanding Resource Waters. Waters of the AIWW from Daybeacon 17 (between Chadwick Bay and Alligator Bay) to Morris Landing (south of Spicer Bay) and waters of Topsail Sound southward from approximately New Topsail Inlet to Middle Sound are classified as *SA ORW* (Figure A-5). As stated above, waters in the vicinity of New Topsail and New River Inlets may experience temporary elevated turbidities over existing conditions during initial construction and renourishment. Monitoring studies done on the impacts of offshore dredging indicate that sediments suspended during offshore are generally localized and rapidly dissipate when dredging ceases (Naqvi and Pullen, 1982: Bowen and Marsh, 1988; Van Dolah et al., 1992). Overall water quality impacts of the proposed action are expected to be short-term and minor. Living marine resources dependent on good water quality should not experience significant adverse impacts due to water quality changes. Therefore, no impacts to ORW in the vicinity of the project, with the exception of minor, short-term impacts in the vicinity of New Topsail Inlet, would be expected. For more information on water quality, see Section 8.07.2 of the FEIS.

Submerged Aquatic Vegetation (SAV). As depicted in the FEIS, Table 8.2, SAV does not occur in or near the project vicinity and would not be directly or indirectly affected by the proposed project.

For compliance with 15A NCAC 07H. 0208(b)(12) Submerged Lands Mining, see Section 10.12.8.

10.12.3 Shoreline Erosion Policies (15A NCAC 07-M .0202)

Pursuant to Section 5, Article 14 of the North Carolina Constitution, proposals for shoreline erosion response projects will avoid losses to North Carolina's natural heritage. All means should be taken to identify and develop response measures that would not adversely affect estuarine and marine productivity. As discussed in detail in Section 8.01 Marine Environment and Appendix J Cumulative Effects of the FEIS, the project would not be expected to result in adverse impacts to estuarine and marine productivity.

The public right to use and enjoy the ocean beaches must be protected. The protected uses include traditional recreational uses (such as walking, swimming, surf fishing, and sunbathing) as well as commercial fishing and emergency access for beach rescue services. The Corps has several requirements that must be met to fully cost share in a coastal storm damage reduction project (see ER 1105-2-100 and ER 1165-2-130). One of those requirements is that the beaches must be available for public use. As described in ER 1165-2-130 (Federal Participation in Shore Protection, paragraph 6.h.) public use implies reasonable access and parking. The Corps' Wilmington District, additionally, has developed more specific public access and parking requirements for participation in coastal storm damage reduction projects within the District's boundaries of North Carolina and Virginia. Public Access and Parking is discussed in detail in Appendix O of the FEIS.

Erosion response measures designed to minimize the loss of private and public resources to erosion should be economically, socially, and environmentally justified. The FEIS demonstrates that the proposed coastal storm damage reduction project at Topsail Beach is economically, socially and environmentally justified. Pertinent sections of the FEIS include: Section 7.08 Economics of the Selected Plan, Section 8.00 Environmental Effects, Appendix B Economic Analyses, Appendix I Biological Assessment, and Appendix J Cumulative Effects.

The following are required with state involvement (funding or sponsorship) in beach restoration and sand renourishment projects: The entire restored portion of the beach will be in permanent public ownership and it will be a local government's responsibility to provide adequate parking, public access, and services for public recreational use of the restored beach. Public ownership of the shore in the towns of Surf City and North Topsail Beach include dedicated roads and lands below MHW owned by North Carolina. Other parcels are owned by the towns of Surf City and North Topsail Beach, including CAMA public access points and the ends of all roads. The project area includes more than 500 parcels in Surf City and nearly 350 parcels in North Topsail Beach. The primary ownership of the oceanfront parcels is private, including two fishing piers. The entire restored portion of the beach is in public ownership. Other information related to ownership of the shoreline is in Appendix M, Real Estate. Parking, public access and services for the public recreational use of the restored beach are addressed in preceding paragraphs, above. Additional details are available in Appendix O of the report.

10.12.4 Shorefront Access Policies (15A NCAC 07M .0300)

Pursuant to 15A NCAC 07M .0300, the public has traditionally and customarily had access to enjoy and freely use the ocean beaches and estuarine and public trust waters of the coastal region for recreational purposes and the state has a responsibility to provide continuous access to the resources. It is the state's policy to foster, improve, enhance and ensure optimum access to the public beaches and waters of the 20-county coastal region. Access will be consistent with rights of private property owners and the concurrent need to protect important coastal natural resources such as sand dunes and coastal marsh vegetation. Surf City and North Topsail Beach have many public ocean shoreline access sites from dedicated easements, town owned sites, and street rights of way. The availability of parking varies and includes dedicated parking lots at access sites and street right of way parking. As previously stated, the Corps has several requirements that must be met to fully cost share in a coastal storm damage reduction project (see ER 1105-2-100 and ER 1165-2-130). ER1165-2-130 stipulates that to qualify for federal cost sharing of Coastal Storm Damage Reduction projects, the local community must, at a minimum, provide public access every one half mile and parking within a one quarter mile radius of those access points. The Wilmington District has further established a minimum of ten public parking spaces be available within one-quarter mile of each required public access point (see Appendix O of the report).

10.12.5 Mitigation Policy (15A NCAC 07M .0701)

It is the policy of North Carolina to require that adverse impacts to coastal lands and waters be mitigated or minimized through proper planning, site selection, compliance with standards for development, and creation or restoration of coastal resources. Coastal ecosystems will be protected and maintained as complete and functional systems by mitigating the adverse impacts of development as much as feasible by enhancing, creating, or restoring areas with the goal of improving or maintaining ecosystem function and areal proportion. Section 7.03.6 Environmental Monitoring and Commitments of the FEIS, provides a brief summary of environmental commitments to protect listed species related to the construction and maintenance of the proposed project. Further information on the development and details of these commitments is contained in Appendix I, Biological Assessment.

10.12.6 Coastal Water Quality Policies (15A NCAC 07M .0800)

Pursuant to 15A NCAC 07M.0800, no land or water use will cause the degradation of water quality so as to impair traditional uses of the coastal waters. Protection of water quality and the management of development within the coastal area is the responsibility of many agencies. The general welfare and public interest require that all state, federal and local agencies coordinate their activities to ensure optimal water quality. Overall water quality impacts of the proposed action would be expected to be short-term and minor. Living marine and estuarine resources dependent on good water quality are not expected to experience significant adverse impacts due to water quality changes. A Section 401 Water Quality Certificate under the Clean Water Act of 1977 (P.L. 95-217), as amended, is required for the proposed project and would be requested from the NCDWQ at the appropriate time. Project construction would not begin until a Water Quality Certification has been received. For a full discussion of water resources and potential project impacts, see Sections 2.06 and 8.07 Water Resources, of the FEIS, which address hydrology, water quality and groundwater. Pursuant to Section 404 of the Clean Water Act, the impacts associated with the discharge of fill material into waters of the United States are discussed in the Section 404(b)(1) (P.L. 95-217) Guidelines Analysis in Appendix G. Discharges associated with dredging in the offshore borrow areas are considered incidental to the dredging operation, and therefore, are not being considered as being a discharge addressed under the Section 404 (b)(1) Guidelines Analysis. Pursuant to the Sedimentation Pollution Control Act of 1973, a state-approved soil erosion and sedimentation control plan would be implemented during construction to minimize soil loss and erosion.

10.12.7 Policies on Beneficial Use and Availability of Materials Resulting From the Excavation or Maintenance of Navigational Channels (15A NCAC 07M .1100)

It is North Carolina's policy that material resulting from the excavation or maintenance of navigation channels be used in a beneficial way wherever practicable. Policy statement .1102 (a) indicates that, "clean, beach quality material dredged from navigation channels within the active nearshore, beach, or inlet shoal systems must not be removed permanently from the active nearshore, beach, or inlet shoal system unless no practicable alternative exists. Preferably, this dredged material would be disposed of on the ocean beach or shallow active nearshore area where environmentally acceptable and compatible with other uses of the beach." Several navigation channels are within the Surf City and North Topsail Beach project vicinity. They are the AIWW, New Topsail Inlet and Connecting Channels and New River Inlet. When practicable, beach compatible, maintenance dredged material from these navigation channels may be placed on the nourished beach. However, because of the distances from the navigation channels to the nourished beach that would rarely, if ever, be practicable. Any dredged material from navigation channels would be purely supplemental material that would help maintain the project profile.

10.12.8 Policies on Ocean Mining (15A NCAC 07M .1200) and 15A NCAC 07H. 0208(b)(12) Submerged Lands Mining

Mining activities affecting the federal jurisdiction ocean and its resources can, and probably would, also affect the state jurisdictional ocean and estuarine systems and vice-versa. Therefore, it is state policy that every avenue and opportunity to protect the physical ocean environment and its resources as an integrated and interrelated system would be used. Cultural resources and hard-bottom surveys of the offshore borrow areas have been completed. No single, isolated magnetic anomalies or acoustic targets were identified during the survey of the borrow areas and no further cultural resources studies are anticipated for the project. By letter of November 2, 2004, the North Carolina SHPO concurred with the reported findings. As identified through the myriad of investigative studies discussed in Section 8.01.8.2 to identify and avoid nearshore and offshore hard bottom resources, the Corps has demonstrated a commitment to avoidance and minimization of impacts to hard bottom communities. No dredging activities would occur in or near hard bottom communities. For the full discussion of impacts to hard bottoms, see Section 8.01.8.2.

Dredging impacts to the benthic populations of the marine ecosystem from turbidity would be local and temporary but not permanent. Similarly, recent studies show that benthic impacts may be limited to the immediate vicinity of dredging operations. Also, to minimize effects, work would be performed between December 1 and March 31 of the year, during times of low biological activity. For the full discussion of benthic impacts, see Sections 8.01.6 and 8.01.7. Because: (1) no cultural resources sites are present in the area, (2) no hardbottoms are in or near the proposed offshore disposal sites, and (3) the effects of turbidity and sedimentation plumes on offshore hard bottom would be insignificant, the project would not be expected to adversely affect the state jurisdictional ocean and estuarine systems. For more detailed information, see the following sections of the report: Section 2.01 Marine Environment, 2.05 Cultural Resources, 7.04.3 Borrow Area Use Plan, 8.01 Marine Environment, 8.06 Cultural Resources, Appendix I Biological Assessment, and Appendix J Cumulative Effects.

The proposed coastal storm damage reduction project at Surf City and North Topsail Beach conforms to the relevant enforceable policies of Subchapters 7H and 7M of Title 15A of North Carolina's Administrative Code.

10.12.9 Other State Policies

The proposed project has been determined to be consistent with other state policies found in the state's Coastal Management Program document that are applicable. Those include the following:

North Carolina Mining Act. The removal of material from the offshore borrow areas that are within 3 nautical miles of shore have been reviewed by the North Carolina Division of Land Resources and a determination has been made that removal of sand from the sea floor within the 3 miles territorial limits is not an activity that would be classified as mining under the North Carolina Mining Act (G. S. 74-7). *Mining* is defined as:

(a) The breaking of the surface soil to facilitate or accomplish the extraction or removal of mineral, ores, or other solid matter.

(b) Any activity or process constituting all or part of a process for the extraction or removal of minerals, ores, soils, and other solid matter from their original location.

(c) The preparation, washing, cleaning, or other treatment of minerals, ores, or other solid matter so as to make them suitable for commercial, industrial, or construction use.

North Carolina Dredge and Fill Law (G.S. 113-229). Pursuant to the North Carolina Dredge and Fill Law clean, beach quality material dredged from navigational channels within the active nearshore, beach or inlet shoal systems will not be removed permanently from the active nearshore, beach or inlet shoal system. This dredged material will be disposed of on the ocean beach or shallow active nearshore area where it is environmentally acceptable and compatible with other uses of the beach. As discussed in Section 10.12.7, when practicable, clean, beach quality material from maintenance dredging of navigation channels may be placed on the nourished beach at Surf City and North Topsail Beach. Any dredged material from navigation channels would be purely supplemental material that would help maintain the project profile.

Clean Water Act. A section 401 Water Quality Certificate under the Clean Water Act of 1977 (P.L. 95-217), as amended, is required for the proposed project and would be requested from the NCDWQ. Work would not proceed until the section 401 certification is received.

Pursuant to section 404 of the Clean Water Act, the impacts associated with the discharge of fill material into waters of the United States are discussed in the section 404(b)(1) (P.L. 95-217) Guidelines Analysis in Appendix G of the report. Discharges associated with dredging in the offshore borrow areas are considered incidental to the dredging operation, and therefore, are not being considered as being a discharge addressed under the Section 404 (b)(1) Guidelines Analysis.

Sedimentation and Erosion Control. Pursuant to the Sedimentation Pollution Control Act of 1973, a state-approved soil erosion and sedimentation control plan would be implemented during construction to minimize soil loss and erosion.

10.12.10 Local Land Use Plans

Compliance with all applicable CAMA Land Use Plans is discussed below.

On the basis of the information in the 1991 *Pender County Land Use Plan Update*, ocean beaches and shorelines are valuable for public and private recreation and are within natural hazard areas. Pender County's overall policy and management objective for the estuarine system is to, "give the highest priority to their protection to perpetuate their biological, social, economic, and aesthetic values to ensure that development occurring within these AEC's is compatible with natural characteristics so as to minimize the likelihood of significant loss of private property and public resources." (15 NCAC 07H .0203). Also, the *Pender County Land Use Plan* states, "Beach nourishment projects are the responsibility of Surf City." With the exception of the Island Business District/Town Center, the shoreline at Surf City is zoned Residential. According to the *Surf City Land Use Plan*, dated 2005, the town is concerned about the long-term effects of continuing erosion and believes that beach nourishment, followed by regular renourishment, is the best method of dealing with the problem of erosion.

The Onslow County Land Use Plan, dated 1997, states, "Onslow County desires to minimize the hazards to life, health, public safety, and development within flood hazard areas." According to the Onslow County Land Use Plan and the 1996 Town of North Topsail Beach Land Use Plan, the shoreline at North Topsail Beach is classified as Urban Transition. Most development within this classification consists of single and multi-family residences and special uses allowed by the North Topsail Beach zoning ordinance. The town of North Topsail Beach also supports beach renourishment projects and as stated in the 1996 LUP, "…the [t]own is currently investigating potential funding sources for beach renourishment projects."

The proposed coastal storm damage reduction project is sponsored by the towns of Surf City and North Topsail Beach in conjunction with the Corps. The project would result in a wider, more stable beach, thus enhancing the recreational opportunities, biological habitat, and economic and aesthetic values of the beach. Therefore, the proposed project is consistent with all applicable CAMA Land Use Plans.

On the basis of the information presented in this Feasibility Report and EIS, the proposed project is consistent with the North Carolina Coastal Management Program. This determination is being provided to the state for its review and concurrence.

10.13 Coastal Barrier Resources Act

The Coastal Barrier Resources Act (CBRA) of 1982 (P.L. 97-348) prohibits expenditure of federal funds for activities within the designated limits of the Coastal Barrier Resources System unless specifically exempted by section 6 of the act. As stated in that section, federal expenditures are allowable in association with maintenance of existing channel improvements, including disposal of dredged material related to such improvements. Designated maps showing all sites included in the system in North Carolina show Topsail Unit (L06) to be within the Coastal Barrier Resource System and protected under the Coastal Barrier Improvement Act of 1990 (USFWS 1990). This site is *not* included in the project area (Appendix A, Figure A-1) and would not be affected by the selected plan (Appendix A, Figure A-7).

10.14 Estuary Protection Act

The Estuary (Estuarine) Protection Act provides a means to protect, conserve, and restore estuaries in a manner that maintains balance between the need for natural resource protection and conservation and the need to develop estuarine areas to promote national growth. The act authorizes the Secretary of the Interior to work with the states and other federal agencies in undertaking studies and inventories of estuaries of the United States. The proposed project would be expected to have minimal effect on the estuarine environment, as discussed in Section 8 of this report; therefore the project would be in compliance with the Estuary Protection Act.

10.15 Sedimentation and Erosion Control

Pursuant to the Sedimentation Pollution Control Act of 1973, a state-approved soil erosion and sedimentation control plan would be implemented during construction to minimize soil loss and erosion.

10.16 Prime and Unique Agriculture Land

According to the Soil Surveys for Pender County and Onslow counties, North Carolina, the soils on the beach that could be affected by the proposed project are not designated by the Natural Resource Conservation Service as prime or unique agriculture lands. No impacts to prime and unique agriculture lands would be expected to occur.

Table 10.1. The relationship of the proposed action to federal laws and policies

Title of public law	U.S. Code	Compliance status
Abandoned Shipwreck Act of 1987	43 U.S.C. 2101	Full Compliance
American Indian Religious Freedom Act	42 U.S.C. 1996	Not Applicable
Agriculture and Food Act (Farmland Protection Policy Act) of 1981	7 U.S.C. 4201 et seq.	Not Applicable
American Folklife Preservation Act of 1976, As Amended	20 U.S.C. 2101	Not Applicable
Anadromous Fish Conservation Act of 1965, As Amended	16 U.S.C. 757 a et seq.	Full Compliance
Antiquities Act of 1906, As Amended	16 U.S.C. 431	Full Compliance
Archeological and Historic Preservation Act of 1974, As Amended	16 U.S.C. 469	Full Compliance
Archeological Resources Protection Act of 1979, As Amended	16 U.S.C. 470	Full Compliance
Bald Eagle Act of 1972	16 U.S.C. 668	Not Applicable
Buy American Act	41 U.S.C. 102	Full Compliance
Civil Rights Act of 1964 (P.L. 88-352)	6 U.S.C. 601	Full Compliance
Clean Air Act of 1972, As Amended	42 U.S.C. 7401 et seq.	Full Compliance
Clean Water Act of 1972, As Amended	33 U.S.C. 1251 et seq.	Full Compliance
Coastal Barrier Resources Act of 1982	16 U.S.C. 3501-3510	Full Compliance
Coastal Zone Management Act of 1972, As Amended	16 U.S.C. 1451 et seq.	Full Compliance
Comprehensive Environmental Response, Compensation and Liability Act of 1980	42 U.S.C. 9601	Not Applicable
Conservation of Forest Lands Act of 1960	16 U.S.C. 580 mn	Not Applicable
Contract Work Hours	40 U.S.C. 327	Full Compliance
Convict Labor	18 U.S.C. 4082	Full Compliance
Copeland Anti-Kickback	40 U.S.C. 276c	Full Compliance
Davis Bacon Act	40 U.S.C. 276	Full Compliance
Deepwater Port Act of 1974, As Amended	33 U.S.C. 1501	Not Applicable
Emergency Flood Control Funds Act of 1955, As Amended	33 U.S.C. 701m	Not Applicable
Emergency Wetlands Resources Act	16 U.S.C. 3901-3932	Full Compliance
Endangered Species Act of 1973	16 U.S.C. 1531	Full Compliance
Estuary Program Act of 1968	16 U.S.C. 1221 et seq.	Full Compliance
Equal Opportunity	42 U.S.C. 2000d	Full Compliance
Farmland Protection Policy Act	7 U.S.C. 4201 et seq.	Not Applicable
Federal Environmental Pesticide Act of 1972	7 U.S.C. 136 et seq.	Full Compliance
Federal Water Project Recreation Act of 1965, As Amended	16 U.S.C. 4601	Full Compliance
Fish and Wildlife Coordination Act of 1958, As Amended	16 U.S.C. 661	Full Compliance
Flood Control Act of 1944, As Amended, Section 4	16 U.S.C. 460b	Full Compliance
Food Security Act of 1985 (Swampbuster)	16 U.S.C. 3811 et seq.	Not Applicable
Hazardous Substance Response Revenue Act of 1980, As Amended	26 U.S.C. 4611	Not Applicable

Note: Items identified as being in *Full Compliance* assumes their compliance status after the NEPA process is complete.

Table 10.1. (*continued*)

Title of public law	U.S. Code	Compliance status
Historic and Archeological Data Preservation	16 U.S.C. 469	Full Compliance
Historic Sites Act of 1935	16 U.S.C. 461	Full Compliance
Jones Act	46 U.S.C. 292	Full Compliance
Land and Water Conservation Fund Act of 1965	46 U.S.C. 4601	Not Applicable
Magnuson Fishery Conservation and Management Act	16 U.S.C. 1801	Full Compliance
Marine Protection, Research and Sanctuaries Act of 1972	33 U.S.C. 1401	Full Compliance
Migratory Bird Conservation Act of 1928, As Amended	16 U.S.C. 715	Full Compliance
Migratory Bird Treaty Act of 1918, As Amended	16 U.S.C. 703	Full Compliance
National Environmental Policy Act of 1969, As Amended	42 U.S.C. 4321 et seq.	Full Compliance
National Historic Preservation Act of 1966, As Amended	16 U.S.C. 470	Full Compliance
National Historic Preservation Act Amendments of 1980	16 U.S.C. 469a	Full Compliance
Native American Religious Freedom Act of 1978	42 U.S.C. 1996	Not Applicable
Native American Graves Protection and Repatriation Act	25 U.S.C. 3001	Full Compliance
Native American Religious Freedom Act of 1978	16 U.S.C. 469a	Not Applicable
National Trails System Act	16 U.S.C. 1241	Not Applicable
Noise Control Act of 1972, As Amended	42 U.S.C. 4901 et seq.	Full Compliance
Outer Continental Shelf Lands Act 1953, as Amended	43 U.S.C. 1331-1356	Full Compliance
Rehabilitation Act (1973)	29 U.S.C. 794	Full Compliance
Reservoir Salvage Act of 1960, As Amended	16 U.S.C. 469	Not Applicable
Resource Conservation and Recovery Act of 1976	42 U.S.C. 6901-6987	Not Applicable
River and Harbor Act of 1888, Sect 11	33 U.S.C. 608	Not Applicable
River and Harbor Act of 1899, Sections 9, 10, 13	33 U.S.C. 401-413	Full Compliance
River and Harbor and Flood Control Act of 1962, Section 207	16 U.S.C. 460	Not Applicable
River and Harbor and Flood Control Act of 1970, Sections 122, 209 and 216	33 U.S.C. 426 et seq.	Full Compliance
Safe Drinking Water Act of 1974, As Amended	42 U.S.C. 300f	Full Compliance
Shipping Act	46 U.S.C. 883	Full Compliance
Submerged Lands Act of 1953	43 U.S.C. 1301 et seq.	Full Compliance
Superfund Amendments and Reauthorization Act of 1986	42 U.S.C. 9601	Not Applicable
Surface Mining Control and Reclamation Act of 1977	30 U.S.C. 1201-1328	Not Applicable
Toxic Substances Control Act of 1976	15 U.S.C. 2601	Not Applicable
Uniform Relocation and Assistance and Real Property Acquisition Policies Act of 1970, As Amended	43 U.S.C. 4601 et seq.	Full Compliance
Utilization of Small Business	15 U.S.C. 631, 644	Full Compliance
Vietnam Veterans	38 U.S.C. 2012	Not Applicable

Table 10.1. (*continued*)

Title of Executive Order	Executive Order number	Compliance status
Protection and Enhancement of Environmental Quality	11514/11991	Full Compliance
Protection and Enhancement of the Cultural Environment	11593	Full Compliance
Floodplain Management	11988	Full Compliance
Protection of Wetlands	11990	Full Compliance
Federal Compliance with Pollution Control Standards	12088	Full Compliance
Environmental Effects Abroad of Major Federal Actions	12114	Not Applicable
Offshore Oil Spill Pollution	12123	Full Compliance
Procurement Requirements and Policies for Federal Agencies for Ozone-Depleting Substances	12843	Full Compliance
Federal Compliance with Right-To-Know Laws and Pollution Prevention	12856	Full Compliance
Federal Actions to Address Environmental Justice and Minority and Low-Income Populations	12898	Full Compliance
Procurement Requirements and Policies for Federal Agencies for Ozone-Depleting Substances	12843	Full Compliance
Federal Compliance with Right-To-Know Laws and Pollution Prevention	12856	Full Compliance
Federal Actions to Address Environmental Justice and Minority and Low-Income Populations	12898	Full Compliance
Energy Efficiency and Water Conservation at Federal Facilities	12902	Full Compliance
Federal Acquisition and Community Right-To-Know	12969	Full Compliance
Protection Of Children from Environmental Health Risks and Safety Risks	13045	Full Compliance
Coral Reef Protection	13089	Full Compliance
Greening the Government through Waste Prevention, Recycling and Federal Acquisition	13101	Full Compliance
Invasive Species	13112	Full Compliance
Greening the Government Through Leadership in Environmental Management	13148	Full Compliance
Marine Protected Areas	13158	Full Compliance
Consultation and Coordination with Indian Tribal Governments	13175	Not Applicable
Responsibilities of Federal Agencies to Protect Migratory Birds	13186	Full Compliance
Executive Order Facilitation of Cooperative Conservation	13352	Full Compliance

11. SUMMARY OF AGENCY AND PUBLIC INVOLVEMENT

11.01 Scoping

On February 14, 2001, a scoping letter was sent to agencies, interest groups, and the public to request identification of significant resources and issues of concern. Eleven letters of comment were received. The scoping letter, a list of respondents and comment letters are in Appendix K. Comments received addressed various aspects of the project and generally (1) identified resource concerns or (2) other aspects of the project, such as alternatives analysis, dredging window, cumulative impact analysis, and such, needing to be thoroughly addressed. All comments received were considered during the continuation of project planning and design. Additional coordination has been conducted with representatives of the USFWS, NMFS, North Carolina Department of Archives and History, North Carolina Wildlife Resources Commission and the MMS.

11.02 Cooperating Agencies

The Minerals Management Service (MMS) was invited and has agreed to participate as a cooperating agency (pursuant to Section 1501.6 of the CEQ NEPA Regulations) during the preparation of the Integrated Feasibility Report and Environmental Impact Statement. MMS will assist in developing information and preparing environmental analyses in areas which the MMS has special expertise. This assistance enhances the interdisciplinary capability of the study team.

Beach nourishment measures, which include dredging of sediment from offshore borrow areas on the Outer Continental Shelf (OCS) may require authorization by the Minerals Management Service (MMS) for use during initial or maintenance construction or both (see Section 10.11). The MMS may undertake a connected action (i.e., authorize use of the OCS borrow area) that is related to, but unique from the proposed action. The MMS's proposed action is to issue a negotiated agreement pursuant to its authority under the Outer Continental Shelf Lands Act. The purpose of that action is to authorize the use of OCS sand (or other sediment) resources in beach nourishment and coastal restoration projects undertaken by federal, state or local government agencies, and/or in other federally authorized construction projects.

11.03 Fish and Wildlife Coordination

The Fish and Wildlife Coordination Act, as amended (16 U.S.C. 661, *et seq*), requires that the Corps coordinate and obtain comments from the USFWS, the NMFS, where applicable, and appropriate state fish and wildlife agencies, including the NCDMF and the North Carolina Wildlife Resources Commission. The USFWS provided a Planning Aid Report (PAR), dated September 9, 2003, which provided recommendations that have been considered during project development. Information regarding the components of the proposed action, potential alternatives, and related environmental issues has been coordinated with the USFWS, and its views are documented in a Fish & Wildlife Coordination Act (FWCA) Report, dated May 2010 (Appendix L). Specific fish and wildlife recommendations and Corps responses to a draft version of the report, dated June 2008, are presented in the following paragraphs:

1. USFWS Recommendation: There should be a clear presentation of the federal interest in the project area. The discussion should distinguish between efforts to reduce damage during storms and efforts to replace land lost as rising sea level creates natural processes to move the island landward. There should be an acknowledgement that the ocean does not create permanent damage on the natural communities of barrier islands. What appears to be recession of the beach and dune results from the movement of some sand across the island to build up the natural communities on the sound side. Such movement is part of the natural, adaptive process of the island to sea level rise. The reduction in beach width is actually the result of the area being squeezed between the rising ocean and a fixed line of man-made structures. A clear presentation of the nature of the problem will provide the foundation for determining the federal interest and the development of alternatives.

Corps Response: Federal interest is demonstrated by the fact that this project has a favorable benefit to cost ratio and protects a public shoreline. The dune and berm project would reduce damages and prevent land losses due to both storm related, short term erosion and from long term erosion. In the without-project condition, erosion would continue to narrow the beach in front of existing structures, which would both reduce the suitability of the beach for recreation and for natural habitat. In addition, Topsail Beach is a fully developed barrier island, where sound-side deposition of sand by natural overwash processes is already severely restricted.

2. USFWS Recommendation: The efficacy of any program for replacing inundated beaches with imported fill material over 50 years will depend on global sea level rise during the period. Sea level rise along with more intense hurricanes will contribute to the destruction of a beach constructed, at least partially, in shallow ocean waters. Information from the Intergovernmental Panel on Climate Change (IPCC, 2007) and analysis such as Rahrnstorf (2007) should be used in project planning.

Corps Response: The SLR value used in the Surf City and North Topsail Beach (SCNTB) analysis of 9.6 inches (0.8 ft.) over the next 100 years is within the likely range of SLR reported for all but the most pessimistic scenario family presented in the IPCC 2007, Special Report on Emissions Scenarios (SRES), as shown below:

SRES scenario family	Likely range of SLR
Scenario B1 (most optimistic)	7 to 15 inches
Scenario A1T	8 to 18 inches
Scenario B2	8 to 17 inches
Scenario A1B	8 to 19 inches
Scenario A2	9 to 20 inches
Scenario A1FI (most pessimistic)	10 to 23 inches

Over the 50-yr project life, the difference between the SCNTB value and the average SLR values for each of the IPCC 2007 scenarios range from 0.7 to 3.45 inches, with all but the two most pessimistic scenarios being less than 2 inches difference. A tremendous amount of effort would be required to generate the revised storm responses for these relatively small differences in sea level. The computational precision, rounding, curve-fitting, built-in uncertainty, and so on, that composes the analysis could possibly mask much of the expected differences in outcome. Further, it is likely that the without-project condition (with its diminished dune and berm) is going to be more sensitive to SLR than the with-project condition would be, which would only increase the net benefits for the beachfill project.

3. USFWS Recommendation: The Corps is within the [E]xecutive [B]ranch and is therefore required to comply with Executive Order (EO) 11988. This EO was enacted to avoid, to the extent possible, the long and short term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct or indirect support of floodplain development wherever there is a practicable alternative (USACE 2006a, p. 118). Most of Topsail Island is in the 100-year floodplain (Pilkey et al. 1998, p. 171) and most of the island would be largely underwater in a category one or two hurricane and nearly completely submerged in a category three hurricane (Pilkey et al. 1998, p. 173). Except for some dune areas, the entire Surf City-North Topsail Beach project area is subject to hurricane storm surge flooding (USACE 2006b, p. 9). These dangers are reflected in the fact that the northern portion of Topsail Island is included in the Coastal Barrier Resource System (CBRS). Areas included the CBRS were generally considered unsuitable for development because they are vulnerable to hurricanes and other storm damage and because natural shoreline recession and the movement of unstable sediments undermine manmade structures. The current project area was excluded from the CBRS because it was developed at the time of the legislation and not because the development was at less risk. The Corps should present a comprehensive discussion of the justification for any conclusion that the proposed beach construction is in compliance with the requirements of Executive Order 11988. Compliance with this EO should not be based on the high cost of removing the structures, but rather whether the presence of existing structures and the additional growth that would be supported by the federal action represents unwise development in a hazardous floodplain.

Corps Response: As discussed fully in Section 10.08, the project is in full compliance with Executive Order 11988.

4. USFWS Recommendation: The goal of reducing storm damage could be achieved with less environmental harm by using nonstructural measures. However, the Draft GRR/EIS for West Onslow Beach determined (USACE 2006a, p. 54) that the nonstructural plan was not economically feasible and was not fully evaluated for technical feasibility or acceptability. This decision was based on consideration of the costs of removing or relocating structures, but without any economic consideration of the economic benefits to be derived from the natural resources of the area. There was an assumption that a nonstructural approach would continue to result in land losses (USACE 2006a, p. 59). Information presented in this report indicates that the nonstructural approach, if implemented at all levels of government, would allow the formation of a wide, natural beach as the project adjusts its location landward. The remote, undisturbed beach which was recognized by the Corps (USACE 2006a, p. 59) as resulting from a no action approach in the area immediately south of the current project area would support tourism and provide significant economic benefits for the region. The Service recommends that the economic benefits of the nonstructural alternative receive greater consideration in the selection of the preferred course for federal action.

Corps Response: Further analysis of changes in recreation value of the nonstructural plan would most likely result in a negative value of recreational benefits, because there would be less lodging available for visitors. The benefit to cost ratio of 0.92 was developed using the most optimistic assumptions.

5. USFWS Recommendation: If beach construction is ultimately undertaken, the fill material should have a high degree of compatibility with the native beach. The North Carolina Sediment Criteria Rule, contained in the Technical Standards for Beachfill Projects (15A NCAC 07H .0312), should be used in regard to grain size and percent weight of calcium carbonate. In addition, compatibility should be established for other important characteristics such as organic content, heavy mineral content, and color.

Corps Response: The proposed borrow area sediments for this project would comply with grain size and percent weight requirements specified in 15A NCAC 07H .0312, *Technical Standards for Beachfill Projects*. The technical standards require compatibility of the native beach with borrow sources in regards to the percentage of silt, granular sediment, gravel, and calcium carbonate (or shell content for projects initiated before implementation of the rules). However, no federal or state requirements exist for compatibility in regards to organic content, heavy mineral content, or color. Therefore, a compatibility analysis for those items would not be conducted. The standards require that percent silt, granular sediment, and gravel in borrow material not exceed the amount found in the native beach plus 5 percent and the percent carbonate in borrow material not exceed the amount found in the native beach plus 15 percent. The silt, granular sediment, gravel content, and visual shell content for the Surf City/North Topsail Beach project are 1.2, 1.1, 0.5, and 9 percent respectively. Incorporating the tolerance permitted by the beachfill standards results in the following criteria: silt (6.2 percent), granular sediment (6.1 percent), gravel (5.5 percent), and calcium carbonate (24 percent). On the basis of current vibracore data, borrow areas A, F, L, S, and P exceed the standards for various characteristics. However, during the PED phase of the project additional borings or geophysical surveys would be performed to better delineate the borrow area boundaries and material types, with respect to the state sediment criteria rule, to ensure compatibility of beachfill material before placement. Because that additional analysis was included during PED, the borrow areas have been retained for further characterization. Before initial construction and each nourishment event, all material dredged for placement on the beach would comply with the sediment criteria rule.

6. USFWS Recommendation: If beach construction is ultimately undertaken, there should be a plan to monitor the quality of the fill material as it placed on the beach. There should be an effective procedure for stopping operations if inappropriate material is being pumped onto the beach. Since such real time protective measures may not be completely effective, there should also be a plan for inspecting the constructed beach for areas of incompatible material and removing such material before the start of the nest sea turtle nesting season.

Corps Response: The Corps intends to perform rigorous boring analyses of proposed borrow areas to minimize the risk of placing incompatible material on the beach. Throughout the duration of construction operations, the Corps employs full-time construction inspection personnel to perform on-site inspections of the project operations to ensure quality control and compliance with contract specifications. Furthermore, the Corps receives daily production reports from the contractor that provide detailed information pertaining to the contractor's daily operations. All incompliance issues pertaining to compatibility concerns identified in the on-site inspections or the daily reports are immediately forwarded to the Corps environmental staff. Federal and state environmental agencies would be notified if, and how much, potentially incompatible material is encountered during dredging operations. If necessary, the Wilmington District would make the decision on a suitable contingency measure which could include moving the dredge to another site within the borrow area or to another borrow area, depending on availability of sediment, and would notify the agencies of such a contingency measure. However, there is still a risk that some incompatible material is placed on the beach because real-time protective measures are not 100 percent effective. Therefore, the Corps construction inspection personnel would inspect the beach for any significant amount of incompatible material within the project limits throughout the contract duration and if any incompatible material is identified within the constructed berm, the Corps would coordinate with the appropriate agencies to identify the quantity of material and discuss the methods of removal and disposal before the sea turtle nesting season.

7. USFWS Recommendation: Offshore sediment extraction and sediment disposal should be scheduled during the least sensitive period of the year for the organisms dependent on the habitats to be affected. Every effort should be made to complete all beach work, both actual placement and shaping, by the end of March for the benefit of important beach invertebrates and migratory shorebirds.

Corps Response: The proposed dredging window of December 1 through March 31 for initial construction and each nourishment event avoids the identified peak recruitment periods for surf zone fish (March through September [Hackney et al., 1996]) and invertebrate species (May through September [Hackney et al., 1996; Diaz, 1980; Reilly and Bellis, 1978]) in North Carolina. Beach nourishment would therefore be completed before the onshore recruitment of most surf zone fishes and invertebrate species. Furthermore, to complete the full initial construction template, while adhering to the December 1 to March 31 dredging window, the construction effort would occur over a four year time period. Therefore, the duration of each initial construction effort and each subsequent renourishment effort would be limited so that it does not preclude recruitment for any species during its entire recruitment period. Additionally, in accordance with recommendations provided by Hackney et al. (1996), the four initial construction events would occur in stages along the beach, with the full template being constructed for each stage, instead of the entire beach being impacted within each construction event. That approach would also increase the speed of recovery for impacted areas by allowing for recruitment from adjacent un-impacted areas of the beach.

8. USFWS Recommendation: The Corps should ensure that no offshore hardbottom habitats are affected by sedimentation produced by the project, either as a result of offshore dredging or sediment washing off the beach. This goal may be accomplished by actual surveys of the offshore sediment extraction sites. The use of video surveys of established transects which has been undertaken could be used to monitor the biological health of offshore borrow areas. A sufficient buffer should be required between the dredging operation and hardbottoms. At a minimum, sediment extraction should comply with the North Carolina law (15A NCAC 07H. 0208(b)(12)(A)(iv)) requiring that mining of submerged land should not be conducted on or within 500 meters (1,640 feet) of significant biological communities, such as high relief hardbottom areas. Offshore hardbottoms that clearly show less biological significance could have reduced buffers provided that an adequate monitoring program is implemented. If the monitoring program indicates that offshore hardbottoms are being adversely affected, the project should include specific measures to mitigate any adverse impacts.

Corps Response: As discussed in Section 8.01.8.2, myriad nearshore and offshore investigations have been performed to assess the presence or absence of hard bottom within the proposed project area. Specifically, side-scan sonar and multibeam surveys were performed within the nearshore environment (within the –30 ft. contour) and high-resolution side-scan sonar surveys were performed within all proposed borrow areas. Identified anomalies in the nearshore were ground truthed using divers and video documentation to confirm the presence/absence of hard bottom. On the basis of ground-truth results of in-situ dive efforts, no hard bottom was identified within the depth of closure limits for the project. Additional ground-truth efforts were performed within select locations among the offshore borrow sites. Selected transects captured low, moderate, and high relief hard bottom areas as defined by the high-resolution side-scan imagery. Though hard bottom was documented at all but one transect, no high relief hard bottom was confirmed. Video surveys and benthic characterization assessments confirmed that the lower relief systems were adapted to high sedimentation conditions and reduced buffers would offer adequate protection. On the basis of the data collected from all the investigative studies, the proposed project would adhere to the 500 m buffer requirement for moderate and high-relief sites and would adhere to a 400 ft. buffer for identified low relief sits. To (1) ensure that required buffer distances are adhered to, (2) avoid physical impacts to hard-bottom resources, and (3) monitor the potential for leakage of sediment, the Corps would require all dredges to implement the Silent Inspector automated dredge plant monitoring system. In the event that a physical impact by the hopper dredge dragheads to previously unexposed hard bottom occurs, the incident would be thoroughly documented and coordinated with the appropriate state and federal resource agencies. Based on the outcome of this coordination, appropriate action would be taken to investigate and mitigate potential impacts.

Project monitoring of sedimentation impacts from dredging activities within the proposed 122-m (400-ft.) buffer would be implemented when appropriate. Sediment monitoring at select offshore transects, including controls, would occur before, during, and, if necessary, after construction and would include the installation of sediment traps (collectors) and in-situ sediment depth measurements. If sediment accumulation at the compliance transects is more than 10 percent of the sediment accumulated on average per day at the three control sites, the Corps would direct the contractor to stop dredging operations within the 122-m (400-ft.) buffer and move to another area 500 m (1,640 ft.) from the identified hard bottom sites.

On the basis of the available information pertaining to the dredged sediments, hopper dredge overflow activities, and associated potential turbidity plumes, and implementing a 122-m (400-ft.) to 500-m. (1,640-ft.) buffer distance depending on relief, no significant effects would be expected from the sedimentation and turbidity associated with the proposed dredging activities. The potential impacts to the hard-bottom communities would not be expected to exceed the natural sedimentation and turbidity conditions of the project area. For a thorough hard bottom impact evaluation, see Section 8.01.8.2 of the report.

9. USFWS Recommendation: While the use of highly compatible fill material would minimize turbidity and sedimentation due to runoff from the constructed beach, small inclusion of mud and silt pose a risk to nearshore hardbottoms. Project planning should establish a program to monitor the location, areal extent, and major organisms of nearshore hardbottoms before initial construction. If nearshore hardbottoms are present, these areas should be surveyed after initial construction to determine any adverse sedimentation and change in the biological community. If it appears likely that nearshore hardbottoms could be covered by sediment moving off the constructed beach, there should be a monitoring program to detect any overall loss of exposed hardbottoms and to develop and implement appropriate mitigation measures. Mitigation measures could include a reduction in the amount of beachfill near vulnerable hardbottoms.

Corps Response: See the above response to USFWS recommendation #8. On the basis of data collected from nearshore side-scan sonar, multibeam, and in-situ ground-truth surveys, no hard bottom was identified within the –30-ft. contour

10. USFWS Recommendation: Project plans should include measures to avoid adverse impacts associated with placement of the sediment pipeline and measures to monitor and mitigate any spills from the pipeline. During both initial construction and reconstruction events, the delivery pipeline should avoid areas where early shorebird reproductive activities may occur. Pipeline placement should avoid all hardbottom areas. There should be a plan to monitor pipelines for leaks and an established plan of action in the case a joint in the dredge pipe should break. This plan should describe measures to contain and clean the spill.

Corps Response: Dredging associated with the project would be accomplished using a hopper dredge. For beach nourishment projects, depending on the specific hopper dredge used, the average hopper load ranges between 6,000 and 12,000 cubic yards. When a full load is achieved, the hopper dredge would sail to a *pumpout* location just offshore of the beach. The hopper dredge would pump the material out of the hopper into a submerged pipeline, which would approach the beach at a given area and extend to the placement area. Therefore, for hopper dredge pumpout operations, both submerged (in water) and exposed (on the beach) pipeline would transport the sediment to the placement area. For pipeline that is on dry beach, the contractor would be required to monitor the pipeline for leaks no less frequently than once every 2 hours. If a leak is detected, the contractor would perform an assessment and implement the appropriate fix to correct the problem. All pipeline inspections are logged and submitted daily to the Corps to document their completion.

For submerged pipeline, the contractor would be required to traverse the pipeline via a boat to perform a visual assessment for indications of a pipe leak. In addition to visual surveys, contractors can track pipe breaks or leaks using density gauges and meters onboard the dredge. According to the standard contract specifications, any pipe leak in the water or on land would be considered displaced material and its removal would be required according to an assessment of the severity of the situation. After the contractor and the Corps complete an assessment of the leak and after coordinating the assessment with the appropriate agencies, a cleanup measure would be implemented.

Bathymetric surveys, including side-scan sonar and multibeam techniques, as well as diver ground truth surveys have been performed by the Corps throughout the nearshore (less than –30 ft. NGVD) and have confirmed that no hard-bottom communities are present within the –30-ft. contour offshore of the proposed project area. Furthermore, seismic profile coverage, vibracores, and diver surveys have provided information, between the active beach (–23 ft NGVD) and 3 miles offshore of Surf City and North Topsail Beaches. Because hopper dredge pumpout stations would be just offshore of the project area, existing bathymetric survey data collected by the Corps would be used to ensure that submerged pipeline routes avoid hard-bottom communities.

All staging areas, pipeline routes, and associated construction activities for the project would avoid high-value piping plover and shorebird habitat, in the vicinity of New River Inlet, to the maximum extent practicable.

11. USFWS Recommendation: The project should include an annual monitoring program on beach and subtidal invertebrates that form an important food resource for shorebirds and surf fishes. While other monitoring programs have been implemented in North Carolina, each project has unique features such as the sediment source and the responses of invertebrates at one location may not be application to each beach construction effort. The project should include a requirement for a pre-project assessment of beach invertebrate biomass and community composition, i.e., the number of species present. The program should have adequate control areas such as Hutaff Island, south of Topsail Island, or Bear Island, north o the project area. After construction, the Corps should monitor the recovery of intertidal and near shore invertebrate populations. If the assessments indicate a significant decline in either biomass or the number of species present when compared to control areas, there should be procedures in place to develop mitigation for this community. Data from these studies will be especially important if the reconstruction interval is reduced as sea level continues to rise. While the Corps predicted (USACE 2006a, p. 130) that benthic populations on West Onslow Beach may recovery within one to four years after large-scale sediment placement, a gradual reduction of the reconstruction interval could preclude adequate recovery and threaten these organisms which form an important base to the coastal food chain. The overall project plan should include funding for developing procedures to better understand mole crab and coquina clam life history requirements and developing effective measures to mitigate adverse impacts to these important resources.

Corps Response: Section 8.01.6 Benthic Resources—Beach and Surf Zone, addresses beach nourishment impacts to the benthic invertebrate community and discusses a thorough literature review indicating short-term impacts to benthic invertebrate populations with recovery occurring between 1–4 years depending on sediment compatibility. For study sites where nourished sediments were compatible with the native beach, recovery occurred within one year. Several Corps contracts addressing beach nourishment impacts to benthic invertebrate populations have recently been completed or are ongoing throughout the North Carolina beaches including Bogue Banks, Brunswick Beaches, and Dare County. The data that that has come back from the studies continue to support the large historical database, which indicates an initial impact to the benthic invertebrate resource with recovery occurring immediately after nourishment when the sediment is compatible with the native beach. Furthermore, the Dare County Beaches coastal storm damage reduction project has a significant monitoring plan, which includes a pre- and post-construction benthic invertebrate assessment. Because of the large historical monitoring database, the consistency of the data from these studies, and the continuing monitoring studies that are underway on other beach projects in North Carolina, the Corps does not plan to collect additional monitoring data for Surf City and North Topsail Beaches. However, the Corps is encouraged by the USFWS' recommendation to develop procedures to better understand benthic invertebrate life history requirements and the relationship those requirements have to beach activities. The opportunity to better understand the life cycle requirements of the benthic invertebrate community and the relationship to beach nourishment projects would allow for better management decisions to be made on future projects. The Corps recently participated in funding a study performed by Philip S. Kemp Jr., of the Carteret Community College, to investigate the feasibility of harvesting, holding, and culturing *Donax* spp. for resource enhancement aquaculture. The Corps is interested in putting together a workgroup, consisting of technical experts and resource agency representatives, to continue identifying study objectives that answer questions regarding critical life cycle requirements of benthic invertebrates. Additionally, the Corps will contribute funds to carry out subsequent scientific investigation to develop management guidelines and effective measures to mitigate identified impacts on such resources. Such a funding action would be fully coordinated with all concerned agencies.

12. USFWS Recommendation: A program for beach construction should include surveys for seabeach amaranth both before and for three years after sediment placement in order to avoid direct burial and to monitor recovery of the plant. If the seabeach amaranth surveys that have been conducted within the Town of Topsail Beach since 1992 (USACE 2006a, p. 1-16) do not extend into the current project area, this work should be extended to include the current sediment placement areas. With the proposed four-year reconstruction cycle, surveys for this endangered plant would be made every year. If data indicate a declining trend in the presence of this federally threatened species, the development of mitigation measures may be advisable. The project should also monitor beach vitex in the project as part of an effort to eradicate this harmful invasive foreign plant.

Corps Response: The Corps would perform monitoring for seabeach amaranth on Surf City and North Topsail Beaches to assess the pre- and post-nourishment presence of plants. The survey would broken down into survey reaches for each town in accordance with the designated Corps sea beach amaranth survey reaches from 1991 to 2008 to maintain consistent data and survey techniques over time and results would be provided to USFWS. Beach vitex surveys are ancillary to seabeach amaranth surveys. Surveyors note the presence of beach vitex during amaranthus surveys, and the data is provided to the USFWS, which in turn is shared with the Carolinas Beach Vitex Task Force.

13. USFWS Recommendation: Nesting by sea turtles will benefit from strict sediment compatibility standards and work schedules that avoid the nesting and hatching season (May 1 through November 15). Current plans for beach construction avoid sediment disposal during this period. However, artificial beaches pose a risk to sea turtle nesting due to: (1) sediment compaction; (2) escarpment formation; and, (3) altered sand temperature which may occur as a result of a change in sediment color. To mitigate sediment compaction, the Service recommends that compaction monitoring should occur after each construction event and for three subsequent years. Considering that reconstruction is scheduled for every four years, a sediment compaction survey should be made each year of the project. However, compaction monitoring would not be required if the sediment used to construct the beach is completely washed away. Beach tilling should only be performed as a result of an identified compaction problem and not performed routinely in place of compaction monitoring. Similarly, visual surveys for escarpments should be made along the constructed beach immediately after completion of the sediment placement and prior to May 1. Additional surveys should be made for three years following initial construction. As with compaction monitoring, escarpment survey should be made each year of the project. Survey results should be submitted to the Service prior to any action being taken. After discussion with the Service, escarpments that interfere with sea turtle nesting or exceed 18 inches in height for a distance of 100 feet should be leveled to the natural beach contour by May 1. The Service should be contacted immediately if new escarpments that interfere with sea turtle nesting or exceed 18 inches in height for a distance of 100 feet form during the nesting and hatching season to determine the appropriate action to be taken. If it is determined that escarpment leveling is required during the nesting or hatching season, the Service will provide a brief written authorization that describes methods to be used to reduce the likelihood of impacting existing nests. A program for detecting and securing appropriate care for stranded sea turtles should be part of the project.

Corps Response: The proposed dredging and beach nourishment schedule of December 1 through March 31 for both initial construction and each nourishment interval would avoid the sea turtle nesting season. Therefore, no direct impacts to nesting sea turtles or incubating hatchlings would be expected. As identified in Section 4.00, Commitments to reduce impacts to Listed Species, of the Biological Assessment, the Corps is committed to assessing post-nourishment beach compaction, escarpment formation, and sea turtle nest temperature relative to sediment color. Sediment compaction could occur from the project and could affect the nesting environment of sea turtles. Though sediment placed on the beach would be compatible with the native material, the risk of sediment compaction and subsequent impacts to the nesting environment of sea turtles still exists. The USFWS has traditionally provided guidelines for assessing beach compaction, which include the use of a cone penetrometer instrument to assess compaction across 500-ft. spaced transects at varying stations and depths across the beach profile. A threshold value of 500 pound per square inch was used as an indicator for tilling requirements. Recent studies indicate that because of the variability of compaction measurement values among users (Piatkowski et al., 2001), among compaction instrumentation (Ferrell et al., 2001), as well as variability of compaction throughout a beach (Davis et al., 1999), care should be taken when performing quantitative assessments of sediment compaction. On the basis of the results and recommendations of the studies, the Wilmington District has modified its approach toward assessing beach compaction for nourishment and disposal projects and has been working with the NCWRC and the USFWS toward a more qualitative evaluation of post construction compaction conditions relative to native beach conditions. The results of such new coordinated process in evaluating post project beach compaction have been successful. Therefore, for initial construction and during each nourishment event, the Corps would work with the towns of Surf City and North Topsail Beaches and the NCWRC to continue the new compaction assessment protocol, but would not adhere to the traditional USFWS compaction guidelines. Tilling would be performed only if deemed necessary by the technical staff of the NCWRC, USFWS, and Corps, according to compaction assessment results.

Additionally, the beach would be monitored for escarpment formation before each nesting season. If an escarpment exceeds 18 inches for a distance of 100 ft. during construction operations it would be leveled. Furthermore, if it is determined that escarpment leveling is required during the nesting or hatching season, the towns or the Corps would coordinate with the USFWS to receive authorization that describes methods to be used to reduce the likelihood of affecting existing nests. Escarpment surveying and leveling would be performed by the Corps during initial construction and each nourishment interval, and the towns of Surf City and North Topsail Beaches would be responsible for surveys and, if necessary, leveling before the nesting season in the years between nourishment intervals.

The Corps is interested in understanding the threshold of sediment color change and resultant heat conduction on affecting temperature-dependent sex determination of sea turtles. The Corps would contribute funds for the NCWRC to continue its temperature studies to gather nest temperatures on nourished beaches throughout the state, including

Topsail Island, in comparison to non-nourished native sediment temperatures. This data could be used to help develop management criteria for sediment color guidelines.

Throughout the duration of each nourishment event, both initial construction and periodic nourishment, the contractor would be required to monitor for the presence of stranded sea turtles, live or dead. If a stranded sea turtle is identified, the contractor would immediately notify the NCWRC of the stranding and implement the appropriate measures as directed. Topsail Beach is home to the Karen Beasley sea turtle hospital, which has the facilities to provide care for stranded and injured sea turtles.

14. USFWS Recommendation: Piping plovers and other shorebirds are especially susceptible to human disturbance during territory establishment and early nesting attempts and after the chicks have hatched. Construction plans should determine whether any sections of the project area beaches are suitable nesting habitat for shorebirds and schedule work in such areas between December 1 and March 31.

Corps Response: The December 1 to March 31 construction window identified for the project would avoid disturbances to piping plovers and other shorebirds during territory establishment and early nesting attempts and after the chicks have hatched. Additionally, all staging areas, pipeline routes, and associated construction activities would avoid high-value piping plover and shorebird habitat, in the vicinity of New River Inlet, to the maximum extent practicable.

15. USFWS Recommendation: While the West Indian manatee is not likely to be in the project area during the proposed construction period, protective measures should be in place to safeguard this endangered species. Corps plans for the West Onslow Beach Project call (USACE 2006a, p. 1-12) for the implementation of the Service's *Precautions for General Construction in Areas Which May Be Used by the West Indian Manatee in North Carolina*. Those guidelines should provide adequate protection for this species.

Corps Response: The Corps would implement precautionary measures for avoiding impacts to manatees during construction activities as detailed in the *Guidelines for Avoiding Impacts to the West Indian Manatee in North Carolina Waters* established by the USFWS.

11.04 Coordination of this Document

A draft version of this report was provided to a standard list of federal, state, and local agencies; elected officials; environmental groups; and interested individuals for a 45-day review and comment period. Comments received and Corps responses to the comments are provided in Appendix T.

The current version of this report is being provided to the same list of federal, state, and local agencies; elected officials; environmental groups; and interested individuals for a 30-day review and comment period.

The Corps invites your comments and suggestions regarding the proposed action. In accordance with Council on Environmental Quality regulations (40 CFR 1500–1508) for implementing the NEPA, your comments should be as specific as possible and should be made with recognition that NEPA documents must focus on the issues that are truly significant to the proposed action rather than amassing needless detail. The NEPA process is intended to help public officials make decisions on the basis of an understanding of environmental consequences. NEPA directs that federal activities be conducted so as to attain the widest range of beneficial uses of the environment without degradation, risk to health or safety, or other undesirable or unintended consequences. As individual resources and stakeholder interests increasingly compete for priority, public officials are challenged to make management decisions that reflect a balance of the overall public interest. Please respond with a focus on essential issues that would be useful in guiding our decisions and actions as this project proceeds.

11.05 Recipients of this Document

(or Notice of Availability)

Federal Agencies

Advisory Council on Historic Preservation
Center for Disease Control and Prevention
Federal Emergency Management Administration
National Marine Fisheries Service, Southeastern Regional Office
National Marine Fisheries Service, Habitat Conservation Division, Beaufort Marine Fisheries Center, Beaufort, NC
National Park Service, Southeast Archeological Center
U.S. Coast Guard, Fifth District, Portsmouth, VA
U.S. Coast Guard, Marine Safety Office, Wilmington, NC
U.S. Forest Service, Southern Region, Atlanta, GA
U.S. Department of Agriculture, State and Area Conservationists, Natural Resources Conservation Service
U.S. Department of Energy, Office of Environmental Compliance
U.S. Department of Interior, Energy and Resources Division
U.S. Department of Interior, Office of Environmental Policy and Compliance
U.S. Department of Interior, Minerals Management Service, Herndon, VA
U.S. Department of Housing and Urban Development, Greensboro, NC
U.S. Department of Transportation, Federal Highway Administration, Raleigh, NC
U.S. Environmental Protection Agency, Region 4, Atlanta, GA
U.S. Environmental Protection Agency, Office of Federal Activities, Washington, D. C.
U.S. Fish and Wildlife Service, Raleigh Field Office
U.S. Marine Corps Base, Camp Lejeune, NC

State Agencies

NC Commission of Indian Affairs

NC Department of Environment and Natural Resources (NC State Clearinghouse)
NC Department of Transportation
NC Division of Coastal Management
NC Division of Marine Fisheries, Wilmington, NC
NC Division of Marine Fisheries, Shellfish Sanitation, Beaufort, NC
NC Department of Cultural Resources, Division of Archives and History
NC National Estuarine Research Reserve
NC Wildlife Resources Commission

Local Agencies

CAMA Officer, Surf City, NC
CAMA Officer, North Topsail Beach, NC
Cape Fear Council of Governments
North Topsail Beach Town Manager
Onslow County Emergency Services
Onslow County Board of Commissioners
Onslow County Planning & Development
Onslow County Manager
Onslow County Health Department
Pender County Board of Commissioners
Pender County Emergency Management
Pender County Manager
Pender County Planning Coordinator
Pender County Health Department
Sea Turtle Hospital, Topsail Beach
Surf City Town Manager
Topsail Beach Town Manager
Town of North Topsail Beach, NC
Town of Surf City
Town of Topsail Beach, NC

Elected Officials

Honorable Kay Hagan, US Senate
Honorable Richard Burr, US Senate
Honorable Walter B. Jones, US House of Representatives
Honorable Mike McIntyre, U.S. House of Representatives
Honorable Harry Brown, NC House of Representatives
Honorable George G. Cleveland, NC House of Representatives
Honorable Carolyn H. Justice, NC House of Representatives
Honorable R. C. Soles, Jr., North Carolina Senate
Honorable Russell E. Tucker, NC House of Representatives
Honorable Sandra Spaulding Hughes, NC House of Representatives
Pender County Board of Commissioners

Onslow County Board of Commissioners
Topsail Beach, Board of Commissioners

Conservation Groups

National Audubon Society
North Carolina Coastal Federation
North Carolina Coastal Land Trust
North Carolina Environmental Defense Fund
North Carolina Nature Conservancy
Pender Watch
Tar River Land Conservancy

Libraries, Museums, and News Media

NC Collection, Joyner Library, East Carolina University, Greenville, NC
Pender Chronicle
Jacksonville Daily News

Interested Businesses, Groups, and Individuals

Cape Fear Community College (Jason Rogers)
Duke University, Department of Department of Earth and Ocean Sciences(Geology),
Dr. Orrin Pilkey
Land Management Group, Inc.
Mr. Ed Flynn
Mr. Glenn Hargett, Communications and Community Affairs Director, Jacksonville, NC
Mr. W. D. Aman, Sr.
Sea Turtle Hospital
UNC-Wilmington, Center for Marine Science (Troy Alphin)

12. CONCLUSIONS

The coastal storm problems and needs of the study area have been reviewed and evaluated with regard to the overall public interest and with consideration of engineering, economic, environmental, social, and cultural concerns. The conclusions of this study are as follows:

a. The Surf City and North Topsail Beach shorelines are susceptible to major damage and erosion from coastal storms.

b. The selected plan consist of a sand dune constructed to an elevation of 15 ft. above the NGVD, fronted by a 50-ft-wide beach berm constructed to an elevation of 7 ft. above NGVD. The berm and dune project extends along a reach of 52,150 ft. On the north end, the project would adjoin an adjacent nonfederal beachfill project for North Topsail Beach. At the south end, the project would transition into the federal beachfill project for Topsail Beach. If no adjacent beachfill project is occurring, the plan would include a transition consisting of a tapered berm only, starting with a transition berm width of 200 ft. that uniformly tapers to zero. If an adjacent beachfill project is occurring, any transition would be shorter and designed to fit the adjacent project.

c. The selected plan is feasible on the basis of engineering and economic criteria and is acceptable by environmental, cultural, and social laws and standards.

d. The selected plan is supported by the nonfederal sponsor—the towns of Surf City and North Topsail Beach. The sponsors have the capability to provide the necessary nonfederal requirements identified and described in report Section 9.02, Division of Plan Responsibilities.

13. RECOMMENDATIONS

This study addresses the needs for coastal storm damage risk reduction for the portion of Topsail Island that includes the towns of Surf City and North Topsail Beach. Other portions of Topsail Island have been or will be addressed in separate reports. The following recommendations include items for implementation by federal, North Carolina, and local governments and agencies, including the structural coastal storm damage reduction project.

Hurricane Risk Education

Numerous people die each year as a result of hurricanes, primarily because of the failure to evacuate to an area of safety. Any loss of life is tragic, and any number of those deaths might have been prevented. Even one death prevented is sufficient reason to improve our methods of educating the public on hurricane and storm threats and to ensure that all is done to warn all those residents or visitors to the coastline of North Carolina as to the dual hazards of wind and surge/waves. It is particularly vital to inform the public as to the potential for hurricane occurrence, particularly in the dangerous hurricane season, so they pay continued attention to media reports on weather. Education needs to include articulation of effects related to the potential magnitude of the threat, the urgency to heed potential calls to evacuate, and providing the means by which to make wise choices on evacuation methods and route (see recommendations given below under Hurricane Evacuation Planning). The following are suggested guidelines for implementation by state and local government, in the interests of good education on hurricane storm threats:

- Provide good science and information to the residents and visitors to coastal North Carolina, so they can understand the nature of the threat, and its possibility of happening at any time within the hurricane season. This information should be provided in both written form and as an initial *page* on televisions provided in visitor's housing, and also in a variety of venues, including the following:
    - Posting and televised education in supermarkets, libraries, and public buildings
    - Teacher-provided, posted, and televised education in schools and at public meetings and gatherings, at intervals not to exceed 1 year
    - Publicly posted and visitor-housing-posted information on evacuation routes, and procedures, on publicly accessible Web sites, updated regularly (minimum 1 yr.)

It is not possible to maintain the lives and safety of coastal North Carolina residents and visitors if they do not have sufficient warning and if they then do not use that knowledge to evacuate in a timely manner.

Education of hurricane risks is an ongoing effort of multiple agencies and educational institutions and not a funded program under existing Corps authorities. Updating Web sites containing evacuation routes and procedures should be done under existing programs implemented by the state and local governments.

Hurricane and Storm Warning

Residents and visitors to the coast of North Carolina need to recognize that they live in, or visit, a high-hazard area. Although certain times of the year pose less risk than others, each year's hurricane season provides a strong possibility of hurricane impact somewhere along the coast of North Carolina. All residents and visitors need to be made aware of the current hurricane threat. But first, meteorological conditions must be evaluated, and any threat must be assessed and characterized by experts at NOAA's National Weather Service. That interpretation must then be passed to national and local media for dissemination. Continued support of NOAA's program, and the following supportive activities are critical to an adequate warning process:

- Ongoing efforts to upgrade the existing system of NOAA buoys, transmission capabilities, and advanced warning measures that provide data on the location and nature of weather conditions.
- Efforts directed at the interpretation of that data and its dissemination to the media and public, through the National Weather Service.
- Public appreciation for the need to be aware at all times of, and the need to listen to weather reports and advice given on various media. Television weather reports, radio, and the Internet all provide excellent, up-to-date information on weather conditions, and the development of threatening situations. Simply living in or visiting the barrier islands of North Carolina should be sufficient to create a consistent and ongoing process of being exceptionally aware of the weather and its potential consequences.
- The vital importance of heeding the advice of experts. One should know what needs to be done when a storm is approaching. Family members should conduct evacuation drills, keep needed phone numbers and travel supplies on hand, and be prepared to leave on short notice. One should be aware of evacuation routes, keep a full tank of gas during the hurricane season and have a plan for where one should go, how to maintain contact with other family members, and where one will relocate temporarily, particularly if the event turns out to be longer than expected.

Hurricane Evacuation Planning Upgrading

The critical need for adequate evacuation planning was borne out by Hurricanes Bertha, Fran, and Floyd, of the late 1990s, and brought even more to the forefront by the monumental impacts of Hurricane Katrina in 2005. An evacuation plan is an essential component of a comprehensive plan for ensuring the safety of residents of, and visitors, to the coast of North Carolina. The preservation of life is the single most important goal and objective of the recommendations. Joint Federal Emergency Management Agency (FEMA)/NOAA/Corps/North Carolina studies of evacuation routes and populations along the coastline has provided a tremendous amount of value to-date in aiding local government, individual, and family readiness in the face of approaching events. Support for that program is a critical element of the recommendations for the towns of Surf City and North Topsail Beach in support of its residents and visitors. The towns of Surf City and North Topsail Beach both have evacuation and emergency response plans already in place. Important facets of these plans include:

- Annual review of hurricane evacuation plans

- State evacuation route signage
- Reverse 911 phone systems
- Low frequency AM Station
- NIMMS (emergency response command and control) training for all emergency personnel
- WEBEOC.org – a website for coordinating communication during emergencies
- Mutual aid agreements with inland emergency agencies
- Coordination of evacuation and emergency shelters with Onslow/Pender County Emergency Management
- Active re-entry pass system, for safe re-entry after an event

The following are important additional recommendations in support of efforts to support Hurricane Evacuation Planning:

- Much can still be done to update this ongoing effort and to provide new and more widely disseminated data and tools for evacuation planning by the state and the towns of Surf City and North Topsail Beach, and also for use by individuals and families in their preparation for an impending event.
- Evacuation route signage is an important part of a successful evacuation campaign. Maintenance of hurricane evacuation route signage is viewed as a vital link in ensuring the safety of residents and visitors alike.
- The provision of additional signage illustrating surge height achieved during past events would be an added and continual link to ongoing education efforts. That could take the form of signs placed in locations in which there is significant traffic, such as major thoroughfares, where pedestrians walk, and particularly in those highest hazard zones according to elevation/depth data.

Evacuation Planning is an ongoing effort of multiple agencies, including the Corps, but its implementation is not a funded program under existing Corps authorities. Updating Web sites containing evacuation routes and procedures should be periodically updated under existing programs implemented by North Carolina.

Floodplain Management

Management of the floodplain is a nonfederal responsibility, yet it is considered a key component of all plans for hurricane and storm damage reduction. The towns of Surf City and North Topsail Beach participate in the National Flood Insurance Program, which requires the towns to engage in active and responsible floodplain management. In Surf City, property owners have 2,148 flood insurance policies composed of nearly $480 million insurance in force. North Topsail Beach property owners possess 1,384 flood insurance policies providing approximately $240 million insurance in force. Because so much of the Surf City and North Topsail Beach are within a recognized floodplain, the towns continue to engage in activities that reduce threats to existing and potential future development, including structure setbacks, building code and construction monitoring, and flood zone management. The Corps encourages the towns to continue to update building codes and encourage strong pursuit of activities such as first-floor elevation and building code upgrading in the effort to reduce the potential for future structural and content damage.

Building Codes
The towns of Surf City and North Topsail Beach have adopted the IBC to guide the design and construction of residential and commercial structures in the study area. To ensure that the latest design and construction techniques are being used that apply to hurricane-resistant construction, all future construction is encouraged to follow the latest version of the IBC (2007) and ensure enforcement of the codes through diligent building permit processing and on-site inspections of construction. Annual training classes on the use and enforcement of the new IBC should be encouraged. In addition, Surf City and North Topsail Beach should consider adopting the document *FEMA 550 Guidelines for Elevating Residential Structures on the Gulf Coast* as a part of their updated building codes for construction, because of the possibility of surge inundation associated with hurricane events.

Long-Term Critical Infrastructure and Services Upgrading

Upgrading critical infrastructure and services, such as Fire and Police services, is considered a vital recommendation in the reduction of threats to lives and property. The need to bring those services up to immediate restoration in the wake of a hurricane is of vital importance to the community. The methodical upgrading of the towns' Fire and Police services facilities as part of their capital improvement programs will provide long-term savings in capital outlay, and potentially save lives and residential and commercial property damage. Such a program may be instituted under a modified capital improvement program, where structures reaching the end of their economic life are successively replaced by upgraded structures, locating vital communications and power supplies above the elevation of a maximum probable surge event, and capable of surviving the ravages of wind or surge, as funds become available.

Upgrading or replacing services is primarily a local charge, implemented through capital improvement plans, with funding from a variety of federal, state, and local resources, and will take many years to accomplish, because of the varying age and condition of each facility.

Structural Damage Reduction Features
On the basis of the conclusions of this study, I recommend the implementation of the selected plan, identified as Plan 1550, which consists of a 52,150-ft-long dune system to be constructed to an elevation of 15 ft NGVD fronted by a 7-ft NGVD elevation, 50-ft-wide beach berm, with such modifications thereof as in the discretion of the Commander, Corps, may be advisable, at an initial first construction cost estimated at $123,135,000 (October 2010 price levels). The baseline cost estimate for construction in FY 2015 is $138,493,000.

As a result of the Feasibility study and EIS, I recommend that the project be authorized and implemented in accordance with the findings of this report.

I further recommend that construction of the proposed project be contingent on the project sponsor giving written assurances satisfactory to the Secretary of the Army that it will do the following:

a. Provide 35 percent of initial project costs assigned to coastal storm damage reduction, plus 50 percent of initial project costs assigned to reducing damages to undeveloped public lands, plus 50 percent of initial project costs assigned to recreation, plus 100 percent of initial project costs assigned to reducing damages to undeveloped private lands and other private shores that do not provide public benefits and 50 percent of periodic nourishment costs assigned to hurricane and storm damage reduction, plus 100 percent of periodic nourishment costs assigned to reducing damages to undeveloped private lands and other private shores that do not provide public benefits and as further specified below:

(1). Enter into an agreement which provides, before executing the PPPA, 25 percent of design costs.

(2). Provide, during the first year of construction, any additional funds needed to cover the nonfederal share of design costs.

(3). Provide all lands, easements, and rights-of-way, and perform or ensure the performance of all relocations determined by the federal government to be necessary for the initial construction, periodic nourishment, operation, and maintenance of the project.

(4). Provide, during construction, any additional amounts as are necessary to make its total contribution equal to 35 percent of initial project costs assigned to hurricane and storm damage reduction plus 100 percent of initial project costs assigned to reducing damages to undeveloped private lands and other private shores that do not provide public benefits and 50 percent of periodic nourishment costs assigned to hurricane and storm damage reduction, plus 100 percent of periodic nourishment costs assigned to reducing damages to undeveloped private lands and other private shores that do not provide public benefits.

b. Operate, maintain, and repair the completed project, or functional portion of the project, at no cost to the federal government, in a manner compatible with the project's authorized purposes and in accordance with applicable federal and state laws and regulations and any specific directions prescribed by the federal government.

c. Give the federal government a right to enter, at reasonable times and in a reasonable manner, on property that the nonfederal sponsor, now or hereafter, owns or controls for access to the project for the purpose of inspecting, operating, maintaining, repairing, replacing, rehabilitating, or completing the project. Completion of OMRR&R by the federal government will not relieve the nonfederal sponsor of responsibility to meet the nonfederal sponsor's obligations, or to preclude the federal government from pursuing any other remedy at law or equity to ensure faithful performance.

d. Hold and save the United States free from all damages arising from the initial construction, periodic nourishment, OMRR&R of the project and any project related betterments, except for damages due to the fault or negligence of the United States or its contractors.

e. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, and other evidence is required, to the extent and in such detail as will properly reflect total costs of construction of the project, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 CFR 33.20.

f. Perform, or cause to be performed, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), P.L. 96-510, as amended, 42 U.S.C. 9601–9675, that may exist in, on, or under lands, easements, or rights-of-way that the federal government determines to be required for the initial construction, periodic nourishment, operation, and maintenance of the project. However, for lands that the federal government determines to be subject to the navigation servitude, only the federal government will perform such investigations unless the federal government provides the nonfederal sponsor with prior specific written direction, in which case, the nonfederal sponsor will perform such investigations in accordance with such written direction.

g. Assume, as between the federal government and the nonfederal sponsor, complete financial responsibility for all necessary cleanup and response costs of any CERCLA-regulated materials in, on, or under lands, easements, or rights-of-way that the federal government determines to be necessary for the initial construction, periodic nourishment, operation, or maintenance of the project.

h. Agree that, as between the federal government and the nonfederal sponsor, the nonfederal sponsor will be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, and repair the project in a manner that will not cause liability to arise under CERCLA.

i. Comply with the applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, P.L. 91-646, as amended by (42 U.S.C. 4601–4655), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way, required for the initial construction, periodic nourishment, operation, and maintenance of the project, including those necessary for relocations, borrow materials, and dredged or excavated material disposal, and inform all affected persons of applicable benefits, policies, and procedures in connection with that act.

j. Comply with all applicable federal and state laws and regulations, including section 601 of the Civil Rights Act of 1964, P.L. 88-352 (42 U.S.C. 2000d), Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, titled *Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army*, and all applicable federal labor standards and requirements, including, 40 U.S.C. 3141–3148 and 40 U.S.C. 3701–3708 (revising, codifying, and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a *et seq*.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 *et seq*.) and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c *et seq*.).

k. Comply with section 402 of the WRDA of 1986, as amended (33 U.S.C. 701b-12), which requires the nonfederal interest to participate in and comply with applicable federal floodplain management and flood insurance programs, prepare a floodplain management plan within one year after the date of signing a PPA, and implement the plan no later than one year after project construction is complete.

l. Provide the nonfederal share of that portion of the costs of mitigation and data recovery activities associated with historic preservation, that are in excess of 1 percent of the total amount authorized to be appropriated for the project, in accordance with the cost-sharing provisions of the agreement.

m. Participate in and comply with applicable federal floodplain management and flood insurance programs.

n. Do not use federal funds to meet the nonfederal sponsor's share of total project costs unless the federal granting agency verifies in writing that the expenditure of such funds is authorized.

o. Prevent obstructions of or encroachment on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments), which might reduce the level of damage reduction it affords, hinder operation and maintenance or future periodic nourishment, or interfere with its proper function, such as any new developments on project lands or the addition of facilities that would degrade the benefits of the project.

p. Not less than once each year, inform affected interests of the extent of damage reduction afforded by the project.

q. Publicize floodplain information in the area concerned and provide such information to zoning and other regulatory agencies for their use in preventing unwise future development in the floodplain and in adopting such regulations as might be necessary to prevent unwise future development and to ensure compatibility with damage reduction levels provided by the project.

r. For so long as the project remains authorized, the nonfederal sponsor must ensure continued conditions of public ownership, access, and use of the shore on which the amount of federal participation is based.

s. Provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms.

t. At least twice annually and after storm events, perform surveillance of the beach to determine losses of nourishment material from the project design section and provide the results of such surveillance to the federal government.

u. Comply with section 221 of P.L. 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5b), and section 103 of the WRDA of 1986, P.L. 99-662, as amended (33 U.S.C. 22130, which provides that the Secretary of the Army must not commence the construction of any water resources project or separable element thereof, until the nonfederal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element.

The nonfederal sponsor (both towns) have indicated that they have available the necessary funds to provide the nonfederal share of the project first costs and periodic renourishment costs. I am confident that the nonfederal sponsor will provide their share.

This recommendation is subject to the cost-sharing policies as outlined in this report and is endorsed, provided that, before construction, the nonfederal sponsor enters into a written PPA, as required by P.L. 91-611 section 221, as amended.

The total first cost of the project, at Oct 2010 price levels, is $123,135,000. The federal share of the total first project cost is estimated at $80,038,000. The nonfederal share of the total first project cost is estimated at $43,097,000. As previously indicated, the total project benefit-cost ratio is 3.7 to 1, which means that for every dollar spent for the project, 3 dollars and 70 cents are realized in NED benefits from the project.

The recommendations contained herein reflect the information available at this time and current departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to the Congress as proposals for implementation funding. However, prior to transmittal to the Congress, the sponsor, the states, interested federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

Jefferson M. Ryscavage
Colonel, U.S. Army
District Commander

14. POINT OF CONTACT

Any comments or questions regarding this Feasibility Report and EIS should be addressed to Ms. Jan Brodmerkel, Project Manager, U.S. Army Corps of Engineers, 69 Darlington Avenue, Wilmington, NC 28403, telephone (910) 251-4673.

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