EXECUTIVE SUMMARY

Ocean Isle Beach is located along the eastern portion of Brunswick County. The island was incorporated in 1959 and has a current year-round resident population of approximately 554, with a seasonal population of 25,000. The island is bordered to the south by the Atlantic Ocean, the north by the Atlantic Intracoastal Waterway (AIWW), the west by Tubbs Inlet, and the east by Shallotte Inlet. Ocean Isle Beach is approximately 5.6 mi long and approximately 0.6 mi wide.

The Town is seeking Federal and State permits to allow the construction of a shoreline protection project that would serve to mitigate chronic erosion experienced along the eastern portion on the Town's oceanfront shoreline so as to preserve the integrity of its infrastructure, provide protection to existing development, and ensure the continued use of the oceanfront beach along this area. There are 238 parcels east of station 15+00 (located just west of Shallotte Boulevard); 45 of which have homes. All of the parcels and homes are vulnerable to erosion damages over the next 30 years should the past erosion trends continue. In addition, over 1,800 feet of roads and associated utilities could also be damaged or lost over this 30-year timeframe. Of the 45 homes at risk, 18 are considered to be located on the oceanfront row, 12 on the second row, and the remaining 15 farther back on the 3rd and 4th rows. The Town, the State, and private owners have been directly impacted by this chronic erosion. To date, five (5) homes have been lost on the east end of Ocean Isle Beach since 2005. As a result of these losses, portions of the Town's infrastructure were damaged including approximately 560 feet of E 2nd St. and the associated storm sewers, waterlines, and other utilities. The North Carolina Department of Transportation (NCDOT) has completely lost the east ends of 1st and 2nd Streets, as well as incurred additional costs in maintaining its infrastructure, including the installation of sandbags, repaving sections of damaged roads, clean-up of damaged section of roads.

The main concerns of residents and owners at Ocean Isle Beach are the economic losses resulting from damages to structures and their contents due to hurricane and storm activity and the loss of beachfront land due to the ongoing shoreline erosion along the east end of the island in proximity to Shallotte Inlet. Historical data establishes that current shoreline management strategies have not been successful in providing the proper shoreline protection sought by the Town. With a total tax value of property within the limits of Ocean Isle Beach of approximately $1,816,012,300 (based on the most recent appraisal in 2012), the Town realizes the need to protect homes and infrastructure along the east end of the island. This valuation includes the valuation of 3,247 commercial and residential structures and property and 1,456 vacant lots (Ivey, pers. comm.).

Currently, there are 238 parcels and 45 homes east of station 15+00 (located just west of Shallotte Boulevard) that are vulnerable to erosion damages over the next 30 years should the past erosion trends continue. In addition, over 1,800 feet of roads and associated utilities could also be damaged or lost over this 30-year timeframe. Of the 45 homes at risk, 18 are considered to be located on the oceanfront row, 12 on the second row, and the remaining 15 farther back on the 3rd and 4th rows.

To alleviate these problems attributed to erosion, several potential solutions were evaluated within this Environmental Impact Statement (EIS). These include abandoning the existing infrastructure and retreating from the oceanfront shoreline; continued management of the ocean shoreline with present and past activities such as beach scraping, periodic nourishment, and placement of sandbags; relocating the inlet to a more optimal orientation accompanied with beach nourishment along the eroding shorelines; beach nourishment alone; and the construction of a terminal groin accompanied with beach nourishment. After consideration of the costs, benefits and environmental consequences of the proposed and alternative actions, the Town has identified and is proposing a shore protection project including the construction of a 750 foot terminal groin located approximately 148 feet east of station 0+00. A 3,214 foot section of shoreline located directly west of the terminal groin would be pre-filled with 264,000 cubic yards of material obtained from Shallotte Inlet, the same source of material as the Federal project. The nourishment interval for this proposed project would be every 5 years.

The structural design of the groin would include a 300 foot shore anchorage section constructed with either concrete or steel sheet piles that would begin at a point 450 feet landward of the baseline. The top elevation of the sheet pile will vary from +4.5 feet NAVD88 over the landward 130 feet and increase to +4.9 feet NAVD over the last 170 feet. The top of the landward most portion of the shore anchorage section would be below the existing ground level. The sheet pile would tie into a rubblemound section that would extend 750 feet seaward from the end of the shore anchorage section and terminate 600 feet seaward of the baseline

The rubblemound portion of the terminal groin would be constructed with loosely placed armor stone on top of a foundation mat or mattress and would have a crest elevation of +4.9 feet NAVD. The loose nature of the armor stone was designed to facilitate the movement of littoral material through the structure while the relative low crest elevation of +4.9 feet NAVD would allow some sediment to pass over the structure during periods of high tide.

This EIS meets requirements under the Federal Environmental Assessment and Review Process in determining how to best meet the needs of the people and the environment. This EIS includes an evaluation of resources and considerations involved in responding to the chronic erosion on the eastern portion of Ocean Isle Beach so as to preserve the integrity of its infrastructure, provide protection to existing development, and ensure the continued use of the oceanfront beach along the easternmost portion of its oceanfront shoreline. Significant resources which occur in the study area include socioeconomic resources, marine resources, terrestrial resources, threatened and endangered species, recreation and aesthetic resources, and cultural resources.

This EIS contains the following information:

- **Chapter 1, Introduction –** Explains the purpose of the development of an EIS, describes agency and public coordination efforts, issues and concerns elicited by the development of the EIS and discusses applicable laws, rules and regulations.
- **Chapter 2, Purpose and Need –** Identifies purpose and needs of the project and discusses how the shoreline along Ocean Isle Beach has been managed in the past.
- **Chapter 3, Project Alternatives–** Describes project rationale and alternatives considered.
- **Chapter 4, Affected Environment –** Identifies existing resources which occur in the study area.
- **Chapter 5, Environmental Consequences –** Evaluates the project alternatives and discusses the anticipated changes to the existing environment including direct, indirect, and cumulative effects.
- **Chapter 6, Avoidance and Minimization –** Describes several actions and measures incorporated to avoid or minimize adverse effects to resources.

Major Conclusions

Chronic erosion has been a major threat to the homes, infrastructure, and natural resources along the eastern portion of Ocean Isle Beach. Action is needed to alleviate this threat. The Town is seeking Federal and State permits to allow for the construction of a terminal groin with supplemental fill obtained from Shallotte Inlet and placed west of the structure. These actions would serve to mitigate the chronic erosion on the eastern portion of the island so as to preserve the integrity of its infrastructure, provide protection to existing development, and ensure the continued use of the oceanfront beach.

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Chapter 1 INTRODUCTION

1. What is the purpose of this Environmental Impact Statement?

The Town of Ocean Isle Beach is seeking Federal and State authorization for construction of a terminal groin, and associated beach fillet with required maintenance, to be located at the eastern end of Ocean Isle Beach. The proposed terminal groin and beach fillet is the Town's preferred alternative of several alternatives considered in this document. This proposed terminal groin is one of four such structures approved by the General Assembly to be constructed in North Carolina following passing of Senate Bill 110 (SB110). SB110 was amended by Senate Bill 151 (SB151) in 2013 and set forth additional stipulations that must be met prior to the issuance of State of North Carolina permits. In 2015, HB97 allowed for two additional terminal groins within the state located specifically in Onslow County and Carteret County. The U.S. Army Corps of Engineers (USACE) determined that there is not sufficient information to conclude that the project would not result in significant adverse impact on the human environment. Therefore, the USACE has prepared a draft Environmental Impact Statement (DEIS) pursuant to the National Environmental Policy Act (NEPA) to evaluate the environmental effects of the alternatives considering the project's purpose and need. The Town of Ocean Isle Beach has identified the purpose and need of the proposed terminal groin and beach fillet to provide shoreline protection that would mitigate chronic erosion on the eastern portion on the Town's oceanfront shoreline so as to preserve the integrity of its infrastructure, provide protection to existing development, and ensure the continued use of the oceanfront beach along this area. The purpose and need of the proposed terminal groin is further discussed in Section 2 of this DEIS.

The purpose of this environmental impact statement (EIS) is to assist in decision making – "to help public officials make decisions that are based on understanding of environmental consequences, and take actions that protect, restore, and enhance the environment" (43 CFR §1500.1). If a Federal agency anticipates that an undertaking may significantly impact the environment, or if a project is environmentally controversial, a Federal agency may choose to prepare an EIS without having to first prepare an EA. During pre-consultations with key agencies, it was determined that an EIS would be required for the proposed actions. The EIS will insure that the policies and goals defined in NEPA are adequately addressed in the USACE permit evaluation process. It will provide full and fair discussion of significant environmental impacts and shall inform decision makers and the public of the reasonable alternatives which would avoid or minimize adverse impacts or enhance the quality of the human environment.

NEPA is a United States environmental law created in 1969 that established a U.S. national policy promoting the enhancement of the environment and also established the President's Council on Environmental Quality (CEQ). NEPA ensures that relevant environmental information is available to public officials and citizens before decisions are made and actions are taken. The Act requires federal agencies to prepare an EIS for major actions that could have significant impacts on the quality of the human environment. Under NEPA, "environment" includes the natural and physical environment (such as air, water, geography, geology) as well as people's relationship with the environment (such as health, safety, jobs, schools, housing, and aesthetics). An EIS must include an evaluation of both short-term and long-term effects as well as possible mitigation measures, if needed.

This DEIS document has also been developed in accordance with the requirements of the State Clearinghouse review process under the North Carolina Environmental Policy Act (NCEPA, G.S. 113A-1). Upon the development and submittal of the Final EIS, additional filing under the NCEPA will not be required.

Each alternative presented in this document will be evaluated for its ability to satisfy the stated purpose and need. Such analysis will include evaluation of stated project goals and objectives, as well as the environmental, economic, and social consequences associated with each alternative. This evaluation process will help lead to the selection of the least environmentally damaging practicable alternative (LEDPA) that meets the project needs and objectives while resulting in minimal negative environmental impacts.

2. What is the NEPA EIS process and how does it relate to the Town of Ocean Isle Beach's proposed project?

This EIS will be prepared using the following sequence: gathering government and public comments to define the issues that should be analyzed in the EIS (a process known as "scoping"); gathering available data, preparing the draft EIS document and releasing it to the public requesting feedback; receiving and responding to public comments on the draft EIS; and preparing the subsequent final EIS. Decisions are not made in an EIS document; rather, the EIS primarily serves as an assessment of various project alternatives and their respective effects on the environment. Furthermore, the document is utilized to help evaluate and determine which, of the project options is the LEDPA that meets the applicant's purpose and needs. This final evaluation will be made in the Record of Decision (ROD). The following describes the general concepts in the NEPA EIS process, which was used in evaluating the Town's proposed project:

<u>Scoping</u>

Scoping is the process of identifying the key issues as they pertain to the proposed action. The USACE began the scoping process for this EIS by publishing a Notice of Intent (NOI) in the *Federal Register* to let the public know that it is considering an action and will prepare an EIS. During the scoping period, the public can provide comments on the proposed action, alternatives, issues, and environmental impacts to be analyzed in the EIS. Scoping may involve public meetings and other means to obtain public comments on the EIS. A Notice of Availability was published in the *Federal Register* announcing the release of the Draft EIS in January, 2015. A public commenting period was open from January 23, 2015 through March 16, 2015. On March 3, 2015, a Public Hearing convened where additional comments were recorded.

<u>Draft EIS</u>

During scoping, information is collected and used for the preparation of a draft EIS. The draft EIS presents, analyzes, and compares the potential environmental impacts for the proposed action and alternatives and their implementation, and provides additional information on the methodologies and assumptions used for the analyses. A Notice of Availability (NOA) is published in the *Federal Register* announcing the release of the draft EIS for public review and comment. The NOA begins a 45-day comment period. Public comments on the draft EIS are considered in the preparation of the final EIS.

Final EIS

After the draft EIS commenting period is completed and through continuing scoping, a final EIS is prepared, published in the *Federal Register*, and released for any additional comments for a 30-day period. All comments received during the commenting period will be addressed where applicable to prepare the final EIS.

Record of Decision

After the final EIS is published, a minimum 30-day waiting period is required before a ROD can be issued. The ROD notifies the public of the decision made on the proposed action and presents the reasons for that decision. The decision-making process may include consideration of factors such as cost, technical feasibility, agency statutory missions, and national objectives, as well as the potential environmental impacts of an action(s).

3. How has the public been involved?

In accordance with the National Environmental Policy Act (NEPA) and State Environmental Policy Act (SEPA) requirements, an early and open public forum process, identified as "scoping", was initiated to identify significant issues related to the proposed action and establish an appropriate scope of work for addressing those issues in the EIS document.

Appendix A: Scoping Meeting, PDT Meetings, and Public Hearing Meeting Minutes

This appendix includes the minutes from the initial scoping meeting, PDT meetings, and the Public Hearing.

In order to engage the general public, including residents of Ocean Isle Beach and all stakeholders, a Notice of Intent (NOI) was issued and published in the Federal Register (77 FR 58530) on September 21, 2012. This Notice of Intent served to inform the public of the "intent to prepare a DEIS for the installation of a terminal groin structure at Shallotte River Inlet and to conduct supplemental beach nourishment along the eastern oceanfront shoreline of Ocean Isle Beach, in Brunswick County, NC". The NOI provided the project description and described the proposed action, potential impacts, project alternatives, and the scoping process. Along with this issuance, a Public Notice (PN) containing similar information was released by the USACE on the same date. As announced in the NOI and PN, the initial scoping meeting was held on October 3, 2012 in the Ocean Isle Beach Town Hall Public Assembly in Ocean Isle Beach. As stated above, a Public Hearing following the release of the Draft EIS convened on March 3, 2015 to provide the public an additional forum to submit comments. The public commenting period for the Draft EIS was open from January 23, 2015 through March 16, 2015.

In a continual effort to include the public, State and Federal agencies, and all interested stakeholders in the process, a Project Review Team (PRT) was assembled. The PRT members were individually asked to: 1) provide input for the development of the EIS, 2) keep the public informed of project development, 3) discuss project-related concerns, and 4) to identify natural resources and biological data from within the Permit Area. The PRT is comprised of a broad-based team of individuals who represent the following interests: local, state and federal government officials; business and property owners; non-governmental organizations; as well as the project design team Coastal Planning & Engineering of North Carolina, Inc. (CPE-NC) (Table 1.1). The first PRT meeting was held on March 5, 2013. See Appendix A, Subpart 1 for meeting minutes. Additional members may be added to this group in the future. Potential members may include representatives from tribal entities and representatives from other groups expressing interest in this project.

Table 1.1- Ocean Isle Beach Shoreline Management Project PRT Members

Name	Representing	Email
Third Party Preparer		
Rosov, Brad	CPE-NC	brad.rosov@cbi.com
Finch, Greg	CPE-NC	greg.finch@cbi.com
Project Design Team		
Jarrett, James	CPE-NC	james.jarrett@cbi.com
Willson, Ken	CPE-NC	kenneth.willson@cbi.com
Local Government		
Smith, Debbie	OIB, Mayor	mayor@oibgov.com
Ivey, Daisy	OIB, Town Manager	daisy@oibgov.com
Whiteside, Justin	OIB	justin@oibgov.com
Lead Federal Agency		
Beter, Dale	USACE – SAW (RG)	dale.e.beter@usace.army.mil
Tyler Crumbley	USACE – SAW (RG)	tyler.crumbley@usace.army.mil
Pruitt, Carl	USACE – SAW (OC)	carl.e.pruitt@usace.army.mil
Castens, Pam	USACE – SAW	pamela.g.castens@usace.army.mil
Horton, Todd	USACE – SAW	james.t.horton@usace.army.mil
Wutkowski, Mike	USACE – SAW	michael.j.wutkowski@usace.army.mil
State Agencies		
Huggett, Doug	NCDCM	doug.huggett@ncdenr.gov
Howell, Jonathan	NCDCM	jonathan.howell@ncdenr.gov
Wilson, Debbie	NCDCM	debra.wilson@ncdenr.gov
Snider, Holley	NCDCM	holley.snider@ncdenr.gov
Coburn, Chad	NCDWQ	chad.coburn@ncdenr.gov
Baker, Jessi	NCDMF	jessi.baker@ncdenr.gov
Deaton, Anne	NCDMF	anne.deaton@ncdenr.gov
Gledhill-Earley, Renee	NCSHPO	renee.gledhill-earley@ncdcr.gov
Dunn, Maria	NCWRC	maria.dunn@ncwildlife.org
Schweitzer, Sara	NCWRC	sara.schweitzer@ncwildlife.org
Godfrey, Matthew	NCWRC	matt.godfrey@ncwildlife.org
Federal Agencies		
Rhode, Fritz	NMFS	fritz.rhode@noaa.gov
Wilbur, Pace	NMFS	pace.wilbur@noaa.gov
Ellis, John	USFWS	john_ellis@fws.gov
Matthews, Kathy	USFWS	kathryn_matthews@fws.gov
Holliman, Dan	EPA	Holliman.daniel@epa.gov
Other Stakeholders		
Giles, Mike	Coastal Federation	capefearcoastkeeper@nccoast.org
Zivanovic-Nenadovic, Ana	Coastal Federation	anaz@nccoast.org
Simmons, Harry	NCBIWA	harry.simmons@ncbiwa.org
Candler, Steve	Brunswick County Association of Realtors	steve@bcarnc.com
Golder, Walker	Audubon North Carolina	wgolder@audubon.org

Name	Representing	Email
Cleary, Bill	Independent Contractor	wcleary@charter.net
Hewett, David	Town of Holden Beach	dhewett@hbtownhall.com.
Sherrill, Wilson	Councilman, Town of Sunset Beach	wilsonsherrill@hotmail.com
Lawing, Marty	Brunswick County, Manager	mlawing@brunsco.net
Stone, Steve	Brunswick County, Assistant Manager	sstone@brunsco.net

4. How have government agencies been involved?

Participation in the EIS process by Federal, state, and local government agencies and other interested organizations and persons has been encouraged. The USACE has conducting additional consultation efforts with the U.S. Fish and Wildlife Service (USFWS) under the Endangered Species Act and the Fish and Wildlife Coordination Act; with the National Marine Fisheries Service (NMFS) under the Magnuson-Stevens Act and Endangered Species Act; and with the North Carolina State Historic Preservation Office (NCSHPO) under the National Historic Preservation Act. Specifically, the USACE has concluded consultation with the USFWS regarding species listed under the Endangered Species Act (ESA) via the development of a Biological Assessment (BA). NMFS has completed consultation in regards to essential fish habitat via the development of an Essential Fish Habitat (EFH) assessment. Additionally, because this EIS assesses the potential water quality impacts pursuant to Section 401 of the Clean Water Act, coordination efforts are being made with the North Carolina Division of Water Quality (DWQ), and a DWQ Section 401 water quality certification is required. Furthermore, the USACE has worked closely with the North Carolina Division of Coastal Management (DCM) through the development of this EIS to ensure the process complies with all State Environmental Policy Act (SEPA) requirements and to determine consistency with the Coastal Zone Management Act (CZMA).

As stated above, representatives of the relevant federal agencies have been involved in the scoping meeting and the subsequent PRT meetings. Their input has been integrated into this EIS document.

5. What is the Ocean Isle Beach Shoreline Management Project and where is it located?

The Town of Ocean Isle Beach is seeking Federal and State permits to allow development of a shoreline protection project that would mitigate chronic erosion on the eastern portion on the Town's oceanfront shoreline so as to preserve the integrity of its infrastructure, provide protection to existing development, and ensure the continued use of the oceanfront beach along this area.

Ocean Isle Beach is located along the eastern portion of Brunswick County. The island was incorporated in 1959 and has a current year-round resident population of approximately 554, with a seasonal population of 25,000. The island is bordered to the south by the Atlantic Ocean, the north by the Atlantic Intracoastal Waterway (AIWW), the west by Tubbs Inlet, and the east by Shallotte Inlet (Figure 1.1). Ocean Isle Beach is approximately 5.6 mi long and approximately

0.6 mi wide. The proposed project is located along the oceanfront shoreline on the southeast end of the island.

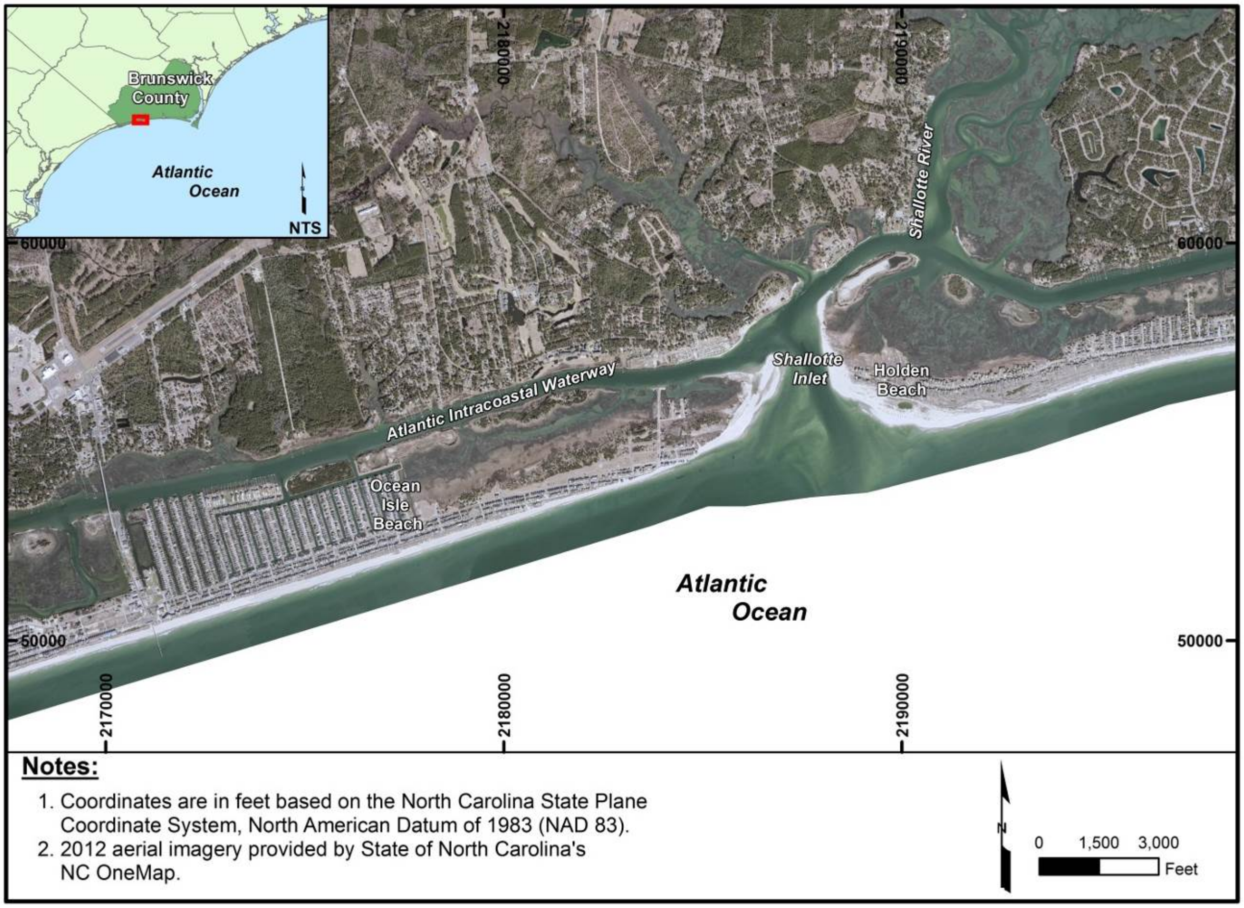


Figure 1.1. Ocean Isle Beach Shore Protection Project Location Map

Between March and May 2001, the USACE initiated a storm damage reduction project with the construction of a beach fill project extending along 17,100 feet (3.25 miles) of the Town's shoreline from just west of Shallotte Blvd (station 10+00 on the USACE baseline) to a point approximately 3,700 feet west of the Ocean Isle Beach Pier & Arcade (USACE baseline station 181+00). The limits of the Federal project and the Federal borrow area located within Shallotte Inlet are shown in Figure 1.2. A total of 1,866,000 cubic yards was placed along the project shoreline. The beach fill included a combination of variable width berms constructed to an elevation of +6.0 ft NAVD (North American Vertical Datum). A dune having a crest elevation of +8.5 feet was also provided along 5,150 feet of the project between baseline stations 51+50 and 103+00. The westernmost 9,500 feet of the Town's shoreline was not included in the Federal project as this area is rather stable and is fronted by an established dune system. The eastern end of Ocean Isle Beach between Shallotte Boulevard and Shallotte Inlet was not included in the Federal project because the predicted high rates of loss that would occur from a beach fill placed in this area.

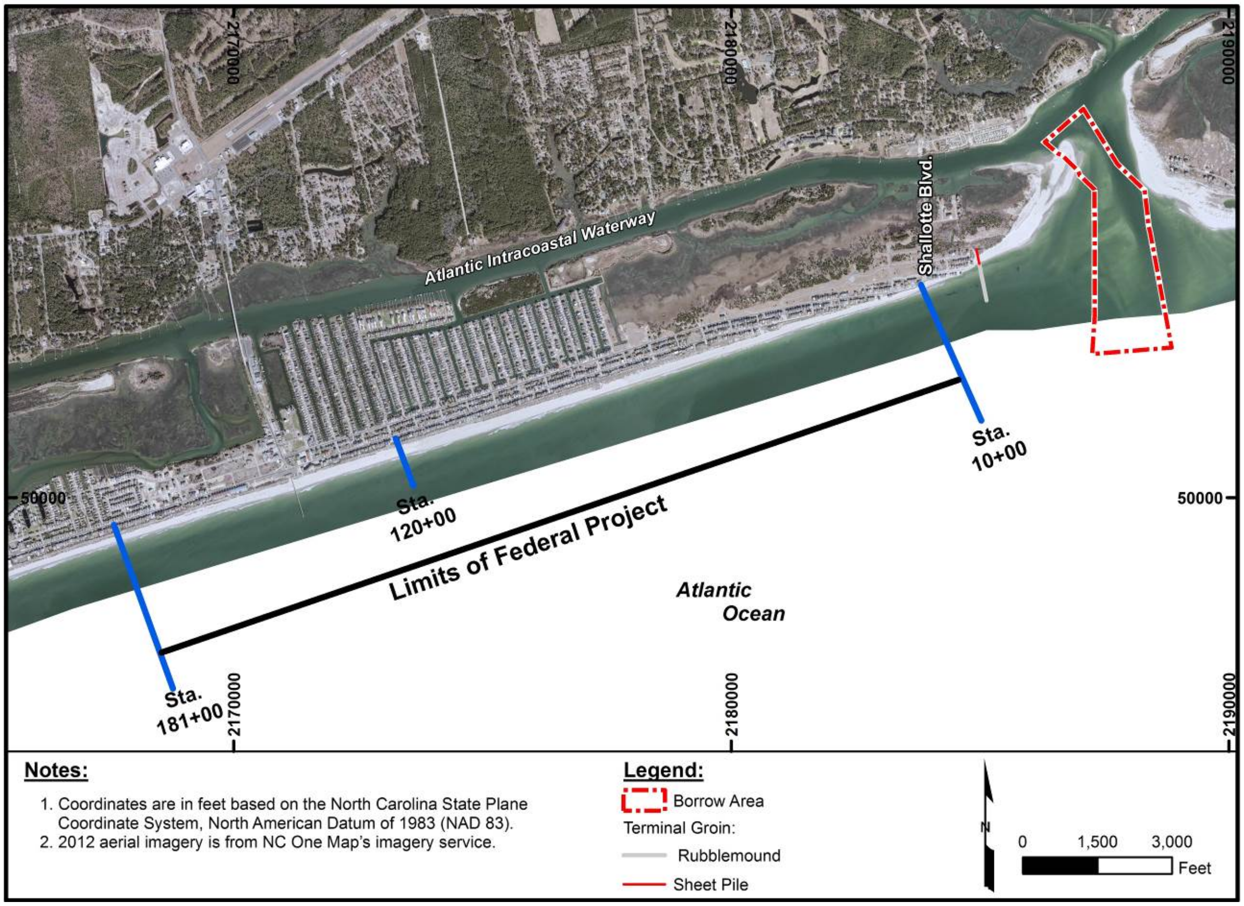


Figure 1.2. Map of Ocean Isle Beach showing the limits of the Federal project, the Federal borrow area, and the proposed terminal groin.

> **What is NAVD?**
>
> The North American Vertical Datum (NAVD) is the vertical control reference used in surveying land elevation. Lines of elevation surveying beginning at the dune and continuing approximately 1 mile offshore are used to monitor sand movement in beach nourishment projects and measure project performance.

Based on the USACE economic evaluation, the cost of protecting the end of the island east of Shallotte Boulevard using only beach nourishment exceeded the value of the development and was therefore excluded from the Federal project. While the east end of the Town did not meet the Federal standards, the economic value of the properties and infrastructure on the east end of the Town are important to the Town's economy. Also, the continued loss of buildings and infrastructure conveys a negative image of the Town, and potentially could have a negative effect on the value of properties not directly impacted by the chronic erosion. Accordingly, the Town of Ocean Isle is evaluating various shoreline management alternatives that could reduce the erosion impacts to a more manageable level.

During the formulation of the Federal storm damage reduction project, the USACE attributed much of the chronic erosion on the eastern portion of Ocean Isle Beach to changes in the orientation and position of the main ebb channel through Shallotte Inlet. In this regard, when the ocean bar channel of Shallotte Inlet is oriented toward the west end of Holden Beach (as it had been from the mid 1970's until the construction of the Federal project) the west side of the ebb tide delta of the inlet also migrates toward the east exposing the east end of Ocean Isle Beach to direct wave attack. In addition, with the main bar channel situated closer to Holden Beach, flood channels tend to form close to shore along the east end of Ocean Isle Beach. The presence of the flood channels, combined with wave driven currents, transports sediment off the east end of the island and into Shallotte Inlet at a faster rate than the supply of wave driven sand being transported toward the east off the main portion of the island.

Given the impact of the bar channel on the east end of Ocean Isle Beach, the USACE formulated the storm damage reduction project to include a borrow area that extends from the confluence of Shallotte Inlet and the AIWW across the ebb tide delta of Shallotte Inlet (Figure 1.3). In designing the inlet borrow area in this manner, the USACE had hoped that the repositioned bar channel would result in the reconfiguration of the ebb tide delta off the east end of Ocean Isle Beach, which would lessen the erosion rates on the east end of Ocean Isle Beach. However, the repositioning of the bar channel did not lessen erosion rates as hoped. Since repositioning the bar channel, shoreline erosion rates have remained high resulting in the loss of five (5) homes, 560 feet of E. 2nd Street, and associated water lines, storm sewers, and other utilities since 2005. The NC Department of Transportation (NCDOT) has also expended considerable effort in response to erosion on the east end of the island. NCDOT's efforts have included the installation of sandbag revetments, repaving damaged sections of roads, and clean-up of damaged sections. Even with these efforts, the east ends of 1st and 2nd Streets have been lost.

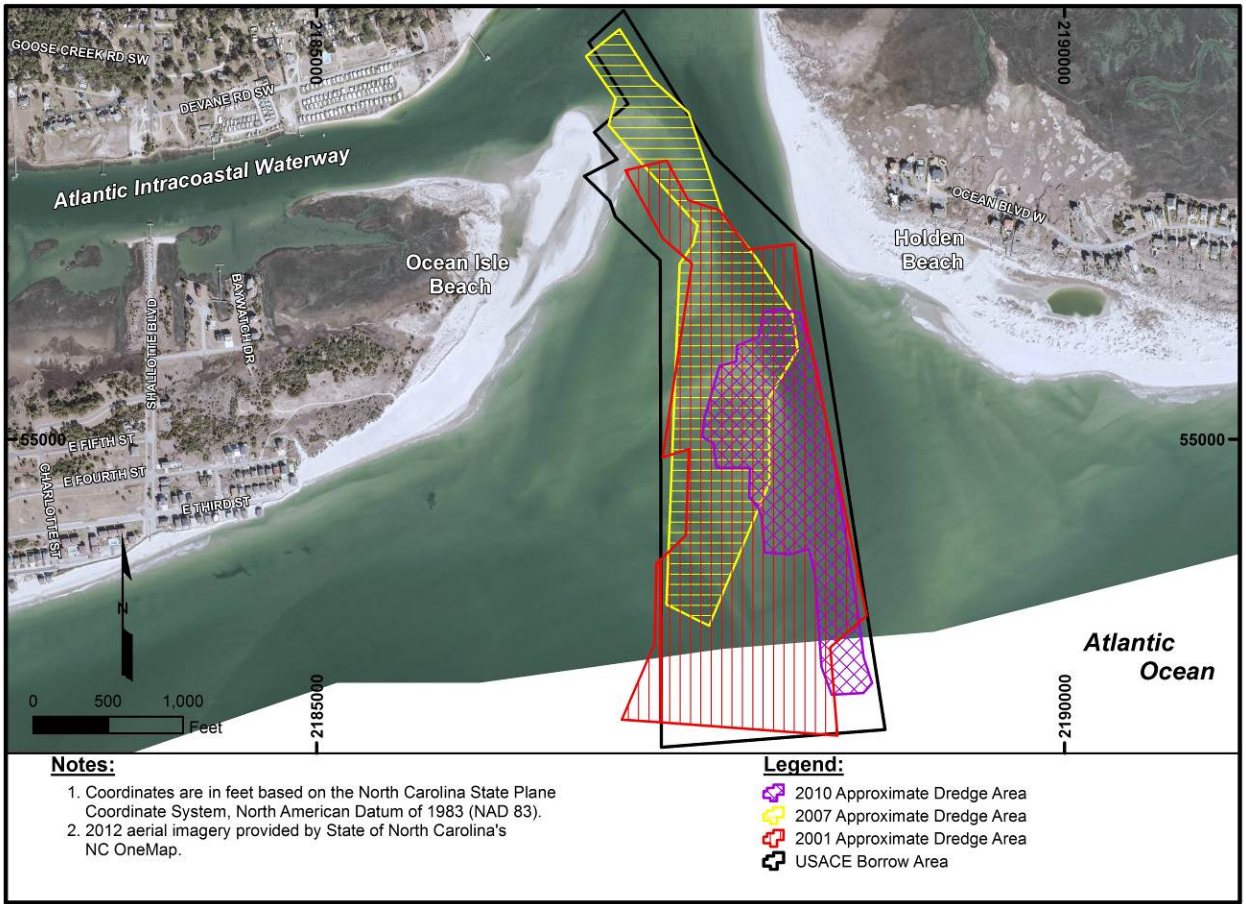


Figure 1.3. Map of the authorized borrow area at Shallotte Inlet and approximate dredged footprints.

To alleviate these problems attributed to erosion, several alternatives have been evaluated. A description of the alternatives is provided in Chapter 3 with evaluation of the impacts of each alternative given in Chapter 5. The Applicant's Preferred Alternative includes the construction of a terminal groin 750 ft. in length with a 300 ft. shore anchorage section to protect against possible flanking of the landward end of the structure (Figure 1.1). This structure is intended to control tidal current-induced shoreline changes immediately west of Shallotte Inlet. In addition to the construction of the terminal groin, a 3,214 ft. section of oceanfront shoreline adjacent to the structure would be nourished with material excavated from the borrow area utilized by the USACE in Shallotte Inlet (Figure 1.1).

> **What is a Terminal Groin?**
>
> A shoreline protection structure that reduces beach erosion by temporarily trapping sand before it reaches the inlet. Once the sand forms an "accretion fillet" to protect the shoreline, sand continues its normal flow by moving over, thru or around the structure.

6. What issues were identified as part of scoping?

During scoping (through public meetings and written comments), several issues were identified in association with the proposed project, including: funding concerns, impacts to environmental resources within the inlet complex, sand quality and compatibility, and environmental concerns associated with the construction and effects of a terminal.

Summaries of the public scoping meetings and PRT meetings held to date are listed below. Minutes to the PRT meetings are to be found in Appendix A.

- The October 3, 2012 Public Scoping Meeting convened at Town Hall in Ocean Isle Beach. The scoping meeting was designed to solicit comments from the public, Federal, State and local agencies and officials, and other interested parties to identify issues to be addressed in the EIS document. Attendees included local residents, resource agencies, and representatives from the Town of Ocean Isle Beach, non-governmental organizations, and (CPE-NC). Concerns expressed from the attendees are documented in Appendix A.

- The March 5, 2013 PRT Meeting included the following: The USACE provided an introduction to the NEPA process and the USACE's involvement as the lead Federal agency in the process. They also described the role of the PRT and the 3rd Party Contractor. The DCM reviewed the SB110 language and how the DCM is interpreting it for this project. A representative of CPE-NC presented the draft permit area, the project purpose and needs, and an inventory of baseline biological data. CPE-NC also presented the proposed project alternatives. The meeting format allowed for open discussions during and after the presentation.

- The March 3, 2015 Public Hearing in response to the release of the DEIS was held at Union Elementary School in Shallotte, North Carolina. This public hearing provided a forum for the general public to submit written or oral comments in response to the information contained within the DEIS.

7. What laws are involved?

The following section includes a description of applicable Federal and State laws associated with the Ocean Isle Beach Shoreline Management Project. This EIS document has been prepared to satisfy both the National Environmental Policy Act (NEPA) and the North Carolina State Environmental Policy Act (SEPA) requirements in accordance with State and Federal law.

National Environmental Policy Act of 1969

The National Environmental Policy Act (42 U.S.C. 4321; 40 C.F.R. 1500.1) includes six fundamental objectives that have been developed since its enactment in 1970. These objectives include: supplemental legal authority; procedural reform; disclosure of environmental information; resolution of environmental problems; foster intergovernmental coordination and cooperation; and enhance public participation in governmental planning and decision making

(Bass *et al.*, 2001). A NEPA document is required when a project includes a Federal action including the need for Federal permits, the use of Federal funding, or if the action is to take place on Federal lands.

Section 10 of the Rivers and Harbors Act of 1899

Pursuant to Section 10 of the Rivers and Harbors Act of 1899, certain structures or work in or affecting navigable waters of the US will be regulated under the purview of USACE (33 CFR 322.1). The Act states that "it shall not be lawful to excavate or fill…..alter or modify the course, location, condition, or capacity of, any port roadstead, haven, harbor, canal, lake, harbor of refuge, or enclosure within the limits of any breakwater, or of the channel of any navigable water of the United States unless the work has been recommended by the Chief of Engineers and authorized by the Secretary of War…." (USACE, 2006). The geographic jurisdiction of the Rivers and Harbors Act includes all navigable waters of the United States which are defined (33 CFR Part 329) as, "those waters that are subject to the ebb and flow of the tide and/or are presently used, or have been used in the past, or may be susceptible to use to transport interstate or foreign commerce." This jurisdiction extends seaward to include all ocean waters within a zone three nautical miles from the coastline (the "territorial seas").

Clean Water Act of 1972

Section 404 of the Clean Water Act established a permit program under the purview of the USACE, to regulate the discharge of dredged and fill material into waters of the U.S., including wetlands. These waters consisting of, but not limited to, "all waters which are currently used or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide" (33 CFR 328.3(a)(1)). This program is jointly administered by the Environmental Protection Agency and the USACE.

Section 401 of the Clean Water Act includes the delegation of Federal authority to the State of North Carolina to issue a 401 Water Quality Certification. The 401 Water Quality Certification is applicable to all projects that require a Federal permit (i.e., Section 404 Permit) for discharge of dredge material into waters and wetlands of the U.S. The 401 Water Quality Certification Program is administered by the North Carolina Division of Water Quality to prevent the degradation of waters in the State and to prevent any violations of the State water quality standards.

Endangered Species Act of 1973

The ESA was signed on December 28, 1973, and provides for the conservation of species that are endangered or threatened throughout all or a significant portion of their range, and the conservation of the ecosystems on which they depend. The ESA replaced the Endangered Species Conservation Act of 1969; it has been amended several times. The lead Federal agencies for implementing ESA are the USFWS and the NMFS. The USFWS maintains a worldwide list of endangered species. Species include birds, insects, fish, reptiles, mammals, crustaceans, flowers, grasses, and trees. Coordination with the USFWS and NMFS includes consultation under Section 7 of the ESA, as amended.

National Historic Preservation Act of 1966

The National Historic Preservation Act is legislation intended to preserve historical and archaeological sites in the United States of America. The act created the National Register of Historic Places, the list of National Historic Landmarks, and the State Historic Preservation Offices. The National Historic Preservation Act also includes provisions for ensuring coordination with Native American tribes for the protection of tribal artifacts or remains through coordination with the Tribal Historic Preservation Officer. Under certain conditions, a tribe may assume all or any part of the functions of a State Historic Preservation Officer with respect to tribal lands.

Senate Bill 3035, the National Historic Preservation Act, was signed into law on October 15, 1966. Several amendments have been made since. Among other things, the act requires Federal agencies to evaluate the impact of all Federally funded or permitted projects on historic properties (buildings, archaeological sites, etc.) through a process known as *Section 106 Review*.

Archival research, field work and coordination with the North Carolina State Historic Preservation Officer (SHPO), have been conducted in accordance with the National Historic Preservation Act of 1966 (Public Law 89-665), the National Environmental Policy Act of 1969 (Public Law 11-190), Executive Order 11593, the Advisory Council on Historic Preservation Procedures for the protection of historic and cultural properties (36 CFR Part 800) and the updated guidelines described in 36 CFR 64 and 36 CFR 66.

The North Carolina Office of State Archaeology (OSA) protects endangered archaeological sites on private or public lands through enforcement of the North Carolina Archaeological Resources Protection Act (G.S. 70, article 2), the North Carolina Archaeological Records Program (G.S. 70, article 4), and the “Abandoned Shipwreck Law” (G.S. 121, article 3).

Magnuson-Stevens Fishery Conservation and Management Act of 1996

The Magnuson Fishery Conservation and Management Act of 1976, amended Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA) in October 1996 and also referred to as the Sustainable Fisheries Act, were enacted by the U.S. Congress to protect marine fish stocks and their habitat, prevent and stop overfishing and minimize bycatch. Congress defined Essential Fish Habitat (EFH) as "those waters and substrate necessary to fish for spawning, breeding, feeding or growth to maturity." The MSFCMA requires that EFH be identified for all fish species Federally managed by the Fishery Management Councils and the National Marine Fisheries Service (NMFS).

Fish and Wildlife Coordination Act of 1958

The Fish and Wildlife Coordination Act of 1958, as amended, mandates that Federal and State agencies cooperate “to protect, rear, stock, and increase the supply of game and fur-bearing animals….[and] study the effects of domestic sewage, trade wastes, and other polluting substances on wildlife.” The Act also requires consultation with the Bureau of Fisheries, Fish and Wildlife Service and State fish and wildlife agencies where the "waters of any stream or other body of water are proposed or authorized, permitted or licensed to be impounded, diverted…or otherwise controlled or modified" by any agency under a Federal permit or license. Additional amendments to the Act have "permitted lands valuable to the Migratory Bird Management Program to be made available to the State agency exercising control over wildlife resources (USFWS, 2006).

Marine Mammal Protection Act of 1972

The Marine Mammal Protection Act was enacted to protect marine mammals that were subject to potential danger of extinction or depletion as a result of human activities, The Act requires measures be taken to ensure these species or stocks do not fall below their optimum sustainable population level. Furthermore, the Act requires measures be taken to replenish these species or stocks as they have been determined to provide international importance.

Coastal Zone Management Act of 1972

Enacted by Congress in 1972, the Coastal Zone Management Act (CZMA) does not require, but encourages that each State preserve, protect, restore or enhance natural coastal resources including; wetlands, floodplains, estuaries, beaches, dunes, barrier islands and coral reefs, as well as the fish and wildlife that utilize these resources. Since this Act is voluntary, any State that implements a coastal management program as defined in this Act will receive Federal financial aid.

The North Carolina DCM has developed and enforces a coastal management plan with the rules and policies that supports the ideals and concepts of the CZMA. The North Carolina DCM enforces this Act using the rules and policies of the Coastal Area Management Act of 1974 (enabled and delegated in 1972; adopted and implemented in 1974).

North Carolina Environmental Policy Act (As Amended)

The North Carolina (or State) Environmental Policy Act of 1971 (SEPA) requires State agencies to review and report the environmental effects of all activities that involve an action by a State agency, an expenditure of public monies or private use of public land, and that may have a potential negative environmental effect on natural resources, public health and safety, natural beauty, or historical or cultural elements of the State. This Environmental Impact Statement has been developed in accordance with the requirements of the State Clearinghouse review process under the North Carolina Environmental Policy Act, based upon the agreement between the North Carolina DCM and the USACE. Upon the development and submittal of the final EIS, additional filing under the NC EPA will not be required.

North Carolina Coastal Area Management Act of 1974

The North Carolina Coastal Area Management Act (CAMA) (§ 113A-100) was implemented to preserve the physical, aesthetic, cultural and recreational values, including the management of land and water resources in North Carolina's 20 coastal counties. Under CAMA, permits are necessary for development type projects proposing work in any Areas of Environmental Concern (AEC) established by the Coastal Resources Commission (CRC). An AEC includes areas of natural importance such as 1) estuarine and ocean systems, 2) ocean hazard system, 3) public water supplies, and 4) natural and cultural resource areas. Under CAMA, the proposed work cannot cause significant damage to one or more of the historic, cultural, scientific, environmental or scenic values or natural systems identified in the AECs listed. In addition, significant cumulative effects cannot result from a development project (NCDCM, 2003).

North Carolina Dredge and Fill Law

Under CAMA (§ 113-229), the North Carolina DCM regulates projects that involve excavation or filling in any estuarine waters, tidelands, marshlands, or State-owned lakes. An applicant proposing work in such lands must obtain a permit from both the North Carolina Department of Environmental Quality and the USACE (NCDCM, 2006).

North Carolina Surface Water Quality Standards

The North Carolina Division of Water Resources' Surface Waters and Wetlands Standards (North Carolina Administrative Code 15A NCAC 02B .0100 & .0200) were implemented for assigning and regulating water quality standards for waters in the State of North Carolina. The water column in the Ocean Isle project area is classified as both SA waters and Outstanding Resource Waters. Class SA waters are surface waters suitable for shellfishing for market purposes. Waters designated as Class SA have specific water quality standards that must be met, as well as the water quality standards assigned to both Class SB and SC waters. Outstanding Resource Waters (ORW) includes waters of exceptional water quality. Waters designated as ORW and/or Class SA waters are also classified as High Quality Waters (HQW) (NCDWQ, 2003).

Based on the above classifications, water quality standards applicable to the project area include: 1) "turbidity in the receiving water shall not exceed 25 Nephelometric Turbidity Units (NTU)", 2) "changes in salinity due to hydrological modifications shall not result in the removal of the functions of a Primary Nursery Area (PNA)", 3) temperature "shall not be increased above the natural water temperature by more than 0.8°C (1.44°F) during the months of June, July or August nor more than 2.2°C (3.96°F) during other months, and in no cases to exceed 32°C due to the discharge of heated liquids", 4) dissolved oxygen cannot decrease below 5.0 mg/l, except in "poorly flushed tidally influenced streams or embayments, or estuarine bottom waters" which may have decreased values from natural causes, and 5) pH levels "shall be normal for the waters in the area, which generally range between 6.8 and 8.5 except that swamp waters may have a pH as low as 4.3 if it is the result of natural conditions" (NCDWQ, 2006).

Limitations on Erosion Control Structures, North Carolina General Statute § 113A-115.1

This law establishes limitations of erosion control structures along the ocean shoreline. The "ocean shoreline" is defined as "the Atlantic Ocean, the oceanfront beaches, and frontal dunes". Furthermore, the term "ocean shoreline" includes "an ocean inlet and lands adjacent to an ocean inlet but does not include that portion of any inlet and lands adjacent to the inlet that exhibits characteristics of estuarine shorelines". This statute defines such a structure as "breakwater, bulkhead, groin, jetty, revetment, seawall, or any similar structure". Terminal groins, or specifically a groin that is constructed at the end of a littoral cell or on the updrift side of an inlet to prevent sediment passage into the channel beyond, are included under this statute, as of the passing of SB110. NCGS 113A-115.1, as amended, allows a total of six (6) terminal groins within the State as long as the applicant meets a suite of requirements. These requirements include the preparation of an Environmental Impact Statement, proof of financial assurance to cover post construction monitoring and mitigation (if warranted), and notification to adjacent property owners amongst other requirements.

In addition to the above Federal and State laws, the project must comply with requirements outlined in various statutes applicable to the regulatory program, as well as pertinent Executive Orders and Memoranda. Compliance with these provisions will be documented in the ROD. Additionally, the project may be subject to certain local government regulations.

Chapter 2 PURPOSE AND NEED

1. What are the purpose and need of this project?

The main concern of residents and property owners at Ocean Isle Beach are economic losses resulting from damages to structures and their contents due to hurricane and storm activity, as well as the loss of beachfront land due to the ongoing shoreline erosion along the east end of the island in proximity to Shallotte Inlet. Historical data establishes that current shoreline management strategies have not been successful in providing the proper shoreline protection sought by the Town. The total tax value of property within the limits of Ocean Isle Beach is approximately $1,816,012,300 (based on the 2012 reappraisal). This valuation includes 3,247 commercial and residential structures and property and 1,456 vacant lots (Ivey, pers. comm.). Based upon the importance of the property to the tax base, the Town realizes the need to protect homes and infrastructure along the east end of the island.

The purpose and need of the Ocean Isle Beach Shoreline Management Project are as follows:

- To reduce or mitigate erosion along 3,500 feet of Ocean Isle Beach oceanfront shoreline west of Shallotte Inlet;
- To maintain the Town's tax base by providing long-term protection of property and infrastructure through reduced storm damage and erosion on the oceanfront shoreline of Ocean Isle Beach between Shallotte Inlet and the western terminus of the Federal Project;
- Maintain existing recreational resources; and
- Balance the needs of the human environment with the protection of existing natural resources.

In particular, the Town of Ocean Isle Beach is seeking Federal and State permits to allow the development of a shoreline protection project that would mitigate chronic erosion on the eastern portion on the Town's oceanfront shoreline so as to preserve the integrity of its infrastructure, provide protection to existing development, and ensure the continued use of the oceanfront beach along this area

2. How is the Ocean Isle Beach shoreline managed today?

Between March and May 2001, the USACE constructed a Federal beach fill project for storm damage reduction that covered 17,100 feet (3.25 miles) of the Town's shoreline beginning at Shallotte Boulevard (station 10+00 on the USACE baseline) on the east and extended to a point approximately 3,700 feet west of the Ocean Isle Beach Pier & Arcade (USACE baseline station 181+00) (Figure 1.2). The westernmost 9,500 feet of the Town's shoreline was not included in the Federal project as this area is rather stable and is fronted by an established dune system. The eastern end of Ocean Isle Beach between Shallotte Boulevard and Shallotte Inlet was also not included in the Federal project because the predicted high rates of loss that would occur from beach fill placed in this area. Based on the USACE economic evaluation, the cost of protecting the extreme east end of the island exceeded the value of the development and infrastructure it would protect, and was therefore excluded from the Federal project.

Initial construction of the Federal project in 2001 involved the placement of 1,866,000 cubic yards of material obtained from a borrow area located in Shallotte Inlet (Figure 1.2). The Shallotte Inlet borrow area was also designated as a source for future periodic beach nourishment, which was scheduled to occur every three (3) years. Based on USACE estimates, 300,000 cubic yards (100,000 cubic yards/year) would be needed every 3 years to maintain the Federal project.

The Ocean Isle Beach project has been nourished twice since initial construction. The first periodic re-nourishment operation was accomplished between December 2006 and January 2007 and involved both a Federal and a non-Federal component. The Federal component, which was completed in December 2006, placed 449,400 cubic yards of material between stations 10+00 and 72+00, while the non-Federal component placed 155,000 cubic yards between stations -3+00 and 17+00. Approximately 40,000 cubic yards of material from this non-Federal component was placed within the Federal project limits. The non-Federal component represented an attempt by the Town to address the extreme erosion problem east of Shallotte Boulevard. The second periodic re-nourishment operation occurred between April and May 2010 and involved the placement of 509,200 cubic yards of material between stations 10+00 and 120+00. The western 6,000 feet of the Federal project continues to perform very well and has not required periodic nourishment since construction in 2001.

Since the initial construction (2001) and excluding the 2007 non-Federal effort on the east end, a total of 1,758,600 cubic yards of periodic nourishment has been placed within the limits of the Federal project generally between stations 10+00 and 120+00. Most of the non-Federal effort in January 2007 placed material outside the federally authorized limits of the project. However, assuming the material was equally distributed, and allowing for a transition section on the west end, an estimated 30,000 cubic yards was probably placed within the project between stations 10+00 and 17+00. Thus, including the non-Federal nourishment, a total of 1,798,600 cubic yards of material has been placed within the Federally authorized limits of the Ocean Isle Beach project since its initial construction in 2001 (Table 2.1). This represents an average annual nourishment rate of approximately 136,000 cubic yards/year. This actual nourishment rate is close to the USACE estimated nourishment requirement of 100,000 cubic yards/year. However, based on an evaluation of USACE survey data discussed below, erosion along the eastern 2,000 feet of the project between stations 10+00 and 30+00 progressed into the design template prior to each nourishment event. The erosion into the design template indicates the volume of material provided by the nourishment operations has not been sufficient to maintain the full protective value of the project in this area.

Table 2.1. Shoreline Protection Project History on Ocean Isle Beach

Project Start Date	Volume (c.y.)	Source	Region
March, 2001	1,866,000	Shallotte Inlet	Federal Project Domain
December, 2006	449,400	Shallotte Inlet	Federal Project Domain
December, 2006	155,000	Shallotte Inlet	East of the Federal Project
April, 2010	509,200	Shallotte Inlet	Federal Project Domain
April 2014	800,000	Shallotte Inlet	Federal Project Domain

Although it is outside the Federal shore protection project, the USACE has periodically deposited material on the east end of Ocean Isle Beach from maintenance of the Atlantic Intracoastal Waterway (AIWW) at the intersection of the AIWW with Shallotte Inlet. Although no definitive total volume has been provided by the USACE, an estimated 300,000 to 400,000 cubic yards of navigation maintenance material has been placed on the extreme east end of Ocean Isle Beach since 2001. All of this material has been deposited generally within the area fronting the development east of Shallotte Boulevard (i.e., outside the limits of the Federal project). The material removed from the AIWW has eroded quickly and has been generally ineffective in slowing the rate of erosion in the area east of Shallotte Boulevard.

Even with the rather substantial beach nourishment efforts by the USACE and the Town, erosion along the east end of Ocean Isle Beach has continued to affect existing structures and infrastructure. Not only have the beach nourishment efforts failed to provide adequate and dependable protection against the chronic erosion and the damage caused by coastal storms, the Town and affected property owners have undertaken a concerted effort to lessen the impact of the erosion by installing sandbag revetments along approximately 1,400 feet of shoreline, beginning at a point west of Shallotte Boulevard and extending to the east end of the development. Most of the sandbags were initially installed around 2005 and have been periodically repaired and replaced as the bag revetments fail under the continued landward retreat of the shoreline. Due to continued erosion, the sandbag revetment was extended 400 feet to the west or just past Charlotte Street in 2012. Some of this sandbag placement was accomplished by the North Carolina Department of Transportation in an attempt to protect the eastern end of 2nd Street.

Sandbags protecting a home along the eastern portion of Ocean Isle Beach, October 23, 2013

Despite the completion of the initial construction of the Federal project in 2001, substantial beach nourishment and the installation of temporary sandbag revetments, the Town, the State, and private owners have been directly impacted by erosion at the east end of the Town. Damages that have been suffered include the following:

a. Five (5) homes have been lost on the east end of Ocean Isle Beach since 2005, four (4) east of Shallotte Boulevard and one (1) just west of Shallotte Boulevard.
b. Portions of the Town's infrastructure were damaged, including approximately 560 feet of E 2nd St. and the associated storm sewers, waterlines, and other utilities. The loss of this section of E 2nd St. occurred subsequent to the installation of sandbags along the entire threatened section of the road.
c. The NCDOT has completely lost the east ends of 1st and 2nd Streets, as well as incurred additional costs in maintaining its infrastructure, including the installation of sandbags, repaving sections of damaged roads, and clean-up of damaged section of roads.

According to data provided by the Town, they have spent about $3.7 million responding to erosion on the east end of the island since 2005. State costs are approximately $1 million. These efforts include the installation of sandbags, dune construction, replacement of public accesses, relocation of water and sewer lines, and beach fill. Since 2001, the Federal government has spent approximately $15.6 million constructing and maintaining Ocean Isle Beach's Coastal Storm Damage Reduction project.

The NCDCM maintains a database of all active sandbag permits within the State. According to the NCDCM and the Ocean Isle Beach Planning and Inspections Department, sandbag revetments are currently protecting 57 dwellings/dwelling units along the east end of Ocean Isle Beach (Whiteside, pers. comm.). This includes units within two condominiums- the Sand Dwellers I and the Sand Dwellers II as well as single family residences on East 2nd Street and East 3rd Street. These structures are deemed to be imminently threatened, as defined by State Standard Rule 15A NCAC 7H .0308 (NCDCM, 2007a) (See Figure 2.1). The basic premise of this rule is that a structure in the Ocean Hazard Area is considered imminently threatened when its foundation is less than 20 ft from the toe of the erosion scarp. Figure 2.2 depicts the location of each residential structure on Ocean Isle Beach protected by sandbags. Based upon 2013 assessments, the potential loss of these threatened structures would reduce the total tax base by $7,424,965 (Whiteside, pers. comm.) (Table 2.2). It should be noted that this valuation is reflective of numerous petitions by homeowners to the tax assessment office to re-evaluate their property, taking into consideration the current state of high erosion (Smith, pers. comm.). These property values could be substantially higher once long term shoreline protection measures are implemented.

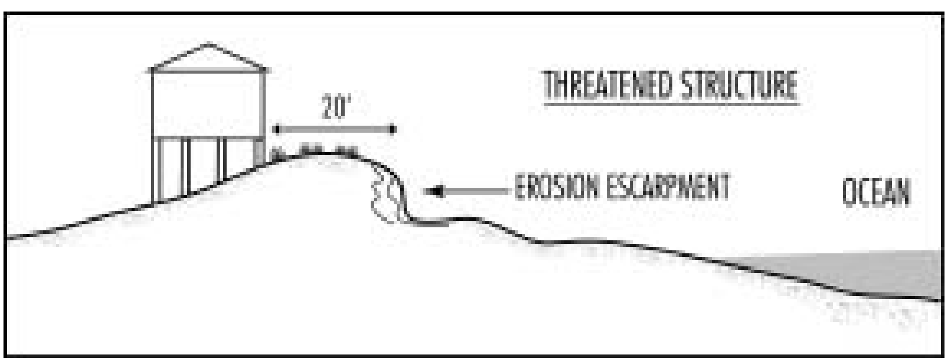


Figure 2.1. Diagram Depicting Imminently Threatened Structures (NCDCM, 2003)

Figure 2.2. Location of Homes Protected with Sandbags on the East End of Ocean Isle Beach

Table 2.2. Analysis of Dwellings Protected by Sandbags on Ocean Isle Beach

Property Address	Tax Value (2013)
442 East Second Street	$208,330
444 East Second Street	$117,456
445 East Second Street - Units 1-16	$1,824,000
446 East Second Street	$131,540
447 East Second Street – Units 1-24	$2,704,320
450 East Second Street	$65,535
458 East Second Street	$14,150
460 East Second Street	$14,790
462 East Third Street	$410,240
464 East Third Street	$376,168
466 East Third Street	$170,960
468 East Third Street	$291,860
469 East Third Street	$444,816
470 East Third Street	$207,730
474 East Third Street	$205,740
476 East Third Street	$91,290
478 East Third Street	$57,700
480 East Third Street	$86,810
484 East Third Street	$1,530
TOTAL VALUE	**$7,424,965**

Chapter 3 PROJECT ALTERNATIVES

1. What alternatives are evaluated in this EIS?

This section describes in detail the various alternatives evaluated for responding to the erosion threat along the eastern 2,500 feet (0.47 mi) of Ocean Isle. These alternatives include:

- Alternative 1 – No Action (Continue Current Management Practices)
- Alternative 2 – Abandon / Retreat
- Alternative 3 – Beach Fill Only (Including Federal Project)
- Alternative 4 – Shallotte Inlet Bar Channel Realignment with Beach Fill (Including Federal Project)
- Alternative 5 - Terminal Groin with Beach Fill (Including Federal Project)/Preferred Alternative

A description of each alternative is provided below detailing what the alternative entails, a summary of how it was formulated, and the economic cost for implementation. More details regarding the formulation of each alternative is provided in the Engineering Report (Appendix B). A summary of the economic impacts of the alternatives as well as their environmental consequences is provided in Chapter 5.

The primary tools used to evaluate the effectiveness of the various alternatives in meeting the needs and objectives included:

- Light Detection and Ranging (LiDAR) Surveys
- USACE Beach Profile Surveys
- Delft3D Model
- Maximum Periodic Nourishment Volume Per Operation

<u>LiDAR Surveys</u>
Shoreline changes along the Town of Ocean Isle Beach were evaluated using LiDAR data collected by USACE JALBTCX (Joint Airborne LiDAR Bathymetry Technical Center of Expertise), USGS (U.S. Geological Survey), NASA (National Aeronautics and Space Administration), and NOAA (National Oceanographic and Atmospheric Administration). LiDAR is an optical remote sensing technology that measures the ground elevation or seafloor at relatively high spatial resolutions. LiDAR data is better suited for surveying subaerial platforms since light penetration may be restricted by water clarity. For this analysis, only elevations collected along the dry beach were evaluated. Twelve (12) sets of LiDAR data collected over a 16-year period between 1996 and 2012 were used for the shoreline study. These data sets had an accuracy ranging from 6.2-15cm vertical and 76-100cm horizontal.

<u>USACE Beach Profile Surveys</u>
Beach profile surveys of Ocean Isle and the west end of Holden Beach obtained prior to and following the initial construction in 2007 and maintenance events through 2010 for the federal storm damage reduction project were used to compute volume losses and shoreline change rates.

Delft3D Model

Delft3D was the primary modeling package used for evaluating this project. The model simulates flows, sediment transport, and bathymetric changes by using advanced sediment transport formulations that respond to forcing functions that include waves, tides, winds, and density gradients. The model takes into account the movement of sediment along the bottom (bedload transport) as well as sediment transported in the water column (suspended transport). Details of the application of the Delft3D model are provided in Appendix C. As stated in Appendix C, the model was calibrated for a three year period from April 2007 to April 2010 using input parameters (waves, tides, and winds) derived from known or observed conditions. The same "known" conditions were used in the simulation of the other alternatives with any difference in the response of the model clearly attributable to man-induced changes associated with the each alternatives.

These tools were used to help assess and determine the differences between the alternatives and were not intended to represent predictions of what changes to expect in the future. Accurate future predictions for large-scale and long-term coastal changes are too difficult to make due to the absence of the necessary capabilities for those predictions (Barter, Burgess, and Hosking, 2003). With the dynamic nature and complexity of coastal inlets, there remain some processes that are not fully understood and can be difficult for quantitative predictions in estimating short- and long-term migration trends, collective morphologic evolution, and cycles of inlets and the interactions among inlets, adjacent beaches, bays, and estuaries (Demirbilek and Rosati, 2011). There continues to be limitations on modeling for predicting future long-term coastal changes, but numerical models are valid for qualitative comparisons (Beck, pers. comm. 2014).

Maximum Periodic Nourishment Volume per Operation

In order to provide an equitable basis for comparing the relative cost of alternatives, including periodic beach nourishment, a maximum volume of 408,000 cubic yards per nourishment operation was adopted. The 408,000 cubic yard maximum volume is equal to the approximate volume of material placed on the Ocean Isle Beach federal storm damage reduction project apportioned over a three year period. By adopting this maximum volume, the optimal periodic nourishment interval for some of the options differed from the 3-year nourishment cycle associated with the Federal project. While nourishment intervals greater than three years would probably not create any budgetary problems for the USACE, intervals less than three years would. This notwithstanding, the maximum nourishment volume of 408,000 cubic yards/operations was still applied.

Alternative 1: No Action (Continue Current Management Practices)

Description

Under Alternative 1, the Town of Ocean Isle Beach and individual property owners on the east end of Ocean Isle Beach would continue to respond to erosion threats in the same manner as in the past. These measures include possible intermittent beach nourishment as a result of the Federal storm damage reduction project, deployment of sandbags, and beach scraping. The NCDOT has also installed sandbags and conducted road repairs to maintain infrastructure within the project area.

As mentioned in Chapter 1, a Federal storm damage reduction project was constructed along 17,100 feet of the Town's shoreline west of Shallotte Boulevard between March 10 and May 7, 2001. Material for construction and periodic nourishment of the Federal project is being derived from a borrow area located in Shallotte Inlet as shown in Figure 1.3 in Chapter 1. The Federal project includes beach profile monitoring along 27,000 feet of shoreline on Ocean Isle Beach and about 10,000 feet of shoreline on the west end of Holden Beach. Associated with the monitoring program are shoreline change thresholds which, if exceeded, would require the federal project to mitigate for the adverse shoreline changes that exceed the thresholds. To date (October 2014) the monitoring program has not detected any adverse shoreline changes on either Ocean Isle Beach or Holden Beach.

Since initial construction, Ocean Isle Beach has been nourished three times. Although the maintenance of this project was scheduled to be constructed on a 3-year cycle following the initial construction in 2001, the performance of the project was better than anticipated and allowed for a delay in the implementation of the first maintenance event (Ocean Isle Beach, NC Static Line Exception Progress Report, 2014). The first periodic maintenance operation was accomplished nearly six years after initial construction between December 2006 and January 2007 and involved both a Federal and a non-Federal component. The Federal component, which was completed in December 2006, placed 449,400 cubic yards of material between stations 10+00 and 72+00, while the non-Federal component, completed in January 2007, and placed 155,000 cubic yards between stations -3+00 and 17+00. The portion of the fill placed between stations 10+00 and -3+00, was estimated to be 115,000 cubic yards, and was outside the authorized limits of the Federal project and represented an attempt by the Town to address the chronic erosion with beach nourishment alone. While most portions of the federal project west of station 30+00 performed reasonably well following initial construction in 2001, project performance was not the only factor that postponed the first nourishment until 2006-2007. There were also federal and state funding issues and a poor dredging climate due to the impacts of 2004 hurricanes in the State of Florida that contributed to the schedule. The decision not to place additional sand east of station 10+00, which lies outside the authorized limits of the federal project, was a local decision based on the rapid loss of the fill placed in the area by the Town of Ocean Isle Beach in January 2007.

The second periodic nourishment operation occurred between April and May 2010 and involved the placement of 509,200 cubic yards of material with federal funds. The western 6,000 feet of the Federal project continues to perform very well and has not required periodic nourishment since construction in 2001. The Town did not attempt to place any additional fill east of station 10+00 during the 2010 operation due to poor performance of the fill placed east of station 10+00 in January 2007. As mentioned above, the Town placed 155,000 cubic yards of fill between baseline stations -3+00 and 17+00 in January 2007 and, as documented by beach profile surveys, essentially all of this material was lost by September 2007. This supplemental fill cost the Town $720,000 (including the cost of permitting). As a result, the Town determined continued nourishment of this portion of its shoreline was not an economical erosion response measure.

The third periodic nourishment operation for the Ocean Isle Beach storm damage reduction project was completed in April 2014 with the placement of approximately 800,000 cubic yards of material. The average amount of fill placed on Ocean Isle Beach to maintain the Federal project has been around 408,000 cubic yards every three years. The average distribution of the 408,000 cubic yards of material every three years along Ocean Isle Beach has been equivalent to the following:

Station 10+00 to 30+00	174,000 cubic yards
Station 30+00 to 60+00	177,000 cubic yards
Station 60+00 to 90+00	42,000 cubic yards
Station 90+00 to 120+00	15,000 cubic yards

The storm damage reduction project has performed well west of station 120+00 and has not required any nourishment since initial construction. With the completion of the first periodic nourishment operation in 2007, periodic nourishment of the project has been accomplished about every three years with nourishment concentrated in the project area east of baseline station 120+00.

In addition to the Federal storm damage reduction project, the USACE has periodically deposited material on the east end of Ocean Isle Beach from maintenance of the Atlantic Intracoastal Waterway (AIWW) at the intersection with Shallotte Inlet. An estimated 300,000 to 400,000 cubic yards of navigation maintenance material has been placed on the east end of Ocean Isle Beach since 2001. All of this material has been deposited generally within the area fronting the development east of Shallotte Boulevard (i.e., outside the limits of the Federal project). This material has eroded quickly and has been generally ineffective in slowing the rate of erosion in the area east of Shallotte Boulevard.

Additional erosion response measures undertaken by the Town on the east end include placement of a sandbag revetment along 1,400 feet of shoreline, beginning at a point west of Shallotte Boulevard and extending east to the end of development. This revetment was installed around 2005. In 2012, the sandbag revetment was extended 400 feet to the west, or just past Charlotte Street. Some of the recent sandbag placement was accomplished by NCDOT in an attempt to protect the eastern end of 2nd Street. The damage to the Town of Ocean Isle Beach has suffered since 2004 as a result of erosion on the east end, as well as the cost of erosion response measures are summarized in Table 3.1. In addition to the construction of the sandbag revetment, the Town placed 155,000 cubic yards of material one time between stations -3+00 and 17+00 in 2007 under CAMA permit #91-05. The area between 10+00 and 17+00 overlaps with the Federal project. Due to the failure of this locally funded nourishment project to provide any long-term shoreline protection along the east end of the island, the Town has opted not to attempt beach nourishment as a stand-alone project within this area again.

Individual property owners on the east end of Ocean Isle Beach have continued to experience damage despite erosion response measures undertaken by the Town and NC DOT. Since 2005, five (5) homes have been lost, and between 20 and 25 parcels have become unbuildable due to the inability to meet building setback requirements as dictated by the rules established by the NC Coastal Resources Commission (CRC). The estimated appraised value of the lost homes and parcels since 2005 totals approximately $1.6 million.

Table 3.1. Erosion damages and the cost of erosion response measures on the east end of Ocean Isle Beach since 2004.

Damages and Response Measures	Estimated Cost
Sandbags, demolition, clean-up, sand fences, public accesses, grassing	$1,025,800
Permits for beach fill, sandbags, fill dirt, & sewer line relocation	$720,000
Dune construction in 2007	$37,800
Repair beach accesses at Columbia, Shallotte, and Charlotte St. - 2007	$34,800
130 feet sandbags Shallotte Blvd. - 2008	$59,200
Beach fill on east end – January 2007	$721,600
Loss of 3011 feet sewer line and 10 manholes	$452,000
Relocate waterline and fire hydrant	$35,000
Loss of 3,000 feet of paved roads	$1,800,000
400-foot sandbag extension - 2012	$200,000
TOTAL	**$5,086,200**

Based on tax information available from the Brunswick County GIS, there are 155 parcels east of station 15+00 (located just west of Shallotte Boulevard) with a tax value of $2,000 or greater, 45 of which have homes. Parcels with values less than $2,000 are non-conforming (i.e., cannot meet existing NC DCM setback requirements) and are not included in the analysis. All of these parcels and homes are vulnerable to erosion damage over the next 30 years should the past erosion trends continue are shown on Figure 3.1. In addition, over 1,800 feet of roads and associated utilities could also be damaged or lost over this 30-year timeframe. Of the 45 homes at risk, 18 are considered to be located on the oceanfront row, 12 on the second row, and the remaining 15 farther back on the 3rd and 4th rows.

While Alternative 1 includes the future installation of sandbags to protect threatened structures and infrastructure, past experience has shown sandbags can only delay the shoreline retreat rather than permanently halt it. A good example of the extent to which sandbag structures have affected shoreline changes occurred between 2005 and 2008. In 2005, a sandbag revetment protected approximately four (4) homes east of Shallotte Boulevard. By 2008, the sandbag revetment had failed and the shoreline made an almost instantaneous correction by jumping back to a position it would have occupied had the sandbags never been installed (Appendix B). This instantaneous "shoreline correction" resulted in the loss of four (4) homes directly east of Shallotte Boulevard. This type of shoreline/sandbag behavior is expected to continue (i.e., when homes or infrastructure become threatened, sandbags will be installed); however, within about 3 to 5 years following their installation, the sandbags will likely fail and the new shoreline will be established landward of the sandbags in a position it would have occupied had the bags never been in place.

The evaluation of the economic consequences for Alternative 1, which is discussed in detail in the Engineering Appendix (Appendix B), assumed the shoreline would move landward in 5-year increments with sandbags being installed every 5 years to delay the retreat of the shoreline. At the end of each 5-year increment, the sandbag revetments were assumed to fail and the shoreline would move to a new position based on the historic shoreline change rate that would have occurred in the absence of the sandbags. Future shoreline (scarp) positions over the next 30-

years, assuming past erosion trends and past erosion response measures continue, are shown in Figure 3.1. The shoreline (scarp) positions are shown in 5-year increments.

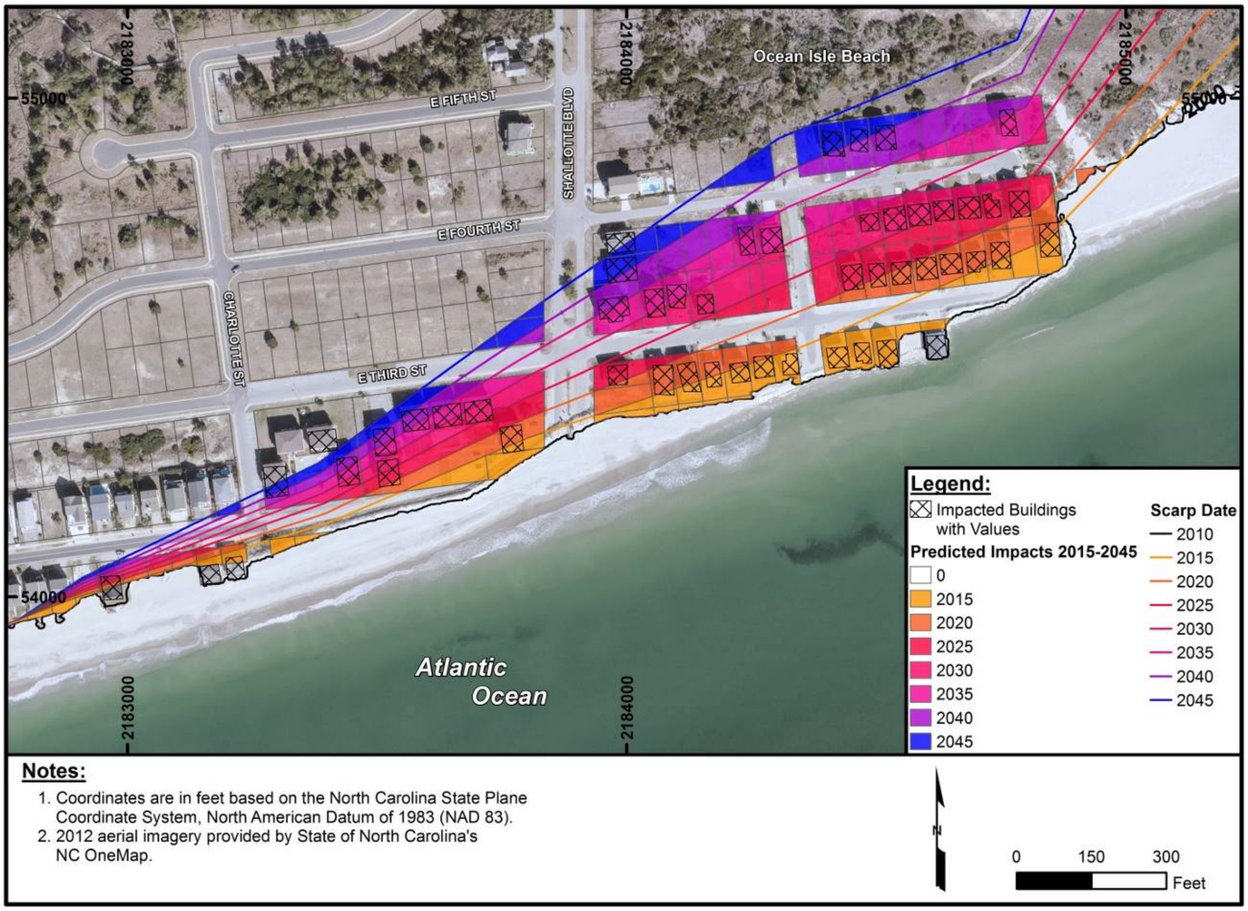


Figure 3.1. Future Scarp Line Positions under Alternative 1 - Current Management Practices.

Under Alternative 1, when homes become threatened, the individual property owners would need to either abandon the structure or move it to another location on Ocean Isle Beach, if possible. These are individual decisions and cannot be predicted with any degree of certainty. Also, should a property owner decide to move the structure, owners of vacant lots on Ocean Isle would have to be willing to sell. Again, this is something that cannot be determined.

Based on actual experience since 2001, two (2) homes have been relocated while four (4) threatened homes were demolished. This ratio of one-third relocated to two-thirds demolished was used in the assessment of the economic impact associated with Alternative 1. The direct cost to demolish a structure was computed as $15/square foot while relocation costs were computed at $50/square foot plus $50,000 for new foundation piles, utilities, driveways, permits, etc. Installation of temporary sandbag revetments would cost $500/linear foot.

The dollar value of damages to roads and associated utilities was based on replacement costs as a proxy since replacement would not be an option once erosion has overtaken the road. A summary of the implementation cost for Alternative 1 is provided below with more details given in Chapter 5.

<u>30-Year Cost – Alternative 1</u>

Under Alternative 1, a total of 45 houses would be impacted by erosion trends within the next 30 years. The economic impact of the damage was calculated at approximately $3.18 million for the cost of relocating or demolishing threatened structures, $2.89 million for the value of structures that would be demolished, and $21.36 million for the loss of approximately 155 parcels. The value of homes that were assumed to be moved to another lot totaled about $1.30 million. The relocated homes were assumed to maintain their tax value, however the lots on which they were located would eventually be lost to erosion. In addition, damages to roads and utilities would total $2.29 million, with the cost of installing temporary sandbag revetments equal to $5.40 million. The damages and erosion response costs over the next 30 years would total approximately $35.11 million. Approximately 32% of the total damages would occur within the first ten years of the 30-year planning period.

The Town of Ocean Isle Beach would continue to participate in the Federal storm damage reduction project under Alternative 1. Assuming each three-year periodic nourishment operation provides an average of 408,000 cubic yards of material, the cost for future periodic nourishment would be around $6,644,000. Based on the existing Project Cooperation Agreement with the Federal Government, the Federal share of the cost for each periodic nourishment operation would be 65% or $4,320,000 with the non-Federal share equal to $2,324,000 or 35%. Over the 30-year planning period, the total cost for periodic nourishment of the Federal project would be $66.44 million with the Federal government share equal to $43.19 million and the non-Federal share equal to $23.25 million.

The cost for periodic nourishment of the Federal project is included in the 30-year costs for Alternative 1 due to the impact of some of the other alternatives on future nourishment cost. Thus, the total economic cost for Alternative 1 over the 30-year planning period, including the cost for periodic nourishment of the Federal storm damage reduction project, is $101.55 million.

<u>Equivalent Average Annual Cost – Alternative 1</u>

A comparison of the equivalent average annual costs for all of the alternatives evaluated is provided in Table 3.12 at the end of this Chapter. The equivalent average annual costs were computed over the 30-year planning period using a discount rate of 4.125%. The equivalent average annual cost is a convenient means of comparing costs of various actions associated with each management alternative that would be implemented at different times during the analysis period. One way to interpret the equivalent average annual cost is to consider the amount of money one would have to invest each year at a given interest rate in order to pay for the estimated 30-year cost of the alternative.

The equivalent average annual cost for Alternative 1 is $3,173,000.

Alternative 2: Abandon/Retreat

Description

For Alternative 2, the Town of Ocean Isle Beach, NCDOT, and the individual property owners would not take any action to slow erosion in the area east of Shallotte Boulevard to Shallotte Inlet. This includes installation of new sandbags, beach scraping/bulldozing, or intermittent beach nourishment projects described above in Alternative 1. Also, the Town of Ocean Isle Beach would not make any effort to pursue a long-term beach nourishment project or inlet channel relocation project aimed at addressing the east end erosion problem. Periodic nourishment of the federal storm damage reduction project would continue with an average of 408,000 cubic yards of material being placed on Ocean Isle Beach between baseline stations 10+00 (Shallotte Boulevard) and 120+00. Periodic nourishment would also occur between baseline stations 120+00 and 181+00 (west end of the federal project) on an as needed basis.

Once the existing temporary sandbag revetments on the east end of the island fail or have to be removed upon reaching the end of their permit period, the affected structures would either be abandoned (demolished) or moved to another lot on the island. The shoreline retreat scenario for Alternative 2 assumed the existing 1,800-foot sandbag revetment on the east end of the island would fail and the shoreline would move to a position it would have occupied in 2015 had the sandbags not been present. At this time, however, the sandbag revetments remain in place. Following the failure of the sandbag revetment, the shoreline would migrate at historic rates, measured for each profile on the east end of the island (Appendix B) for at least the next 30 years.

Under this scenario, potential damages would begin in the Year 2015 and would continue uniformly until the Year 2045. Future damages were based on the scarp migration rates provided in Table 4.1 of Appendix B with damages to homes and parcels determined on yearly basis rather than every 5 years as was the case for Alternative 1. Homes would be considered impacted once the scarp line reaches the front of the structure, and parcel values would decrease to zero whenever one-half of the parcel is lost. Given this shoreline retreat scenario, the same homes and infrastructure damaged under Alternative 1 (Figure 3.1) would also be damaged under Alternative 2. The main difference in the economic impact would be the timing as to when individual homes and infrastructure would be damaged or lost. Again, under Alternative 2, losses would occur in every year throughout the 30-year analysis period rather than in 5-year increments as under Alternative 1 as sandbag revetments would not be used to provide temporary erosion protection in Alternative 2.

30-Year Cost – Alternative 2

The total cost of damages and erosion response measures over the 30-year planning period would be $29.71 million which is $5.40 million less than Alternative 1 due to eliminating the use of sandbags. As is the case for Alternative 1, the total 30-year cost under Alternative 2 includes the cost for continued nourishment of the federal storm damage reduction project over the next 30 years. Adding beach nourishment costs to the projected damages results in a total 30-year cost of $96.15 million for Alternative 2.

Equivalent Average Annual Cost – Alternative 2
The equivalent average annual cost for Alternative 2 is $3,084,000.

Alternative 3: Beach Fill Only (Including Federal Project)

Description
Under Alternative 3, a private (non-Federal) beach nourishment activity would occur every two years over a 3,500-foot section of Ocean Isle Beach's oceanfront shoreline. The 3,500-foot section proposed for nourishment would occur on the east end of Ocean Isle Beach situated between baseline station -5+00 (500 feet east of the end of development) and station 30+00 (located just west of Lumberton Street). This particular area is highly influenced by littoral process in and around Shallotte Inlet as discussed in Chapter 1. The beach fill only alternative overlaps 2,000 feet of the Federal project (i.e., between stations 10+00 and 30+00). A schematic of the beach fill for Alternative 3 is provided in Figure 3.2. Note that the beach fill placed under Alternative 3 would be in addition to the fill normally placed during periodic nourishment operations for the Federal storm damage reduction project.

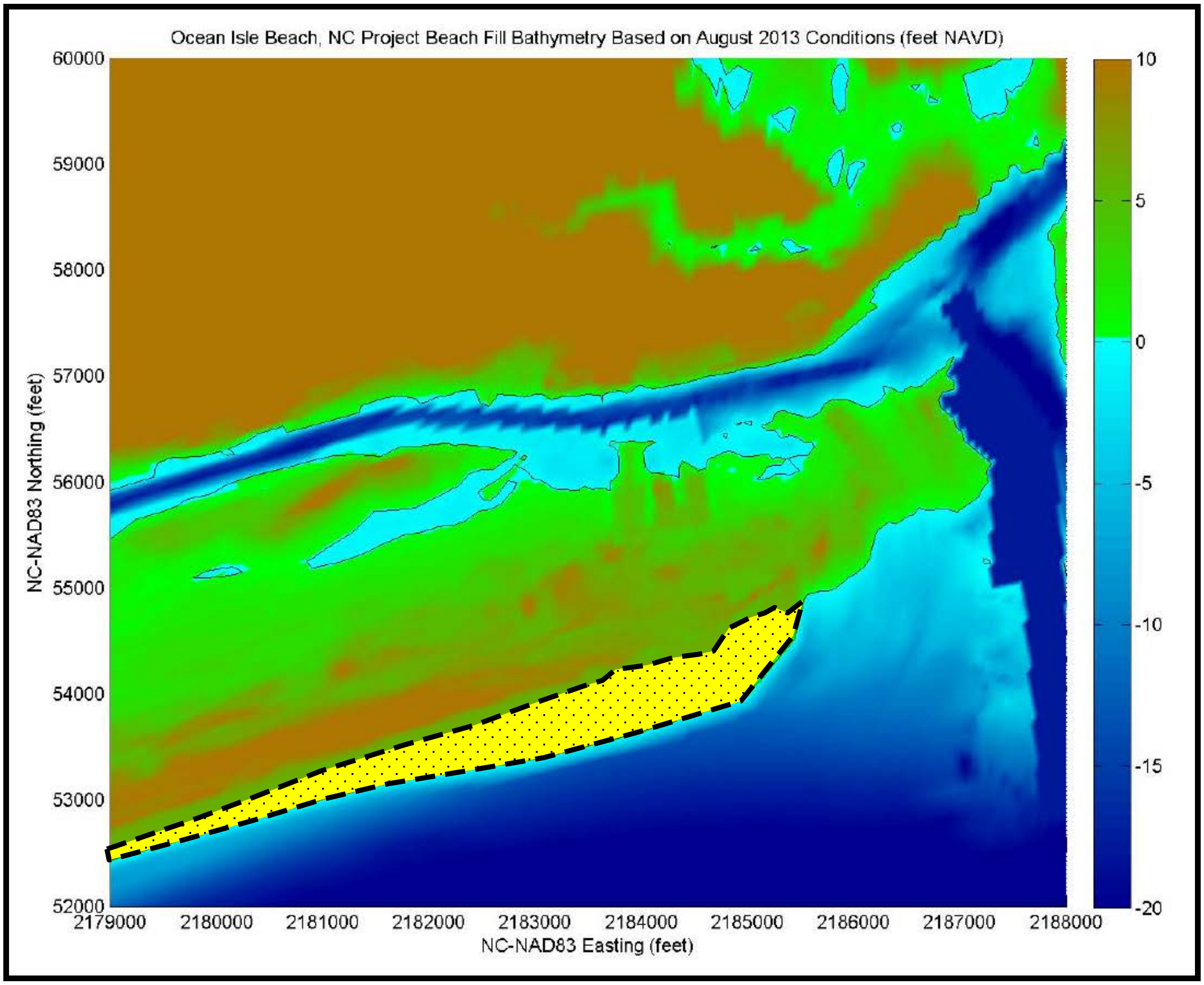


Figure 3.2. Beach Fill Only to include Federal Project – Alternative 3.

Details of the formulation of the beach fill only alternative are provided in Appendix B. Based on a Delft3D model assessment of beach fill performance on the east end of Ocean Isle Beach, volumetric losses from a beach fill placed east of baseline station 30+00 would be expected to erode at a rate of 140,000 cubic yards/year. Of this total, 58,000 cubic yards/year is attributable to the Federal project and the balance of 82,000 cubic yards/year associated with the performance of the beach fill under Alternative 3. For the shoreline segment situated between baseline stations 30+00 and 120+00, the model assessment for Alternative 3 did not indicate any change from existing conditions. Volume losses from the area west of station 30+00 have averaged 78,000 cubic yards/year. Thus, if Alternative 3 is implemented, the total periodic nourishment requirement for the area extending from station -5+00 to station 120+00, which includes both the federal project and the local beach fill project, would average 218,000 cubic yards/year. Providing the additional nourishment attributed to the Alternative 3 fill, which is estimated to be 82,000 cubic yards/year, would be a non-federal responsibility.

The assessment of all the alternatives that involve beach nourishment assumed the maximum volume of material that would be placed on Ocean Isle Beach during any one periodic nourishment operation would be limited to a maximum volume of approximately 408,000 cubic yards. This is the same as the average volume placed on Ocean Isle Beach every three years to maintain the federal storm damage reduction project. The establishment of this 408,000 cubic maximum per nourishment operation provides an equitable way to compare the impacts and cost of each alternative.

A two-year nourishment cycle may not be practicable given the existing three-year nourishment cycle established for the federal project. In this regard, the federal budgetary process normally involves estimates of future funding requirements two years in advance of the fiscal year funds being requested. Also, the economic justification for the federal project was based on the three-year cycle. Decreasing the nourishment interval to two years would increase the cost of the federal project by imposing additional mobilization and demobilization costs compared to the three-year cycle. Modification of the nourishment cycle would also require a reassessment of the benefits and costs of the federal project.

With the estimated periodic nourishment requirement for Alternative 3 equal to 218,000 cubic yards/year and an assumed 408,000 cubic yards maximum per nourishment operation, nourishment of Ocean Isle Beach under Alternative 3 would be needed every 1.9 years. However, a more practical periodic nourishment interval of 2 years was adopted for Alternative 3 by relaxing the 408,000 cubic yard maximum slightly. Using this adjustment, periodic nourishment of Ocean Isle Beach under Alternative 3 would involve the placement of 436,000 cubic yards between stations -5+00 and 120+00 every 2 years.

The initial design for the Alternative 3 beach fill included an average beach width of 30 feet between baseline stations -5+00 and 30+00 with 500-foot transitions or taper sections on each end of the fill. Construction of the 30-foot wide beach fill would require 107,000 cubic yards. With periodic nourishment planned every two years, an advanced nourishment volume of 280,000 cubic yards would also be placed within these fill limits resulting in a total initial fill volume for

Alternative 3 of 387,000 cubic yards. Note that this volume of fill would be in addition to the fill normally placed in this area to maintain the Federal storm damage reduction project.

The width of the design beach fill and the density of fill placement between each baseline station on the east end of Ocean Isle Beach for Alternative 3 are listed in Table 3.2.

Table 3.2. Design beach fill widths and fill densities for Alternative 3 – Beach Fill Only

Baseline Stations	Type of Fill	Design Fill Width (ft)	Fill Density (cy/lf)
-10+00 to -5+00	Transition	0 to 76	0 to 85
-5+00 to 0+00	Main Fill	76 to 151	85 to 170
0+00 to 5+00	Main Fill	151 to 133	170 to 150
5+00 to 10+00	Main Fill	133 to 107	150 to 120
10+00 to 15+00	Main Fill	107 to 89	120 to 100
15+00 to 20+00	Main Fill	89 to 66	100 to 75
20+00 to 25+00	Main Fill	66 to 44	75 to 50
25+00 to 30+00	Main Fill	44 to 21	50 to 24
30+00 to 35+00	Transition	21 to 0	24 to 0

<u>30-Year Cost – Alternative 3</u>
The long-term erosion damage that could occur to existing development on the east end of Ocean Isle Beach would be prevented under Alternative 3. The initial placement of 387,000 cubic yards east of baseline station 30+00 to construct the beach for Alternative 3 was assumed to take place during a normal periodic nourishment cycle for the Federal project. Based on this assumption, and the actual experience of placing the additional fill on the east end during the 2006-07 nourishment operation, the cost for the 387,000 cubic yards of material was based on the dredging cost (i.e., there would not be any additional mobilization and demobilization costs for the added fill).

The economic costs for Alternative 3 would be associated with providing the necessary volume of material to offset these future erosion threats. The total 30-year cost for Alternative 3, which includes continued nourishment of the Federal storm damage reduction project, is estimated to be $108.77 million.

The Federal government would presumably continue to provide its share of the cost for periodic nourishment of the Federal project but would not participate in the additional nourishment costs associated with Alternative 3. Therefore, the Federal share of the 30-year project costs under Alternative 3 would be equal to that of Alternatives 1 and 2 ($43.19 million with the balance of $65.58 million the responsibility of non-Federal interests). Under this assumed cost sharing arrangement, the Federal share of future periodic nourishment costs along Ocean Isle Beach under Alternative 3 would be about 39.7% (=$43.19/$108.77) with the non-Federal share equal to 60.3%.

<u>Equivalent Average Annual Cost – Alternative 3</u>
The equivalent average annual cost for Alternative 3 is $3,646,000.

Alternative 4: Shallotte Inlet Bar Channel Realignment with Beach Fill (Including Federal Project)

Description

Under Alternative 4, the Town of Ocean Isle Beach will request that the Federal project dredging scheme employed by the USACE be modified to concentrate sediment removal for periodic nourishment from the same general footprint used by the USACE during initial construction of the federal storm damage reduction project in the Shallotte Inlet borrow area. However, if the USACE does not agree that their dredging should be in accordance with the proposed dredging scheme, the Town would have the option of conducting additional dredging themselves, or compensating the USACE for any additional costs, if any, to dredge in accordance with the proposed dredging scheme. The plan formulation for the Federal storm damage reduction project included an assessment of the impacts the orientation and position of the main channel crossing the ocean bar of Shallotte Inlet had on the east end of Ocean Isle Beach. The USACE concluded that when the channel was positioned approximately midway between the west end of Holden Beach and the east end of Ocean Isle Beach and oriented generally perpendicular to the adjacent shorelines, the east end of Ocean Isle Beach had a tendency to accrete. This condition was noted in historical aerial photographs of the inlet between 1954 and 1965 (Appendix B).

. Between March and May 2001, the USACE included a deeper-wider channel through Shallotte Inlet as a borrow source for initial construction and periodic beach nourishment and removed 1,866,000 cubic yards from Shallotte Inlet to construct the Federal storm damage reduction project along 17,100 feet of shoreline beginning at Shallotte Boulevard and extending west to a point approximately 3,700 feet west of the Ocean Isle Beach Pier & Arcade.

As discussed in Appendix B, the relatively wide expanse of the borrow area shown in the after dredging survey on Figure 4.4 in Appendix B, did not concentrate flow in any one channel across the ocean bar. The result was rapid shoaling of the borrow area primarily from the west side which concentrated ebb flow, and hence the main ebb channel, on the east side of the inlet just off the west end of Holden Beach. During the subsequent periodic nourishment operations completed to date, the borrow area was merely dredged to obtain the volume of material needed for the storm damage reduction project rather than maintaining the channel in a fixed location. Since the dredging operations did not attempt to remove material from a preferred channel alignment, the main flow channel of Shallotte Inlet continued to concentrate more toward the east side of the inlet.

If an inlet channel is relocated for the purpose of effecting shoreline changes on either side of the inlet, the channel must be maintained in the preferred position and alignment. Since this has not been the case, Alternative 4 would modify the dredging scheme to concentrate sediment removal for periodic nourishment along a channel that would be confined within the footprint of the borrow area that was used by the USACE for initial construction of the Ocean Isle Beach federal storm damage reduction project. i.e., the confined channel would only use a portion of the footprint of the initial USACE borrow area. The dredge cut during each dredging operation would extend across the ocean bar and merge with the existing -17.9 foot NAVD depth contour in the ocean in order to encourage flow to move through the dredged channel. By continuing to use the same cut area for each nourishment operation, the borrow area should eventually become the dominant flow path for waters exiting through the inlet. Over time, the inlet should respond to the new "permanent" channel position and alignment with a wholesale shift in the ebb tide delta to the west resulting in the accumulation of sediment on the west side of the ebb tide delta. As a result of the reconfiguration of the ebb tide delta, the shoreline on the east end of Ocean Isle Beach should respond in much the same manner as was observed between 1954 and 1965 during which time the east end of the island accreted.

The initial beach fill for Alternative 4 would be the same as that described for Alternative 3 involving the placement of 387,000 cubic yards between baseline stations -5+00 and 30+00. Again, the 387,000 cubic yard beach fill would be in addition to the volume of material normally placed on Ocean Isle Beach during periodic nourishment of the Federal project.

To make the borrow area in Shallotte Inlet function as a true channel relocation, material removed during periodic nourishment operations would be derived from the same general area as used for initial construction of the federal storm damage reduction project. By continuing to use the same general cut area for each nourishment operation, the borrow area should eventually become the dominant flow path for waters exiting through the inlet. Over time, the inlet should respond to the new "permanent" channel position and alignment with a wholesale shift in the ebb tide delta to the west resulting in the accumulation of sediment on the west side of the ebb tide delta. As a result of the reconfiguration of the ebb tide delta, the shoreline on the east end of Ocean Isle Beach should respond in much the same manner as was observed between 1954 and 1965.

The evaluation of the impacts of repetitive channel relocations within the same general footprint as used during initial construction of the federal storm damage reduction project were simulated in the Delft3D model by re-dredging the channel/borrow area using the bathymetry at the end of the three-year simulation for Alternative 1 as the starting point. The "re-dredging" of the channel/borrow area simulated the same dimensions of the channel as that created during initial construction of the federal project. The results of the model simulations over the ensuing three-year period following the channel/borrow area re-dredging is provided in detail in Appendix B.

Following the re-dredging of the channel/borrow area in Year 3, average annual volumetric losses over the next three-year simulation from the shoreline segments along the east end of Ocean Isle Beach relative to the losses under Alternative 3 were 65% for the segment between -5+00 and 30+00 with losses from the other three segments west of station 30+00 equal to 63%, 89%, and 44%, respectively, relative to the losses under Alternative 3. Applying these relative volume changes to the volume changes for Alternative 3 and imposing the maximum volume of 408,000 cubic yards per operation for each nourishment episode results in the projected periodic nourishment requirements provided in Table 3.3 for Alternative 4 over the 30-year planning period.

Table 3.3. Periodic nourishment volumes under Alternative 4.

Project Year	Operation Description	Nourishment Volume (cubic yards)[1]
0	Initial beach fill for Alternative 4	387,000
2	First periodic nourishment	384,000
5	Second periodic nourishment	381,000
9	Third periodic nourishment	336,000
13	Fourth periodic nourishment	336,000
17	Fifth periodic nourishment	336,000
21	Sixth periodic nourishment	336,000
25	Seventh periodic nourishment	336,000
29	Eight periodic nourishment	336,000

[1]Nourishment operations limited to maximum fill volume of 408,000 cubic yards per operation.

<u>30-Year Cost – Alternative 4</u>
Alternative 4 would prevent long-term erosion damage to development along the east end of Ocean Isle Beach in the area east of baseline station 30+00.

Over the 30-year planning period, providing the periodic nourishment volumes along Ocean Isle Beach would cost a total of $53.15 million. The Federal government should continue to participate in periodic nourishment of the federal storm damage reduction project, contributing 65% of the cost for providing beach fill within the authorized Federal limits. Based on the projected decrease in periodic nourishment of the federal storm damage reduction project as presented in Table 3.3 and adjusting for fill that would be placed outside the limits of the federal project, the Federal share over the 30-year planning period would be $30.89 million (58.1%) leaving a balance of $22.26 million (41.9%) for non-Federal interests.

<u>Equivalent Average Annual Cost – Alternative 4</u>
The equivalent average annual cost for Alternative 4 is $1,920,000.

Alternative 5: Terminal Groin with Beach Fill (Including Federal Project)/Applicant's Preferred Alternative

<u>Description</u>
Under Alternative 5, the applicant's preferred alternative, a 750-foot terminal groin with beach fill would be constructed 148 feet east of baseline station 0+00. This structure is intended to provide shoreline stabilization and would serve to reduce the erosion rate further west, thereby reducing the nourishment interval of the Federal project from every 3 years to every 5 years and relieve the necessity of sandbag revetments within the project area. Dredged material would be obtained from Shallotte Inlet within the limits of the borrow area used for the Federal project. The initial fillet construction would be completed and maintained by the Town of Ocean Isle Beach. The purpose of a terminal groin on the east end of Ocean Isle Beach would be to create a permanent accretion fillet west of the structure. This would be accomplished by controlling tide induced or influenced sediment transport off the extreme east end of the island. The resulting position and alignment of the shoreline within the accretion fillet would mimic that of the shoreline immediately to the west. Once the accretion fillet is fully formed, wave driven

sediment transport will move either through, over, or around the seaward end of the structure. The elimination or reduction in tide induced sediment transport off the extreme east end of the island should improve the performance and longevity of beach fill placed east of Shallotte Boulevard as well as the performance of a portion of the federal storm damage reduction project that extends west of Shallotte Boulevard. Since wave induced sediment transport (i.e., littoral sand transport) would still be in play, erosion will continue to be a management issue for the shorelines lying outside the direct influence of the terminal groin and for the shoreline directly west of the structure. The shoreline adjacent to the east and in proximity to the proposed terminal groin would, however, be relatively stabilized due to the protection afforded by the structure.

The design objective for the terminal groin alternative was to minimize the combined cost associated with construction and maintenance of the terminal groin and nourishment of the Ocean Isle Beach west to USACE baseline station 120+00. This optimization process involved the evaluation of three terminal groins each of which would begin at a point 450 feet landward of the baseline and extend 300 feet seaward as a sheet pile shore anchorage section. The discussion regarding the various terminal groin lengths was included in this EIS to demonstrate the formulation of the preferred alternative as it relates to the optimal length of the terminal groin. From the seaward end of the shore anchorage section the remaining length of the terminal groins would be constructed as a rubblemound with the lengths of the rubblemound sections being 250 feet, 500 feet, and 750 feet. The three terminal groin lengths evaluated are referred to as the 250-foot, 500-foot, and 750-foot terminal groins in this document. The crest of the 250-foot terminal groin would terminate approximately 100 feet seaward of the baseline, the 500-foot terminal groin would terminate 350 feet seaward of the baseline, and the 750-foot terminal groin would terminate 600 feet from the baseline. The head of the terminal groins would be constructed with a slope of 1V:3H which, depending on profile depths at the end of the structure during the time of construction, could add approximately 35 feet to the total length of the 250-foot terminal groin, 40 feet to the 500-foot terminal groin, and 50 feet to the 750-foot terminal groin. Plan views of the three (3) terminal groin options are shown in Figures 3.3a to 3.3c.

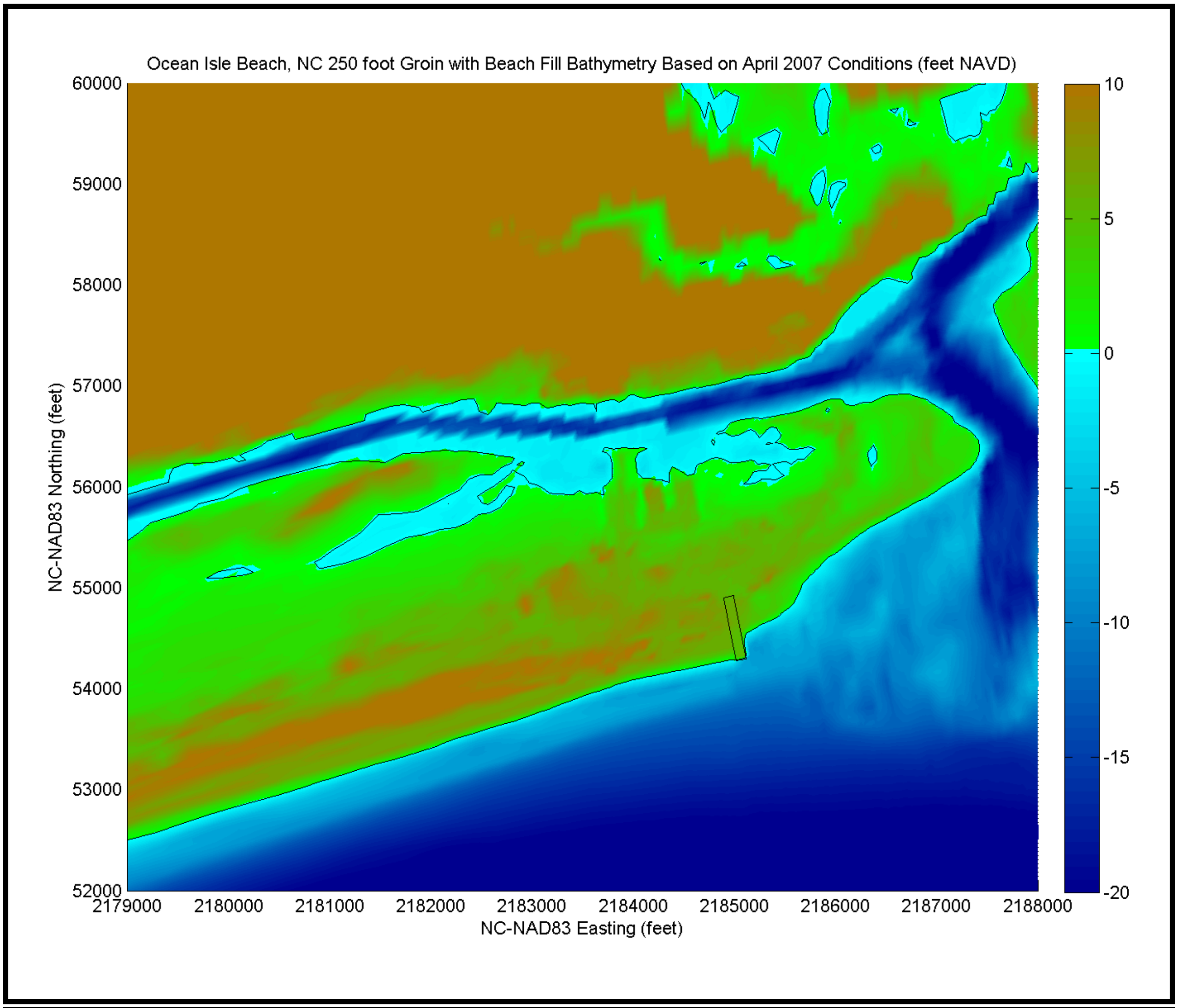


Figure 3.3a. Schematic 250-foot terminal groin.

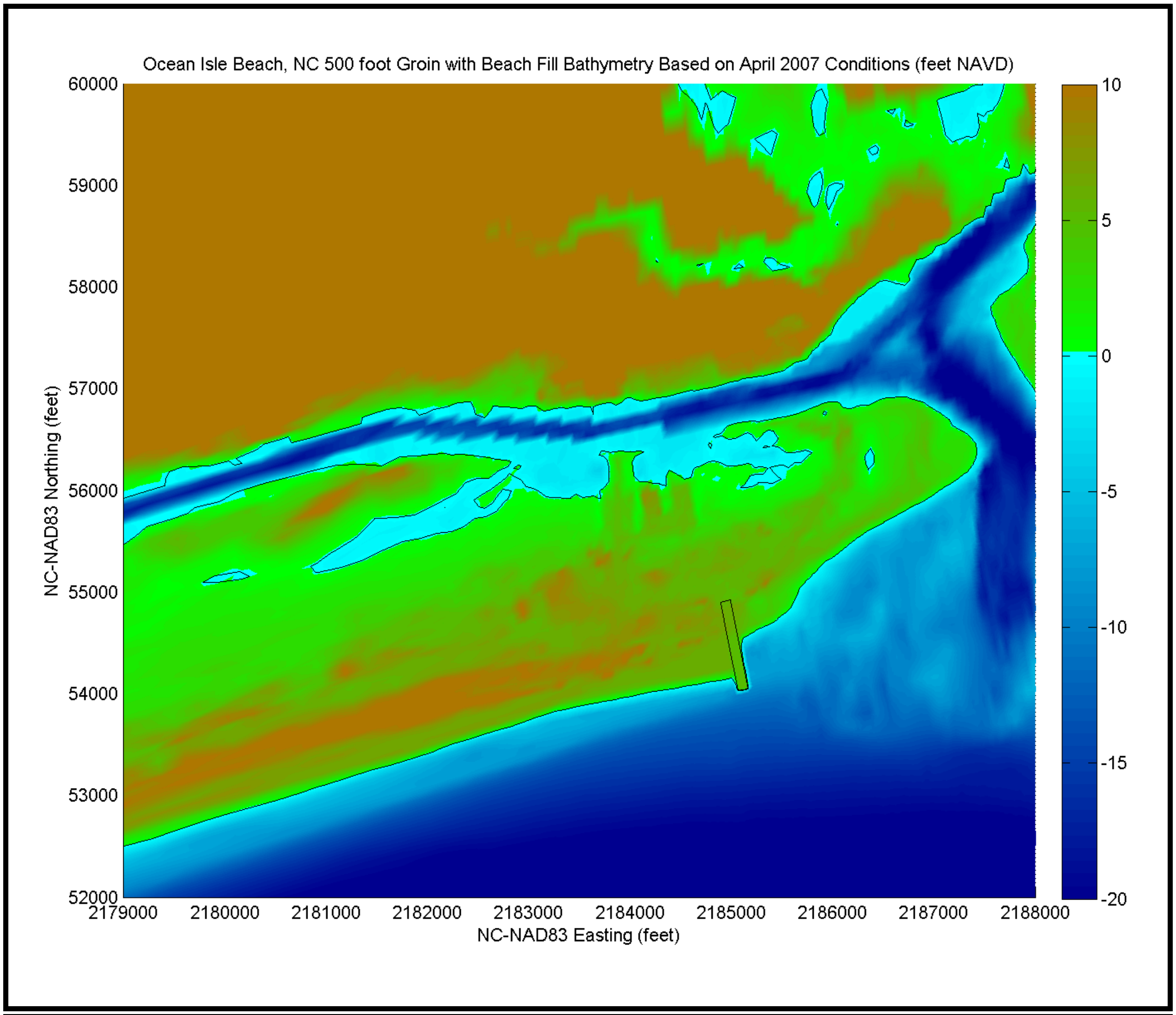


Figure 3.3b. Schematic 500-foot terminal groin.

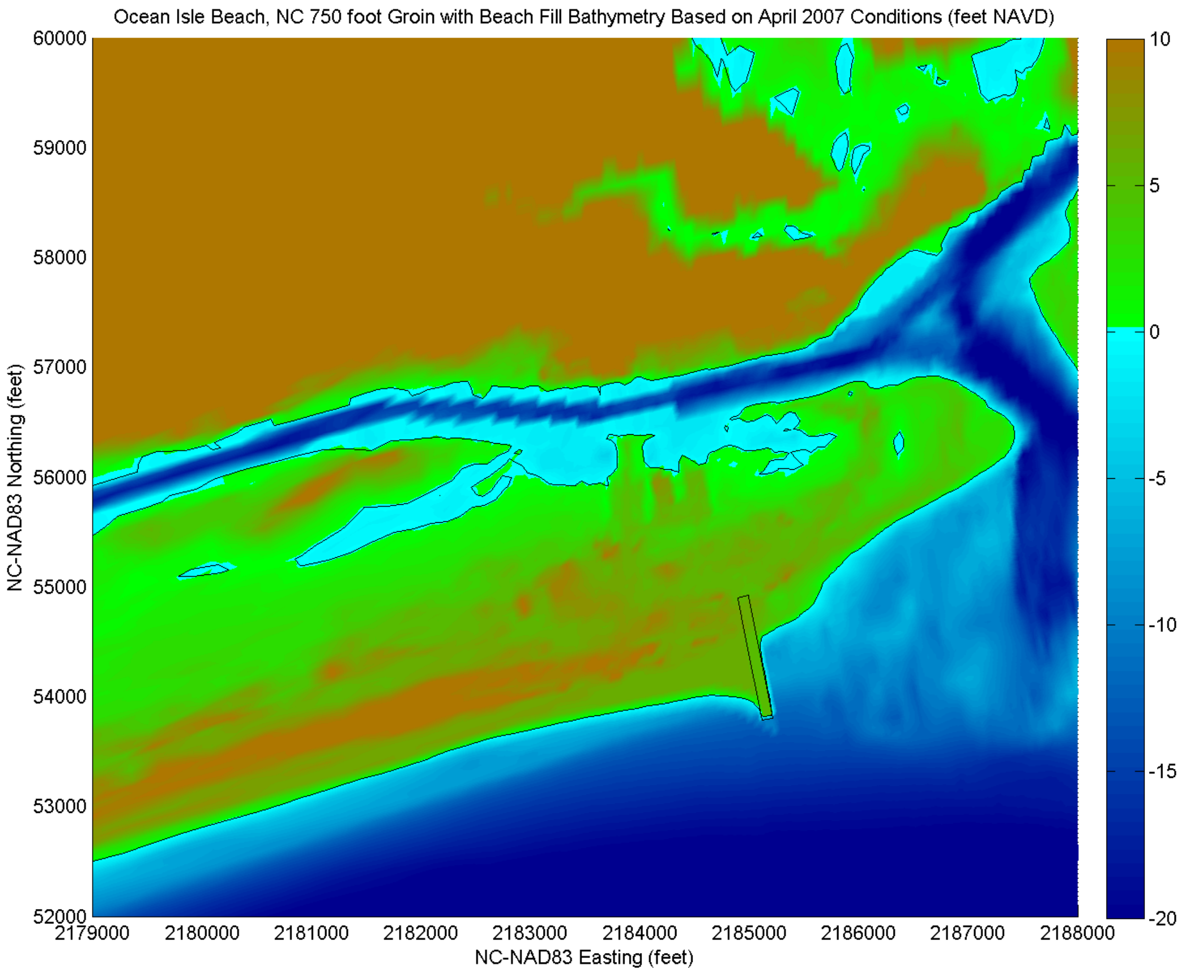


Figure 3.3c. Schematic 750-foot terminal groin.

The tool used to assess the impacts of the proposed terminal groins was the Delft3D model, a description of which is provided in Appendix B. The Delft3D model was calibrated and verified using 2007 conditions in Shallotte Inlet and along the adjacent shorelines. The simulation of the terminal groin options also used the 2007 initial conditions as a starting point with the only difference in the model setup between Alternative 1 and the three (3) terminal groin options were the terminal groins and the associated beach fills to pre-fill the area immediately west of the structures. That is, the inlet hydrography and offshore hydrography as well as the model forcing functions (waves, tides, winds, etc.) were all the same in each of the model simulations. Therefore, differences in the response of the model relative to Alternative 1 could be attributed to the structures and their accompanying beach fill.

The structures were positioned 148 feet east of baseline station 0+00 and each were tied to the upland with a 300-foot long shore anchorage section extending landward of the rubblemound portion of the structure. As shown in Appendix B, the landward end of the shore anchorage section would be well landward of the historic shoreline positions in this area. The shore anchorage section of each terminal groin option would be constructed with sheet piles (either steel or concrete) while the seaward portions would be constructed using stones. The stone or rubblemound portion of the structures would have a crest elevation of +4.9 feet NAVD to allow sediment to pass over the top of the structures during periods of high tide. The stone structures would also be constructed with relatively large voids between the stones to facilitate sediment movement through the structures. Preliminary design details for the terminal groin options are provided in Appendix B.

The beach fill needed to pre-fill the area west of the structures, generally referred to as the accretion fillet, varied due to the different seaward projection of the structures. This fillet would most likely be filled in conjunction with the Federal Project. Characteristics of the beach fills for the three (3) terminal groin options are provided in Table 3.4.

Table 3.4. Fillet beach fills for the three terminal groin options

Terminal Groin Option	Fill Length (ft.)(1)	Fill Volume (cy)(2)
250-ft	1,693	87,000
500-ft	2,194	185,000
750-ft	3,214	264,000

(1)Measured west of terminal groin
(2)Volume needed to pre-fill the accretion fillet

Summary of Model Results

The evaluation of the model results for the terminal groin options focused on changes in volumetric erosion rates on the east end of Ocean Isle Beach and the potential changes along the sand spit lying east of the terminal groins. The model was also used to assess potential changes in shoreline behavior on the west end of Holden Beach that could be associated with the installation of a terminal groin on the east end of Ocean Isle Beach. All of the model simulations, including that for Alternative 1, resulted in significant accretion seaward of the -6-foot depth contour off the east end of Ocean Isle Beach due to the bar channel of Shallotte Inlet assuming a southwesterly orientation. Since this response was not related to the terminal groins, the evaluation of the model results for the terminal groin options focused on model indicated volume changes landward of the -6-foot NAVD contour for both the terminal groin options and Alternative 1.

In general, the model results for the three terminal groin options above the -6-foot depth contour were the same west of station 30+00 on Ocean Isle Beach, indicating that none of the terminal groin options would impact volume changes between stations 30+00 and 120+00. On the Holden Beach side of Shallotte Inlet, the model indicated that volume changes above the -6-foot NAVD depth contour between stations HB 385 and HB 345 were virtually the same for Alternative 1 and the three terminal groin options evaluated (Table 3.5). For example, the model indicated a loss of 134,000 cubic yards/year above the -6-foot NAVD depth contour between HB 385 and HB 345 for Alternative 1. For the three terminal groin options, the model volume changes over this same area above the -6-foot NAVD depth contour were -34,200 cubic yards/year, -31,000 cubic yards/year, and -34,500 cubic yards/year for the 250-foot, 500-foot, and 750-foot terminal groins, respectively. The slight difference in the model indicated results are well within the accuracy of the model, therefore, the model results reflect no difference in the response on the west end of Holden Beach compared to Alternative 1.

Table 3.5. Delft3D model volume changes landward of the -6-foot NAVD contour on the east end of Ocean Isle Beach and the west end of Holden Beach for Alternative 1 and the three terminal groin options.

Baseline Station ID	Length (ft)	Volume Change for Alternative:			
		1: No Action	250-ft TG	500-ft TG	750-TG
Ocean Isle Beach					
-20 to -30	992	-1,500	31,300	24,700	7,400
-5 to -20	2,384	-11,000	-31,300	-53,300	-49,900
Groin to OI 0	148	-1,600	10,900	21,300	33,300
OI 0 to OI 5	545	-8,500	22,000	56,300	75,900
OI 5 to OI 10	577	-13,000	-1,300	31,600	48,200
OI 10 to OI 15	423	-9,300	-8,200	10,300	22,700
OI 15 to OI 20	501	-13,500	-13,500	-1,300	13,100
OI 20 to OI 25	499	-16,500	-14,700	-8,700	-400
OI 25 to OI 30	521	-10,900	-12,300	-7,700	-3,000
Total (Groin to OI 30)	**3,214**	**-73,300**	**-17,100**	**101,800**	**189,800**
Annual Rate (Groin to OI 30)		**-24,000**	**-6,000**	**+34,000**	**+63,000**
Holden Beach					
HB 385 to HB 345	**4,740**	**-34,000**	**-34,200**	**-31,000**	**-34,500**

Model indicated volume changes out to the -18-foot NAVD depth contour in this same area of Holden Beach were of the same order of magnitude for Alternative 1 and the three terminal groin options. For Alternative 1, the model volume change out to the -18-foot NAVD depth contour was -46,000 cubic yards/year while the model indicated volume changes for the 250-foot, 500-foot, and 750-foot terminal groins were -51,000 cubic yards/year, -58,000 cubic yards/year, and -62,000 cubic yards/year, respectively. It should be noted that modeled elevation changes have an accuracy of +/- 0.2 feet and therefore the margin of error for the modeled volume changes would depend on the size of the area being evaluated.

For the 250-foot structure, the model indicated a relatively stable beach would be created for a distance of about 700 feet west of the structure with some significant reduction in volumetric erosion rates over an additional 1,000 feet (to approximately station 17+00). For the 500-foot terminal groin, the model indicated a stable beach west to station 15+00 with some significant reduction in volume losses from stations 15+00 to 30+00 relative to Alternative 1. Similarly, the 750-foot terminal groin would essentially stabilize the shoreline west to station 20+00 and significantly reduce volume losses west to station 30+00.

The model results of volume changes above the -6-foot NAVD depth contour measured between the terminal groins and station 30+00 indicate the volumetric erosion rates and hence the periodic nourishment requirements in this area would be reduced by 29.2% for the 250-foot terminal groin and by 75.0% and 95.8% for the 500-foot and 750-foot terminal groins, respectively (Table 4.13 within Section 4 of Appendix B). Applying these reduced nourishment requirements for the beach segment between the terminal groin and station 30+00, which in the past has averaged 174,000 cubic yards every three years, results in the total three-year nourishment requirement for each terminal groin option given in Table 3.5. Note the three-year nourishment requirements for the portion of the Federal project west of station 30+00 given in Table 3.6 are the same as under existing conditions.

Table 3.6. Estimated three-year nourishment requirement for terminal groin options

Terminal Groin Option	Three-year nourishment requirement between stations:				Total 3-yr nourishment
	Groin to 30+00	30+00 to 60+00	60+00 to 90+00	90+00 to 120+00	
250-foot	123,000	177,000	42,000	15,000	**357,000**
500-foot	45,000	177,000	42,000	15,000	**279,000**
750-foot	6,000	177,000	42,000	15,000	**240,000**

The reduction in periodic nourishment requirements, particularly for the 500-foot and 750-foot terminal groin options, provides an opportunity to increase the time interval between nourishment operations from the location of the proposed terminal groin to station 120+00. Since the past, nourishment operations have placed an average of 408,000 cubic yards on Ocean Isle Beach every three years, the target volume for nourishment operation for the three (3) terminal groin options was set to be equal to or less than 408,000 cubic yards per operation. For the 250-foot terminal groin, increasing the nourishment interval to 4 years would require a volume of 476,000 cubic yards. Since this exceeds the target volume of 408,000 cubic yards/operation, the nourishment interval for the 250-foot terminal groin would remain at 3 years. For the 500-foot terminal groin, the nourishment interval could be increased to 4 years which would require 372,000 cubic yards of nourishment per operation, which is less than the target volume of 408,000 cubic yards. Similarly, the nourishment interval for the 750-foot terminal groin could be increased to 5 years which would require 400,000 cubic yards per operation.

The selected nourishment interval and nourishment volume for each terminal groin option is summarized as follows:

Terminal Groin Option (ft)	Nourishment Interval (yr)	Nourishment Volume (cy)
250	3	357,000
500	4	372,000
750	5	400,000

The Delft3D model simulations of the three terminal groin options indicated some possible reduction in sediment retention in the Shallotte Inlet borrow area for each of the terminal groin options. In the case of the 250-foot structure, the estimated rate of sediment retention would be 219,000 cubic yards/year which is about 87.3% of the retention rate of 251,000 cubic yards/year measured in the existing borrow area. For the 500-foot and 750-foot terminal groin options, retention rates in the borrow area are estimated to be 160,000 cubic yards/year and 128,000 cubic yards/year, respectively. In the case of the 250-foot structure, the volume of sediment retained in the borrow area over a three-year period would be 657,000 cubic yards which is more than the 3-year nourishment requirement given above. Similarly, the estimated retention rate with the 500-foot terminal groin should total 640,000 cubic yards over a 4-year period with a comparable volume of 640,000 cubic yards retained over 5-years in the case of the 750-foot structure. Both of these retention rates exceed the periodic nourishment volumes for the terminal groin options as provided above.

In the past, the USACE has combined periodic nourishment of the Ocean Isle Beach project into contracts involving Wrightsville Beach, Masonboro Inlet, Carolina Beach and Kure Beach. In this regard, dredging contracts for Wrightsville Beach and Masonboro Inlet are on a four-year dredging cycle while Carolina Beach and Kure Beach are on three-year cycles. The use of the selected periodic nourishment intervals for the 500-foot and 750-foot terminal groin options given above could have some impact on the ability to combine contracts for these projects; however, the potential cost savings for extending the nourishment interval would offset most of if not all of the cost impacts.

Cost Comparison – Terminal Groin Options

The selection of the optimal terminal groin option was based on a comparison of the cost for each option including the cost of the terminal groin, its maintenance cost, the cost of the initial beach fill for the accretion fillet, and periodic nourishment costs for Ocean Isle Beach west to station 120+00. Details of the cost estimates are provided in Section 4 of Appendix B. A summary of the total initial construction cost of each terminal groin option, which includes the cost of the structure and the beach fill to pre-fill the accretion fillet, periodic nourishment cost, and maintenance cost for the terminal groin is provided in Table 3.7. The maintenance cost for the terminal groin is presented as 1% of the cost of the armor stone that would have to be replaced or repaired; however, maintenance of the structure would not be required every year. Since the timing of when repairs would be needed cannot be predicted in advance, the maintenance costs were distributed uniformly over the 30-year planning period.

Table 3.7. Summary of cost for terminal groin options.

Terminal Groin Option	Initial Construction Cost	Periodic Nourishment Cost per Event	Nourishment Interval (years)	Terminal Groin Average Annual Maintenance Cost
250-foot	$2,328,000	$6,205,000	3	$7,000
500-foot	$3,966,000	$6,334,000	4	$13,000
750-foot	$5,700,000	$6,575,000	5	$21,000

The inlet management plan that would be implemented if the terminal groin alternative is constructed has been presented in Chapter 6 along with the added cost of beach profile surveys that would be required in the management plan. The inlet management plan includes shoreline position thresholds on both the west end of Holden Beach and the east end of Ocean Isle Beach that would trigger mitigation response measures should the post-groin construction shoreline progress landward of these thresholds. Mitigation would likely be in the form of beach nourishment. No costs are provided for this possible mitigation since prediction of if mitigation would be needed is not possible nor is the volume of beach fill that would have to be provided to offset the shoreline change impacts.

The thirty year costs for each terminal groin option are given in Table 3.8 with the equivalent average annual cost shown in Table 3.9. The thirty year cost and equivalent average annual cost of beach nourishment for Alternatives 1 and 2 are also given in Table 3.7 and 3.8, respectively, for comparison purposes. These costs were based on stand-alone project costs and do not represent the combination of mobilization costs for multiple projects as was done by the USACE in 2009-10.

Table 3.8. Thirty-year beach nourishment cost for Alternatives 1 and 2 and total cost for the three terminal groin options.

Alternative	Total 30-Year Cost
Alternatives 1 & 2	$66,440,000
250-foot terminal groin	$68,521,000
500-foot terminal groin	$51,127,000
750-foot terminal groin	$45,864,000

Table 3.9. Equivalent annual cost of terminal groin options and beach nourishment under Alternatives 1 and 2.

Alternative	Equivalent Annual Cost
Alternatives 1 & 2	$2,126,000
250-foot terminal groin	$2,129,000
500-foot terminal groin	$1,682,000
750-foot terminal groin	$1,567,000

Cost Sharing

All initial costs to pre-fill the accretion fillet and construct the terminal groin as well as any future maintenance of the terminal groin would be a non-Federal responsibility. Following construction of the terminal groin, all future beach nourishment would occur within the limits of the Federal storm damage reduction project and would be eligible for cost-sharing with the Federal government in the same 65%/35% Federal/non-Federal ratio as under the existing Project Cost Sharing Agreement. The resulting Federal and non-Federal cost responsibilities for the total 30-year project costs for the terminal groin options and Alternatives 1 and 2 are given in Table 3.10.

Table 3.10. Cost-Sharing responsibilities for 30-year project cost of the terminal groin options and the existing federal storm damage reduction project.

Alternative	Total 30-Year Cost	Federal Share	Non-Federal Share
Alternative 1 & 2	$66,440,000	$43,190,000	$23,250,000
250-foot terminal groin	$68,521,000	$41,518,000	$27,003,000
500-foot terminal groin	$51,127,000	$28,390,000	$22,737,000
750-foot terminal groin	$45,864,000	$23,034,000	$22,830,000

Selection of Terminal Groin Option

The 250-foot terminal groin would only have a minor impact on volume losses off the east end of Ocean Isle Beach and would only stabilize the shoreline for about 700 feet west of the structure and slightly reduce volume losses over another 1,000 feet. Also, the total 30-year cost for the 250-foot option would be slightly more than Alternative 1 and the non-Federal 30-year cost would be greater than that for Alternative 1 (Table 3.10). This is due to the inability of the 250-foot structure to reduce periodic nourishment requirements that would offset the cost for constructing and maintaining the structure. Therefore, the 250-foot terminal groin in not considered to be a viable option.

With regard to the 500-foot structure, it would provide positive shoreline effects in terms of shoreline stability and reduced nourishment requirements west to about station 20+00. The 750-foot structure's positive shoreline effects would extend west to station 30+00 and would almost eliminate all nourishment requirements east of station 30+00.

Construction of the 750-foot terminal groin, and its associated beach fill needed to pre-fill the accretion fillet west of the terminal groin, would cost about $1.7 million more than the 500-foot terminal groin option (Table 4.16 in Appendix B). However, over the 30-year analysis period, the total cost for the 750-foot option would be about $4.4 million less than the 500-foot structure. While non-federal cost over the 30-year analysis period would be slightly less for the 500-foot structure, the added shoreline stability provided by the 750-foot structure combined with a longer renourishment interval, especially in light of the possibility of future reductions in Federal funding for the Ocean Isle Beach storm damage reduction project prompted the Town of Ocean Isle Beach to select the 750-foot terminal groin as its preferred alternative.

Terminal Groin Construction Methodology

The exact method used to construct the terminal groin would be left to the discretion of the construction contractor; however, the contractor would have to abide by defined construction corridors, approved access locations and staging areas, permitted construction timeframes as well as other restrictions that would limit adverse environmental impacts directly associated with the construction activity as defined below.

The stone required to construct the terminal groin would be transported to Ocean Isle Beach down the AIWW via barges from a rail terminal similar to one located in Wilmington, NC. The stone would be off-loaded on to trucks at a facility located on the north end of Shallotte Boulevard (Figure 3.4). The existing pier located at this site would probably have to be upgraded in order to accept the loading associated with the stone transfer operation. The stone would be transported by trucks from the offloading facility down Shallotte Boulevard and E. 4th Street to a temporary stone storage area located on the beach at the end of E. 4th Street. The rubblemound portion of the terminal groin would be constructed from a temporary trestle or pier installed parallel to the alignment of the terminal groin. The trestle would be removed upon completion of the rubblemound portion of the terminal groin.

A minimal amount of excavation would be required for the landward 100 to 150 feet of the rubblemound portion of the structure in order to place the foundation stone or mattress at an elevation of -5.0 feet NAVD. From that point seaward, the foundation stone/mattress would be placed on grade.

The sheet pile for the landward portion of the terminal groin would be transported directly to the site by truck from where it would be offloaded and driven into place with typical pile driving equipment. A 50-foot wide construction corridor would be established on either side of the shore anchorage section. The construction corridor would be restored to pre-construction conditions as much as possible by grading any disturbed land and replanting with native vegetation.

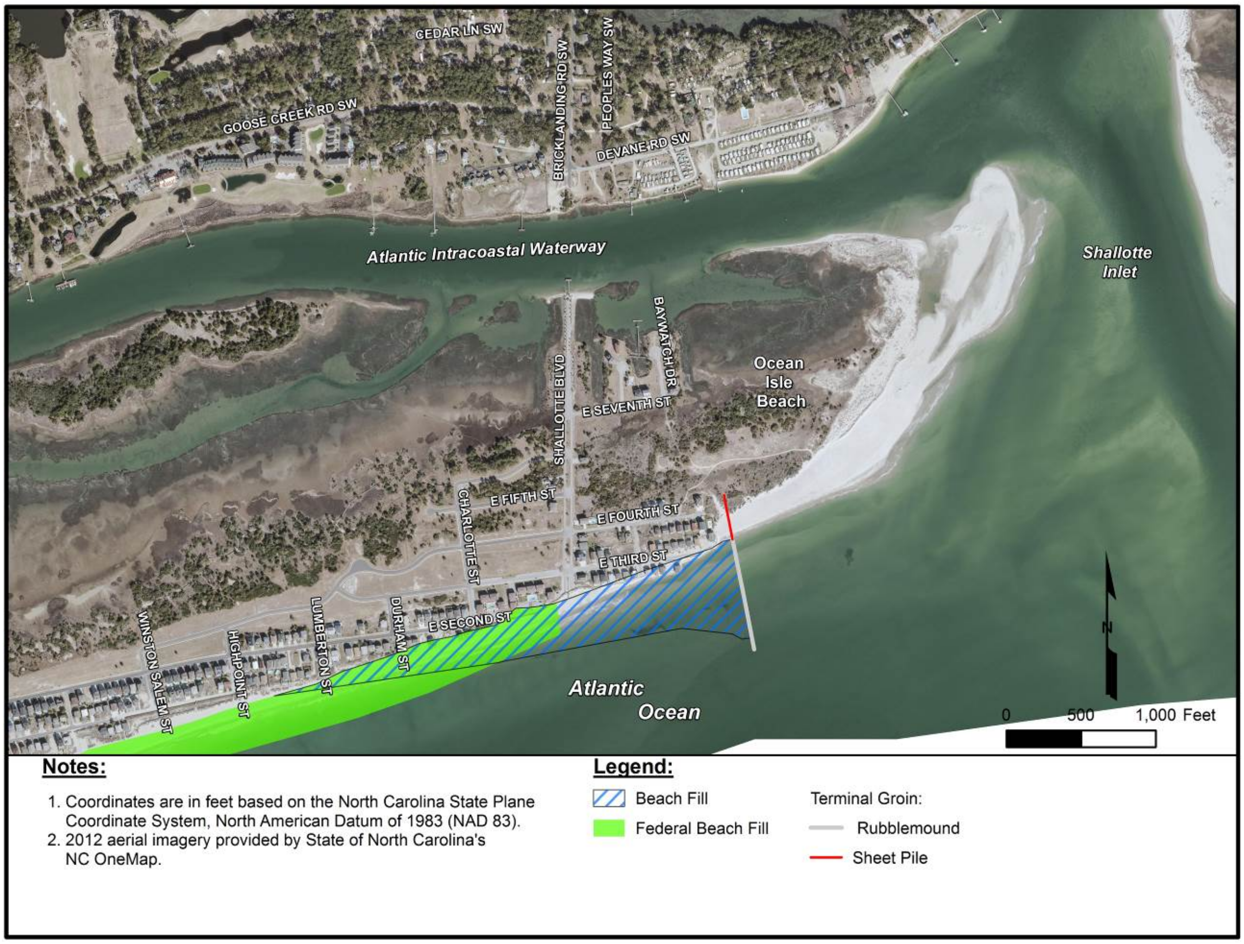


Figure 3.4. Terminal groin construction.

<u>Cost Summary</u>

Alternative 5 would eliminate long-term erosion damage to existing development on the east end of Ocean Isle Beach east of baseline station 30+00.

The equivalent average annual cost for all of the alternatives, computed using a discount rate of 4.125% and an amortization period of 30 years is provided in Table 3.11. The equivalent annual cost for Alternatives 1 and 2 include the annualized cost associated with future damages due to a continuation of long-term erosion.

The costs of each alternative over the 30-year planning period are given in Table 3.12. As noted in Table 3.12, the 30-year cost comparison for the alternatives is limited to the cost associated with providing shoreline protection, i.e., beach fill, terminal groin, or a combination of beach with a terminal groin. Damages associated with continued beach erosion under Alternatives 1 and 2 are excluded.

Table 3.11 Summary of average annual economic impact of alternatives.

Alternative	Long-Term Erosion Damages & Response Cost	Construction & Periodic Nourishment Cost	Total Economic Cost
1 - No New Action	$1,048,000	$2,126,000	$3,173,000
2 – Abandon/Retreat	$958,000	$2,126,000	$3,084,000
3 - Beach Nourishment	$0	$3,646,000	$3,646,000
4 – Channel Relocation	$0	$1,920,000	$1,920,000
5 - 750-ft terminal groin	$0	$1,567,000	$1,567,000

Table 3.12 Summary of 30-year implementation costs of alternatives

Alternative	Total 30-Year Beach Nourishment/Implementation Cost	Federal Share	Non-Federal Share
1- No New Action	$66,440,000[(1)]	$43,190,000	$23,250,000
2 – Abandon/Retreat	$66,440,000[(1)]	$43,190,000	$23,250,000
3 – Beach Nourishment	$108,768,000	$43,190,000	$65,578,000
4 – Channel Relocation	$53,150,000	$30,866,000	$22,264,000
5 – 750-ft terminal groin	$45,864,000	$23,034,000	$22,830,000

[(1)]Nourishment of federal storm damage reduction project only, does not include demolition, relocation, or sandbags.

Chapter 4 AFFECTED ENVIRONMENT

1. What is the environmental setting of this project?

Ocean Isle Beach is a coastal barrier island located along the Atlantic Ocean on the coastline of Brunswick County in southeastern North Carolina. The island is situated midway between the metropolitan cities of Wilmington, NC and Myrtle Beach, SC. Spanning approximately 5.5 miles, Ocean Isle Beach is oriented in an east/west direction with Shallotte Inlet located along its eastern end and Tubbs Inlet at its western end. The island has a current year-round resident population of approximately 554, with a seasonal population of 25,000. The Permit Area encompasses 4,411 acres and includes a wide diversity of estuarine and nearshore habitat types supporting diverse ecosystems typically associated with both a developed and undeveloped barrier island system in southeastern North Carolina. The proposed project is located on the easternmost portion of the island and within the channel and shoals in Shallotte Inlet.

The Permit Area, as shown in Figure 4.1, is defined as the boundary of where direct and indirect effects of the project will, or may likely occur. The Permit Area was identified and delineated based on the modeling results depicting potential sedimentation distribution in proximity to Shallotte Inlet as a result of the applicant's preferred alternative and the point of intercept calculated along the oceanfront shoreline from proposed nourishment activities.

Natural communities found within the permit area include: dune grass, scrub-shrub, salt marsh, beaches and foredunes. The natural area supports a gull-tern-skimmer colony, and the upper beach provides habitat for seabeach amaranth (*Amaranthus pumilus*). Threatened and endangered animals supported by the area include the loggerhead sea turtle (*Caretta caretta*), piping plover (*Charadrius melodus*), Carolina diamondback terrapin (*Malaclemys terrapin centrata*), black skimmer (*Rhychops niger*), least tern (*Sterna atillarum*), Atlantic sturgeon (*Acipenser oxyrinchus*), and eastern painted bunting (*Passerina ciris ciris*). The USFWS has designated 296 acres as Piping Plover Critical Habitat along portions of the western tip of Holden Beach. This area provides foraging and nesting grounds for the endangered piping plover (Figure 4.1).

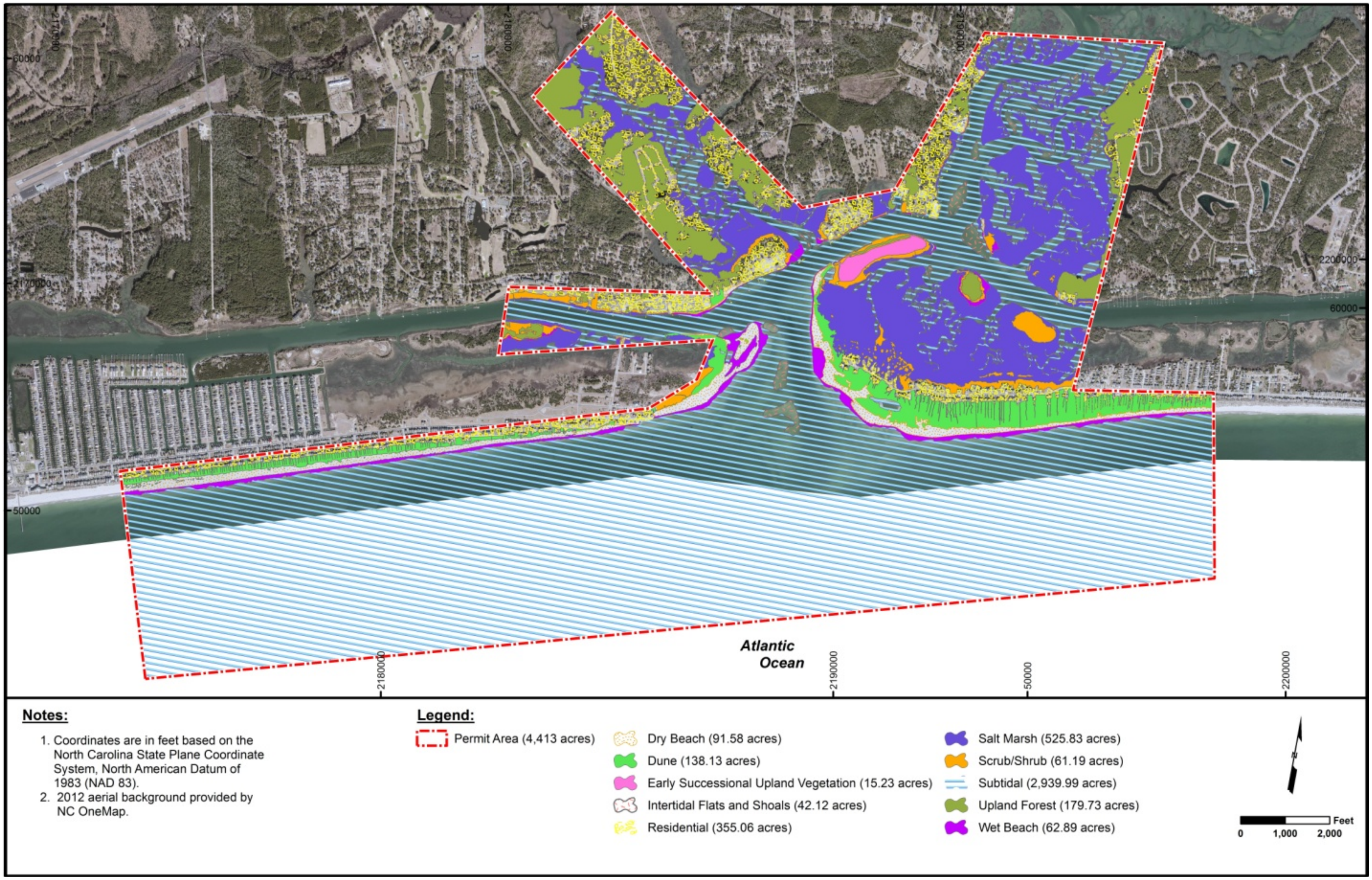


Figure 4.1. Ocean Isle Beach Environmental Setting Map within the Permit Area

The North Carolina Division of Marine Fisheries (NCDMF) has designated about 595 km^2 (230 mi^2) of fishery nursery areas throughout North Carolina, dividing the habitats into three categories of nursery areas: Primary, Secondary and Special Secondary Nursery Areas (NCDMF, 2007). Primary Nursery Areas (PNAs) are usually shallow with soft muddy bottoms and surrounded by marshes and wetlands. PNAs are located within the Permit Area, specifically along the back side of Ocean Isle Beach along the AIWW, portions of the Shallotte River, and Saucepan Creek. To protect juveniles, many commercial fishing activities are prohibited in these waters including the use of trawl nets, seine nets, dredges or any mechanical methods used for taking clams or oysters.

The geomorphology of the Permit Area is characterized by beaches, dunes and marshes typical of a barrier island complex. The Atlantic Coastal Plain and Long Bay are both underlain by relatively flat-lying sedimentary units which gently dip and thicken as they move to the southeast.

Barrier islands in North Carolina, such as Ocean Isle Beach, are primarily composed of unconsolidated fine- to medium-sized quartz and shell material that is in a constant state of flux due to wind, waves, currents and storms. The oceanfront beach and the backing dunes are deposits of sand that are constantly changing their shape, and hence position, with time as they respond to coastal processes.

Areas of Environmental Concern

North Carolina passed the Coastal Area Management Act in 1974 and then developed regulations in 1978 to limit development in coastal environments. Inlet Hazard Areas of Environmental Concern (IHAEC) were defined as natural hazard areas that are vulnerable to erosion, flooding and other adverse effects of sand, wind, and water because of their proximity to dynamic ocean inlets. North Carolina's IHAEC boundaries were originally approved by the Coastal Resources Commission (CRC) in 1979. Presently, IHAEC boundaries are more than 20 years out-of-date and new boundaries have been proposed by the CRC.

What are Areas of Environmental Concern?

The Coastal Resources Commission designates areas as AECs to protect them from uncontrolled development, which may cause irreversible damage to property, public health or the environment, thereby diminishing their value to the entire state. The CRC has set up four categories of AECs:

A. The Estuarine and Ocean System
B. The Ocean Hazard System
C. Public Water Supplies
D. Natural and Cultural Resource Areas

Many AECs have also been designated as Significant Natural Heritage Areas (SNHA) by the North Carolina Natural Heritage Program (NCNHP). The NCNHP has identified more than 2,000 SNHAs in North Carolina, which are defined as an area of land or water important for conservation of biodiversity. SNHA's contain one or more natural heritage elements such as high-quality or rare natural communities, rare species, and/or special animal habitats. The NCNHP has identified one natural area documented within a one-mile radius of the Permit Area. This site, the 150 acre Brantley Island, is an interstream upland terrace located along the north side of the

Intracoastal Waterway. The terrace grades downslope to stream channels along the east and west sides of the site. The upland supports the Coastal Fringe Evergreen Forest natural community, and the stream channels support the Coastal Plain Small Stream Swamp (Blackwater Subtype).

2. What are the characteristics of the various habitats found within the project area?

Barrier islands within North Carolina are dominated by wave and tidal processes, often with large flood and ebb tidal deltas. Like other inlets in southeastern North Carolina, Shallotte Inlet serves as the primary pathway of sediment transportation into the estuary system. The Permit Area contains various habitat types such as salt marsh, upland hammocks, intertidal flats, shoals, dunes and beaches (Figure 4.2).

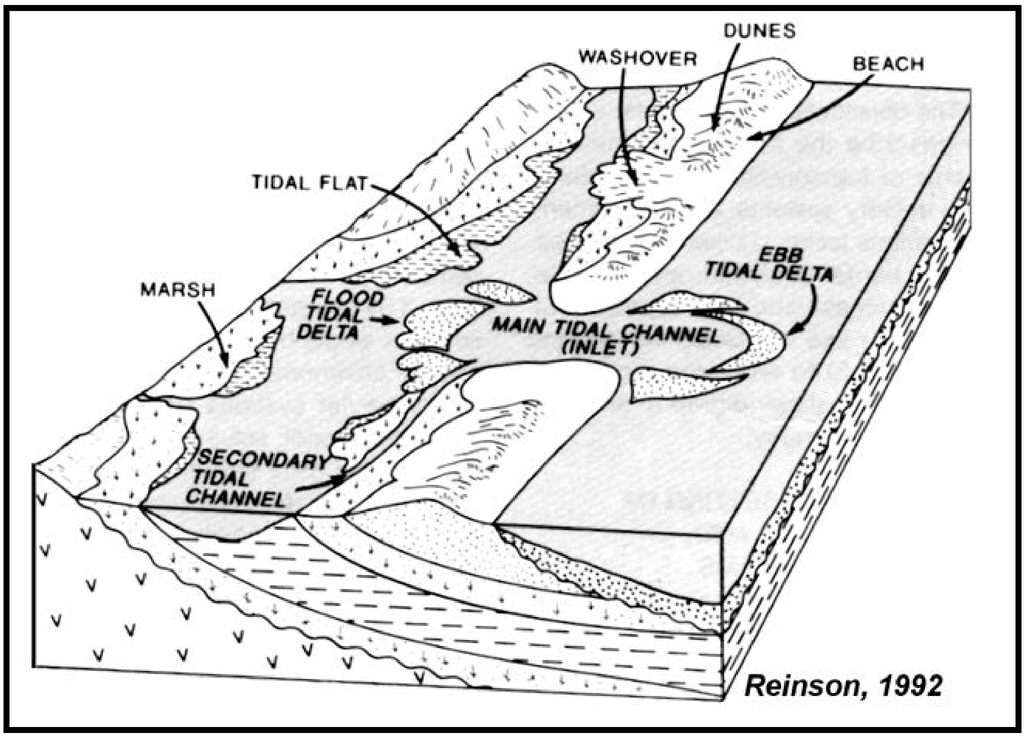


Figure 4.2. Schematic depicting various habitats associated with a barrier island

A. Estuarine Habitats

While estuaries are also often known as bays, lagoons, harbors, inlets, or sounds, the defining feature of an estuary is the mixing of fresh and saline water (32 to 36 parts per thousand [ppt]). Flush with nutrients and inhabited by resilient organisms, estuaries are among the most productive ecosystems on earth. They provide rich feeding grounds for coastal fish and migratory birds, and spawning areas for fish and shellfish (NPS, 2007). This section will characterize the following estuarine communities that are found, or have potential to be found, within the Permit Area including salt marshes, submerged aquatic vegetation (SAV) and shellfish areas.

1. Salt Marsh Communities

These community types are found in relatively flat and poorly drained topographic areas found along the North Carolina coastline and are subject to regular and irregular tidal flooding. These systems are extremely important for water filtration and water storage during flood events, as well as supplying food and providing habitat for a wide-array of flora and fauna. Coastal wetlands within the project vicinity include tidal salt marshes, and occur along the shoreline and island fringes along the backside of Ocean Isle Beach and Holden Beach.

Salt Marsh Communities

In eastern North Carolina, salt marsh communities can be found along 4,500 miles of coastal shoreline, which encompasses 2.1 million acres of estuarine habitat (NCCF, 2007).

Estuarine systems, such as those characterized within the Ocean Isle Beach Permit Area, have been designated as AEC by the CRC. These areas have been identified as "sensitive and productive coastal lands and waters where uncontrolled development might cause irreversible loss of property, public health and the natural environment" (NCDCM, 2006). Section 15A NCAC 07H .0205 of the North Carolina Administrative Code defines coastal wetlands 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 shall not include hurricane or tropical storm tides (NCDCM, 2008). There are four kinds of coastal marsh habitats found in North Carolina; low marsh, high marsh, brackish marsh, and freshwater marshes. Of these kinds, the Permit Area contains low and high marsh.

Low salt marsh environments are regularly flooded with the tides and are characterized by organic mats with smooth cordgrass (*Spartina alterniflora*) as the dominant vegetative species. *S. alterniflora* marshes occur within the intertidal zone along the sounds and tidal creeks, and provide valuable nursery habitat for commercially valuable species of marine and estuarine organisms. The zonation of vegetation in salt/brackish marsh is largely determined by variations of salinity and drainage of sediment porewater. Some species are restricted in the low marsh because of high porewater salinity, frequent inundation, and high-sulfide porewaters associated with frequent inundation (Street *et al*., 2005). Smooth cordgrass can tolerate a wide range of environmental conditions, including pH levels from 5.4 to 7, salinities from 3% to 5%, and a water table four inches above ground level (ANHP, 2004).

Cowardin (1979) classifies high marsh as an estuarine intertidal emergent wetland or palustrine, emergent wetland. High salt marsh environments are irregularly flooded lands where plant species such as saltmeadow cordgrass (*S. patens*), glasswort (*Salicornia* Spp.), salt (or spike) grass (*Distichlis spicata*), and sea lavender (*Limonium carolinianum*) may be found. Saltmeadow cordgrass grows at the seaward edge of the high marsh, just above the high water line, providing habitat for a variety of waterfowl and songbirds, as well as other types of wildlife indigenous to the area. This environment is important in stabilizing the shifting sands of the barrier islands. Eventually, over time, the high marsh habitat can transform as it becomes vegetated with dominant shrub species such as marsh elder (*Iva frutescens*), wax myrtle (*Myrica cerifera*), and yaupon holly (*Ilex vomitoria*).

For both low and high salt marsh, the benthic communities consist of many faunal species. A 2007 wildlife utilization study conducted in the low salt marshes within the Bogue Inlet complex revealed high numbers of macroinvertebrates including fiddler crabs (*Uca puglator*), periwinkle snails (*Littorina irrorata*), oysters (*Crassostrea virginica*), and unidentified species of mud crabs, clams, and mussels (Rosov and York, 2007). Other common macro invertebrates in the salt marsh include blue crabs (*Callinectes sapidus*) and grass shrimp (*Palaemonetes* sp.) (Meyer, 1991).

Five hundred and twenty-six (526) acres of marsh have been delineated within the Permit Area, as determined through interpretation of high resolution aerial photography.

<u>Benefits of Salt Marsh Habitats to Shorebirds, Colonial Waterbirds and other Waterbirds</u>
Due to their biological productivity, estuaries provide ideal areas for migratory birds to rest and forage during their long migratory journeys. Various species of shorebirds utilize marsh habitats for wintering, as well as feed on fish, shrimp and fiddler crabs found in the salt marsh. Along with a number of shorebirds and waterbirds, various waterfowl including dabbling ducks, diving ducks, geese, swans and coots utilize the salt marsh (Cowardin, 1979).

Colonial waterbirds that utilize marsh habitat include black skimmers, gull-billed terns, common terns, least terns, egrets (*Egretta* spp.), and green herons (*Butorides virescens*). Most of these species prefer sandy beaches and shoaling habitats for nesting. The green heron is a habitat generalist, frequenting most coastal freshwater bodies as well as some saltwater bodies. The green heron nests in coastal shrub thickets, upland and swamp forests, and salt marshes, as well as in suburbs where habitat is deemed suitable. This species is less colonial than other wading birds, and although it often nests in mixed colonies with other herons and ibis (*Plegadis falcinellus* and *Eudocimus albus*), the green heron will frequently nest singly or in colonies of a few pairs. Nests are typically elevated in trees or shrubs between five (5) and 30 ft off the ground (Alsop, 2002).

Willets (*Catoptrophorus semipalmatus*), American oystercatchers *(Haematopus palliatus)*, piping plovers, Wilson's plovers, and killdeers (*Charadrius vociferous*) usually nest above the high tide line on coastal beaches, on sand flats at the ends of sand spits, in blowout areas behind dunes and in overwash areas. However these various shorebirds also utilize various estuarine habitats including intertidal-emergent and submerged vegetated areas, intertidal-unvegetated, managed wetlands, as well as inland habitats for feeding (Hunter *et al*., 2001; Brown *et al*., 2001).

A variety of other waterbird species that are not classified as shorebirds or colonial waterbirds can also be found utilizing different estuarine habitats. For example, species such as red-breasted mergansers (*Mergus serrator*), clapper rails (*Rallus longirostris*) and ospreys (*Pandion haliaetus*) can be found in and surrounding inlet habitats such as Shallotte Inlet. These waterbirds can be found in estuaries, marshes, and in the vicinity of Shallotte Inlet year-round or part of the year. However, they are mainly present during spring and fall migrations, as well as during the winter.

Benefits of Salt Marsh Habitat to Terrapins

The Carolina diamondback terrapin (*Malaclemys terrapin centrata*) is the only North American turtle found in brackish waters, and are common in salt marsh environments. Juveniles use matted species of *Spartina* and other marsh grasses as cover. The marshes behind Ocean Isle Beach provide suitable habitat for diamondback terrapins.

Benefits of Salt Marsh Habitats to Fishery Resources

Finfish and shellfish using salt/brackish marsh habitats fall into several categories based on location and timing of use (Street *et al*., 2005). Essential Fish Habitat (EFH) species that are expected to occur in estuarine emergent wetlands of North Carolina include the penaeid shrimp, summer flounder and others. Year-round residents of the marsh include small forage species such as killifish (*Fundulus confluentus, F. luciae, F. majalis, Lucania parva, Fundulus heteroclitus*), sheepshead minnows (*Cyprinodon variegates*), grass shrimp (*Palaemonetes pugi),* bay anchovies (*Anchoa mitchilli*) and silversides (*Membras martinica, Menidia* spp.). Transient species include those spawning near the marsh, and those spawned in deeper waters using marsh habitat as nursery or foraging areas. Among transient species, some prefer the edge of salt/brackish marsh (i.e. flounder) while others are found near the marsh edge on non-vegetated bottom (i.e., spot (*Leiostomus xanthurus*) and Atlantic croaker (*Micropogonias undulatus*)). Some species are not found in the marsh, but derive substantial food resources from marsh plants as detritus (i.e., menhaden (*Brevoortia* spp.)) or from microalgae produced on the marsh surface. Of the fishery species in North Carolina, penaeid shrimp and red drum are considered critically linked to marsh edge habitat (SAFMC, 1998).

Red drum spawning occurs in the fall (August through October) in estuaries and around coastal inlets with optimal temperatures being between 22^0 C and 30^0 C (72^0 F to 86^0 F) (NCDMF 2005). In North Carolina, spawning adults were reported to be common in salinities above 25 ppt in Bogue Sound and the Cape Fear River. Spawning adults were present but not frequently encountered in Pamlico Sound and the New River (ASMFC, 2002).

Penaeid shrimp are reported to spawn offshore, moving into estuaries during post-larval stage during the early spring. As the shrimp grow larger in size, they migrate to higher salinity environments. In late summer and fall, they return to the ocean to spawn (NCDMF, 2005). It is during the July through October period that approximately 77% of the North Carolina shrimp harvest (for all waters) is landed, 66% of which is taken from ocean sub-areas <3 mi offshore and south of Cape Hatteras (NCDMF, 2005). In a NCDMF juvenile brown, white and pink shrimp sampling program (1999 – 2003) the majority of shrimp were "collected in close proximity to shallow wetland systems, such as salt marsh".

- Brown Shrimp

  Brown shrimp spawn in the deep ocean during February and March. Larval immigration to estuaries peaks from mid-March through mid-April. Brown shrimp prefer peat and muddy bottoms as habitat (NCDMF, 2005).

- Pink Shrimp

Pink shrimp spawn in ocean waters from April to July. Post larvae immigrate to estuaries from May to November. Juvenile pink shrimp are reported to over-winter in North Carolina estuaries. Pink shrimp prefer foraging in shallow waters among marine plants. They are nocturnal feeders but may feed during the day in turbid water (NCDMF, 2005).

- White Shrimp

White shrimp spawn at depths greater than 30 feet in the ocean from March to November. Post larvae immigrate to estuaries two to three weeks after hatching when they become benthic. Juvenile white shrimp prefer muddy bottoms in low to moderate salinity estuarine waters and brackish waters. White shrimp migrate south from estuaries during fall and early winter. “Some of the slower-growing individuals overwinter in the estuaries, but usually do not survive in North Carolina” (NCDMF, 2005).

2. Submerged Aquatic Vegetation (SAV)

SAV habitat occurs along the entire east coast of the United States, with the exception of South Carolina and Georgia, where high freshwater input, high turbidity, and large tidal amplitude (vertical tide range) inhibit their occurrence. Along the Atlantic coast, North Carolina supports more SAV than any other state, except for Florida (Funderburk et al. 1991; Sargent et al. 1995). The 2005 CHPP reported that, based on interpretation and field verification by NOAA of remotely-sensed imagery taken during 1985-1990, the total area of visible SAV was approximately 134,000 acres (Ferguson and Wood, 1994). Since 2005, some additional mapping efforts have added over 20,000 acres of mapped vegetated areas, suggesting SAV habitat covers over 150,000 acres in coastal North Carolina (Deaton et al., 2010).

Submerged Aquatic Vegetation

North Carolina is in a “transitional area which represents the southernmost extension for some cold-adapted species and the northernmost extension of warm-adapted species.

In North Carolina, Submerged Aquatic Vegetation (SAV) is defined as “estuarine waters vegetated with one or more species of submerged vegetation such as eelgrass (*Zostera marina*), shoalgrass (*Halodule wrightii*) and widgeon grass (*Ruppia maritima*). These vegetation beds occur in both subtidal and intertidal zones and may occur in isolated patches or cover extensive areas (Street *et al.*, 2005). In North Carolina the dominant seagrass is *Z. marina*. *H. wrightii* is also observed in North Carolina; however it is not as abundant. Seagrass meadows are now much reduced, probably due to elevated nitrogen and increased sedimentation (Mallin *et al*., 2000).

Mapped SAV habitat occurs mostly along the estuarine shoreline of the Outer Banks (Pamlico and Core/Bogue sounds), with sparse cover along much of the mainland shores of the estuarine system (Ferguson et al., 1989). Estuarine SAV occurs sporadically west of Bogue Inlet to the border with South Carolina, but these areas had not been suitably photographed in the early 1990’s (Ferguson and Wood, 1994). Small areas of SAV habitat have been observed in the past by DMF biologists in the New River, Alligator and Chadwick bays, Topsail Sound and inside Rich’s Inlet (DMF southern district office staff, pers. comm., 2002). More recent imagery and monitoring have verified the presence of patchy SAV beds south of Bogue Sound (S. Chappell and A. Deaton/DMF, pers. observation). No SAV resources have been identified via surveys reviewed by DMF staff in proximity to Ocean Isle Beach (Deaton, pers. comm.)

Benefits of SAV Areas to Fishery Resources

Submerged aquatic vegetation provides important structural fish habitat and other important ecosystem functions in estuarine and riverine systems in coastal North Carolina. Submerged aquatic vegetation is recognized as an EFH because of five (5) interrelated features – primary production, structural complexity, modification of energy regimes, sediment and shoreline stabilization, and nutrient cycling. Water quality enhancement and fish utilization are especially important ecosystem functions of SAV relevant to the enhancement of coastal fisheries (Deaton, 2010).

3. Shellfish

The shellfish industry is a large economic industry for North Carolina coastal areas. Three (3) species of shellfish found in North Carolina coastal waters include eastern oysters (*Crassostrea virginicus*), hard clams (*Mercenaria mercenaria*), and bay scallops (*Argopecten irradians concentricus*).

Shellfish

Common terms used to describe shell bottom habitats in North Carolina are “oyster beds,” “oyster rocks,” “oyster reefs,” “oyster bars” and “shell hash.”

Shellfish are also an important resource in the estuarine environment within the permit area. The structures that shellfish create, such as beds and reefs, are used by many species of fish and invertebrates (Burrel, 1986). The SAFMC defines this 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” (SAFMC, 1998). The South Atlantic Fishery Management Council (SAFMC) has designated oyster reefs as EFH for red drum (NMFS, 1999). Although no NCDMF-designated Oyster Management Areas (OMA) are located within the Permit Area, several oyster cultch planting areas are found along the AIWW on the back side of Ocean Isle Beach and Holden Beach as well as the lower portion of the Shallotte River (Stephen Taylor, pers. comm.). The State prohibits the use of trawls, dredges and other types of bottom-disturbing fishing gear at these sites.

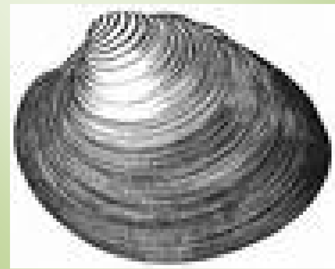
Table 4.1 below summarizes the spawning seasons for the three (3) shellfish species typically found within the Permit Area.

Table 4.1. Spawning Seasons for Shellfish

Species	Spawning Seasons
Hard Clam (*Mercenaria mercenaria*)	May through November
Eastern Oyster (*Crassostrea virginica*)	May through September
Bay Scallops (*Argopecten irradians*)	August through December

The NCDMF Shellfish Mapping Program was developed using a stratified random sampling design that delineates all bottom habitats (or strata) and samples the density of oysters, clams, and bay scallops in these areas (Street *et al*. 2005). Benthic habitat surveys in Shallotte Inlet and the estuarine habitats behind Ocean Isle Beach and Holden Beach were conducted by the NCDMF and results are shown in Figures 4.3 and 4.4, created by the NCDMF Shellfish Mapping Program (Conrad, pers. comm.). These figures illustrate the distribution of the various habitats within proximity to Shallotte Inlet.

Hard clam



- <u>Hard Clams</u>

According to the NCDMF, the stock status of hard clams (*Mercenaria mercenaria*) is unknown because there is no data available to assess the population size (NCDMF, 2001). Hard clams are an estuarine-dependent mollusk found primarily in sandy and vegetated bottoms. Increased fishing, poor water quality, and habitat loss has impacted this fishery (NCDMF, 2003a). The EFH for the hard clam, as designated by the SAFMC, includes subtidal and intertidal flats, oyster reefs and shell banks, and SAV (NCDMF, 2001). The State Fishery Management Plan was updated in 2008.

Hard clams are suspension feeders that subsist primarily on phytoplankton. Growth of hard clam larvae is quickest at temperatures found between 22.5°C and 36.5ºC (72.5°F and 97.9°F) with salinities of 21.5 to 30.0 ppt (Eversole, 1987). They spawn from May through November, when water temperatures reach 68°F. Salinities above 25 ppt significantly affect normal embryonic development while temperatures too low will not allow maturation and spawning (Eversole, 1987). Hard clams can be found in nearly all of the sheltered marine waters of North Carolina. Based on research examining clam landings per trip, the NCDMF found that the harvest of clams appeared to be particularly stable (NCDMF, 2001).

Eastern oyster

- <u>Eastern Oysters</u>

Eastern oysters (*Crassostrea virginica*) are long-lived (approximately 40 years) and are capable of forming large reefs. According to the NCDMF, the eastern oyster has a stock status designation of concern due to a long-term decline most likely caused by over harvesting, habitat disturbances and pollution. Oysters require a relatively clean, firm substrate to attach to and can be found in intertidal or subtidal estuarine environments. Spawning in North Carolina occurs from May through September. Vast intertidal reefs formed by oysters are significant biological and physical formations in the estuaries of North Carolina. Fish, crabs, and shrimp utilize oyster beds as refuge and as a source of food. The intertidal oyster beds also provide habitat for various infaunal and epifaunal species.

The eastern oyster 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 MLW to 1 m (3.28 ft) above MLW (Burrel, 1986). The eastern oyster is a prolific bivalve, whose stocks have been depleted, which identified a need for a State Fishery Management Plan (updated in 2008) in parallel with the Hard Clam Fishery Management Plan.

Bay Scallop

- Bay Scallop

The NCDMF lists the bay scallop (*Argopecten irradians*) as a species of concern based on poor recruitment and low abundances. NCDMF developed a fisheries management plan for the bay scallop in 2007. *A. irradians* is an estuarine-dependent bivalve found in seagrass (mainly eelgrass) beds. 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 (Fay *et al*., 1983). Adult scallops prefer calm waters, secluded from high winds, storms, with tides and depths of 0.3 to 10 m (0.98 to 32.8 ft). Environmental factors, such as temperature and rainfall, play a critical role in scallop abundance (NCDMF, 2003). They spawn between August and December when water temperatures are approximately 60ºF.

Benefits of Shellfish Habitat Areas to Fishery Resources

Shell bottom provides critical fisheries habitat not only for oysters but also for recreationally and commercially important finfish, other mollusks, and crustaceans. The SAFMC has designated oyster reefs as EFH for red drum (*Sciaenops ocellatus*). The ecological functions of oyster reefs related to oyster production are well known and accepted. These functions include aggregation of spawning stock, chemical cues for successful spat settlement, and refuge from predators and siltation. Oysters have also been described as "ecosystem engineers" that create reef habitat important to estuarine biodiversity and fishery production. Several studies have found higher biological abundance and diversity on shell bottom than adjacent softbottom, particularly pinfish (*Lagodon rhomboides*), blue crabs (*Callinectes sapidus*), and grass shrimp (*Palaemonetes pugio*) (Street *et al*., 2005).

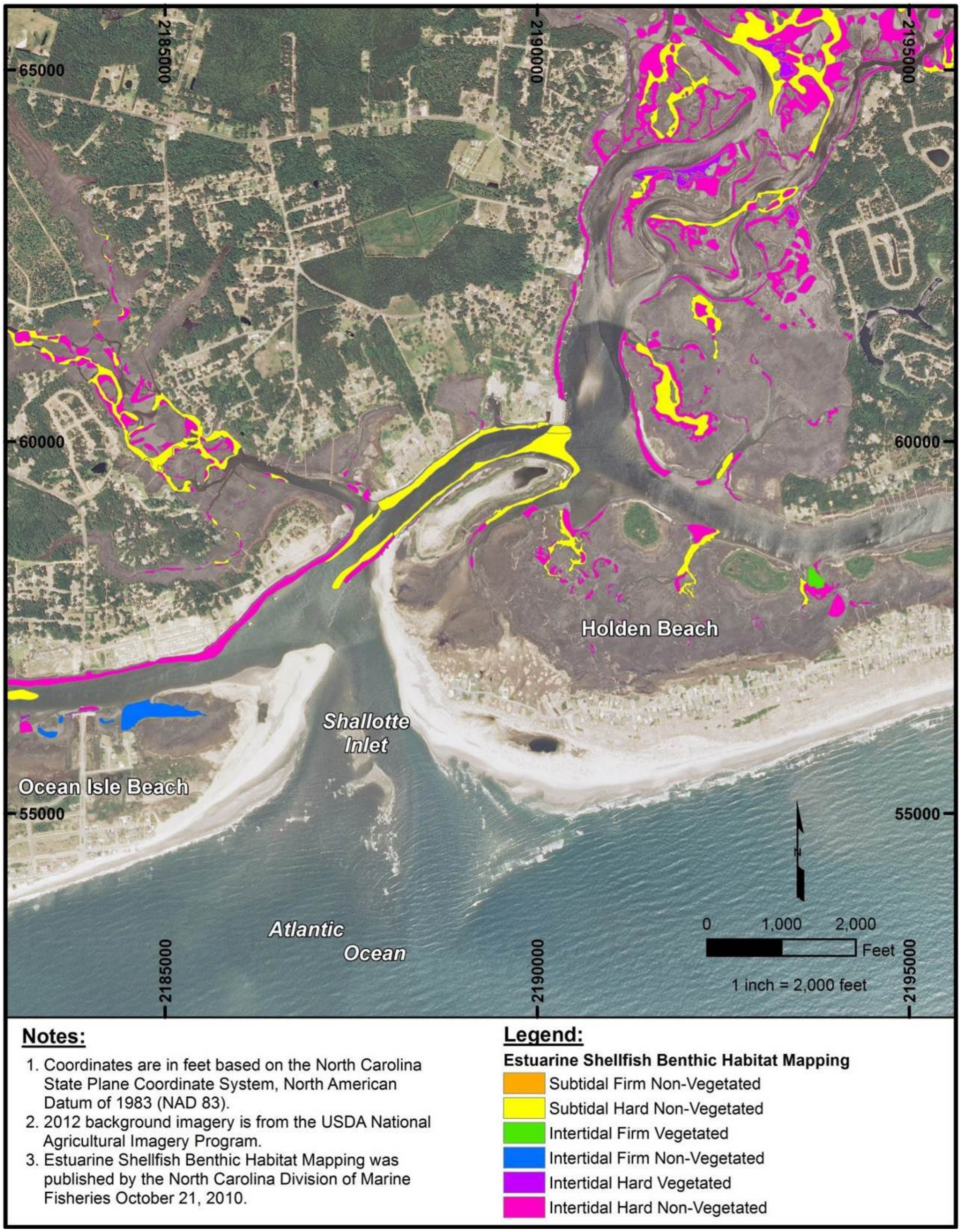


Figure 4.3. NCDMF Shellfish Mapping Program

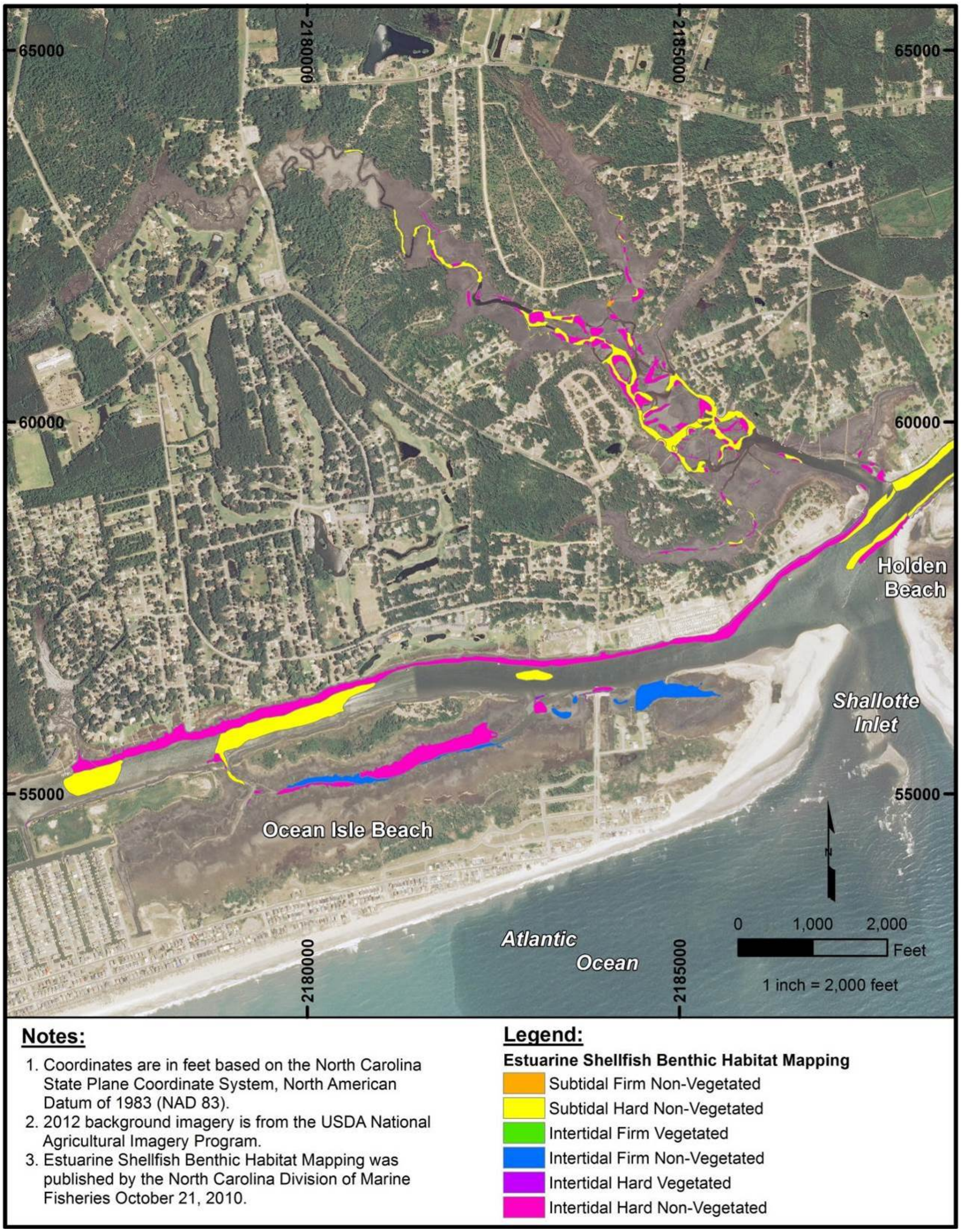


Figure 4.4. NCDMF Shellfish Mapping Program

B. Upland Hammock Habitat

Maritime hammocks, also known as maritime forests, tropical hammocks or coastal hammocks, are characterized as narrow bands of forest that develop almost exclusively on stabilized back dunes of barrier islands, inland of primary dunes and scrub. This habitat type is typically dominated by species of broad-leaved evergreen trees and shrubs, maritime hammocks are climax communities influenced heavily by salt spray. Figure 4.1 depicts the upland hammock habitat and designates the area as "scrub-shrub" and "upland forest". The dominant wind direction and influence of salt spray is usually evidenced by the sculpted vegetation (Texas Cooperative Research Unit, 2002). One hundred-eighty acres of upland hammock as well as 61 acres of scrub-shrub habitat have been delineated within the Permit Area, as determined through interpretation of high resolution aerial photography.

Benefits of Upland Hammocks to Colonial Waterbirds

Colonial waterbirds utilize a variety of habitats for foraging, roosting, and nesting, which includes estuaries, oceanfronts, open dunes, inland areas, and intertidal shoal habitats. These birds also use a variety of habitats for nesting. Some colonial waterbirds such as brown pelicans, herons, and egrets utilize vegetated, upland environments. These three (3) colonial waterbird groups prefer trees, shrubs, and grass lands for nesting and, as a result, may utilize the upland hammocks identified within the Permit Area.

C. Inlet Dunes and Dry Beach Habitats

This section identifies and discusses the dune and beach communities within the Shallotte Inlet complex. These habitats are present around the periphery of the inlet. Inlet dunes and inlet beaches are similar to coastal dunes and coastal beaches, however, as a result of episodic overwash, these habitats are typically not as established as coastal beaches and often lack the vegetation common on the coastal beach and dune systems. Inlet dunes are defined as any hill, mound, or ridge of sand along the inlet coastline created by natural or artificial forces. The inlet dry beach habitat is defined as the portion of the ocean beach in proximity to the inlet that is between mean high water and the toe of the dune. These inlet dunes and beaches are also susceptible to forecasted sea level rise.

Benefits of Inlet Dunes and Dry Beaches to Shorebirds, Colonial Waterbirds, and Other Waterbirds

Most shorebirds are long distance migrants, who migrate through and winter in North Carolina en route to find suitable breeding sites in the Arctic. To complete these flights, shorebirds must obtain a large food reserve. The inlet dunes and beaches in proximity to Shallotte Inlet provide migration stop-over areas used by shorebirds to replenish food reserves and accumulate fat needed for the long flights. There are few places that have the necessary combination of resources. In some areas, between 50% and 80% of the entire population of a species may visit a single site (MCCS, 2003). Migratory arctic-bound shorebird species that may be found during the non-breeding season within inlets of North Carolina include

Upland hammock

These forested systems are typically dominated by live oak (*Quercus virginiana*), loblolly pine (*Pinus taeda*), and red cedar (*Juniperus virginiana*) trees with an understory of shrub thicket which can support such species as swamp bay (*Persea palustris*) and sweetbay (*Magnolia virginiana*).

the red knot (*Calidris canutus rufa*), dunlin (*Calidris alpine)*, western sandpiper (*Calidris mauri)*, and sanderlings (*Calidris alba*). Many arctic breeding species are experiencing declines, including the red knot, which was recently listed on December 11, 2104 as a threatened species under the Endangered Species Act.

Shorebirds utilize these inlet dunes and beaches for breeding, wintering and migrating. Many species rely on a few, key stopover sites to complete their annual migratory cycle. The Outer Banks of North Carolina constitute a prime example of a potentially important area for which only limited information on migratory birds is available (Dinsmore, *et al*., 1998).

Colonial waterbirds also utilize this habitat. These species include terns (*Sterna* spp.), black skimmers (*Rynchops niger*), herons, egrets (Family Ardeidae), gulls (*Larus* spp.), ibis (Family Threskiornithidae), and pelicans (*Pelecanus occidentalis*) (Cameron, pers. comm.). Wading birds using the inlet complex include herons, egrets, and ibises (*Threskiomis* spp.). In addition to intertidal shoal habitats, these birds can be found foraging, roosting, and nesting in estuaries, along the oceanfront, and in open dunes located within the inlet complex.

Some species of waterbirds, such as terns and black skimmers, nest on bare sand and shell with little or no vegetation. These species will change nesting areas in response to changing environmental conditions, such as areas with recent increases in vegetation or storm events. In selecting nesting habitat, waterbirds typically recognize the preferred habitats and locations that have yielded past success, but mainly adhere to group dynamics. This type of grouping creates nesting, resting, and foraging areas with large colonies that can include multiple species of waterbirds.

D. Overwash Habitats

One type of barrier island habitat that is an important feature is overwash areas. Natural processes, such as storms, create overwash features behind primary sand dune areas. Overwash areas are usually created during strong storm events and usually occur in low areas during spring high tide conditions when seawater flows through the primary dune line, spreading out sand from the beach and dunes. Recently created overwash fans are generally unvegetated and function similar to the dry beach community. Overwash areas are characterized by low, loose sand flats, perhaps piled into dunelets and/or divided by sluiceways that quickly develop scattered weedy shrubs and herbs. After the site has gone for an extended period without storm scouring the vegetation may develop into a dense mat of vines and grasses. Island overwash is an important process in maintaining the natural geomorphology of coastal barrier islands. When overwash occurs, the net volume of sand is often maintained and the island migrates landward (Donnelly *et al.*, 2006). Barrier islands naturally migrate landward as a result of storm events and sea level rise. This is accomplished through overwash events where sediments are pushed to the sound side, which contributes to building marsh on the sound side.

<u>Benefits of Overwash Habitats to Shorebirds, Colonial Waterbirds, and other Waterbirds</u>

Overwash features are not unique to inlets; however, the dynamic and productive microhabitats formed as a result of inlet migration are very important to both breeding and non-breeding waterbirds. Overwash habitats include ephemeral pools and bayside mudflats which are important feeding areas to piping plovers at the start of the nesting season and throughout the year (Fraser, 2005; USFWS, 1996). Overwash habitat is utilized by wildlife, particularly shorebirds, colonial waterbirds and other waterbirds as they provide suitable foraging and nesting habitat for these birds. Willets, American oystercatchers, piping plovers, Wilson's plovers, and killdeers usually nest on open areas above the high tide line on coastal beaches, on sand flats at the ends of sand spits, and along blowout areas behind dunes and in overwash areas. These open habitats are utilized by breeding and non-breeding colonial waterbirds. In particular, the Wilson's plover and the federally threatened piping plover are both dependent on hurricanes and storms to provide the overwash habitat needed for nesting habitat (Street *et al*., 2005).

E. Intertidal Flats and Shoals

> **Intertidal flats and shoals**
>
> These habitats areas are considered to be important feeding areas to shorebirds at the start of the nesting season and throughout the year. This includes the Federally protected piping plover (Fraser, 2005; USFWS, 1996).

Intertidal flats and shoals are defined as non-vegetated, soft sediment habitats, found between mean high-water and mean low-water spring tide datum (Dyer et al., 2000) and are generally located in estuaries and other low energy marine environments. Mean high water is defined as the average elevation of all high waters recorded at a particular point or station over a considerable period of time. Mean low water is defined as the average elevation of all low waters recorded at a particular location also over a considerable period of time. Intertidal flats and shoals are distributed widely along coastlines world-wide, accumulating fine-grain sediments on gently sloping beds, forming the basic structure upon which coastal wetlands build. The tidal flats and shoals of North Carolina provide habitat to a variety of migratory shorebirds, colonial waterbirds, marine mammals, reptiles, fish and macro-infauna. For this reason, these habitats are considered to be a valuable natural resource. These habitats have developed in a dynamic system and therefore tend to be ephemeral in nature, especially with regard to dynamic island formation within the inlet. These resources are primarily found within the Permit Area in tidal areas associated with Shallotte River as well as within Shallotte Inlet. A total of 42 acres of intertidal flats and shoals are located within the Permit Area. These resources are primarily found within Shallotte Inlet and the lower portion of the Shallotte River.

Benefits of Tidal Flats and Shoals to Shorebirds, Colonial Birds and Other Waterbirds

During all months of the year, Shallotte Inlet provides important foraging, roosting and nesting habitats for shorebirds, colonial birds, and other waterbirds. The intertidal shoals and sand flats provide isolated habitat for roosting and foraging. Most shorebirds are aquatic and terrestrial probers/gleaners that can wade in the surf of intertidal areas. Prey resources for shorebirds include mainly invertebrates and small fish. Breeding and non-breeding federally endangered species and species of special concern also utilize intertidal flats and shoals. Therefore, Shallotte Inlet's habitats and the shorebirds that utilize them are a very important natural resource to the coast of North Carolina.

Benefits of Tidal Flats and Shoals to Benthic Macroinfaunal Community

These tidal flats and shoals in the inlet complex provide habitat for the macroinfaunal community due to their softbottom consistency. Softbottom habitats are comprised of unconsolidated sediment and defined as "unvegetated", lacking visible structural habitat. However, this "soft" substrate supports an abundance of macroalgae and numerous burrowing organisms (macroinfauna) living below the surface (Street *et al*., 2005).

Macroinfaunal species are resident to the upper 1 m (3.28 ft) of the substrate due to the available oxygen content and aeration properties; although some larger species may live deeper in the seabed (USFWS, 2002). Dominant macroinfaunal species typical of the bays and sounds of North Carolina include bivalves, decapods, polychaetes, and amphipods.

Macroinfaunal species are a primary food source for several migratory and resident shorebirds, waterbirds, and many commercially and recreationally important fish. Bird species can be found utilizing Shallotte Inlet and the surrounding estuarine environments as a stop-over feeding station while traveling to their wintering and nesting grounds. Migratory fish species utilizing the inlet depend upon the macroinfaunal community as a food reserve en route to upstream estuarine habitats.

Benefits of Tidal Flats and Shoals to Fishery Resources

As stated above, these habitat areas host an abundance of macro species which are food sources for many fishery resources. The tidal flats and shoals of North Carolina are habitat to a variety of, anadromous, estuarine, and marine fish species (USFWS, 2002), such as cobia (*Rachycentron canadum*), lane snapper (*Lutjanus synagris*), red drum (*Sciaenops ocellatus*), red grouper (*Epinephelus morio*), spadefish (*Chaetodipterus faber*), gag (*Mycteroperca microlepis*), king mackerel (*Scomberomorous cavalla*), white shrimp (*Penaeus setiferus*), brown shrimp (*Penaeus aztecus*), pink shrimp (*Penaeus duorarum*), Atlantic sharpnose shark (*Rhizoprionodon terraenovae*), southern flounder (*Paralichthys lethostigma*), and summer flounder (*Paralichthys dentatus*) (USFWS, 2002). These species benefit from tidal flats and shoals as the habitat is used for refuge, corridor, nursery, and spawning purposes (Deaton et al., 2010).

Oceanfront beach and dune habitats

Section 15A NCAC 7H .0305(c) of the North Carolina Administrative Code defines primary dunes as the first mounds of sand located landward of the ocean beaches having an elevation equal to the mean flood level (in a storm having a one percent chance of being equaled or exceeded in any given year) for the area plus six feet.

F. Oceanfront Dry Beach and Dune Habitats

1. Oceanfront Dune Communities

The primary dune extends landward to the lowest elevation in the depression behind that same mound of sand (commonly referred to as the dune trough). Frontal dunes are defined as the first mound of sand located landward of the ocean beach having sufficient vegetation, height, continuity and configuration to offer protective value (NCDCM, 2008).

Dunes and their associated plant species are important in providing shorefront protection against coastal storms and supplying sand to the beach system during periods of erosion. A total of 159 acres of dune communities are located within the Permit Area primarily, the oceanfront shoreline along Ocean Isle Beach and Holden Beach behind the dry beach habitat. This habitat is also found within the back side of the inlet system.

Benefits of Oceanfront Dune Communities to Plant Species

High temperatures, strong winds, and varying wet and dry conditions typical of a dune environment provide unique conditions for plant species with specific adaptations. These specific adaptations include plant species that grow extensive root systems, allowing for prolific growth in unconsolidated beach sand. Perennial grasses are the primary stabilizers of frontal dune systems along beaches and dunes. North Carolina is located in a vegetation transition zone, between American beach grass (*Ammophila breviligulata*) to the north, and sea oats (*Uniola paniculata*) to the south.

2. Oceanfront Dry Beach Communities

Eroded material from the dune system contributes to the dry beach located between the toe of dune or scarp and mean high water (MHW) line. The dry beach area is susceptible to wind and storm surge, which supports less vegetation than the dune community. However, this habitat type provides recreational areas for humans and nesting grounds for sea turtles and shorebirds. A total of 114 acres of dry beach communities are located along the ocean shoreline on Ocean Isle Beach and Holden Beach within the Permit Area.

Benefits of Oceanfront Dry Beach Habitats to Sea Turtles

Five (5) species of sea turtles nest on North Carolina beaches: the green sea turtle, loggerhead sea turtle, leatherback sea turtle, hawksbill sea turtle and Kemp’s ridley sea turtle. Sea turtles prefer to nest on wide sloping beaches or near the base of the dunes. Dry beaches must allow for the following in order for nesting to be successful: beach areas above the mean high water line must be wide enough to allow nesting to occur; access to the dry beach must be devoid of obstructions (i.e. fencing, seawalls); the sand compaction must allow for digging, and; the nesting area must be located away from areas of inundation throughout the nesting season. The composition, color, and grain size can affect the incubation time, gender, and hatching success of turtle hatchlings (Street *et al*., 2005).

Benefits of Oceanfront Dry Beach Habitats to Shorebirds, Colonial Waterbirds and other Waterbirds

Beach-nesting birds that utilize dry beach habitats for nesting include terns, black skimmers, Wilson’s plovers, piping plovers and American oystercatchers. Terns and black skimmers nest on bare sand and shell with little or no vegetation. These species will change nesting areas in response to changing environmental conditions, such as increased vegetation. Waterbirds use group dynamics to select suitable nesting areas. This grouping creates nesting, resting, and foraging areas with large colonies that can include multiple species of waterbirds (Cameron, pers. comm., 2007). This is one reason why it is important that these birds have a number of suitable nesting, foraging, and roosting sites along the coast. For colonial waterbirds such as black skimmers and gulls, they utilize estuarine habitats, oceanfront shorelines, open dunes, inland areas, and dry beach habitats for foraging, roosting, and nesting. Portions of the Permit Areas are regulated under a Critical Habitat listing as identified in the Endangered Species Act.

G. Wet Beach Communities

The intertidal zone of oceanfront barrier island beaches or wet beach communities are areas that are periodically exposed and submerged by tides, varying in frequency and with lunar tidal cycles. Like intertidal shoals, these areas are comprised mainly of sandy bottoms and shell hash and are influenced by tidal changes and are susceptible to storms. This high energy area is habitat to many benthic organisms and foraging grounds for birds and finfish. A total of 63 acres of wet beach habitat are found primarily along the oceanfront shoreline of Ocean Isle Beach and Holden Beach within the Permit Area.

1. Benthic Infaunal Community

On oceanfront beaches, most benthic organisms in the intertidal zone consist of infaunal burrowing forms, particularly polychaete worms (Phylum Annelida), coquina clams (*Donax variabilis and D. paruvula*) and mole crabs (*Emerita talpoida*) (USFWS, 2002). Many benthic organisms are filter feeders, which pump large amounts of water through their bodies. As they pump water, they remove sediments and organic matter, thus filtering the water. Some of the organic matter filtered from the water is not used and instead deposited in the sediment. These nutrients can later be recycled by benthic organisms and dispersed back into the water column, making them available to other organisms. Thus, benthic organisms are critical in maintaining the high production rates of estuaries.

While several species of amphipods and polychaetes populate the intertidal and shallow subtidal beaches of North Carolina, their contribution to the total biomass of benthic infauna is low due to their small body size. Due to their short life spans and frequent reproduction events and despite their relatively low biomass, these species are important to the benthic infaunal community in regard to their contribution to primary and secondary productivity. Therefore, mole crabs and coquina clams dominate the benthic infaunal community due to their biomass (Peterson *et al.*, 2000).

- Mole Crab

Mole crabs (*Emerita talpoida)* live at depths above 5 cm under sand in shallow water in the swash zone or marine intertidal areas (Bowman and Dolan, 1985). *E. talpoida* is a very mobile species and is highly adaptable to the harsh and dynamic swash zone environment. Mole crabs have the color of rippled sand at the water's edge and live mostly buried in the sand, with their antennae reaching into the water forming a "V" shaped obstacle in the water as the wave recedes. These antennae filter plankton and organic debris from the water. Mole crabs also eat the tentacles of Portuguese man o' war (*Physalia physalis*), which are collected by winding the tentacle around the mole crab's leg. Camouflage protects the mole crab from predators, primarily fish and birds. Males are smaller than females, only reaching 20 mm, making the sexes easy to tell apart when fully grown. Females grow to 35 mm in length and carry their bright orange colored eggs under their telson until they are ready to hatch. Recruitment can occur year round, but large numbers of recruits are found in early summer and in early fall. Diaz (1980) found that most recruitment occurred in September as a result of summer spawning. Amend and Shanks (1999) also found that the reproductive season ended in late September.

Female mole crabs do not rely on tidal cues to time larval release; instead, larvae are released at sunset regardless of the time of the tide. Since larval release occurs within the intertidal zone, the physical wave motions and currents are most likely strong enough to transport larvae away from the shoreline to coastal areas for development (Ziegler and Forward, 2005). Amend and Shanks (1999) reported that larval release is also influenced by wave height during rough seas where larvae are rapidly transported offshore away from adult habitat and predation.

As the swash zone changes with the tide, so does the location of the mole crabs. The mole crabs move up and down the beach with the tides. In the winter, storms carry them offshore possibly into sandbars; however, when the sand is transported back onshore in the spring, the mole crabs travel with it. Bowman and Dolan (1985) found that the overwintering populations migrate onshore in April during a period of rapidly increasing water temperatures. These population fluctuations are an important consideration when using *E. talpoida* as an indicator species for assessing environmental impacts.

- Coquina Clam

Coquina clams (*Donax variabilis)* are small, generally less than 2.5 cm in length, and possess wedge-shaped shells (Ruppert and Fox, 1988). Like most bivalves, coquinas are filter feeders, ingesting phytoplankton, bacteria, and other small suspended particles in the surf zone. The wet beach environment is extremely dynamic, eroding and accreting several times in a period of months. Although many organisms feed in the surf zone, this clam has unique adaptations to this habitat type, making the coquina clam a key habitat indicator species.

Donax variabilis migrates shoreward with the incoming tide and seaward with the outgoing tide (Ellers, 1995). While these clams spend most of their time buried in the sand, they emerge several times per tidal cycle to ride waves. Ellers (1995) named this method of movement "swash-riding" where each clam emerges from the sand and the flow from waves drags it to a new position to maintain optimum position at the sea's edge. Coquina clams actively migrate up and down the beach during spring and summer; however these tide-related migrations cease in winter as *D. variabilis* eventually moves into the subtidal zone in late fall. The fluctuation of the location of populations in relation to the changing tides is an important consideration when assessing this species and one should expect variation if sampling at different tidal levels.

Both males and females are required for reproduction. Spawning occurs subtidally in winter and juveniles recolonize the intertidal beach in late winter (Ruppert and Fox, 1988). The typical lifespan of coquina clams is two years.

The temporal pattern of presence and recruitment of macroinvertebrates of the South Atlantic Bight are depicted in Table 4.2 below.

Table 4.2. Temporal presence and major recruitment periods of surf zone invertebrates of the South Atlantic Bight (Hackney, et al., 1996).

Species	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Coquina Clams (Donax variablis)	P	P	P	P	H	H, R	H,R	H	H	H	P	P
Ghost Crabs (Ocypode quadrata)	P	P	P	P	P	P, R	P, R	P, R	P, R	P	P	P
Beach Hoppers (Orchestiodea)	?	?	P	P	P	P	P	P	P	P	P	P
Sand Hoppers (Talorchestia)	?	?	P	P	P	P	P	P	P	P	P	P
Worms (Polychaetes)	P	P	P, R	H, R	H, R	H, R	H, R	H, R	H, R	H	P	P
Mole Crabs (Emerita taploidea)	P	P	P	P	H	H	H	H, R	H, R	H	P, R	P, R

P = present, H = periods of peak abundance, R = periods of recruitment

<u>Benefits of Wet Beach Habitats to Fishery Resources</u>
Many infaunal species are important food sources for demersal predatory fishes and mobile crustaceans. Some of the species that forage on benthic invertebrates in the swash zone include inshore lizardfish (*Synodus foetens*), Florida pompano (*Trachinotus carolinus*), pigfish (*Orthopristis chrysoptera*), pinfish (*Lagodon rhomboids*), spot (*Leiostomus xanthurus),* kingfish (*Menticirrhus littoralis, M. americanus*), red drum (*Sciaenops ocellatus*), Atlantic croaker (*Micropogonias undulates*), northern sea robin (*Prionotus carolinus*), summer flounder (*Paralichthys dentatus*), weakfish (*Cynoscion regalis*) and penaeid shrimp (Street *et al*., 2005). Many of these species use the high energy environment as protection from other predatory species, as well as for feeding grounds.

<u>Benefits of Wet Beach Habitats to Shorebirds, Colonial Waterbirds, and Other Waterbirds</u>
Many infaunal species are important food sources for a variety of bird species, especially the beach-nesting birds. Colonial waterbirds, such as gulls and black skimmers that utilize estuarine habitats, oceanfront shoreline, open dunes, and inland areas also utilize wet beach habitats for foraging, roosting, and nesting. These colonial waterbirds can rapidly populate and alter ranges in response to changes in environmental conditions.

<u>H. Marine Habitats</u>

Cowardin (1979) classifies marine habitats as open ocean waters overlying the continental shelf and its associated high energy coastline where salinities exceed 30 ppt. With this broad classification, many habitats or community types fall within the definition and have previously been, or will be, discussed in other sections of this EIS. This section, however, will focus on soft and hardbottom communities that are considered marine habitats. Marine nearshore softbottom communities are found in the intertidal zone as well as the subtidal zone. Marine intertidal and subtidal zones along the shoreline are highly affected by tides and bottom friction. North Carolina's tidal amplitude along ocean shoreline is greatest where the continental shelf is widest in the southern coastal area; average tidal height is approximately 2 ft near Cape Hatteras and 4.3 ft near Cape Fear (Street *et al*., 2005).

1. Softbottom (Unconsolidated) Communities

Softbottom habitat is the unvegetated bottom sediment in all coastal systems, and includes features such as inlets, shoals, channel bottoms, intertidal ocean beaches, and cape shoals. Softbottom plays a key role in primary productivity in shallow estuarine and marine systems. This habitat strongly influences the water column through dynamic cycling processes, storing and releasing nutrients and chemicals over time. Other ecosystem functions of softbottom include the reduction of physically destructive storm effects on oceanfront beaches, and providing sand sources for barrier island and inlet migration.

Softbottoms consist of both mud and sand substrates. Mudflats are sedimentary intertidal habitats created by deposition in low energy coastal environments, particularly estuaries and other sheltered areas and therefore are not pervasive in marine habitats. The sediments generally consist of silts and clays with a "high organic content" (NMFS, 2006). Sand bottoms consist of materials with grain sizes more coarse than silt (>0.0625 mm). Periodic storms can affect benthic communities along the Atlantic coast to depths of approximately 115 ft. As a result, softbottom communities tend to be dominated by opportunistic taxa which have adapted to relatively quick recovery from disturbance (Street *et al.*, 2005). Seasonal climatic changes can also influence the diversity and abundance of macroinfaunal species in these areas. Species abundance during the late winter and early spring is typically higher with densities of over 3,500 per 100cm^2 commonly observed (Mallin *et al*., 2000), although individual species vary considerably in their abundance throughout the year.

Generally, inadequate data are available to clearly indicate the current condition of softbottom habitat. Fortunately this habitat is relatively resistant to a changing environment and is the most abundant submerged coastal fish habitat. This "soft" substrate supports an abundance of macroalgae and numerous burrowing organisms (macroinfauna) living below the surface (Street *et al*., 2005). Intertidal shoal, marine intertidal (wet beach) and subtidal areas in the Permit Area provide a total of 3045 acres of possible habitat for softbottom communities.

Benefits of Softbottom Communities to Fishery Resources

Muddy bottoms are not pervasive in the marine environment, but they are located in the estuarine habitats within the Shallotte River and behind Ocean Isle Beach and Holden Beach. Sandy substrates dominate the marine softbottom communities located off the ocean shoreline.

Softbottom habitat is used to some extent by almost all native coastal fish species in North Carolina. Certain species are better adapted to this shallow non-vegetated bottom. Flatfish, rays and skates are well suited for utilization of softbottom. Juvenile and adult fish species that forage on the rich abundance of macroalgae, detritus and small invertebrates are highly dependent on the softbottom. Softbottom habitat is particularly important as a foraging area for all size ranges of bottom feeding fish and invertebrates, such as blue crabs, shrimp, flounders, striped mullet, spot, croaker, and kingfish. Burrowing mollusks (e.g., hard clams, coquina clams), flatfishes (e.g., southern flounder, hogchoker) and baitfish (e.g., striped mullet) are highly associated with shallow softbottom, while larger benthic feeding predators (e.g., weakfish, coastal sharks, sturgeons) typically utilize deeper softbottom areas. On April 5, 2012, NMFS listed the Carolina Distinct Population Segment of Atlantic sturgeon as a federally endangered species and the ASMFC has developed a Coastal Shark FMP and NMFS includes sharks in its Consolidated Atlantic Highly Migratory Species FMP. Recent assessment results indicate great uncertainty about the various shark species. Its current status is of concern because of the overfished status of sandbar shark, dusky, blacknose, and porbeagle. The scalloped hammerhead has been petitioned for threatened or endangered status (NCDMF, 2012).

Valued fishery species that depend on healthy softbottom habitat include hard clams, shrimp, blue crabs, southern flounder, Atlantic croaker, striped mullet, kingfish, and spot. Of these, the NCDMF 2012 stock status of Atlantic and shortnose sturgeons and southern flounder was listed as “Depleted”. The stock status of blue crabs, coastal sharks and Atlantic croaker was listed as “Concern”.

Offshore sand bottom communities along the North Carolina coast are relatively diverse habitats containing over a hundred polychaete taxa (Posey and Ambrose, 1994). Tube dwellers and permanent burrow dwellers are important benthic prey for fish and epibenthic invertebrates.

<u>2. Hardbottom (Consolidated sediment) Communities</u>

The term “hardbottom” refers to areas of rock or consolidated sediments in temperate, subtropical, and tropical regions, generally located in the ocean rather than in the estuarine system. Hardbottom habitats are also called “live bottom” due to the variety and abundance of invertebrates and plants that attach to or bore into these hard substrates. The topography of these habitats can vary from a relatively flat, smooth surface to a scarped ledge with stepped relief. Hardbottom habitats include shallow kelp-covered areas in rocky headlands, rock outcrops, submarine canyon walls, and the deep-water plateau. Along the south Atlantic states, hardbottom ranges from the shoreline and nearshore (within the state’s 3-mi jurisdictional limit) to beyond the continental shelf edge (>200 m deep). It typically occurs in clusters across the shelf in specific areas. Estimates of the percent cover of hardbottom vary greatly along the south Atlantic coast between Cape Canaveral and Cape Hatteras (NOAA, 2007; Street *et al.*, 2005).

Benthic water temperatures at hardbottom habitats in the ocean off North Carolina range from approximately 52.8° F to 80.6° F (11° C to 27° C). Salinity is typically around 35 ppt with little fluctuation. The composition of invertebrate, algal, and fish communities varies with temperature, depth and season.

Based on the 2010 CHPP location map of hardbottom in vicinity to Ocean Isle Beach, shown in Figure 4.5, no hardbottom habitats are likely to be present within the Permit Area.

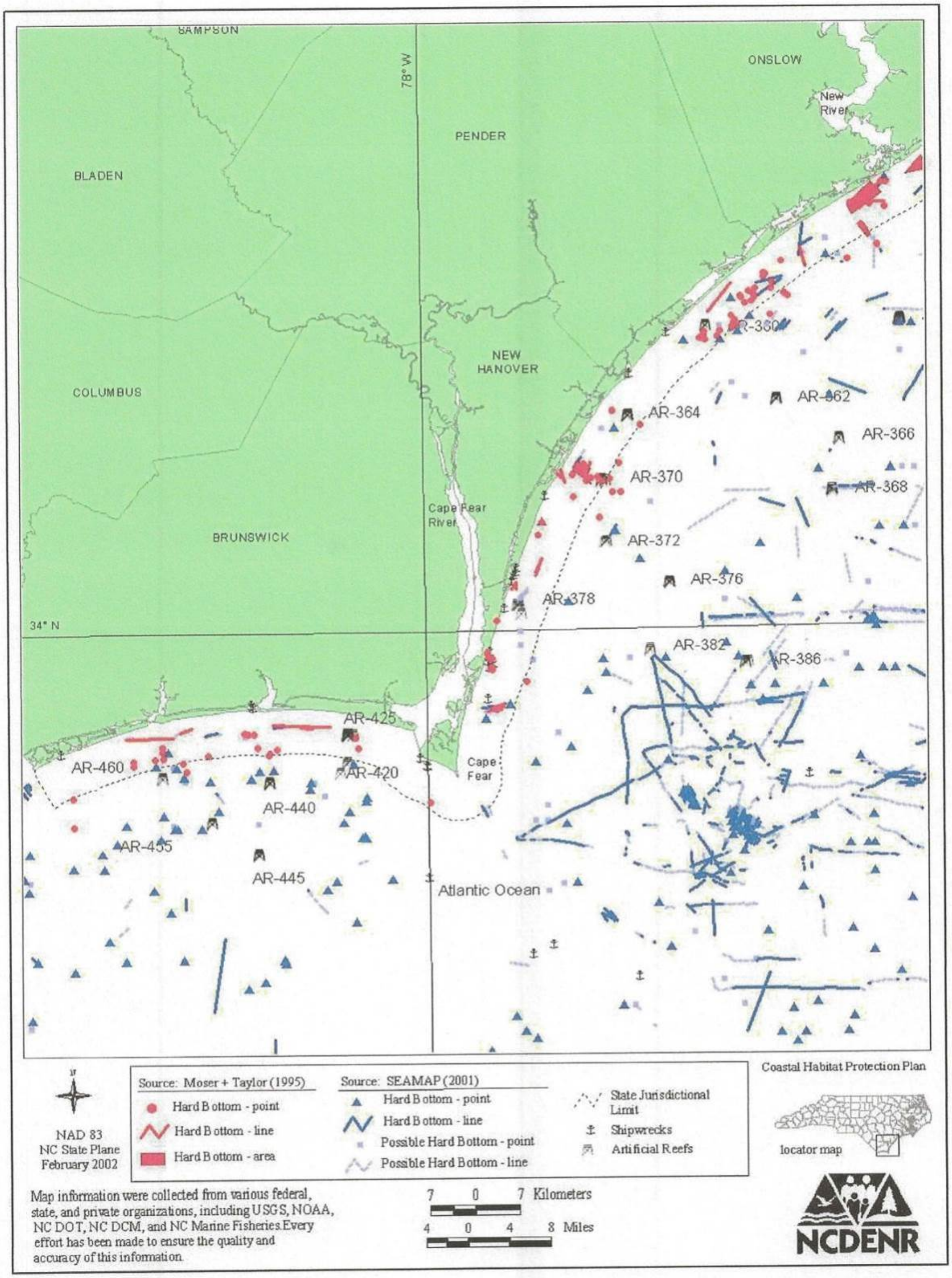


Figure 4.5. 2010 CHPP Location of hardbottom, possible hardbottom, shipwrecks, and artificial reefs in state and Federal water of North Carolina – southern coast.

I. Water Column

> **Water column**
>
> Water column habitat is defined in North Carolina's Coastal Habitat Protection Plan (CHPP) as "the water covering a submerged surface and its physical, chemical, and biological characteristics" (Deaton, *et al.,* 2010). It connects all other aquatic habitats, and is the "medium of transport for nutrients and migrating organisms between river systems and the open ocean" (SAFMC, 1998).

The water column is a conceptual column of water ranging from its surface to bottom sediments. The concept of water column is important since many aquatic processes are explained by the vertical mixing of chemical, physical or biological parameters. The depth of water column varies greatly throughout the Permit Area. Within the waterbodies in proximity to Shallotte Inlet and Intracoastal Waterway, the depth ranges from less than 1 foot to approximately -14 feet MLW; and the water column depth from the inlet gorge to the outer bar channel of Shallotte Inlet ranges from approximately -5 feet to nearly -20 feet MLW. Along the ocean shoreline, the water column ranges from approximately -2 feet deep within the surf zone to approximately -25 feet deep. Conditions that influence the water column are hydrodynamic flow processes and salinity levels. The water column encompasses approximately 2,940 surface acres within the Permit Area.

1. Hydrodynamics and Salinity

Hydrodynamic flows in nearshore shallow environments, including the surf zone, are different from coastal and deep-ocean flows mainly because of the shoreline barrier, shallow depths, bathymetric features associated with the continental shelf, and nearshore inputs of freshwater. Moreover, flows in nearshore waters tend to be more complex than in the deep and coastal ocean because many processes operate there, including surface gravity waves, buoyancy driven flows, wind-forcing, surface and internal tides, large-amplitude internal waves and bores, and boundary-layer effects (Pineda et al, 2007). These differences between nearshore and coastal/open ocean hydrodynamics are important for larval transport.

Ocean tides on Ocean Isle Beach are semi-diurnal (occurring approximately every 12 hours), with a spring-neap variation of 28 days. In the throat of the inlet, the tidally influenced currents are flood-dominated, which means that water flows are greater as the water flows from the ocean through the inlet. For more information regarding the tides and tidal flow within the Permit Area, refer to the Engineering Analysis (Appendix B).

A primary factor affecting the distribution of estuarine-dependent fish and shellfish is salinity. Marine waters of the Permit Area vary on a daily basis in current and salinity conditions due to fresh water inflow, tides, and wind.

Benefits of Water Column to Fishery Resources

Estuarine and marine water column environments in the Permit Area include the beach areas and surf zones of Ocean Isle Beach, Holden Beach, and Shallotte Inlet. Fish that utilize the water column of North Carolina include: anadromous fish, which can be found in coastal waters but migrate into rivers to spawn in freshwater (e.g. striped bass, Atlantic and shortnose sturgeon, herring); estuarine-dependent species (e.g. flounder, blue crab, penaeid shrimp, red drum); permanent resident species (e.g. black sea bass, Atlantic bumper, lizardfish); and seasonal migrant species (e.g. bluefish, Spanish and king mackerel, cobia, spiny dogfish). The transport of larval fish from the offshore water column to the estuarine nursery areas through inlets plays a vital role in the life cycle of many fish species.

2. Larval Transport

Larval transport is defined as the horizontal translocation of a larva of any species between points (Pineda, et al, 2007). In the southeastern USA, many species of estuarine-dependent fishes spawn offshore and their larvae are transported into estuaries. The dispersal and subsequent retention of larvae back into the estuary is regulated by a number of factors including astronomical and meteorological tides. Some larvae have the capability to actively migrate horizontally and vertically in the water column to utilize the stratification, tidal currents, flows, and other physical properties of the aquatic environment to help regulate their transport from spawning grounds to settlement areas.

Larvae utilize inlets as the conduit between the open ocean and the estuarine environment. Shallotte Inlet, a relatively large inlet separating Ocean Isle Beach from Holden Beach to the east, drains the Shallotte River and connects to the AIWW. The mass of flowing water flowing in and out of the inlet during tidal exchange acts as a conduit for larvae found within the water column in proximity to the inlet. Settle *et al.* (2005) estimated that the larval fish concentrations in proximity to Bogue Inlet ranged throughout the water column between 0.5 and 5.0 larvae per cubic meter. Assuming that there is similar larval concentration in proximity to Shallotte Inlet, Shallotte Inlet would also serve as an important pathway for numerous species of zooplankton into the estuary.

3. What are the characteristics of the threatened, endangered, and State listed species found within the project area?

Federal and State Listed Species

The following section describes the Federal and State listed species that occur, or have the potential to occur in the Permit Area (as listed in Table 4.3).

Table 4.3. Federal and State Listed Species Found or Have the Potential to be Found within the Permit Area

Common Name	Scientific Name	Federal Status	State Status
Reptiles			
Green Sea Turtle	*Chelonia mydas*	Threatened	Threatened
Hawksbill Turtle	*Eretmochelys imbricate*	Endangered	Endangered
Kemp's ridley Sea Turtle	*Lepidochelys kempii*	Endangered	Endangered
Leatherback Sea Turtle	*Dermochelys coriacea*	Endangered	Endangered
Loggerhead Sea Turtle	*Caretta caretta*	Threatened	Threatened
Carolina Diamondback Terrapin	*Malaclemys terrapin centrata*	None	Species of Special Concern
American Alligator	*Alligator mississippiensis*	Threatened	Threatened
Mammals			
West Indian Manatee	*Trichechus manatus*	Endangered	Endangered
North Atlantic Right whale	*Eubaleana glacialis*	Endangered	Endangered
Sei whale	*Balaenoptera borealis*	Endangered	Endangered
Sperm whale	*Physeter macrocephalus*	Endangered	Endangered
Finback whale	*Balaenoptera physalus*	Endangered	Endangered
Humpback whale	*Megaptera novaeangliae*	Endangered	Endangered
Blue Whale	*Balaenoptera musculus*	Endangered	Endangered
Fish			
Shortnose sturgeon	*Acipenser brevirostrum*	Endangered	Endangered
Atlantic sturgeon	*Acipenser oxyrinchus*	Endangered	Endangered
Vascular Plants			
Seabeach amaranth	*Amaranthus pumilus*	Threatened	Threatened
Venus Flytrap	*Dionaea muscipule*	Species of Concern	Species of Special Concern
Coralbean	*Erythina herbacea*	None	Endangered
Saltmarsh Dropseed	*Sporobolus virginicus*	None	Threatened
Moundlilly Yucca	*Yucca gloriosa*	None	Significantly Rare Peripheral
Rain Lilly	*Zephyranthes simpsonii*	Species of Concern	Endangered
Birds			
Piping Plover	*Charadrius melodus*	Threatened	Threatened
Wilson's Plover	*Charadrius wilsonia*	None	Species of Special Concern
Least Tern	*Sternula antillarum*	None	Species of Special Concern
American Oystercatcher	*Haematopus palliatus*	None	Species of Special Concern
Common Tern	*Sterna hirundo*	None	Species of Special Concern
Gull-billed Tern	*Sterna nilotica*	None	Threatened
Black Skimmer	*Rynchops niger*	None	Species of Special Concern
Eastern Painted Bunting	*Passerina ciris ciris*	None	Species of Special Concern
Red Knot	*Calidris canutus*	Threatened	Candidate Species
Insects			
Southern Oak Hairstreak	*Satyrium favonius favonius*	None	Significantly Rare
Coppery Emerald	*Somatochlora georgiana*	None	Significantly Rare

Key: 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."

Species of Special Concern- Any species of wild animal native or once native to North Carolina that is determined by the Wildlife Resources Commission to requiremonitoring but that may be taken under regulations adopted under the provisions of Article 25

A. Reptiles

1. Sea Turtles

Sea turtles are large marine reptiles that spend most of their lives in marine or estuarine habitats. Sea turtles can be found in subtropical and temperate oceans as well as in sub-arctic seas around the world (Musick and Limpus, 1997). Several studies have shown that the beaches adjacent to inshore and offshore waters along the Atlantic Coast of the United States are important foraging and developmental habitats for many threatened and endangered species of sea turtles (Shoop and Kenney, 1992; Ehrhart, 1983; Keinath *et al*., 1987).

Although sea turtles spend most of their lives in the ocean, female turtles must return to land to nest (Miller, 1997). Therefore, oceanfront beaches such as those found along Ocean Isle Beach provide an important habitat for sea turtle survival. Female sea turtles show nest site fidelity by returning to the nesting beach where they hatched (Limpus *et. al*., 1984; Limpus, 1985). Nesting females prefer beaches with limited lighting and open-water access, while other factors such as elevation from water inundation, dune vegetation, beach slope and the moisture and compaction of the sand may also influence site selection (Hendrickson, 1982; Mortimer, 1982). Female sea turtles typically emerge from the water at night, select a nest site and excavate a chamber to deposit their eggs. Females cover the nests and return to sea allowing the eggs to develop for 6 to 13 weeks depending upon the species of sea turtle and the temperature of the nest (Miller, 1985). Hatchlings will emerge at night and migrate from the nest to the ocean where they begin their offshore migration into the open ocean.

Five (5) species of sea turtles utilize the waters of North Carolina for breeding, feeding and development. These species include: the loggerhead sea turtle; green sea turtle; hawksbill sea turtle; Kemp's ridley sea turtle; and the leatherback sea turtle (Epperly *et al*., 1990; USFWS, 2003a). Sea turtles can be found in offshore as well as inshore waters at all times of the year, although they are more common inshore during the spring, summer and fall months (Epperly *et al*., 1995a). Immigration of sea turtles into North Carolina's sounds and estuaries occurs most frequently in the spring with dispersal throughout the sounds as the waters warm. Emigration out of inshore occurs during the latter part of fall when the waters begin to cool. Although the exact numbers and frequencies of species inhabiting the inshore and offshore waters of North Carolina are not available, it is known that these habitats are used at various times throughout the year by all five (5) sea turtle species discussed (Epperly *et al*., 1990). Species composition of turtles captured by fisherman in the inshore waters of North Carolina consisted of loggerheads (71%), greens (17%) and Kemp's ridley (12%) (Epperly *et al*., 1995b). Public sightings reported all five (5) species in inshore waters with leatherbacks and hawksbills being observed infrequently (Epperly *et al*., 1995a).

- *Green Sea Turtle*

Green sea turtle

Breeding populations of green sea turtles along Florida and the Pacific coast of Mexico have been Federally listed as endangered, while all other populations have been listed as threatened under the Endangered Species Act since July 28, 1978. Additionally, a green sea turtle Critical Habitat was designated for the coastal waters surrounding Culebra Island, Puerto Rico (NMFS, 2006). Green sea turtles are mid- to large-sized sea turtles that reach an average weight of 136.2 kg (303 lbs) (Pritchard, 1997). Feeding habitats for adults are specific to seagrasses and marine algae, while hatchlings may be found feeding on various plants and animals. Green sea turtles are generally found near seagrass habitats in shallow aquatic environments, such as nearshore reefs, bays and inlets. Coral reefs and rocky patches may also be utilized for shelter and feeding when seagrass is not available (Hirth, 1997).

The green sea turtle is globally distributed with an estimated population of 600,000 adults (USFWS, 2003b). While green sea turtle populations generally range throughout warm tropical and temperate waters of more than 140 countries, their nesting and feeding grounds are predominantly located along coastal areas between 30° North and 30° South. The green sea turtle nesting season of southern U.S. populations generally occurs between June and September, but varies depending upon its locality. Hatchling incubation time and sex determination are both temperature dependent (Mrosovsky, 1995). Green sea turtle hatchlings emerge at night and migrate offshore spending several years feeding and growing in oceanic current systems (USFWS, 2003b).

Along the U.S. beaches of the Atlantic, green turtles primarily nest in Florida. Less significant nesting populations have been identified in the U.S. Virgin Islands, Puerto Rico, Georgia, South Carolina, and North Carolina (USFWS, 2003b). NCDENR reports that the green sea turtle has been observed in Brunswick, Carteret, Dare, Hyde, New Hanover, Onslow, and Pender Counties. While green sea turtles have been sighted, primarily from spring through fall, along the entire North Carolina coastline, nesting activities have only been observed in Onslow, Brunswick, and Hyde Counties. According to data supplied by the State, one green turtle nest was recorded on Holden Beach between 2009 and 2014 (Godfrey, pers. comm.; www.seaturtle.org, last visited 4/10/15). No green turtles were recorded nesting on Ocean Isle Beach during this time.

- *Hawksbill Sea Turtle*

The Hawksbill sea turtle was listed as endangered in 1970. The hawksbill is also internationally protected under Appendix 1 of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) (NMFS, 2007). A Critical Habitat designation has also been identified for the waters surrounding Mona and Monito Islands of Puerto Rico. These islands provide primary foraging habitat for several life stages for this species (NMFS, 2007; USFWS, 2003c).

Hawksbill sea turtle

Hawksbill turtles are usually found in tropical and subtropical waters of the Atlantic, Pacific and Indian Oceans occurring from 30°N to 30°S latitude (NMFS, 2007). These turtles are widely distributed in the Caribbean and the western Atlantic Ocean. Hawksbill turtles prefer the clear shallow waters of coral reefs, creeks, estuaries and lagoons in tropical areas. Their diet primarily consists of sponges but also includes algae, fish, mollusks, and other benthic species found in the nearshore zone. Adults may reach up to 0.9 m (3 ft) in length and weigh on average about 136 kg (300 pounds) (USFWS, 2003c).

Hawksbill neonate behavior is similar to other sea turtles; they remain pelagic for several years before returning to coral reef habitats. Juveniles move from pelagic to coastal habitats at a much smaller size than other turtles (20 to 25 cm [to 10 in] carapace length) (Lutcavage and Musick, 1985). Juveniles are not often seen in waters deeper than 19.8 m (65 f) (Witzell, 1983), however they are frequently associated with floating *Sargassum* in the open ocean (Musick and Limpus, 1997).

Within the U.S., hawksbill turtles are most common in the waters surrounding Puerto Rico, U.S. Virgin Islands and Florida (NMFS, 2007). Hawksbills are recorded in the continental U.S. from all the Gulf states and from the eastern seaboard as far north as Massachusetts, but sightings north of Florida are rare (NMFS, 2007). The U.S. Fish and Wildlife Service North Carolina Office reports that the presence of hawksbill sea turtles along the North Carolina coast is rare (USFWS, 2007); therefore, none are expected to be present in the study area.

The hawksbill has experienced major population decline with only five regional nesting populations remaining in the Seychelles, Mexico, Indonesia, and two in Australia (USFWS, 2003c). Nesting females lay on average 3-5 nests per season which contain 130 eggs per nest (NMFS, 2007). Nesting season varies with locality, but most nesting occurs sometime between April and November (USFWS, 2003c). According to data supplied by the State, no hawksbill turtle nests have been recorded on Ocean Isle Beach or Holden Beach between 2009 and 2012 (Godfrey, pers. comm.).

- *Kemp's Ridley Sea Turtle*

The Kemp’s ridley sea turtle has been listed as endangered under the Endangered Species Act since December 2, 1970 (USFWS, 2003d). The range of Kemp’s ridley includes the Gulf coast of Mexico, the Atlantic coast of North America as far north as Newfoundland and Nova Scotia, and the Gulf coast of the U.S., especially Padre Island, Texas (USFWS, 2003d). Kemp’s ridley is the smallest of the eight species of sea turtles, averaging 35-45 kg (78-100 lbs) with an average length between 56 and 76 cm (22 and 30 in) (Marquez, 1994; USFWS, 2003d). As juveniles, Kemp’s ridley turtles feed primarily on crabs, clams, mussels, and shrimp and are most commonly found in productive coastal and estuarine areas. Recruitment from pelagic habitats occurs at a carapace size between 20 and 25 cm (7.9 and 9.8 in) (Lutcavage and Musick, 1985).

Hatchlings are dispersed within the Gulf and Atlantic by oceanic surface currents. According to the U.S. Fish and Wildlife Service, rare nesting events have been recorded in Florida, South Carolina and North Carolina (USFWS, 2003d). Most sea turtle species are widely distributed; however, the Kemp's ridley is mostly restricted to the Gulf of Mexico (Miller, 1997). They have also been sighted in shallow coastal waters along the east coast of the United States.

As reported by the USACE (2006):

> *..Kemp's ridley sea turtle is commonly observed migrating within North Carolina inshore waters during the spring and fall, but has been documented to nest only once in North Carolina, on Oak Island in 1992* (Godfrey, pers. comm).

Kemp's ridley turtles are also occasionally found stranded on the beaches of North Carolina (Mihnovets, 2003). These strandings may be attributed to the juvenile sea turtles getting caught in the southern Gulf of Mexico loop current that eventually moves these turtles east and north up the eastern Atlantic coast (Musick and Limpus, 1997). Conservation measures initiated in the late 1970's are thought to be contributing to the Kemp's ridley population recovery; however, the Kemp's ridley sea turtle still remains the rarest sea turtle in the world (Pritchard, 1997). According to data supplied by the state, no Kemp's ridley turtle nests have been recorded on Ocean Isle Beach or Holden Beach between 2009 and 2012 (Godfrey, pers. comm.).

Kemp's ridley sea turtle

- *Leatherback Sea Turtle*

The leatherback sea turtle was listed as an endangered species on June 02, 1970 (under a law that preceded the Endangered Species Act of 1973), and then listed as endangered throughout its range in the United States under the Endangered Species Act of 1973 (NMFS, 2007). A Critical Habitat designation is listed for Sandy Point, St. Croix, U.S Virgin Islands and surrounding waters (NMFS, 2007; USFWS, 2003e).

Nesting leatherback sea turtle

The U.S. range of the leatherback extends from Nova Scotia south to Puerto Rico and the U.S. Virgin Islands. Small nesting populations occur in Florida, St. Croix, and Puerto Rico (USFWS, 2003e). Although nesting in the State of North Carolina is rare, Rabon *et al.* (2003) confirmed seven leatherback turtle nests between Cape Lookout and Cape Hatteras. The nesting frequency included two nests in 1998, four nests in 2000, and one nest in 2002. Leatherback sea turtles nest an average of five to seven times within a nesting season, with an observed maximum of 11 nests. The average inter-nesting interval is about 9-10 days (USFWS, 2003e). While infrequently found in inshore waters, Epperly *et al.* (1995) reported that, on average, 15 leatherback sea turtles per year were sighted in inshore waters (within three miles of shore) of North Carolina between 1989 and 1992. According to Epperly *et al.* (1995) these inshore sightings coincide with the appearance of jellyfish and diminish by late June. The NCWRC (Everhart, 2007) reported a leatherback false crawl in North Carolina in 2007. According to data supplied by the State, no leatherback turtle nests have been recorded on Ocean Isle Beach or Holden Beach between 2009 and 2012 (Godfrey, pers. comm.).

Loggerhead sea turtle

- *Loggerhead Sea Turtle*

The loggerhead sea turtle has been listed in the Federal Register as threatened throughout its range since July 28, 1978 (USFWS, 2003f). Loggerheads are large reddish-brown turtles weighing between 91-159 kilograms (200-350 lbs) (Pritchard, 1997). Adult loggerheads nest at night along sandy beaches and may nest from one to seven times within a nesting season (USFWS, 2003f). The average nest depth for loggerhead sea turtles is 61 cm (24 inches). Loggerhead sea turtles are the only marine sea turtles that have been reported to nest predominantly outside of the tropics (Bolten and Witherington, 2003).

Hatchling loggerheads migrate offshore into circular oceanic current systems (gyres) and are often found in drifting masses of *Sargassum* macroalgae until they have grown to be much larger juveniles (Carr, 1967; Fletmeyer, 1978). Loggerhead sea turtles will remain within the gyre for several years before leaving their pelagic habitats to return to their coastal foraging and nesting habitats (Klinger and Musick, 1995; Bolten *et al.*, 1993). Recruitment into coastal habitats occurs when their carapace length is between 25 and 70 cm (9.8 and 27.5 in) (Lutcavage and Musick, 1985; Bolten *et al.*, 1993).

Five (5) nesting subpopulations in the western North Atlantic have been identified through genetic DNA analysis and include: 1) the Northern subpopulation from North Carolina to Northeast Florida; 2) the South Florida subpopulation north of Cape Canaveral, following the eastern coastline south and around to Sarasota on Florida's west coast; 3) the Dry Tortugas, Florida, subpopulation; 4) the Northwest Florida subpopulation, found along the panhandle of Florida's northwest coast; and 5) the Yucatán subpopulation, which includes the eastern Yucatán Peninsula, Mexico (USFWS, 2003f).

Eighty percent (80%) of all loggerhead nesting that occurs in the southeastern U.S. takes place in Florida. Loggerhead sea turtle nesting occurs to a lesser extent on suitable beaches on islands off the Gulf States and along the entire North Carolina coastline, including Brunswick County where the study area is located (USFWS, 2003f). The Fish and Wildlife Service reported that although declines in nesting since the 1970's have been documented, no long-term trend data is available for the Northern subpopulation (USFWS, 2003f). Bolten and Witherington (2003) reported that studies on the Northern subpopulation from 1989 to 1998 illustrated a stable or declining population trend.

Loggerhead nesting data for the study area on Ocean Isle Beach, North Carolina from 2009 to 2014 shows an average of 22.3 nests per year. Table 4.4 includes the number of loggerhead sea turtle nests that were documented between 2009 and 2014 on Ocean Isle Beach and Holden

Beach, North Carolina (Godfrey, pers. comm.). Figures 4.6 - 4.11 depict the distribution of nests along the beaches within and in proximity to the Permit Area. Godfrey (pers. comm.) expressed the difficulties in reporting sea turtle population and nesting trends since the availability of observers and consistency in data collection can contribute to the unreliability of the data.

Table 4.4. Number of Loggerhead Sea Turtle Nests Documented in defined Permit Area, Ocean Isle Beach and Holden Beach, NC, 2009-2012 (Godfrey, pers. comm., 2012; www.seaturtle.org last visited 4/10/15)

Loggerhead Sea Turtle (*Caretta caretta*)		
Year	**Ocean Isle Beach**	**Holden Beach***
2009	25	23
2010	23	30
2011	22	30
2012	24	46
2013	36	73
2014	4	19

***Data for Holden Beach reflects total number nests documented for entire beach, including those outside of the Permit Area.**

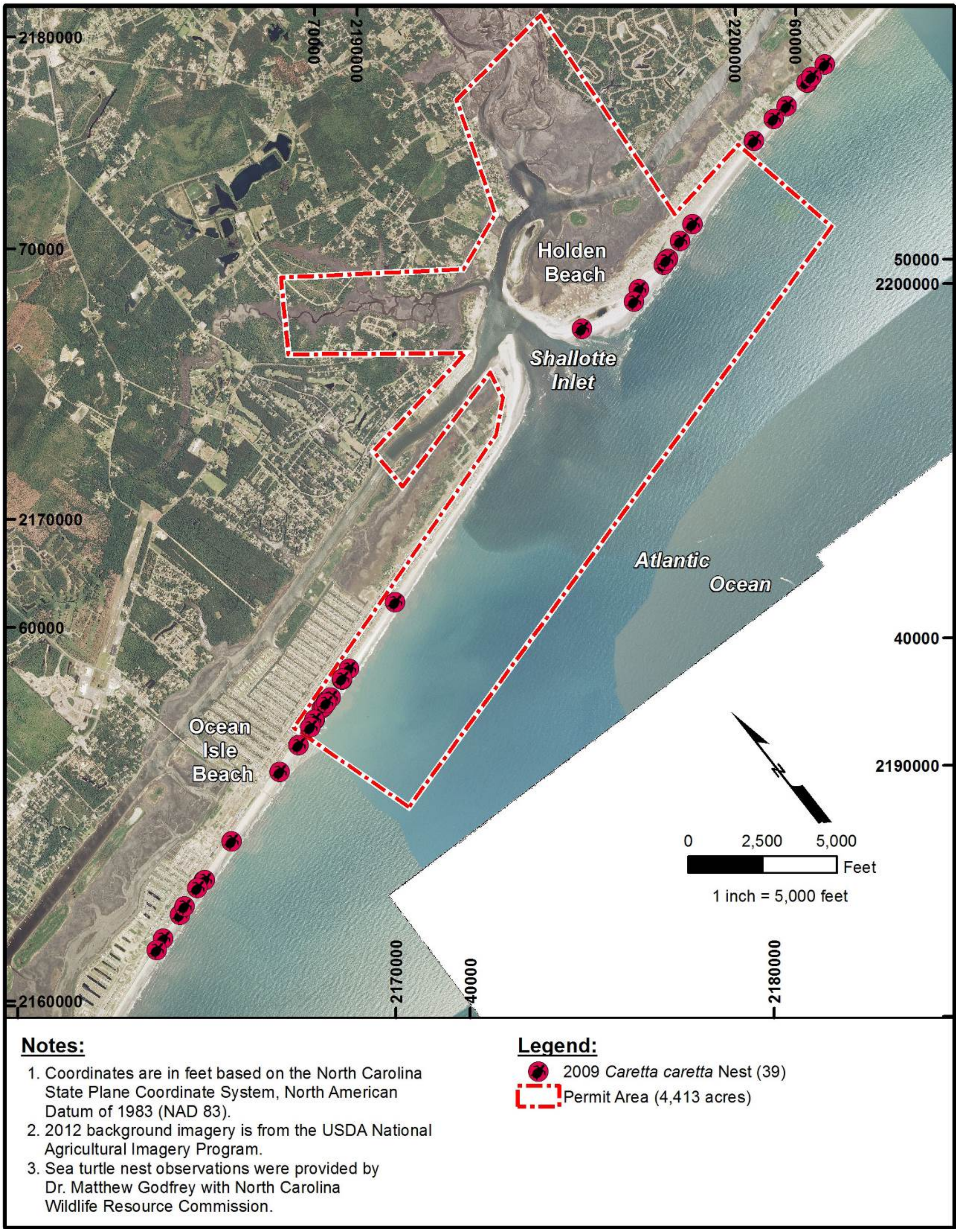


Figure 4.6. 2009 Loggerhead sea turtle nests within and in proximity of the Permit Area.

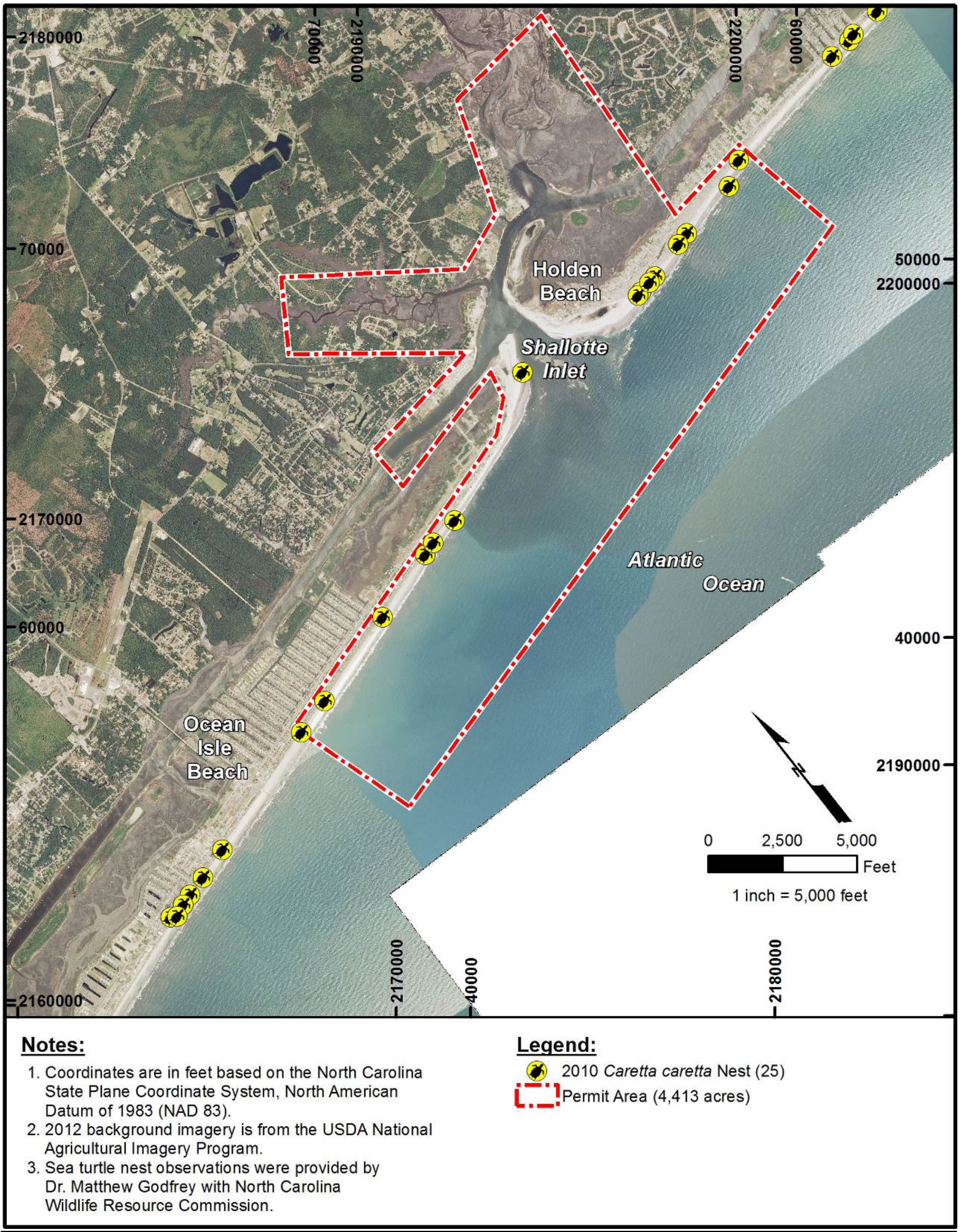


Figure 4.7. 2010 Loggerhead sea turtle nests within and in proximity of the Permit Area.

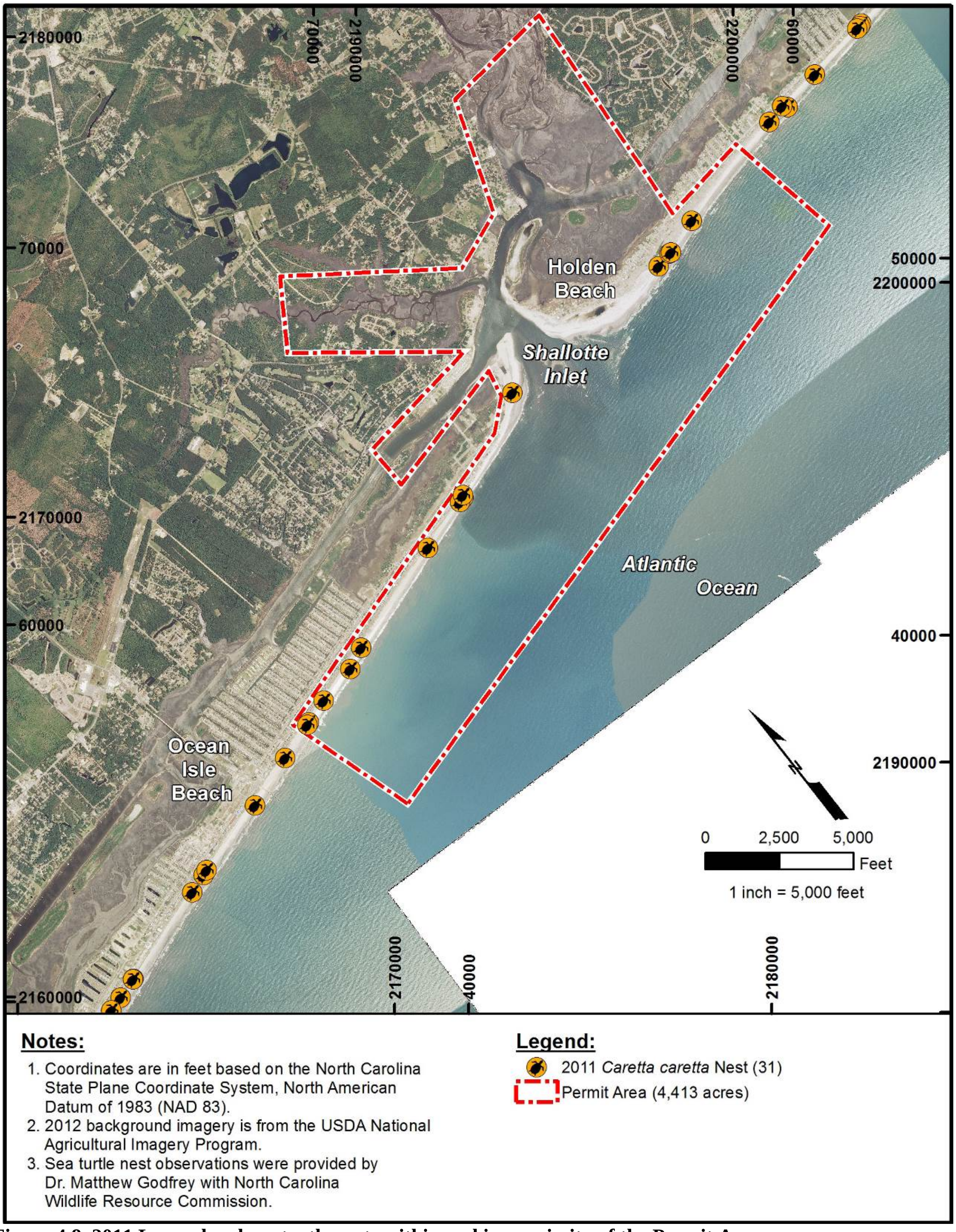
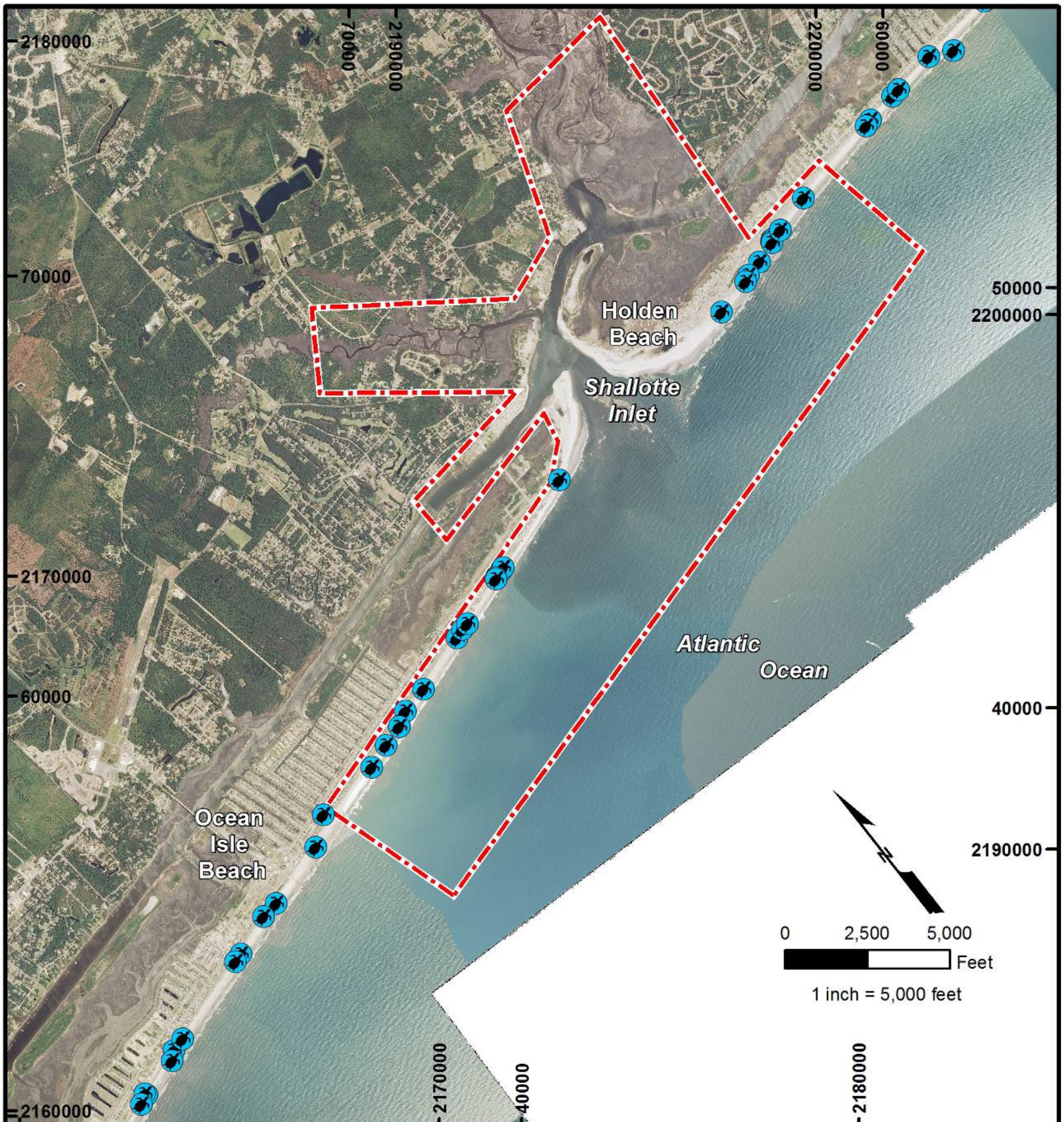


Figure 4.8. 2011 Loggerhead sea turtle nests within and in proximity of the Permit Area.



Notes:

1. Coordinates are in feet based on the North Carolina State Plane Coordinate System, North American Datum of 1983 (NAD 83).
2. 2012 background imagery is from the USDA National Agricultural Imagery Program.
3. Sea turtle nest observations were provided by Dr. Matthew Godfrey with North Carolina Wildlife Resource Commission.

Legend:

2012 *Caretta caretta* Nest (44)

Permit Area (4,413 acres)

Figure 4.9. 2012 Loggerhead sea turtle nests within and in proximity of the Permit Area.

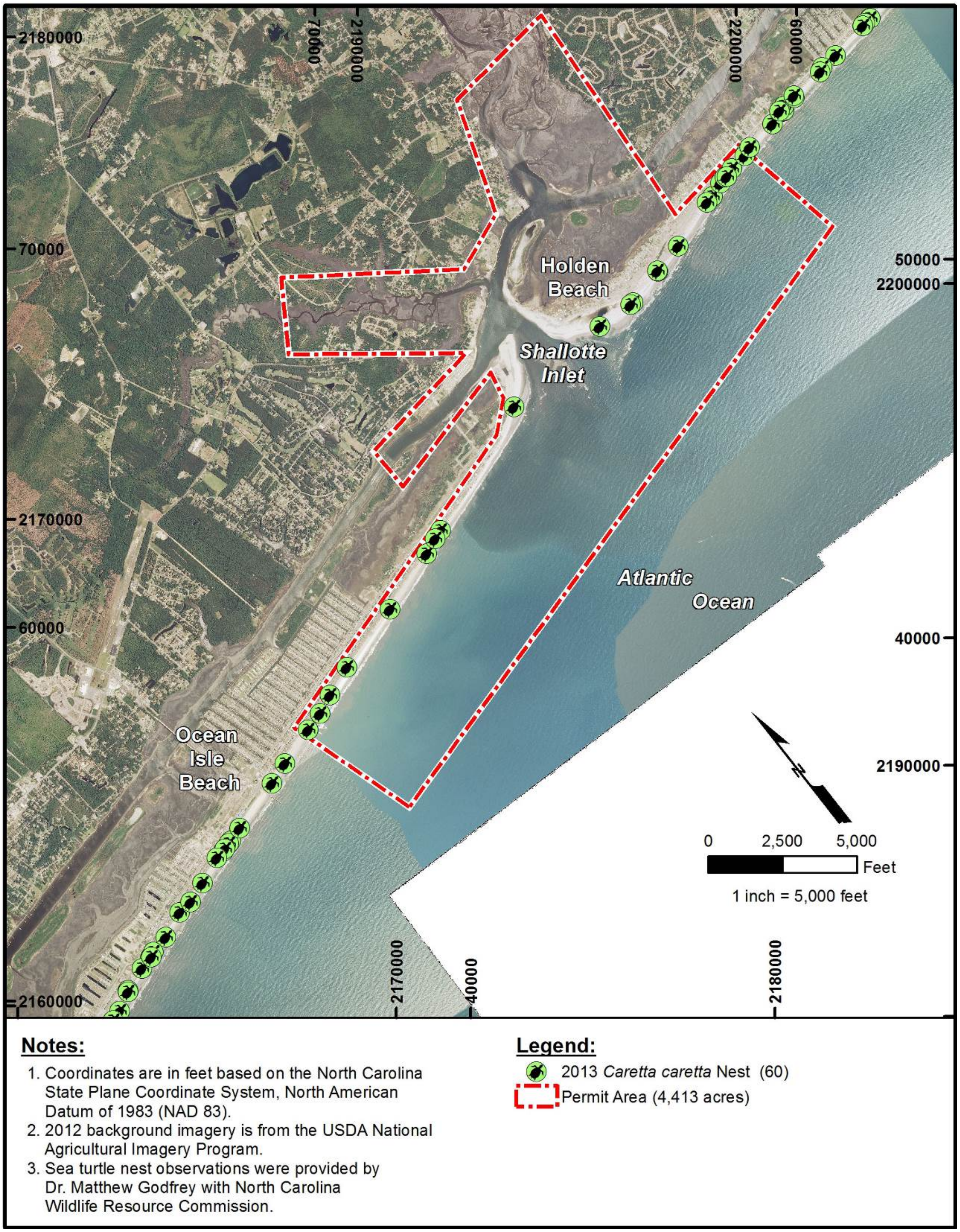


Figure 4.10. 2013 Loggerhead sea turtle nests within and in proximity of the Permit Area.

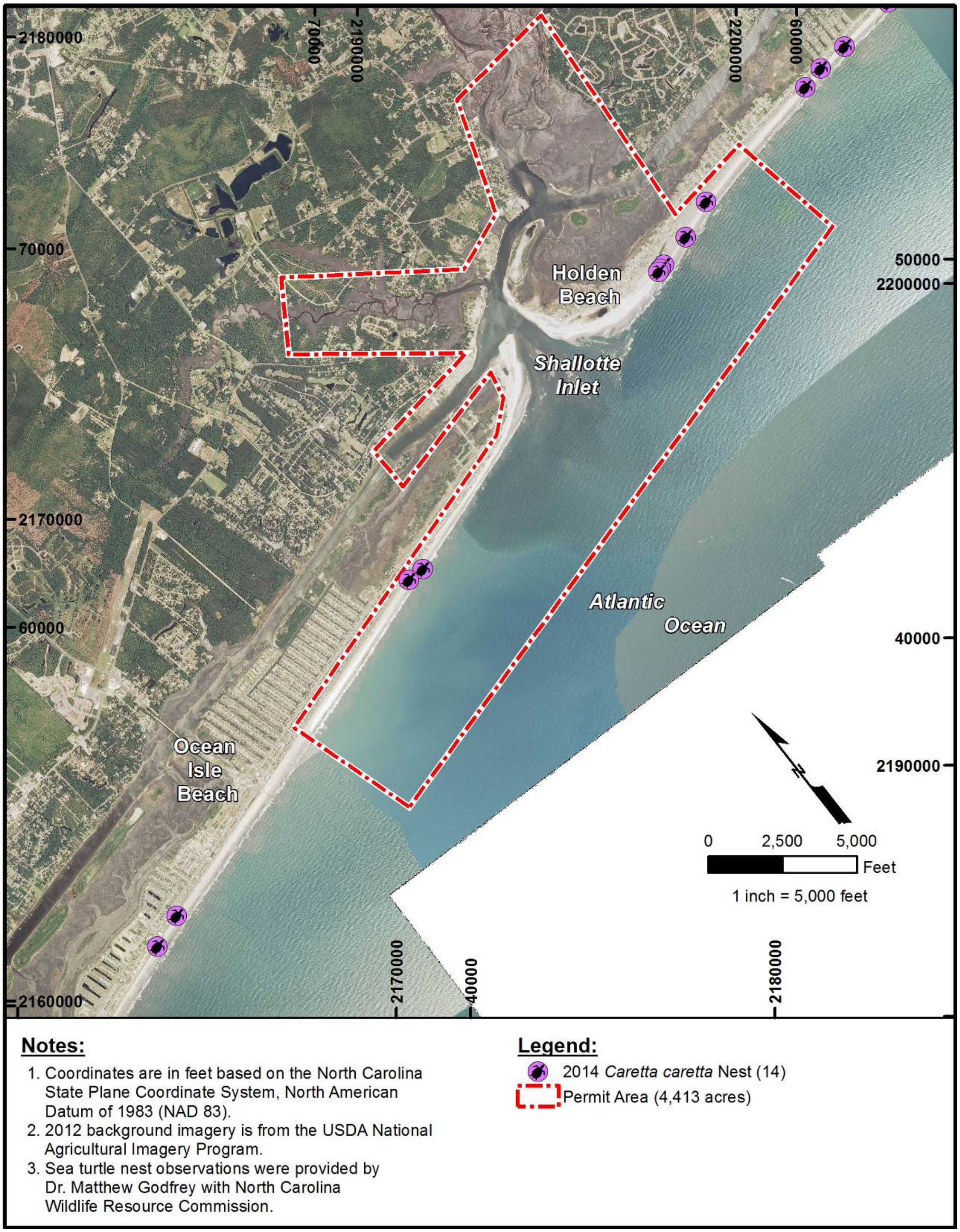


Figure 4.11. 2014 Loggerhead sea turtle nests within and in proximity of the Permit Area.

On July 10, 2014, the USFWS designated 1,189.9 km of the western Atlantic and Gulf of Mexico coastlines as terrestrial critical habitat for the Northwest Atlantic Ocean Distinct Population Segment (NWA DPS) of loggerhead sea turtles. This included 90 units of critical habitat throughout the coastal counties of North Carolina, South Carolina, Georgia, Florida, Alabama, and Mississippi. The rule designates only specific areas of the terrestrial environment within each of the units as critical habitat based on the presence of primary biological features (PBFs) and primary constituent elements (PCEs) deemed essential for conservation of loggerheads. The USFWS describes the PBFs of terrestrial habitat for loggerheads as 1) sites for breeding, reproduction or development of offspring, and 2) habitats protected from disturbance or representative of the historical, geographic, and ecological distributions. PCE's are the specific elements of the physical or biological features that provide for a species' life history processes. For the loggerhead NWA DPS, three PCE's were defined:

- Suitable nesting beach habitat that has (a) relatively unimpeded nearshore access from the ocean to the beach for nesting females and from the beach to the ocean for post-nesting females and hatchlings and (b) is located above MHW to avoid being inundated frequently by high tides
- Sand that allows for suitable nest construction, (b) is suitable for facilitating gas diffusion conducive to embryo development, and (c) is able to develop and maintain temperatures and moisture content conducive to embryo development.
- Suitable nesting beach habitat with sufficient darkness to ensure nesting turtles are not deterred from emerging onto the beach and hatchlings and post-nesting females orient to the sea (78 FR 18000)

A portion of the Permit Area falls within the unit LOGG-T-NC-08, which encompasses 13.4 km (8.3 miles) of shoreline along Holden Beach (Figure 4.12). The habitat within this unit extends from the Lockwoods Folly Inlet to Shallotte Inlet and includes lands from the Mean High Water (MHW) line to the toe of the secondary dune or developed structures. This unit supports expansion of nesting from the adjacent unit LOGG-T-NC-07, which has high density nesting by loggerheads. Unit LOGG-T-NC-08 contains all the PBFs and PCEs considered essential to the conservation of this species (78 FR 18000).

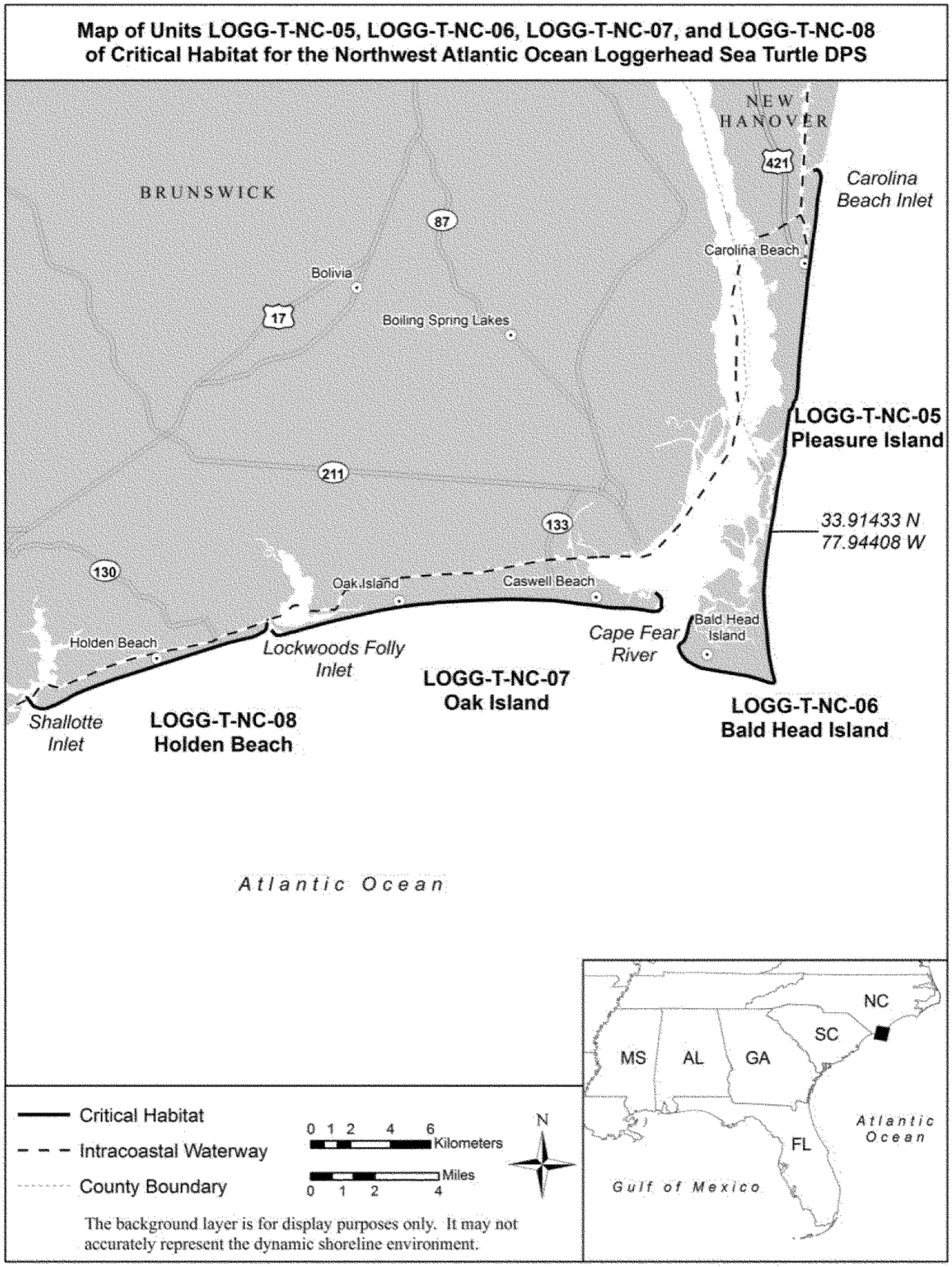


Figure 4.12. USFWS Critical Habitat Units LOGG-T-NC-05, -06, -07, and -08. The Permit Area includes a section of the Holden Beach shoreline, within unit LOGG-T-NC-08 (78 FR 18000).

Additionally, on July 10, 2014, NMFS designated marine critical habitat for the loggerhead sea turtle NWA DPS within the Atlantic Ocean and the Gulf of Mexico. Specific areas include 36 occupied marine areas within the range of the NWA DPS. The NMFS defined habitats essential to conservation of this DPS as neritic (which includes nearshore reproductive, foraging, winter, breeding, and migratory habitats) as well as Sargassum habitat.

PBFs and PCEs for neritic habitat
NMFS identified PFBs and PCEs for each of the neritic and *Sargassum* habitats, which are summarized as follows (Refer to 78 FR 46005 for detailed descriptions of each element):

- Nearshore reproductive habitat PBF is the portion of nearshore waters adjacent to nesting beaches. PCEs include waters offshore the highest density nesting beaches that are free of obstruction or artificial lighting, as well as manmade structures.
- Foraging habitat PBFs include continental shelf or estuarine waters frequently used by adults or juveniles for foraging. PCEs include sufficient prey availability and water temperatures above 10°C.
- Winter habitat PBF includes warm water habitat south of Cape Hatteras, NC near the western edge of the Gulf Stream used during winter months. PCE's include waters above 10°C from November through April, shelf waters near the western boundary of the Gulf Stream, and depths between 20 and 100 m.
- Breeding habitat PBFs include areas supporting high concentrations of reproductive male and female loggerheads. Proximity to the primary Florida migratory corridor and Florida nesting grounds are considered PCEs.
- Migratory habitat PBF is defined as high use, narrow migratory corridors bounded by land and the western edge of the Gulf Stream. PCEs include constricted corridors that concentrate migratory pathways, and passage conditions to allow for movement between nesting, breeding, and foraging areas.
- *Sargassum* PBF includes developmental and foraging habitat for juvenile loggerheads where surface waters form accumulations of floating *Sargassum* and other material. PCEs include areas where *Sargassum* community components are concentrated (e.g. convergence zones and downwelling areas) that have water temperatures suitable for *Sargassum* and loggerheads.

A portion of the Permit Area (specifically, the westernmost end of Holden Beach) falls within critical habitat unit LOGG-N-5, which encompasses nearshore reproductive habitat for the loggerhead sea turtle from Carolina Beach Inlet , around Cape Fear to Shallotte Inlet, from the MHW line seaward 1.6 km. This unit contains areas adjacent to high density nearshore reproductive habitat (including Holden Beach and high density nearshore reproductive habitat of loggerhead sea turtles within North Carolina (78 FR 43006) (Figure 4.13).

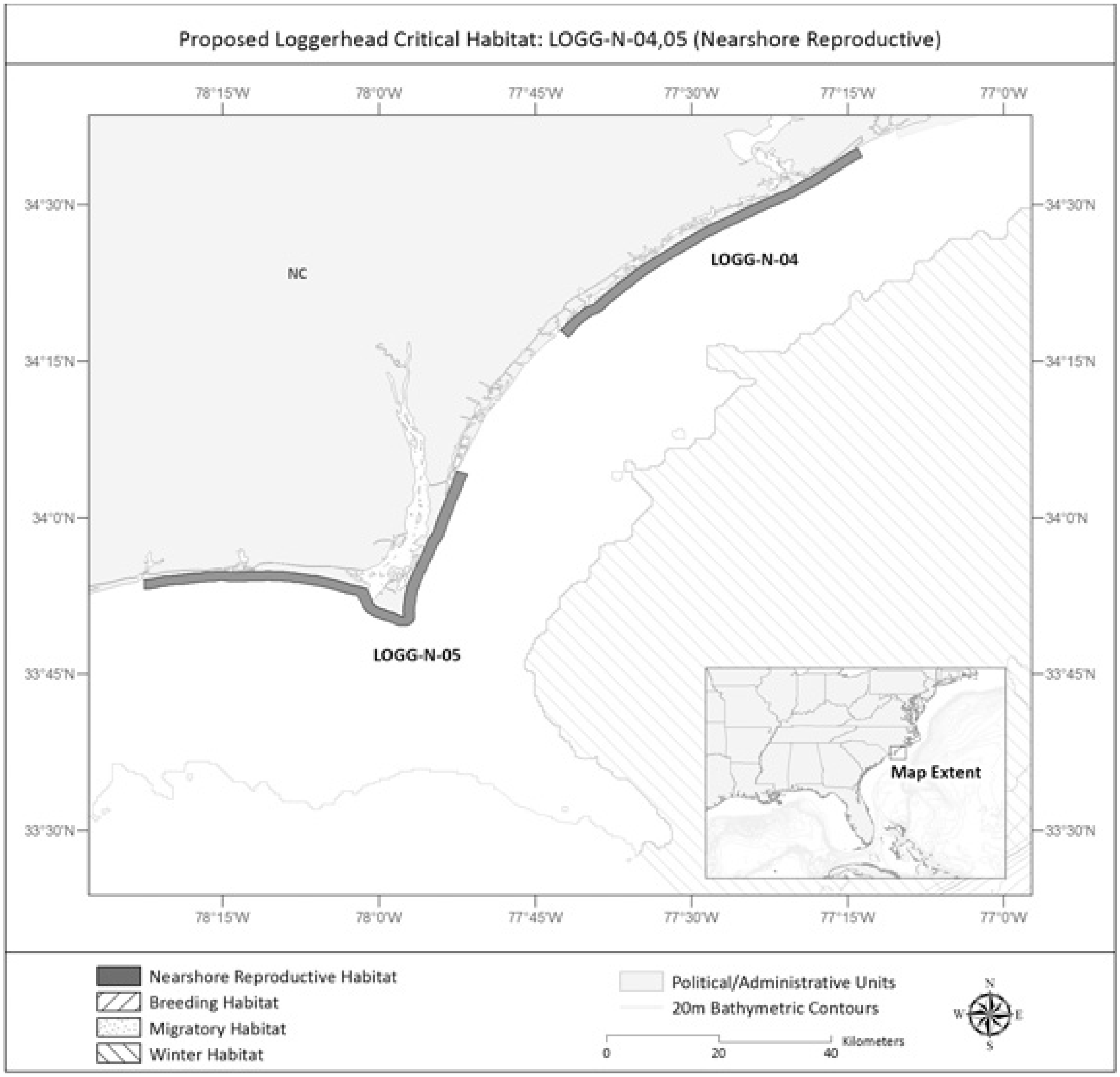


Figure 4.13. NMFS proposed critical habitat units LOGG-N-04 and LOGG-N-05. The Permit Area falls within the unit LOGG-N-05 (78 FR 43006).

2. Terrapins

The Carolina diamondback terrapin (*Malaclemys terrapin centrata*) is State and Federally listed as a Species of Special Concern. They are commonly found within the inshore waters of North Carolina. This subspecies ranges from Cape Hatteras to northeastern Florida and tolerates a wide range of salinities (Robinson and Dunson, 1975). They are the only North American turtle species native to brackish waters and are commonly found in salt marshes, impoundments, tidal creeks, lagoons and mud flats. These areas serve as central feeding grounds for this species throughout most of the year.

Carolina diamondback terrapin

Carolina diamondbacks are primarily carnivorous, feeding upon crabs, snails and nereid worms. During the winter months, Carolina diamondback terrapins hibernate in the muddy burrows along the embankments of tidal creeks. Nesting typically occurs after the mating season in May. Females build nests in sandy substrates above the high tide mark during the months of May and June and eggs are left to incubate for 60 to 120 days depending upon temperature conditions within the nest (Martof *et al*., 1980). Unlike sea turtles, emergence takes place during the day and hatching diamondback terrapins move to the surrounding vegetation rather than out to sea. It has been reported that juvenile terrapins (2.5 to 7 mm [1 to 3 in]) spend their time out of water living beneath surface debris and matted *Spartina* grasses, rarely entering open water. Adult terrapins spend their summer months in full marine conditions and other times of the year are spent in submerged mud and brackish water (Davenport, 1992).

<u>B. Mammals</u>

<u>1. West Indian Manatees</u>

The West Indian manatee (*Trichechus manatus*) is listed as a Federally protected species under the ESA and the Marine Mammal Protection Act of 1972. The average size of an adult manatee is 10 feet, weighing approximately 2,200 lbs and typically referred to as the "sea cow."

West Indian manatee

West Indian Manatees are rare visitors to the Ocean Isle Beach area, however, manatee sightings have been reported in the Atlantic Intracoastal Waterway including observations north of State Highway 101, July 2000; Beaufort waterfront and near Calico Creek, August 1999; Hammocks Beach State Park, June 1998; Sportsman Pier in Atlantic Beach, August 1994; US Coast Guard Station at Fort Macon, August 1994; Barden Inlet, November 1992; Peletier Creek, October 1990; and the west end of Shackleford Banks, August 1983. All of these observations occurred in Carteret County. Though none of these sightings occurred within the project vicinity, it is likely that manatees transit through the region since sightings occurred north of Ocean Isle Beach. Due to a lack of existing literature on the number of manatees utilizing the coastal waters of North Carolina, it is difficult to determine the number of manatees utilizing the nearshore waters of the Cape Fear region and the study area.

<u>2. Whales</u>

Blue, finback, humpback, North Atlantic right, sei, and sperm whales all occur infrequently in the ocean off the coast of North Carolina. Of these, only the North Atlantic Right (NARW) and the humpback whale come close enough inshore to encounter the Permit Area, therefore the following discussion will only consider these two species in greater detail. Both the humpback whale and the right whale are Federally listed as endangered.

- *Humpback Whales*

Humpback whale

Humpback whales (*Megaptera novaeangliae*) were listed as Federally endangered throughout their range on June 2, 1970 under the Endangered Species Act and are considered "depleted" under the Marine Mammal Protection Act. The North Atlantic population of the humpback whale is estimated at 10,600 individuals (Waring et al., 1999), however the minimum population estimates for the Gulf of Maine stock is 647 individuals (NMFS, 1991a).

Humpbacks are found in protected waters over shallow bars and shelf waters, which are used for breeding and feeding. They migrate towards the poles in the summer and toward the tropics in the winter to breeding and birthing grounds. Humpbacks visit the North Carolina coast during the migratory season, especially between the months of December and April (Conant, 1993). Migrating humpbacks can be found nearshore, but probably migrate well offshore of the study area to their principal wintering range (NMFS, 1991a).

- *Right Whales*

Right whale and calf

The right whale (*Baleana glacialis*) is considered the world's most endangered large whale, with a total population of only around 300 individuals. Recent models predict this population will be extinct in less than 200 years (NMFS, 2006). The North Atlantic right whale utilizes six (6) major habitats or congregation areas including the coastal waters of the southeastern United States, the Great South Channel, Georges Bank/Gulf of Maine, Cape Cod and Massachusetts Bays, the Bay of Fundy and the Scotian Shelf. The southeastern United States (Charleston, SC to the east coast of Florida) is considered Critical Habitat for the right whale because of these calving grounds (NMFS, 1991b). A Critical Habitat designation recognizes specific areas "that are essential to the conservation of a listed species, and that may require species management considerations or protection". During late winter and early spring, right whales begin moving north past the North Carolina coast (this includes cow/calf pairs and others wintering south of Cape Hatteras). Southerly migration to wintering areas south of Cape Hatteras begins as early as October (NMFS, 1991b). Right whales have been documented along the North Carolina coast between December and April with the majority of sightings reported between mid to late March. It is unclear as to the frequency with which right whales occur in offshore waters in the southeastern United States (NMFS, 1991b). The Right Whale Program of the New England Aquarium reported that 93% of all North Carolina sightings between 1976 and 1992 occurred between mid-October and mid-April (Slay, 1993). Typically, when spotted, right whales are observed very close to the shoreline only a few hundred meters offshore (Schmidly, 1981).

Aerial surveys were performed by University of North Carolina, Wilmington to monitor North Atlantic right whales (*Eubalaena glacialis*) between October 2005 to August 2006 and February to June 2008. Observations were noted along the flight paths for right whales as well as several other species (Figure 4.14).

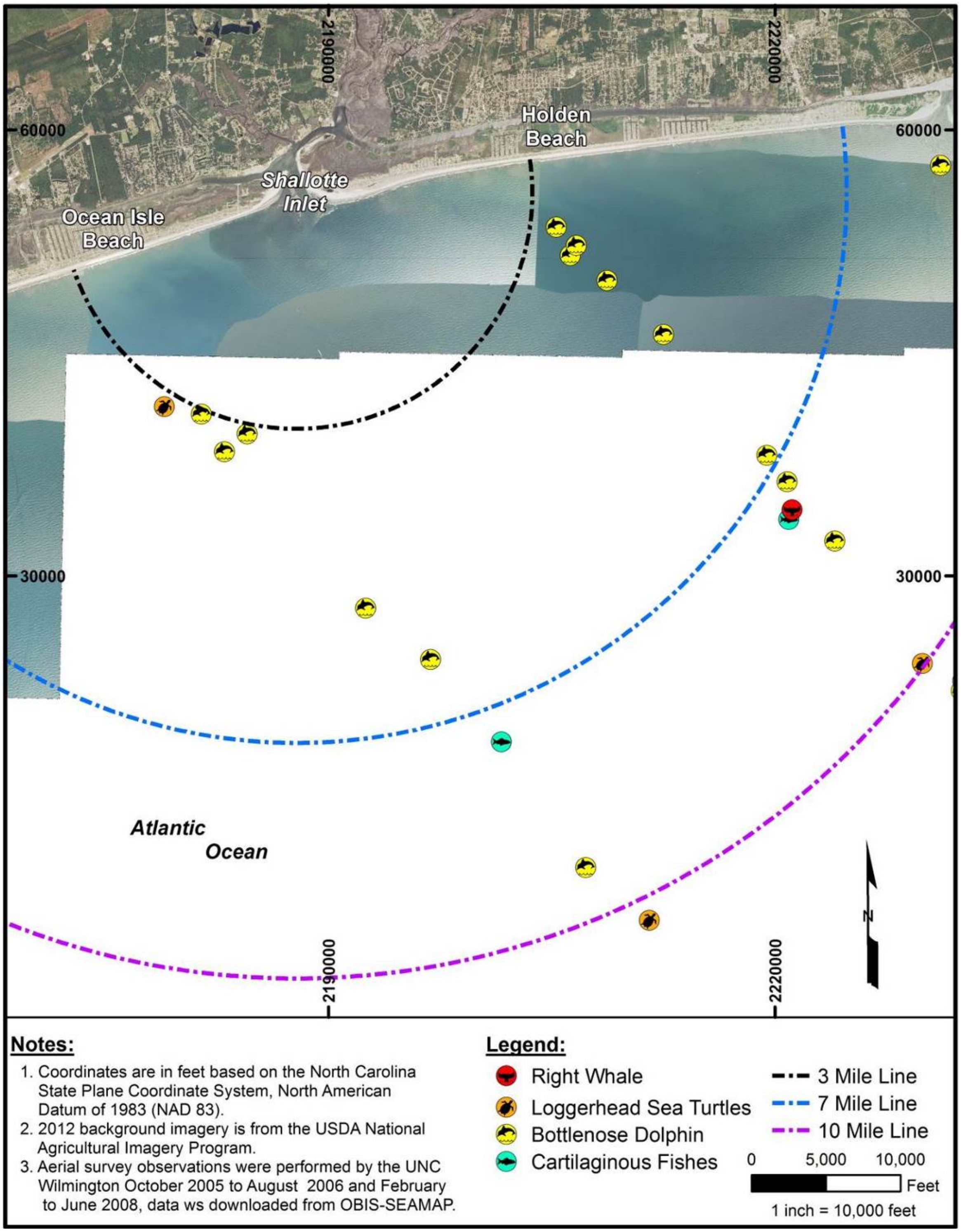


Figure 4.14. Right Whale Sightings in Proximity to the Permit Area.

C. Fish

1. Shortnose Sturgeon

Shortnose Sturgeon

The shortnose sturgeon, *Acipenser brevirostrum*, was listed as endangered on March 11, 1967 under the Endangered Species Preservation Act of 1966 (a predecessor to the Endangered Species Act of 1973). NMFS later assumed jurisdiction for shortnose sturgeon under a 1974 government reorganization plan (38 FR 41370) (NOAA, 2007). Shortnose sturgeon is the smallest of the three sturgeon species that are found in eastern North America, rarely exceeding a length of 1.1 m (3.5 ft) and a weight of 6.4 kg (14 lbs) (NMFS, 1998). Shortnose sturgeon are bottom feeders, typically feeding on crustaceans, insect larvae, worms, mollusks, and some plants (NMFS, 1998). They appear to feed in either freshwater riverine habitats or near the freshwater/saltwater interface. This species is anadromous, primarily utilizing riverine and estuarine habitats, migrating between freshwater and mesohaline river reaches. Spawning occurs in upper, freshwater areas, typically in January and February, while feeding and overwintering activities may occur in both fresh and saline habitats. Aside from seasonal migrations to estuarine waters, this species rarely occurs in the marine environment (NMFS, 1998; Atlantic Sturgeon Status Review Team, 2007).

The shortnose sturgeon inhabits lower sections of rivers and coastal waters along the Atlantic coast from the St. John River in New Brunswick, Canada to the St. Johns River, Florida (NOAA, 2007). The NMFS federal recovery plan (1998) for the endangered shortnose sturgeon identifies 19 distinct population segments, each defined as a river/estuarine system in which these fish have been captured within the generation time of the species (30 years). This species is significantly more common in northern portions of its range. Shortnose sturgeon are found in rivers, estuaries, and the sea, but populations are most often confined to natal rivers and estuaries (NMFS, 1998). Those shortnose sturgeon captured in the ocean are usually taken close to shore, in high salinity environments; there are no records of shortnose sturgeon in the NMFS database for the northeast offshore bottom trawl survey (NMFS, 1998).

There are few confirmed historical reports of shortnose sturgeon captures. Because fishermen and scientists often confused shortnose sturgeon with Atlantic sturgeon, there are no reliable estimates of historical population sizes (NMFS, 1998). There are several reports of shortnose sturgeon taken in North Carolina in the early 1800s, but the distribution and status of this species has not been fully documented in North Carolina. No shortnose sturgeon were reported in North Carolina waters between 1881 and 1987. Since then, several shortnose sturgeon have been caught in the Brunswick and Cape Fear rivers by commercial fishermen. A single fish was caught in the Pee Dee River, and it is now believed that a shortnose sturgeon population may also exist in western Albermarle Sound (NCWRC, 2007). With this discovery, the species is once again considered to be a part of the State's fauna; however, because of the lack of suitable freshwater spawning areas in the proposed 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. Atlantic Sturgeon

In 2009, the Natural Resources Defense Council (NRDC) petitioned NMFS to list the Atlantic sturgeon (*Acipenser oxyrinchus*) under the Endangered Species Act of 1973 (ESA). As a result of the petition, on February 6, 2012, the Carolina Distinct Population Segment (DPS) for Atlantic sturgeon has been designated as endangered under the ESA. Atlantic sturgeon are similar in appearance to shortnose sturgeon (*Acipenser brevirostrum*), but can be distinguished by their larger size, smaller mouth, different snout shape, and scutes (NMFS, 2011). The Atlantic sturgeon is a long-lived, estuarine dependent, anadromous fish. They are benthic feeders and typically forage on invertebrates including crustaceans, worms, and mollusks. Atlantic sturgeon can grow to approximately 14 feet (4.3 m) long and can weigh up to 800 lbs (370 kg) (NMFS, 2011). They are bluish-black or olive brown dorsally (on their back) with paler sides and a white belly. Spawning adults migrate upriver in spring, beginning in February-March in the south, April-May in the mid-Atlantic, and May-June in Canadian waters. In some areas, a small spawning migration may also occur in the fall. Spawning occurs in flowing water between the salt front and fall line of large rivers (NMFS, 2011). Atlantic sturgeon spawning intervals range from 1 to 5 years for males and 2 to 5 years for females (NMFS, 2011).

Atlantic Sturgeon

Adults range from Hamilton Inlet, Labrador (Scott and Scott, 1988) south to the St. Johns River in Florida (Vladykov and Greeley 1963). Following spawning, males may remain in the river or lower estuary until the fall; females typically exit the rivers within four to six weeks. Juveniles move downstream and inhabit brackish waters for a few months and when they reach a size of about 30 to 36 inches (76-92 cm) they move into nearshore coastal waters (Smith, 1985).

Tagging data indicates that these immature Atlantic sturgeon travel widely once they emigrate from their natal (birth) rivers. Although Atlantic sturgeon are regularly caught in North Carolina, details of their distribution patterns and habitat preferences are unknown (Ross et al., 1988). Atlantic sturgeon have been reported in the Atlantic Ocean off South Carolina in months of low water temperatures (November–April) from nearshore to well offshore in depths up to 40 m (Collins and Smith, 1997). Moser et al. (1998) obtained sturgeon records from Federal, private, and State surveys and documented use of nearshore Atlantic Ocean habitats from the North/South Carolina state line to off the mouth of Chesapeake Bay. Stein et al. (2004) found peak Atlantic sturgeon captures along the coast in 10–50 m depths. A study conducted between 1988 and 2006 examined the offshore distribution of Atlantic sturgeon based on incidental captures in winter tagging cruises conducted off the coasts of Virginia and North Carolina, including in and near extensive sand shoals adjacent to Oregon Inlet and Cape Hatteras. A total of 146 juvenile Atlantic sturgeon were captured during this investigation by bottom trawling in depths from 9.1 to 21.3m (Laney et al, 2007). Many of the fish were captured over sandy substrate which coincides with results observed in several other studies (Laney et al., 2007). In a tagging study conducted by Moser and Ross (1995), 100 juvenile Atlantic sturgeon were captured within the Cape Fear River. Of these, four (4) fish were observed moving from the river into the ocean and were caught in gill nets set from shore at Carolina Beach, Kure Beach, and Ft. Fisher (Moser and Ross, 1995). Therefore, these fish are known to frequent nearshore waters in proximity to the Cape Fear River.

D. Plants

Seabeach Amaranth

Seabeach amaranth (*Amaranthus pumilus*) is Federally and State-listed as threatened. It grows in low clumps comprised of sprawling, fleshy, reddish branches with dark leaves. The plant is profusely branched and generally grows to 1 m (39 in) in diameter. Historically, this species was found from Massachusetts to South Carolina, but according to USACE surveys between 1992 and 2004 (unpublished data), its distribution is now limited to North and South Carolina with some populations on Long Island, New York (USACE, 2006).

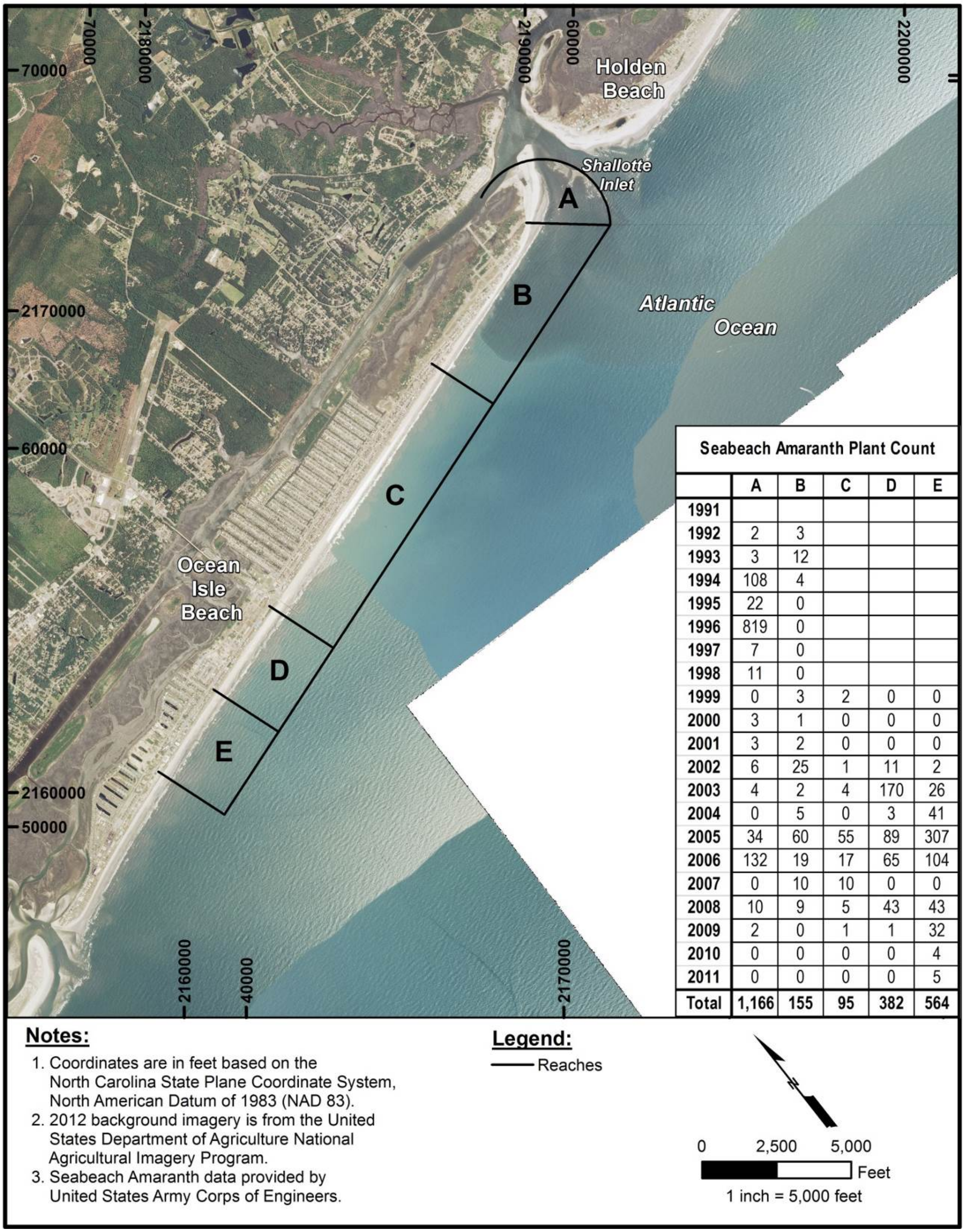
Seabeach amaranth

Seabeach amaranth is an effective sand binder, building dunes where it grows. A single large plant may be capable of creating a dune up to 60 cm high, containing 2 to 3 cu m of sand, although most are smaller (Weakley and Bucher, 1992). The plant is typically found at elevations from 0.2 m to 1.5 m (0.6 ft to 4.9 ft) above mean high tide (Weakly and Bucher, 1992). Seabeach amaranth appears to function in a relatively natural and dynamic manner, allowing it to occupy suitable habitat as it becomes available (USFWS, 1993).

As part of the monitoring associated with the Federal storm damage reduction project, Ocean Isle Beach has been surveyed by the USACE for seabeach amaranth since 1992 (Piatkowski, pers. comm.). A total of 2,362 plants (ranging from 4 to 819 each year) have been recorded on Ocean Isle Beach (Table 4.5 and Figure 4.15) (Piatkowski, pers. comm.). Seabeach amaranth experiences a great deal of natural population variability from one year to the next, as is evident by survey results (Table 4.5 and Figure 4.15). These natural fluctuations can be attributed to a number of factors, such as erosion, storms and seed dispersal.

Table 4.5. Ocean Isle Beach USACE annual Seabeach amaranth data (1992 to 2011)

Year	Seabeach amaranth (*Amaranthus pumilus*)	Year	Seabeach amaranth (*Amaranthus pumilus*)
1992	5	2002	45
1993	15	2003	206
1994	112	2004	49
1995	22	2005	545
1996	819	2006	337
1997	7	2007	20
1998	11	2008	110
1999	5	2009	36
2000	4	2010	4
2001	5	2011	5
Total	**1005**	**Total**	**2,362**



Seabeach Amaranth Plant Count

	A	B	C	D	E
1991					
1992	2	3			
1993	3	12			
1994	108	4			
1995	22	0			
1996	819	0			
1997	7	0			
1998	11	0			
1999	0	3	2	0	0
2000	3	1	0	0	0
2001	3	2	0	0	0
2002	6	25	1	11	2
2003	4	2	4	170	26
2004	0	5	0	3	41
2005	34	60	55	89	307
2006	132	19	17	65	104
2007	0	10	10	0	0
2008	10	9	5	43	43
2009	2	0	1	1	32
2010	0	0	0	0	4
2011	0	0	0	0	5
Total	1,166	155	95	382	564

Figure 4.15. Seabeach amaranth distribution within the Permit Area

E. Birds

The following section reviews and describes threatened and endangered bird species, both breeding and non-breeding, that have been documented within the Permit Area and/or within the vicinity of the project site. Bird species of special concern and of high conservation priority in North Carolina are also listed and discussed.

The North Carolina Wildlife Resource Commission and partners have performed breeding surveys for colonial nesting waterbirds within proximity to the Permit Area on a regular basis since 1977. Specifically, surveys have been conducted along the eastern and western portion of the island in proximity to Tubbs Inlet and Shallotte Inlet. Surveys for breeding piping plovers have been conducted since 1989 at the same locations. Surveys for non-breeding piping plovers have been conducted in more recent years. These surveys include data from breeding and non-breeding seasons for several listed bird species as well as other shorebirds and waterbirds.

1. Piping Plover

The piping plover (*Charadrius melodus*) was Federally listed in 1986 under the Endangered Species Act of 1973, as amended with three separate breeding populations in North America: 1) the Atlantic Coast population (threatened), 2) the Northern Great Plains population (threatened), and 3) the Great Lakes population (endangered). Piping plovers are also listed as threatened throughout their wintering range (USFWS, 1996). All three populations migrate to the coastal shorelines of the South Atlantic, Gulf of Mexico and the beaches of the Caribbean Islands to winter (USFWS, 2007).

Piping plover

The habitat for wintering piping plover is protected under a Critical Habitat listing as identified by the ESA. On July 10, 2002, 137 areas along the coasts of North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, and Texas were designated as Critical Habitat for wintering piping plover. Critical Habitat designation for North Carolina wintering piping plover includes a portion of Holden Beach and Shallotte Inlet in Unit NC-17 (Figure 4.16), which is described by the USFWS as follows (USFWS, 2001):

> *This unit begins just west of Skimmer Court on the western end of Holden Beach. It includes land south of SR 1116, to where densely vegetated habitat, not used by the piping plover, begins and where the constituent elements no longer occur to the MLLW along the Atlantic Ocean. It includes the contiguous shoreline from MLLW to where densely vegetated habitat, not used by the piping plover, begins and where the constituent elements no longer occur along the Atlantic Ocean, Shallotte Inlet, and Intracoastal Waterway stopping north of Skimmer Court Road. The unnamed island and emergent sandbars to MLLW within Shallotte Inlet are also included.*

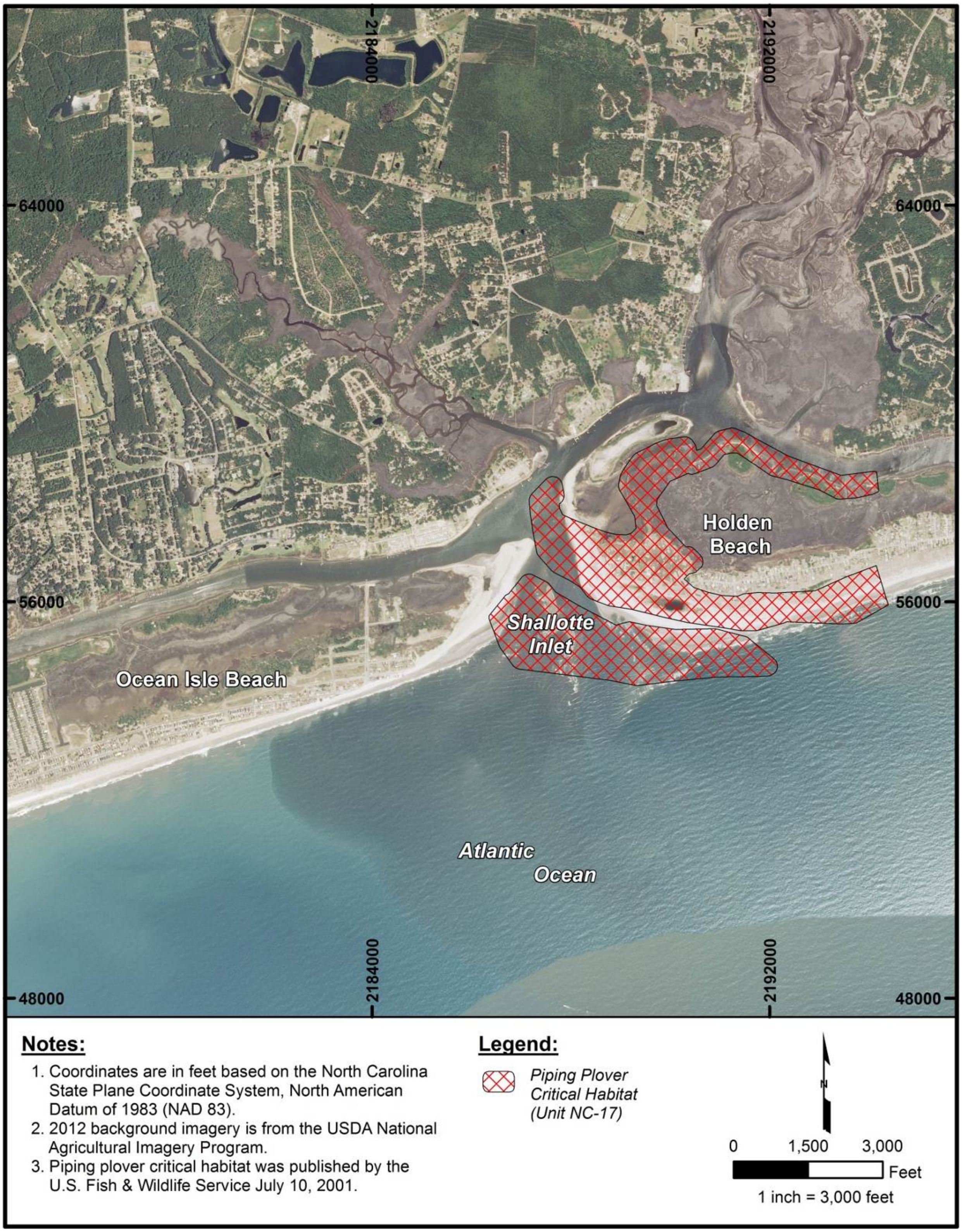


Figure 4.16. Piping Plover Critical Habitat Unit NC-17 in Proximity to the Permit Area.

Although wintering piping plover Critical Habitat exists within the Permit Area, this species also nests in the region. Piping plovers nest in dry sand habitats above the high tide line along coastal beaches, spits, flats, barrier islands and other sparsely vegetated dune and beach environments, although they may utilize other shoreline habitats if these are not available. Their nests are comprised of sand and shell material making them well camouflaged, with an average clutch size of three to four eggs (USFWS, 1996).

The North Carolina coastline is important to piping plovers since it provides habitat for wintering, breeding, and migration. Piping plovers have been documented arriving on their breeding grounds in North Carolina beginning as early as mid-March. By mid-July, adults and young may begin to depart for their wintering areas. The piping plover is present year round in North Carolina and utilizes the coastal habitats for foraging, roosting, nesting, wintering and migrating (Cameron pers. comm., 2007).

In 1990 the USFWS (2008) counted fewer than 1,000 piping plover nests in the Atlantic Coast population (including Canada). By 1996, a total of 1,348 breeding pairs were documented. The number of breeding pairs has continued to steadily increase, reaching 1,438 pairs in 2000 and 1,690 pairs in 2002 (USFWS, 2008). The number of piping plover breeding pairs in North Carolina decreased from 55 pairs in 1989 to 24 pairs in 2003. However, estimates indicate a slight increase occurred in breeding pairs to 37 in 2005 and 46 in 2006 (USFWS, 2008).

NCWRC and partners have conducted shorebird surveys along portions of Ocean Isle Beach since annually since 1987. The focus of the monitoring effort has been concentrated in proximity to Tubbs Inlet and Shallotte Inlet (Schweitzer, pers. comm). These surveys were conducted opportunistically during the breeding season, fall migration, winter, and spring migration, however most years did not include surveys during each season (Table 4.6). In total, 49 individual piping plovers and four (4) breeding pairs were observed in these locations between 1987 and 2010 (Schweitzer, pers. comm.) (Table 4.6). This data suggests that the areas in proximity to the inlets on Ocean Isle Beach provide important habitat for piping plovers.

Table 4.6. Piping Plover Survey Data (1987-2009) for Ocean Isle Beach

Year	Season	Number of birds	Number of breeding pairs
1987	Winter	0	
	Spring Migration	No Data	
	Breeding	No Data	No Data
	Fall Migration	No Data	
1989	Winter	No Data	
	Spring Migration	No Data	
	Breeding	0	0
	Fall Migration	No Data	
1990	Winter	No Data	
	Spring Migration	0	
	Breeding	No Data	No Data
	Fall Migration	No Data	
1991	Winter	0	
	Spring Migration	No Data	

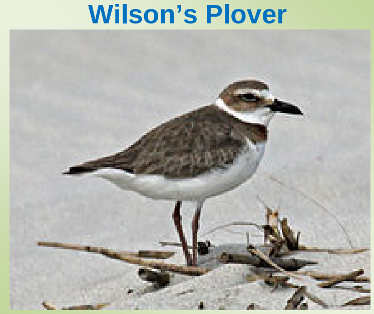
Year	Season	Number of birds	Number of breeding pairs
	Breeding	1	0
	Fall Migration	No Data	
1994	Winter	No Data	
	Spring Migration	No Data	
	Breeding	0	0
	Fall Migration	No Data	
1996	Winter	0	
	Spring Migration	No Data	
	Breeding	No Data	No Data
	Fall Migration	No Data	
1997	Winter	No Data	
	Spring Migration	No Data	
	Breeding	0	0
	Fall Migration	No Data	
1998	Winter	No Data	
	Spring Migration	No Data	
	Breeding	4	2
	Fall Migration	No Data	
1999	Winter	No Data	
	Spring Migration	No Data	
	Breeding	0	0
	Fall Migration	No Data	
2000	Winter	No Data	
	Spring Migration	No Data	
	Breeding	0	0
	Fall Migration	No Data	
2001	Winter	0	
	Spring Migration	4	
	Breeding	0	0
	Fall Migration	2	
2002	Winter	No Data	
	Spring Migration	No Data	
	Breeding	0	0
	Fall Migration	5	
2003	Winter	No Data	
	Spring Migration	No Data	
	Breeding	0	0
	Fall Migration	No Data	
2004	Winter	No Data	
	Spring Migration	No Data	
	Breeding	0	0
	Fall Migration	2	
2005	Winter	No Data	
	Spring Migration	4	
	Breeding	0	0
	Fall Migration	No Data	
2006	Winter	4	
	Spring Migration	No Data	

Year	Season	Number of birds	Number of breeding pairs
	Breeding	2	0
	Fall Migration	No Data	
2007	Winter	No Data	
	Spring Migration	3	
	Breeding	4	2
	Fall Migration	1	
2008	Winter	4	
	Spring Migration	2	
	Breeding	1	0
	Fall Migration	4	
2009	Winter	No Data	
	Spring Migration	2	
	Breeding	No Data	No Data
	Fall Migration	No Data	

2. Wilson's Plover

The Wilson's plover (*Charadrius wilsonia*) is designated by the State of North Carolina as a Species of Special Concern (species which are determined by the NCWRC to require monitoring). This is a peripheral species (North Carolina lies at the periphery of its species range) requiring monitoring by the NCNHP. There is no Federal status for this species, and it is considered globally secure (G5 rank) (NCNHP, 2006). However, Wilson's plovers are listed as species of high conservation concern in the US Shorebird Conservation Plan (Brown et al., 2001). Wilson's plover breed in eastern and southern coastal areas of the United States and overwinter along the Florida Atlantic coast and Gulf coasts to northern South America. Shorebird surveys conducted between 1987 and 2009 along the easternmost and westernmost portions of Ocean Isle Beach resulted in a total of 23 breeding pairs of Wilson's plovers during the breeding season (Schweitzer, pers. comm.).

Wilson's Plover



3. American Oystercatcher

American oystercatchers *(Haematopus palliatus)* are State listed as a Species of Special Concern. However, the American oystercatcher is considered stable globally (G5), and is not Federally listed under the ESA. Along the western Atlantic coast, the eastern race of the American oystercatcher breeds from Massachusetts to Florida, with the highest concentrations from Virginia to Georgia (Humphrey, 1990). Since monitoring began in 1987, a total of four (4) nesting pairs of American Oystercatchers were observed on Ocean Isle Beach (Schweitzer, pers. comm.).

American oystercatcher

4. Common Tern

The common tern (*Sterna hirundo*) is designated by the State of North Carolina as Species of Special Concern. There is no Federal status for this species, although the common tern is considered globally secure (G5 rank). Common terns seem to be undergoing a decline in the southeast and are therefore listed as a species of regional concern (Hunter et al., 2001).


Common tern

Common terns have experienced dramatic population declines in North Carolina and are currently down from their long-term average by 66% (Cameron et al. 2004). Common terns move frequently in response to changes in their highly ephemeral nesting habitat. No common terns were observed during NCWRC surveys along Ocean Isle Beach since 1987 (Schweitzer, pers. comm.).

5. Gull-Billed Tern

The gull-billed tern (*Sterna nilotica*) is designated by the State of North Carolina as threatened. There is no Federal status for this species, and it is considered globally secure (G5 rank). However, these terns are listed as species of high conservation concern (Kushlan et al., 2002).


Gull-billed tern

6. Black Skimmer

The black skimmer (*Rynchops niger*) is designated by the State of North Carolina as a Species of Special Concern (species which are determined by the NCWRC to require monitoring). There is no Federal status for these species, although the black skimmer is considered globally secure (G5 rank) (Kushlan et al., 2002).


Black skimmer

NCWRC has conducted periodic coast-wide surveys of colonial nesting waterbirds since 1972. In 1995 and 2000, one (1) and ten (10) nests were observed, respectively, on the eastern portion of Sunset Beach in proximity to Tubbs Inlet. No black skimmer nests have been observed on portions of Ocean Isle Beach (Schweitzer, pers. comm.).

7. Eastern Painted Bunting

The Eastern painted bunting (*Passerina ciris ciris)* is State-listed as a Species of Special Concern. The eastern population of painted bunting breeds in a restricted range within the Atlantic Coastal Plain, from North and South Carolina to Georgia and Florida. In North Carolina, eastern painted bunting breeding habitats are found in a narrow range along marine coasts and waterways (Audubon North Carolina, 2007). NCWRC Biologist Dave Allen described their habitat as


Eastern painted bunting

"…early succession habitat such as shrubby areas with occasional shrubs, edge habitat and even marsh edges or marsh interior if some shrubs or trees are nearby. This includes some residential area" (Allen, pers. comm., 2007).

A volunteer monitoring program has been established for the painted bunting in partnership between the University of North Carolina at Wilmington (UNCW), SCNDR, USFWS, and the North Carolina Museum of Natural Sciences. This goal of this program, called the Painted Bunting Observation Team (PBOT), is to observe, record, and catalogue sightings of painted buntings. PBOT reports that the Eastern painted bunting has been observed all along the Brunswick County coast but specific data detailing observations is not available (Painted Bunting Observer Team, pers. comm., 2013).

8. Red Knot

Red Knot

The red knot (*Calidris canutus rufa*) was designated as a candidate species in 2006. On December 9, 2014, the red knot was listed as threatened under the ESA, by the USFWS. At nine to ten inches long, the red knot is a large, bulky sandpiper with a short, straight, black bill. During the breeding season, the legs are dark brown to black, and the breast and belly are a characteristic russet color that ranges from salmon-red to brick-red. Males are generally brighter shades of red, with a more distinct line through the eye. When not breeding, both sexes look alike with plain gray above and dirty white below with faint, dark streaking. As with most shorebirds, the long-winged, strong-flying knots fly in groups, sometimes with other species. Red knots feed on invertebrates, especially bivalves, small snails, crustaceans, and, on breeding grounds, terrestrial invertebrates.

Large numbers of red knots rely on Atlantic stopover habitats during the spring and fall migration periods. Red knots winter at the southern tip of South America and breed above the Arctic Circle. These small shorebirds fly more than 9,300 miles from south to north every spring and reverse the trip every autumn, making the red knot one of the longest-distance migrating animals. Migrating red knots break their spring migration into non-stop segments of 1,500 miles or more, converging on just a few critical stopover areas along the way. Large flocks of red knots arrive at stopover areas along the Atlantic coast each spring, with many of the birds having flown directly from northern Brazil. Red knots are faithful to these specific sites, stopping at the same locations year after year. Mole crabs (*Emerita talpoida*) and coquina clams (*Donax sp.*) are an important food source for migrating knots in North Carolina. Birds arrive at stopover areas with depleted energy reserves and must quickly rebuild their body fat to complete their migration to Arctic breeding areas. During their brief 10 to 14-day stay in the mid-Atlantic, red knots typically double their body weight. Threats to the red knot include disturbance, reduced food availability at stopover areas, and shoreline development.

Surveys conducted by the NCWRC along Ocean Isle Beach within proximity to Shallotte Inlet between 2004 and 2014 resulted in the observation of one red knot on June 2, 2014. This individual was observed along the inlet beach foraging. Due to a lack of consistent, standardized surveys conducted in the area, these results should be interpreted with caution (Schweitzer, pers. comm).

4. What are the public interest factors considered within the project area?

The USACE regulations under 33 CFR 320.4 require projects under regulatory authority of the USACE (e.g., Clean Water Act and/or Rivers and Harbors Act) to be evaluated considering certain public interest criteria. The following public interest factors will be considered in this EIS. Additional factors pertiaining to the public interest review will be addressed within the Record of Decision (ROD).

Public Safety

In 2011, the NCWRC reported seven (7) boating accidents in Brunswick County resulting in zero fatalities. The waters in North Carolina, including those found within the Permit Area are policed by the North Carolina Marine Patrol administered through the North Carolina Division of Marine Fisheries. Their jurisdiction includes all coastal waters, extends to 3 miles offshore, and ranges to 200 miles offshore for some Federally regulated species. Officers monitor 2.5 million acres of water and over 4,000 miles of coastline. Currently, the Marine Patrol has 59 officers that work in three law enforcement districts along the North Carolina coast. In addition to checking commercial and recreational fishermen, officers patrol waterways, piers, and beaches in coastal areas. Officers use a variety of different size boats, aircraft, helicopters, and patrol vehicles to accomplish these tasks.

Aesthetic Resources

The Town of Ocean Isle Beach covers approximately 4.4 square miles, is approximately seven (7) miles long and varies from approximately 0.10 miles to 0.60 miles wide. Ocean Isle Beach is a barrier island situated between the Atlantic Ocean and the AIWW. The island is bordered to the west by Tubbs Inlet and Sunset Beach and to the east by Shallotte Inlet and Holden Beach. The Permit Area includes a wide diversity of estuarine and nearshore habitat types supporting diverse ecosystems typically associated with a developed and undeveloped barrier island system in southeastern North Carolina and also provides uninterrupted to slightly interrupted natural vistas to both residents and non-residents.

Recreational Resources

The terrestrial and aquatic environments within the Permit Area offer a number of recreational opportunities. Bird watching, surfing, fishing, sunbathing, boating and swimming are available to both tourists and local residents. During peak summer periods, the Shallotte River, Shallotte Inlet, Tubbs Inlet, the AIWW and the adjacent shoreline beaches are heavily utilized for watersports and sunbathing.

Navigation

The Shallotte River and Shallotte Inlet serve as the access point for numerous recreational and fishing vessels year round. During the year, especially during peak tourist season (June – August), the inlet can experience intense recreation navigation usage. Despite this frequent usage, Shallotte Inlet is not maintained by a federally authorized dredging activity. Little River Inlet is the closest maintained inlet which is located approximately 11 miles to the southwest. Although smaller recreational vessels can typically navigate through Shallotte Inlet into the ocean, larger vessels will generally access the ocean through Little River Inlet.

Socio-Economic Resources

Brunswick County has a diverse economic base relying on tourism, construction, retail trade, healthcare, manufacturing and government. As the population continues to grow, the area becomes more attractive to national retailers and companies. Ocean Isle Beach, is primarily a residential community with limited commercial and retail facilities. The population of the Town increased from 426 in 2000 to 550 in 2010 according to US Census data. Between November 2012 and January 2013, 34 homes sold on the island with an average listing price of $416,554. Average price per square foot for Ocean Isle Beach NC was $184, a decrease of 38.7% compared to the same period last year. The median sales price for homes in Ocean Isle Beach NC for Nov 12 to Jan 13 was $235,000 based on 34 home sales. Compared to the same period one year ago, the median home sales price decreased 19%, or $55,000, and the number of home sales decreased by 42.4%.

Land Use

The CAMA requires Counties, Cities and Towns within the 20 coastal counties to periodically prepare Land Use Plans to protect and manage the health of the coastal environment and economy. The North Carolina Division of Coastal Management requires that these counties keep the Land Use Plans up to date. The current Brunswick County Land Use Plan was certified by the CRC on November 7, 2007 and most recently recertified on August 25, 2011. The primary focus of the plan has been protection and appropriate development of coastal areas of environmental concern on a countywide perspective.

As a small residential community with a largely tourist based economy, Ocean Isle Beach has limited land use compatibility problems when compared with larger urban municipal areas. The amount of commercial activity in the community is limited as there are no large manufacturing or industrial operations. The Town of Ocean Isle Beach 2009 CAMA Land Use Plan Vision Statement states the Town's goal to "maintain and enhance our community as the finest family orientated beach community in the United States" (Imperial et al., 2009).

Infrastructure

The Odell Williamson Bridge across the AIWW is the only means of ingress or egress to the Town from the mainland. The two-lanes connect into a three-lane road (NC 904) that intersects with First Street. First Street is the major thoroughfare that runs from the west end to the east end of the beach. The bridge is operated and maintained by the NCDOT. Based upon information provided by the DOT Bridge Maintenance Unit, the Odell Williamson Bridge was constructed of pre-stressed concrete in 1984.

There are no private wastewater systems operating within the Town of Ocean Isle Beach. The Town of Ocean Isle Beach began operating its wastewater treatment system in 1987. Connection to the public sewer system is required for all residents and businesses within the Town. The collection system is a gravity sewer system with 28 miles of collection lines and 36 sewer lift stations. The main pump station consists of four (4) pumps and a back-up generator. In the past ten years, approximately two miles of collection lines and two (2) pump stations have been added as upgrades. The collection system serves only areas within the municipal boundary.

Three types of stormwater systems exist within the Town of Ocean Isle Beach; the Town owned systems, systems owned and operated by the Department of Transportation (DOT), and private systems. Private owners are required to have engineered stormwater systems designed to capture the first 1.5 inches of rainfall. The Town-owned stormwater system is a combination of catch basins piped to outfalls, swales, ditches and catch basins tied to an underdrain system. The DOT also has some catch basins into french drains, and along the Causeway the DOT uses a curb and gutter system. New developments within the Town are required to install a stormwater system by use of swales or catch basins into an underdrain system.

Solid Waste

The Town of Ocean Isle Beach makes every feasible effort to minimize the generation of waste and to recycle waste for which viable markets exist and to use recycled materials where feasible. The Town contracts with Waste Industries for solid waste disposal, additional curb side pick-ups, beach strand pick-ups and recycling.

All Construction and Demolition (C&D) materials and yard debris is taken to the Brunswick County Landfill near Supply for disposal. Solid waste debris is taken to a landfill in Sampson County for disposal. County facilities are adequate to meet current and future needs under the current waste disposal scenario. It should be noted that sufficient solid waste disposal facilities are not available within the County limits; however, this is a factor which Ocean Isle Beach has little control over.

Drinking Water

The Town of Ocean Isle Beach's water system primarily serves customers located within the Town's municipal boundary. The Town purchases all of the water used in the Town from the Brunswick County water system. The water is treated at a surface water plant in Leland, N.C. The source water for this water plant is the Cape Fear River. The Town no longer uses wells as a source of water. The Town has no private water systems in its municipal boundary and has had no water quality issues that were a threat to public health.

Noise Pollution

The amount of commercial activity in the Town remains limited and there are no industrial or manufacturing uses. Increased noise levels are limited primarily to issues related to the influx of tourists. Per the Town's Code of Ordinances (Part II, Chapter 22, Article III), no unreasonably loud, disturbing, and unnecessary noise between 10:00 p.m. and 7:30 a.m. is allowed. And, no construction activity shall take place before the hours of 8:00 a.m. and after the hours of 8:00 p.m.

Select North Carolina Primary Surface Water Classifications

HQW: Rated excellent based on biological and physical/chemical characteristics.

SA: Tidal salt waters that are used for commercial shellfishing or marketing purposes and are also protected for all Class SC and Class SB uses.

SB: Tidal salt waters protected for all SC uses in addition to primary recreation such as swimming.

SC: All tidal salt waters protected for secondary recreation such as fishing, boating, and other activities involving minimal skin contact.

Water Quality

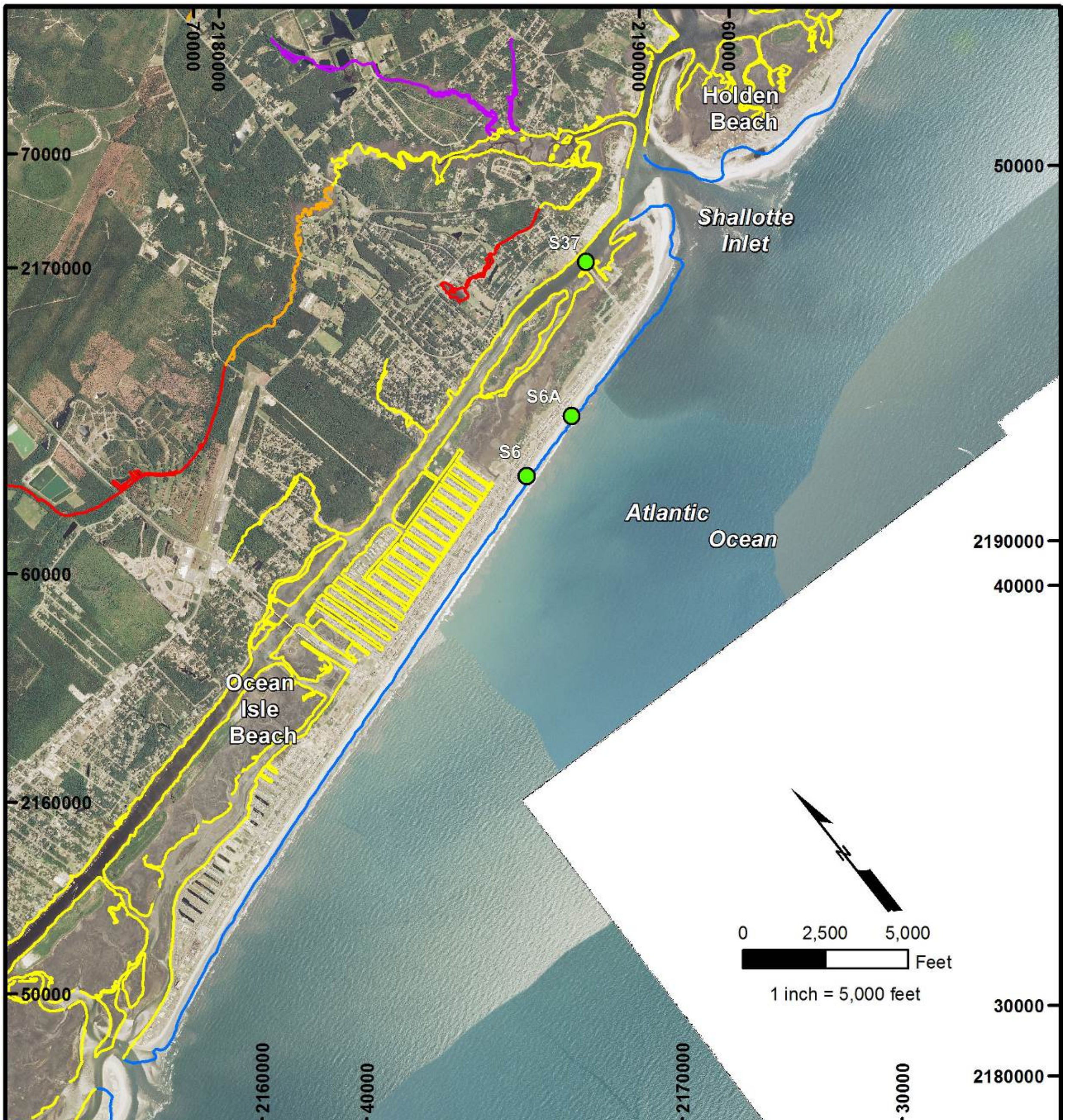
Many of the waterways within and in proximity to the Permit Area are designated as either High Quality Waters (HQW) or Outstanding Resource Waters (ORW) (Figure 4.17) by the North Carolina Division of Water Quality (NCDWQ). NCDWQ defines HQW as:

> *Waters which are rated excellent based on biological and physical/chemical characteristics through Division monitoring or special studies, primary nursery areas designated by the Marine Fisheries Commission, and other functional nursery areas designated by the Marine Fisheries Commission.*

ORW waters are described by the NCDWQ as:

> *A subset of High Quality Waters. This supplemental classification is intended to protect unique and special waters having excellent water quality and being of exceptional state or national ecological or recreational significance. To qualify, waters must be rated Excellent by DWQ and have one of the following outstanding resource values:*

- *Outstanding fish habitat and fisheries,*
- *Unusually high level of waterbased recreation or potential for such kind of recreation,*
- *Some special designation such as North Carolina Natural and Scenic River or National Wildlife Refuge,*
- *Important component of state or national park or forest, or*
- *Special ecological or scientific significance (rare or endangered species habitat, research or educational areas).*



Notes:

1. Coordinates are in feet based on the North Carolina State Plane Coordinate System, North American Datum of 1983 (NAD 83).
2. 2012 background imagery is from the USDA National Agricultural Imagery Program.
3. Water quality classification published by North Carolina Division of Environment and Natural Resources Division of Water Quality, November 6, 2012.

Legend:

Water Quality Classifications

- Secondary Recreation Fresh Swamp Waters
- Secondary Recreation Fresh Swamp Waters, High Quality Waters
- Market Shellfishing Salt Water, High Quality Waters
- Primary Recreational Salt Water
- Secondary Recreation Salt Water, High Quality Waters
- Recreational Water Quality Monitoring Site

Figure 4.17. Water Quality Classifications in Proximity to the Permit Area.

The North Carolina Department of Environmental and Natural Resources, Division of Marine Fisheries, Shellfish Sanitation Section is responsible for monitoring and classifying coastal waters as to their suitability for shellfish harvesting for human consumption. Recommendations are made to the Division of Marine Fisheries to close those waters that have the potential for causing illness and opening those that are assured of having clean, healthy shellfish. All shellfish growing areas are surveyed every three years to document all existing or potential pollution sources to assess the bacteriological quality of the water and to determine the hydrographic and meteorological factors that could affect water quality. Water samples are collected at least six times a year from each growing area and tested for fecal coliform bacteria, which are an indicator that human or animal wastes are present in the water. A number of waterways in proximity to Ocean Isle Beach have been closed for shellfishing due to poor water quality. These include the waters within the canal system on Ocean Isle Beach, much of the AIWW, and Saucepan Creek (Figures 4.18 and 4.19).

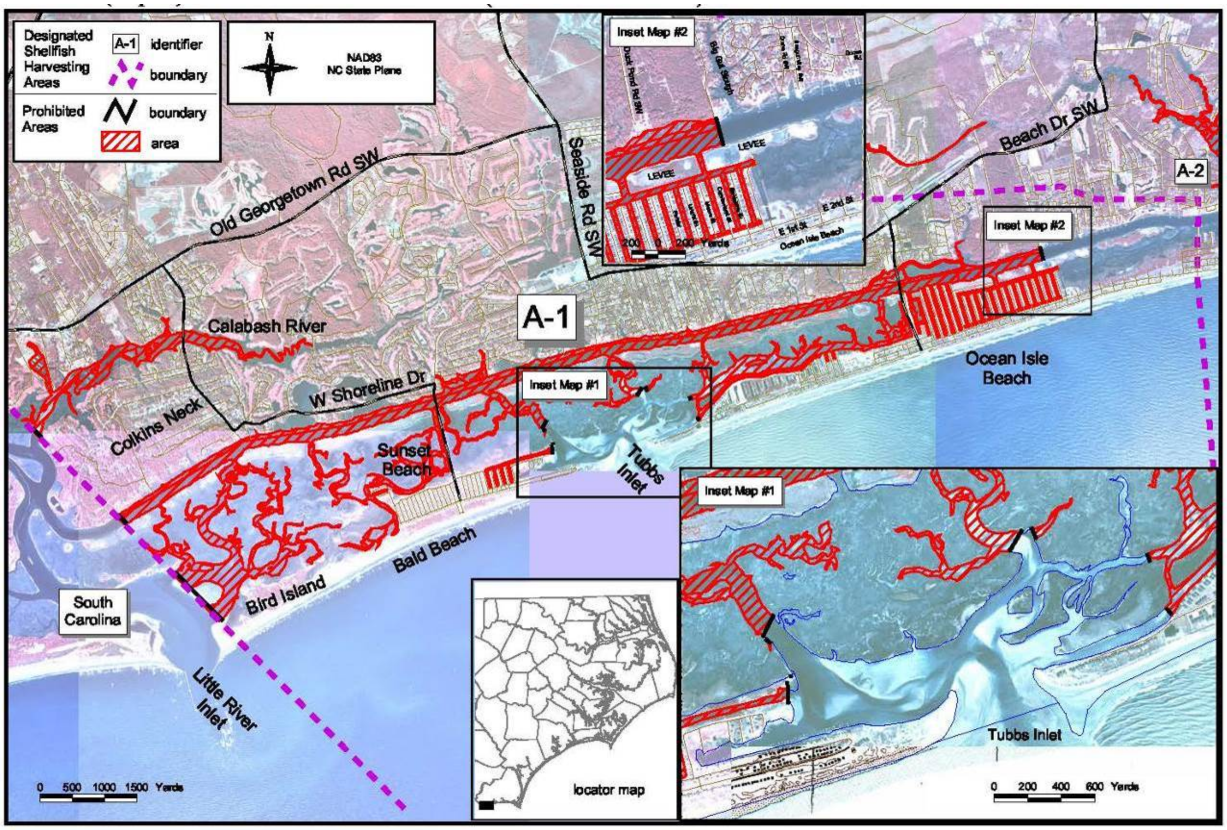


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Figure 4.18. NCDENR Shellfish Sanitation Map of Shellfish Closures in Proximity to the Ocean Isle Beach Permit Area

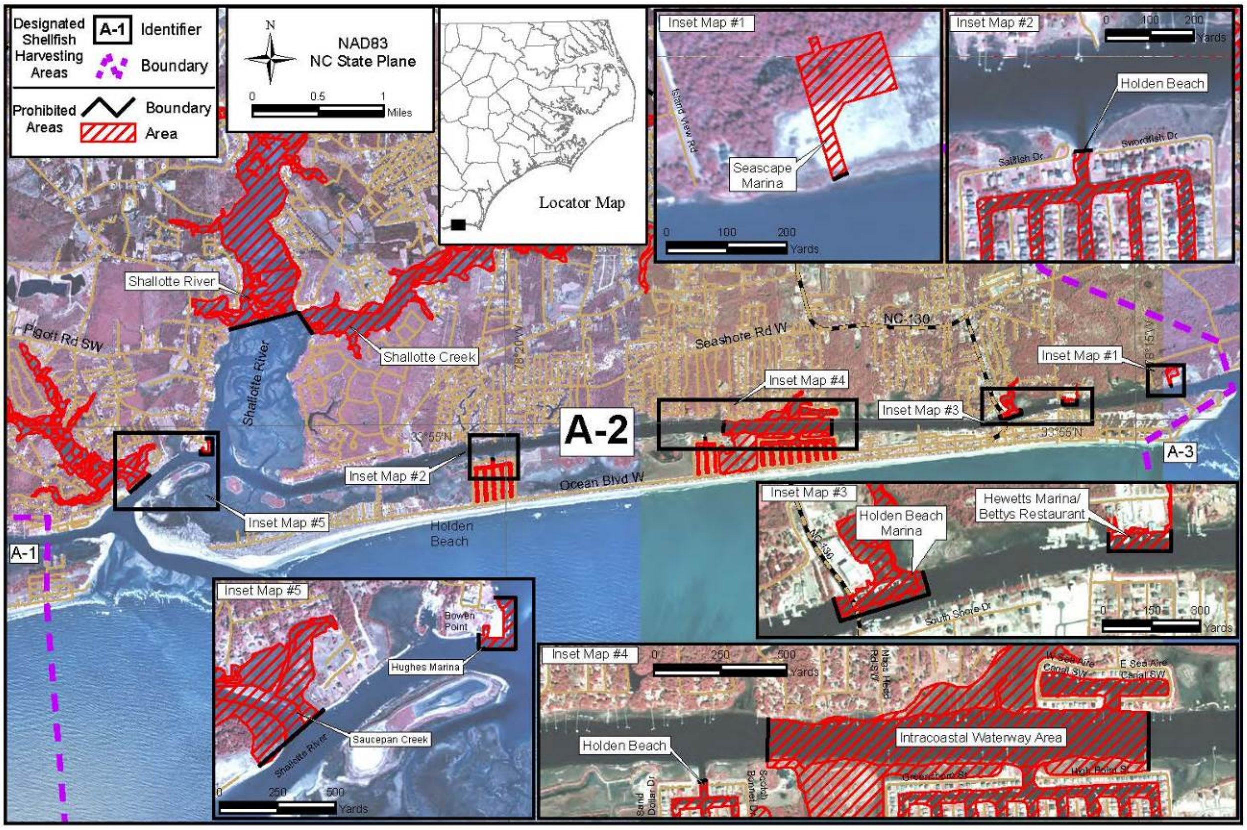

Figure 4.19. NCDENR Shellfish Sanitation Map of Shellfish Closures in Proximity to the Ocean Isle Beach Permit Area

The North Carolina Recreational Water Quality Program (RWQ) also tests coastal waters. Their mission is to protect the public health by monitoring the quality of N.C.'s coastal recreational waters and notifying the public when bacteriological standards for safe bodily contact are exceeded. The coastal waters monitored include the ocean beaches, sounds, bays and estuarine rivers. RWQ tests for *Enterococci* bacteria, an indicator organism found in the intestines of warm-blooded animals. While *Enterococci* will not cause illness itself, its presence is correlated with that of organisms that can cause illness. The program tests 20 ocean and sound-side areas, most of them on a weekly basis. Lower-use beaches are tested twice a month.

Three RWQ sampling stations are located within or near the Permit Area. These stations include Station S37 (located in the AIWW, soundside access at east end of Ocean Isle Beach), S6A (located at Greensboro St. emergency vehicle access), and S6 (located at the Public Access at First and Chadbourn St.) (Figure 4.17). Information taken at the stations includes salinity readings. In 2012, measurements obtained by RQW within stations S37, S6A, and S6 averaged 34.3 ppt, 34.8 ppt, and 34.6 ppt, respectively. These salinity levels support a wide range of fishery resources that are typical in inlet and estuarine complexes similar to Shallotte Inlet and associated water bodies.

1. Turbidity and Total Suspended Solids (TSS)

Turbidity, expressed in Nephelometric Turbidity Units (NTU), quantitatively measures the light scattering properties of the water. However, the properties of the material suspended in the water column that create turbid conditions are not reflected when measuring turbidity. The two reported major sources of turbidity in coastal areas are very fine organic particulate matter, and sand sized sediments that are re-suspended around the seabed by local waves and currents (Dompe and Haynes, 1993). In Class SA waters, North Carolina state guidelines limit turbidity to values under 25 NTU above ambient levels outside turbidity mixing zones (NCDWQ, 2003).

Total Suspended Solids (TSS) are basically solids that are present anywhere in the water column. TSS can include a wide variety of material, such as silt, decaying plant and animal matter, industrial wastes, and sewage. Currently, there are no standards associated with TSS in North Carolina.

2. Nutrients

Nutrients in the waters within the Permit Area are influenced from the Shallotte River, inland tidal creeks, AIWW, and the marsh environment. Non-point source pollution including stormwater runoff provides a conduit for nutrients entering these waterbodies which can influence their levels.

Non-Relevant Resources

1. Hazardous, Toxic, and Radioactive Waste

There are no known hazardous, toxic, or radioactive wastes in the Permit Area that would be affected by a proposed project.

2. Energy Requirements and Energy Conservation

A proposed project within the Permit Area would not be expected to utilize an unusual amount of energy beyond typical construction needs.

3. Air Pollution

It is not expected that any activities associated with the proposed project alternatives would significantly contribute to air pollution within the Permit Area.

5. How would cultural resources be affected by the project?

Historical Properties and Cultural Resources

1. Shallotte Inlet Cultural Resources

Tidewater Atlantic Research, Inc. (TAR), of Washington, North Carolina has previously performed two Underwater Archaeological Remote Sensing Surveys for the USACE in the vicinity of the proposed project in Shallotte Inlet.

In coordination with Chris Southerly, Assistant State Archaeologist, and confirmed by both TAR survey reports, there is the possibility of at least nine (9) known but undiscovered shipwrecks in the Shallotte Inlet vicinity from the 19^{th} and 20^{th} centuries. In addition, the last known location of shipwreck site 001SHI (UAU field tag #140) is aground and buried on the beach in proximity to the proposed terminal groin (Southerly, pers. comm. 2013).

In December 2014, TAR conducted a marine and terrestrial remote-sensing survey of the proposed terminal groin construction area. Analysis of the remote-sensing data generated during the Ocean Isle Beach survey identified a total of 22 magnetic anomalies in the offshore project environment and 4 anomalies in the terrestrial project environment. Sonar identified 16 targets in the marine environment. All of the anomalies and all of the sonar images are associated with previous groin structures or small objects that represent debris associated with those groins or perhaps residential material deposited by storms. None of the anomalies and sonar images appears to represent more complex signatures associated with historic vessel remains. AS concluded by the study, no additional investigation is recommended in conjunction with the proposed groin construction. See Appendix F for additional details regarding this study.

Tribal entities within the State of North Carolina will be directly notified of this proposed project and will be given the opportunity to provide comments.

Chapter 5 ENVIRONMENTAL CONSEQUENCES

1. What are the alternatives under consideration?

This chapter includes both a qualitative and quantitative comparative assessment of the direct, indirect, and cumulative impacts associated with the alternatives under consideration for the Ocean Isle Beach Shoreline Management Project. Impacts will relate to both the economic impact and the resources and interest factors described in Chapter 4.

The alternatives under consideration include:

- Alternative 1 – No Action (Continue Current Management Practices)
- Alternative 2 – Abandon / Retreat
- Alternative 3 – Beach Fill Only (Including Federal Project)
- Alternative 4 – Shallotte Inlet Bar Channel Realignment with Beach Fill (Including Federal Project)
- Alternative 5 - Terminal Groin with Beach Fill (Including Federal Project)/Applicant's Preferred Alternative

2. How were the environmental impacts analyzed?

The Council on Environmental Quality regulations (40 CFR §§ 1508.7 and 1508.8) define direct effects as those caused by the action and occur at the same time and place. Indirect effects are defined as those caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems. Cumulative impact is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.

Effects and impacts as used in these regulations are synonymous. Some examples of Effects include ecological (such as the effects on natural resources and on the components, structures, and functioning of affected ecosystems), aesthetic, historic, cultural, economic, social, or health, whether direct, indirect, or cumulative. Effects may also include those resulting from actions which may have both beneficial and detrimental effects, even if on balance the agency believes that the effect will be beneficial.

Anticipated impacts to habitats were determined by CPE-NC through the analysis of numerical modeling results, historical and recent erosion rates, recent biological characterization investigations, and results from past research and studies. Delft3D, the primary modeling package used for this project, simulated flows forced by a combination of waves, tides, winds, and density gradients, along with sediment transport and bathymetric change using advanced transport formulations that account for bedload and suspended load transport.

With regard to the model results, the Delft3D model responds to prescribed or predetermined input conditions including waves, tides, winds, etc. The model results are by no means intended to represent predictions of what changes to expect in the future with certainty, as this would require an ability to predict future weather and oceanic conditions. Rather, the Delft3D model results for Alternative 1 (No New Actions) obtained under a prescribed set of forcing conditions forms a basis for comparing relative changes in Shallotte Inlet and the adjacent shorelines that could be attributable to physical changes in the system associated with each alternative.

When the model was run to simulate a man-induced change it was run with the same forcing functions, i.e., waves, winds, and tides, used in the calibration process to represent without project conditions. If the model reacted differently from the results obtained during the calibration process, the indicated different response would have been entirely due to the simulated man-induced change. The magnitude of the change was based on a relative comparison between the model results without the man-made change (Alternative 1) and the results with the change (Alternatives 3, 4, and 5). These relative differences were then translated to the expected “real world” response by adjusting observed shoreline changes by the relative difference in the response of the model to the conditions.

Note the model results for Alternative 1 are also applicable to Alternative 2, Abandon/Retreat, since physical conditions pertaining to Alternatives 1 and 2 are similar and both alternatives include the continued periodic nourishment of the federal storm damage reduction project.

Waves in Delft3D were simulated using SWAN (Simulating Waves Nearshore), an advanced wave transformation model that incorporates most wave transformation processes, including breaking, shoaling, refraction, reflection, diffraction, and bottom friction. Water levels, currents, and bathymetric changes are simulated using Delft3DFLOW. Delft3D simulated the relevant coastal processes over short-term (days- weeks) and long-term (seasons-years) time scales. These models were employed to determine impacts for Alternatives 1, 3, 4 and 5. The model output for Alternative 1 was also applicable for Alternative 2 as neither alternative included new action.

With the exception of Alternative 4, model simulations for all the alternatives were carried out over a three-year period. In the case of Alternative 4, the model results for Alternative 1 at the end of the 3-year simulation was used as the starting point for simulating the re-dredging of the channel/borrow area. Following this simulated re-dredging in the model, the model was run for three additional years to simulate the impacts of a second channel/borrow area excavation on shoreline changes and reconfiguration of the ebb shoal of Shallotte Inlet. The use of the three-year period for the other alternatives was based on the periodic nourishment interval for the federal storm damage reduction project. The formulation of each of the alternatives, particularly the alternatives involving beach nourishment, was based on the modeled performance of the beach fill over the three-year model simulation. In some instances, the modeled performance of the beach fill as well as criteria established to evaluate the alternatives suggested periodic nourishment intervals either shorter or longer than three years. However, since the model results were only used to obtain a relative comparison of the performance of each alternative, the three-year model simulation provided sufficient information on which to make engineering judgements with regard to determining long-term periodic nourishment requirements of each of the alternatives.

For additional information on the model, including calibration and results please refer to Appendix B and C.

In order to determine changes to habitat acreages within the Permit Area, several methods were employed. Direct impacts were determined by identifying the footprints of project-related activities (i.e. proposed areas to be dredged, beach fill locations, staging area, etc.). These footprints were overlaid upon the baseline habitat map delineated from 2012 aerial photography. The area of specific habitat types which fell within this footprint was determined to be directly impacted and the acreages were extrapolated utilizing GIS software. Indirect impacts were determined by the changes to the shoreline during post-construction conditions as interpreted from the Delft3D modeling results. The modeled mean higher high water (MHHW) lines were initially determined from a 2013 shoreline survey and entered into Delft3D. The indicated shoreline locations for each modeled alternative were then overlaid onto the baseline habitat map. The habitats where then clipped along the MHHW lines. Any portions of the habitats that were located seaward of the MHHW were also considered to be impacted by the modeled changed position of the MHHW. Note that if an area of the habitat was directly impacted and the same area was impacted indirectly, this acreage was considered already disturbed biologically and was not counted in the indirect habitat impact totals. While several upland habitat types are present within the permit area, this Delft3D analysis of indirect impact only evaluates habitats which are present on the oceanfront of the islands and the shorelines along the mouth of the inlet within the permit area. For Alternatives 1 and 2, post-construction Year 3 model outputs were utilized for the analysis of indirect impacts due to the fact that beach nourishment is planned for every three years. Because the beach nourishment cycle for Alternatives 3 and 4 are proposed every two years at the beginning of the 30-Year project, Year 2 post-construction conditions were chosen for the indirect analysis. Finally, Alternative 5 involves a 5-year nourishment cycle, and hence, the Year-5 post-construction Deflt3D model output was utilized for the analysis of indirect impacts. These results should be interpreted with caution as they are not intended to be a precise prediction of habitat change considering they are in part based on modeling simulations and are therefore only intended to provide insight on potential changes. Table 5.1, shown below, is an attempt to depict the range of impacts that could be incurred for each alternative in terms of the geographic scope of habitats present within the project area. While it is understood that the various footprints of the project-related actions along with shoreline change could result in habitat impacts, it is difficult to calculate the overall net impacts (positive or negative) due to the difficulty of assessing the conversion from one habitat type to another. Therefore, Table 5.1 illustrates the estimated amount of habitats impacted but it does not account for changes in habitat due to conversion from one habitat type to another.

Table 5.1- Area (in acres) of various habitats that is expected to be affected by project alternatives over a 5-year period.

Habitat Type	Impact Type	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5
Inlet Dry Beaches	Direct	0	0	0.6	0.6	0
	Indirect	5-10	5-10	5-10	5-10	5-10
Inlet Dunes	Direct	0	0	0	0	0
	Indirect	1-2	1-2	1-2	1-2	1-2
Oceanfront Dry Beach	Direct	15.1	15.1	16.5	16.5	15.9
	Indirect	0-5	0-5	0-5	0-5	0-5
Oceanfront Dunes	Direct	0	0	0	0	0
	Indirect	0	0	0	0	0
Intertidal Flats and Shoals	Direct	11.2	11.2	11.2	11.2	11.2
	Indirect	1-2	1-2	1-2	1-2	1-2
Subtidal/Water Column	Direct	161.1	161.1	197.2	197.2	180.7
	Indirect	0.45	0.45	0.45	0.45	0.45
Softbottom	Direct	161.1	161.1	197.2	197.2	180.7
	Indirect	0.45	0.45	0.45	0.45	0.45
Wet Beach	Direct	14.4	14.4	16	16	15.6
	Indirect	25-30	25-30	25-30	25-30	25-30

Alt.1: No Action   Alt 3: Beach Fill Only   Alt 5: Terminal Groin with Beach Fill
Alt 2: Abandon/Retreat   Alt 4: Realignment of Shallotte Inlet Ocean Bar Channel

3. What impact would each alternative have on the shorelines of Ocean Isle Beach, Holden Beach, and Sunset Beach?

Measured shoreline changes along Ocean Isle Beach and the west end of Holden Beach together with changes along the oceanfront and inlet shoreline inferred by the numerical model known as Delft3D were used to compare potential differences in impacts associated with each of the alternatives. Delft3D simulates changes in hydrodynamics, sediment transport, and the morphology of the inlet and nearshore environments in response to changes imposed by project alternatives over a 3-year period. Appendix C provides details of the Delft3D model development and calibration while the results of the model simulations for Alternatives 1, 3, 4, and 5 are provided in Appendix B. The results of the model simulation for Alternative 1 are also applicable to Alternative 2, Abandon and Retreat, since the primary difference between these two alternatives is the use of temporary sandbag revetments under Alternative 1 to protect upland development while Alternative 2 does not involve the use of temporary sandbag structures. Measured shoreline changes and volume changes obtained from the ongoing beach monitoring program on Ocean Isle Beach and the west end of Holden Beach under the auspices of the federal storm damage reduction project are also provided in Appendix B.

A brief summary of the measured shoreline and volume changes along Ocean Isle Beach and Holden Beach under existing conditions and implied changes deduced from the model results for all of the alternatives follows. As stated in Appendix C, the model was calibrated for a three-year eriod from April 2007 to April 2010 using input parameters (waves, tides, and winds) derived from known or observed conditions. The same “known” conditions were used in the simulation of the other alternatives with any difference in the response of the model clearly attributable to man-induced changes associated with each alternative. Under existing conditions, the west end of Holden Beach is separated from the east end of Ocean Isle Beach by the borrow area in Shallotte Inlet which is dredged to a depth of 15 to 18 feet below NAVD. The sediment trap and the behavior of the inlet would have a much greater influence on the ability of littoral sediment to move from west to east across the inlet compared to the relatively minor changes in sediment transport patterns associated with the terminal groin in which wave driven sediment transport will move either through, over, or around the seaward end of the structure.

Delft3D modeling was not performed to assess potential impacts to Sunset Beach. However, the sediment budget presented in the Engineering Report (Appendix B) found the predominant direction of littoral sand transport was to the east for areas east of baseline station 120+00. As explained in Appendix B, the sediment budget was developed using relative sand transport rates derived from the results of the Delft3D model and measured volume changes along the shorelines for the 2007 – 2010 time period. Consequently, no project alternative is anticipated to impact the oceanfront shoreline at Sunset Beach.

- <u>Alternative 1 – No Action</u> (Continue Current Management Practices)

Under Alternative 1, the Federal storm damage reduction project that covers 17,100 feet of the ocean shoreline of Ocean Isle Beach west of Shallotte Boulevard would continue to be nourished approximately every three years with material removed from the borrow area located in Shallotte Inlet. Also, the same erosion response measures employed by the Town, NCDOT, and property owners on the extreme east end of the island would continue. The erosion response measures have included installation of sandbag revetments, occasional beach scraping (bulldozing), periodic disposal of navigation maintenance material, and demolition or relocation of threatened homes. Note the Town of Ocean Isle Beach attempted a supplemental beach fill along the eastern end of the island in conjunction with the 2006-2007 periodic nourishment operation for the Federal storm damage reduction project; however, due to the failure of the supplemental fill to provide any significant long-lasting relief to the erosion threat, the Town of Ocean Isle Beach does not plan to use this approach in the future.

The average volume of material placed along Ocean Isle Beach every three years to nourish the Federal storm damage reduction project is provided in Table 5.2. Note the Federal project has not required any nourishment between stations 120+00 and 181+00 (the west end of the Federal project). Under Alternative 1, future periodic nourishment of the Ocean Isle Beach storm damage reduction project would continue to be the same as in the past.

Table 5.2. Average three-year nourishment volume for the Ocean Isle Beach Federal storm damage reduction project.

Beach Segment (baseline stations)	Three-year Nourishment Volume (CY)
10+00 to 30+00	175,000
30+00 to 60+00	177,000
60+00 to 90+00	42,000
90+00 to 120+00	14,000
Total	**408,000**

Along the westernmost 4,000 feet of Holden Beach, measured volume changes averaged a loss of 44,000 cubic yards/year between April 2007 and April 2010.

Future impacts on development on the east end of Ocean Isle Beach were evaluated based on the continuation of erosion trends determined from a comparison of US Geological Survey LiDAR surveys obtained between 1997 and 2010. This span of time represents the time period when the Shallotte Inlet and its adjacent shorelines were modified through the utilization of the inlet's borrow area. This time period also represents the time in which the sandbag revetment was constructed and impacted short-term shoreline responses by delaying the movement of the shoreline. The plan formulation for the east end of Ocean Isle Beach did not include any assessment of potential storm damage reduction with any of the alternatives. Due to the past efforts involving the installation of sandbag revetments and other measures such as the disposal of navigation maintenance material on the east end of the island, as explained in Appendix B, the LiDAR surveys were used to track the movement of the erosion scarp line.

Based on the past performance of sandbag revetments on the east end of Ocean Isle Beach, once a sandbag revetment fails, the shoreline tends to make an almost instantaneous correction by moving to a position it would have occupied in the absence of the sandbags. Also, the life of sandbag revetments appeared to be approximately five (5) years. Therefore, the impact analysis for Alternative 1 assumed sandbag revetments would be installed every five (5) years throughout the 30-year evaluation period with the failure of the sandbags every five (5) years followed by an immediate landward jump in the shoreline position following the sandbag failure.

The Delft3D simulation of volume changes along Ocean Isle Beach and the west end of Holden Beach for Alternative 1 were evaluated over a three-year simulation period with the results evaluated for volume changes landward of the -18-foot NAVD depth contour and landward of the -6-foot NAVD depth contour. As discussed below, the model volume changes seaward of the -6-foot NAVD depth contour indicated accretion off the east end of Ocean Isle Beach for all of the alternatives. This similarity in the model response was due to the orientation of the Shallotte Inlet ocean bar channel which maintained a southwesterly alignment during the three-year simulations for all alternatives. In this regard, the initial conditions for all alternatives assumed material would be removed from the Shallotte Inlet borrow area to nourish the Federal storm damage reduction projects. The assumed cut in the Shallotte Inlet borrow area, which is shown in Figure 4.2a in Appendix B, was positioned on the west side of the borrow area and oriented toward the southwest.

Given the influence of the channel orientation, the primary difference in the model volume changes occurred landward of the -6-foot NAVD depth contour. Therefore, modeled volume changes landward of -6 feet NAVD were used to determine relative differences in the shoreline response between alternatives.

For Alternative 1, the model volume change rates landward of -6 feet NAVD are summarized in Table 5.3 for segments along Ocean Isle Beach and for the western 4,000 feet of Holden Beach. The location of the two segments on Ocean Isle Beach east of baseline station 0+00 (with negative station numbers) are shown in Figure 5.1 with the segment between stations -5+00 and -20+00 representing the ocean facing portion of the sand spit on the east end of the island, while the segment between stations -20+00 and -30+00 borders a portion of the main channel of Shallotte Inlet (see Figure 5.1 for reference).

Table 5.3. Model volume change rates above -6 feet NAVD along Ocean Isle Beach and the west end of Holden Beach for Alternative 1.

Beach Segments (baseline stations)	Model Volume Change (cy/yr)
Ocean Isle Beach	
-20+00 to -30+00	-1,000
-5+00 to -20+00	-4,000
-5+00 to 30+00	-24,000
30+00 to 60+00	-18,000
60+00 to 90+00	-14,000
90+00 to 120+00	-7,000
Holden Beach	
385+00 to 345+00	-11,000

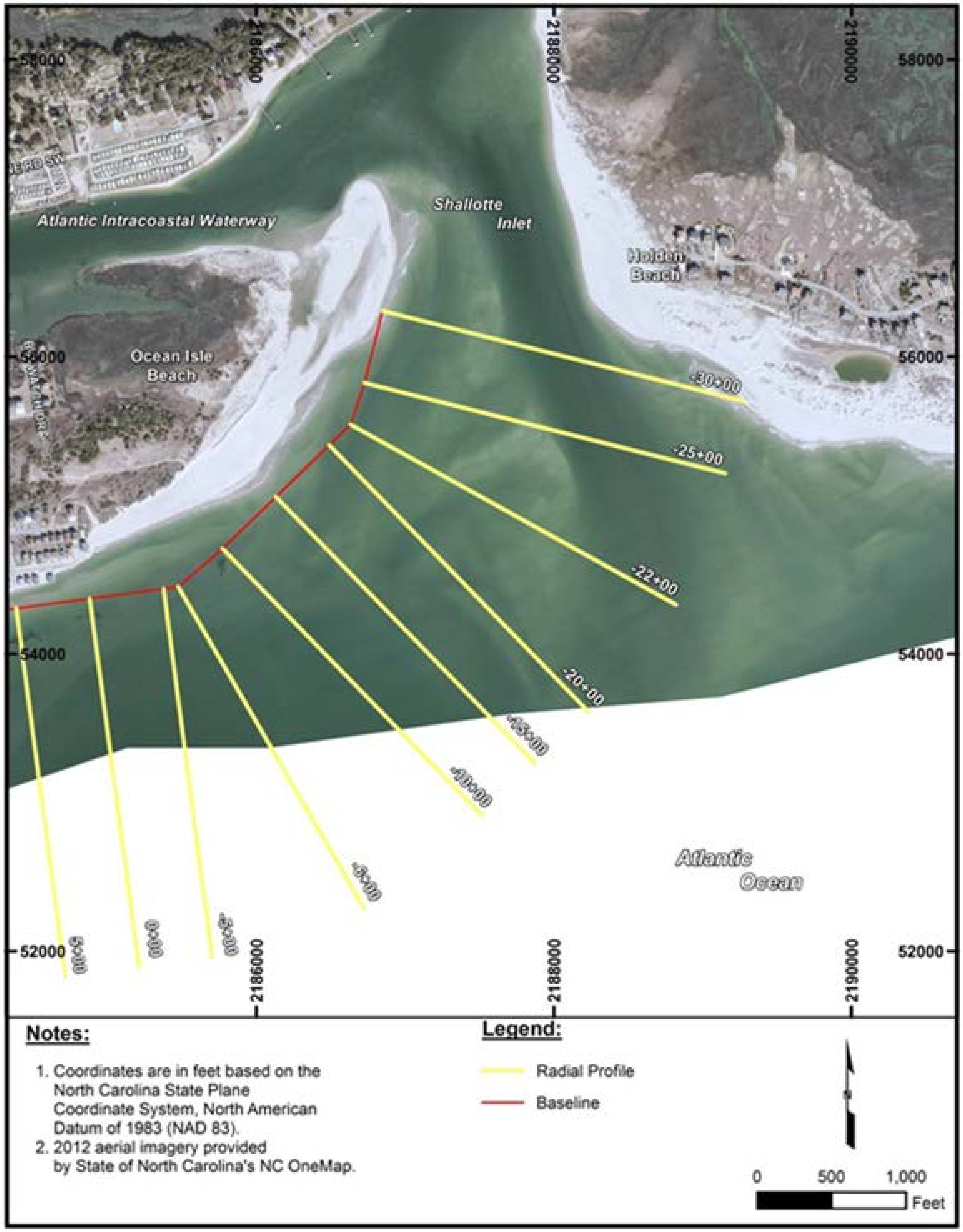

Figure 5.1. Radial profiles around east end Ocean Isle Beach.

The modeled erosion (red) and deposition (green) patterns within the project area that occurred over the 3-year simulation period for Alternative 1 are shown in Figures 5.2 to 5.4. During the 3-year simulation, the ocean bar channel of Shallotte Inlet maintained an orientation toward the southwest which resulted in significant shoaling of the area seaward of the -18-foot NAVD depth contour off the east end of Ocean Isle Beach. Erosion occurred landward of the -6-foot NAVD depth contour along the entire project area.

As shown in Figure Table 5.3, the sand spit extending off the east end of Ocean Isle Beach into Shallotte Inlet experience erosion. The ocean facing segment between station -5+00 and -20+00 lost material at a rate of 3,700 cubic yards/year while the segment closer to the inlet (-20+00 to -30+00) eroded at a rate of 700 cubic yards/year. The distal end of the sand spit experienced some significant erosion over the three-year simulation as indicated by the red-shaded area in Figure 5.4.

On the western 4,000 feet of Holden Beach, the model indicated erosion of 11,000 cubic yards/year landward of the -6-foot NAVD depth contours. However, there was essentially no change in the shoreline along the Holden Beach shoreline facing Shallotte Inlet.

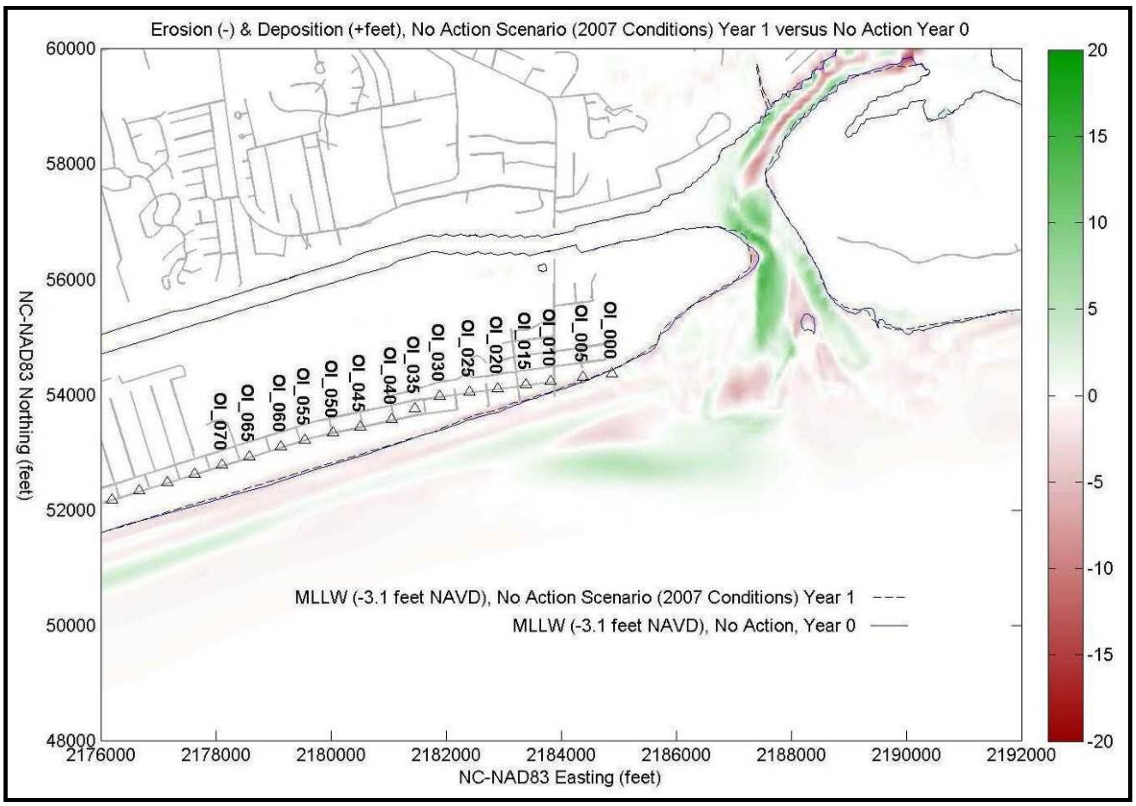

Figure 5.2. Alternative 1 erosion/deposition patterns after Year 1 of the Delft3D model simulation

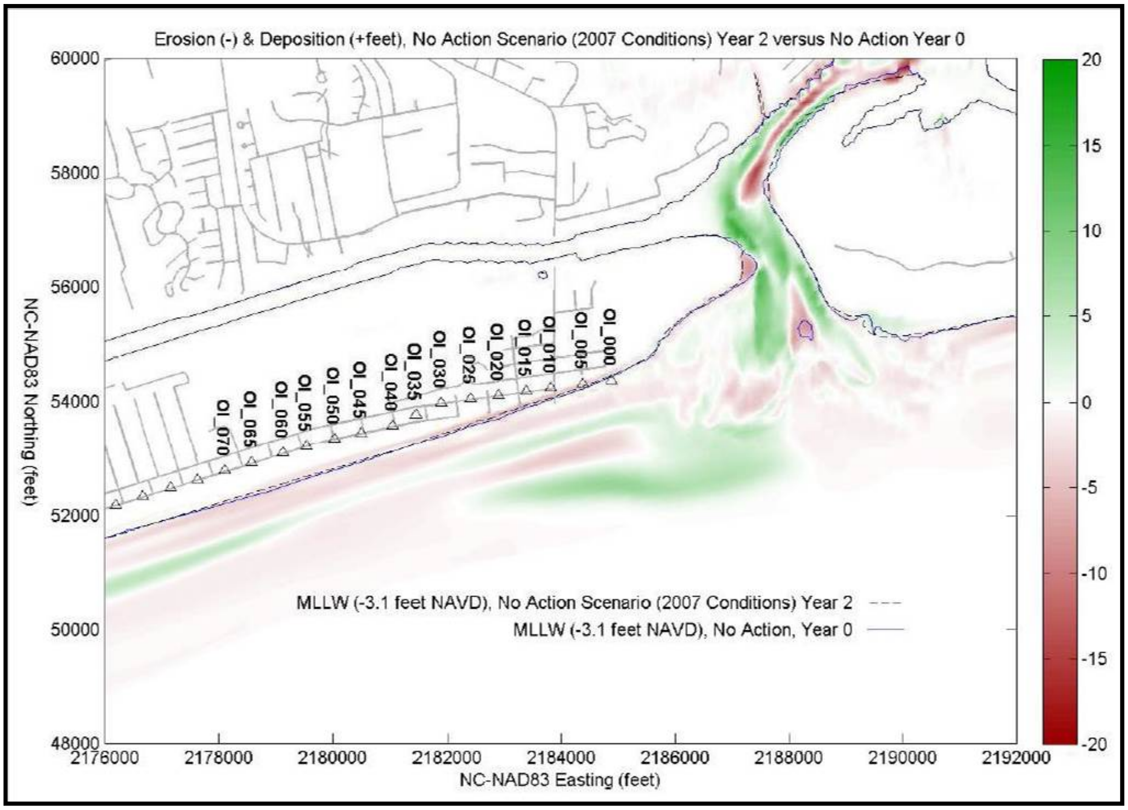

Figure 5.3. Alternative 1 erosion/deposition patterns after Year 2 of the Delft3D model simulation

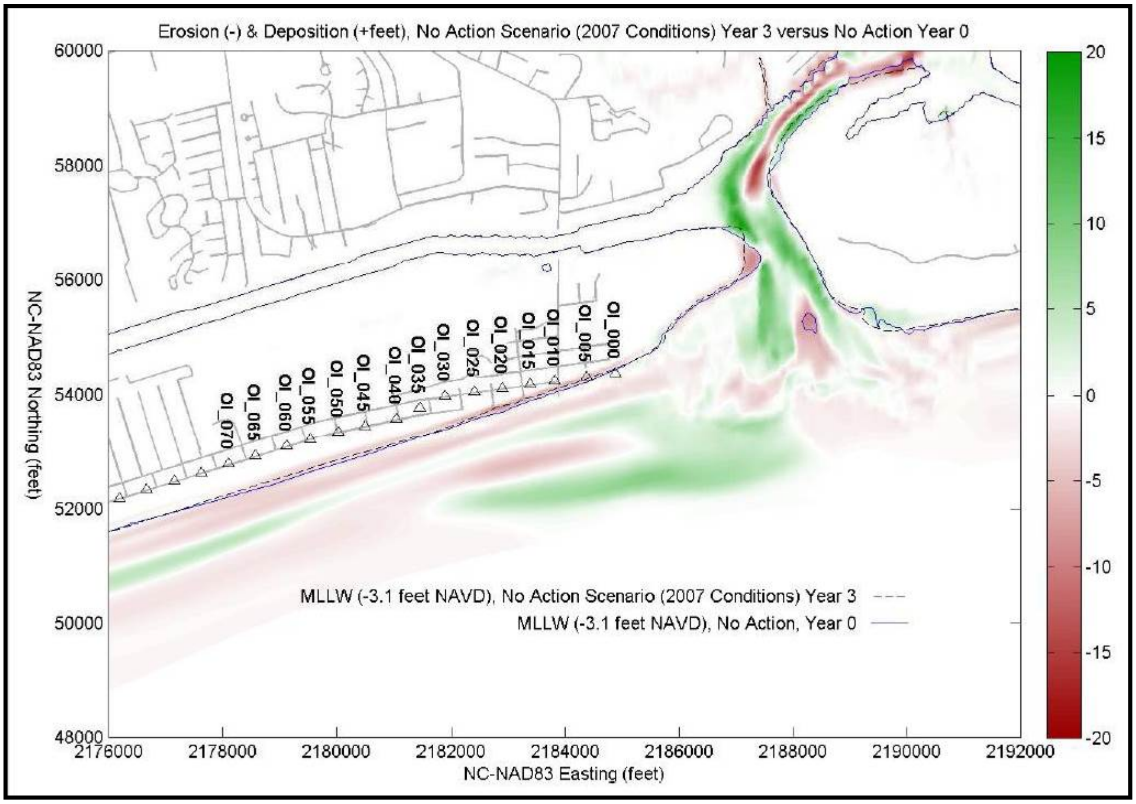

Figure 5.4. Alternative 1 erosion/deposition patterns after Year 3 of the Delft3D model simulation.

In the portion of Shallotte Inlet situated between the west end of Holden Beach and the east end of Ocean Isle Beach, the model indicated significant accretion which was associated with the accumulation of sediment in the Shallotte Inlet borrow area. In this regard, the initial model setup, which was based on April 2007 conditions, represented post-nourishment conditions along Ocean Isle Beach as well as post-dredging conditions in Shallotte Inlet.

The model indicated some scour or erosion of the portion of the AIWW extending from Shallotte Inlet northeast to the mouth of Shallotte River. Also, there was some accumulation of sediment along the shorelines bordering the waterway. West of the confluence of the inlet with the waterway, the model did not indicate any significant erosion or deposition.

- Alternative 2 – Abandon/Retreat

Periodic nourishment of the Federal storm damage reduction project along Ocean Isle Beach would continue under Alternative 2. Since no other action would be taken to protect development on the east end of Ocean Isle Beach, the Delft3D model results for Alternative 1 are also applicable to Alternative 2. With erosion on the east end of the island continuing unabated, the same homes and infrastructure that could be damaged with the continued landward movement of the erosion scarp line on the east end of the island over the next 30 years under Alternative 1 would face the same fate under Alternative 2. The only difference would be when erosion impacts occur. With no action being taken to protect threatened homes and infrastructure, damages would occur continuously throughout the 30-year analysis period rather than in five (5) year increments as in Alternative 1.

- Alternative 3 – Beach Fill Only (Including Federal Project)

Alternative 3 includes beach fill along a 3,500-foot section on the east end of Ocean Isle Beach situated between baseline stations -5+00 (500 feet east of the end of development) and station 30+00 (located just west of Lumberton Street). Shoreline changes on both Ocean Isle Beach and Holden Beach were simulated over a 3-year period using the Delft3D numerical model (Appendix C). The use of beach fill combined with adequate periodic nourishment should be able to prevent erosion damage along the east end of Ocean Isle Beach.

Sediment transport along the extreme east end of Ocean Isle Beach is generated by both wave driven littoral currents and tidal currents flowing in and out of Shallotte Inlet. This combination of sediment transport factors results in sediment moving into Shallotte Inlet off the east end of the island at a faster rate than wave driven currents alone can move sediment into the area. The addition of a beach fill along the extreme east end of the island would produce a bulbous shape in the shoreline which would be conducive to horizontal spreading or diffusion of the material away from the fill area. This phenomenon was observed following the Town's attempt to nourish the east end of the island in January 2007 (see Appendix B for additional information). The combination of wave currents, tidal currents, and diffusion of fill material combined to produce rather large losses from the fill and in turn large volumes of periodic nourishment that would be needed to maintain the desired level of erosion protection on the east end of the island.

Based on a Delft3D model assessment of beach fill performance on the east end of Ocean Isle Beach, volumetric losses from beach fill placed east of baseline station 30+00 would be expected to erode at a rate of 140,000 cubic yards/year (Appendix B). Under existing conditions, losses from this area average 91,000 cubic yards/year. For the shoreline segment situated between baseline stations 30+00 and 120+00, the model assessment for Alternative 3 did not indicate any change from existing conditions. Volume losses from the area west of station 30+00 have averaged 78,000 cubic yards/year. Thus, if Alternative 3 is implemented, the total periodic nourishment requirement for the area extending from station -5+00 to station 120+00, which includes both the Federal project and the local beach fill project, would average 218,000 cubic yards/year.

The simulated erosion and deposition patterns in the vicinity of Shallotte Inlet after the three year simulation for Alternative 3 are shown in Figure 5.5. Along the Ocean Isle Beach sand spit between stations -5+00 and -20+00, the model indicated there would be no net change in volume above the -6-foot NAVD depth contour after three years which is a slight improvement compared to Alternative 1. This improvement was due to the migration of sediment from the east end beach fill toward Shallotte Inlet. However, the indicated volume change between stations -20+00 and -30+00 was -15,300 cubic yards/year which was over four (4) times the loss rate indicated for Alternative 1. This increase in the rate of volume loss on the eastern end of the sand spit is counterintuitive given the eastward spreading of the beach fill material that resulted in the stabilization of the segment between stations -5+00 and -20+00. One possible explanation would be changes in wave patterns on the east end of the spit due to waves refracting around the bulbous shape of the beach fill. Considering the margin of error associated with the Delft3D model, the difference could also be associated with the inherent difference in the response of the model to various permutations associated with the addition of the relatively large beach fill.

Volume losses off the distal end of the Ocean Isle sand spit shown in Figure 5.5 were similar to the losses simulated for Alternative 1. Volume changes on the west end of Holden Beach landward of the -6-foot NAVD depth contour averaged 12,000 cubic yards/year which was essentially the same as for Alternative 1.

As was the case for Alternative 1, there was significant sediment accumulation in Shallotte Inlet that was associated with infilling of the borrow area. Changes inside the inlet and along the AIWW to the mouth of the Shallotte River also mimicked changes observed for Alternative 1 with some scour in the middle of the channel and sediment accumulation on both sides of the channel.

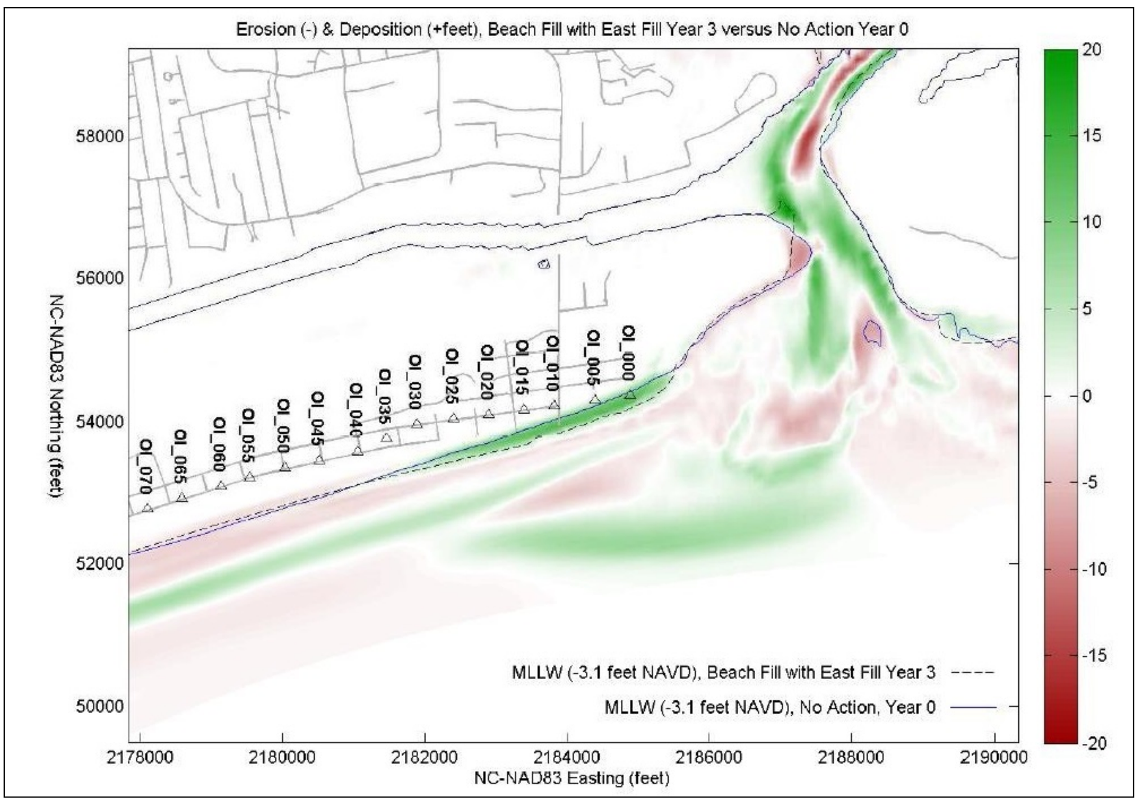

Figure 5.5. Alternative 3 – Erosion/deposition patterns after 3 years of the Delft3D simulation.

- Alternative 4 – Shallotte Inlet Bar Channel Realignment with Beach Fill (Including Federal Project)

The existing Federal storm damage reduction project for Ocean Isle Beach was formulated by the USACE to include a borrow area in Shallotte Inlet that would replicate a new bar channel situated midway between the west end of Holden Beach and the east end of Ocean Isle Beach and oriented approximately perpendicular to the alignment of the adjacent shorelines. The borrow area was about 950 feet wide through the gorge of the inlet (i.e., the area between the ends of the two islands) widening to around 1,400 feet at the seaward end (Figure 4.9 in Appendix B). The rather large expanse of the borrow area was not effective in concentrating ebb flow into a well-defined channel and subsequent shoaling in the borrow area, which occurred primarily from the west side, resulted in the formation of a dominant ebb channel close to the west end of Holden Beach.

Normally, in a situation similar to Ocean Isle Beach, a channel relocation project would position the new channel closer to the east end of the island in order to effect a build-up of material on the west side of the inlet. However, in the case of Shallotte Inlet, the initial borrow area and the areas subsequently dredged during periodic nourishment operations did not concentrate in one particular channel corridor, rather, the focus of the dredging operation was on obtaining beach nourishment material needed to maintain the Federal project. As a result, the only positive change on the east end of Ocean Isle Beach has been the formation of a sand spit projecting off the east end of the island into Shallotte Inlet.

The Delft3D model for Alternative 1 was run with a simulated post-nourishment channel condition as shown in Figure 4.2a in Appendix B. Over the three-year simulation, the model did indicate some accumulation of sediment on the west side of the inlet's ebb tide delta but no positive impact on shoreline erosion rates along the shoreline fronting development on the east end of the island. As the model suggests, if future periodic nourishment operations are concentrated in a preferred channel corridor, the forced concentration of flow through the channel corridor should eventually result in the reconfiguration of the ebb tide delta to a condition comparable to that which existed between the mid 1950's and mid 1960's, a time during which the east end of Ocean Isle Beach experienced relative stability.

To make the borrow area in Shallotte Inlet function as a true channel relocation, material removed during periodic nourishment operations should be derived from the same general area as used for initial construction of the federal storm damage reduction project. By continuing to use the same general cut area for each nourishment operation, the borrow area should eventually become the dominant flow path for waters exiting through the inlet. Over time, the inlet should respond to the new "permanent" channel position and alignment with a wholesale shift in the ebb tide delta to the west resulting in the accumulation of sediment on the west side of the ebb tide delta. As a result of the reconfiguration of the ebb tide delta, the shoreline on the east end of Ocean Isle Beach should respond in much the same manner as was observed between 1954 and 1965.

The evaluation of the impacts of repetitive channel relocations within the same general footprint as used during initial construction of the federal storm damage reduction project were simulated in the Delft3D model by re-dredging the channel/borrow area using the bathymetry at the end of the three-year simulation for Alternative 1 as the starting point. The "re-dredging" of the channel/borrow area simulated the same dimensions of the channel as that created during initial construction of the federal project. The results of the model simulations over the ensuing three-year period following the channel/borrow area re-dredging is provided in detail in Appendix B.

Erosion and deposition patterns at the end of Year 6 of the model simulation for Alternative 4 is provided on Figure 5.6. At the end of Year 6, sediment continued to accumulate west of Shallotte Inlet which is one of the desired results associated with the channel relocation alternative.

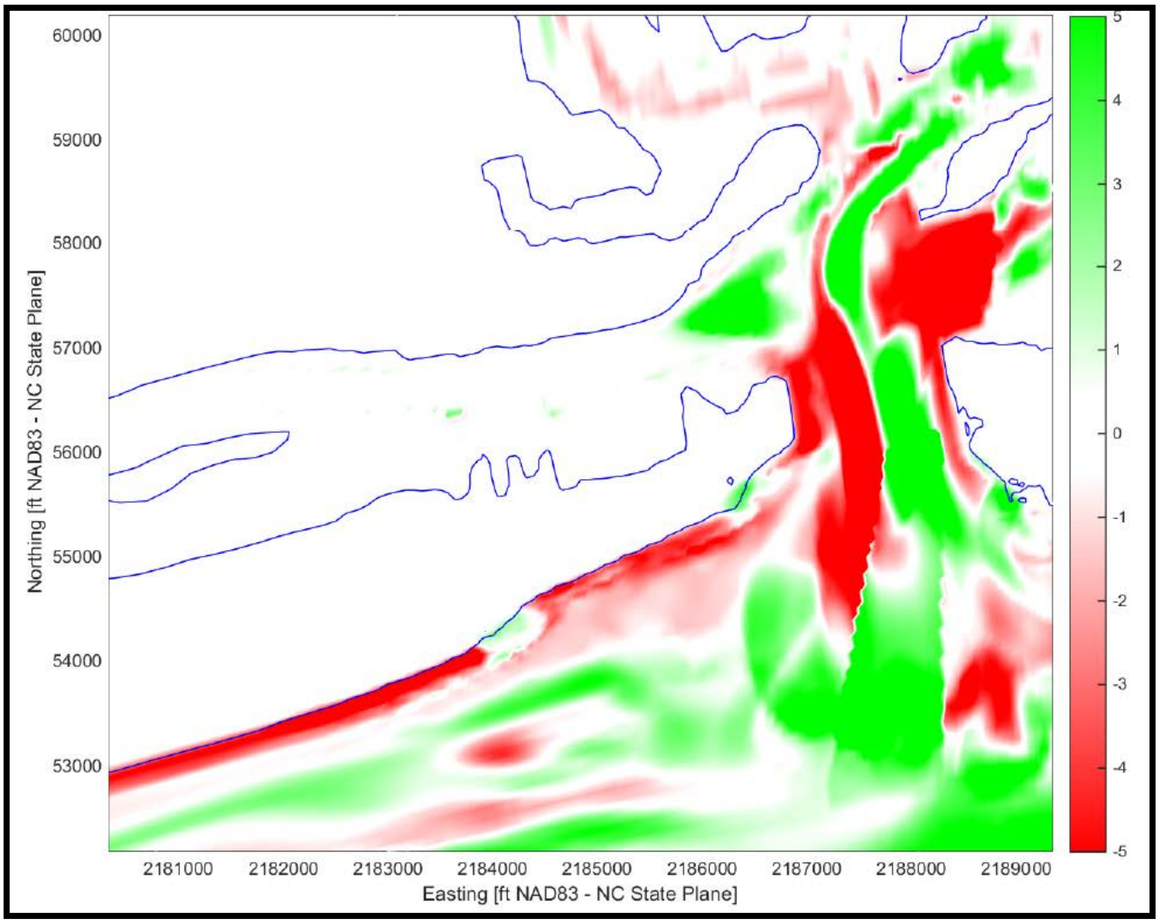

Figure 5.6. Alternative 4 scour and deposition patterns at the end of Year 6 of the Delft3D model simulation.

Following the re-dredging of the channel/borrow area in Year 3, average annual volumetric losses over the next three-year simulation from the shoreline segments along the east end of Ocean Isle Beach relative to the losses under Alternative 3 were 65% for the segment between -5+00 and 30+00 with losses from the other three segments west of station 30+00 equal to 63%, 89%, and 44%, respectively, relative to the losses under Alternative 3. Applying these relative volume changes to the volume changes for Alternative 3 results in projected volume losses following the re-dredging of the channel/borrow area provided in Table 5.4 for model years 3 to 6. Assuming a subsequent re-dredging of the channel would result in similar volume loss reduction, the projected volume losses from the east end of Ocean Isle Beach between years 6 and 9 are also provided in Table 5.4. The projected annual rates of volume change along the east end of Ocean Isle Beach were assumed to remain the same as the losses indicated for model years 6 to 9 in Table 5.4 for the remainder of the 30-year evaluation period.

Table 5.4. Average annual rates of volume change along the east end of Ocean Isle Beach indicated by the Delft3D model results for Alternative 4.

Model Years	-5+00 to 30+00	30+00 to 60+00	60+00 to 90+00	90+00 to 120+00	Total
0 to 3[1]	-140,000	-33,000	-13,000	-6,000	-192,000
3 to 6	-91,000	-21,000	-12,000	-3,000	-127,000
6 to 9	-59,000	-13,000	-11,000	-1,000	-84,000

[1]Same as Alternative 3

Applying the 408,000 cubic yard volume limit per nourishment operation adopted for evaluating each alternative, periodic nourishment under Alternative 4 would be needed 2 years after the first channel/borrow area dredging event with 384,000 cubic yards needed to restore the beach fill. In this regard, extending the nourishment interval to 3 years following the first re-dredging of the channel/borrow area would require 508,000 cubic yards of nourishment which exceeds the 408,000 cubic maximum referenced above. With the projected reduction in volume loss from the east end of Ocean Isle Beach following subsequent channel/borrow area dredging events as shown in Table 5.4, the next periodic nourishment operation under Alternative 4 would be needed 3 years after the first renourishment, i.e., during project year 5. For this operation, a total of 381,000 cubic yards would be needed to restore the beach fill along the east end of Ocean Isle Beach. Assuming volume losses would continue to decrease for at least one more channel dredging operation as indicated in Table 5.4, periodic nourishment would be needed 4 years later with the nourishment volume projected to be 336,000 cubic yards. Periodic nourishment requirements under Alternative 4 were assumed to remain at 336,000 cubic yards every four years for subsequent nourishment operations.

- <u>Alternative 5 - Terminal Groin with Beach Fill</u> (Including Federal Project)/Applicant's Preferred Alternative

Alternative 5 includes the construction of a terminal groin on the east end of Ocean Isle Beach and the placement of beach fill west of the structure to fill the area generally referred to as an accretion fillet. The terminal groin would have a 300-foot long shore anchorage section constructed with sheet piles (either concrete or steel) that would begin 450 feet landward of the baseline. The seaward 750 feet of the terminal groin would be constructed as a rubblemound and would project 600 feet seaward of the baseline. The crest elevation of the rubblemound section would be +4.9 feet NAVD88. The head or seaward end of the terminal groin would be constructed with a 1V:3H slope would add approximately 50 feet to the overall length of the structure depending on the profile depths at the time of construction. The seaward section would be constructed with loosely placed armor stone to facilitate the movement of sand past the structure.

The shore anchorage section would have a top elevation varying from +4.9 feet NAVD to +4.5 feet NAVD.

Based on the Delft3D model evaluations, the terminal groin would essentially stabilize the shoreline west of the structure to about baseline station 30+00 and would reduce periodic nourishment requirements of the Federal project east of station 30+00 by 95%. The model indicated erosion and deposition patterns at the end of the three year simulation as shown in Figure 5.7.

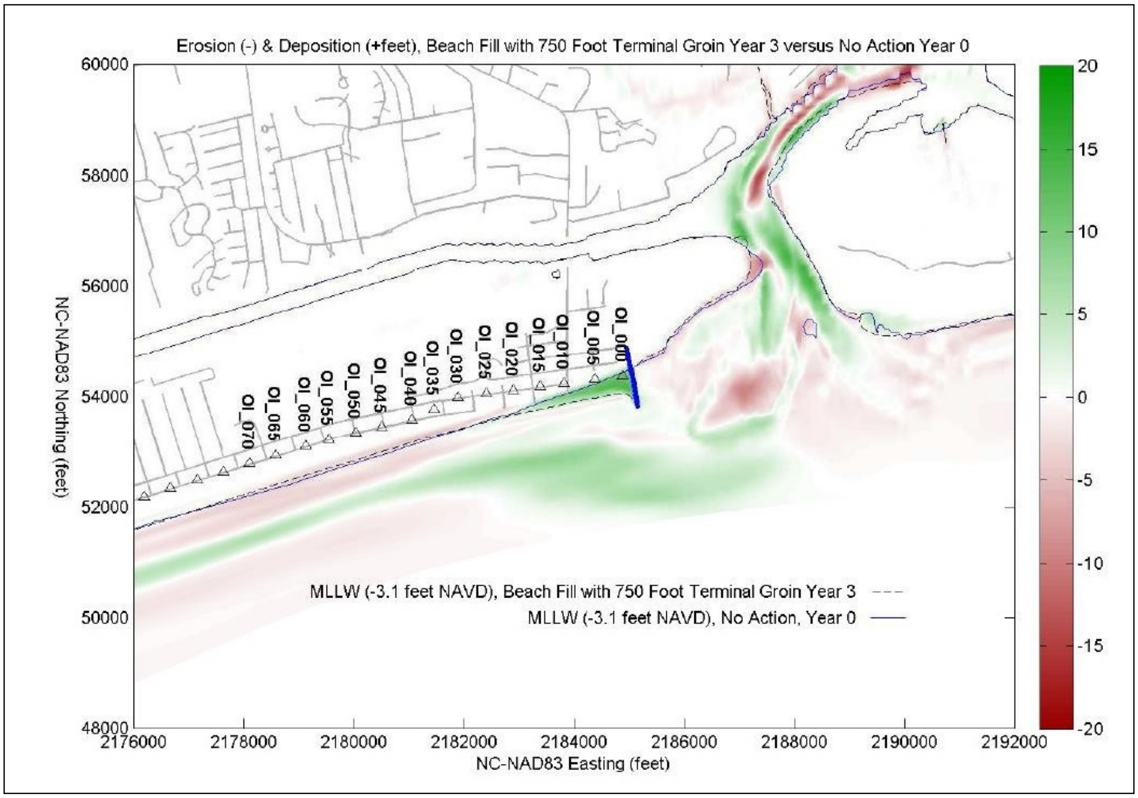

Figure 5.7. Alternative 5 erosion/deposition patterns at the end of the three-year Delft3D model simulation.

The terminal groin was found to not have any significant impact on the shoreline or periodic nourishment requirements of the Federal project west of station 30+00. Similarly, the model indicated changes on the west end of Holden Beach landward of the -6-foot NAVD contour that were the same as Alternative 1, the No Action alternative.

With the model results indicating no change in the shoreline response west of baseline station 30+00 on Ocean Isle Beach with the terminal groin in place, the areas farther to the west, including the west end of Ocean Isle Beach, Tubbs Inlet, and Sunset Beach would not be impacted by the terminal groin. In this regard, the sediment budget presented in the Engineering Report (Appendix B) found the predominant direction of littoral sand transport was to the east for areas east of baseline station 120+00. As explained in Appendix B, the sediment budget was developed using relative sand transport rates derived from the results of the Delft3D model and measured volume changes along the shorelines for the 2007 – 2010 time period.

In any event, regardless of the predominant direction of sand transport in an area, once waves interact with a tidal inlet, specifically the ebb tide delta of an inlet, incoming waves tend to refract and focus in toward the middle of the inlet in much the same manner as eyeglasses focus light rays in to the eye. This refraction effect can influence the direction of wave approach into the inlet for several thousand feet on either side of the inlet. For example, if waves approach Shallotte Inlet from the southeast, which would tend to move sediment along the shore in an east to west direction, wave refraction will generally change the direction of wave approach on the west side of Shallotte Inlet to a southwest direction. An example of this wave refraction phenomenon is shown on the October 2009 Google Earth photo below (Figure 5.8). When this photo was taken, offshore waves were approaching the inlet from the southeast, as shown by the dashed white lines superimposed over the incoming wave crests. Once the waves encountered the inlet, the wave direction just west of the inlet changed to the southwest. On this particular date, the wave refraction phenomenon appeared to extend west to approximately baseline station 10+00 (Shallotte Boulevard).

Figure 5.8. Wave refraction at Shallotte Inlet, October 2009.

The change in wave direction caused by the wave refraction phenomenon would tend to move sediment to the east for some distance west of the inlet. In general, the wave refraction impacts around Shallotte Inlet extend west to approximately Shallotte Boulevard, i.e., sediment transport from Shallotte Boulevard east to Shallotte Inlet would normally be expected to toward the east most of the time. The wave refraction phenomenon, which exists around most inlets, is one of the factors contributing to the high rate of sediment loss off the east end of Ocean Isle Beach. Consequently, installation of a terminal groin in the area between Shallotte Inlet and Shallotte Boulevard would not have an impact on the infrequent occasions when sediment is transported to the west out of the area. The main impact of the terminal groin would be to establish a permanent shoreline alignment comparable to the shoreline alignment that presently exists between station 30+00 and Shallotte Boulevard.

For the segment of the shoreline just east of the terminal groin (baseline stations -5+00 to -20+00), volume losses landward of the -6-foot NAVD contour during the first year of the simulation totaled 53,000 cubic yards, while the segment between stations -20+00 and -30+00 gained 17,000 cubic yards. Over the next two years of the simulation, volume losses in the segment between stations -5+00 and -20+00 ceased with the total volume loss from this segment after three years equal to 50,000 cubic yards, i.e., a gain of 3,000 cubic yards following the first year of the simulation. This minor amount of accretion over the last two years of the simulation is not considered to be significant, but the apparent stabilization of the segment after the first year is significant in that the segment appeared to reach a quasi-state of equilibrium in response to changes imposed by the structure.

For the segment between stations -20+00 and -30+00, the initial accretion of 17,000 cubic yards was followed by a gradual volume loss over the last two years with the end result being an accumulation of 7,000 cubic yards at the end of the three-year simulation. Given the accuracy of the model, this relative minor build-up of material within this segment is deemed not significant.

Model volume changes over the three-year simulation period for Alternative 1 compared to all three of the terminal groin options are provided in Table 4.14 in Appendix B. For the section of the beach between the proposed terminal groin and Station 30+00, all three terminal groin options showed significant improvement in terms of reduced volume losses with the 750-foot options providing the most improvement. The one area that did show higher losses over the entire 3-year simulation was between station -5+00 and -20+00. But as discussed above, the majority of this loss occurred during the first year of the simulation and then stabilized with essentially no additional losses recorded in model years 2 and 3.

Within the confines of Shallotte Inlet, the model indicated changes (at the end of the three year simulation for Alternative 5, as shown in Figure 5.7) were similar to the changes produced for the other alternatives. Overall, the sediment accumulation within the inlet complex, which includes the east and west ebb tide deltas, the inlet borrow area, and the interior channels, was about 40% less for Alternative 5 compared to Alternative 1. The reduced rate of sediment accumulation in the inlet complex is consistent with the reduction in volumetric losses off Ocean Isle Beach attributable to the terminal groin.

On the Holden Beach side of Shallotte Inlet, the model results for the terminal groin alternative did not indicate any significant difference in the response of the shoreline compared to Alternative 1. Model indicated volume losses above the -6-foot NAVD contour for Alternative 1 were -12,000 cubic yards/year compared to -11,000 cubic yards/year for Alternative 5.

Coastal structures found along the North Carolina coast, such as jetties and other terminal groins (both already constructed and those in the planning stages), are not anticipated to have a significant effect on any resources found within the Permit Area.

4. What other projects are occurring or being implemented within the vicinity of Ocean Isle Beach may cumulatively affect this project?

There are a number of shoreline protection activities and navigation projects that have occurred or are scheduled to occur on, or in proximity to, Ocean Isle Beach. These activities, as listed below, have or could impose cumulative impacts on resources within the Project Area. It is not anticipated, however, that these projects have significant effects on the proposed project area of the preferred alternative

- Maintenance of Wilmington Shipping Channel
- Maintenance of the AIWW
- Proposed Holden Beach Terminal Groin and Beach Nourishment
- Lockwoods Folly Inlet Maintenance with Oak Island Beach Nourishment

5. What are the general environmental impacts associated with the project?

The various environmental consequences associated with the alternatives are described within each alternative's corresponding section. While each alternative contains unique features, several of these alternatives include similar actions which will elicit comparable environmental consequences. These include dredging and/or beach nourishment, which are associated with Alternatives 3, 4, and 5. The environmental impacts associated with these actions are described below and summarized in Appendix D. Since sea level rise is applicable to each alternative, the potential effects of sea level rise are also described below.

General Environmental Consequences Related to Dredging

The general environmental impacts of dredging include a direct temporary increase in turbidity and total suspended solids (TSS) within the water column. Sediment loading increases turbidity and TSS, which can result in a decrease in biological productivity, clogging of fish gills, and reduced recruitment of invertebrates. Furthermore, turbidity can cause low oxygen events leading to fish kills, and cause mortality of organisms in the substrate, including oysters. High concentrations of suspended solids can cause many problems for aquatic life including low dissolved oxygen levels that can lead to fish kills. High TSS can also cause an increase in surface water temperature, because the suspended particles absorb heat from sunlight (Mitchell and Stapp, 1992). However, turbidity from dredging may also protect small or young fish from visual predators (Livingston, 1975).

Habitat alteration from dredging may have been responsible for major reductions noted in brown shrimp (-88%), blue crab (-75%), Atlantic croaker (-45%), and spot (-19%) following dredging for a marina site on Pierces Creek (Neuse River) (Street et al. 2005). Recruitment of invertebrate larvae, growth of filter feeding invertebrates, and visual foraging for prey by adult fish are also affected by turbidity from dredging (Reilly and Bellis 1983).

Dredging within the permit area is expected to result in temporary increases in suspended sediment or particulates and turbidity in the immediate area of construction activity. Turbidity is a measure of the degree to which the water loses its transparency due to the presence of suspended particulates.

During the Bogue Inlet Channel Erosion Response Project, turbidity levels were shown to remain within ambient conditions (9.7 to 35.2 NTUs) during the dredging operations. The State standard for turbidity is 25 NTUs while TSS does not have a defined standard. Any increase in turbidity associated with the excavation of the channels to the oceanfront shoreline should be of short duration. Natural conditions support fluctuating turbidity levels in the nearshore and offshore water column of the Permit Area. Storm events are known to increase these levels due to the re-suspension of sand and fine materials. These fluctuating turbidity levels would continue with or without the dredging efforts proposed with these alternatives. No cumulative effects are expected to occur from the dredging and placement activities. Elevated turbidity is anticipated only immediately adjacent to the dredge operation and would only persist while dredging and the subsequent beach filling occurs. As such, turbidity monitoring within specified areas (to be determined) will only be implemented should significant concerns arise from state or federal agencies.

Dredging activity will also impact infaunal resources. Dredging results in a direct mortality of all organisms present within the dredged material (Posey and Alphin, 2002). Although the recruitment pattern is altered, the recovery of species after sediment removal is relatively quick, depending upon the opportunistic nature of the species (Street *et al*., 2005; Posey and Alphin, 2002). At dredge sites monitored off the coast of New Jersey, infaunal assemblages recovered within one year after disturbance, while biomass and taxonomic richness took 1.5 to 2.5 years to recover (Street *et al*., 2005). The diversity of micro and macrofauna tend to be dominated by opportunistic species that recover quickly when affected by natural causes (Mallin *et al*., 2000; Street *et al*., 2005; Posey and Alphin, 2002). Softbottom communities may also change with natural shifting patterns of sediment erosion or deposition (Street *et al*., 2005). Posey and Alphin (2002) suggests that effects of beach nourishment from dredging of an offshore borrow area is minimal compared to the natural variability of the system. The temporal spacing between the periodic maintenance events within the proposed dredged areas should allow for full recovery of benthos populations.

The project construction window, including dredging activities, will be limited to November 16 through April 30. The applicant will adhere to the timing of construction that is typically applied and relative to the dredge type in order to protect threatened and endangered species while minimizing adverse impacts to offshore, nearshore, intertidal and beach resources. No dredging will occur outside of the approved time periods without prior approval from all relative State and Federal agencies.

A hydraulic cutter-suction pipeline dredge (pipeline dredge) would be used for Alternatives 3, 4, and 5. As opposed to hopper dredges, pipeline cutterhead dredges are mounted (fastened) to barges and are not usually self-powered. Rather, they are towed to the dredging site and secured in place. A pipeline dredge sucks dredged material through one end, the intake pipe, and then pushes it out the discharge pipeline directly into the disposal site. Compared to similar types of dredging methodologies, a pipeline dredge creates minimal disturbance to the seafloor resulting in lower suspended particulates and turbidity levels. Anchor (2003) conducted a literature review of suspended sediments from dredging activities. This report concluded that the use of a hydraulic dredge (i.e., pipeline dredge) limits the possibilities for re-suspension of sediment to the point of extraction. Also, since the sediment is suctioned into the dredge head, the sediment cannot directly enter into the middle or upper water column. The utilization of a pipeline dredge minimizes safety and navigational concerns as the dredge will be well lit, stationary, and will include usage of buoys to mark the location of anchors. Unlike a hopper dredge, no incidences of sea turtle takes from a pipeline dredge have been identified during the research and development of this document. Therefore, the use and methods involved with this type of machinery reduce or eliminate the likelihood of an incidental take.

As with typical dredging and beach nourishment activities, the work includes the use of a dredge plant, pipelines, support barges and bulldozer equipment. Work generally occurs on a 24-hour/7 days/week schedule within the dredging window resulting in the presence of equipment within navigable waters and along the shoreline. During that time, navigation within the work zone is prohibited for safety reasons disrupting use of certain travel areas. Dredgers are required to operate within United States Coast Guard requirements to reduce the potential of boat accidents. In addition to navigation, the presence and operation of the equipment on the land and water can result in an increase of noise and impact aesthetics within the localized area. This is expected to last for the extent of the dredging operation.

<u>General Environmental Consequences Related to Beach Fill</u>

Along with dredging activities, the placement of beach compatible material may also impact several resources. Specifically, the placement of beach fill material could impact the infaunal resources found within the wet beach community as well as nesting turtles and nesting, resting, and foraging birds found along the dry beach community. The North Carolina Coastal Resources Commission adopted the State Sediment Criteria Rule Language (15A NCAC 07H .0312) for borrow material aimed at preventing the disposal of an inordinate amount of coarse material (primarily shell and shell hash) on the beach (NCDCM, 2007). Adhering to these criteria will serve to reduce the potential for environmental impacts. Given the proposed borrow area is completely confined to the authorized dredge depth of a maintained sediment deposition basin within the inlet shoal system, compatibility as defined by (15A NCAC 07H.0312) is primarily defined in Section (2) (e) and (3) (a). Section (2) (e) allows an applicant to use previously collected data to establish sediment characteristics where both a pre-dredge and a post-dredge data set exist. Section (3) (a) states that compatibility for sediment completely confined to the permitted dredge depth of a sediment deposition basins within the inlet shoal system is defined as having an average percentage by weight of fine-grained (less than 0.0625 millimeters) sediment less than 10%. As stated above, the composite fine-grained sediment within the footprint of the area dredged in 2001 based on the data from six (6) vibracores collected in 1998 is 1.3%. The composite fine-grained sediment within the same footprint of the area dredged in 2001 based on data collected after the dredging event is

1.95%. The composite percent fine grained material for the existing beach sampled along the east end of Ocean Isle Beach is 1.34%. Therefore, sediment proposed for use under this action, which is confined to the footprint of the area dredged in 2001 in Shallotte Inlet, is compatible in accordance with 15A NCAC 07H.0312. Should incompatible material be encountered within the Shallotte Inlet borrow area, the contractor will immediately cease operation and reposition the drag arm to an alternate location within the borrow area. If incompatible material is placed on the beach, the USACE and DCM will be contacted immediately to determine how to manage the material properly. See Appendix E (Geotechnical Report) for more information regarding the characteristics of the borrow material and the native beach.

The addition of beach fill to Ocean Isle Beach will cause short-term direct impacts to the adjacent wet beach community. Beach fill material will equilibrate offshore where it will, at least temporarily, cover the softbottom community. As an example, results from an infaunal monitoring following the beach nourishment associated with the Bogue Inlet Channel Relocation Project at Emerald Isle, NC demonstrated that infaunal species found in the marine intertidal (wet beach) environment decreased in population immediately following construction (Carter and Floyd, 2008). Amphipods, an important food source for fisheries and bird resources, showed the slowest recovery, as it was documented that they had not reached pre-construction population levels until 17 months following the beach fill project. During the same timeframe, coquina clam populations found along beach filled areas had converged with populations in nearby control sites indicating recovery (Carter and Floyd, 2008). Nelson (1985) indicates that organisms that reside in intertidal zones are more adaptable to fluctuations in their environment, including high sediment transport and turbidity levels. This may support the reasoning for some organisms to withstand burial up to 10 cm. Other studies reported by Maurer (National Research Council, 1995) supported the burial capabilities of nearshore species, which found that these species are capable of burrowing through sand up to 40 cm. Although the wet beach infauna can adapt to fluctuations in the natural environment, the addition of sediment to the wet beach would have immediate, short-term negative impacts specifically in areas where beach fill will exceed 40 cm in conjunction with the compaction or pushing of fill from bulldozers leveling the material as it is being placed on the beach.

Although the marine intertidal infauna can adapt to fluctuations in the natural environment, the addition of sediment to the wet beach would have immediate, short-term negative direct impacts. Rakocinski *et al.* (1996) found that the mole crab populations exhibited a pattern of initial depression after being covered by sediment but fully recovered in less than one year after beach nourishment. Temporary burial of infaunal organisms could indirectly affect the birds and fish that forage on these organisms in the short and long-term. Negative cumulative effects could occur if the diversity and abundance of infaunal populations do not recover between nourishment events if the events are occurring within short time periods of each other and/or if the material placed on the beach is less compatible with the native beach sediment. In North Carolina, mole crab abundance recovered within months, but the coquina clam and amphipods did not recover within the time frame of the study (Peterson et al. 2006). Peterson et al. (2014) monitored the recovery of a sandy beach community for 3-4 years following nourishment and documented amphipods and coquina clams had reduced densities for 3-4 years following nourishment while mole crabs had lower density for 1-2 years following nourishment.

However, a study by Van Dolah *et al.* (1994) found the use of fill sediments that closely match the native sediments showed an ecological recovery of infaunal species within eight months. Thus, the use of borrow area sediments that are compatible with the native beach and the proper temporal spacing between events should prevent any negative long-term cumulative impacts to the marine intertidal communities. Based on the documented recovery of infaunal organisms, the time intervals between nourishment operations and the use of compatible fill material, significant adverse direct, indirect or cumulative impacts to infaunal resources are not anticipated.

The dry beach community along nourished shorelines may also result in negative impacts to some invertebrate species including the conspicuous ghost crab. Lindquist and Manning (2001) noted that the ghost crab population was significantly reduced for 6 to 8 months following beach bulldozing. These findings were similar to the findings of Peterson et al. (2000) in which the number of ghost crabs in the upper beach zone were reduced by 55-65% three months following beach bulldozing at Bogue Banks, NC and 86-99% lower than on nearby reference beaches. Peterson et al. (2014) also noted that ghost crabs had lower abundances for 4 years following a nourishment event. However, other studies reported a recovery of infaunal species abundance and diversity within 60 days of beach bulldozing and no long term changes to species composition subsequent to beach scraping (ASFMC, 2002).

Beach nourishment presents both positive and negative effects on nesting sea turtles. In most cases where beach nourishment has taken place, the oceanfront shoreline has been greatly eroded with tidal fluctuation occurring at the base of the dune. This reduces the suitable nesting areas for sea turtles and destroys nests with eggs that have been established. As a result of beach fill, wider beaches can benefit sea turtles since they require dry beaches to nest, preferring to nest along wide sloping beaches or near the base of the dunes. Potential adverse effects on nesting habitat include alteration of beach substrate characteristics and modification of the natural beach profile. Physical characteristics such as density, compaction, shear resistance, moisture content, slope, sand color, grain size, grain shape, sand mineral content, and gas exchange can affect the success of sea turtle nests (Nelson and Dickerson 1988, Crain et al. 1995). Substrate alteration may affect the ability of female turtles to nest, the suitability of the nest incubation environment, and the ability of hatchlings to emerge from the nest. Escarpments formed during and after beach nourishment may prevent nesting females from reaching suitable nesting habitat, resulting in the selection of marginal or unsuitable nesting sites in front of escarpments, or result in nest exposure as escarpments recede landward. Numerous studies have described the effects of beach nourishment on nesting success (Crain et al. 1995, Steinitz et al. 1998, Ernest and Martin 1999, Herren 1999). These studies indicate a reduction in nesting success during the first post-nourishment year, followed by a return to normal levels by the second or third year. Declines in nesting success have been attributed to substrate compaction, escarpment formation, and/or modification of the natural beach profile. Beach nourishment also has the potential to improve poor quality nesting habitats associated with chronically eroded beaches (Brock et al. 2009). Davis et al. (1999) and Byrd (2004) documented increases in nesting success immediately following the nourishment of eroded beaches. Increases in nesting success were attributed to the addition of dry beach habitat.

Embryonic development and hatching success are influenced by temperature, gas exchange, and moisture content within the nest environment (Carthy et al. 2003). Changes in substrate characteristics such as grain size, density, compaction, organic content, and color may alter the nest environment, leading to adverse effects on embryonic development and hatching success (Nelson and Dickerson 1988, Nelson 1991, Ackerman et al. 1991, Crain et al. 1995). Nourished beaches often retain more water than natural beaches, thus impeding gas exchange within the nest (Mrosovsky 1995, Ackerman 1996). Uncharacteristically dark sediments absorb more solar radiation, thus potentially resulting in warmer nest temperatures. Dark sediments may produce nest temperatures that are too high for successful embryonic development (Matsuzawa et al. 2002). Higher temperatures may significantly reduce incubation periods and contribute to a higher incidence of late-stage embryonic mortality (Ernest 2001). Nest temperature also influences sex determination in hatchlings, with warmer temperatures producing more females and cooler temperatures producing more males (Wibbels 2004). Consequently, dark sediments may alter hatchling sex ratios. Investigations of beach nourishment effects on hatching success have reported variable results; including positive effects (Broadwell 1991, Ehrhart and Holloway-Adkins 2000), negative effects (Ehrhart 1995, and no effect (Raymond 1984, Nelson et al. 1987, Broadwell 1991, Ryder 1993, Steinitz et. al. 1998, Herren 1999, Brock et al. 2009). The variation in findings has been attributed to differences in the physical attributes of individual projects, the extent of erosion on the pre-nourishment beach, and construction techniques (Brock et al. 2009). Sediments recovered within the vertical boundaries of the proposed borrow area in Shallotte Inlet were described by the USACE as having a tan and or gray color (USACE, 1997c; Catlin, 2009). The wet Munsell Color values for sediment samples collected by CPE-NC in 2013 and 2014, range from 5 (gray to olive gray) to 7 (light gray), with a typical value of 7 (light gray). The samples collected by CPE-NC in 2013 and 2014 represent the existing beach, which is a composite of the characteristics of material that has been placed on the beach during past nourishment projects and native beach sediment.

The turbidity plume at the disposal end of the pipeline does not usually increase above ambient conditions when the material being dredged is of a coarse grain size as this material typically settles rapidly compared to finer material, as observed during the dredging and inlet relocation at Bogue Inlet in 2005. The increase in dry beach habitat as a result of beach nourishment is also expected to positively affect the bird species that utilize this habitat for roosting, foraging and nesting. Typically, the placement of beach compatible material serves to protect the dunes and beaches thereby causes positive direct and indirect impact. These events generally do not occur on a regular basis and the periodic loss of habitat utilized for foraging/resting shorebirds will continue.

<u>Sea Level Rise</u>

Many physical processes have the potential to influence shoreline change, sea level rise being one of them. The International Panel on Climate Change (IPCC, 2007) has concluded that global mean sea level rose at an average rate of about 1.7 ± 0.5 mm/year (0.07 inches/year) during the twentieth century. Recent climate research has documented global warming during the twentieth century, and has predicted either continued or accelerated global warming for the twenty-first century and possibly beyond (IPCC, 2007). This rate is anticipated to increase over the next 100 years. Rahmstorf (2007) predicts that global sea level in 2100 may rise 0.5 m (1.6 ft) to 1.4 m (4.6 ft) above the 1990 level. In 2012, the State of North Carolina passed legislation (House Bill 819) declaring that only “historic rates of sea-level rise may be extrapolated to estimate future rates of rise but shall not include scenarios of accelerated rates of sea-level rise unless such rates are from statistically significant, peer-reviewed data and are consistent with historic trends.” As such, the State of North Carolina has not adopted a planning benchmark for sea level rise, and no such benchmark is currently under consideration.

According to www.tidesandcurrents.noaa.com, the regional trends in North Carolina show an increase of 0 to 3 mm/yr (0 to 0.00984 ft/yr). Guidelines from the USACE suggest that relevant sea level rise data should include a minimum of 40 years of data. Several monitoring stations within proximity to Ocean Isle Beach contain this level of data including stations located in Beaufort (collecting data since 1953), Wilmington (collecting since 1935), and Southport (collecting since 1933), North Carolina. Data from these stations show that the rate of increase in sea level rise in Beaufort is 0.84 ft./century (0.26 m/century) while the rate in Wilmington and Southport are both 0.68 ft./century (0.21 m/century).

Sea level change can cause a number of impacts in coastal and estuarine zones, including changes in shoreline erosion, inundation or exposure of low-lying coastal areas, changes in storm and flood damages, shifts in extent and distribution of wetlands and other coastal habitats, changes to groundwater levels, and alterations to salinity intrusion into estuarine sand groundwater systems (e.g., CCSP, 2009). North Carolina has been identified by NOAA as one of three states with significant vulnerability to sea level rise. The State possesses the largest estuarine system on the U.S. Atlantic coast, with an extensive barrier island chain, and over 2,300 square miles of coastal land vulnerable to a 1 m rise in sea level (Poulter et al, 2009).

The impacts of historic rates of rise in sea level are implicitly included in the historic shoreline change data used for Ocean Isle Beach. By extrapolating data from long term sea level monitoring sites located in Wilmington, NC and Southport, NC, the rate of rise in sea level applicable to the project area is shy of 1 foot (0.31 m) per century. Some projections suggest the rate of sea level rise could double within the next 50 to 100 years however since only a portion of the observed shoreline change rates are associated with sea level rise, doubling the rate of sea level rise would not double the historic rate of shoreline change due to the fact that shoreline change rates are affected by both sea level rise and other factors that affect the sediment budget of an area.

No direct or indirect impacts are expected to occur as a result of sea level rise for any of the project alternatives. If sea levels continue to increase as predicted, then unmanaged areas of the dry beach and dune communities may become more vulnerable to erosion leading to negative cumulative impacts to these habitats. However, the project alternatives involving beach nourishment may help protect from these cumulative impacts. As an example of how sea level rise may or may not affect the performance of a beach nourishment project, the Wrightsville Beach and Carolina Beach Federal storm damage reduction projects can be evaluated. Both of these projects have been in existence since 1965 and have been subjected to a similar rate of sea level rise applicable to Ocean Isle Beach. A review of the nourishment rates for these two projects with and without sea level rise shows no significant change in the volume or frequency of periodic nourishment needed to maintain the projects.

6. What are the environmental and economic impacts associated with each specific alternative?

The following sections describe the additional environmental and economic impacts anticipated for each alternative being considered. For each alternative, a discussion of the project's effects on specific resources as well as several public interest criteria (i.e., Estuarine Habitats, Upland Hammock, Inlet Dunes and Dry Beaches, Intertidal Flats and Shoals, Oceanfront Dry Beach and Dune Habitats, Wet Beach Communities, Marine Habitats, Water Quality, Public Safety, Aesthetics, Recreational Resources, Navigation, Infrastructure, Solid Waste, Economics, Noise Pollution) is provided in order to better evaluate the environmental consequences of the project. Some of these criteria have been extracted from the list of public interest criteria identified in 33CFR 320.4. The analysis of these criteria in this Chapter does not replace, or remove the need for, a more specific evaluation of the project with respect to the public interest criteria that will be provided in the Record of Decision. Appendix D provides a summary of the impacts presented in tablature form.

A: IMPACTS ASSOCIATED WITH ALTERNATIVE 1: NO ACTION (CONTINUE CURRENT MANAGEMENT PRACTICES)

Under Alternative 1, the Town and individual property owners would continue to respond to erosion threats in the same manner as in the past which includes a continuation of the Federal project and the maintenance of sandbags. The limits of the initial Federal project extended from base stations 0+00 to 183+00, however, the subsequent renourishment events in 2006/2007 and 2010 did not extend as far west. For the purposes of this analysis, it will be assumed that the future nourishment events for the Federal project will include the advanced fill template between stations 0+00 and 90+00. In recent years, shoreline management measures also included intermittent beach nourishment sponsored by the Town along the extreme eastern portion of the island. This area is not included in the Federal project. However, due to the limited success of the localized nourishment events, it is unlikely that the Town would continue with these efforts and therefore will not be included in the assessment of impacts for Alternative 1. The history of the Federal and local beach nourishment projects, as shown in Table 5.5, have involved various volumes and fill limits. As stated above, it would be assumed that the Town would actively deploy sandbags as needed to protect threatened structures (Figure 2.6). Currently 57 dwellings/dwelling units are protected by sandbags along the east end of the island.

Table 5.5. Ocean Isle Beach's Historical Beach Nourishment

Project Start Date	Volume (c.y.)	Source	Region
March, 2001	1,866,000	Shallotte Inlet	Federal Project Domain
December, 2006	449,400	Shallotte Inlet	Federal Project Domain
December, 2006	155,000	Shallotte Inlet	East of the Federal Project
April, 2010	509,200	Shallotte Inlet	Federal Project Domain

The impacts associated with a continuation of existing conditions, as defined by Alternative 1, are described below.

ESTUARINE HABITATS

<u>Salt Marsh Communities</u>

Direct and Indirect Impacts: The salt marsh resources within the Permit Area are located primarily along the sound sides of Ocean Isle Beach, Holden Beach and within the Shallotte River and associated creeks. During the 3-year Delft3D simulation, the model indicated some scour or erosion along a portion of the AIWW extending from Shallotte Inlet northeast to the mouth of the Shallotte River. Although some salt marsh habitat is located within this general area behind Holden Beach, neither direct nor indirect impacts are anticipated to be significantly incurred.

Cumulative Impacts: Since 2001, Shallotte Inlet and its tidal prism have remained relatively stable as the location of the throat of the inlet has been maintained as part of the Federal project. Alternative 1 includes the continuation of the Federal project and therefore it is expected that the salt marsh communities will continue to respond to naturally evolving shorelines. Therefore, beyond the existing natural processes of erosion and accretion, no significant adverse cumulative impacts are anticipated with Alternative 1 on salt marsh communities.

<u>Shellfish Habitat</u>

Direct, Indirect, and Cumulative Impacts: The dredging of material from Shallotte Inlet is predicted to cause a short term increase in turbidity and sedimentation levels which could impact shellfish resources. Due to the low silt percentage and the well-sorted sands in the majority of the areas to be dredged, the turbidity levels are expected to remain below the State standard outside the immediate area of dredging. However, due to the remote location of shellfish resources from Shallotte Inlet, no impacts are anticipated to these resources with the implementation of the No Action alternative.

UPLAND HAMMOCK

Direct and Indirect Impacts: The activities associated with No Action alternative are not anticipated to cause direct or indirect impacts to the upland hammock resources located within the Permit Area. This can be attributed to the distance of the resource from the oceanfront shoreline and lack of construction in proximity to these resources.

Cumulative Impacts: The elevation of the upland hammock communities relative to sea level will minimize direct and/or indirect impacts to occur. However, the upland hammocks within the permit area may be threatened by potential sea level rise over time. Sea level rise is forecasted to increase in rate and result in a rise as much as 1 meter by the year 2100 (Miller, pers. comm.). This rate is predicted to be considerably less (1 foot over the next 100 years) according to local monitoring stations. In addition, as stipulated by North Carolina HB 819, only "historic rates of sea-level rise may be extrapolated to estimate future rates of rise but shall not include scenarios of accelerated rates of sea-level rise unless such rates are from statistically significant, peer-reviewed data and are consistent with historic trends.”. However, if any rise is validated, the increase in sea level could result in potential cumulative impacts to coastal upland hammocks present in the permit area. Outside of natural effects from sea level rise, no project impacts to upland hammocks are anticipated.

INLET DUNES AND DRY BEACHES

Direct Impacts: Sediment transport along the extreme east end of Ocean Isle Beach and the western end of Holden Beach is generated by both wave driven littoral currents and tidal currents flowing in and out of Shallotte Inlet. This combination of sediment transport factors results in sediment moving into Shallotte Inlet off the ends of the islands at a faster rate than wave driven currents alone can move sediment into the area. Aside from these natural processes and the continued use of the Shallotte Inlet borrow area, the implementation of Alternative 1 will not result in any direct impacts to the inlet dunes and dry community on the Ocean Isle Beach side or the Holden Beach side of Shallotte Inlet. The Federal project includes beach profile monitoring along 27,000 feet of shoreline on Ocean Isle Beach and about 10,000 feet of shoreline on the west end of Holden Beach. Associated with the monitoring program are shoreline change thresholds which if exceeded would require the federal project to mitigate for the adverse shoreline changes that exceed the thresholds. To date (October 2014) the monitoring program has not detected any adverse shoreline changes on either Ocean Isle Beach or Holden Beach.

Indirect and Cumulative Impacts: As shown in Table 5.2 above, Delft3D model results suggest that the sand spit extending off the east end of Ocean Isle Beach into Shallotte Inlet experienced erosion over the three-year simulation. The ocean facing segment between station -5+00 and -20+00 lost material at a rate of 3,700 cubic yards/year while the segment closer to the inlet (-20+00 to -30+00) eroded at a rate of 700 cubic yards/year. The distal end of the sand spit experienced some significant erosion over the three-year simulation as indicated by the red-shaded area in Figure 5.4 above. On the western 4,000 feet of Holden Beach, the model indicated erosion of 11,000 cubic yards/year landward of the -6-foot NAVD depth contours. However, there was essentially no change in the shoreline along the Holden Beach shoreline facing Shallotte Inlet.

GIS analysis utilizing the biotic community map suggests indirect impacts of 1-2 acres to the inlet dune communities and 5-10 acres of impact to the inlet dry beach communities. The majority of these impacts are being incurred on the Ocean Isle Beach side of the inlet.

The area along the extreme eastern portion of the oceanfront shoreline of Ocean Isle Beach outside of the Federal project template would be expected to result in negative indirect impacts due to the continued loss of suitable dry beach habitat, particularly in the areas with sandbag revetments. These indirect impacts would include a reduction of suitable habitat for the protected plant seabeach amaranth, shorebirds including piping plovers and red knots, and a reduction in area for humans to recreate. Furthermore, the survival rate of sea turtle hatchlings could be reduced due to possible inundation of encroaching mean high water marks through severe erosion.

As stated in Chapter 4, critical habitat designation for North Carolina wintering piping plover includes a portion of inlet dunes and dry beach habitat along Holden Beach within Unit NC-17 (USFWS, 2001). Research has shown that wintering plovers on the Atlantic coast prefer wide beaches in the vicinity of inlets (Nicholls and Baldassarre, 1990; Wilkinson and Spinks, 1994). While wintering piping plovers have Critical Habitat within the Permit Area, piping plovers also nest in the region. Piping plovers nest in dry sand habitats above the high tide line along coastal beaches, spits, flats, barrier islands and other sparsely vegetated dune and beach environments, although they may utilize other shoreline habitats if these are not available. In addition, critical habitat has been designated for nesting sea turtles within Unit LOGG-T-NC-08 which encompasses the dry beach habitat along Holden Beach. Should the erosion continue along the inlet beaches on Ocean Isle Beach and Holden Beach, the overwintering critical habitat and nesting habitat for piping plovers and critical habitat for nesting sea turtles could be impacted.

INTERTIDAL FLATS AND SHOALS

Direct Impacts: Because the authorized borrow area within Shallotte Inlet for the Federal project and local beach nourishment activities often includes areas of intertidal shoals, Alternative 1 is expected to directly impact these resources due to the periodic excavation of material. Based off the delineated biotic community map using 2012 aerial photography, a total of 11.2 acres of intertidal shoals would be directly impacted by the excavation of the authorized Federal borrow area (Figure 4.1). These shoals are considered to be ephemeral and clearly it is not possible to anticipate the precise extent of these habitat types in the future, however, it is reasonable to assume that approximately 10-15 acres could be removed during subsequent dredging operations within the inlet. This would result in the loss of infaunal prey organisms residing in this habitat within the borrow area.

The intertidal flats and shoals located elsewhere within the Permit Area, including the AIWW, Shallotte River, and other locations outside of the Federal borrow area would not be expected to be directly impacted by Alternative 1 as the tidal prism is not anticipated to be significantly altered.

Indirect Impacts: As mentioned in Chapter 4, shorebirds, colonial waterbirds and other waterbirds will utilize intertidal flats and shoals in the inlet complex for foraging while traveling to their wintering and nesting grounds. Breeding and non-breeding federally threatened species and species of special concern also utilize intertidal shoals. Macroinfaunal species found within intertidal flats and shoals are a primary food source for several migratory and resident shorebirds, waterbirds, as well as for many commercially and recreationally important fish. As stated above, a portion of the piping plover critical habitat unit NC-17 is located within Shallotte Inlet due to the presence of intertidal flats and shoals. These unconsolidated communities lack structure and are dynamic in nature. Therefore, the unconsolidated and unvegetated communities that occur in the inlet complex are expected to continue to be naturally redistributed. Periodic storms and seasonal climatic changes influence abundance and diversity of micro- and macrofauna, tending toward a more opportunistic community (Mallin *et al*., 2000; Street *et al*., 2005).

The direct mortality of the macroinfaunal population in the dredged intertidal flats and shoals may have an indirect impact on bird and fish species that utilize flats and shoals as foraging grounds, refuge, nursery grounds, and spawning habitat. It is anticipated that some benthic organisms will populate the dredged area within a short period of time, but there will be a time lag for when the area repopulates to its pre-construction community diversity and total numbers. In this recovery period, some individual bird and/or fish species may have to adjust to their foraging habits and temporarily use other areas. Several different fish species inhabit the intertidal flats and shoals and the water column within these areas. As reported by USACE (1984), species that utilize these habitats include red drum, spotted seatrout, bluefish, Atlantic croaker, kingfish, and mullet. These species forage upon many of the benthic organisms that reside within intertidal flats and shoals. Studies examining the effects of dredging and disposal on nearshore and estuarine fish populations have reported rapid recovery or minimal effects following the removal of benthic organisms associated with dredging (Courtenay *et al.*, 1980; de Groot, 1979a; de Groot, 1979b; Posey and Alphin, 2000). Furthermore, due to the winter time construction, many of these species will be located offshore and will not be utilizing the nearshore or inlet intertidal flats and shoal areas. For any fish species that may be present, it is expected, like the bird resources, that their mobility will provide them the opportunity to temporarily relocate to adjacent habitats while dredging occurs.

Delft3D modeling suggests that a total of 1-2 intertidal acres within the Permit Area could be indirectly impacted most likely attributable to changes in sediment transport through the inlet. The USACE monitored the borrow area following the 2006-07 and 2010 nourishment operations and indicated that the borrow area collects and average of 16,500 cubic yards/month or slightly less than 200,000 cubic yards/year (Dennis, 2012 personal communication). Provided that this infilling rate continues, the existing condition of abundant intertidal flats and shoal would be expected to persist and provide habitat value for foraging birds and fish within approximately 2 years.

Cumulative Impacts: Intertidal flats and shoals are an extensive habitat type within the coastal waterways in southeast North Carolina. Although the extent of intertidal flats and shoals within the Permit Area may be altered during dredging events within the inlet and during response to storm events, the habitat is expected to persist because the delivery of material through the inlet and down the Shallotte River is expected to continue. The infaunal species which utilize them are not anticipated to be adversely impacted due to their resilient nature.

OCEANFRONT DRY BEACH AND DUNE HABITATS

Oceanfront Dune Communities

Direct Impacts: Although the design template for the Federal beach nourishment project includes the construction of a dune section extending from baseline station 51+50 to baseline station 103+00, future nourishment is not anticipated to include dune construction due to the fact that these future operations will be limited to providing advanced fill only. Therefore, no impacts to the oceanfront dune communities are anticipated along Ocean Isle Beach. The extensive oceanfront dune communities located along Holden Beach are not anticipated to be impacted aside from natural overwashing and other storm-induced events.

Indirect Impacts: The nourishment of the Federal project would be expected to provide protection of the existing oceanfront dunes along Ocean Isle Beach due to the increased size of the dry beach. A more stable beach condition as a result of the placement of material along the extreme east end of Ocean Isle Beach could potentially promote conditions suitable for dune plant species establishment and growth. In turn, plant stems tend to trap wind-borne sand. In the absence of any significant erosion, these areas could potentially form into smaller foredunes near the upper beachdune transition zone. As such, the vegetative dune communities would be positively indirectly impacted by Alternative 1. This would include positive impacts to seabeach amaranth, birds, and other biological resources utilizing the oceanfront dunes as habitat.

Cumulative Impacts: The dune construction associated with the Federal project is scheduled to occur every three (3) years until the authorization expires in the year 2051. As such, the cumulative impacts of the dune resources along portions of Ocean Isle Beach would be positive as the nourishment would serve to protect these resources. However, these resources, along with those present on Holden Beach, remain vulnerable to storm damage and overwashing. Furthermore, if the predicted increase in rates of sea level rise (Miller, pers. comm.; IPCC, 2007) is validated, this will potentially threaten the long term viability of dunes within the permit area as storm surges combined with increased sea level could degrade these resources.

<u>*Oceanfront Dry Beach Communities*</u>

Direct Impacts: The dry beach area is a high energy area that does not support much vegetation; however this habitat is utilized by several species of sea turtles and shorebirds. Beaches, as well as inshore and offshore waters, along the Atlantic Coast of the United States are important developmental habitats for many of the threatened and endangered species of sea turtles (Shoop and Kenney, 1992; Ehrhart, 1983; Keinath et al., 1987); which includes the oceanfront shoreline of Ocean Isle Beach and Holden Beach (Figures 4.6-4.9).

The dry beach community along Ocean Isle Beach may be directly impacted in response to the Federal beach nourishment and the maintenance of sandbag revetments associated with Alternative 1. Beach nourishment activity will initially disturb the dry beach habitat due to the use of bulldozers, however ultimately it will serve to increase the amount of dry beach habitat. As described above previously General Environmental Consequences Related to Beach Fill, the invertebrates and infaunal communities present within the dry beach habitat will be directly impacted due to burial, however due to the resilient nature of these organisms and the use of compatible material, the impacts will be temporary.

While sandbags may provide protection to the structures behind them, they are impermeable structures and therefore will not absorb wave energy which could cause local beach scour to accelerate. A total of 15.1 acres of dry beach along the Ocean Isle Beach shoreline would be directly impacted by the addition of fill material by the Federal beach nourishment project every three (3) years. Due to the ineffectiveness of local beach nourishment efforts along the extreme east end of the island, for the purposes of this analysis no additional events would be anticipated and therefore no additional impacts to the dry beach would be expected.

No direct impacts to the oceanfront dry beach are anticipated to occur along Holden Beach as a result of Alternative 1.

Indirect Impacts: Delft3D model results suggest that approximately 0-5 acres of oceanfront dry beach habitat may be impacted following the construction of the Federal beach nourishment project. High rates of erosion would persist along the east end of Ocean Isle Beach from the -6 foot NAVD contour between stations 0+00 and 0+30. Delft3D model results suggest that 24,000 cubic yards of material would be lost per year within this location. Erosion would also be expected to continue further west with erosion rates of 18,000, 14,000, and 7,000 cubic yards per year at between stations 30+00-60+00, 60+00-90+00, and 90+00-120+00, respectively. The west end of Holden Beach between stations 385+00 and 344+00 is also experiencing erosion from the -6 foot contour at a rate of 44,000 cubic yards per year.

An alternate indicator of the erosion threat along the study area is the position and movement of the erosion scarp. The movement of the erosion scarp is impacted to a lesser degree by sand placement and to some extent by the installation of sandbag revetments. The position of the scarp line also provides a more reasonable indicator as to when a structure is likely to experience erosion damage. Figure 5.9 shows the position of the erosion scarp from the analysis of the LiDAR data. The decreasing trend in the recession of the scarp line moving west away from Shallotte Inlet provides additional evidence of the negative shoreline impacts Shallotte Inlet is having on the east end of Ocean Isle Beach. Some of the decrease in scarp recession west of profile 10 can be attributed to nourishment of the Federal storm damage reduction project. However, with very little material placed directly on the shoreline near profile 10, the impact of the Federal project is more indirect in this area and is associated with horizontal spreading of the fill material toward the east.

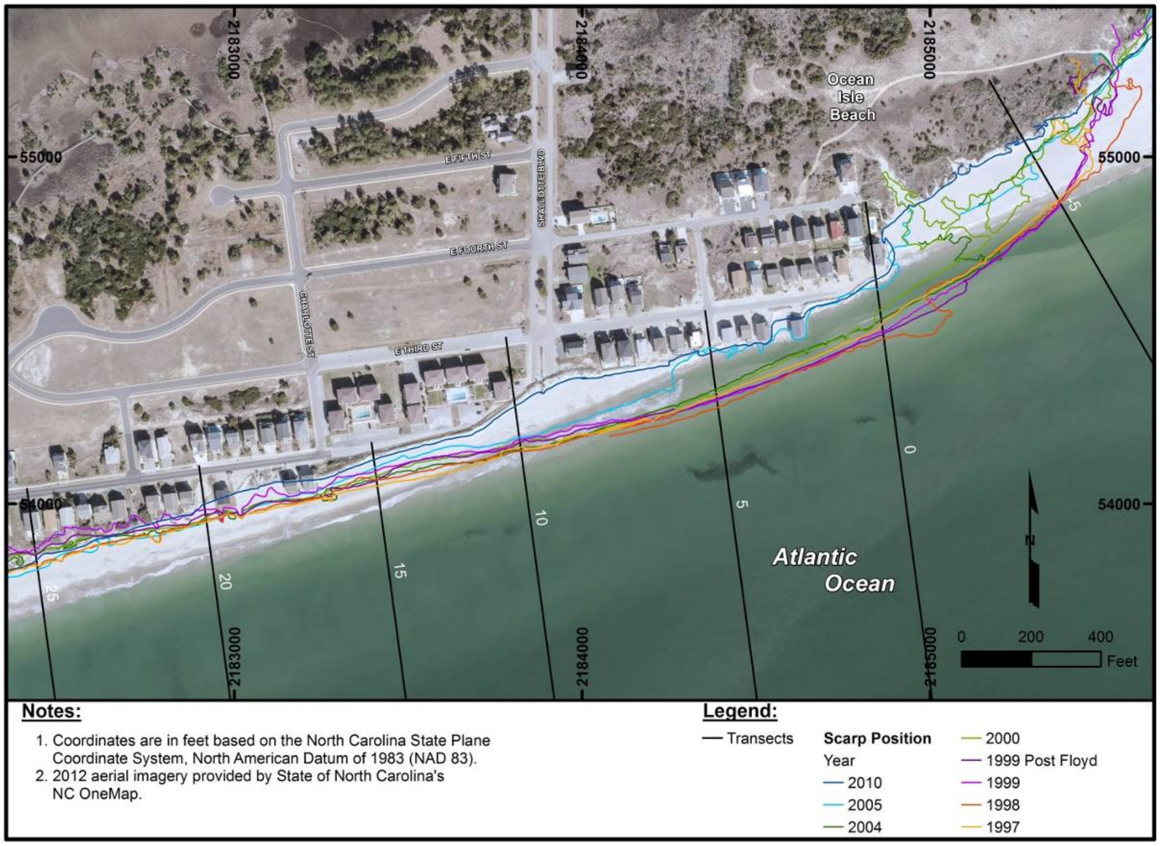

Figure 5.9. Scarp Line Position (1997-2010)

Along with directly impacting infaunal communities, beach nourishment will indirectly impact the nesting and resting habitats for shorebirds including piping plovers and red knots provided by the dry beach due to the temporary removal of prey. As stated under the General Environmental Consequences Related to Beach Fill section above, the infaunal prey is expected to recover within approximately 1 year following construction.

According to Greene (2002), beach nourishment can benefit endangered and threatened sea turtles by restoring habitat along eroded beaches. Some studies have found no significant difference between nourished and non-nourished beaches in the number of eggs per nest, as well as, hatching and emergence success (Nelson *et al*., 1985; Ryder, 1991). Other projects have shown increased numbers of nests, hatchlings, and survival rate of young turtles (Raymond, 1984). The widened beach along the fill area within the Federal project will benefit sea turtles since they require dry beaches to nest, preferring to nest along wide sloping beaches or near the base of the dunes. The composition, color, and grain size of the placed sand can affect the incubation time, sex, and hatching success of turtle hatchlings (Street *et al*., 2005). Physical characteristics such as density, compaction, shear resistance, moisture content, slope, sand color, grain size, grain shape, sand mineral content, and gas exchange may affect the success of sea turtle nests (Nelson and Dickerson 1988, Crain et al. 1995). The fill placed on Ocean Isle Beach will conform to the State sediment criteria rules and therefore is not expected to impact the nesting success of sea turtles.

Cumulative Impacts: Although the periodic beach nourishment activities associated with Alternative 1 result in the increase of dry beach, the events are not enough to abate the chronic erosion along the eastern end of Ocean Isle Beach; therefore a loss of dry beach habitat would be expected to continue over time. This would therefore result in an overall reduction of adequate turtle nesting habitat, shorebird and water bird habitat, and recreational opportunities along the oceanfront portion of the island. In addition, recreational opportunities such as sunbathing and beach combing would be expected to be reduced due to the eroding shoreline conditions.

If sea levels continue to increase as predicted, then unmanaged areas of the dry beach community may become more vulnerable to erosion leading to negative cumulative impacts to the dry beach. However, an example of how sea level rise may or may not affect the performance of a beach nourishment project, the Wrightsville Beach and Carolina Beach Federal storm damage reduction projects can be evaluated. Both of these projects have been in existence since 1965 (48 years) and have been subjected to the same rate of sea level rise applicable to Ocean Isle Beach. A review of the nourishment rates for these two projects with and without sea level rise shows no significant change in the volume or frequency of periodic nourishment needed to maintain the projects.

WET BEACH COMMUNITIES

Direct Impacts: The addition of beach fill to Ocean Isle Beach between stations 10+00 and 90+00 will cause direct impacts to approximately 14.4 acres of the wet beach community. The infaunal communities found within the wet beach environment, which include macro infaunal species such as polychaete worms (Phylum *Annelida*), coquina clams (*Donax variabilis and D. paruvula*) and mole crabs (*Emerita talpoida*), would be directly impacted as they become buried by fill material. A study conducted by Maurer (National Research Council, 1995) concluded that the burial these species are capable of burrowing through sand up to 40 cm, however deeper burial depths often prove to be fatal. Despite this, due to the rapid recruitment of these organisms combined with the use of compatible beach fill material, these impacts should be temporary. As mentioned in Chapter 4, Nelson (1985) indicates that organisms that reside in intertidal zones are more adaptable to fluctuations in their environment, including high sediment transport and turbidity levels. Furthermore, infauna living in a high-energy environment, especially the intertidal area, are well adapted to disturbances (Van Dolah et. al, 1994; Levison and Van Dolah, 1996).

The wet beach communities on Holden Beach are not anticipated to be impacted.

Indirect Impacts: Indirect impacts may affect shorebirds, crustaceans, and fish attempting to forage along the stretch of shoreline receiving fill. The removal of the benthic infaunal species may indirectly impact these higher trophic species as the abundance of their prey is temporarily reduced. However, the magnitude of indirect impacts to these higher level trophic species may be mitigated by the large area of habitat available beyond the nourishment site. Furthermore, peak larval recruitment periods for most benthic species are avoided by federal disposal typically occurring during winter months.

Sandbags used to provide storm protection for threatened structures on Ocean Isle Beach may reduce the area of wet beach by providing a temporary barrier to the migration of wet beach along the active beach profile. These structures are generally installed when the mean hide tide is within twenty feet of a home or other infrastructure, which is the state requirement prior to authorizing oceanfront sandbags. This leaves minimal or no wet beach habitat to support infaunal communities. Based on future shoreline change analysis, approximately 25-30 acres of wet beach are anticipated to be indirectly impacted within the Permit Area, specifically along the oceanfront shoreline along the east end of Ocean Isle Beach.

Cumulative Impacts: The periodic beach nourishment activities occurring on Ocean Isle Beach will temporarily impact the wet beach but is not expected to result in long term impacts. However, sandbag placement could potentially result in cumulative impacts on wet beaches along the ocean shoreline of Ocean Isle Beach over a longer period. The wet beach habitat in southeast North Carolina is expected to persist despite the potential for increased rates in sea level rise and shore management activities.

MARINE HABITATS

Softbottom Communities

Direct Impacts: Softbottom communities are dynamic in nature where periodic storms and seasonal climatic changes influence abundance and diversity of micro and macrofauna, tending toward a more opportunistic community (Mallin *et al*., 2000; Street *et al*., 2005). Softbottom communities may also change with natural shifting patterns of sediment erosion or deposition (Street *et al*., 2005). Despite their dynamic state, softbottom resources could directly be impacted by increased levels of turbidity, immediate removal, and immediate burial of infaunal biota during dredge and fill operations as described above under the sections entitled General Environmental Consequences Related to Dredging and General Environmental Consequences Related to Beach Fill. These effects would occur during the dredging within Shallotte Inlet and the placement within the toe of fill between stations 10+00 and 90+00 in the Permit Area totaling 161.1 acres of softbottom habitat. These direct impacts include 17.3 acres of softbottom habitat within the Shallotte Inlet borrow area.

Because the beaches along the western portion of Holden Beach will not receive disposal material, impacts to softbottom resources outside of natural shifting processes on or around Holden Beach in response to Alternative 1 are not anticipated.

Indirect Impacts: Indirect impacts include the temporary loss of prey for foraging fish and invertebrates from the softbottom habitats within the footprint of the borrow area within Shallotte Inlet. Additional indirect impacts to the softbottom habitat could be incurred as a result of the placement of material on the existing dry beach as the profile reaches equilibrium. A literature review of the effects of beach nourishment on benthic habitat performed by Taylor Engineering (2009), prepared for the Florida Department of Environmental Protection, evaluated documents that covered a wide variety of sites along the Atlantic and Gulf coasts and spanned the years of 1980 to 2007. The review concluded that benthic habitat within nourished areas typically recovered within 2 to 7 months. Variability was attributed to the season in which fill activities occurred and the compatibility of the fill material, with winter projects having less of an impact. The Nags Head beach nourishment project provides a recent example of the effect of a project that was conducted during the peak period of benthic productivity. The project was constructed over the months of May through October, spanned approximately 10 miles and utilized an offshore borrow source located within states waters. The first post year monitoring report for the 2011 project was released in June of 2013. The report concludes that benthic populations in the nourished beach as well as the offshore borrow area are generally not significantly different from control stations and demonstrate viable populations of organisms during the earliest post project sample events (CZR, 2013). These potential impacts may be minimized further as the effects of sediment alteration in high energy sandy environments, such as Shallotte Inlet, are often minimized (Saloman et al. 1982, Pullen and Naqvi 1983). A total of 0-1 acre of softbottom may be indirectly impacted as a result of the implementation of Alternative 1.

Cumulative Impacts: Although the infaunal resources within the footprint of the dredging activities within Shallotte Inlet would be expected to recover relatively rapidly, cumulative impacts to this resource within this location could be incurred due to the fact that the Federal project calls for dredging every three years as the borrow area fills in. The USACE monitored one of the borrow areas following the 2006-07 and 2010 nourishment operations and determined that the borrow area collects an average of 16,500 cubic yards/month or slightly less than 200,000 cubic yards/year (Dennis, 2012 personal communication). In general, the softbottom resources within the State of North Carolina are extensive and the impacts associated with dredging the 17.3 acre footprint within Shallotte Inlet is not expected to cause cumulative impacts to infaunal communities as a whole within the State.

WATER QUALITY

Turbidity and TSS

Direct and Indirect Impacts: Excessive sediment loading increases turbidity and sedimentation, which can result in the clogging of fish gills and reduced recruitment of invertebrates. Furthermore, turbidity can suppress SAV growth, cause low oxygen events leading to fish kills, and cause mortality of organisms in the softbottom community, including shellfish. Dredging within Shallotte Inlet and the placement of beach fill material along the east end of Ocean Isle Beach is expected to result in temporary increases in suspended sediment and turbidity. Areas of increase are expected along the nearshore environment where placement occurs and within the borrow area where the cutterhead dredge operates. Measurements for turbidity and TSS were taken before, during, and after dredging within Nixon Channel in proximity to Figure Eight Island, NC and the associated placement of beach fill along the northern oceanfront shoreline. Cleary and Knierim (2001) determined that both parameters increased at the point of discharge on the oceanfront shoreline, however, these values returned to ambient conditions rapidly. Therefore, any increase in turbidity associated with the dredge and fill activities associated with Alternative 1 would be of short duration, as observed in Nixon Channel and during the Bogue Inlet Channel Relocation Project in Emerald Isle, NC. Any increase of turbidity or TSS will be minimized further because the silt content of the material in the existing permit area in Shallotte Inlet is relatively low, averaging about 1.3%.

Cumulative Impacts: Natural conditions within the Permit Area exhibit fluctuations in turbidity and TSS levels as a result of sediment transport during ambient conditions as well as during storm events. Dredging of the inlet every three years as part of the Federal project will be expected to result in increased turbidity, however, those dredging events will be limited to a finite duration of time spanning several months every three years. Under Alternative 1, erosion of the soundside shoreline would continue with minimal changes in turbidity levels as a result. Turbidity and TSS levels would be expected to increase during storm events. Therefore, naturally fluctuating turbidity and TSS levels would continue with or without beach nourishment and dredging efforts proposed under Alternative 1, therefore no adverse cumulative effects are anticipated.

Nutrients

Direct, Indirect, and Cumulative Impacts: The implementation of Alternative 1 is not anticipated to impact the nutrients within the waters located in the Permit Area.

WATER COLUMN

Hydrodynamics and Salinity

Direct, Indirect, and Cumulative Impacts: Based on the modeled changes to the tidal prism for Alternative 1, the tidal prism of the inlet as a whole is not anticipated to substantially change over the 3-year simulation period following dredging within the Federal borrow area within Shallotte Inlet. Despite these anticipated minor alterations in tidal prism, hydrodynamics and salinity are not expected to be impacted in response to Alternative 1 due to the large volume of water moving through the system.

Larval Transport

Direct Impacts: The dredging associated with the Federal beach nourishment project associated with Alternative 1 are not anticipated to significantly impact larval transport through Shallotte Inlet despite the unavoidable entrainment of larvae. The lack of significant direct impacts is due to the relatively small volume of water pumped through the dredge compared to the tidal exchange within the inlet combined with the limited duration of dredging. In addition, dredging would be performed during the winter months when most larvae are found within the water column ingressing into the estuary in lower densities compared to spring and summer months (Ross and Epperly 1985). As such, these impacts are anticipated to be limited. It should be noted, however, that some fish expected to be within the project area are winter and early spring spawners including spot, Atlantic croaker, southern and summer flounders, and menhaden.

Indirect and Cumulative Impacts: No indirect or cumulative impacts are anticipated.

PUBLIC SAFETY

Direct and Indirect Impacts: The current erosion rate along the oceanfront shoreline on the eastern end of Ocean Isle Beach is presently threatening the integrity of numerous dwellings and infrastructure. The activities associated with Alternative 1 will provide some level of protection from storm induced erosion in the near term, and thereby provide positive direct to public safety in the short term. However, despite the implementation of the Federal shoreline protection project, the installation of sandbags, and other sporadic beach nourishment events along the east end of Ocean Isle Beach, 45 homes east of station 15+00 (located just west of Shallotte Boulevard) would be considered to be vulnerable to erosion damages over the next 30 years should the past erosion trends continue. In addition, over 1,800 feet of roads and associated utilities could also be damaged or lost over this 30-year timeframe. Of the 45 homes at risk, 18 are considered to be located on the oceanfront row, 12 on the second row, and the remaining 15 farther back on the 3rd and 4th rows. While Alternative 1 includes the future installation of sandbags to protect threatened structures and infrastructure, past experience has shown sandbags can only delay the shoreline retreat, but not permanently halt it. It is therefore expected that additional homes and infrastructure could succumb to erosion and present a significant public safety hazard due to unstable roadways, debris from demolished homes, and unstable water and sewer pipes. These impacts may include the release of sewage and other hazardous materials onto the beach and into the coastal waters resulting in closed areas of the beach impeding recreation

During the construction of Alternative 1, public safety will be temporarily impacted due to the usage of heavy machinery within Shallotte Inlet and along the oceanfront shoreline Ocean Isle Beach. Pipelines would be extended from the Shallotte Inlet borrow area to the oceanfront shoreline on Ocean Isle Beach. However, construction will take place within the environmental dredging window of November 16 through April 30 when public use of the inlet and the beach is at its lowest peak. No public safety impacts would be incurred on Holden Beach.

Cumulative Impacts: The activities described within Alternative 1 are anticipated to only provide short-term protection from erosion and storm induced damage to Ocean Isle Beach's infrastructure. Ultimately, demolition activities, road undermining, and exposure of utilities would continue as long as the erosion continues to threaten the infrastructure. The longer the situation exists, the higher the risk of personal injury. These impacts may be further exacerbated if the predicted rise in sea level occurs over the next thirty (30) years.

AESTHETIC RESOURCES

Direct Impacts: During dredging and fill events, the presence of construction equipment would temporarily detract from the aesthetics of the waterways and beach of Ocean Isle Beach. The aesthetic resources are also expected to be impacted by the continued presence of sandbags along Ocean Isle Beach's oceanfront shoreline.

Indirect and Cumulative Impacts: The chronic erosion experienced along portions of Ocean Isle Beach would be expected to continue despite the implementation of the Federal project and the continued use of sandbags. The threatened homes and infrastructure could eventually succumb to the threat of damage and destruction associated with the loss of the protective shoreline resulting in negative impacts to the natural beauty of the beach. Continued erosion along the oceanfront shoreline along the eastern portion of Ocean Isle Beach could also result in a significant loss of land, personal property, and roads, which would negatively affect the aesthetic quality of the island. These impacts may be further exacerbated if the predicted rise in sea level occurs over the next thirty (30) years. It is expected that the presence of sandbags will persist over a long period of time.

RECREATIONAL RESOURCES

Direct Impacts: Negative direct impacts will include the reduction of recreational opportunities such as sunbathing, beachcombing, surf fishing, and walking along the beach during beach fill events. Impacts to recreation are expected to be minimal since beach fill activities will generally take place during winter months when recreational activities are at their lowest levels.

Indirect and Cumulative Impacts: Immediately following construction, recreational resources and opportunities are expected to benefit from the increased size and extent of the nourished beaches along Ocean Isle Beach's oceanfront shoreline. This will offer additional area for surf fishing, bird watching, and other recreational opportunities. However, recreational activities will be interrupted every three (3) years during maintenance dredging and beach fill operations. As the erosion continues along the affected stretch of shoreline on Ocean Isle Beach, recreational opportunities such as beachcombing, sunbathing, surf fishing, and walking along the beach may be negatively impacted towards the end of the three (3) year nourishment cycle. Furthermore, access along the stretch of beach with high erosion may be restricted during the time of high tide due to the presence of sandbags.

NAVIGATION

Direct, Indirect, and Cumulative Impacts: The continued dredging within Shallotte Inlet every three years in association with the Federal project will benefit navigation due to the excavation of material well below the required depth for navigation. The area beyond the authorized borrow area, however, would remain relatively shallow, yet navigable. During the dredging, however, navigation will be temporarily directly impacted due to the presence of the dredge and associated pipelines within the inlet. At no time will complete restriction of navigation occur in the inlet during dredge operations. Restrictions will be determined by the United States Coast Guard (USCG) and will be limited to the areas where the dredge and the pipelines are located.

INFRASTRUCTURE

Direct and Indirect Impacts: Infrastructure along Ocean Isle Beach's extreme east end (east of station 15+00) may be directly impacted despite the shore protection efforts associated with Alternative 1. However, the area to the west of station 15+00 would be expected to incur some protection and hence positively impact infrastructure due to the short-term protection provided by beach nourishment and sandbags.

Cumulative Impacts: The implementation of Alternative 1 will have a negative cumulative impact on the sustainability of existing infrastructure on Ocean Isle Beach due to the ineffectiveness of historical beach nourishment projects along the extreme eastern portion of the island over time.

Past nourishments at this location have proven to provide short term protection due to the inability for the material to persist on the nourished beach. Therefore, the continuation of beach nourishment events and the use of sandbags are anticipated to afford only temporarily protection to those homes and infrastructure located on the eastern portion of the island. Several of the homes located on the eastern portion of the island with protective sandbags are considered to be unsafe during storm events. Based on Delft3D and other analysis, there are currently 238 parcels and 45 homes east of station 15+00 that are vulnerable to erosion damage over the next 30 years should the past erosion trends continue. Of the 45 homes at risk, 18 are considered to be located on the oceanfront row, 12 on the second row, and the remaining 15 farther back on the 3rd and 4th rows. In addition, over 1,800 feet of roads and associated utilities could also be damaged or lost over this 30-year timeframe.

SOLID WASTE

Direct Impacts: Should the sandbagged homes along the extreme eastern end of Ocean Isle Beach succumb to erosion and become demolished, increased levels of solid waste would be expected. Further to the west, no direct impacts will be anticipated due to the short term protection provided by beach nourishment, beach scraping, and installation of sandbags.

Indirect and Cumulative Impacts: The continued chronic erosion of the oceanfront shoreline along the east end of Ocean Isle Beach could result in the degradation and destruction of residential homes, public roads, and service utilities. Alternative 1 provides many of the threatened structures with only temporary protection and therefore, they may ultimately need to be demolished in the event of a severe storm or the continuation of chronic erosion. The debris generated from the demolition of these structures could indirectly and cumulatively impact the amount of solid waste deposited in local sanitary landfills. The volume of material to be placed in the landfill may have to be accounted for in Brunswick County's long range plan for solid waste facilities.

Cumulative impacts could also result from the gradual deterioration of the sandbag revetments. While permit restrictions may warrant future removal of the existing and future sandbag structures, removal of all of the sandbag debris is problematic as the material settles deep into the sand. Over time, any remaining material could be uncovered and become flotsam which could pose a threat to marine animals.

ECONOMICS

Direct, Indirect, and Cumulative Impacts: Under Alternative 1, a total of 45 houses would be impacted by erosion trends within the next 30 years. The economic impact of the damage was calculated at approximately $3.18 million for the cost of relocating or demolishing threatened structures, $2.89 million for the value of structures that would be demolished, and $21.36 million for the loss of approximately 155 parcels. The value of homes that were assumed to be moved to another lot totaled about $1.30 million. The relocated homes were assumed to maintain their tax value, however the lots on which they were located would eventually be lost to erosion. In addition, damages to roads and utilities would total $2.29 million with the cost of installing temporary sandbag revetments equal to $5.40 million. The damages and erosion response costs over the next 30 years total approximately $35.11 million. Approximately 32% of the total damages would occur within the first ten years of the 30-year planning period.

The Town of Ocean Isle Beach will continue to participate in the Federal storm damage reduction project under Alternative 1. Assuming each three-year periodic nourishment operation will provide an average of 408,000 cubic yards of material, the cost for future periodic nourishment would be around $6,644,000. Based on the existing Project Cooperation Agreement with the Federal Government, the Federal share of the cost for each periodic nourishment operation would be 65% or $4,320,000 with the non-Federal share equal to $2,324,000 or 35%. Over the 30-year planning period, the total cost for periodic nourishment of the Federal project would be $66.44 million with the Federal government share equal to $43.19 million and the non-Federal share equal to $23.25 million.

The cost for periodic nourishment of the Federal project is included in the 30-year costs for Alternative 1 due to the impact of some of the other alternatives on future nourishment cost. Thus, the total economic cost for Alternative 1 over the 30-year planning period, including the cost for periodic nourishment of the Federal storm damage reduction project, would be approximately $101.55 million.

NOISE POLLUTION

Direct Impacts: Dredging in Shallotte Inlet, which is included in Alternative 1, would temporarily raise the noise level in the areas of the dredge and the discharge point on the beach. Homes within proximity of the discharge point would experience higher noise levels due to ongoing usage of bulldozers leveling the material. This would be short-term since the equipment would be constantly relocating as work moves down the beach. Construction equipment would be properly maintained to minimize these effects in compliance with local laws. Also, dredging and beach placement would occur during times when residents and visitors are less likely to be present.

Indirect and Cumulative Impacts: No indirect or cumulative impacts pertaining to noise pollution are anticipated due to the low frequency of beach nourishment events and the time of year.

B. IMPACTS ASSOCIATED WITH ALTERNATIVE 2: ABANDON/RETREAT

For Alternative 2, the Town of Ocean Isle Beach, NC DOT, and the individual property owners would not take any action to slow erosion in the area east of Shallotte Boulevard to Shallotte Inlet. This includes installation of new sandbags, beach scraping/bulldozing, or intermittent beach nourishment projects described above in Alternative 1. Also, the Town of Ocean Isle Beach would not make any effort to pursue a long-term beach nourishment project or inlet channel relocation project aimed at addressing the east end erosion problems. Periodic nourishment of the federal storm damage reduction project would continue with an average of 408,000 cubic yards of material being placed on Ocean Isle Beach between baseline stations 10+00 (Shallotte Boulevard) and 120+00. Once the existing temporary sandbag revetments fail or have to be removed upon reaching the end of their permit period, the affected structures would either be abandoned (demolished) or moved to another lot on the island. The shoreline retreat scenario for Alternative 2 assumed the existing 1,800-foot sandbag revetment on the east end of the island would fail and the shoreline would move to a position it would have occupied in 2015 had the sandbags not been present. Given adequate funding, the Federal beach nourishment project would be assumed to continue on a 3-year nourishment interval along the island.

ESTUARINE HABITATS

Salt Marsh Communities

Impacts to the salt marsh communities would be the same as those described for Alternative 1.

Shellfish Habitat

Impacts to shellfish habitat for Alternative 2 are the same as those discussed above for Alternative 1.

UPLAND HAMMOCK

Impacts to upland hammock habitat for Alternative 2 are the same as those discussed above for Alternative 1.

INLET DUNES AND DRY BEACHES

Impacts to the inlet dunes and dry beaches would be the same as those described for Alternative 1.

INTERTIDAL FLATS AND SHOALS

Impacts to the intertidal flats and shoals would be the same as those described for Alternative 1.

OCEANFRONT DRY BEACH AND DUNE HABITATS

Oceanfront Dune Communities

Impacts to the oceanfront dune communities would be the same as those described for Alternative 1.

Oceanfront Dry Beach Communities

Direct Impacts: The direct impacts to the oceanfront dry beach communities would be the same as those described for Alternative 1.

Indirect Impacts: The indirect impacts associated with Alternative 2 would be similar to those described for Alternative 1, however, once the existing 1,800-foot sandbag revetment on the east end of the island would fail or have to be removed upon reaching the end of their permit period, the affected structures would either be abandoned (demolished) or moved to another lot on the island. The shoreline retreat scenario for Alternative 2 assumed sandbag revetment would fail and the shoreline would move to a position it would have occupied in 2015 had the sandbags not been present. Following the failure of the sandbag revetment, the shoreline would migrate at historic rates, measured for each profile on the east end of the island (Appendix B) for at least the next 30 years.

Cumulative Impacts: The cumulative impacts to the oceanfront dry beach communities would be the same as those described for Alternative 1.

WET BEACH COMMUNITIES

Direct Impacts: The direct impacts to the wet beach communities would be the same as those described for Alternative 1.

Indirect Impacts: Indirect impacts may affect shorebird, crustacean and fish attempting to forage along the stretch of shoreline receiving fill. The removal of the benthic infaunal species may indirectly impact these higher trophic species as the abundance of their prey is temporarily reduced. However, the magnitude of indirect impacts to these higher level trophic species may be mitigated by the large area of habitat available beyond the nourishment site. Furthermore, peak larval recruitment periods for most benthic species are avoided by Federal disposal typically occurring during winter months.

Without sandbags, the wet beach community could become further impacted as the scarp line continues to advance and eventually undermine homes and infrastructure. Once abandoned, if these homes are not demolished and removed, they would be expected to succumb to the erosion and fall upon the wet beach community thereby impacting its biological resources further.

Cumulative Impacts: The cumulative impacts to the wet beach communities would be the same as those described for Alternative 1.

MARINE HABITATS

Softbottom Communities

Impacts to the softbottom communities would generally be the same as those described for Alternative 1. However, should the Town decide to forgo its attempts to nourish the extreme east end of the island, the borrow area within Shallotte Inlet may not be utilized to the same extent as presented in Alternative 1.

WATER QUALITY

Turbidity and TSS

Impacts to the turbidity and TSS would be the same as those described for Alternative 1.

Nutrients

Similar to Alternative 1, Alternative 2 is not anticipated to impact the nutrients within the waters located within the Permit Area.

WATER COLUMN

Hydrodynamics and Salinity

Impacts to the hydrodynamics and salinity would be the same as those described for Alternative 1.

Larval Transport

Impacts to the hydrodynamics and salinity would be the same as those described for Alternative 1. However, should the Town decide to forgo its attempts to nourish the extreme east end of the island, the frequency and/or duration of dredging within Shallotte Inlet may be reduced thereby limiting impacts to larval transport through the inlet.

PUBLIC SAFETY

The impacts to public safety for Alternative 2 would be similar to those described for Alternative 1, however, with no action being taken to protect threatened homes and infrastructure via the utilization of sandbags, damages would occur continuously throughout the 30-year analysis period rather than in 5-year increments as in Alternative 1.

AESTHETIC RESOURCES

Direct Impacts: During dredging and fill events, the presence of construction equipment would temporarily detract from the aesthetics of the waterways and beach of Ocean Isle Beach.

Indirect and Cumulative Impacts: The chronic erosion experienced along portions of Ocean Isle Beach would be expected to continue despite the implementation of the Federal beach fill project. The threatened homes and infrastructure could eventually succumb to the threat of damage and destruction associated with the loss of the protective shoreline resulting in negative impacts to the natural beauty of the beach. Continued erosion along the oceanfront shoreline along the eastern portion of Ocean Isle Beach could also result in a significant loss of land, personal property, and roads, which would negatively affect the aesthetic quality of the island. These impacts may be further exacerbated if the predicted rise in sea level occurs over the next thirty (30) years. It is expected that the presence of sandbags will persist over a long period of time.

RECREATIONAL RESOURCES

Impacts to recreational resources would be the same as those described for Alternative 1.

NAVIGATION

Impacts to the navigation would be the same as those described for Alternative 1.

INFRASTRUCTURE

The impacts to infrastructure for Alternative 2 would be similar as those described for Alternative 1, however, with no action being taken to protect threatened homes and infrastructure via the utilization of sandbags, damages would occur continuously throughout the 30-year analysis period rather than in 5-year increments as in Alternative 1.

SOLID WASTE

Direct Impacts: Without continued shoreline management involving the maintenance of the sandbag revetments, homes along the extreme eastern end of Ocean Isle Beach succumb to erosion and become abandoned or demolished, increased levels of solid waste would be expected. Further to the west, no direct impacts will be anticipated due to the short term protection provided by the Federal beach nourishment project.

Indirect and Cumulative Impacts: The continued chronic erosion of the oceanfront shoreline along the east end of Ocean Isle Beach could result in the degradation and destruction of residential homes, public roads, and service utilities. Without providing many of the threatened structures with temporary protection via sandbag revetment maintenance, these areas may ultimately need to be demolished in the event of a severe storm or the continuation of chronic erosion. The debris generated from the demolition of these structures could indirectly and cumulatively impact the amount of solid waste deposited in local sanitary landfills. The volume of material to be placed in the landfill may have to be accounted for in the Brunswick County's long range plan for solid waste facilities.

Cumulative impacts could also result from the gradual deterioration of the sandbag revetments. Over time, any remaining material from degrading or buried sandbags could be uncovered and become flotsam which could pose a threat to marine animals.

ECONOMICS

Direct, Indirect, and Cumulative Impacts: Under Alternative 2, the Town of Ocean Isle Beach would continue to participate in periodic nourishment of the Federal storm damage reduction project. As noted above under Alternative 1, the total 30-year cost for continued nourishment of the Federal project would be $66.44 million. The existing cost- sharing agreement for the Federal project would continue under Alternative 2. In addition to the cost for beach nourishment, the economic impact of Alternative 2 would include the loss of 238 parcels, the costs of relocating or demolishing 45 threatened homes, the value of demolished homes, and damages to roads and utilities. Over the 30-year planning period these potential damages total $29.71 million. Note the 30-year cost for Alternative 2 is less than Alternative 1 due to eliminating the use of sandbags. The addition of damages and erosion response cost to the cost of continued nourishment of the Federal storm damage reduction project results in a total economic impact under Alternative 2 of $96.15 million. As with Alternative 1, the cost for periodic nourishment of the Federal project is included in the 30-year costs for Alternative 2 due to the impact of some of the other alternatives on future nourishment cost. The equivalent average annual cost for Alternative 2 is $3,084,000.

NOISE POLLUTION

Impacts to noise pollution would be the same as those described for Alternative 1.

C. IMPACTS ASSOCIATED WITH ALTERNATIVE 3: BEACH FILL ONLY (INCLUDING FEDERAL PROJECT)

Alternative 3 would address the east end erosion issue through the initial construction and subsequent periodic nourishment of a beach fill. The interval between nourishment events has been formulated to be 2 years. The main fill of this alternative would cover 3,500 feet of shoreline along the eastern end of Ocean Isle Beach from baseline station -5+00 (500 feet east of the end of development) and station 30+00 (located just west of Lumberton Street). The fill would include 500-foot transition or taper section on each end of the fill to merge the fill with the existing Federal storm damage reduction project making the entire fill length 4,500 feet (Figure 4.4). The main fill of the Beach Fill Only alternative would overlap 2,000 feet of the Federal project between stations 10+00 and 30+00. While the beach fill only alternative would cover more than the 2,500-foot length of shoreline in the project area, the added length is needed to provide a gradual merger of the beach fill with the Federal storm damage reduction project.

ESTUARINE HABITATS

Salt Marsh Communities

Impacts to the salt marsh communities would be the same as those described for Alternative 1.

Shellfish Habitat

Impacts to shellfish habitat would be the same as those described above for Alternative 1.

UPLAND HAMMOCK

Impacts to upland hammock habitat would be the same as those described above for Alternative 1.

INLET DUNES AND DRY BEACHES

Direct Impacts: The placement of beach fill along the eastern portion of the island includes 0.6 acre of inlet dry beach habitat. Beach nourishment activity will initially disturb this portion of dry beach habitat due to the use of bulldozers, however ultimately it will serve to increase the amount of dry beach habitat. As described above previously General Environmental Consequences Related to Beach Fill, the invertebrates and infaunal communities present within the dry beach habitat will be directly impacted due to burial, however due to the resilient nature of these organisms and the use of compatible material, the impacts will be temporary. No direct impacts are anticipated to the inlet dry beach habitat on Holden Beach. In addition, no direct impacts are anticipated to be incurred within the inlet dune communities on either side of Shallotte Inlet.

Indirect and Cumulative Impacts: The simulated erosion and deposition patterns in the vicinity of Shallotte Inlet after the three year simulation for Alternative 3 are shown above in Figure 5.6. Along the Ocean Isle Beach sand spit between stations -5+00 and -20+00, the model indicated there would be no net change in volume above the -6-foot NAVD depth contour after three years which is a slight improvement compared to Alternatives 1 and 2. This improvement was due to the migration of sediment from the east end beach fill toward Shallotte Inlet. However, the indicated volume change between stations -20+00 and -30+00 was -15,300 cubic yards/year which was over 4 times the loss rate indicated for Alternatives 1 and 2. This increase in the rate of volume loss on the eastern end of the sand spit is counter intuitive given the eastward spreading of the beach fill material that resulted in the stabilization of the segment between stations -5+00 and -20+00. One possible explanation would be changes in wave patterns on the east end of the spit due to waves refracting around the bulbous shape of the beach fill. Considering the margin of error associated with the Delft3D model, the difference could also be associated with the inherent difference in the response of the model to various permutations associated with the addition of the relatively large beach fill.

Volume changes on the west end of Holden Beach landward of the -6-foot NAVD depth contour averaged 12,000 cubic yards/year which was essentially the same as for Alternatives 1 and 2.

GIS analysis utilizing the biotic community map suggests indirect impacts of 1-2 acres to the inlet dune communities and 5-10 acres of impact to the inlet dry beach communities. The majority of these impacts would occur on the Ocean Isle Beach side of the inlet. The loss of this habitat would result in a reduction of suitable habitat for the protected plant seabeach amaranth, shorebirds including piping plovers and red knots, and a reduction in area for humans to recreate. Furthermore, the survival rate of sea turtle hatchlings could be reduced due to possible inundation of encroaching mean high water marks through severe erosion.

As stated in Chapter 4, critical habitat designation for North Carolina wintering piping plover includes a portion of inlet dunes and dry beach habitat along Holden Beach within Unit NC-17 (USFWS, 2001). Research has shown that wintering plovers on the Atlantic coast prefer wide beaches in the vicinity of inlets (Nicholls and Baldassarre, 1990; Wilkinson and Spinks, 1994). While overwintering piping plovers have Critical Habitat within the Permit Area, piping plovers also nest in the region. Piping plovers nest in dry sand habitats above the high tide line along coastal beaches, spits, flats, barrier islands and other sparsely vegetated dune and beach environments, although they may utilize other shoreline habitats if these are not available. Should the erosion continue along the inlet beaches on Ocean Isle Beach and Holden Beach, the overwintering Critical Habitat and nesting habitat could be impacted.

INTERTIDAL FLATS AND SHOALS

Direct Impacts: Direct impacts to the intertidal flats and shoals would be the same as those described for Alternative 1.

Indirect Impacts: Indirect impacts to the intertidal flats and shoals would be the same as those described for Alternative 1.

Cumulative Impacts: Dredging is scheduled to occur every two years from within the Shallotte Inlet borrow area. As such, the intertidal flats and shoals found within or in proximity to the borrow area would be excavated every other year for a period of 30 years (the anticipated life span of the permit for this project). Although these flats and shoals tend to be ephemeral and have reformed following past dredging operations, the 2 year interval associated with Alternative 3 may prevent this habitat from reforming completely. The recovery of infaunal species residing in intertidal flats and shoals after sediment removal may vary depending upon the opportunistic nature of the individual species (Street *et al*., 2005; Posey and Alphin, 2002). At dredge sites monitored off the coast of New Jersey, infaunal assemblages recovered within one year after disturbance, while biomass and taxonomic richness took 1.5 to 2.5 years to recover (Street *et al*., 2005). With this in mind, the temporal spacing between the periodic maintenance events every two years within the proposed dredged areas may not allow for full recovery of benthos populations within the intertidal flats and shoals in Shallotte Inlet. This could indirectly impact foraging piping plovers which utilize the intertidal flats and shoals within Shallotte Inlet as part of their critical habitat Unit NC-17. The intertidal flats and shoals outside of Shallotte Inlet within the Permit Area, however, would not be anticipated to be impacted.

OCEANFRONT DRY BEACH AND DUNE HABITATS

Oceanfront Dune Communities

Impacts to the oceanfront dune communities would be the same as those described for Alternative 1.

Oceanfront Dry Beach Communities

Direct Impacts: During the initial construction, approximately 16.5 acres of dry beach would be directly impacted by the placement of beach fill material along the oceanfront dry beach between stations -5+00 and 90+00. Beach nourishment activity will initially disturb the dry beach habitat due to the use of bulldozers, however ultimately it will serve to increase the amount of dry beach habitat. As described above previously General Environmental Consequences Related to Beach Fill, the invertebrates and infaunal communities present within the dry beach habitat will be directly impacted due to burial, however due to the resilient nature of these organisms and the use of compatible material, the impacts will be temporary.

On the Holden Beach side of Shallotte Inlet, the model indicated volume changes above the -6-foot NAVD depth contour along the western 4,000 feet of the island were virtually the same between Alternative 1 and the three terminal groin options evaluated. Also, volume changes out to the -18-foot NAVD depth contour in this same area of Holden Beach were of the same order of magnitude, ranging from -46,000 cubic yards/year for Alternative 1 to -62,000 cubic yards/year for Alternative 5. Given the inherent accuracy of the numerical model, the differences in the model results are deemed to be not significant. As such, no direct impacts to the oceanfront dry beach are anticipated to occur along Holden Beach as a result of Alternative 1.

Indirect Impacts: The erosion rate along the eastern portion of Ocean Isle Beach between base stations 0+00 and 30+00 has averaged 91,000 cubic yards per year since the initial construction of the Federal project in 2001 (Table 5.6). In addition, as depicted in Figure 5.1, the average annual retreat of the scarp line between stations 0+00 and 20+00, measured between September 1999 and May 2010, was approximately 10 feet/year.

Table 5.6. Volume change rates for post-nourishment periods on east end of Ocean Isle Beach (baseline stations 0+00 to 30+00)

Post-nourishment time period	Time Interval Years	Measured rate of volume change cubic yards/year
Dec 2001 to Mar 2006	4.2	-72,000
Apr 2007 to May 2010	3.1	-88,000
May 2010 to Aug 2013	3.2	-114,000
Average 2001 to 2013	**10.5**	**-91,000**

Based on the Delft3D model simulated performance of a beach fill on the east end of the island, implementation of Alternative 3 would increase the volume loss rate to 140,000 cubic yards/year from within this area. For the area west of station 30+00 to station 120+00, the Delft3D model simulation for Alternative 3 did not indicate any differences in the erosion rates compared to losses being experienced under existing conditions (i.e., Alternative 1). Erosion losses within this area have averaged 78,000 cubic yard/year. Thus, under Alternative 3, the expected volume loss between station -5+00 and station 120+00 totals 218,000 cubic yards/year. The estimated volumetric loss rates between various stations on Ocean Isle Beach under Alternative 3 are summarized in Table 5.7. A total of 0-5 acres of oceanfront dry beach would be anticipated to be lost to indirect impacts.

Table 5.7. Annual rates of volume change along Ocean Isle Beach under Alternative 3.

-5+00 to 30+00	30+00 to 60+00	60+00 to 90+00	90+00 to 120+00	Total
-140,000	-59,000	-14,000	-5,000	-218,000

Along with directly impacting infaunal communities, beach nourishment will indirectly impact the nesting and resting habitats for shorebirds including piping plovers and red knots provided by the dry beach due to the temporary removal of infaunal prey resources. As stated under the General Environmental Consequences Related to Beach Fill section above, the infaunal prey is expected to recover within approximately 1 year following construction.

The implementation of Alternative 3 would also be expected to provide a positive indirect impact to the various biological resources utilizing the dry beach for habitat as a result of an increase in net habitat acreage along the eastern portion of Ocean Isle Beach. These biological resources include nesting sea turtles, shorebirds, and seabeach amaranth.

According to Greene (2002), beach nourishment can benefit endangered and threatened sea turtles by restoring habitat along eroded beaches. Some studies have found no significant difference between nourished and non-nourished beaches in the number of eggs per nest, as well as, hatching and emergence success (Nelson *et al*., 1985; Ryder, 1991). Other projects have shown increased numbers of nests, hatchlings, and survival rate of young turtles (Raymond, 1984). The widened beach along the fill area within the Federal project will benefit sea turtles since they require dry beaches to nest, preferring to nest along wide sloping beaches or near the base of the dunes. The composition, color, and grain size of the placed sand can affect the incubation time, sex, and hatching success of turtle hatchlings (Street *et al*., 2005). Physical characteristics such as density, compaction, shear resistance, moisture content, slope, sand color, grain size, grain shape, sand mineral content, and gas exchange may affect the success of sea turtle nests (Nelson and Dickerson 1988, Crain et al. 1995). The fill placed upon Ocean Isle Beach will conform to the State sediment criteria rules and therefore is not expected to impact the nesting success of sea turtles.

The oceanfront dry beach communities on Holden Beach are not anticipated to be impacted through the implementation of Alternative 3.

Cumulative Impacts: The 2 year nourishment interval associated with Alternative 3 may limit the recovery of infaunal resources between fill events on Ocean Isle Beach and thereby reduce the quality of habitat for foraging shorebirds. This periodic disturbance may also impact seabeach amaranth due to the possibility of repeated burial. These resources which utilize the oceanfront dry beach communities, however, are expected to persist within the Permit Area due to the abundance of available habitat. Therefore, recreational opportunities and residential use would be expected to be maintained.

WET BEACH COMMUNITIES

Direct Impacts: The addition of beach fill to Ocean Isle beach between stations -5+00 and 90+00 will cause direct impacts to approximately 16.0 acres of the wet beach community due to burial following the placement of fill material. As discussed for Alternatives 1 and 2, these impacts are considered to be short-term because studies have demonstrated rapid recovery times for organisms inhabiting wet beaches. As mentioned in Chapter 4, Nelson (1985) indicates that organisms that reside in intertidal zones are more adaptable to fluctuations in their environment, including high sediment transport and turbidity levels. Also, as previously stated, with the use of beach compatible material, infaunal organisms are expected to respond as studies have shown (Van Dolah et al., 1994), and dredging would occur during winter months when infaunal community activity and its onshore populations are at their lowest.

Indirect Impacts: Indirect impacts may affect shorebird, crustacean and fish attempting to forage along the stretch of shoreline receiving fill. The removal of the benthic infaunal species may indirectly impact these higher trophic species as the abundance of their prey is temporarily reduced. However, the magnitude of indirect impacts to these higher level trophic species may be mitigated by the large area of habitat available beyond the nourishment site. Furthermore, peak larval recruitment periods for most benthic species are avoided by Federal disposal typically occurring during winter months.

Sandbags used to provide storm protection for threatened structures on Ocean Isle Beach may reduce the area of wet beach by providing a temporary barrier to the migration of wet beach along the active beach profile. These structures are generally installed when the mean high tide is within twenty feet of a home or other infrastructure, which is the State requirement prior to authorizing oceanfront sandbags. This leaves minimal or no wet beach habitat to support infaunal communities. Based on future shoreline change analysis, approximately 25-30 acres of wet beach are anticipated to be indirectly impacted within the Permit Area, specifically along the oceanfront shoreline along the east end of Ocean Isle Beach.

Cumulative Impacts: As a result of the renourishment activity (based on the Town's proposal and the Federal project) that would occur approximately every 2 years, negative cumulative effects could occur if the diversity and abundance of infaunal populations do not recover between nourishment events. However, as researched, organisms that reside in intertidal zones are more adaptable to fluctuations in their environment, including high sediment transport and turbidity levels (Nelson, 1985). Other studies reported by Maurer (National Research Council, 1995) supported the burial capabilities of nearshore species, which found that these species were capable of burrowing through sand up to 40 cm. As stated above, Nelson (1985) has demonstrated the adaptability and rapid recovery for organisms residing in the marine intertidal zone. With this in mind, the temporal spacing between the periodic maintenance events every two years within the proposed dredged areas may not allow for full recovery of benthos populations within the wet beach community along Ocean Isle Beach. The wet beach within the Permit Area outside of the fill template including those found along Holden Beach, however, would not be anticipated to be impacted

MARINE HABITATS

Softbottom Communities

Direct Impacts: The activities associated with Alternative 3 would result in direct impacts of softbottom community every two years within portions of the Permit Area. This includes the softbottom communities within the toe of fill and within the proposed borrow area in Shallotte Inlet. Excavating this borrow area will cause an immediate removal of infaunal and non-motile epibenthic organisms from the softbottom community. Construction of the beach would result in the direct deposition of material from mean low water (MLW) to the construction toe-of-fill, which covers softbottom habitat. These actions would result in a direct impact of 197.2 acres of softbottom habitat. It should be reiterated that the material placed over the softbottom habitat meets the State's sediment criteria requirements and is therefore considered to be compatible to the native sediment. As previously described, the adaptive nature of the infaunal species will limit these impacts. Recolonization of these infaunal species typically tends to occur within the order of several months. Softbottom communities may also change with natural shifting patterns of sediment erosion or deposition (Street *et al*., 2005).

Because the beaches along the western portion of Holden Beach will not receive disposal material, impacts to softbottom resources outside of natural shifting processes on or around Holden Beach in response to Alternative 3 are not anticipated.

Indirect Impacts: Indirect impacts to the softbottom community would be expected to be the same as those described under Alternative 1, however, because the beach fill associated with Alternative 3 extends further east to station -5+00, these indirect effects would be slightly greater. In total, 0-1 acres of softbottom would be indirectly impacted.

Cumulative Impacts: Although the infaunal resources within the footprint of the dredging activities within Shallotte Inlet would be expected to recover relatively rapidly, cumulative impacts to this resource within this location could be incurred due to the fact that nourishment is scheduled to occur every two years. This would result in impacts to the softbottom resources within the borrow area and toe of fill every two years. In general, however, the softbottom resources within the State of North Carolina are extensive and the impacts associated with this alternative are not expected to cause cumulative impacts to infaunal communities as a whole within the State.

WATER QUALITY

Turbidity and TSS

Direct and Indirect Impacts: The direct and indirect impacts of turbidity and TSS associated with Alternative 3 are anticipated to be the same as those described for Alternative 1, however the duration of an increased of localized turbidity during each dredge and fill event would be increased considering the slightly larger fill template.

Cumulative Impacts: Renourishment of Ocean Isle Beach would be scheduled every two years under Alternative 3. Although this relatively high renourishment rate would result in periods of higher turbidity within the Permit Area on a more frequent basis, in general, the cumulative impacts as described under Alternative 1 would also apply for Alternative 3.

Nutrients

Direct, Indirect, and Cumulative Impacts: The implementation of Alternative 3 is not anticipated to impact the nutrients within the waters located in the Permit Area.

WATER COLUMN

Hydrodynamics and Salinity

The impacts to hydrodynamics and salinity would be the same as those described for Alternative 1.

Larval Transport

The impacts to larval transport would be the same as those described for Alternative 1.

PUBLIC SAFETY

Direct and Indirect Impacts: During the construction of Alternative 3, public safety will be temporarily impacted due to the usage of heavy machinery within Shallotte Inlet and along the oceanfront shoreline Ocean Isle Beach. Pipelines would be extended from the Shallotte Inlet borrow area to the oceanfront shoreline on Ocean Isle Beach. However, construction will take place within the dredging window of November 16 through April 30 when public use of the inlet and the beach is at its lowest. The implementation of Alternative 3 will help alleviate the erosional pressure along the extreme eastern end of Ocean Isle Beach thereby providing protection to the 57 dwellings/dwelling units currently protected by sandbags. Without the threat of these homes being damaged or demolished, public safety should increase due to the avoidance of hazardous conditions caused by continued erosion including the exposure of utilities and leaking septic tanks. Furthermore, the sandbags, which could pose a public safety hazard due to their size and orientation to the eroded shoreline, would be removed and/or covered up and replaced with a nourished beach tapered from a developed dune ridge. No public safety impacts would be incurred on Holden Beach

Cumulative Impacts: Public safety within Shallotte Inlet and along the oceanfront shoreline Ocean Isle Beach will be temporarily impacted during each maintenance event scheduled approximately every two years. These impacts will be similar in nature as those described above. No impacts are anticipated along Holden Beach.

AESTHETIC RESOURCES

Direct Impacts: During dredging and fill events, the presence of construction equipment would temporarily detract from the aesthetics of the waterways and beach of Ocean Isle Beach.

Indirect and Cumulative Impacts: Renourishment would be implemented every two years under

Alternative 3 resulting in diminished aesthetics as a result of the presence of construction equipment within the inlet and along the eastern portion of Ocean Isle Beach over the 30 year permit period.

RECREATIONAL RESOURCES

Direct Impacts: Direct impacts would be similar to those described for Alternative 1.

Indirect and Cumulative Impacts: Immediately following construction, recreational resources and opportunities are expected to benefit from the increased size and extent of the nourished beaches along Ocean Isle Beach's oceanfront shoreline. This will offer additional area for surf fishing, bird watching, and other recreational opportunities. However, recreational activities will be interrupted every two years during maintenance dredging and beach fill operations.

NAVIGATION

Impacts to navigation will be the same as those described for Alternative 1, however, the frequency of renourishment activities will be every two years resulting in increased temporary impacts to navigation as a result of the presence of dredge equipment in Shallotte Inlet.

INFRASTRUCTURE

Direct, Indirect, and Cumulative Impacts: Alternative 3 is expected to benefit the infrastructure on Ocean Isle Beach due to the long-term protection from erosion. The beach nourishment plan included in Alternative 3 would provide protection between stations -5+00 and 90+00 along the Ocean Isle Beach shoreline.

SOLID WASTE

Direct, Indirect, and Cumulative Impacts: Both short and long-term benefits are expected from the reduction of solid waste with the implementation of Alternative 3. This alternative will provide protection along portions of Ocean Isle Beach thereby decreasing the risk of damage to residential buildings and infrastructure. This would alleviate the potential for increased solid waste through demolition of buildings and infrastructure.

ECONOMICS

Direct, Indirect, and Cumulative Impacts: The long-term erosion damages that could occur to existing development on the east end of Ocean Isle Beach would be prevented under Alternative 3. The initial placement of 387,000 cubic yards east of baseline station 30+00 to construct the beach for Alternative 3 was assumed to take place during a normal periodic nourishment cycle for the Federal project. Based on this assumption and the actual experience of placing the additional fill on the east end during the 2006-07 nourishment operation, the cost for the 387,000 cubic yards of material was based on the dredging cost (i.e., there would not be any additional mobilization and demobilization costs for the added fill).

The economic costs for Alternative 3 would be associated with providing the necessary volume of material to offset these future erosion threats. The total 30-year cost for Alternative 3, which includes continued nourishment of the Federal storm damage reduction project, is estimated to be $108.77million.

The Federal government would presumably continue to provide its share of the cost for periodic nourishment of the Federal project but would not participate in the added nourishment costs associated with Alternative 3. Therefore, the Federal share of the 30- year project costs under Alternative 3 would be equal to that of Alternatives 1 and 2 or $43.19 million with the balance of $65.58 million the responsibility of non-Federal interests.

The equivalent average annual cost for Alternative 3 is $3,646,000.

NOISE POLLUTION

Direct Impacts: Direct impacts to noise pollution would be the same as those described for Alternative 1.

Cumulative Impacts: Although nourishment would be scheduled every two years under Alternative 3, no cumulative impacts would be anticipated due to the relative short duration of elevated noise during operations within the Permit Area.

D. IMPACTS ASSOCIATED WITH ALTERNATIVE 4: REALIGNMENT OF SHALLOTTE INLET OCEAN BAR CHANNEL (INCLUDING FEDERAL PROJECT)

Alternative 4 is similar to Alternative 3 in that it involves the continuation of the Federal project along with a supplemental fill containing 387,000 cubic yards of material placed between baseline stations -5+00 and 30+00. This alternative, however, will serve to manage the erosion stress associated with Shallotte Inlet along the east end of Ocean Isle Beach by repetitive dredging of the channel/borrow area along the same general alignment and orientation as that used for initial construction of the federal storm damage reduction project. Repetitive dredging of the ocean bar channel in the same general footprint from year to year should result in the reconfiguration of the ebb tide delta of Shallotte Inlet over time and lead to a gradual reduction in volume losses off the east end of Ocean Isle Beach.

The reconfiguration of the ebb tide delta would include onshore movement of sediment from the delta located off the west end of Holden Beach and rebuilding the delta off the east end of Ocean Isle. A larger delta on the west side of Shallotte Inlet would provide some wave sheltering for the east end of the island and could eliminate the formation of flood channels that run parallel and close to the shoreline on the east end of Ocean Isle Beach. In order to make the borrow area in Shallotte Inlet function as a true channel relocation, material removed during periodic nourishment operations should be derived from the same general area as used by the USACE for initial construction of the Ocean Isle Beach storm damage reduction project. The dredge cut should also extend across the ocean bar and merge with the existing -17.9 foot NAVD depth contour in the ocean in order to encourage flow to move through the dredged cut rather than through the natural bar channel. By continuing to use the same cut area for each nourishment operation the borrow area should eventually become the dominant flow path for waters exiting through the inlet.

Based on the results of the Delft3D model for Alternative 4, which simulated the re-dredging of the channel/borrow area in the same general location as used by the USACE, (see Appendix B), periodic nourishment would be needed two years following the first re-dredging of the channel/borrow area. Following the second re-dredging, the next periodic nourishment operation would not be needed for 3 years. Given the shoreline response indicated by the Delft3D model, subsequent periodic nourishment operations would only be needed every four years until the end of the 30-year project evaluation period.

ESTUARINE HABITATS

Salt Marsh Communities

Impacts to the salt marsh communities would be the same as those described for Alternative 1.

Shellfish Habitat

Impacts to shellfish habitat would be the same as those described above for Alternative 1.

UPLAND HAMMOCK

Impacts to upland hammock habitat would be the same as those described above for Alternative 1.

INLET DUNES AND DRY BEACHES

Direct Impacts: Direct impacts to the inlet dunes and dry beaches would be anticipated to be the same as described above for Alternative 3.

Indirect and Cumulative Impacts: During the initial 4 years of the adjustment period, the shoreline along the sand spit on the east end of Ocean Isle Beach would be expected to respond in a manner similar to Alternative 3 (i.e., the area between stations -5+00 and 20+00 would become relatively stable while the segment between -20+00 and -30+00 would continue to erode). At the end of the 20-year adjustment period, losses off of the sand spit between stations -5+00 and -30+00 would be expected to cease as the build-up of material on the west side of Shallotte Inlet would protect the spit against severe wave attack resulting in accretion along the entire sand spit.

The west end of Holden Beach would not be impacted by the changes associated with Alternative 4, and is expected to continue to behave in a manner similar to both Alternative 1 and Alternative 3. In general, Alternative 4 would gradually require less and less material from the Shallotte Inlet borrow area for periodic nourishment along Ocean Isle Beach. The reduction in the volume of material removed should gradually diminish the rate of sediment accumulation in Shallotte Inlet.

Similar to Alternative 3, GIS analysis utilizing the biotic community map suggests indirect impacts of 1-2 acres to the inlet dune communities and 5-10 acres of impact to the inlet dry beach communities. The majority of these impacts being incurred on the Ocean Isle Beach side of the inlet. The loss of this habitat would result in a reduction of suitable habitat for the protected plant seabeach amaranth, shorebirds including piping plovers and red knots, and a reduction in area for humans to recreate. Furthermore, the survival rate of sea turtle hatchlings could be reduced due to possible inundation of encroaching mean high water marks through severe erosion.

As stated in Chapter 4, critical habitat designation for North Carolina wintering piping plover includes a portion of inlet dunes and dry beach habitat along Holden Beach within Unit NC-17 (USFWS, 2001). Research has shown that wintering plovers on the Atlantic coast prefer wide beaches in the vicinity of inlets (Nicholls and Baldassarre, 1990; Wilkinson and Spinks, 1994). While overwintering piping plovers have Critical Habitat within the Permit Area, piping plovers also nest in the region. Piping plovers nest in dry sand habitats above the high tide line along coastal beaches, spits, flats, barrier islands and other sparsely vegetated dune and beach environments, although they may utilize other shoreline habitats if these are not available. Should the erosion continue along the inlet beaches on Ocean Isle Beach and Holden Beach, the overwintering Critical Habitat and nesting habitat could be impacted.

INTERTIDAL FLATS AND SHOAL

Direct Impacts: Direct impacts to the intertidal flats and shoals would be the same as those described for Alternative 1.

Indirect Impacts: Indirect impacts to the intertidal flats and shoals would be the same as those described for Alternative 1.

Cumulative Impacts: Dredging is scheduled to occur two years after the second re-dredging of the channel/borrow with the interval increasing to 3 years after the third re-dredging and then every 4 years for the remainder of the 30-year evaluation period. The repeated removal of material from the same general area within the borrow area will eventually concentrate the majority of flow through the realigned channel and eventually result in the reconfiguration of the inlet and the inlet ebb tide delta comparable to that which existed between 1954 and 1965. The Delft3D model results reported in Appendix B indicated material would continue to accumulate west of Shallotte Inlet with subsequent re-dredging of the channel/borrow area in the same general footprint.

Although intertidal flats and shoals tend to be ephemeral and have reformed following past dredging operations, the initial 2 year interval associated with Alternative 4 may prevent this habitat from reforming completely. The recovery of infaunal species residing in intertidal flats and shoals after sediment removal may vary depending upon the opportunistic nature of the individual species (Street *et al*., 2005; Posey and Alphin, 2002). At dredge sites monitored off the coast of New Jersey, infaunal assemblages recovered within one year after disturbance, while biomass and taxonomic richness took 1.5 to 2.5 years to recover (Street *et al*., 2005). With this in mind, the temporal spacing between the periodic maintenance, which will gradually increase to every 4 years, should allow for almost full recovery of benthos populations within the intertidal flats and shoals in Shallotte Inlet between dredging operations. The intertidal flats and shoals outside of Shallotte Inlet within the Permit Area, however, would not be anticipated to be impacted.

OCEANFRONT DRY BEACH AND DUNE HABITATS

Oceanfront Dune Communities

Impacts to the oceanfront dune communities would be the same as those described for Alternative 1.

Oceanfront Dry Beach Communities

Direct and Indirect Impacts: The direct and indirect impacts for Alternative 4 would be the same as described above for Alternative 3.

Cumulative Impacts: The initial 2 year nourishment interval associated with Alternative 4 may limit the recovery of infaunal resources, however, with the dredge interval eventually increasing to every 4 years between fill events on Ocean Isle Beach, the quality of habitat for foraging shorebirds should not be significantly impacted. The periodic disturbance may impact seabeach amaranth due to the possibility of repeated burial. The nourishment interval, however, would be expected to increase from two years to every 4 years after 5 years. This increased interval would be expected to reduce any indirect impact to seabeach amaranth, nesting and foraging birds, and nesting sea turtles.

WET BEACH COMMUNITIES

Direct and Indirect Impacts: The direct and indirect impacts to the wet beach would be expected to be the same as those described for Alternative 3.

Cumulative Impacts: As a result of the renourishment activity which will eventually increase from an initial 2 year interval to once every 4 years, negative cumulative effects could occur if the diversity and abundance of infaunal populations do not recover between nourishment events. However, as researched, organisms that reside in intertidal zones are more adaptable to fluctuations in their environment, including high sediment transport and turbidity levels (Nelson, 1985). Other studies reported by Maurer (National Research Council, 1995) supported the burial capabilities of nearshore species, which found that these species were capable of burrowing through sand up to 40 cm. As stated above, Nelson (1985) has demonstrated the adaptability and rapid recovery for organisms residing in the marine intertidal zone. With this in mind, the temporal spacing between the periodic maintenance events every two years within the proposed dredged areas may not allow for full recovery of benthos populations within the wet beach community along Ocean Isle Beach. Alternative 4 includes an extended nourishment interval of 4 years beginning after year 9. This increased interval may allow for a more successful recolonization of infaunal resources within the wet beach and therefore keep cumulative impacts to a minimum.

The wet beach within the Permit Area outside of the fill template, including those found along Holden Beach, however, would not be anticipated to be adversely impacted.

MARINE HABITATS

Softbottom Communities

Direct and Indirect Impacts: The direct and indirect impacts to the softbottom communities would be expected to be the same as those described for Alternative 3.

Cumulative Impacts: Although the infaunal resources within the footprint of the dredging activities within Shallotte Inlet would be expected to recover relatively rapidly, cumulative impacts to this resource within this location could initially occur during the first 5 years following implementation as the periodic dredge/beach nourishment interval increased from 2 years to once every 4 years. This would result in initial impacts to the softbottom resources within the borrow area and toe of fill during the first 5 years following the initial construction of Alternative 4. This gradual increase in the periodic nourishment interval may allow for a more successful recolonization of infaunal resources within the softbottom communities and therefore keep cumulative impacts to a minimum. In general, the softbottom resources within the State of North Carolina are extensive and the impacts associated with this alternative are not expected to result in adverse cumulative impacts to infaunal communities as a whole within the State.

WATER QUALITY

Turbidity and TSS

Direct and Indirect Impacts: The direct and indirect impacts to water quality would be expected to be the same as those described for Alternative 3.

Cumulative Impacts: Renourishment of Ocean Isle Beach would be scheduled 2 years after initial construction and 3 years after the second channel/borrow area excavation event and then even out to once every 4 year for the remained of the 30-year evaluation period. The renourishment schedule under Alternative 4 would initially result in periods of higher turbidity within the Permit Area during the first 5 years following initial construction but then moderate as the periodic nourishment interval increases to once every 4 years.

Nutrients

Direct, Indirect, and Cumulative Impacts: The implementation of Alternative 4 is not anticipated to impact the nutrients within the waters located in the Permit Area.

WATER COLUMN

The impacts to hydrodynamics and salinity would be the same as those described for

Alternative 1.

Larval Transport

The impacts to larval transport would be the same as those described for Alternative 1.

PUBLIC SAFETY

Direct and Indirect Impacts: The direct and indirect impacts to public safety would be expected to be the same as those described for Alternative 3.

Cumulative Impacts: Public safety within Shallotte Inlet and along the oceanfront shoreline of Ocean Isle Beach under Alternative 4 will be temporarily impacted as described above under Alternative 3 during each maintenance event. However, this impact would gradually decrease as the periodic nourishment interval increases from 2 years to 4 years in year 5 after initial construction.

Direct Impacts: The direct and indirect impacts to the aesthetic resources would be expected to be the same as those described for Alternative 3.

Indirect and Cumulative Impacts: The first renourishment under Alternative 4 would be implemented two years after initial construction and then 3 years later following the first maintenance operation. Periodic nourishment and channel/borrow area excavation events would then increase to every 4 years for the remainder of the 30-year evaluation period. Aesthetic resources would be diminished during dredging events as a result of the presence of construction equipment within the inlet and along the eastern portion of Ocean Isle Beach.

RECREATIONAL RESOURCES

Direct Impacts: Direct impacts would be similar to those described for Alternative 1.

Indirect and Cumulative Impacts: Immediately following construction, recreational resources and opportunities are expected to benefit from the increased size and extent of the nourished beaches along Ocean Isle Beach's oceanfront shoreline. This will offer additional area for surf fishing, bird watching, and other recreational opportunities. However, recreational activities will be interrupted during maintenance dredging and beach fill operations which will eventually occur about every 4 years from year 5 to year 30 of the evaluation period.

NAVIGATION

Impacts to navigation will be the same as those described for Alternative 1, however, the frequency of renourishment activities, as outline above, will result in temporary impacts to navigation as a result of the presence of dredge equipment in Shallotte Inlet. With the dredging interval eventually increasing to once every 4 years, the impacts on navigation associated with the dredging operations would be less than under existing conditions.

INFRASTRUCTURE

Direct, Indirect, and Cumulative Impacts: Alternative 4 is expected to benefit the infrastructure on Ocean Isle Beach due to the long-term protection from erosion. The beach nourishment plan included in Alternative 4 would provide protection between stations -5+00 and 90+00 along the Ocean Isle Beach shoreline.

SOLID WASTE

Direct, Indirect, and Cumulative Impacts: Both short and long-term benefits are expected from the reduction of solid waste with the implementation of Alternative 4. This alternative will provide protection along portions of Ocean Isle Beach thereby decreasing the risk of damage to residential buildings and infrastructure. This would alleviate the potential of increased amount of solid waste through demolition.

ECONOMICS

Direct, Indirect, and Cumulative Impacts: Alternative 4 would prevent long-term erosion damages to development and infrastructure along the east end of Ocean Isle Beach east of baseline station 30+00.

Over the 30-year planning period, providing the periodic nourishment volumes along Ocean Isle Beach would cost a total of $53.15 million. The Federal government should continue to participate in periodic nourishment of the Federal storm damage reduction project, contributing 65% of the cost for providing beach fill within the authorized Federal limits. Based on the projected decrease in periodic nourishment of the Federal storm damage reduction project, the F ederal share over the 30-year planning period would be $30.89 (58.1%) million leaving a balance of $22.26 (41.9%) million for non-Federal interests.

The equivalent average annual cost for Alternative 4 is $1,920,000 based on an amortization period of 30 years and an interest rate of 4.125%.

NOISE POLLUTION

Direct Impacts: Direct impacts to noise pollution would be the same as those described for Alternative 1.

Cumulative Impacts: Given the periodic beach nourishment schedule for Alternative 4 as presented above, Impacts associated with noise pollution would gradually diminish over the 30-year planning period as the nourishment interval increases from 2 years to 4 by the end of project year 5No adverse cumulative impacts would be anticipated due to the relative short duration of elevated noise during operations within the Permit Area.

E. IMPACTS ASSOCIATED WITH ALTERNATIVE 5: TERMINAL GROIN WITH BEACH FILL (WITH FEDERAL PROJECT)/ APPLICANT'S PREFERRED ALTERNATIVE

Alternative 5 includes the continuation of the Federal project along with the construction of a 750 foot terminal groin located approximately 148 feet east of station 0+00. As mentioned earlier, the length of the terminal groin refers to the length of the rubblemound section described below. A 3,214 foot section of shoreline located directly west of the terminal groin would be pre-filled with 264,000 cubic yards of material obtained from Shallotte Inlet, the same source of material as the Federal project. Due to the presence of the terminal groin, the nourishment interval for the Federal project could be increased from every 3 years to every 5 years.

The structural design of the groin would include a 300 foot shore anchorage section that would begin 450 feet landward of the baseline. The top elevation of the shore anchorage section would vary from +4.5 NAVD88 feet over the first 170 feet and increase to +4.9 feet NAVD88 over the last 130 feet where it will tie into the rubblemound section. The top of the landward most portion of the shore anchorage section would be below the existing ground level. The rubblemound section would extend 750 feet seaward from the end of the shore anchorage section and terminate 600 feet seaward of the baseline. The rubblemound portion of the terminal groins would be constructed with loosely placed armor stone on top of a foundation mat or mattress and would have a crest elevation of +4.9 feet NAVD. The loose nature of the armor stone was designed to facilitate the movement of littoral material through the structure while the relative low crest elevation of +4.9 feet NAVD would allow some sediment to pass over the structure during periods of high tide.

Studies on the Impacts of Terminal Groins

In early 2010, the State of North Carolina explored the environmental impacts attributable to a series of five (5) terminal groins located in Florida and North Carolina within the "North Carolina Terminal Groin Study Final Report" (NCDENR, 2010). This report included a review of past scientific, engineering, and publicly accessible information and data related to the five terminal groin projects.

One of the terminal groin structures used in the NCDENR report was the Oregon Inlet terminal groin located in the Outer Banks of North Carolina. In 1989, the North Carolina Department of Transportation (NCDOT) initiated construction of the Oregon Inlet terminal groin on Pea Island National Wildlife Refuge to provide protection from erosion occurring along the base of the Herbert C. Bonner Bridge, which spans the Oregon Inlet and connects Hatteras Island to the mainland, in Dare County. Permit stipulations required regular monitoring of the physical conditions along a six mile segment of the shoreline extending from the terminal groin on Pea Island southward. This post- monitoring was initiated after the completion of the terminal groin in 1991. Results have shown that the project erosion rates are much less than historical rates in the first four miles of the study area (Overton, 2011). In the fifth and sixth mile, the rates are closer to the historical rate; however, they do not exceed the historical rate at any point. Overton (2011) points out that the construction of the groin has not appeared to have caused adverse impacts to the shoreline over the six-mile study area. It should be noted that since 1991, a total of 4.3

million cubic yards of material from the dredging of Oregon Inlet by the USACE has been placed on the beach or immediately offshore of the beach within the study area. The Pea Island terminal groin project did not have a beach nourishment component, rather, the material placed on Pea Island following the construction of the terminal groin was associated with the disposal of navigation maintenance material removed from Oregon Inlet to maintain the federal navigation channels. It is presumed that the placement of the terminal groin has helped to retain a net of 18.7 million cubic yards of material on the beaches within the study area (Overton, pers. comm.).

In summary, as stated above, the construction of the groin does not appear to have caused an adverse impact on the shoreline over the six-mile study area (Overton, pers. comm.; Overton, 2011). Also, it may be presumed that some of this decrease of erosion can be attributed to the placement of the material along this stretch of shoreline. Any direct comparison of the Pea Island terminal groin to the one proposed for the east end of Ocean Isle Beach would be inappropriate due the difference in scale of the physical characteristics of the two inlets and the littoral environment at both sites. In this regard, the littoral climate in the Oregon Inlet area produces gross sediment transport rates of the order of 2.5 million cubic yards/year compared to sediment transport rates of around 500,000 cubic yards/year for Ocean Isle. In terms of physical attributes, Oregon Inlet is about three times as wide as Shallotte Inlet and has a tidal prism that is an order of magnitude greater than the tidal prism of Shallotte Inlet. However, given the positive shoreline response along the north end of Pea Island as the result of the terminal groin and periodic disposal of navigation maintenance material, a terminal groin project on the east end of Ocean Isle Beach which would include a periodic beach nourishment component as a feature of the overall plan, is expected to produce comparable positive shoreline responses on the east end of Ocean Isle Beach."

One of the conclusions drawn from the report stated "the environmental effects of a terminal groin structure alone could not be assessed for the sites without considering the associated beach nourishment activity" (NCDENR, 2010). Because Alternative 5 includes a beach nourishment project to be constructed in conjunction of the terminal groin, the findings from the study would generally apply and are therefore included below where applicable.

ESTUARINE HABITATS

Salt Marsh Communities

Impacts to the salt marsh communities would be the same as those described for Alternative 1.

Shellfish Habitat

Impacts to shellfish habitat for Alternative 2 are the same as those discussed above for Alternative 1.

UPLAND HAMMOCK

Impacts to upland hammock habitat for Alternative 2 are the same as those discussed above for Alternative 1.

INLET DUNES AND DRY BEACHES

Direct Impacts: The construction of the terminal groin will not directly impact inlet dunes or inlet dry beach communities as the footprint of the structure lies entirely within the oceanfront dry beach communities. Therefore, direct impacts to the inlet habitats are expected to be the same as those described for Alternative 1.

Indirect and Cumulative Impacts: The design of the proposed terminal groin is intended to allow for the continuation of sediment transport from the west of the structure on Ocean Isle Beach into Shallotte Inlet. For the segment of the shoreline just east of the terminal groin (baseline stations -5+00 to -20+00), volume losses landward of the -6-foot NAVD contour during the first year of the simulation totaled 53,000 cubic yards while the segment between stations -20+00 and -30+00 gained 17,000 cubic yards. Over the next two years of the simulation, volume losses in the segment between stations -5+00 and -20+00 ceased with the total volume loss from this segment after three years equal to 50,000 cubic yards, i.e., a gain of 3,000 cubic yards following the first year of the simulation. This minor amount of accretion over the last two years of the simulation is not considered to be significant but the apparent stabilization of the segment after the first year is significant in that the segment appeared to reach a quasi-state of equilibrium in response to changes imposed by the structure.

For the segment between stations -20+00 and -30+00, the initial accretion of 17,000 cubic yards was followed by a gradual volume loss over the last two years with the end result being an accumulation of 7,000 cubic yards at the end of the three-year simulation. Given the accuracy of the model, this relative minor build-up of material within this segment is probably not significant.

The volume changes within the inlet area along Ocean Isle Beach described above represents the flux of material moving around the terminal groin structure. Similar to the other alternatives, GIS analysis utilizing the biotic community map suggests indirect impacts of 1-2 acres to the inlet dune communities and 5-10 acres of impact to the inlet dry beach communities. The majority of these impacts being incurred on the Ocean Isle Beach side of the inlet. The loss of this habitat would result in a reduction of suitable habitat for the protected plant seabeach amaranth, shorebirds including piping plovers and red knots, and a reduction in area for humans to recreate. Furthermore, the survival rate of sea turtle hatchlings could be reduced due to possible inundation of encroaching mean high water marks through severe erosion.

As stated in Chapter 4, critical habitat designation for North Carolina wintering piping plover includes a portion of inlet dunes and dry beach habitat along Holden Beach within Unit NC-17 (USFWS, 2001). Research has shown that wintering plovers on the Atlantic coast prefer wide beaches in the vicinity of inlets (Nicholls and Baldassarre, 1990; Wilkinson and Spinks, 1994). While overwintering piping plovers have Critical Habitat within the Permit Area, piping plovers also nest in the region. Piping plovers nest in dry sand habitats above the high tide line along coastal beaches, spits, flats, barrier islands and other sparsely vegetated dune and beach environments, although they may utilize other shoreline habitats if these are not available. Should the erosion continue along the inlet beaches on Ocean Isle Beach and Holden Beach, the overwintering Critical Habitat and nesting habitat could be impacted.

INTERTIDAL FLATS AND SHOALS

Direct Impacts: Direct impacts to the intertidal flats and shoals would be the same as those described for Alternative 1.

Indirect Impacts: As described under Alternative 1, shorebirds, colonial waterbirds and other waterbirds will utilize intertidal flats and shoals in the inlet complex for foraging while traveling to their wintering and nesting grounds. Breeding and non-breeding federally threatened species and species of special concern also utilize intertidal shoals. Macroinfaunal species found within intertidal flats and shoals are a primary food source for several migratory and resident shorebirds, waterbirds, as well as for many commercially and recreationally important fish. A portion of the piping plover critical habitat unit NC-17 is located within Shallotte Inlet due to the presence of intertidal flats and shoals. These unconsolidated communities lack structure and are dynamic in nature. Therefore, the unconsolidated and unvegetated communities that occur in the inlet complex are expected to continue to be naturally redistributed. Periodic storms and seasonal climatic changes influence abundance and diversity of micro- and macrofauna, tending toward a more opportunistic community (Mallin *et al*., 2000; Street *et al*., 2005).

The construction of a terminal groin along the eastern end of Ocean Isle Beach may influence the transport of material into the inlet and thereby impact the intertidal flats and shoals communities. A study of the 20-year old terminal groin in Oregon Inlet may be utilized to obtain a general understanding of impacts of an existing terminal groin in North Carolina to the intertidal shoals and flats on both sides of the inlet. As described by USFWS (2008), habitat behind the terminal groin on Pea Island has undergone vegetative succession over the 20 years due to infill of vernal ponds by wind and water-borne sand, and it is no longer as suitable for piping plover nesting and foraging habitat as when the terminal groin structure was initially constructed. Since the piping plover is primarily a winter resident at Oregon Inlet, which is also designated as Critical Habitat for piping plover, the major threat to this species in the vicinity of the inlet is the degradation of intertidal foraging habitat (USACE 2001). Should the erosion continue along the inlet beaches on Ocean Isle Beach and Holden Beach, the overwintering critical habitat and nesting habitat for piping plovers, resting red knots, state-listed bird species of special concern as well as critical habitat for nesting sea turtles could be impacted.

The construction of the terminal groin in 1990 resulted in the formation of about a 50-acre fillet; thus, restoring and stabilizing the tip of Pea Island (Dennis and Miller 1993). This provided valuable habitat for piping plovers and other shorebirds for a number of years following construction by the creation of a vernal pool or mud flat. However, in more recent years the presence of the terminal groin, as well as other actions such as dredging and nourishment, has modified habitat important to piping plovers by eliminating intertidal flats on the downshore side of the structure and allowing encroachment of vegetation in the stabilized areas. This stabilization of the northern tip of Pea Island has changed some of the inlet dynamics as it pertains to piping plover habitats. Despite this, piping plovers have continued to utilize portions of Pea Island for foraging activity. Although only limited data of piping plover populations are available prior to the construction of the terminal groin, post-construction data demonstrates the variability in annual counts. Populations of piping plovers on Pea Island have been relatively low prior to 2000. Between the years 1986 and 1999, an average of two (2) piping plovers was observed per year with an annual range of 0 to 8 individuals.

During this time, the intertidal pool created soon after the construction of the groin had been modified and became vegetated. Although this specific area adjacent to the groin was no longer valuable habitat for piping plovers, other intertidal flats and shoals located along Pea Island in proximity to the inlet provided this important habitat in subsequent years. In 2000, observations on Pea Island increased sharply to 87 individuals. Annual observations subsequently declined to 33 individuals in 2001, and increased sharply to 307 individuals in 2002. Pea Island observations declined steadily over the next three years, reaching a low of four (4) individuals in 2005. Annual observations increased to 19 individuals in 2006; however, no piping plovers were reported from Pea Island during 2007 or 2008. In 2009, a total of 40 individuals were observed on Pea Island (NCDENR, 2010).

As stated for other project alternatives, several different fish species utilize the intertidal flats and shoals, as well as the water column within these habitats As reported by USACE (1984), species that utilize these habitats include red drum, spotted seatrout, bluefish, Atlantic croaker, kingfish, and mullet. These species forage upon many of the benthic organisms that reside within intertidal flats and shoals. However, due to the winter time construction, many of these species will be located offshore and will not be utilizing the nearshore or inlet intertidal flats and shoal areas. For any fish species that may be present, it is expected, like the bird resources, that their mobility will provide them the opportunity to temporarily relocate to adjacent habitats while dredging occurs.

Delft3D modeling suggests that a total of 1-2 acres of intertidal within the Permit Area could be indirectly impacted most likely attributable to changes in sediment transport through the inlet. The USACE monitored the borrow area following the 2006-07 and 2010 nourishment operations and indicated that the borrow area collects an average of 16,500 cubic yards/month or slightly less than 200,000 cubic yards/year (Dennis, 2012 personal communication). Provided that this infilling rate continues, the existing condition of abundant intertidal flats and shoal would be expected to persist and provide habitat value for foraging birds and fish within approximately 2 years.

Cumulative Impacts: Intertidal flats and shoals are an extensive habitat type within the coastal waterways in southeast North Carolina. Although the extent of intertidal flats and shoals within the Permit Area may be altered during dredging events within the inlet and during a response to storm events, the habitat is expected to persist because the delivery of material through the inlet and down the Shallotte River is expected to continue. The dredging interval within Shallotte Inlet for Alternative 5 is every five years which, due to the rate of infilling, would allow for the reformation of the intertidal flats and shoals within the borrow area and the recovery of infaunal resources between dredging events. As such, the infaunal species which utilize them are not anticipated to be adversely impacted due to their resilient nature. Therefore, based on the above, the cumulative effects of the project are expected to be minor with respect to intertidal flats and shoals.

OCEANFRONT DRY BEACH AND DUNE HABITATS

Oceanfront Dune Communities

Impacts to the oceanfront dune communities would be the same as those described for Alternative 1. The construction of the dune would not include any indirect impacts to oceanfront dune communities.

Oceanfront Dry Beach Communities

Direct Impacts: The placement of beach quality material between the terminal groin located just east of station 0+00 and station 90+00 along with the construction of the terminal groin would directly impact approximately 16.0 acres of the dry beach habitat. This includes the direct impacts incurred during the initial fill placement, the footprint of the terminal groin, and the staging area for materials on the dry beach.

The design of the terminal groin structure, as proposed, would include a rubble mound component with effective length of 750 linear feet which would extend 600 feet seaward from the baseline. A sheet pile shore anchorage section would extend landward of the rubblemound section and terminate 450 feet landward of the baseline.

The stone used for the construction of the rubble mound portion of the groin would be transported by trucks from an offloading facility on Shallotte Boulevard and E. 4th Street to a temporary stone storage area encompassing a total of 0.29 acre located on the beach at the end of E. 4th Street. The rubblemound portion of the terminal groin would be constructed from a temporary trestle or pier installed parallel to the alignment of the terminal groin. The trestle would be removed upon completion of the rubblemound portion of the terminal groin. A minimal amount of excavation will be required for the landward 100 feet to 150 feet of the rubblemound portion of the structure in order to place the foundation stone or mattress at an elevation of -5.0 feet NAVD. From that point seaward, the foundation stone/mattress would be placed on grade. The sheet pile for the landward portion of the terminal groin would be transported directly to the site by truck from where it would be offloaded and driven into place with typical pile driving equipment. A 50-foot wide construction corridor would be established adjacent to the shore anchorage section. A typical cross-section of the rubblemound portion of the groin is depicted on Figure 5.10.

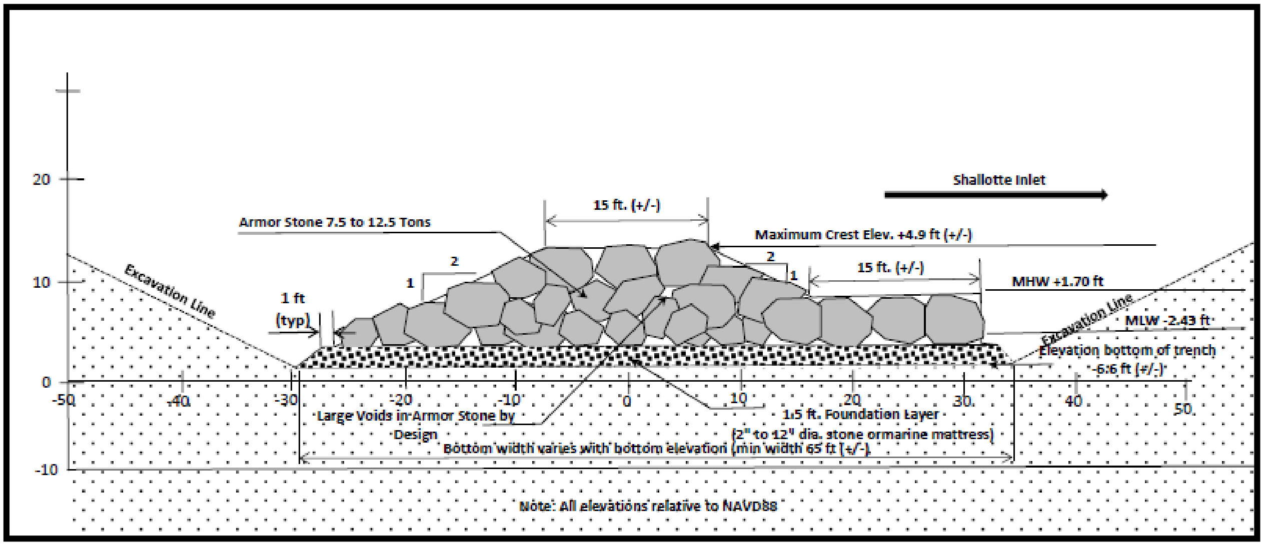

Figure 5.10. Typical rubblemound cross-section for terminal groin

The direct impacts will include the mortality of crustaceans including ghost crabs, however, these communities are expected to recover within the order of months to more than one year (National Research Council, 1995; Carter and Floyd, 2008). This reduction in dry beach habitat will initially reduce available habitat for seabeach amaranth, sea turtles, and shorebirds, including the piping plover and red knot, however the increased beach width and stability as a result of nourishment will compensate for this loss. This area will become beneficial habitat for resting colonial waterbirds.

The composition, color, and grain size of the beach sand can affect the incubation time, sex, and hatching success of turtle hatchlings (Street *et al*., 2005). Physical characteristics such as density, compaction, shear resistance, moisture content, slope, sand color, grain size, grain shape, sand mineral content, and gas exchange may affect the success of sea turtle nests (Nelson and Dickerson 1988, Crain et al. 1995). The fill placed on Ocean Isle Beach will conform to the State sediment criteria rules and therefore is not expected to impact the nesting success of sea turtles. Because the material utilized for the nourishment will meet State Sediment Criteria, the widened dry beach is expected to increase sea turtles nesting habitat with native compatible material. The proposed project would be conducted during the winter and, therefore, would not impact potential nesting activity by birds or turtles.

Hard structures such as terminal groins can indirectly affect nesting sea turtles and hatchlings. The type of effect is dependent on structure design, which can be shore parallel, shore perpendicular, long, short, high, low, permeable, or impermeable. The proposed structure will be a shore-perpendicular terminal groin with a 300-ft shore anchorage section and 750 linear foot rubble mound portion. Direct affects from this type of groin may include: (1) prevention of access to suitable nesting sites, (2) abandonment of nesting attempts due to interaction with the structure, and (3) interference with proper nest cavity construction and nest covering. Mosier (2000) demonstrated that hard structures such as seawalls on the beach can physically block a nesting female from accessing a more suitable higher elevation nesting environment. In the study of three nesting beaches on the east coast of Florida, 86% of nesting females that encountered a hard structure during emergence returned to the water without nesting as a result of the inability to access higher elevation nesting habitat (Mosier, 2000). According to Lucas *et. al*. (2004), in a study designed to assess sea turtle response to beach attributes (i.e. hard structures), turtles emerged onto portions of the beach where anthropogenic structures threatened to block access to optimal nesting habitat; however, upon encountering the structures, turtles abandoned the nesting sequence. This study indicated that only the most seaward structures affected sea turtle nesting. Depending on the design of shore perpendicular structures the structure may act as an impediment or a trap (Foote *et. al*., 2002) to nesting females and/or hatchlings (Davis *et. al*., 2002). The constructed fillet is expected to extend close to the terminus of the 750 foot seaward component of the proposed terminal groin designed for Alternative 5. Therefore, effects of the structure would be expected to be minimal to nesting sea turtles and emerging hatchlings.

Indirect Impacts: The installation of the terminal groin will provide for an expanded and more stable dry beach, particularly updrift of the structure. Delft3D model results suggest that the 750-foot terminal groin would essentially stabilize the shoreline west to station 20+00 and significantly reduce volume losses west to station 30+00. The model results of volume changes above the -6-foot NAVD depth contour measured between the terminal groins and station 30+00 indicate the volumetric erosion rates and hence the periodic nourishment requirements in this area would be reduced by 95.8%. Since the groin is designed to allow for sediment transport towards the inlet, any potential adverse effects to downdrift dry beach would be minimized. The increase in stable dry beach as a result of the implementation of Alternative 5 is considered more advantageous to various fauna as well as flora. However, some resident and migratory fauna, particularly the shorebirds such as piping plover and red knot, rely on the dynamic coastal processes such as overwash, to provide optimal foraging, roosting, and nesting habitat. The presence of the groin and other hard structures could influence such processes in the down-drift area. As stated previously, with the model results indicating no change in the shoreline response west of baseline station 30+00 on Ocean Isle Beach with the terminal groin in place, the areas farther to the west, including the west end of Ocean Isle Beach, Tubbs Inlet, and Sunset Beach would not be impacted by the terminal groin. A total of 0-5 acres of oceanfront dry beach would be anticipated to be indirectly impacted.

Cumulative Impacts: Habitat for resting colonial waterbirds, nesting shorebirds, and nesting sea turtles along the ocean dry beach is expected to be maintained at the location of the terminal groin fillet and along the fill area included within the Federal project with renourishment occurring every 5 years. This relatively long interval will allow for the recovery of infaunal organisms to recovery in between nourishment events and, thus, will also increase the habitat value of the dry beach to foraging shorebirds. Maintaining the dry beach along the oceanfront shoreline will help ensure that bird and sea turtle habitat will persist. Maintenance of the rubblemound portion of the terminal groin should be infrequent and would depend on the frequency of severe storms that exceed the design conditions for the armor stone. If maintenance of the rubblemound portion is needed, this could involve simply recovering and replacing displaced stones or adding stone to replace the ones that could not be located on site. Any maintenance work within the dry beach area would be restricted within a designated corridor in order to limit any potential impacts.

WET BEACH COMMUNITIES

Direct Impacts: The addition of beach fill to Ocean Isle beach between the terminal groin located approximately 150 feet east of stations 0+00 and 90+00 will cause direct impacts to approximately 15.6 acres of the wet beach community due to burial following the placement of fill material as well as the construction of the terminal groin. As discussed for Alternatives 1 and 2, these impacts are considered to be short-term because studies have demonstrated rapid recovery times for organisms inhabiting wet beaches. As mentioned in Chapter 4, Nelson (1985) indicates that organisms that reside in intertidal zones are more adaptable to fluctuations in their environment, including high sediment transport and turbidity levels. Also, as previously stated, with the use of beach compatible material, infaunal organisms are expected to respond as studies have shown (Van Dolah et al., 1994), and dredging would occur during winter months when infaunal community activity and its onshore populations are at their lowest. The portion of the wet beach directly impacted by the footprint of the terminal groin will not be expected to recover due to the fact that it is being replaced by the permanent structure.

Indirect Impacts: The indirect impacts to the wet beach habitat within the Permit Area may affect shorebird, crustacean and fish foraging, and recreational fishing through a temporary reduction in prey during and immediately after construction. A total of 25-30 acres of wet beach may be impacted as a result of implementing Alternative 5. These impacts should be reduced due to the fact that the material utilized for beach fill will be compatible with native material, thereby reducing the recovery period for infaunal communities. Furthermore, peak larval recruitment periods for most benthic species may be avoided as the implementation of Alternative 5 would occur during winter months.

The ability for infaunal species to repopulate disturbed wet beach habitat in proximity to a shoreline stabilizing structure was demonstrated following the construction of the rubble weir jetty structures at Murrells Inlet, South Carolina. These structures, constructed in the late 1970's, includes a 3,347 foot jetty extending into the ocean with a 1,348 foot weir section on the north side of the inlet. The southern jetty includes a 3,317 foot structure that extends into the ocean without a weir system. The macrobenthic communities of the intertidal and nearshore subtidal environments were sampled during the construction of the jetties and once again five (5) years later. Comparison of species abundance between years and among localities (updrift and downdrift) suggested no widespread impacts to macrobenthic fauna were attributable to jetty construction (Knott et al, 1984). Although the physical conditions are not identical at both locations, a similar response would be anticipated following the construction of the terminal groin on Ocean Isle Beach.

Cumulative Impacts: As a result of the construction of the terminal groin associated with Alternative 5, the fillet and the beach included within the Federal Storm Damage Reduction Project would be renourished approximately every five (5) years, cumulative effects are not expected as the diversity and abundance of infaunal populations would be expected to recover between nourishment events. It has been shown that organisms that reside in intertidal zones are more adaptable to fluctuations in their environment, including high sediment transport and turbidity levels (Nelson, 1985).

Other studies reported by Maurer (National Research Council, 1995) supported the burial capabilities of nearshore species, which found that these species were capable of burrowing through sand up to 40 cm. As stated above, Nelson (1985) has demonstrated the adaptability and rapid recovery for organisms residing in the marine intertidal zone. With this in mind, the temporal spacing between the periodic maintenance events every five (5) years within the proposed dredged areas may allow for full recovery of benthos populations within the wet beach community along Ocean Isle Beach.

MARINE HABITATS

Softbottom Communities

Direct Impacts: The activities associated with Alternative 5 would result in direct impacts to softbottom community every five (5) years within portions of the Permit Area. This includes the softbottom communities within mean low water (MLW) to the construction toe-of-fill, the softbottom communities within the proposed borrow area in Shallotte Inlet, and the softbottom communities within the footprint of the terminal groin.

Excavating the borrow area and construction of the terminal groin will cause an immediate removal of infaunal and non-motile epibenthic organisms from the softbottom community. A total of 105 acres of softbottom resources could be impacted within the borrow area while nearly 76 acres will be directly impacted as a result of placement of beach fill and the construction of the terminal groin resulting in the smothering and burial of these organisms within the area. Construction of the beach would result in the direct deposition of material from the dune or berm crest seaward to the construction toe-of-fill. Over time, the slope of the fill would adjust and equilibrate seaward. Softbottom habitats located seaward of the toe of fill would be indirectly impacted during the equilibration timeframe, which is expected to occur over a 12 month timeframe. Burial depths during the adjustment period will vary. Studies reported by Maurer (National Research Council, 1995) supported the burial capabilities of nearshore species, which found that these species were capable of burrowing through sand up to 40 cm. As described above, the resilient nature of the infaunal species will limit the indirect impacts. Recolonization of these infaunal species typically tends to occur within the order of several months. Softbottom communities may also change with natural shifting patterns of sediment erosion or deposition (Deaton et al., 2010). In total, these actions would result in a direct impact of 180.7 acres of softbottom habitat. It should be reiterated that the material placed over the softbottom habitat meets the State's sediment criteria requirements and is therefore considered to be compatible to the native sediment. As previously described, the adaptive nature of the infaunal species will limit these impacts. Recolonization of these infaunal species typically tends to occur within the order of several months. Softbottom communities may also change with natural shifting patterns of sediment erosion or deposition (Deaton et al., 2010).

Because the beaches along the western portion of Holden Beach will not receive disposal material, impacts to softbottom resources outside of natural shifting processes on or around Holden Beach in response to Alternative 3 are not anticipated.

Indirect Impacts: Negative indirect impacts include the temporary loss of prey for foraging fish and invertebrates from the dredged softbottom habitat within Shallotte Inlet and along the toe of fill in areas receiving beach fill. These negative impacts will only be incurred following each construction event which is scheduled every five (5) years. This renourishment interval may allow for these impacts to be minimized. As such, the softbottom habitat within the Permit Area located outside the footprint of the terminal groin, the infaunal communities are expected to fully recover. A portion of this softbottom habitat will be permanently removed from within the footprint of the terminal groin. It is not known what the full effects of this will be on the fishery resources, but with the softbottom habitat surrounding the footprint of the structure, the fishery resource should be capable of locating food sources and foraging within nearby areas.

Fish, including mullet that migrate over the nearshore softbottom habitat, may be impeded when they encounter the terminal groin. A study conducted at Murrells Inlet examined the movement of fish and plankton across the weir jetty. These data suggest that few swimming organisms were moving across the weir during the study. Further evidence supporting the hypothesis that the weir is a barrier to free swimming species came from visual observations. Visible schools of fishes, including menhaden and mullet, were never observed passing directly over the weir. The crest of the weir remained visible at the surface of the water even at high tide, and its location was marked by the turbulence from passing waves (USACE, 1981). Although the jetty at Murrells Inlet acted as a barrier for fish migration, the physical nature of the proposed structure at Ocean Isle Beach is much shorter in length. Furthermore, the accretion fillet is expected to fill seaward and would therefore reduce the exposed area of the groin. In this regard, fish and other motile organisms will be expected to pass by the structure as they migrate along the shoreline which is expected to extend near the seaward terminus of the groin. Therefore, migrating fish may be only minimally impacted by the presence of the terminal groin.

Cumulative Impacts: After the initial construction of the terminal groin, cumulative impacts are expected to be the same as Alternatives 1 and 3.

WATER QUALITY

Turbidity and TSS

Direct Impacts: The direct impacts regarding the turbidity and TSS in response to the excavation of the Shallotte borrow area and the placement of material along the beach would be comparable to those described under Alternative 1. Alternative 5, however, also includes the construction of the terminal groin which would involve additional direct impacts. The construction of the groin is proposed to take place concurrent with beach fill disposal. A minimal amount of excavation will be required for the landward 100 feet to 150 feet of the rubblemound portion of the structure in order to place the foundation stone or mattress at an elevation of -5.0 feet NAVD. From that point seaward, the foundation stone/mattress would be placed on grade. At this time, construction methods may include the use of a temporary pier structure constructed parallel to the terminal groin. This activity may result in additional localized, temporary impacts to the water quality through increased turbidity during construction, but these effects would dissipate rapidly and are considered relatively minor.

Indirect and Cumulative Impacts: Indirect and cumulative impacts are expected to be similar to those described under Alternative 1. However, because dredging and renourishment are anticipated to occur approximately at a minimum of every five (5) years, these would occur less frequently. Due to factors described above, no indirect or cumulative impacts regarding turbidity are expected.

Nutrients

Direct, Indirect, and Cumulative Impacts: The implementation of Alternative 5 is not anticipated to impact the nutrients within the waters located in the Permit Area.

WATER COLUMN

Hydrodynamics and Salinity

Direct, Indirect, and Cumulative Impacts: The tidal prism within the inlet as a whole would not be anticipated to change substantially over the 5-year simulation period following dredging within the Federal borrow area within Shallotte Inlet. Despite these anticipated minor alterations in tidal prism, hydrodynamics and salinity are not expected to be impacted in response to Alternative 5 due to the large volume of water moving through the system.

Larval Transport

Direct, Indirect, and Cumulative Impacts: Perpendicular coastal structures, particularly long jetties, can potentially interfere with the passage of larvae and early juvenile fish, such as bluefish, from offshore spawning grounds into estuarine nursery areas. Successful transport of larvae from fish spawning on the continental shelf through the inlet is dependent on along-shore transport processes which occur within a narrow zone parallel to the shoreline (Blanton et al. 1999; Churchill et al. 1999; Hare et al. 1999). Obstacles such as jetties adjacent to inlets may block the natural passage for larvae into inlets and reduce recruitment success (Kapolnai, et al. 1996; Churchill et al. 1997; Blanton et al. 1999). Miller (1992) and Settle (NMFS, unpub. data), estimated that successful passage of winter-spawned, estuarine-dependent larvae through Oregon Inlet could be reduced 60-100% while reviewing the potential impacts of a previously proposed dual jetty system at Oregon Inlet.

The Fish and Wildlife Coordination Act Report concluded that the Oregon Inlet project should not be constructed because of, among other concerns, the impact of jetties on larval fish passage (USACE, 1999). Although there are conflicting opinions on the magnitude of fisheries impacts of a dual jetty system at Oregon Inlet, it was postulated that the construction of the Oregon Inlet structures could prevent some portion of ocean- spawned larvae from reaching estuarine nursery areas (USACE, 1999). Construction or lengthening of jetties, particularly where inlets occur infrequently along the coast (such as Oregon Inlet), could lower successful fish recruitment and fishery productivity (Kapolnai et al. 1996; Churchhill et al. 1997; Blanton et al. 1999).

While concerns regarding larval transport into estuarine habitats through inlets due to interference by jetties may have merit, the proposed terminal groin on Ocean Isle Beach is not expected to substantially impact larval fish transport. As described in Chapter 3, the fillet of the terminal groin will be artificially filled with beach compatible material immediately following construction which will effectively extend the dry beach shoreline seaward approaching the end of the terminal groin. Therefore, unlike the proposed duel jetties at Oregon Inlet which were planned to extend approximately 2,500 from the shoreline, the single terminal groin would not act as a direct impediment to longshore transport of larvae into the inlet. Once the beach protrudes to near the end of the structure, either by natural longshore transport or through beach nourishment, wave processes transport sand around and over the groins into the tidal inlet. The same sand by-passing action would also affect the movement of estuarine dependent larval forms thereby reducing any impacts to numerous species.

Limited research is available to support this notion. The most relevant and recent research is presented in the Terminal Groin Study, Final Report, prepared by Moffatt & Nichol in March of 2010 for the Coastal Resource Commission. The report concludes "In terms of larval transport, a terminal groin may reduce unrestricted access into inlet systems" (NCDENR, 2010). However, the report also states "As noted in the Physical Assessment Section, once a beach protrudes to near the end of the structure, either by natural longshore transport or through beach nourishment, wave processes transport sand around and over the groins into the tidal inlet. The same sand by-passing action would also affect the by-pass of estuarine dependent larval forms" (NCDENR, 2010).

More recently, a study was developed by Olsen Associates, Inc. examining the potential impacts to tidal hydraulics and transport of fish larvae in response to the construction of a terminal groin at the western terminus of Bald Head Island, North Carolina. Using the Delft3D particle tracking model, it was determined that a terminal groin at Bald Head Island would have no far-reaching effects on the tidal hydraulics of the inlet. Differences in tidal flows were shown to be minor and localized within the general vicinity of the structure. These predicted minimal alterations to tidal flows were not expected to meaningfully hamper the ability of fish larvae to reach the inlet from the nearshore waters proximate to Bald Head Island (Olsen Associates, Inc. 2012). Therefore, as supported by the relative short length of the proposed terminal groin at Ocean Isle Beach with the combination of beach fill south of the structure, minimal impacts associated with larval transport are expected.

Larvae are expected to be entrained within the dredge while operating within Shallotte Inlet resulting in direct impacts. However, because peak juvenile settlement generally occurs within the estuary in spring through early summer (Ross and Epperly, 1985), these impacts are anticipated to be limited as the dredging activity will be limited to the late fall and winter months. Some fish species (including spot, Atlantic croaker, southern and summer flounders, and menhaden) spawn during the winter and early spring, and therefore could be impacted.

PUBLIC SAFETY

Direct, Indirect, and Cumulative Impacts: During the construction of Alternative 5, construction hazards will increase due to the usage of heavy machinery within Shallotte Inlet and along the oceanfront shoreline of Ocean Isle Beach during beach nourishment activities and the construction of the terminal groin. Safety precautions, such as access restriction and use of USCG navigation rules will be undertaken to reduce this risk. Also, construction will be conducted during a period when boat traffic and beach use is at its lowest. The implementation of Alternative 5 will help alleviate the erosional pressure along of the extreme eastern end of Ocean Isle Beach thereby providing protection to the 57 dwellings/dwelling units currently protected by sandbags. Without the threat of these homes being damaged or demolished, public safety should increase due to the avoidance of hazardous conditions caused by continued erosion including the exposure of utilities and leaking septic tanks. Furthermore, the sandbags, which could pose a public safety hazard due to their size and orientation to the eroded shoreline, would be removed and/or covered up and replaced with a nourished beach tapered from a developed dune ridge.

The shore anchorage section of the groin would be constructed with sheet pile, either steel or concrete. The sheet piles would have a top elevation of +4.9 feet NAVD for a distance of about 130 feet between the landward end of the rubblemound section and the existing dune. The top elevation of the shore anchorage section would be reduced to +4.5 feet NAVD for the remaining 170 feet (Figure 5.9). The top of the landward most portion of the shore anchorage section would be below the existing ground level and therefore would not pose a threat to public safety. The rubble mound portion of the groin will have a maximum crest elevation of +4.9 feet NAVD. Considering that the beach fill associated with Alternative 5 will be constructed to +6 feet NAVD, the much of the groin will be constructed below grade and, therefore, would not impose a public safety concern for individuals. In addition, a U.S. Coast Guard approved navigation aid possibly consisting of a three-pile dolphin and light, may be installed at the seaward end of the terminal groin. This will reduce the chance of the structure becoming a navigational hazard to vessels. No public safety impacts would be incurred on Holden Beach.

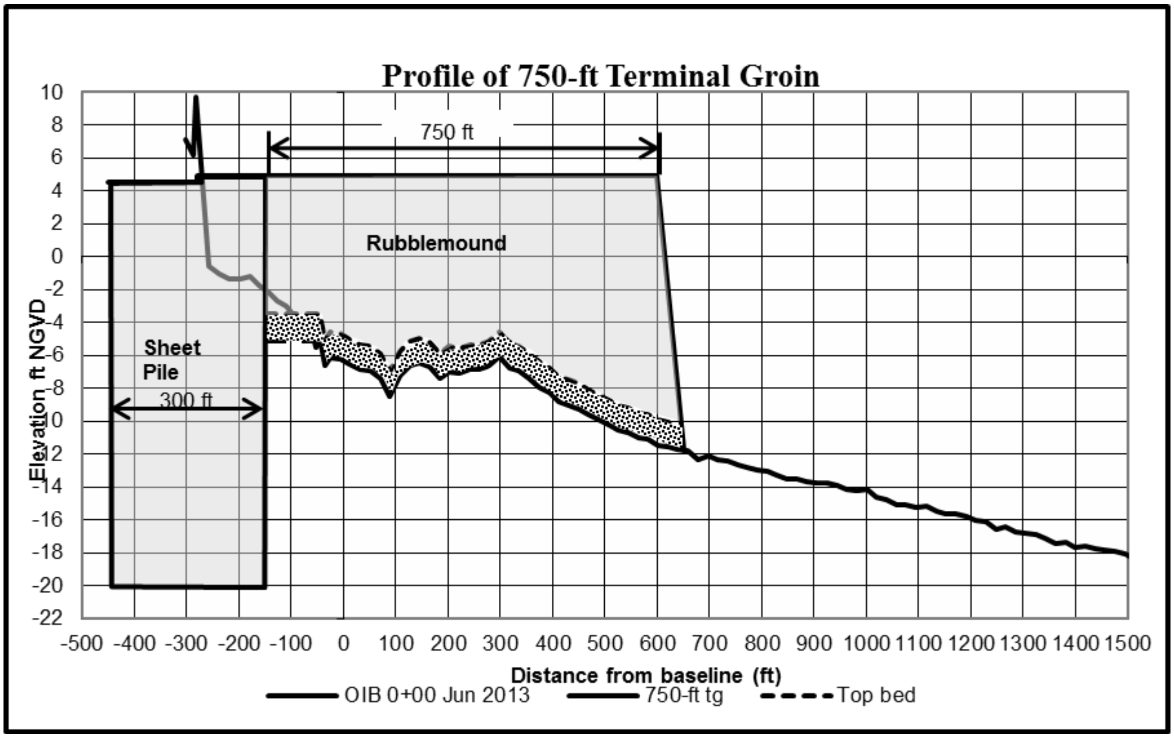

Figure 5.11. Profile of the 750-foot terminal groin.

AESTHETICS

Direct Impacts: Temporary impacts to aesthetics will result from the implementation of Alternative 5 due to the usage of heavy machinery within Shallotte Inlet and on the oceanfront shoreline of Ocean Isle Beach due to the construction of the terminal groin and the dredge and beach fill operation. Following completion of the construction phase of Alternative 5, the aesthetic resources will be as they were prior to construction with the exception of the terminal groin situated on the east end of the island. The landward portion of the terminal groin, which will be constructed with steel or concrete sheet piles, will have a crest elevation ranging between +4.5 and +4.9 feet NAVD which is close to the existing ground elevation. The rubblemound portion of the terminal groins would be constructed with loosely placed armor stone on top of a foundation mat or mattress and would have a crest elevation of +4.9 feet NAVD. Considering that the beach fill associated with Alternative 5 will be constructed to +6 feet NAVD, the much of the groin will be constructed below grade and, therefore, would not restrict the aesthetics of the beach. The area disturbed by the construction activities will be restored to near pre-construction conditions by grading and planting of native plants if needed. As a result, most of the landward portion of the groin will not be visible. The terminal groin and the dredge and fill operation will occur during the winter months when the number of residents on the island are at their lowest. Therefore, while the aesthetics may be temporarily impacted, less people will notice the disruption. No long term adverse impacts to the aesthetics are anticipated within proximity to Ocean Isle Beach.

Indirect and Cumulative Impacts: Indirect and cumulative impacts will occur due to the anticipated five (5) year nourishment interval on Ocean Isle Beach. Due to the length of time in between maintenance events, cumulative effects are expected to be minimal.

RECREATIONAL RESOURCES

Direct Impacts: Direct impacts would be similar to those described for Alternative 1.

Indirect and Cumulative Impacts: Immediately following construction, recreational resources and opportunities are expected to benefit from the increased size and extent of the nourished beaches along Ocean Isle Beach's oceanfront shoreline. This will offer additional area for surf fishing, bird watching, and other recreational opportunities. However, recreational activities will be interrupted every five years during maintenance dredging and beach fill operations.

NAVIGATION

Direct, Indirect, and Cumulative Impacts: The initial construction followed by periodic maintenance dredging in Shallotte Inlet will benefit navigation due to a maintained depth created by the dredging activities. During the dredging, however, navigation will be temporarily directly impacted due to the presence of the dredge and its associated pipelines within the inlet. At no time will complete restriction of navigation occur in Shallotte Inlet during dredge operations. There will be some minor negative impacts to navigation due to the presence of barges used to transport the stone for construction of the terminal groin. These impacts to navigation will be imposed during every maintenance event, which is scheduled approximately every five years.

The terminal groin will be clearly marked; therefore it should not pose a threat to boats. Therefore, following construction of Alternative 5, boaters should find navigation within Shallotte Inlet easier to navigate after initial dredging and after each maintenance event, which is anticipated to occur at a minimum every five (5) years. Therefore, navigation is expected to be positive over the long-term.

INFRASTRUCTURE

Direct, Indirect, and Cumulative Impacts: Alternative 5 is expected to benefit the infrastructure on Ocean Isle Beach due to the long-term protection from erosion. The beach nourishment plan included in Alternative 5 would provide protection between 148 feet east of stations 0+00 and 90+00 along the Ocean Isle Beach shoreline.

SOLID WASTE

Direct, Indirect, and Cumulative Impacts: Impacts to solid waste would be anticipated to be similar to those described for Alternative 4.

ECONOMICS

Direct, Indirect, and Cumulative Impacts: Alternative 5 would prevent long-term erosion damages to development and infrastructure along the east end of Ocean Isle Beach east of baseline station 30+00.

The initial construction cost of the terminal alternative totals $5,700,000 which includes the construction of the structure as well as the placement of fill material within the fillet. The periodic nourishment cost every five (5) years involving fill within the fillet and the advanced fill for the Federal project is expected to be $6,575,000 (Table 5.8).

The equivalent annual cost for the terminal groin options were computed using compound interest methods with an interest rate of 4.125% and a 30-year amortization period. While maintenance of the terminal groin would not be required every year, given the uncertainty as to when repairs may be needed, terminal groin repairs were assumed to occur every year at an annual rate of $21,000. The 30-year implementation cost for Alternative 5 is anticipated to be $45,864,000. The equivalent annual cost for Alternative 5 is $1,567,000.

The inlet management plan that would be implemented if the terminal groin alternative is constructed. The plan is presented in Chapter 6 along with the added cost of beach profile surveys that would be included in the management plan. The plan includes shoreline position thresholds on both the west end of Holden Beach and the east end of Ocean Isle Beach that would trigger some mitigation response measures should the post-groin construction shoreline progress landward of these shoreline thresholds. Mitigation would likely be in the form of beach nourishment. No costs are provided for this possible mitigation since prediction of mitigation would be needed.

Table 5.8. Projected costs associated with the implementation of Alternative 5

Task	Unit	Amount	Cost
Initial Construction			
Fillet Beach Fill	CY	264,000	$ 2,277,000.00
Terminal Groin	linear feet	1,100	$ 2,783,000.00
Engineering & Design	job	lump sum	$ 200,000.00
Construction Oversight	job	lump sum	$ 440,000.00
Total Initial Construction			$ 5,700,000.00
Periodic Nourishment Every Five Years			
Nourishment	CY	400,000	$ 6,575,000.00
Terminal Groin Maintenance (Average Annual)			
Maintenance Cost			$ 21,000.00

NOISE POLLUTION

Direct Impacts: Direct impacts from noise pollution would be generated during the construction of the terminal groin as a result of the use of a pile driver to construct the temporary trestle and heavy machinery to transport the rubble mound material.

Indirect and Cumulative Impacts: No adverse long-term indirect or cumulative impacts resulting from noise pollution are anticipated under Alternative 5

Chapter 6 AVOIDANCE, MINIMIZATION, AND MITIGATION

The following describes actions and measures incorporated into the design of the Applicant's Preferred Alternative – Alternative 5 to avoid and/or minimize direct, indirect, and cumulative effects to the resources found within the Permit Area and the species that utilize them. The 2013 legislation still requires the applicant to implement an inlet management plan that includes the following:

(1) A monitoring plan.
(2) A baseline for assessing adverse impacts and thresholds for when adverse impact must be mitigated.
(3) A description of mitigation measures to address adverse impacts.
(4) A plan to modify or remove the terminal groin if adverse impacts cannot be mitigated.

1. How will Alternative 5 (Applicant's Preferred Alternative) construction practices avoid and minimize environmental impacts?

Construction Schedule

Dredging within Shallotte Inlet along with the nourishment of the estuarine and oceanfront shoreline of Ocean Isle Beach would be scheduled to protect threatened and endangered species, minimize adverse impacts to offshore, nearshore, intertidal and beach resources to the maximum extent possible and occur between the environmental dredge window of November 16 and April 30. The timing of construction activities was specifically scheduled to occur outside of the sea turtle nesting season, the West Indian manatee summer occurrence in North Carolina, the piping plover (and other shorebirds) migratory and breeding seasons, and the seabeach amaranth flowering period. Also, the construction of the terminal groin as well as the sand placement and dredge operations will be conducted outside of primary invertebrate production and recruitment periods (spring and fall) which will limit impacts to amphipods, polychaetes, crabs and clams.

Terminal Groin Structure

Of the three design lengths of the terminal groin evaluated through the use of the Delft3D model, the 750-foot alternative including a 300-foot shore anchorage section was selected as the Applicant's Preferred Alternative. The type of material used to construct the terminal groin was also evaluated. Options included steel or concrete sheet pile and the use of rock rubble mound design. The applicant's preferred alternative includes a sheet pile for the shore anchorage section and the rubble mound design for the seaward portion of the groin. The use of this material is expected to provide habitat for sessile benthic organisms as well as crustaceans and fin fish. In addition, the rubble mound design will allow for material to flow around, over, and through the structure allowing for the continuation of sediment transport. Therefore, environmental benefits are anticipated due to the use of the rubble material opposed to sheet pile. The navigational hazard of the low-profile terminal groin would be mitigated by the construction of a U.S. Coast

Guard approved navigation aid possibly consisting of a three-pile dolphin and light, may be installed at the seaward end of the terminal groin. The determination for the need of such a structure will be made by the US Coast Guard.

During the construction of the groin, a 50-foot construction corridor will be established around each side of the footprint of the structure and all construction activity will be required to remain within the corridor. This will ensure that the environmental impacts will be kept to a minimum within the construction area. Furthermore, the barge access location for the unloading of the rubble mound material will be situated along the Shallotte Inlet shoreline where impacts to vegetation would be minimal.

The design of the groin will be "leaky" in nature and will have a relatively low-profile. This will permit seawater and fish larvae to flow over the top and through the structure which will serve to minimize any impacts associated with restricting the passage of fish larvae beyond the structure.

Dredge Type

A hydraulic cutterhead is proposed for dredging the proposed borrow area within Shallotte Inlet. A cutterhead dredge uses a rotating cutter assembly at the end of a ladder arm to excavate bottom material, which is then drawn into the suction arm and pumped to the shoreline. On the beach, pipelines will transport the sediment to the designated beach fill area. Bulldozers will be used to construct seaward shore parallel dikes to contain the material on the beach, and to shape the beach to the appropriate construction cross-section template. During construction, the contractor will utilize surveying techniques for compliance with the designed berm width, height, and slope.

Compared to similar types of dredging methodologies, a cutterhead dredge creates minimal disturbance to the seafloor resulting in lower sedimentation and turbidity levels. Anchor (2003) conducted a literature review of suspended sediments from dredging activities. This report concluded that the use of a hydraulic dredge (i.e., cutter suction) limits the possibilities for re-suspension of sediment to the point of extraction. Also, since the sediment is suctioned into the dredge head, the sediment cannot directly enter into the middle or upper water column.

No incidences of sea turtle takes from a hydraulic dredge have been identified during the research and development of this document. Therefore, the use and methods involved with this type of machinery reduces or eliminates the likelihood of an incidental take.

Dredge Positioning

DREDGEPAK® or similar navigation and positioning software will be used by the contractor to accurately track the dredge location in relation to the hardbottom buffer protection zones. The software will provide real-time dredge positioning and digging functions to allow color display of dredge shape, physical feature data as found in background Computer Aided Design (CAD) charts and color contour matrix files from hydrographic data collection software described above on a Cathode Ray Tube (CRT) display. The software shall also provide a display of theoretical volume quantities removed during actual dredging operations.

Dredge anchors shall not be placed any further than 200 feet from the edge of the areas to be dredged. The dredge contractor will be required to verify the location of the anchors with real time positioning each and every time the anchors are relocated.

Sediment Compatibility

Beach nourishment projects may indirectly impact sea turtles by influencing the quality of the nesting habitat and may disrupt reproduction and foraging grounds. Incompatibility of nourishment material within the nesting habitat can potentially affect nesting females' ability to successfully nest (Lutcavage et al., 1997). If the nourishment sand is dissimilar from the native sand, results can include changes in sand compaction, beach moisture content, sand color, sand grain size and shape, and sand grain mineral content, all of which may alter sea turtle nesting behavior (Crain et al., 1995). Nest site selection and digging behavior of the female can be altered or deterred, if she finds the beach unsuitable. Additionally, escarpments may develop on nourished beaches, and can prevent sea turtles from accessing the dry beach and cause the female to return to the water without nesting. Unable to reach preferable nesting sites, females may also choose to deposit nests in unfavorable areas seaward of the escarpment, making them vulnerable to wash-out (Crain et al., 1995).

These negative impacts can be lessened by ensuring beach fill is compatible with the native beach receiving the fill. The North Carolina Coastal Resources Commission adopted the State Sediment Criteria Rule Language (15A NCAC 07H .0312) for borrow material aimed at preventing the disposal of incompatible material on the beach. The North Carolina State standards (15A NCAC 07H.0312) (2) (e) allow an applicant to use two sets of sampling data with at least one dredging event in between to characterize material for future nourishment events. If both sets of data are shown to be compatible as stated in the Rule, subsequent projects can use the material from the same borrow area. In addition, Section (3) (a) of the Rule states that sediment completely confined to the permitted dredge depth of a maintained sediment deposition basin within an inlet shoal system is considered compatible if the average percentage by weight of fine-grained (less than 0.0625 millimeters) sediment is less than 10%. These changes took effect in September 2013 after beach sampling and analysis were completed for this proposed project. Although compatibility of the borrow area as it relates to the State sediment criteria only requires sediment to contain less than 10% fines by weight, this analysis considers color, grain size, and percent calcium carbonate as well. The rule language has been adhered to during the planning and development of the Ocean Isle Beach Shoreline Management Project, which reduces the potential for negative effects of beach nourishment (See Appendix D– Geotechnical Report). Ultimately, adherence to the Sediment Criteria Rule Language will serve to minimize impacts to nesting sea turtles and minimize turbidity.

The composite fine-grained sediment within the footprint of the area dredged in 2001 based on the data from six (6) vibracores collected in 1998 is 1.3%. The composite fine-grained sediment within the same footprint of the area dredged in 2001 based on data collected after the dredging event) is 1.95%. The composite percent fine grained material for the existing beach sampled along the east end of Ocean Isle beach is 1.34%. Therefore, sediment confined to the footprint of the area dredged in 2001 in Shallotte Inlet is compatible in accordance with 15A NCAC 07H.0312. Vibracore data obtained from the 2005 and 2009 vibracores recovered from within the proposed borrow area indicate a percent carbonate by weight of 15.5%. The carbonate content of the existing beach ranges from 5% to 7% with a composite value of 6%.

Analyses of the samples collected from the existing beach by CPE-NC and the USACE indicate that sediment along the eastern end of Ocean Isle Beach has a mean grain size of 0.23 mm. The composite median grain size for the area analyzed using the 1998 vibracores is 0.16 mm. The composite mean grain size for the area analyzed using the 2005 and 2009 vibracores is 0.36 mm.

A change in sediment color due to beach nourishment could alter the natural incubation temperatures of sea turtle nests (Morreale et al., 1982). Sex determination in hatchlings is dependent upon temperature: higher temperatures tend to skew the hatching sex ratio in favor of female hatchlings (Broderick *et al*., 2001). To provide the most suitable sediment for nesting sea turtles, the color of the nourishment material must resemble the natural beach sand in the area. Sediments recovered within the vertical boundaries of the proposed borrow area were described by the USACE as having a tan and or gray color. The wet Munsell Color values for sediment samples collected by CPE-NC in 2013 and 2014, range from 5 (gray to olive gray) to 7 (light gray), with a typical value of 7 (light gray). The samples collected by CPE-NC in 2013 and 2014 represent the existing beach, which is a composite of the characteristics of material that has been placed on the beach during past nourishment projects and native beach sediment.

As a result of sediment compliance efforts, compaction of fill material on the beach is less likely to occur due to the lower silt content. Compaction of fill could impact the ability of sea turtles to dig and nest along the nourished beach, resulting in an increase in false crawls. Also, macroinfauna indicative of a healthy benthic community depend upon variable particle sizes and available interstitial pore space in the substrate for aeration properties. Compaction of the fill material could impact resident macroinfaunal populations thereby affecting the migratory and resident shorebirds, waterbirds, as well as the commercially and recreationally important fish that depend upon them.

Pipeline Observations

In order to minimize impacts on wintering piping plover, the pipeline alignment will be designed to avoid potential piping plover wintering habitat. The alignment will be coordinated with, and approved by, the USACE, NCDCM, and the NC WRC. As-built positions of the pipeline will be recorded using GPS technology and included in the final construction observation report.

In order to avoid impacts associated with the transport of fill material to the disposal sites, the Town of Ocean Isle Beach will negotiate with the dredging contractor to monitor and assess the pipeline during construction. This will serve to avoid leaking of sediment material from the pipeline couplings, other equipment, or other pipeline leaks that may result in sediment plumes, siltation and/or elevated turbidity levels. The Town of Ocean Isle Beach, along with their

Engineer, will coordinate with the dredgers and have in place a mechanism to cease dredge and fill activities in the event that a substantial leak is detected (leaks resulting in turbidity that exceed State water quality standards or sedimentation). Operations may resume upon appropriate repair of affected couplings or other equipment.

2. What are the monitoring initiatives being developed?

Several monitoring initiatives have been implemented along the Town of Ocean Isle Beach as part of the permit conditions for previously implemented beach nourishment projects. A description of existing and proposed monitoring initiatives in support of the Town of Ocean Isle Beach Erosion Mitigation Plan is included below.

Construction Observations

Several initiatives will be undertaken by the Town of Ocean Isle Beach, the Engineer, or his duly authorized representative to monitor construction practices. Construction observation and contract administration will be periodically performed during periods of active construction. Most observations will be during daylight hours; however, random nighttime observations may be conducted. The Town of Ocean Isle Beach, the Engineer, or his duly authorized representative will provide onsite observation by an individual with training or experience in beach nourishment and construction observation and testing, and that is knowledgeable of the project design and permit conditions. The project manager, a coastal engineer, will coordinate with the field observer. Multiple daily observations of the pumpout location will be made by the Town of Ocean Isle Beach, the Engineer, or his duly authorized representative for QA/QC of the material being placed on the beach. Information pertaining to the quality of the material will periodically be submitted to the USACE and NCDCM for verification. If incompatible material is placed on the beach, the USACE and NCDCM will be contacted immediately to determine appropriate actions.

Material Color
The Town of Ocean Isle Beach, the Engineer, or their duly authorized representative, will collect a representative sub-surface (6 in below grade) grab sediment sample from each 100-ft long (along the shoreline) section of the constructed beach to visually assess grain size, wet Munsell color, granular, gravel, and silt content. Each sample will be archived with the date, time, and location of the sample. Samples will be collected during beach observations. The sample will be visually compared to the acceptable sand criteria (Table 6.1). If determined necessary by the Engineer, or his duly authorized representative, quantitative assessments of the sand will be conducted for grain size, wet Munsell color, and content of gravel, granular and silt. A record of these sand evaluations will be provided within the Engineer's daily inspection reports and submitted to USACE and NCDCM for verification.

Escarpments
Visual surveys of escarpments will be made along the beach fill area immediately after completion of construction. Escarpments in the newly placed beach fill that exceed 18 inches or greater for 100 ft shall be graded to match adjacent grades on the beach. The decision for

escarpment removal will be determined upon consultation with USACE and NCDCM. Removal of any escarpments during the sea turtle hatching season (May 1 through November 15) shall be coordinated with the North Carolina Wildlife Resources Commission (NCWRC), USFWS, and the USACE – Wilmington District.

Water Quality
The inlet, nearshore and offshore water columns are classified as SA (market shellfishing, salt water) and High Quality Water (HQW) under the North Carolina State water quality standards. This classification requires that work within the water column shall not cause turbidity levels to exceed 25 Nephelometric Turbidity Units (NTU) or background (ambient) conditions that are above 25 NTU.

Dredge and fill operations are expected to temporarily elevate turbidity levels in the water column at the borrow area and fill sites. Higher turbidity levels are likely to be found in the discharge zone (nearshore swash zone) during periods of active construction. The use of a cutter suction dredge will minimize the area of disturbance since this type of dredge involves suction for the extraction of sediment.

Turbidity monitoring during construction, if required, will be managed by the contractor. The contractor will be responsible for notifying the construction engineer in the event that turbidity levels exceed the State water quality standards. The contractor will be advised to report any exceedances of the turbidity standard to the NCDENR Division of Water Resources.

Bird Monitoring

The North Carolina Wildlife Resource Commission and partners have performed breeding surveys for colonial nesting waterbirds within proximity to the Permit Area on a regular basis since 1977. Specifically, surveys have been conducted along the eastern and western portion of the island in proximity to Tubbs Inlet and Shallotte Inlet. Surveys for breeding piping plovers have been conducted since 1989 at the same locations. Surveys for non-breeding piping plovers have been conducted in more recent years. These surveys include data from breeding and non-breeding seasons for several listed bird species as well as other shorebirds and waterbirds.   This monitoring is expected to continue for the foreseeable future.

Seabeach Amaranth (*Amaranthus pumilus*)

Ocean Isle Beach has been surveyed by the USACE for seabeach amaranth since 1992 (Piatkowski, pers. comm.). This monitoring is anticipated to continue for the foreseeable future.

Sea Turtles

The Ocean Isle Beach Sea Turtle Patrol has been actively monitoring sea turtle nests on their beach since 1984. Currently, the Ocean Isle Beach Sea Turtle Protection Organization provides monitoring along the island. This monitoring is anticipated to continue for the foreseeable future.

West Indian Manatee (*Trichechus manatus*)

The West Indian manatee can be found in shallow waters (1.5 to 6.1 m [5 to 20 ft]) of varying salinity levels including coastal bays, lagoons, estuaries and inland river systems. *T. manatus* have been recorded in North Carolina and are most likely to occur from June through October when water temperatures are warmest (temperatures above 23.9ºC [75ºF]) (Schwartz, 1995; USFWS, 2001). Although the manatee is not expected to be present during dredge and fill operations, the contractor will adhere to the precautionary guidelines established by the USFWS – Raleigh Office for construction activities in North Carolina waters. Refer to the *Guidelines for Avoiding Impacts to the West Indian Manatee*.

Habitat Mapping

Purpose and Goals

It is anticipated that the implementation of the proposed project has the potential to impact certain biological resources and habitats found within the proposed Permit Area, particularly within the complex of Shallotte Inlet. These include resources such as shellfish habitat, salt marsh, and intertidal communities found within the area to be investigated. Determining the baseline conditions of these resources prior to construction is a fundamental step in quantifying changes in response to the implementation of Alternative 5. Existing data were utilized to delineate and characterize habitats and select species within the proposed Permit Area (Figure 4.1). Data gathered from these activities provided the baseline conditions of a number of biological resources as reported in Chapter 4 of this document. The purpose of the baseline habitat mapping effort was to identify the current extent of the biological resources within the area prior to the construction of the terminal groin and subsequent beach fill and will serve as the baseline assessment of the subject resources within the identified Shallotte Inlet Habitat Mapping Area, as designated in Figure 6.1. Subsequent habitat mapping efforts will be utilized to assess the extent of change to these habitats within the designated boundary following construction activities.

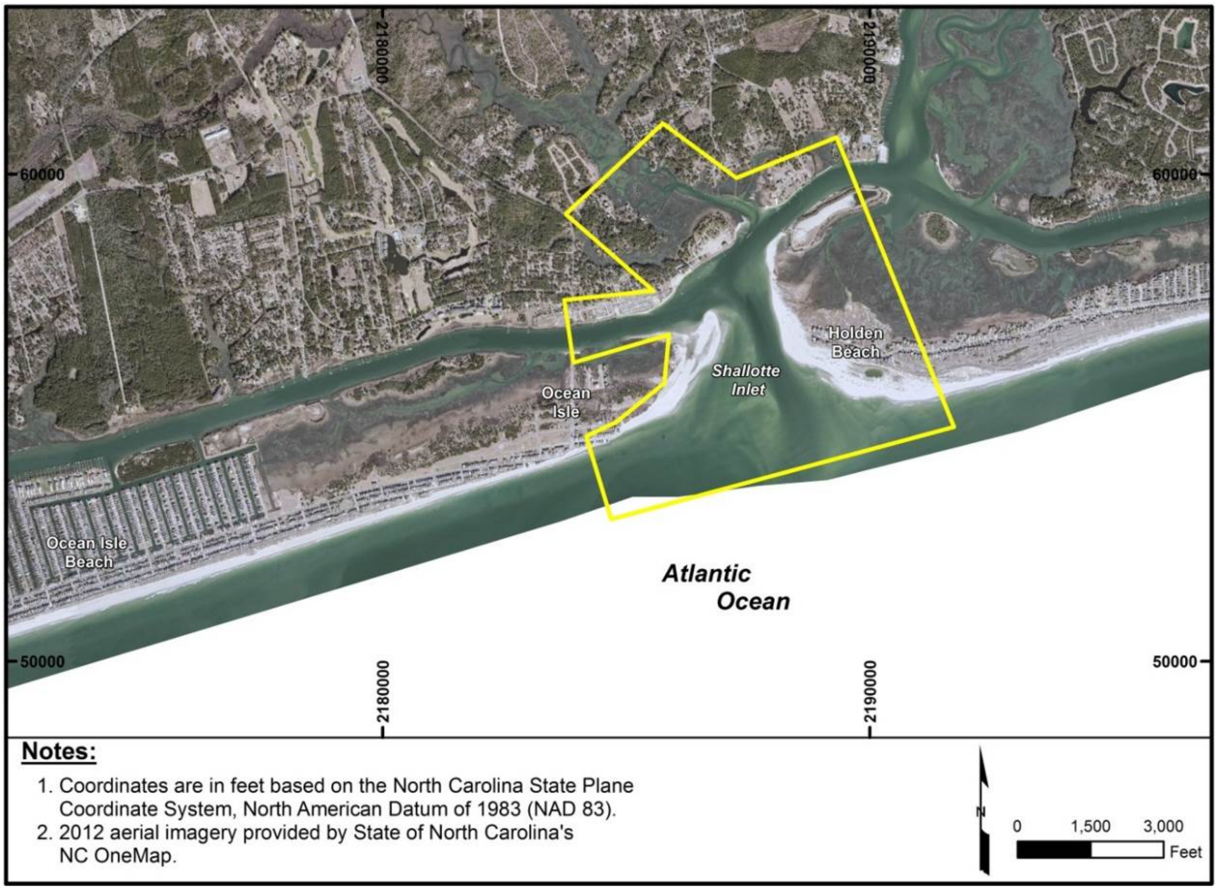

Figure 6.1. Shallotte Inlet Habitat Mapping Area

Monitoring Schedule

Pre-construction photographic interpretation of biotic communities and groundtruthing investigations within the proposed habitat mapping area were completed in March 2014 utilizing high resolution aerial photography acquired in 2012.

The acquisition of high resolution aerial photographs, ground-truth investigations, and identification of biotic communities will be conducted within the Shallotte Inlet Habitat Mapping Area between 1 September and 30 November in the three (3) years following construction of the proposed project. All surveys will be compared to the pre-construction conditions observed from the 2012 aerial photography.

Monitoring Parameters

Aerial Photography: Cartographic aerial photography will include the acquisition of ortho-rectified color digital imagery of the 928 acre Shallotte Inlet Habitat Mapping Area. Resolution of the acquired imagery will be sufficient to accurately delineate and map habitats and features of environmental significance within the survey area. The aerial platform from which the imagery is acquired will have an onboard GPS that will provide an accurate basis for product correction. NMFS will be consulted regarding the performance specifications on the imagery prior to finalizing the plan by the Town of Ocean Isle Beach and authorizing a contract.

In compliance with State and Federal agency requests, digital image acquisition will be scheduled, to the greatest extent possible, to coincide with good weather conditions and an ebb tide that may provide for increased accuracy of habitat interpretation. Considering the weather-dependent nature of this activity, every effort will be made to accomplish this task under optimum conditions.

Aerial imagery will be collected in accordance with NOAA's Coastal Services Center 2001 *Guidance for Benthic Habitat Mapping – An Aerial Photographic Approach* (Finkbeiner et al., 2001). Aerial photographs include the acquisition of ortho-rectified color digital imagery of the Shallotte Inlet Habitat Mapping area. Resolution of the acquired imagery will be sufficient (<0.6 m [2 ft]) to accurately delineate and map habitats and features of environmental significance within the survey area. An emphasis will be placed on those marine and estuarine habitats located immediately within and adjacent to the Shallotte Inlet Habitat Mapping area. The aerial platform from which the imagery is acquired will include an onboard Global Positioning System (GPS) that will provide an accurate basis for product correction.

<u>Salt Marsh, Intertidal Shoals, Supratidal Shoals, and Subtidal Communities</u>: Visual interpretations of biotic community types were digitally mapped using ArcView 9.3 software over high-resolution georeferenced digital multispectral aerial photographs as part of the initial pre-construction assessment of biotic communities. The methods employed for interpretation of aerial photography included visual analysis of color variations in the photographs to delineate habitats (dark areas = submerged land; white areas = sediment exposed above high tide line). Resolution of this imagery (< 2 feet) allowed for adequate delineation of the habitats and features within the Permit Area. Following the development of the preliminary biotic community mapping within the Permit Area via visual interpretation, field investigations were conducted to groundtruth the initial delineations. Sites selected for groundtruthing were determined by identifying areas that were difficult to classify from the aerial photography. These locations were visited via boat and the biotic community type (as identified through aerial photographic interpretation) was then verified. Based on the results of the field investigations, the preliminary habitat map was revised as necessary and acreages were determined.

Reporting

The final product from each post-construction assessment will include a report describing the biotic community map derived from the methods explained above. This report will summarize the acreage of each habitat identified and will compare the acreages to previous investigations (pre-construction and any post-construction efforts that may have occurred). Results of these mapping efforts will be incorporated into the Global Information System (GIS) database developed for this project. Acreages of each habitat type present within the permit area will be provided in a report to the USACE – Wilmington District, NMFS, USFWS, NCWRC, and NCDCM by January 1st of each year.

Ocean Isle Beach Shoreline and Inlet Management Plan

The legislation passed by the NC General Assembly in June 2011 authorizing the permitting of terminal groins at four (4) inlets in North Carolina carried with it the requirement to provide a plan for managing inlet and the estuarine and ocean shorelines likely to be under the influence of the inlet. During the 2013 legislative session, the General Assembly adopted Session Law 2013-384 (Senate Bill 151) that modified some of the requirements that have to be met in order to permit a terminal groin. Most notably, the 2013 legislation no longer requires the applicant to demonstrate structures and infrastructure are "imminently threatened only that they are "threatened" by erosion. The 2013 legislation still requires the applicant to implement an inlet management plan that includes the following:

(1) A monitoring plan.
(2) A baseline for assessing adverse impacts and thresholds for when adverse impact must be mitigated.
(3) A description of mitigation measures to address adverse impacts.
(4) A plan to modify or remove the terminal groin if adverse impacts cannot be mitigated.

As stated in the legislation:
"The inlet management plan monitoring and mitigation requirements must be reasonable and not impose requirements whose costs outweigh the benefits. The inlet management plan is not required to address sea level rise."

The USACE established a comprehensive inlet and shoreline management plan in December 2002 for the Federal storm damage reduction project. The various aspects of that plan, which are described below, are adopted for the Ocean Isle Beach preferred shoreline management project involving a terminal groin and beach fill along the eastern end of the island (Alternative 5). Some aspects of the USACE monitoring program have been modified to address specific issues associated with the implementation of a terminal groin project adjacent to the west side of Shallotte Inlet which are needed to comply with State Legislation.

In addition to the USACE monitoring program and modification described below, which would serve to satisfy items (1) and (2) of the mandated management plan listed above, measures to mitigate project related adverse impacts as well as plans to modify or remove the terminal groin if adverse impacts cannot be mitigated are discussed in the following sections.

<u>(1) Monitoring Plan</u>. Various aspects of the USACE monitoring program, which are described below, are applicable to this project and are suitable for adoption, with some modification, for the Ocean Isle Beach preferred shoreline management project. The expressed purpose of the USACE monitoring program is to:

1) Monitor the Ocean Isle Beach and Holden Beach shorelines adjacent to Shallotte Inlet to verify the anticipated response of the inlet shoulders and ebb-tide shoal to dredging of the inlet as a borrow area.
2) Provide data to track the performance of the beach fill placement in order to plan and schedule the periodic renourishment of the Federal project.
3) Monitor the performance of Shallotte Inlet as a borrow area and sediment trap in order to plan dredging for the periodic renourishment.

The scope of the USACE monitoring program, detailed below, would be generally sufficient to track impacts of the terminal groin on the shoreline of Ocean Isle Beach east and west of the terminal groin, evaluate structure induced changes in the behavior of the inlet shoulders, and determine if the structure is negatively impacting shoreline behavior on the west end of Holden Beach. However, measures to track changes on the extreme west end of Holden Beach and the east end of Ocean Isle Beach have been added to supplement the USACE monitoring program.

With the federal storm damage reduction project having been completed in 2001 followed by subsequent periodic nourishment events in 2006-07, 2010, and 2014, all of which used the borrow area in Shallotte Inlet, the impacts of the federal project following the implementation of the terminal groin project would continue. Therefore, in order to assess incremental impacts of the terminal groin on the adjacent shorelines as well as the environs around Shallotte Inlet, post-terminal groin changes in these areas would need to be compared with changes that were occurring during the time in which only the federal project was active.

The evaluation of habitat changes in the vicinity of Shallotte Inlet will be accomplished through analysis of aerial photographs that are included as part of the routine monitoring program as described on page 195. These same aerial photographs will be used to monitoring shoreline changes along the AIWW east and west of Shallotte Inlet. The shoreline change analysis will include the AIWW shoreline west to Shallotte Boulevard on the Ocean Isle side and east to the mouth of the Shallotte River including Monks Island situated immediately behind the west end of Holden Beach.

<u>Monitoring Program</u>. The USACE monitoring program includes beach profile surveys covering 27,000 feet of shoreline on Ocean Isle Beach and 10,000 feet of shoreline on the west end of Holden Beach (Figure 6.2a), radial profiles around the east and west shoulders of Shallotte Inlet (Figure 6.2b), hydrographic survey of the inlet, and aerial photos. The beach profiles, which are spaced at 500-foot intervals, are surveyed every six months (fall and spring) while the inlet radial profiles are to be taken each spring. The aerial photos are also taken in the spring. To date, the USACE has published two monitoring reports, the first in December 2002 and the second in June 2005. While subsequent monitoring reports have not been published, the USACE has continued to collect monitoring data along the east end of the federal project and the west end of Holden Beach and has used the data to design the 2010 and 2014 periodic nourishment operations. Some of the same monitoring data was used in the evaluation of the various shoreline and inlet management alternatives included in this document.

However, beginning in 2010, budget shortfalls resulted in the USACE modifying the survey coverage with most surveys limited to the area on Ocean Isle Beach that fall within the limits of the federal project. In order to continue survey coverage for the entire town, the Town of Ocean Isle Beach initiated a beach profile monitoring program that includes areas on the east and west ends of the island that have not been surveyed by the USACE since about 2010. The east end surveys include the radial profiles around the east shoulder of Shallotte Inlet starting at station -30+00 and extending west along the beach to baseline station 20+00 (Figure 6.2c). The radial transects used by the Town of Ocean Isle Beach in its monitoring program differ from the radial transects established by the USACE. The west end coverage starts at baseline station 170+00 and extends west to baseline station 275+00.

The numerical modeling of the terminal groin alternative indicated there would not be any shoreline impact, either positive or negative, west of station 30+00 on Ocean Isle Beach or on the west end of Holden Beach. With model indicated impacts ending at station 30+00 on Ocean Isle Beach, there would not be any terminal groin related impacts on Tubbs Inlet, located about 5.3 miles west of the proposed location of the terminal groin, nor would there be any terminal groin related impacts on Sunset Beach. Therefore, the USACE monitoring program is more than sufficient to satisfy the legislative requirements. The inlet and shoreline monitoring program as described in this EIS will occur over the full 30-year project planning period.

<u>(2) Shoreline Change Thresholds</u>. As part of the monitoring plan, the USACE developed shoreline change thresholds for Ocean Isle Beach and Holden Beach using shoreline change data developed by the NC Division of Coastal Management (NCDCM) for the time period 1938 to 1992 supplemented by a March 2001 pre-construction shoreline interpreted from aerial photographs. The USACE used least square analysis to establish shoreline trends at each 50-meter transect included in the NCDCM data set and to establish 95% confidence limits around the computed shoreline change trends. Next, the USACE matched the NCDCM transects to the beach profile monitoring profiles shown in Figure 6.1 and computed average shoreline change rates and average 95% confidence intervals for each profile. With the monitoring profiles spaced every 500 feet and the NCDCM transects every 50 meters, the averages were based on NCDCM transects on each side of the profile station. In general, the average shoreline change rates and confidence intervals applicable to each 500-foot profile station represent the average of 7 NCDCM transects.

In establishing the shoreline change thresholds, the USACE excluded areas on the west end of Holden Beach and the east end of Ocean Isle Beach that are included in the area presently designated as an Inlet Hazard Area. The USACE found shoreline changes within the Inlet Hazard Area to be too erratic to establish long-term trends. The excluded areas are shown in Figure 6.2b.

The shoreline change rates, 95% confidence intervals, and the shoreline change threshold adopted by the USACE for each profile station on Ocean Isle Beach and Holden Beach are provided in Table 6.1. The shoreline change rate threshold adopted by the USACE was computed by subtracting one-half of the 95% confidence interval from the average shoreline change rate at each profile. For the area on the west end of Holden Beach between profile stations 375 and 400, the overall change in the shoreline was accretion, however; the USACE could not establish definitive shoreline change trends due to the unpredictable influence of the Shallotte Inlet bar channel on the shoreline. For this area the USACE adopted a threshold rate of 0 feet/year applicable to profiles 375 to 400.

While the past behavior of the west end of Holden Beach has been somewhat erratic, particularly since completion of initial construction of the federal storm damage reduction project on Ocean Isle Beach, the shoreline change thresholds for the west end of Holden Beach used by the USACE were modified for the terminal groin project by applying the same protocol between stations 375 and 400 as used to establish thresholds for the other transects. Adopting this protocol results in positive, i.e., accretionary, shoreline change thresholds between stations 375 and 400 rather than 0 feet/year adopted by the USACE. These revised shoreline change threshold values for the extreme west end of Holden Beach are provided in Table 6.1.

The use of 95% confidence intervals in establishing shoreline change rate thresholds provides a degree of certainty that observed shoreline change rates that exceed the threshold values are indicative of changes that would not have been expected to occur under pre-project conditions.

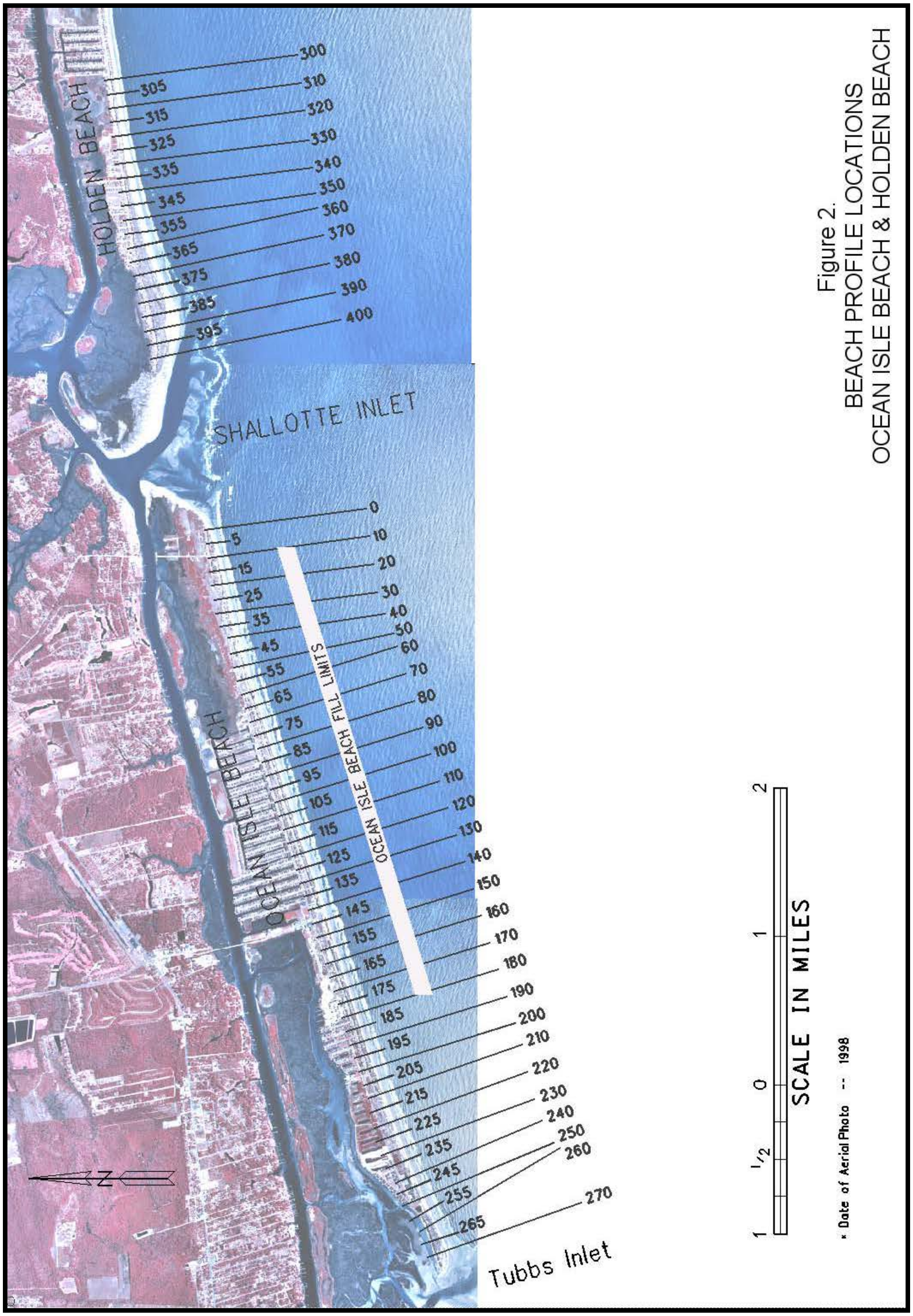

Figure 6.2a. Beach profiles included in the USACE Ocean Isle Beach monitoring program (Figure copied from USACE, 2002).

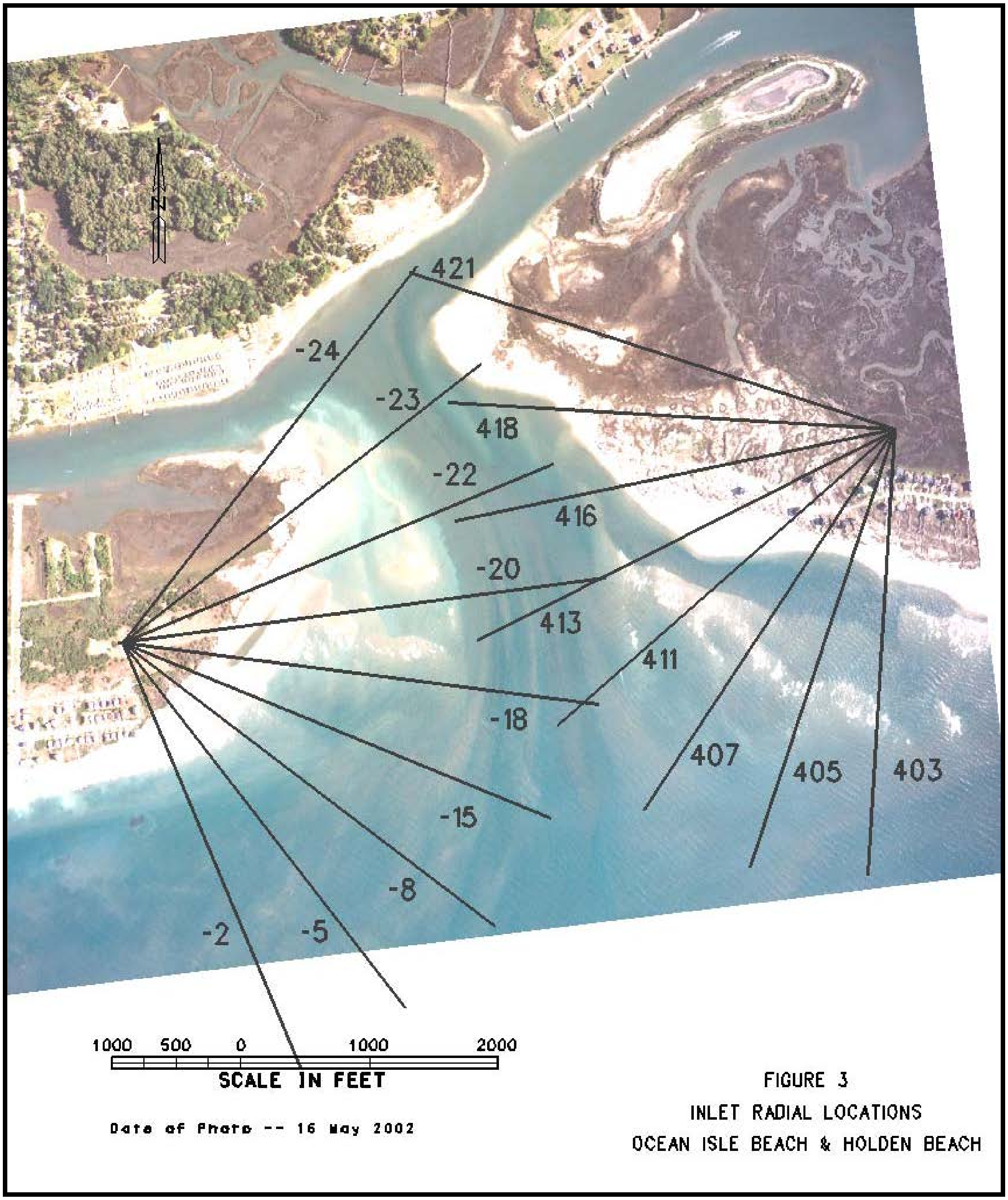

Figure 6.2b. Inlet radial profiles included in the USACE Ocean Isle Beach monitoring program (Figure copied from USACE, 2002).

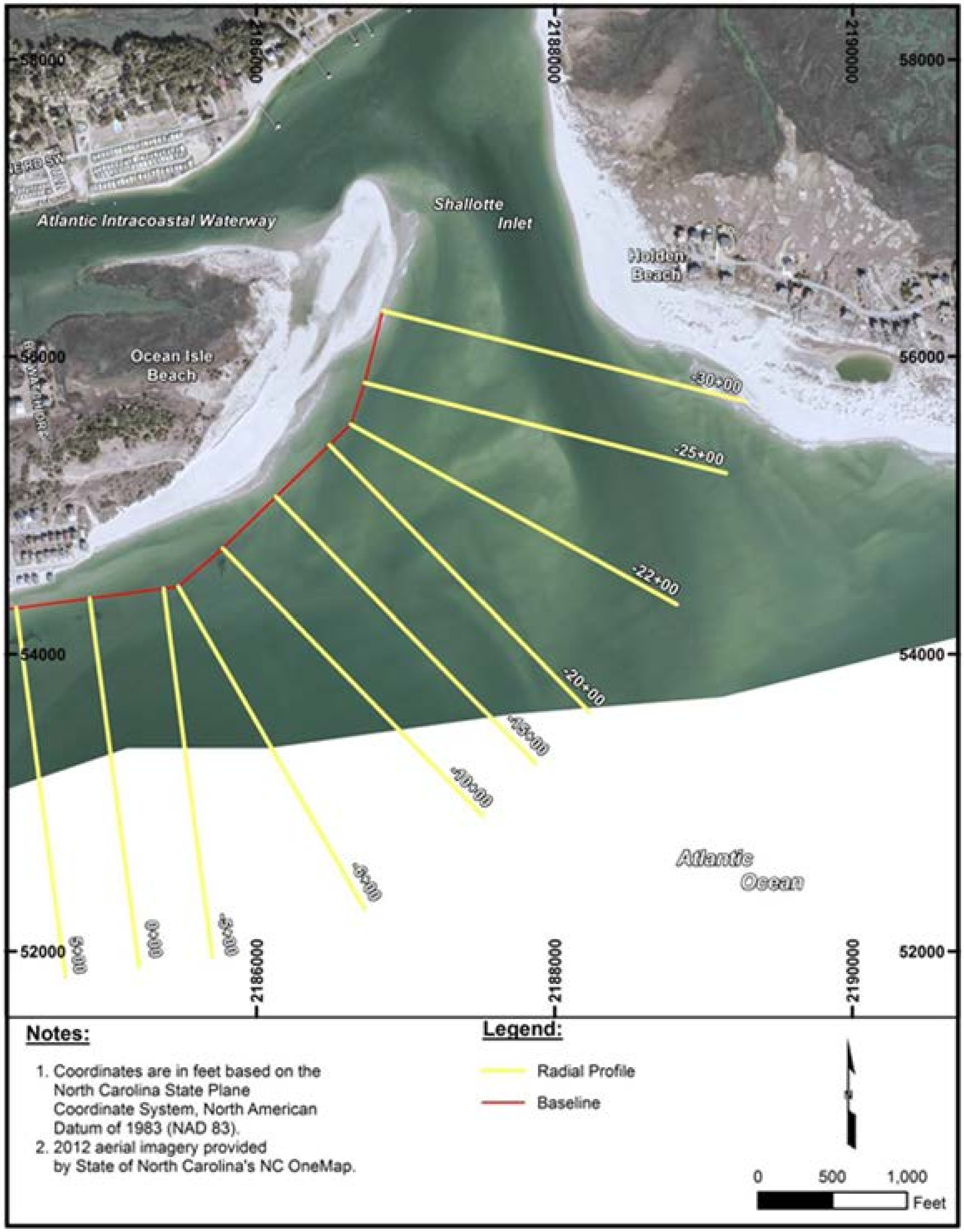

Figure 6.2c. Radial transects on Ocean Isle Beach side of Shallotte Inlet included in the Town of Ocean Isle Beach's monitoring program.

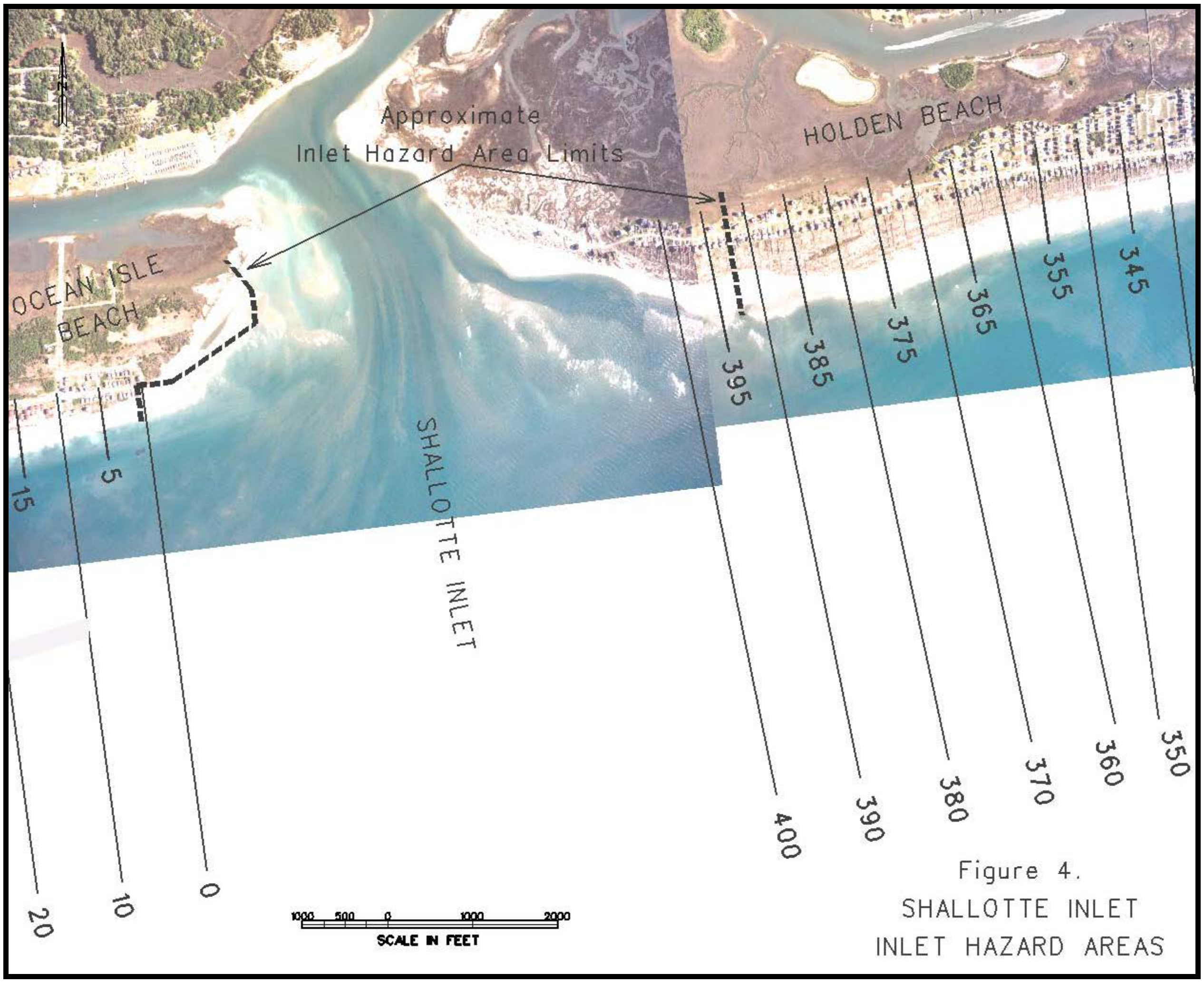

Figure 6.3. Existing Inlet Hazard Area for Shallotte Inlet (Figure copied from USACE, 2002).

Table 6.1. USACE shoreline change thresholds for Ocean Isle Beach and the west end of Holden Beach.

Ocean Isle Beach Shoreline Change Thresholds			
Beach Profile No.	Average Rate Shoreline Change (ft/yr)	Average 95% Confidence Interval (ft/yr)	Shoreline Change Rate Threshold (ft/yr)(1)
5	-2.8	4.0	-4.9
10	-4.3	2.1	-5.3
15	-4.7	1.7	-5.6
20	-3.6	1.7	-4.4
25	-1.0	1.9	-1.9
30	1.0	2.1	0.0
35	1.7	1.9	0.8
40	1.7	1.7	0.8

45	1.3	1.5	0.6
50	1.0	1.5	0.3
55	0.7	1.5	-0.1
60	0.3	1.7	-0.6
65	0.0	2.2	-1.1
70	0.1	2.9	-1.4
75	0.2	3.1	-1.3
80	0.1	3.2	-1.5
85	0.0	3.5	-1.7
90	-0.2	3.4	-1.9
95	-0.4	3.3	-2.0
100	-0.4	3.2	-2.0
105	-0.4	3.1	-1.9
110	-0.3	3.1	-1.8
115	-0.3	3.0	-1.7
120	-0.1	2.8	-1.5
125	0.1	2.5	-1.2
130	0.2	2.4	-1.0
135	0.4	2.3	-0.7
140	1.0	2.1	0.0
145	1.4	1.8	0.5
150	1.4	1.5	0.6
155	1.1	1.6	0.3
160	0.9	1.7	0.1
165	0.9	1.8	0.0
170	1.0	2.2	-0.1
175	1.1	2.5	-0.2
180	1.1	2.5	-0.1
185	1.1	2.6	-0.2
190	1.0	2.6	-0.3
200	1.1	2.6	-0.2
205	1.0	2.8	-0.4
210	1.0	2.8	-0.4
215	1.0	2.6	-0.3
220	1.1	2.5	-0.2
225	1.1	2.6	-0.2
230	1.1	2.7	-0.2
235	1.2	3.1	-0.4
240	1.3	3.4	-0.4
245	1.3	3.7	-0.5

250	1.4	4.2	-0.7
255	1.4	4.8	-1.1
260	1.6	5.6	-1.2
265	1.8	6.2	-1.3
270	1.8	6.2	-1.3

Holden Beach Shoreline Change Thresholds			
Beach Profile No.(2)	Average Rate Shoreline Change (ft/yr)	Average 95% Confidence Interval (ft/yr)	Shoreline Change Rate Threshold (ft/yr)(1)
400	2.1		1.9
395	5.5	7.3	3.3
390	7.0	7.5	3.1
385	7.1	8.0	2.0
380	6.3	8.7	0.7
375	5.3	9.3	1.9
370	4.2	9.1	-0.4
365	3.0	8.3	-1.1
360	2.1	7.4	-1.7
355	1.4	6.7	-1.9
350	1.0	5.9	-2.0
345	0.5	4.9	-1.9
340	0.3	4.4	-1.9
335	-0.2	3.7	-2.1
330	-0.6	3.2	-2.2
325	-0.8	2.5	-2.0
320	-0.9	2.0	-1.9
315	-1.2	1.7	-2.1
310	-1.7	1.5	-2.5
305	-1.7	1.3	-2.4
300	-1.7	1.2	-2.3

(1)Shoreline change rate threshold equal to average rate – (½ x 95% confidence interval).

(2)Threshold rate of 0 ft/yr adopted for profiles 375 to 400 due to influence of Shallotte Inlet bar channel.

To account for possible short term shoreline changes that could be caused by storm events or other factors, the USACE adopted a 2-year confirmation period, i.e., should observed shoreline change rate exceed the threshold rate at any profile station; an additional 2-year period would follow to confirm the trend. Should the shoreline change rate exceed the threshold over the entire 2-year confirmation period, an assessment of the proper responsive measures would be made. If the shoreline change rate decreases below the threshold rate during the confirmation period, the 2-year confirmation period would be reset.

In the event the area is impacted by a catastrophic storm such as a hurricane or severe nor'easter that causes major changes in the shoreline, subsequent shoreline change rates would likely exceed the threshold rates for some time. If after the two year post-storm confirmation period shoreline change rates are still being impacted by the storm induced changes and some of the measured shoreline change rates still exceed the threshold rates, an assessment will be made to determine if a new reference shoreline condition is needed in order to adequately evaluate potential project induced shoreline impacts that occur post storm.

Comparable shoreline change rate thresholds were not established by the USACE for the radial profile lines around the inlet's east and west shoulders (Figure 6.2b) due to the variable nature of the shoreline changes and the lack of definitive shoreline trends. However, the radial transects would be monitored during the life of the project and the behavior of the inlet shorelines as depicted by the radial profiles used to determine if modifications in the Shallotte Inlet borrow area are needed.

As mentioned above, the shoreline and inlet monitoring program and shoreline change rate thresholds established by the USACE for the Ocean Isle Beach storm damage reduction project are adopted for the Ocean Isle Beach Shoreline Management Project with the exception of profiles 375 to 400 on the west end of Holden Beach which were revised based on the same protocol used to establish the thresholds at all the other transects. In this regard, should Federal funding for their monitoring program fall short in any given year, the Town of Ocean Isle Beach would provide the necessary funding to assure the entire program is accomplished as planned.

The Town of Ocean Isle Beach presently pays $17,000 to survey 34 profiles on the east and west end of the island, or $500 per profile. If the Town had to assume the cost of surveying the federal project between station 0+00 and 180+00, the cost to survey these 37 profiles would be an additional $18,500. The USACE monitoring program also includes 21 profiles on the west end of Holden Beach. Again if the USACE is unable to survey the west end of Holden Beach due to a lack of federal funds, the Town of Ocean Isle Beach would assume that responsibility. The cost to survey the 21 profiles on the west end of Holden Beach would be $10,500. Thus, the total cost of the beach profile surveys that would become the responsibility of the Town of Ocean Isle Beach in the absence of federal funding for this activity would be $29,000 per year.

<u>Ocean Isle Beach Sand Spit</u>. The area on Ocean Isle Beach located east of profile station 5+00 was not included in the USACE shoreline change threshold evaluation since this area falls within the existing Inlet Hazard Area established by the NC Coastal Resources Commission. Also, the sand spit, it its present form, did not exist prior to the construction of the Federal project.

Figure 6.4. Sand spit shorelines on east end Ocean Isle Beach – March 1999 to January 2013.

Shoreline changes along the sand spit have been highly variable as shown by the shoreline positions of the sand spit traced from Google Earth aerial photos taken between March 1999 (pre-construction) and January 2013 shown on Figure 6.4. The shorelines on Figure 6.4 do not represent a particular elevation such as mean high water or mean low water; rather the shorelines simply represent the approximate interface of the water with the dry sand beach as shown by the wet/dry line on the photos.

Based on this set of aerial photos, the eastward projection of the sand spit reached a maximum in October 2007 (yellow line in Figure 6.4). Between October 2007 and October 2010 (dark blue line), the sand spit rotated counter clockwise resulting in a landward recession of the shoreline of between 400 feet and 600 feet on the extreme eastern end of the sand spit. The re-curved nature of the sand spit normally results in the formation of a shallow pond between the old spit shoreline and the backside of the new spit. Between October 2010 and January 2013 (red line), the shoreline along the eastern end of the sand spit moved seaward 250 feet to 350 feet in response to a new slug of sand moving to the east. Eastward movement of the slug of sand stopped when it reached the main inlet channel and the sand spit again rotated counter clockwise and eventually merged with the previous sand spit. This cyclic nature of sand spit behavior should continue following the implementation of Alternative 5.

The approximate 1,000 feet of shoreline measured from the last house on the east end of Ocean Isle Beach represents the trailing end of the sand spit. Shoreline behavior in this area is also highly variable but not to the same degree as the eastern tip of the sand spit. This shoreline position variability is due in part to the movement of beach nourishment material being transported to the east off the east end of the Federal storm damage reduction project. In this regard, the October 2009 shoreline (green line in Figure 6.4), which was taken about 6 months prior to the April-May 2010 nourishment operation, had the landward most position of all of the shorelines in the photo dataset.

Even though the establishment of shoreline change thresholds at each radial transect is not practical for the spit area, the March 1999 configuration of the sand spit, as shown in Figure 6.4, is adopted as a threshold for the sand spit area on the east end of Ocean Isle Beach. Post-terminal groin construction changes in the sand spit will be monitored using aerial photographs. Should the sand spit diminish in size to that comparable to the March 1999 threshold, consideration will be given to modifying the structure to allow more sediment to move from west to east past the structure. Beach nourishment in this area would also be considered as a mitigation option.

<u>Holden Beach - Shallotte Inlet Shoreline</u>. A comparison of shoreline changes on the extreme west end of Holden Beach adjacent to Shallotte Inlet is provided in Figure 6.5. The dates of the shorelines shown in Figure 6.5 are the same as the dates shown for the Ocean Isle Beach sand spit in Figure 6.4 and were also obtained from Google Earth photos. The March 1999 shoreline, shown in black in Figure 6.5, represents the position of the shoreline prior to the initial construction of the Ocean Isle Beach federal storm damage reduction project. Between March 1999 and October 2005 (blue line in Figure 6.5), the western end of Holden Beach on the ocean side experienced considerable amount of accretion as the result of the onshore migration of a portion of the ebb tide delta located off the west end of Holden Beach. This onshore migration was attributed to the initial excavation of the Shallotte Inlet borrow area in 2001. At the narrowest point between Holden Beach and Ocean Isle Beach inside the inlet, commonly referred to as the inlet gorge, the shoreline moved east (i.e., eroded) approximately 600 feet between March 1999 and January 2013 as shown by comparing the black and red lines in Figure 6.5.

The erratic behavior of the shoreline along the east shoulder of Shallotte Inlet on the Holden Beach side, particularly in the area between the two islands, and the apparent tendency of the extreme western tip of Holden Beach opposite the inlet gorge to erode under exiting conditions makes it virtually impossible to establish shoreline change rates for the radial transects that could be used as erosion thresholds comparable to the ones established for the ocean-facing beach.

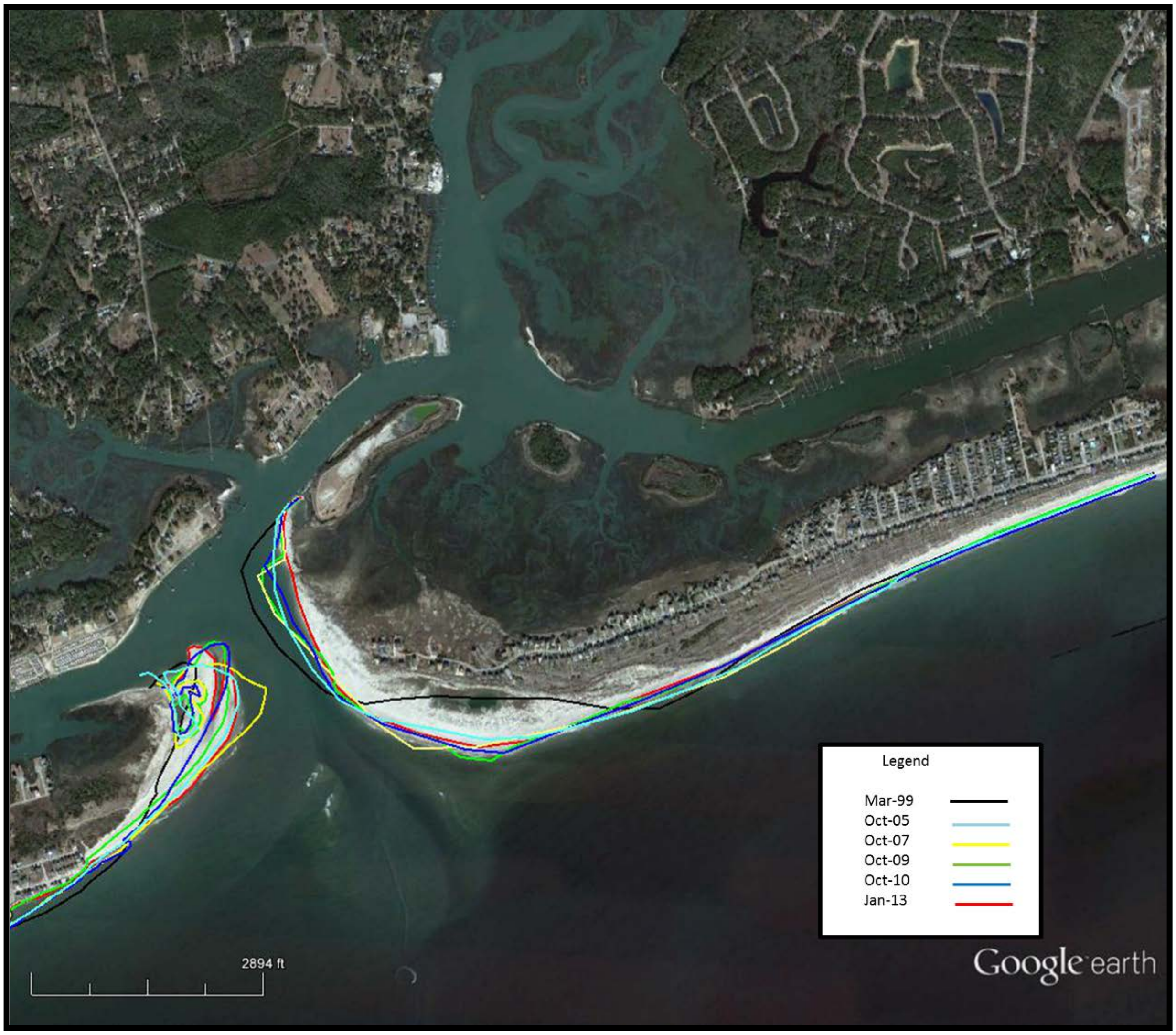

Figure 6.5. Shoreline changes on the extreme west end of Holden Beach next to Shallotte Inlet – March 1999 to January 2013.

The primary purpose of establishing a shoreline threshold on the west end of Holden Beach is to identify when existing development may become vulnerable to erosion damage. Therefore, similar to what was done on the Ocean Isle Beach side, a shoreline position threshold is established on the extreme western end of Holden Beach. The shoreline position threshold is shown in Figure 6.6. If future shorelines move up to this line, the need for remedial action and the type of response would be evaluated and coordinated with all parties involved including the Town of Holden Beach, the Town of Ocean Isle Beach, the State Division of Coastal Management, and the USACE.

The shoreline threshold shown on Figure 6.6 is generally positioned about 300 feet seaward of the front of the ocean front structures along the west end of Holden Beach. The 300-foot distance was based on the maximum shoreline excursions that occurred between October 2005 and January 2013 (Figure 6.5). The 300-foot buffer between the erosion threshold shoreline and the ocean front structures should allow sufficient time to develop mitigation measures should the inlet shoreline recede to the threshold line. Again, based on the observed shoreline changes shown on Figure 6.5, the rate of shoreline change along the west end of Holden did not generally exceed 75 to 100 feet/year.

Figure 6.6. Shoreline Threshold-West End of Holden Beach.

(3) Mitigation Measures. Should shoreline responses along Ocean Isle Beach or Holden Beach exceed the shoreline change thresholds presented above and continue to exceed the thresholds throughout the 2-year verification period, the terminal groin would be evaluated to determine if modifications to the structure could be made that would mitigate the negative shoreline impacts. If modification of the terminal groin would not address the problem, beach nourishment would be provided in the affected areas to compensate for the structure related impacts.

Once the need to provide beach fill to mitigate for project related shoreline impacts is determined, the Town of Ocean Isle Beach would apply for appropriate State and Federal permits. Since the location for the mitigation beach fill cannot be determined in advance, the permit process could not begin until the monitoring program identifies where the impacts have occurred. As a result, the time lapse between the identification of a shoreline erosion problem and the initiation of construction to provide the beach fill could be as long as three (3) years. That is, one year to identify the problem and two years to verify if the problem still exists. During the first year of verification, work will begin to obtain the necessary permits. Any mitigation measure would be limited to the November 16 to March 31 environmental dredging window.

Material for the mitigation beach fill would be obtained from the Shallotte Inlet borrow area. Depending on the timing of when the need for mitigation beach fill is determined, the mitigation beach fill could possibly be provided during the normal periodic nourishment operation. If the timing does not coincide with the normal periodic nourishment cycle, the mitigation fill would be provided during a separate nourishment operation.

Under the existing Federal storm damage reduction project, mitigation of adverse impacts of the Shallotte Inlet borrow area on Holden Beach would be the responsibility of the Town of Ocean Isle Beach. Separating terminal groin and borrow area impacts on the west end of Holden Beach would be difficult if not impossible. However, with the Town of Ocean Isle Beach being responsible for mitigation in both instances, identifying the culpable feature (borrow area or terminal groin) would not be required.

In the event the negative impacts of the terminal groin cannot be mitigated with beach nourishment or possible modifications to the design of the terminal groin, the terminal groin would be removed. Removal would entail the extraction of the sheet pile from the shore anchorage section and the complete removal of all stone, including bedding and armor stone. The terminal groin construction materials would be transported off the island and placed in an appropriate storage site. The terminal groin material, particularly the sheet pile and stone, would have some salvage value; however the opinion on the cost for removal of the terminal groin, excluding any salvage value, is $2.0 million.

<u>(4) Project Modifications</u>. The terminal groin proposed for the east end of Ocean Isle Beach in the applicant’s preferred alternative (Alternative 5) is designed to allow littoral sediment to move over, though, and/or around the structure. The so-called “leaky” nature of the design, a nomenclature suggested by Olsen & Associates for the terminal groin on Amelia Island, Florida, should allow sufficient volumes of sand to move past the structure and continue east along the sand spit to maintain the integrity of the spit. As indicated above, the March 1999 configuration of the sand spit on the Ocean Isle Beach side of Shallotte Inlet will be used as a “threshold” in determining if modifications to the structure are needed to allow more sediment to move past the structure. No such threshold is possible for the inlet shoreline on the Holden Beach side due to the documented erratic behavior of the shoreline prior to and following the initial construction of the Ocean Isle Beach federal storm damage reduction project. In this regard, mitigation on the Holden Beach side would be dictated by shoreline changes that exceed the thresholds established for the federal project.

Consideration would also be given to possibly nourishing the area east of the terminal groin on the Ocean Isle Beach side as a means of restoring the character of the sand spit. The post-construction configuration of the sand spit will be evaluated through interpretation of the aerial photographs. As stated above, should the sand spit diminish in size comparable to the March 1999 condition, consideration will be given to modifying the structure to allow more sediment to move from west to east past the structure of possibly providing beach fill to the area east of the terminal groin during regularly scheduled periodic nourishment operations. Modification to the structure could include removal of stones to increase permeability, shortening the structure, or lowering the crest elevation. The appropriate measures, i.e., structure modifications or beach fill, would be determined following an assessment of the degree of impact the structure is having on the area.

Reporting. Annual reports, comparable to the two monitoring reports previously published by the USACE, would be prepared and submitted to the USACE Wilmington District Regulatory Office and the NC Division of Coastal Management. The reports will summarize shoreline changes observed during the previous year and will compare updated shoreline changes to shoreline change thresholds. The results will be provided in both tabular and graphical form.

Should the monitoring surveys detect shoreline change rates exceeding the threshold rates, the profile where the thresholds are exceeded will be “red flagged.” Subsequent monitoring reports over the following two years will closely follow changes at these profiles to determine if corrective actions are needed.

Summary of Shoreline and Inlet Management Plan. The shoreline and inlet management plan for the Ocean Isle Beach project would include the following:

(1) Beach profile surveys every 6 months covering 27,000 feet of shoreline on Ocean Isle Beach and 10,000 feet of shoreline east of Shallotte Inlet on Holden Beach.
(2) The beach profiles will be spaced at 500-foot intervals along both Ocean Isle Beach and Holden Beach.
(3) Annual hydrographic surveys of Shallotte Inlet extending from the confluence of the inlet with the AIWW seaward to the -30-foot NAVD depth contour in the ocean. The hydrographic surveys will cover the area from approximately station 400+00 on Holden Beach to station 0+00 on Ocean Isle Beach.
(4) The 9 radial profiles on the east end of Ocean Isle Beach and the 8 radial profiles on the west end of Holden Beach, as shown in Figure 6.2, will be surveyed each spring and graphs prepared to show changes over time.
(5) The sand spit shoreline east of the terminal groin will be mapped from the aerial photos taken each spring and plots of the changes in the spit shoreline shown graphically.
(6) Similar shoreline mapping will also be performed on the Holden Beach side of Shallotte Inlet.

(7) An annual report will be prepared summarizing changes observed during the year and identifying any profile stations where the shoreline change thresholds are exceeded.
(8) The report will include a summary of significant meteorological events (tropical and extratropical), man-made activities (beach nourishment), and any other factors that had occurred that could have an impact of past as well as future shoreline changes.
(9) The report will discuss if measures are needed to correct any observed negative shoreline impacts and if so provide recommendations on how to address the impacts.

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