FINAL
INTEGRATED GENERAL REEVALUATION REPORT AND SUPPLEMENTAL ENVIRONMENTAL IMPACT STATEMENT

BREVARD COUNTY, FLORIDA
HURRICANE AND STORM DAMAGE REDUCTION PROJECT
MID-REACH SEGMENT

U.S. Army Corps
of Engineers
Jacksonville District

AUGUST 2010
(Revised April 2011)

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BREVARD COUNTY, FLORIDA
HURRICANE AND STORM DAMAGE REDUCTION PROJECT
MID-REACH SEGMENT

LEAD AGENCY: Jacksonville District, U.S. Army Corps of Engineers

COOPERATING AGENCIES: National Marine Fisheries Service and U.S. Fish and Wildlife Service

The Brevard County General Re-evaluation Report, including Supplemental Environmental Impact Statement, presents the results of a hurricane and storm damage reduction study for the 7.8 mile Mid-Reach segment of Brevard County, Florida. The goal of the Brevard County Mid-Reach project is to reduce the damages caused by erosion and coastal storms to shorefront structures along the Mid-Reach study area. The District supports the non-Federal sponsor's locally preferred plan and recommends the plan as the Recommended Plan. The plan consists of a small-scale beach fill varying from a 0-foot to 20-foot extension of the mean high water line plus advanced nourishment to maintain the design fill volume. The approximate volume of sand to be placed, as calculated from the 2008 survey, includes an initial design fill of 445,000 cubic yards plus an advanced nourishment fill of 210,000 cubic yards for a total fill of 655,000 cubic yards at initial construction. Placement of the sand is anticipated to impact approximately 3.0 acres of nearshore rock hardbottom by direct and indirect cover of which 1.4 acres is expected to include some temporal variation as the advanced nourishment erodes. The mitigation quantity is calculated from the UMAM ratio of 1.6 mitigation acres required for every acre of natural rock impacted, resulting in a mitigation of 4.8 acres.

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BREVARD COUNTY, FLORIDA
HURRICANE AND STORM DAMAGE REDUCTION PROJECT
MID-REACH SEGMENT

EXECUTIVE SUMMARY

1. The Brevard County General Re-evaluation Report, including Supplemental Environmental Impact Statement, presents the results of a hurricane and storm damage reduction study for the 7.8 mile Mid-Reach segment of Brevard County, Florida. The Mid-Reach was previously studied in the Feasibility Report with Final Environmental Impact Statement for Brevard County (1996), but the Mid-Reach segment was removed from the recommended plan due to environmental concerns. A general re-evaluation report for Brevard County, Florida was authorized by the Water Resources Development Act of 2000 to determine if all or a portion of the Mid-Reach is acceptable for addition into the Brevard County hurricane and storm damage reduction project.

2. The goal of the Brevard County Mid-Reach project is to reduce the damages caused by erosion and coastal storms to shorefront structures along the Mid-Reach study area. Project objectives were outlined based on the project problems, opportunities, goals, and Federal and State objectives and regulations. The objectives focused on reducing storm damages to coastal structures, maintaining the recreational beach, maintaining opportunities for recreational use of the nearshore areas, and maintaining environmental quality. The planning process was also constrained by the desire to avoid, minimize and mitigate environmental impacts to the nearshore hardbottom as regulated by the Magnusons-Stevens Fishery Conservation and Management Act.

3. A large number of alternatives were evaluated through an iterative, multi-step process to select the plan for recommendation. Included in the evaluation were both non-structural and structural alternatives. The final array of alternatives focused on beach nourishment in varying scales seeking to minimize impact to the nearshore hardbottom.

4. The District supports the non-Federal sponsor's locally preferred plan as the Recommended Plan. The locally preferred plan is shown in the alternatives evaluation as Local Option 6. The plan consists of a 10-foot extension of the mean high water line plus advanced nourishment to maintain that design fill volume in Reach 1 (R-119 to R-109), a 20-foot extension of the mean high water line plus advanced nourishment to maintain that design fill volume in Reaches 2 and 3 (R-109 to R-99), a 10-foot extension of the mean high water line plus advanced nourishment to maintain that design fill volume in Reaches 4 and 5 (R-99 to R-83), and a dune fill with no added advanced nourishment in Reach 6 (R-83 to R-75.4). The approximate volume of sand to be placed, as calculated from the 2008 survey, includes an initial design fill of 445,000 cubic yards plus an advanced nourishment fill of 210,000 cubic yards for a total fill of 655,000 cubic yards at initial construction.

The construction volumes shown were updated to a 2008 beach survey, and indicate a small change in volume compared to the previous survey. Fill will be accomplished by rehabilitating the Poseidon dredged material management area (DMMA) at Port Canaveral, dredging material from Canaveral Shoals offshore borrow area with placement into the Poseidon DMMA every 6 years, and hauling by dump truck to the Mid-Reach for placement on the beach at approximately 3 year intervals. The renourishment volume is approximately 210,000 cubic yards. The recommended plan offers erosion protection ranging from a 5-year storm level to a 75-year storm, varying along the length of the Mid-Reach. The plan includes 3.0 acres of environmental impact to the nearshore rock resources, following minimization of the impacts as much as possible while still offering maximum storm damage reduction. Mitigation for impacts due to direct and indirect cover of the nearshore rock is included in the 3.0 acre impact, however, 1.4 acres is expected to include some temporal variation as the advanced nourishment erodes. The recommended plan includes impacts in Reaches 1 to 5 and no impact in Reach 6. The area impacted is on the landward edge of the nearshore rock, resulting in a small width of rock impacted but over the whole length of Reach 1 to 5. The calculated impact acreage is 3.0 acres out of the total of 31.3 acres of nearshore rock in the Mid-Reach study area. The nearshore rock seaward of the fill area will not be impacted. The mitigation quantity is calculated from the State of Florida Uniform Mitigation Assessment Method (UMAM) ratio of 1.6 mitigation acres required for every acre of natural rock impacted, resulting in a mitigation of 4.8 acres. Mitigation will be accomplished concurrent with the nourishment project, with construction of articulated concrete mats with embedded coquina rock in water depths of 14 to 16 feet mean low water.

5. From an ecosystem standpoint, minimizing impacts to nearshore rock resources within the Mid-Reach is considered more important than restoring a complete sandy shoreline or wider beach. As stated earlier, the Mid-Reach was previously studied in the Feasibility Report with Final Environmental Impact Statement for Brevard County (1996), but was removed from the recommended plan at that time due to environmental concerns. The U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Environmental Protection Agency, Florida Game and Fresh Water Fish Commission and the Florida Department of Environmental Protection all expressed concern that proposed beach nourishment within the Mid-Reach would have adverse impacts on nearshore coquina rock outcrops and scattered worm rock communities; therefore, the Mid-Reach was dropped from the 1996 recommended plan. This type of habitat is protected by the Magnuson-Stevens Fishery Conservation and Management Act and is considered Essential Fish Habitat and a Habitat of Particular Concern. Research conducted for this study identified a plethora of ecological functions and species attendant to the Mid-Reach rock. Other researchers have also found that hard bottom habitats support the most diverse assemblage of fishes off eastern Florida. Furthermore, the Mid-Reach rock is unique due to its being disjunct from larger hard bottom habitats to the south. The current opinions of Federal and State agencies have established a need to minimize and avoid impacts to this resource. On the other hand, the ocean shoreline or

beach along the Mid-Reach is mostly developed with a mix of commercial, residential, and small public parks. Urbanization has impacted the dune system, and while this project would maintain a dune environment with a select group of native plant species, a full restoration of historical dune habitat is not practical. It is important to note that various agencies are managing/preserving dune habitat along a majority of Brevard County's 72 mile ocean coastline. As proposed, the recommended plan, which has been fully coordinated, minimizes impacts to the nearshore rock resource while still providing hurricane and storm damage reduction benefits.

6. Cost sharing was based on the NED plan. Overall Federal participation in cost for the initial construction of the project is 54% of the NED plan based on shoreline ownership and public access. As the Locally Preferred Plan (LPP) final total project cost estimate is lower than the NED plan, the initial construction of the LPP is cost-shared at 54% Federal participation. The cost summary table on page vi indicates the costs for the Locally Preferred Plan (LPP) including cost sharing percentages. The recommended plan presented in this documentation was demonstrated as being economically feasible, environmentally acceptable, and soundly engineered. Coordination of the plan to date has resolved all issues brought forward during the scoping process. A second cost summary table on page vii indicates the changes to costs if the data was brought up to the October, 2010 price level and interest rate.

7. The recommendation contained herein reflects the information available at this time and current departmental policies governing formulation of individual projects. It does not reflect program and budgeting priorities inherent in the formulation of a national civil works construction program or the perspective of higher review levels within the executive branch. Consequently, the recommendation may be modified before it is transmitted to the Congress as a proposal for authorization and implementation funding. However, prior to transmittal to Congress, the sponsor, the State, interested Federal agencies, and other parties will be advised of any significant modifications and will be afforded an opportunity to comment further.

BREVARD COUNTY MID-REACH SHORE PROTECTION PROJECT
GENERAL REEVALUATION REPORT

PERTINENT DATA

Price Level = March 2010, Interest Rate = 4.375%

PHYSICAL DATA (All elevations are referenced to NGVD)

Project Length (mi)	7.8
Berm Crest Elevation (ft)	+10.6
MHW Shoreline Extension (ft)	variable 0 to 20-foot
Foreshore Slope	1V on 8H
Nearshore Slope	1V on 8H
Nourishment Interval (yr)	3
Volume of Advance Nourishment (cy)	210,000
Volume of Design Fill (cy)	445,000
Volume of Initial Fill (cy)	655,000

Initial Construction Cost	$31,420,436
Monitoring	
Cost Sharable*	$778,836
Non-Cost Sharable	$0
	$32,199,272
Interest During Construction	$34,147
Each Future Nourishment Cost	$8,216,773
Annualized Costs	$4,244,408

ANNUAL BENEFITS

Prevention of Storm Damages:	$11,566,324
Incidental Recreation Benefits	$1,013,900
Total	$12,580,224
BENEFIT TO COST RATIO	**3.0**

PROJECT COST SHARING (%)

Initial Construction		Periodic Nourishment	
Federal	54.0%	Federal	44.2%
Non-Federal	46.0%	Non-Federal	55.8%

Total Project Cost over 50 years ($)	
Federal	$75,497,000
Non-Federal	$88,171,000
Total	$163,668,000

* These costs are for monitoring items that would be needed for Plans and Specs and Post Construction pay estimates.

NOTE: Total project cost includes inflation

BREVARD COUNTY MID-REACH SHORE PROTECTION PROJECT
GENERAL REEVALUATION REPORT

PERTINENT DATA

Price Level = October 2010, Interest Rate = 4.125%

PHYSICAL DATA (All elevations are referenced to NGVD)

Project Length (mi)		7.8
Berm Crest Elevation (ft)		+10.6
MHW Shoreline Extension (ft)		variable 0 to 20-foot
Foreshore Slope		1V on 8H
Nearshore Slope		1V on 8H
Nourishment Interval (yr)		3
Volume of Advance Nourishment (cy)		210,000
Volume of Design Fill (cy)		445,000
Volume of Initial Fill (cy)		655,000
Initial Construction Cost		$31,664,008
Monitoring		
	Cost Sharable*	$784,874
	Non-Cost Sharable	$0
		$32,448,882
Interest During Construction		$31,099
Each Future Nourishment Cost		$8,280,469
Annualized Costs		$4,211,178

ANNUAL BENEFITS

Prevention of Storm Damages:	$11,913,834
Incidental Recreation Benefits	$1,036,600
Total	$12,950,434
BENEFIT TO COST RATIO	**3.1**

PROJECT COST SHARING (%)

Initial Construction		Periodic Nourishment	
Federal	54.0%	Federal	44.2%
Non-Federal	46.0%	Non-Federal	55.8%

Total Project Cost over 50 years ($)	
Federal	$76,082,000
Non-Federal	$88,855,000
Total	$164,936,000

***** These costs are for monitoring items that would be needed for Plans and Specs and Post Construction pay estimates.

NOTE: Total project cost includes inflation

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1 STUDY INFORMATION

1.1 Introduction

The Brevard County Mid-Reach General Re-evaluation Report (GRR), including Environmental Impact Statement, presents the results of a coastal storm damage reduction study for the 7.8 mile Mid-Reach segment of Brevard County, Florida. The Mid-Reach was removed from the recommended plan in the Feasibility Report with Final Environmental Impact Statement for Brevard County (1996) due to environmental concerns. This GRR includes a focused analysis of the Mid-Reach to inform decision makers of the issues in this area.

1.2 Study Authority

A GRR for Brevard County, Florida was authorized by the Water Resources Development Act (WRDA) of 2000:

> SEC. 418 BREVARD COUNTY, FLORIDA
> "The Secretary shall prepare a general reevaluation report on the project for shoreline protection, Brevard County, Florida, authorized by section 101(b)(7) of the Water Resources Development Act of 1996 (110 Stat. 3667), to determine, if the project were modified to direct the Secretary to incorporate in the project any or all of the 7.1 mile reach of the project that was deleted from the south reach of the project, as described in paragraph (5) of the Report of the Chief of Engineers, dated December 23, 1996, whether the project as modified would be technically sound, environmentally acceptable, and economically justified."

Additional language concerning the Mid-Reach was included in the WRDA 2007:

> SEC. 3045. BREVARD COUNTY, FLORIDA.
> "(a) SHORELINE.—The project for shoreline protection, Brevard County, Florida, authorized by section 101(b)(7) of the Water Resources Development Act of 1996 (110 Stat. 3667), is modified to authorize the Secretary to include the mid-reach as an element of the project from the Florida department of environmental protection monuments R-75.4 to R-118.3, a distance of approximately 7.6 miles. The restoration work shall only be undertaken upon a determination by the Secretary, following completion of the general reevaluation report authorized by section 418 of the Water Resources Development Act of 2000 (114 Stat. 2637), that the shoreline protection is feasible.''

1.3 Purpose and Scope

This study will determine if all or a portion of the Mid-Reach is acceptable for inclusion in the Brevard County Shore Protection Project. The study length is 7.8 miles and fills the entire gap between Patrick Air Force Base (PAFB) in the north and the Brevard County South Reach shore protection project, which begins at Florida Department of Environmental Protection (FDEP) monument R-119. After review of the Chief of Engineers report of December 23, 1996, the beginning and ending points are the same as the area removed from the recommended plan at that time. Verification of the distances by aerial photography measure 7.8 miles. This report will determine if the project is technically sound, environmentally acceptable, and economically justified. Appendix A, Engineering Analysis and Design, will include suitable data to proceed into the preconstruction, engineering, and design (PED) phase of the project. Following the PED phase, construction of the recommended plan will be contingent upon available Federal and non-Federal sponsor funds and will be subject to Department of the Army policy, guidance, and regulations.

1.4 Location of the Study Area

The Brevard County Mid-Reach study area is on the east coast of Florida just south of Cape Canaveral. The Mid-Reach includes the Atlantic shoreline from the south end of PAFB to just north of the city of Indialantic (from Florida Department of Environmental Protection (FDEP) monument R-75.4 to R-119, from north to south). This length is approximately 7.8 miles long and is recommended rather than that in the study authorization to complete the entire length between PAFB and the constructed Brevard County South Reach shore protection project. There are three municipalities (Satellite Beach, Indian Harbour Beach, and Melbourne) and portions of unincorporated Brevard County located within the project area. A location map is shown in **Figure 1-1**.

1.5 History of the Investigation

The Atlantic coast of Brevard County has experienced erosion of the shoreline over the last several decades. The local sponsor for this project, the Brevard County Board of County Commissioners, is very interested in resolving the beach erosion problems in Brevard County. The Mid-Reach study area was first investigated in a reconnaissance report for Brevard County, where it was concluded that further investigation was warranted. The feasibility report for Brevard County included the Mid-Reach study area and developed a plan for beach nourishment. During review of the report, concerns were raised on the environmental impact to the nearshore hardbottom in the Mid-Reach. In order to allow the North and South Reaches to continue towards authorization and construction, the Mid-Reach was removed from the recommended plan. Subsequent study authorization of the GRR reinvigorated attention on the Mid-Reach.

Figure 1-1. Brevard County Mid-Reach Study Area

1.6 Prior Reports and Existing Projects

1.6.1 Prior Federal Studies

Summaries of prior Federal studies relevant to this project are as follows:

a. Limited Reevaluation Report and Environmental Assessment, North Jetty Sand-Tightening and Jetty Extension, Canaveral Harbor, Florida. US Army Corps of Engineers, Jacksonville (2003). This report recommended permanent sand tightening and north jetty extension to maximize the positive benefit of sand management at the harbor entrance and to reduce maintenance dredging. The project is designed to maintain impounding of sand north of the north jetty consistent with sand bypassing operations (please see Appendix K, Sub-Appendix K: Prior National Environmental Policy Act Documents for a copy of the Finding of No Significant Impact).

b. Limited Reevaluation Report, Brevard County, Florida, Shore Protection Project. US Army Corps of Engineers, Jacksonville (1999). This report added project refinements of an access lane to Borrow Area I, two alternative borrow areas, two nearshore disposal and sand re-handling areas, and updated benefits, costs and cost sharing.

c. Feasibility Report with Final Environmental Impact Statement. US Army Corps of Engineers, Jacksonville (1996). This study recommended beach nourishment along two reaches: (1) North Reach; and (2) South Reach. PAFB was removed from the study at their own request. The North Reach extended 9.4 miles from Port Canaveral Entrance to PAFB (FDEP Monuments R-1 to R-53). The South Reach extended approximately 11 miles from PAFB to Spessard Holland Park North (R-75.3 to R-138). Of this original South Reach, the northern 7.8 miles were found to have nearshore outcrops of coquina rock and isolated patches of sabellariid worm rock from about R-75.3 to R-118. Beach nourishment along this 7.8-mile long area would result in potential impact (burial) of up to 31 acres of rock hardgrounds. Brevard County and the Corps jointly elected to delete this reach of shoreline. The South Reach was modified to the limits R-119 to R-138 (please see Appendix K, Sub-Appendix K: Prior National Environmental Policy Act Documents for a copy of the Record of Decision).

d. Reconnaissance Report, Brevard County, Florida. US Army Corps of Engineers, Jacksonville (1992). The intent of this reconnaissance study was to assess the shoreline along the Brevard County being impacted by beach erosion. Federal participation was recommended for four reaches: Cocoa Beach, Patrick Air Force Base, Satellite-Indian Harbour Beach, and Indialantic-Melbourne Beach. Patrick Air Force Base was removed from further study by their own request.

e. Design Memorandum, Canaveral Harbor, Florida. US Army Corps of Engineers, Jacksonville (1992). This report recommended deepening the Inner Entrance

Channel to 40 feet and deepening portions of the Middle Turning Basin and West Access Channel to 39 feet.

f. Supplement to the General Design Memorandum, Sand Bypass System, Canaveral Harbor, Florida. US Army Corps of Engineers, Jacksonville (1991). This report recommended using a dredge to move sand from the north side of the north jetty to beaches on the south side of the south jetty as the most cost effective and technically feasible method of bypassing. The analysis used an annual bypassing volume of 106,000 cubic yards, and recommended dredging every five years at a quantity of 530,000 cubic yards each event.

g. General and Detail Design Memorandum Addendum: Brevard County, Florida. US Army Corps of Engineers, Jacksonville (1978). This report provided the engineering, design and cost/benefit analyses for the 2.0 mile Indialantic segment including sand source.

h. General and Detail Design Memorandum: Brevard County, Florida. US Army Corps of Engineers, Jacksonville (1972). This report provided results of the engineering, design, and cost/benefit analyses for the Cape Canaveral segment and Indialantic segments of the beach nourishment project. A segment of 2.1 miles at Cape Canaveral was recommended using material from Canaveral Harbor dredging. The 2.0 mile segment at Indialantic was deferred until an economical sand source could be found.

i. Beach Erosion Control Study on Brevard County, Florida (1967). This report recommended Federal participation in a 2.8 mile beach nourishment project just south of Canaveral Harbor and for 2.0 miles at Indialantic-Melbourne Beach.

1.6.2 Prior Non-Federal Studies
Summaries of prior non-Federal studies relevant to the project are as follows:

a. Assessment of Nearshore Rock and Shore Protection Alternatives Along the “Mid-Reach” of Brevard County, Florida. Olsen Associates (2003). The intent of this study was to “identify (1) the physical abundance and character of nearshore rock outcrops, (2) the severity of beach erosion impacts and (3) potential alternatives for shore protection along approximately 7.6 miles of the Brevard County shoreline between PAFB and the existing northern boundary of the Brevard County Federal Shore Protection Project, South Reach, near Indialantic.” The report describes numerous alternatives, including hydraulic fill from R-99 to R-118.3, truck haul beach fill from R-94.2 to R-99, and truck haul dune fill from R-85.4 to R-89 and R-75.4 to R-81.

b. Independent Study Report, Brevard County, Florida Shore Protection Project. D. Kriebel, R. Weggel, R. Dalrymple. (2002). Also known as the Brevard County Independent Coastal Expert (ICE) Report. This report analyzed the effects of the Canaveral Harbor Federal Navigation Project on erosion of adjacent shorelines.

This study concluded that the Federal navigation project has caused erosion damages to the shoreline of Brevard County over a distance of 10 to 15 miles south of Canaveral Harbor. The report concluded that the entire amount of sand fill planned during the 50-year lifetime of the North Reach of the Brevard County Shore Protection Project should be considered as mitigation for the effects of the Navigation Project and should be constructed at 100% Federal cost.

1.6.3 Adjacent Projects

a. Brevard County Federal Shore Protection Project. This project includes two reaches, described as the North Reach and the South Reach. The North Reach is bounded by Port Canaveral to the north and PAFB to the south. The South Reach begins near the town of Indialantic and extends southward to Spessard Holland Park. PAFB and the previously constructed South Reach beach fills bound the present 'Mid-Reach' study area. The North Reach project fill area includes 9.4 miles of shoreline from Florida Department of Environmental Protection (FDEP) Monument R-03 to R-53. Initial construction was completed in April 2001 and placed approximately 3.1 million cubic yards of material. The Air Force funded a nourishment of its beaches from R-53 to R-70, which was constructed in conjunction with the North Reach and placed 0.6 million cubic yards of fill. The South Reach project was initially nourished in two segments due to permit restrictions concerning turtle nesting season; the first segment (R-122.5 to R-139) was completed in April 2002 and the second segment (R-118.3 to R-123.5) was completed in April 2003. Total fill in the South Reach was approximately 1.6 million cubic yards. The final construction template consisted of a zero-foot design berm plus an advance fill of an additional 50 to 65 feet of berm width depending on the location. The nourishment interval for the North and South Reaches is six-years.

b. Canaveral Harbor Federal Navigation Project. Port Canaveral is located at the north end of Brevard County, approximately 14 miles north of the north limit of the Mid-Reach study area. The entrance channel and jetties are maintained through a Federal Navigation Project. Concerns over the impact of the channel and jetties to downdrift beaches led to an independent study of the effects of Canaveral Harbor completed in September 2002. The findings of the study stated that Canaveral Harbor contributed to the erosion of downdrift beaches up to 10 to 15 miles south of the channel. The Federal Navigation Project includes a bypassing feature, wherein approximately 530,000 cubic yards of material are moved by dredge every 5 years from the north side of the channel to the south side of the channel as mitigation for the channel impacts.

c. Patrick Air Force Base. The US Air Force has constructed beach fill projects on the Atlantic shoreline of Patrick Air Force Base (PAFB). Recent additions of material were placed in a beach nourishment and a dune construction project in 2001 and 2005. In 2001, approximately 598,300 cubic yards of sand were placed from R-53 to R-70 from the Canaveral Shoals II offshore borrow area via direct hopper dredge pump-out. Material in the amount of 321,500 cubic yards was placed between monuments R-54.4 and R-75.3 in conjunction with the Brevard County North Reach

Federal shore protection project in 2005. Placements within the southernmost two miles of the base, where nearshore rock outcroppings exist, was limited to placement above water and in the dune area. The material was obtained from the Canaveral Shoals II borrow area. Based upon the as-built sediment samples along the project area, all of the sand placed was well within State requirements for beach fill. The fines fraction was less than 1% throughout and monitored turbidity levels at both the PAFB and adjacent areas were low (well below maximum allowances) and nearly identical to the levels measured prior to the dredging activities (Olsen 2005c).

d. Brevard County Dune Restoration. In winter 2004/2005, Brevard County completed a dune restoration project in association with the FEMA Emergency Berm Project and the State Interim Dune Project following hurricane damages. The project aimed to provide restoration of the dunes with a placement ranging from 5 to 10 cubic yards per linear foot of shoreline using sand from upland sources. Approximately 307,300 cubic yards of material were placed in the Mid-Reach and another 252,200 cubic yards placed along the South beaches. In spring 2006, FEMA funded a restoration of approximately 127,500 cubic yards in the Mid-Reach and 47,000 cubic yards along the South beaches. The most recent project was funded by the County and State of Florida, without FEMA funding, to place approximately 97,000 cubic yards in the Mid-Reach and 31,000 cubic yards along the South beaches in spring 2008.

1.7 Planning Process and Report Organization

This GRR documents the Mid-Reach study from initiation, through formulation, comparison, and recommendation. The USACE planning process also ensures adherence to applicable laws, regulations and policy. This GRR includes an integrated Supplemental Environmental Impact Statement (SEIS) that documents compliance with applicable environmental laws and regulations. This SEIS supplements the Environmental Impact Statement prepared for the Brevard County Shore Protection Project in 1996.

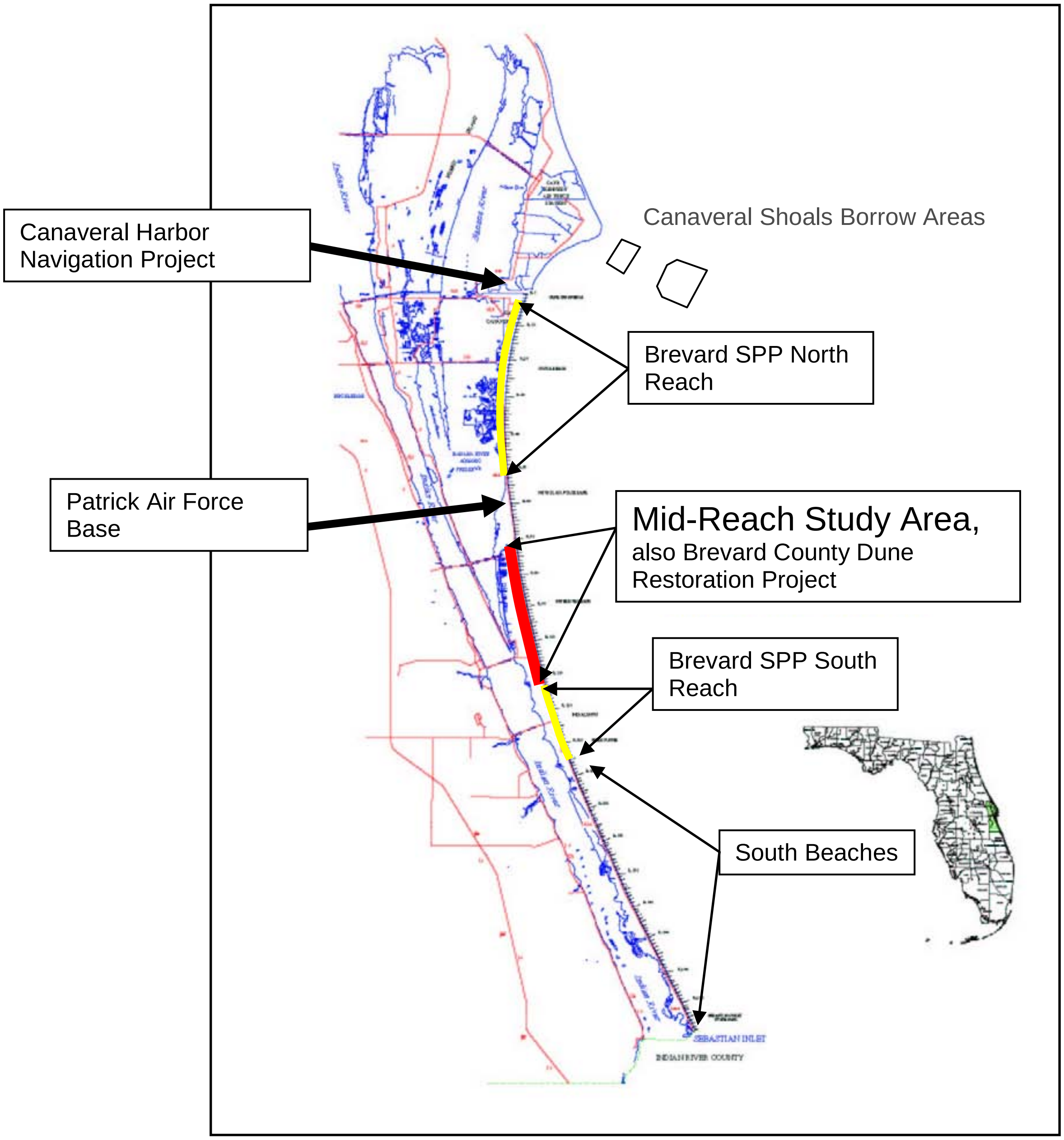

Figure 1-2. Brevard Mid-Reach and Adjacent Projects Map

2 EXISTING CONDITIONS

2.1 General

The existing conditions are quantified and qualified for the Mid-Reach study area. Information gathered in this step helps to describe the problems and opportunities and forecast future conditions. The following paragraphs document the research into past studies and data collection efforts conducted for the Brevard Mid-Reach project.

2.2 Physical Conditions

The Brevard County Mid-Reach study area consists of an open sandy coast subject to frequent storm events. Adjacent properties to the shoreline can be categorized as urban and include residential, commercial, and recreational properties. The physical characteristics of the shoreline were studied to understand the shoreline changes over time and up to present conditions. Information on the existing condition was collected, including aerial photography, topography and bathymetric surveys, shoreline change rates and storm frequency relationships. Many factors influence the coastal processes characteristic to the Brevard County, Florida shoreline. Natural factors include winds, tides, currents, waves, storm effects, and sea level rise. Anthropogenic factors include other shore protection projects and navigation projects. The role of each of these factors and their contribution to beach erosion in Brevard County Mid-Reach are briefly described in the following paragraphs.

2.2.1 Reaches

The 7.8 mile length of the Mid-Reach is separated for analysis into 6 sub-reaches and follows FDEP R monuments: Reach 1 from R-119 to R-109, Reach 2 from R-109 to R-105.5, Reach 3 from R-105.5 to R-99, Reach 4 from R-99 to R-93, Reach 5 from R-93 to R-83, and Reach 6 from R-83 to R-75.4. The Reaches were divided based on the quantity of nearshore rock, in order to address the constraint to avoid impacts. The breaks between reaches correspond to changes in the cumulative quantity of rock. The nearshore rock was quantified using the most recent aerial photography (dated June 2004). The acreage of nearshore rock in the Mid-Reach is highly variable in the longshore direction and, in general, increases to the north. Rock acreage in each reach, based upon June 2004 mapping, is listed in **Table 2-1**. The acreage of rock exposed varies over time with erosional weather events. The surveys from June 2004 indicated approximately 31 acres of exposed rock within the study area. Based on the quantities of rock identified in the Mid-Reach study area, the acreage of rock within each reach was calculated. No rock exists south of the study area, but rock that exists north of the study area will be evaluated for impacts. **Figure 2-1** illustrates the distribution of rock between FDEP monuments and the cumulative distribution of rock acreage. **Figure 2-2** shows the plan view location of the reaches within the Mid-Reach study area.

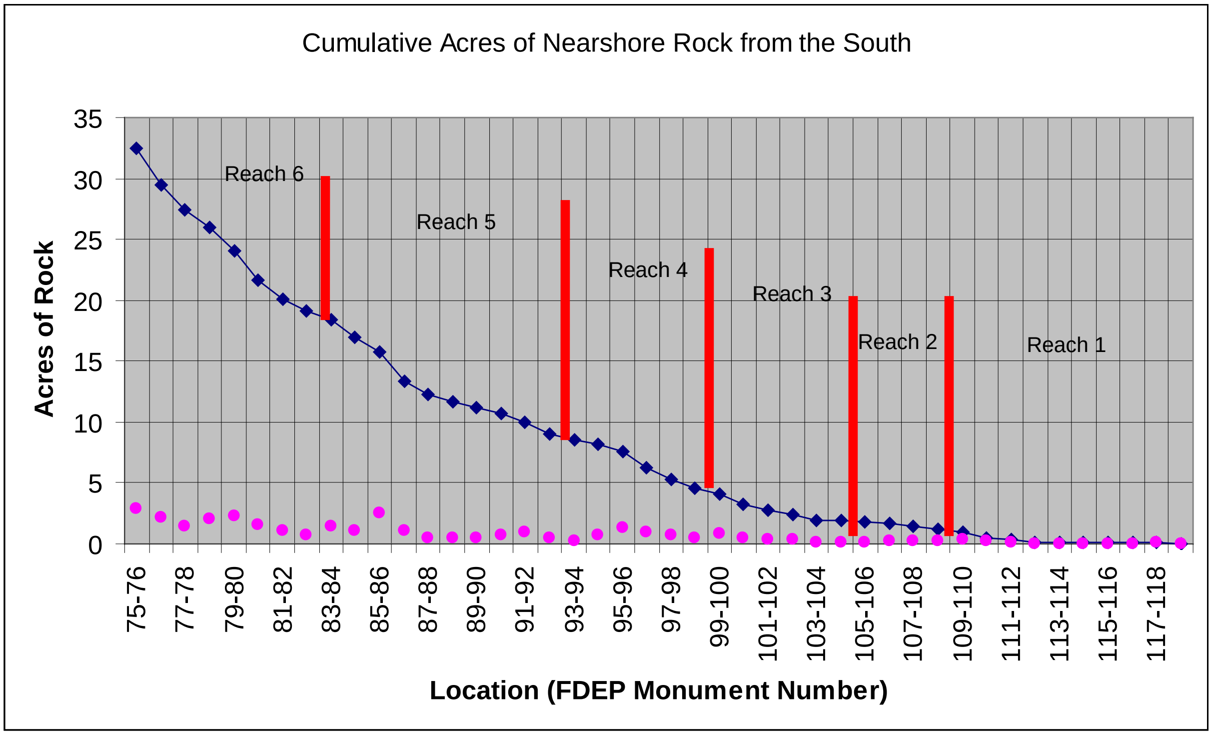

Figure 2-1. Nearshore Rock abundance

Dots represent rock acres between monuments; line indicates cumulative acres from the south end of the Mid-Reach. (data provided by Dial Cordy and Associates)

Table 2-1. Acres of Hardbottom by Reach

	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Sum
Acres of Hardbottom	0.9	0.8	2.4	4.4	9.9	12.9	31.3
Length (miles)	1.8	0.6	1.2	1.1	1.7	1.4	7.8

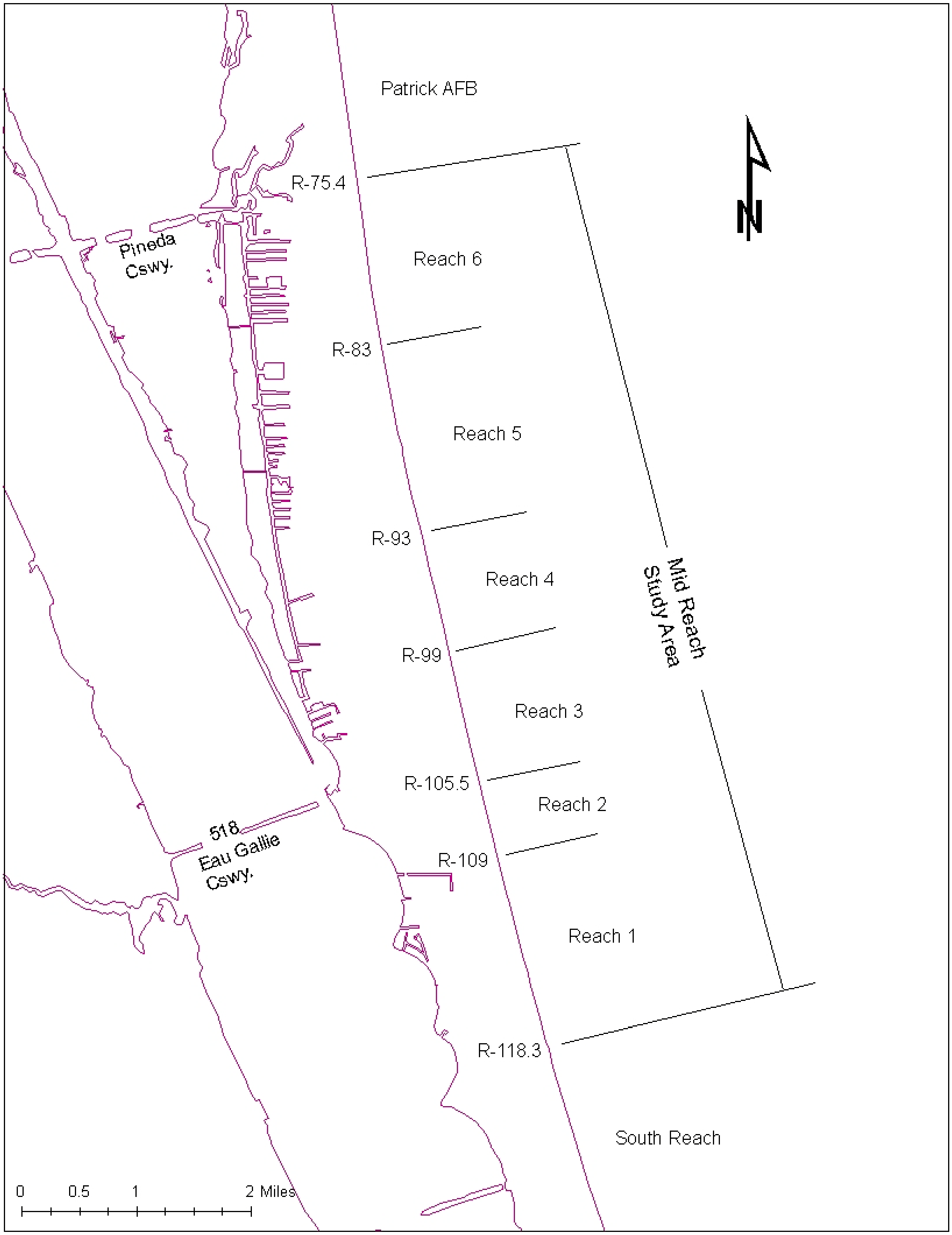

Figure 2-2. Reaches Associated with the Brevard County Mid-Reach Study Area

2.2.2 Shoreline Change

An analysis of historical Brevard County shorelines was undertaken in an effort to identify regions of shoreline erosion and accretion. Mean high water (MHW) shoreline positions for the years 1972 and 1986 were obtained from Florida Department of Environmental Protection (FDEP) surveys. Shorelines from 1994, 2002, and 2005 were extracted from USACE surveys. All shoreline positions are referenced to survey monuments (benchmarks) established by FDEP. The monuments considered in this analysis are R-76 through R-118, which coincides with the limits of the Mid-Reach study area. The mean high water line change is represented in **Figure 2-3** and **Table 2-2**, and summarized in **Table 2-3**. The mean high water line position shows some variation along the Mid-Reach, with areas of considerable erosion. The accretion shown at the southern end of the area is most likely longshore drift from the adjacent Brevard County South Reach shore protection project. When averaged over the entire Mid-Reach, the erosional areas and accretional areas counteract each other to some degree, resulting in an average annual recession of 0.2 foot per year. A unique characteristic of Brevard County is the steep bluff landward of the beach, which is 7 to 12 feet higher than the beach berm. Much of the coastal development is built atop the bluff and is subject to damage from storm-induced erosion. The impacts of tropical storms and nor'easters on the Mid-Reach beaches cause an erosion of the berm and undermining of the bluff, which causes sections of the steep bluff to slough. **Figure 2-3** illustrates the rate of change for the mean high water line and bluff during the period from1972 to 2005. While the 30-year average shoreline change for the Mid-Reach study area represents a relatively small average recession (with significant longshore variation), the bluff is receding at an average rate of over half a foot per year, with localized maximums of more than one foot per year. During the same period, the bluff did not advance at any monument locations. Data suggests that while the beach partially or fully recovers following storms, in part due to input from bluff material, the bluff generally does not recover, thus causing cumulative erosion of the bluff.

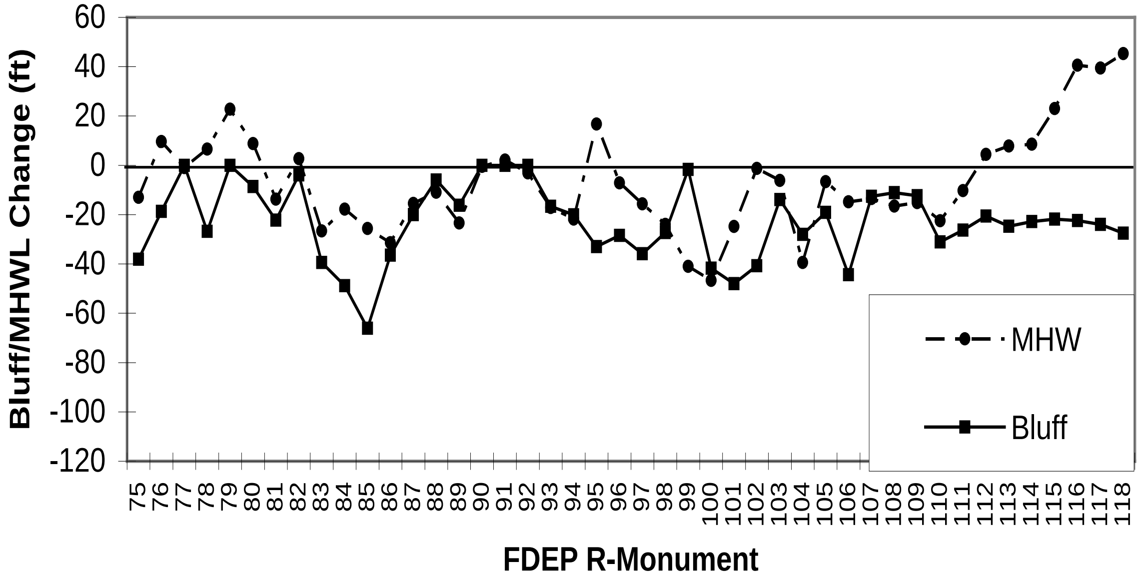

Figure 2-3. Mean High Water Line and Bluff Line Erosion, 1972-2005

Table 2-2. Mean High Water Line and Bluff Line Erosion, 1972-2005

Monument	Change in Bluff Line (feet)	Change in Mean High Water Line (feet)
75	**-38**	**-13**
76	**-19**	**10**
77	**Armored**	**-1**
78	**-27**	**7**
79	**Armored**	**23**
80	**-9**	**9**
81	**-22**	**-14**
82	**-4**	**3**
83	**-39**	**-27**
84	**-49**	**-18**
85	**-66**	**-26**
86	**-36**	**-31**
87	**-20**	**-16**
88	**-6**	**-11**
89	**-16**	**-23**
90	**Armored**	**0**
91	**Armored**	**2**
92	**Armored**	**-3**
93	**-17**	**-17**
94	**-20**	**-22**
95	**-33**	**17**
96	**-28**	**-7**
97	**-36**	**-16**
98	**-27**	**-24**

Monument	Change in Bluff Line (feet)	Change in Mean High Water Line (feet)
99	**-2**	**-41**
100	**-42**	**-47**
101	**-48**	**-25**
102	**-41**	**-1**
103	**-14**	**-6**
104	**-28**	**-39**
105	**-19**	**-7**
106	**-44**	**-15**
107	**-13**	**-14**
108	**-11**	**-17**
109	**-12**	**-15**
110	**-31**	**-23**
111	**-26**	**-10**
112	**-21**	**4**
113	**-25**	**8**
114	**-23**	**9**
115	**-22**	**23**
116	**-22**	**41**
117	**-24**	**39**
118	**-28**	**45**

Brevard County Mid-Reach	**1972-2005**	
From R-75 to R-118	**Bluff Line**	**Mean High Water Line**
Average Change (ft)	**-25.5**	**-6.5**
Average Annual Change (ft/yr)	**-0.8**	**-0.20**

Table 2-3. Average Historical Erosion Rates by Reach

Reach	Length (feet)	Erosion (cy/ft/yr)	Erosion (cy/Reach/yr)
1	9,599	0	0
2	3,406	0.5	1,700
3	6,239	1.2	7,500
4	5,603	1.7	9,500
5	9,029	0.9	8,100
6	7,207	1.4	10,100

2.2.3 Native Beach Materials

The native beach sediments at the Mid-Reach consist predominately of greenish or light grey colored, fine to medium grained quartz and carbonate sand with variable amount of shell fragments. The median grain diameter (D_{50}) of its composite sample is 0.26 mm. The grain size statistics indicate the materials are poorly sorted. The silt contents (passing #230 sieve) in composite samples range from 1.8 percent to 3.6 percent with an average of 2.6 percent. The gravel contents vary from 0 to 4.7 percent with an average of 1.9 percent.

2.2.4 Winds

Winds and the short-period waves they produce are the primary mechanisms of sand transport at the project site. Winds offshore in the project area vary seasonally with typical prevailing winds from the northeast through the southeast. Low-pressure winter cold fronts generally traverse the continental United States from west to east. These conditions occasionally produce strong storms, called nor'easters, which can cause extensive beach erosion and shorefront damage. The summer months (June through October) are characterized by southeast trade winds and tropical weather systems traveling east to west in the lower latitudes. Tropical cyclones may develop into tropical storms and hurricanes, which generate devastating winds, waves and storm surge when they impact the project area.

2.2.5 Tides and Currents

Tides in the area are semi-diurnal, which means there are two high tides and two low tides each day. The mean tidal range at Port Canaveral is 3.5 feet. The National Ocean Service has established tidal datums at the Port Canaveral Entrance, including mean high water (MHW) at 1.99 feet above the National Geodetic Vertical Datum of 1929 (NGVD), and mean low water (MLW) at 1.61 feet below NGVD. The US Army Corps of Engineers, Jacksonville District has established a fixed construction datum for Port Canaveral, also referred to as MLW, which is 1.90 feet below NGVD. The primary ocean current in the project area is the Florida Gulf Stream. With the exception of intermittent local reversals, it flows northward. The average annual current velocity is approximately 28 miles per day, varying from an average monthly low of about 17 miles per day in November to an average monthly high of approximately 37 miles per day in July. The axis of the Florida Gulf Stream typically lies about 30 nautical miles east of Cape Canaveral. The nearshore currents in the Mid-Reach are not directly influenced by the Gulf Stream, but may be influenced indirectly via interaction with incident waves. Littoral currents affect the supply and distribution of sediment on the sandy beaches of Brevard County. Longshore currents, induced by oblique wave energy, generally determine the long-term direction and magnitude of littoral sediment transport. Influence of Port Canaveral's ebb and flood currents on local currents is negligible since the Mid-Reach lies 14 miles to the south of Canaveral Harbor, outside the influence of its tidal fluctuations. The most influential cross-shore currents are generally induced by large storm waves and/or water levels. Storm-induced cross-shore currents often result in the offshore transport of beach material, resulting in temporary or permanent erosion of the beach. There is a shift in wave direction from northerly in the winter to southerly in the summer, with corresponding shift in the direction of littoral transport. The net direction of littoral transport is from north to south.

2.2.6 Waves

The dissipation of energy as waves enter the nearshore zone and break is the principal method of beach erosion. Wave height and period, in combination with tides and storm surge, are the most important factors influencing the project shoreline. Project data is taken from the US Army Corps of Engineers, Waterways Experiment Station's Coastal Engineering Research Center wave hindcast studies from station 442 located 9.9 miles offshore of the project area in 70 feet of water depth. The region encounters relatively high-energy waves during the winter as a result of nor'easters and again in the late summer and fall as a result of tropical storms and hurricanes. Mean monthly wave heights range from 2.33 feet in July to 5.09 feet in November. The data also show an increase of more powerful, longer period waves during the late summer and winter months; whereas, early and mid-summer waves seldom reach greater than 10 seconds. The deep-water wave direction varies from northerly waves from December through March to southeasterly and easterly waves from tropical disturbances from July through October.

2.2.7 Storm Effects

Storm surge can be defined as an increase in water level, resulting from atmospheric weather systems. Surges occur primarily as a result of atmospheric pressure gradients and surface stresses created by wind blowing over a water surface. In addition to wind speed, direction and duration, storm surge is also influenced by water depth, length of fetch and frictional characteristics of the nearshore sea bottom. Storm surge is taken into account in the design of beach fill crest elevations by considering potential coastal flooding and larger waves allowed by the increased water depth. From historical information, a storm frequency table was developed to describe the potential effects of storms on the shoreline. The recession listed in **Table 2-4** is the landward extent where a six inch change in elevation occurred and does not include post storm recovery. The recession is measured from the MHW line landward to the point where a six-inch reduction in elevation occurred. The analyses behind **Table 2-4,** including the SBEACH background in the 1996 Feasibility Study, are detailed in Appendix A.

Table 2-4. Storm Frequency in Reach 3- Indialantic Beach

Probability of Occurrence	Recession (feet)	Return Period (years)
0	500	
0.005	214	200
0.007	209	150
0.01	196	100
0.013	184	75
0.02	164	50
0.04	156	25
0.1	148	10
0.2	134	5
0.5	111	2
1	24	1

2.2.8 Sea Level Rise

Relative sea level (RSL) refers to local elevation of the sea with respect to land, including the lowering or rising of land through geologic processes such as subsidence and glacial rebound. It is anticipated that sea level will rise within the next 100 years. To incorporate the direct and indirect physical effects of projected future sea level change on design, construction, operation, and maintenance of coastal projects, the U.S. Army Corps of Engineers (USACE) has provided guidance in the form an Engineering Circular, EC 1165-2-211.

EC 1165-2-211 provides both a methodology and a procedure for determining a range of sea level rise estimates based on the local historic sea level rise rate, the construction (base) year of the project, and the design life of the project. Three estimates are required by the guidance, a baseline estimate representing the minimum expected sea level change, an intermediate estimate, and a high estimate representing the maximum expected sea level change. Using equation (3) of EC 1165-2-211, Appendix B, baseline, intermediate, and high sea level rise values were estimated over the life of the project. Based on historical sea level measurements taken from NOS gage 8721120 in Daytona Beach, FL (~75 miles to the north), the historic sea level rise rate was determined to be +2.32 +/- .62 mm/year (0.0076 ft/year) (http://tidesandcurrents.noaa.gov/sltrends/index.shtml); the project base year was specified as 2013; and the project period of analysis was projected to be 50 years. **Figure 2-4** shows the three levels of projected future sea level rise for the period of analysis. From these curves the average baseline, intermediate, and high sea level rise rates were found to be 0.0076 ft/year, 0.015 ft/year, and 0.0412 ft/year, respectively.

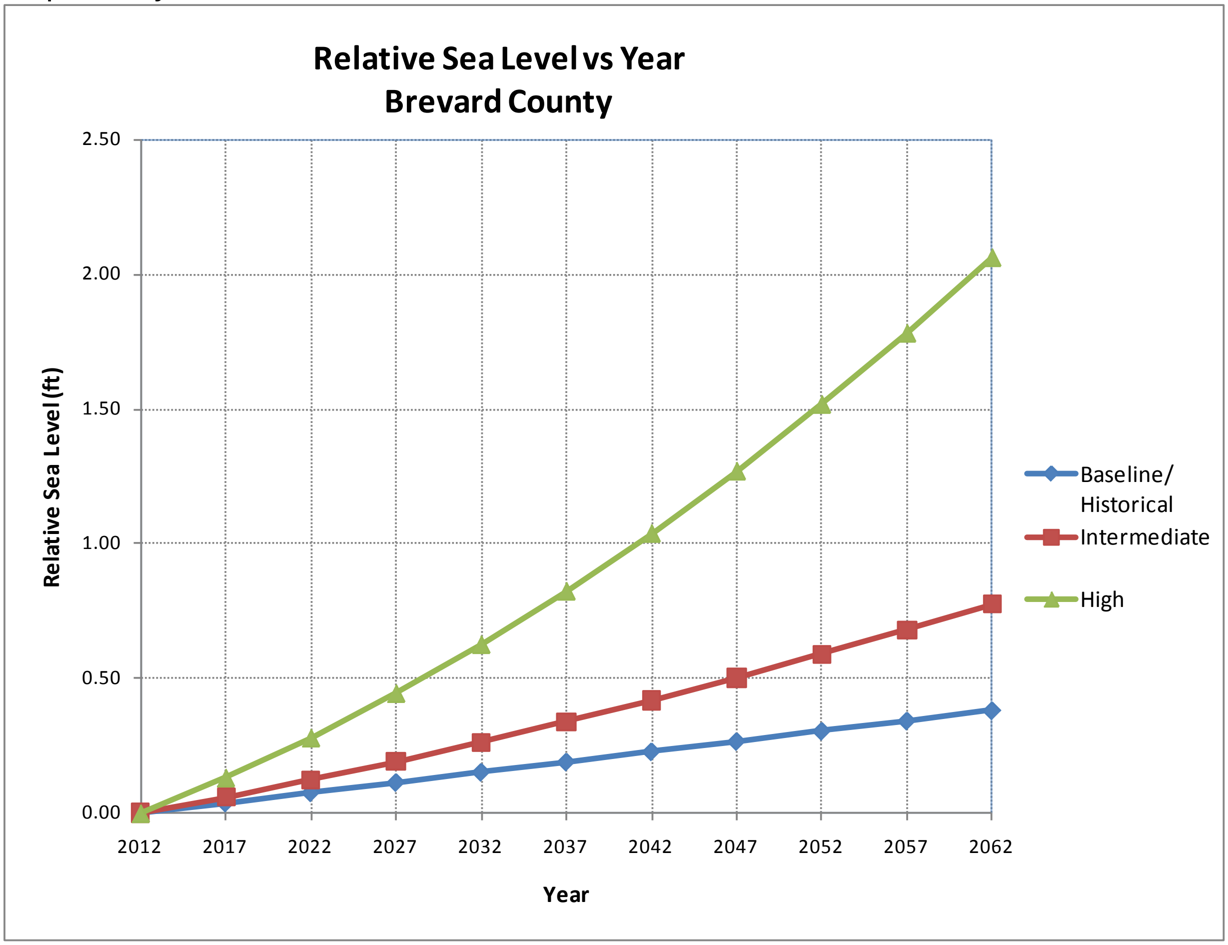

Figure 2-4. Relative Sea Level Rise, Brevard County

Using the calculated sea level rise, berm height, depth of closure, and width of active profile, shoreline recession (in –feet) and volume lost (in cubic yards per foot) are found. **Table 2-5** shows the annualized rates of sea level rise, shoreline recession, and volume change.

Table 2-5. Annualized Rates of Sea Level Rise, Shoreline Recession & Volume Lost

	Sea Level Rise (S) in ft/yr	Shoreline Recession (X) in -ft/yr	Volume Lost (V) in cy/ft/yr
Baseline	0.01	0.50	0.51
Intermediate	0.02	1.01	1.03
High	0.04	2.69	2.75

2.2.9 Effects of Other Shore Protection/Navigation Projects

Canaveral Harbor Federal Navigation Project is approximately 14 miles north of the Mid-Reach study area. The inlet has jetties on both the north and south sides and is a potential obstruction to the normal north to south littoral movement of sand. Studies by Kriebel, et al (2002) and Kraus, et al, (1999) detailed the effects of Canaveral Harbor on Brevard County beaches. These reports found that the Mid-Reach beaches were, on average, moderately erosional both before and after construction of the inlet, and concluded that Canaveral Harbor's influence on sediment transport likely does not extend as far south as the Mid-Reach. Numerous beach nourishments have taken place in Brevard County; **Table 2-6** summarizes these events. Although none of the listed beach fills occurred within the Mid-Reach, several took place on adjacent or nearby shorelines and are highlighted in **Table 2-6**. It is likely that, if any, the effects of adjacent beach nourishment activities were beneficial to the Mid-Reach. In particular, the South Reach initial fill in 2002-2003 and Flood Control and Coastal Emergency (FCCE) beach fill south of the project likely contributed to the mean high water advancement near the Mid-Reach's southern limits. The South Reach monitoring report (2003) indicated that the southern end of the Mid-Reach exhibited net gains of approximately 37,000 cubic yards of sand one year after the South Reach was initially constructed in 2002. These gains can be attributed to end losses from the South Reach fill. The Brevard County Dune Restoration project was constructed within the Mid-Reach study area, with phases being completed in April 2005, April 2006, and April 2008. The fill activity provided restoration of lost fill following hurricane activity in 2004. The effect is short term restoration with minimal impact on the long term erosional characteristics of the shoreline.

Table 2-6. Brevard County Beach Fill Activities

Date	Start	End	Project	Start	Finish	Volume of Fill (cubic yards)
1972	R-0	R-14	Fed Nav Proj O&M Beach Disposal	Mar-72	Sep-72	200,000
1974-75	R-0	R-14	Fed SPP Beach Restoration	Apr-74	Nov-74	1,250,000
1974-75	R-0	R-14	Trident Pier New Work Beach Disp	Apr-74	Nov-74	1,600,000
1980-81	R-126	R-136	Fed SPP Beach Restoration	Oct-80	Jan-81	540,000
1992	R-28	R-31	Fed Nav Proj O&M Nearshore Disposal	Jun-92	Aug-92	158,000
1993	R-28	R-31	Fed Nav Proj O&M Nearshore Disposal	Jul-93	Nov-93	200,000
1994	R-5	R-11	Local Beach Nour, City/Port Auth Co-Sponsors	Feb-94	Apr-94	100,000
1994	R-28	R-31	Fed Nav Proj O&M Nearshore Disposal	Oct-94	Oct-94	65,590
1994	R-28	R-31	Fed Nav Proj O&M Nearshore Disposal	Oct-94	Nov-94	69,390
1995	R-0	R-8	Fed Nav Proj Sand Bypass Beach Disposal	Jan-95	May-95	783,000
1995	R-28	R-31	Fed Nav Proj O&M Nearshore Disposal	Aug-95	Dec-95	322,990
1980-95	R-53	R-75	Patrick AFB	NA		380,000
1996	R-34	R-38	Local Beach Nour, City/Port Auth	Feb-96	Nar-96	40,000

			Co-Sponsors			
1998	R-3	R-14	Fed Nav Proj Sand Bypass Beach Disposal	Apr-98	Jun-98	964,500
1996-98	R-53	R-75	Patrick AFB	NA		250,000
2000-01	R-03	R-53	Fed SPP North Reach Initial Nour	Nov-00	Apr-01	3,138,300
2000-01	R-53	R-64	Patrick AFB Nourishment main fill	Nov-00	Apr-01	515,000
2000-01	R-64.5	R-70	Patrick AFB Nourishment thin fill	Nov-00	Apr-01	83,000
2002-03	R-118.3	R-139	Fed SPP South Reach Initial Nour	Feb-02	Apr-03	1,346,000
2003	R-28	R-39	Fed Nav Proj O&M Nearshore Disposal	Jul-03	Aug-03	50,000
2004/05	R-118.3	R-137.5	Fed SPP South Reach FCCE Fill		May-05	579,000
2004/05	R-5	R-20	Fed SPP North Reach FCCE Fill		May-05	305,000
2004/05	R-33	R-53	Fed SPP North Reach FCCE Fill		May-05	330,000
2004/05	R-75.4	R-118.3	Brevard Co., FDEP, & FEMA Dune Restoration	Dec-04	Apr-05	307,300
2004/05	R-138	R-213	Brevard Co., FDEP, & FEMA Dune Restoration	Dec-04	Apr-05	252,200
2005	R-54.5	R-65	Patrick AFB			258,300
2005	R-65	R-75.4	Patrick AFB			63,200
2006	R-75.4	R-118.3	FEMA Dune Restoration	Feb-06	Apr-06	127,478
2006	R-138	R-213	FEMA Dune Restoration	Feb-06	Apr-06	47,145
2008	R-75.4	R-118.3	Brevard Co. & FDEP Dune Restoration	Feb-08	Apr-08	97,000
2008	R-138	R-213	Brevard Co. & FDEP Dune Restoration	Feb-08	Apr-08	31,000
2010	R-4	R-14	Canaveral Harbor Sand Bypass IV	Feb-10	Apr-10	642,000
2010	R-118.3	R-137.5	Fed SPP South Reach Renourishment	Feb-10	Apr-10	630,000
					Total	15,404,000

Highlighted Nourishment Activities are Near the Mid-Reach Study Area (R75 - R118.3)

2.2.10 Inlet Effects

An independent study was completed in September 2002 by D. Kriebel, R. Weggel, and R. Dalrymple to analyze the effect of the Canaveral Harbor Federal Navigation Project on the shorelines to the south of the harbor. The study concluded that erosion was caused by the project up to 10 to 15 miles south of the inlet. The Brevard County Mid-Reach study area begins at a point 14 miles south of the inlet and includes 7.8 miles of shoreline. The shoreline change analysis included the period when erosion effects on the Mid-Reach study area would have been occurring. Therefore, as the erosive effects of the inlet are included in the shoreline erosion of the area and the limit of the effects of the inlet includes only a small portion of the Mid-Reach study area, no further study to quantify the inlet effects will be included.

2.3 Environmental and Historic Resources

2.3.1 General Environment

The general area of the project includes the coastal barrier island of central Brevard County on Florida's east coast, bound on the west by the extensive estuarine lagoon system of the Banana and Indian Rivers and on the east by the Atlantic Ocean. The immediate project areas specifically include the 7.8-mile long shoreline of central Brevard County located between Patrick Air Force Base and Indialantic ("Mid-Reach" shoreline), the Canaveral Shoals I and II offshore sand borrow areas ("CS-I and CS-II borrow areas") located east of the Canaveral Harbor Entrance, and the Poseidon Dredged Material Management Area ("DMMA") near the northern bank of Canaveral Harbor within the Cape Canaveral Air Station at which temporary stockpiling of dredged sand is proposed **(Figure 2-5)**. Vehicle access to the area is by several causeways that connect the mainland and barrier island.

The ocean shoreline is composed of sandy beach, vegetated dunes and fragmented upland maritime hammock, and nearshore rock outcrops. The exposed rock outcrops occur within about 300 feet width of the mean low water shoreline in water depths of about 0 to 4 feet at low tide, and decrease in occurrence from north to south. The shoreline is mostly developed with a mix of commercial, residential and public park improvements. The shoreline along several properties is presently armored with seawalls and/or buried sand-filled geotextile containers, but does not otherwise feature significant coastal structures.

The CS-I offshore sand borrow area is located in State of Florida waters about 2.5 miles southeast of Cape Canaveral in water depths of about 10 to 25 feet. The CS-II offshore sand borrow area is located in federal (Outer Continental Shelf) waters about 5.7 miles southeast of Cape Canaveral in water depths of about 15 to 40 feet **(Figure 2-6)**. These borrow areas are respectively described in the project's original EIS (USACE, 1996) and subsequent Environmental Assessments (USACE, 1999), and therefore, are not described in detail in this report. The CS-II sand borrow area has been previously dredged for initial construction of the Brevard County Federal Shore Protection Project in 2000-2003 and beach nourishment along Patrick Air Force Base in 2000-01 and subsequent renourishment of both projects in Spring, 2005. The CS-I borrow area has not been dredged.

The Poseidon DMMA is an existing, upland sediment disposal area that was constructed, and previously utilized, for the placement of dredged material from the Canaveral Harbor Federal Navigation Project **(Figure 2-6)**. Beach-compatible sediment also has been previously excavated from the DMMA for placement along the Patrick AFB shoreline in 1998.

The Canaveral Ocean Dredged Material Disposal Site (ODMDS) is a 2 nautical mile (nmi) by 2 nmi square centered at the geographic coordinates 28 18'44"N latitude and 30 31'00"W longitude (NAD 27) or state plane coordinates 1446468 N and

655198 E (NAD 27) **(Figure 2-6)**. This open-ocean site lies within the Canaveral Bight on the shallow continental shelf, and is centered 4.5 nmi offshore of Cocoa Beach. Dredged material from Canaveral Harbor, which meets ocean disposal criteria, is placed here annually.

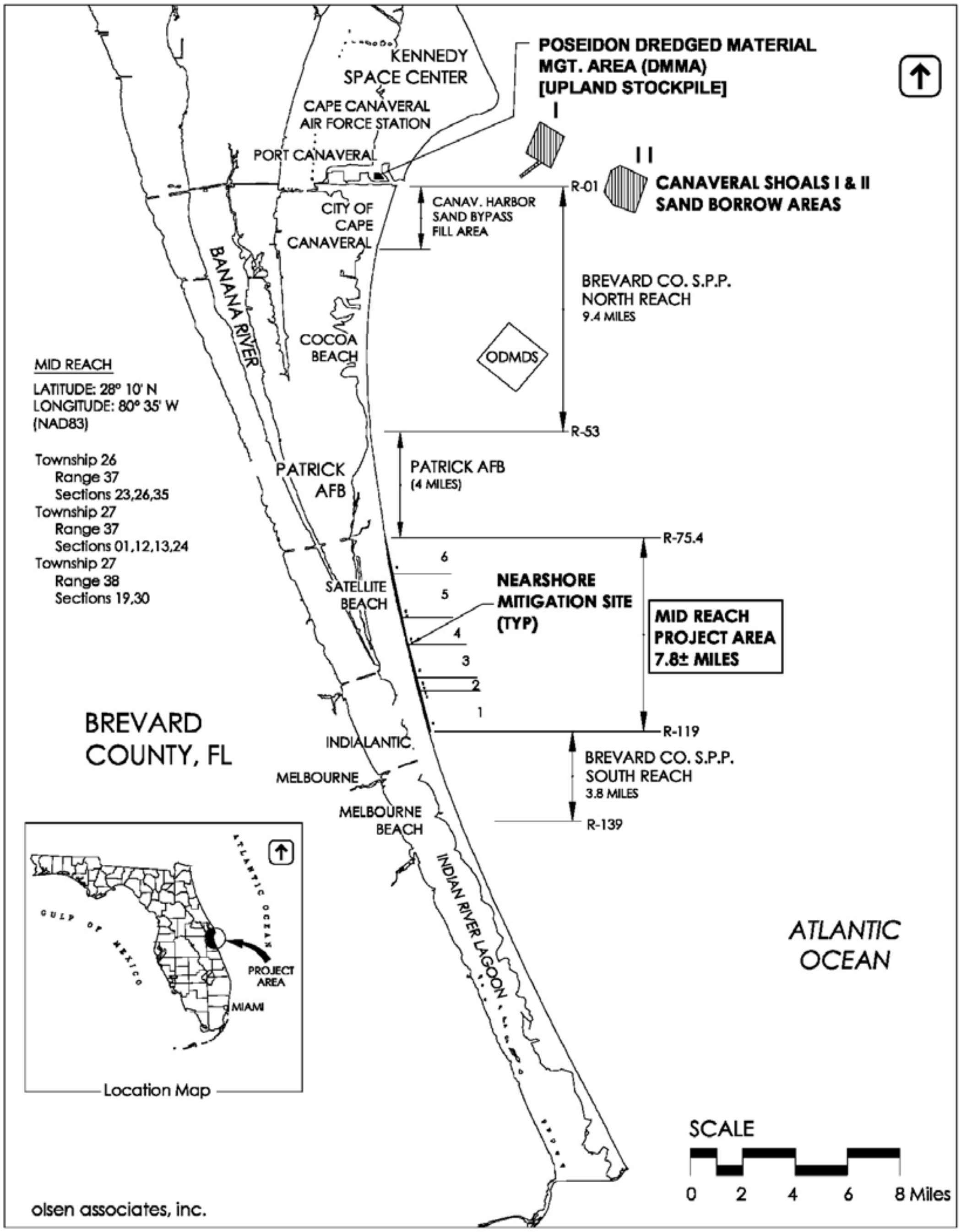

Figure 2-5. Location of project shoreline and major elements.

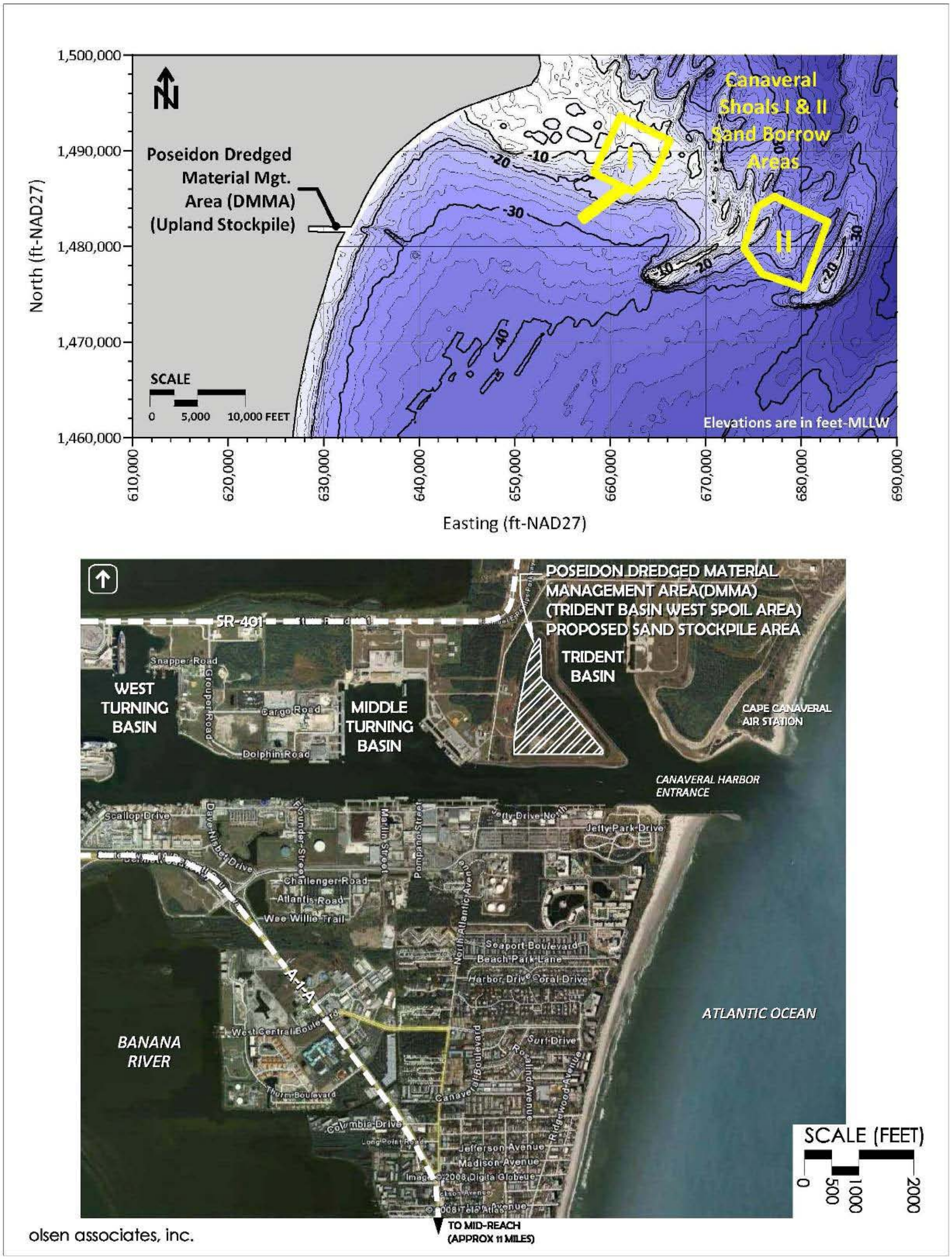

Figure 2-6. Locations of the offshore sand source (borrow) areas and the proposed DMMA temporary sand-source stockpile area.

2.3.2 Vegetation

Along the beach project area, vegetation commonly associated with the coastal strand is observed along the dune line, including seaoats (*Uniola paniculata*), bitter panicgrass (*Panicum amarum*), railroad vine (*Ipomoea pes-caprae*), seacoast marshelder (*Iva imbricata*), seashore paspalum (*Paspalum vaginatum*), marshhay cordgrass (*Spartina patens*), American searocket (*Cakile edentula*), pricklypear (*Opuntia humifusa*), largeleaf marshpennywort *(Hydrocotyle bonariensis*), gulf croton, (*Croton punctatus*), tall morning-glory (*Ipomoea purpurea*), shoreline seapurslane (*Sesuvium portulacastrum*), and seagrape (*Coccoloba uvifera*). Non-native ornamental plants and grasses occur along residential and commercial properties within uplands of the shorefront. The Dredged Material Management Area (DMMA) north of Canaveral Harbor, is characterized by invasive and invasive exotic species such as cattails (*Typha spp*.) and Brazilian pepper (*Schinus terebinthifolia*) which cover the interior berm slopes and floor of the DMMA. The exterior slopes of the berms and surrounding landscape are covered with grassy species such as saltgrass (*Distichlis spicata*) and Bahiagrass (*Paspalum notatum*) with patches of Brazilian pepper.

2.3.3 Threatened and Endangered Species

2.3.3.1 Sea Turtles

Five sea turtle species occur on the eastern Florida inner shelf (shoreline to the 20 meter isobath). In order of abundance, included are the loggerhead, green, hawksbill, Kemp's ridley, and leatherback sea turtles (**Table 2-7**). In general, this region appears to be an important year round habitat for juvenile through adult loggerhead and green sea turtles on both the inner shelf and mid shelf (20 to 40 meter isobath). Inner shelf (nearshore) hard bottom habitats, including wormreef, coquina, and limestone outcroppings, in Brevard County are important developmental habitat for juvenile green turtles (Holloway-Adkins and Provancha, 2005). The abundance and foraging activity of marine turtles along the nearshore rock resource of the Mid-Reach is described in Appendix K- Subappendix A.

Hawksbill, Kemp's ridley, and leatherback sea turtles also are found year round. In contrast with the other sea turtle species, they primarily utilize the mid shelf and, in the case of leatherbacks, the outer shelf and continental slope (Teas, 1993). The leatherback turtle has been observed in waters beyond the hardbottom substrate and juvenile hawksbill turtles have been seen stranded in the area.

All sea turtles in U.S. territorial waters are protected under the Endangered Species Act of 1973. Currently, hawksbills, Kemp's ridleys, and leatherbacks are listed as endangered species and loggerheads are listed as a threatened species. Green sea turtles also are listed as a threatened species, except for the Florida breeding population, which is listed as an endangered species. Due to an inability to distinguish between the latter two populations away from the nesting beach, green sea turtles are considered an endangered species wherever they occur in U.S.

waters (National Marine Fisheries Service [NMFS] and U.S. Fish and Wildlife Service [USFWS], 1991).

Table 2-7. Sea turtle species potentially occurring on the eastern Florida inner shelf. Species are listed in order of relative abundance.

Common and Scientific Names	Status[a]	Life Stages Present	Abundance Within the Project Area	Seasonal Presence	Nesting Season
Loggerhead sea turtle (*Caretta caretta*)	T	Adults, subadults, juveniles, and hatchlings	Abundant	Year-round (most abundant during spring and fall migrations)	April-September
Green sea turtle (*Chelonia mydas*)	T/E[b]	Adults, subadults, juveniles, and hatchlings	Common	Year-round	July-September
Hawksbill sea turtle (*Eretmochelys imbricata*)	E	Adults, subadults, juveniles, and hatchlings	Rare	Year-round	June-September
Kemp's ridley sea turtle (*Lepidochelys kempi*)	E	Juveniles and subadults	Rare	Year-round (most abundant during spring and fall migrations)	(no nesting in area)
Leatherback sea turtle (*Dermochelys coriacea*)	E	Adults, subadults, juveniles, hatchlings	Rare	March-October	March-July

[a] Status: E = endangered, T = threatened under the Endangered Species Act of 1973.
[b] Green sea turtles are listed as threatened except for in Florida, where breeding populations are listed as endangered. Due to inability to distinguish between the two populations away from the nesting beach, green sea turtles are considered endangered wherever they occur in U.S. waters.

South Brevard County has the greatest density of sea turtle nests in Florida and probably produces more turtle hatchlings per kilometer than any other beach in Florida (Ehrhart and Witherington, 1987). Loggerhead, green, and leatherback turtles account for all nests in the area (Meylan et al., 1995).

2.3.3.1(a) Loggerhead Sea Turtle

The loggerhead sea turtle (*Caretta caretta*), named for its characteristic broad and massive skull, is a relatively large sea turtle. This species occurs throughout tropical, subtropical, and temperate waters of the Atlantic, Pacific, and Indian Oceans (Dodd, 1988). In the western Atlantic, it is found in estuarine, coastal, and shelf waters from South America to Newfoundland. It is the most abundant sea turtle within nearshore waters of the project area.

Four genetically distinct loggerhead nesting subpopulations have been identified in the western North Atlantic (Marine Turtle Expert Working Group, 2000). These are 1) the Northern Nesting Subpopulation, extending from North Carolina to northeastern Florida, at approximately 29° N; 2) the South Florida Nesting Subpopulation, extending from 29° N on the Florida east coast to Sarasota on its west coast; 3) the Florida Panhandle Nesting Subpopulation; and 4) the Yucatan Nesting Subpopulation. Loggerhead turtles within the study area belong to the South Florida Nesting Subpopulation.

Loggerhead turtles are present year-round in Florida waters, with peak abundance during spring and fall migrations. Off Cape Canaveral in Brevard County, loggerheads utilize both the inner shelf and mid-shelf during all seasons except winter, when they tend to congregate on the mid-shelf (Schroeder and Thompson, 1987). Henwood (1987) found that three distinct groups of loggerheads (adult males, adult females, and subadults) moved into inner shelf waters off Cape Canaveral at different times of the year. Adult males were most abundant in April and May, adult females from May to July, and subadults during the remainder of the year. These data suggest that nesting adult females are short-term residents that migrate into the area on 2 and 3-year intervals and reside elsewhere during non-nesting years. Adult males do not seem to migrate with adult females but may reside in the vicinity of nesting beaches throughout the year. Following nesting activities, many adult loggerheads disperse to islands in the Caribbean Sea, waters off southern Florida, and the Gulf of Mexico (Meylan and Bjorndal, 1983; Nelson, 1988). Subadult loggerheads forage opportunistically along the Atlantic seaboard, although evidence suggests that a resident population of subadults overwinter in the Canaveral area each year (Henwood, 1987). In Brevard, Indian River, and St. Lucie Counties, juvenile and subadult loggerheads are found throughout the year in estuarine habitats (Ehrhart, 1983, 1992; Henwood, 1987; Ehrhart and Redfoot, 1996; Bresette et al., 2000; Ehrhart et al., 2001; Holloway-Adkins, 2005; Provancha et al., 2005). In comparatively smaller numbers, juvenile and subadult loggerheads have been found in shallow (2 to 4 m deep), hard bottom habitats along the coasts of Brevard and Indian River Counties (Ehrhart et al., 1996; Ehrhart et al., 2001; Holloway-Adkins and Provancha, 2005). In the project area, loggerheads represented less than 2.0% of the turtle species sighted during visual transects. No loggerheads were captured during netting events conducted since 2004 (Holloway-Adkins, 2005; Holloway-Adkins and Provancha, 2005).

Ninety percent of loggerhead nesting in the U.S. occurs in south Florida (Shoop et al., 1985). Their nesting season in southeast Florida (meant here as Brevard County through the Florida Keys) is reported to extend from late April through September. March and April are transitional months for loggerheads off Cape Canaveral, Florida. Juveniles, which are thought to overwinter in the area, depart and are replaced by adult males that migrate into the area to mate (Ryder et al., 1994).

The adult loggerhead population increases in Florida waters during the nesting season (Magnuson et al., 1990). Male and female loggerheads have frequently been captured in the Port Canaveral Shipping Channel in spring and summer months (Henwood, 1987) and were recently captured during fall and winter trawling events

(T. Bargo, unpublished data). However, adult loggerheads were not seen in the project area during daylight in-water surveys and have been infrequently encountered during netting studies conducted in Indian River County (Ehrhart et al., 2001). It appears the nearshore rock resources in these areas represent a travel corridor (to nesting sites) and not a main foraging or developmental habitat for loggerhead sea turtles.

The southeast Florida region supports the largest loggerhead nesting aggregation in the western hemisphere (Schroeder and Thompson, 1987). Annual numbers of South Florida Nesting subpopulation nests in southeast Florida during 1989 to 1998 ranged from 46,295 (1989) to 74,988 (1998), with a mean of 61,731 nests annually (Marine Turtle Expert Working Group, 2000). A study of loggerhead nest distributions along Cape Canaveral found that nesting sites were not distributed randomly and peak nesting areas were revisited annually. Hatchling turtles normally emerge during the night on project beaches between July and September and swim offshore and begin a pelagic existence within *Sargassum* rafts, drifting in current gyres and convergence zones for several years (Carr, 1987; Marine Turtle Expert Working Group, 1996a; Witherington, 2002). Post-hatchlings from the Florida coast eventually enter currents of the North Atlantic Gyre. At a carapace length of approximately 40-60 cm, they leave the pelagic environment and move into nearshore habitats (Carr, 1987; Bowen et al., 1993).

Densities of loggerhead turtle nests (recorded in units of nests per km) reported along the Mid-Reach area and Brevard County beaches south of the Mid-Reach during 2004 and 2005 are shown on **Figure 2-7**. Nest densities recorded from the Mid-Reach area ranged from 67 to 292 nests per km during the 2004 and 2005 nesting seasons. There were markedly higher densities of loggerhead nests along Brevard County beaches south of the Mid-Reach area than along the Mid-Reach area during both nesting seasons. Densities of nests recorded from beaches south of the Mid-Reach area ranged from 83 to 606 nests per km during the 2004 and 2005 nesting seasons.

Loggerhead juveniles feed on insects and marine invertebrates while residing in *Sargassum* mats (Richardson and McGillivary, 1991). Loggerhead adults and subadults are generalist carnivores, feeding primarily on benthic crustaceans (particularly crabs) and mollusks (Dodd, 1988).

2.3.3.1(b) Green Sea Turtle

The green sea turtle (Chelonia mydas), named for the greenish color of its body fat, has a circumglobal distribution in tropical and subtropical waters. The species is made up of several distinct populations. In the U.S., green turtles occur in Caribbean waters around the U.S. Virgin Islands and Puerto Rico and along the mainland coast from Texas to Massachusetts. Adult green turtles are typically found in shallow tropical and subtropical waters, particularly in association with seagrass beds (NMFS and USFWS, 1991).

The green turtle is considered to be common within nearshore waters of the project area. All life stages of green turtles can be found during different times of the year in and around the project area, although juveniles and subadults occur year round in the Mosquito Lagoon portion of the Indian River Lagoon system on Florida's east coast. Immature turtles also may be found on the inner shelf along the entire east coast of Florida; however, relatively low numbers of green turtles have been captured in the Cape Canaveral area, presumably the result of this species' habitat preference (Schmid, 1995; Hirth, 1997).

Primary green turtle nesting sites in U.S. Atlantic waters are high energy beaches along the east coast of Florida, primarily during July and August, with additional sites in the U.S. Virgin Islands and Puerto Rico (NMFS and USFWS, 1991; Hirth, 1997). **Figure 2-8** illustrates densities of green turtle nests (recorded in units of nests per km) reported along the Mid-Reach area and Brevard County beaches south of the Mid-Reach during 2004 and 2005. Nest densities recorded from the Mid-Reach area ranged from 1 to 26 nests per km during the 2004 and 2005 nesting seasons. As in the case of loggerhead turtles, there were markedly higher densities of green turtle nests along Brevard County beaches south of the Mid-Reach area than along the Mid-Reach area during both nesting seasons. Densities of nests recorded from Brevard County beaches south of the Mid-Reach area ranged from 4 to 220 nests per km during the 2004 and 2005 nesting seasons.

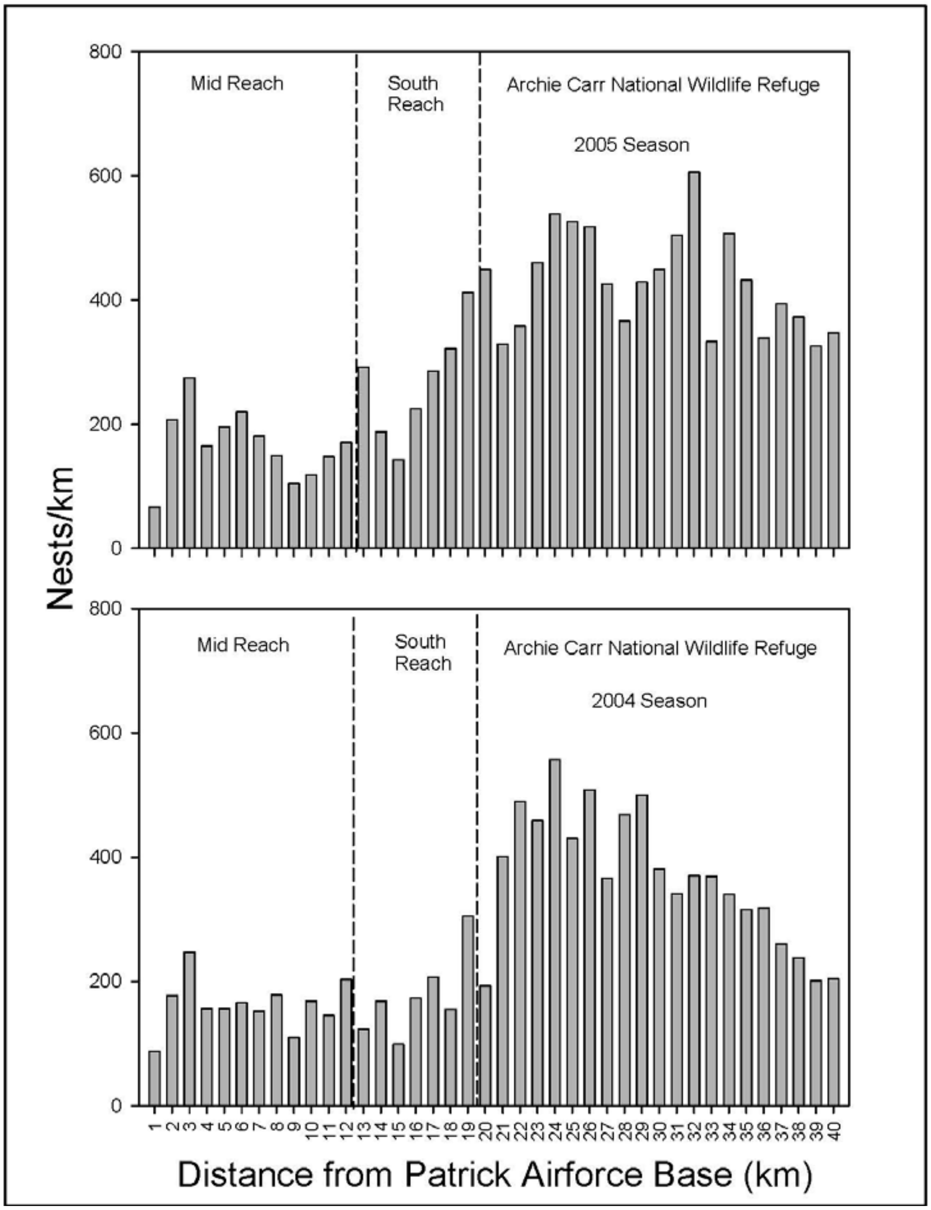

Figure 2-7. Densities of loggerhead turtle nests (nests per km) reported within the Mid-Reach and South Reach areas of Brevard County during the 2004 and 2005 nesting seasons.

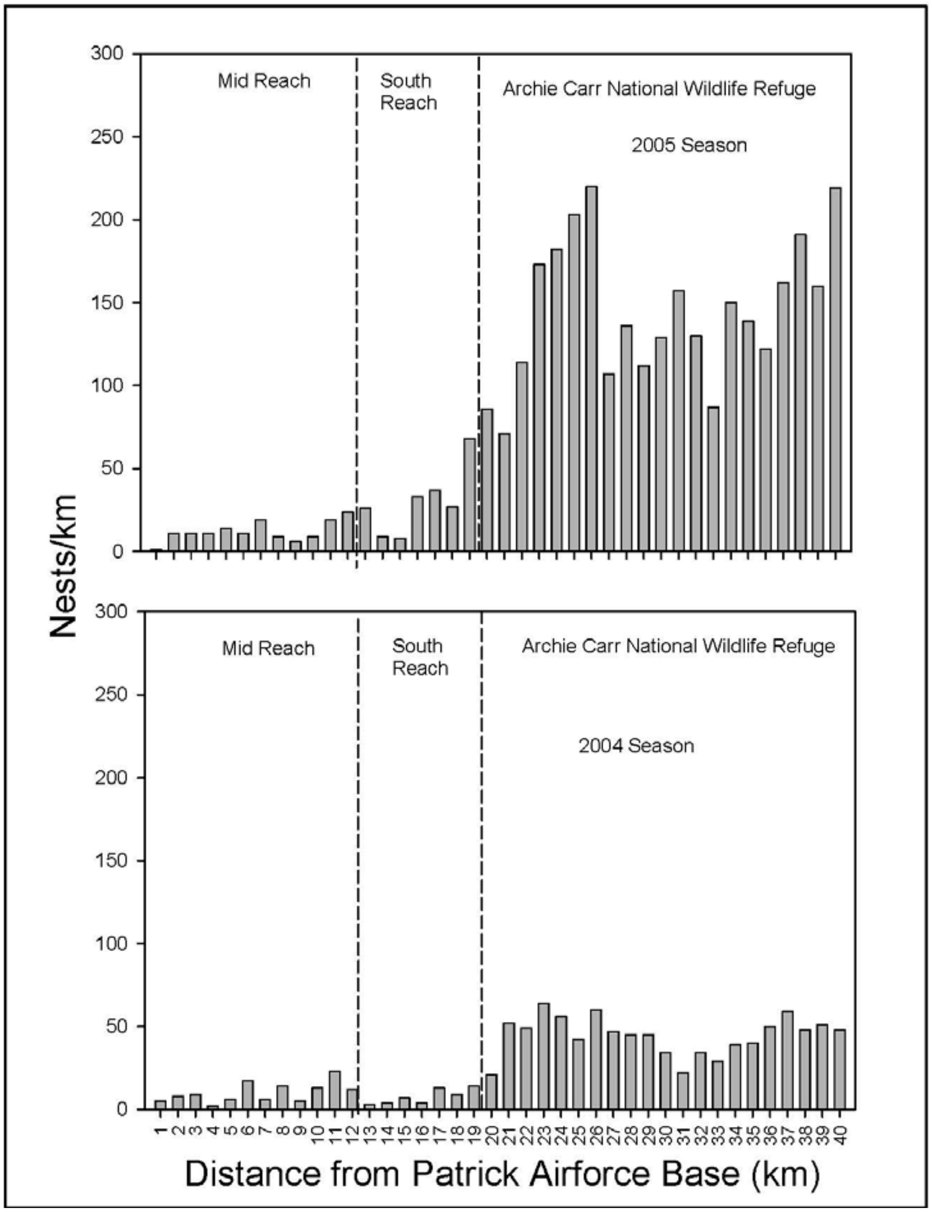

Figure 2-8. Densities of green turtle nests (nests per km) reported within the Mid-Reach and South Reach areas of Brevard County during the 2004 and 2005 nesting seasons.

Adult, juvenile, and hatchling life stages of green turtles can be found during different times of the year within the project area. Green turtle hatchlings normally emerge at night during July through October. They swim offshore similar to their loggerhead counterparts. Little is known about the locations and characteristics of post-hatchling green turtle developmental habitats (Carr, 1987; Hirth, 1997). Subadult green turtles are found in nearshore and inshore habitats when they reach between 20 and 25 cm straight carapace length (Hirth, 1997; Magnuson et al., 1990). Subadult green turtle habitats on the east coast of Florida include shallow estuarine environments like the Indian River Lagoon (Bresette et al., 2000; Ehrhart et al., 1996; Provancha et al., 1998), deeper coral and limestone reefs in south Florida (Wershoven and Wershoven, 1992a; Makowski et al., 2002; Makowski, 2004) and shallow nearshore habitats in Brevard, Indian River, and St. Lucie Counties (Bresette et al., 1998; Ehrhart et al., 2001; Holloway-Adkins et al., 2002). They also have been found in man-made habitats such as shipping channels and turning basins (Henwood, 1987; Redfoot, 1997). Preliminary satellite tracking data indicate large subadult green turtles (>71.0 cm straight carapace length) migrate from nearshore habitats into the southeastern Caribbean (D. Bagley, unpubl. data). Patterns in size-class distribution and abundance of animals in the nearshore habitats may be directly related to seasonal fluctuations in available resources. Migration and/or movement among different habitats may be prompted by physiological changes in life-stage energy requirements for growth or reproduction. Transect and netting studies in Brevard and Indian River Counties indicate juvenile green turtles use the nearshore rock resources year-round (Holloway-Adkins, 2005; Holloway-Adkins and Provancha, 2005; Inwater Research Group, 2005), but it is not known how continuously or for how many years they use these developmental habitats.

Juvenile green turtles over nearshore hard bottom habitats in Brevard and Indian River Counties were found to primarily forage on species of red algae (Ehrhart et al., 1996; Holloway-Adkins, 2001; Holloway-Adkins, 2005). The most frequently consumed species were *Gelidium* spp., *Bryothamnion seaforthii*, *Hypnea* spp., *Gracilaria* spp., *Laurencia* spp., and *Bryocladia cuspidata.* A variety of small invertebrates were found in foraging samples. Occasionally, a large portion of jellyfish was discovered in the samples. However, the overall results indicate green turtles in the nearshore hard bottom habitat are feeding as herbivores (Holloway-Adkins, 2001; Gilbert, 2005; Holloway Adkins and Provancha, 2005). Studies in Brevard and Indian River Counties reveal green turtles also frequently ingest inorganic material (Redfoot, 1997; Holloway Adkins, 2001; Holloway-Adkins and Provancha, 2005). Results of foraging studies along the Mid-Reach are described in Appendix K – Subappendix A. Sand, pieces of rock, and shell debris found in foraging samples indicate green turtles forage close to the substrate and either incidentally or selectively ingest these non-nutritional items for unknown reasons. Stranding events and foraging studies indicate that sea turtles at all life stages are susceptible to ingesting anthropogenic debris (Balazs, 1985; Carr, 1987; Witherington, 2002).

Juvenile green turtles transition through an omnivorous stage of 1 to 3 years (NMFS and USFWS, 1991). Subadult green turtles are primarily herbivorous, foraging on macroalgae and seagrasses in shallow estuarine and nearshore environments (Mendonca, 1983; Wershoven and Wershoven, 1992b; Ehrhart et al., 1996; Redfoot, 1997; Holloway-Adkins, 2001). Adult green turtles commonly feed on algae, seagrasses, and associated organisms, using reefs and rocky outcrops near seagrass beds for resting areas. The major feeding grounds for green turtles in U.S. waters are located in Florida, where the turtles forage mainly on algae and the seagrass *Thalassia testudinum* (Burke et al., 1992).

2.3.3.1(c) Hawksbill Sea Turtle

Hawksbill sea turtles (*Eretmochelys imbricata*) occur in tropical and subtropical seas of the Atlantic, Pacific, and Indian Oceans. In the western Atlantic, hawksbill turtles are generally found in clear tropical waters near coral reefs, including the southeast Florida coast, Florida Keys, Bahamas, Caribbean Sea, and southwestern Gulf of Mexico (NMFS and USFWS, 1993). Along the east Florida coast, hawksbills are probably year round residents, including adults, subadults, and juveniles (B. Brost, 2002, personal communication, Florida Marine Research Institute [FMRI], St. Petersburg, FL). It is considered to be very rare in nearshore waters of the project area.

Nesting areas for hawksbills in the Atlantic are found in south Florida, Puerto Rico, and the U.S. Virgin Islands. Within the continental U.S., nesting beaches are restricted to the southeastern coast of Florida (i.e., Palm Beach, Broward, and Dade Counties), Florida Keys, and southwestern coast of Florida as noted by Meylan (1992) and the NMFS and USFWS (1993). Hawksbill nesting along the east Florida coast occurs between June and September (B. Brost, 2002, pers. comm.).

Hatchling hawksbills are pelagic, drifting with Sargassum rafts. Available data suggest they are herbivorous during this period but become more omnivorous as they age (Ernst et al., 1994). Juveniles shift to a benthic foraging existence in shallow waters, progressively moving to deep waters as they grow and become capable of deeper dives for sponges (Meylan, 1988; Ernst et al., 1994). Adult hawksbills typically are associated with coral reefs and similar hard bottom areas, where they forage on invertebrates, primarily sponges.

2.3.3.1(d) Kemp's Ridley Sea Turtle

The Kemp's ridley (*Lepidochelys kempi*) is the smallest and most endangered of the sea turtles. Its distribution includes the Gulf of Mexico and southeast U.S. coast, although some individuals have been found as far north along the eastern seaboard as Nova Scotia and Newfoundland (Marine Turtle Expert Working Group, 1996b). Adult Kemp's ridleys occur almost exclusively in the Gulf of Mexico, primarily on the inner shelf (Byles, 1988).

Kemp's ridleys along east Florida are primarily juveniles and subadults that use inner shelf waters as developmental habitat, although adult sized individuals also are occasionally found (Schmid and Ogren, 1992). It is considered to be very rare in nearshore waters of the project area. Kemp's ridleys move northward along the coast with the Gulf Stream in spring to feed in productive, inner shelf waters between Georgia and New England (NMFS and USFWS, 1992a). These migrants then move southward with the onset of cool temperatures in late fall and winter (Lutcavage and Musick, 1985). Areas offshore of Cape Canaveral, Florida seem to serve as an important winter foraging ground, based on high capture and recapture rates from October to March (Schmid and Ogren, 1992; Schmid, 1995). Telemetry studies of Kemp's ridley migrations off the U.S. east coast suggest that they do not establish residency in dredged shipping channels during this period, although they have been observed on occasion in and around these channels (Gitschlag, 1996). Recent evidence suggests that immature or subadult individuals that move to the Atlantic inner shelf may return to the Gulf of Mexico as adults to nest on Mexican beaches (Witzell, 1998).

Nesting of Kemp's ridleys occurs almost entirely at Rancho Nuevo beach, Tamaulipas, Mexico, where 95% of the nests are laid along 60 km of beach (NMFS and USFWS, 1992a; Weber, 1995; Marine Turtle Expert Working Group, 2000). In the U.S., nesting occurs infrequently on Padre and Mustang Islands in south Texas and in a few other Gulf of Mexico locations (Marine Turtle Expert Working Group, 2000). After emerging, Kemp's ridley hatchlings swim offshore to inhabit Sargassum mats and drift lines associated with convergences, eddies, and rings. Hatchlings feed at the surface and are dispersed widely by Gulf and Atlantic surface currents. After reaching a size of about 20 to 60 cm carapace length, juveniles enter shallow coastal waters and become benthic carnivores (Marine Turtle Expert Working Group, 2000).

Post pelagic (juvenile, subadult, and adult) Kemp's ridleys feed primarily on portunid crabs, but also occasionally eat mollusks, shrimps, dead fishes, and vegetation (Mortimer, 1982; Lutcavage and Musick, 1985; Shaver, 1991; NMFS and USFWS, 1992a; Burke et al., 1993; Werner and Landry, 1994).

2.3.3.1(e) Leatherback Sea Turtle

The leatherback sea turtle (*Dermochelys coriacea*), named for its unique, flexible carapace, is a circumglobal species that is currently subdivided into two subspecies. The Atlantic subspecies, *D. c. coriacea*, inhabits waters of the western Atlantic from Newfoundland to northern Argentina. The leatherback is the largest living turtle (Eckert, 1995). With its unique deep diving abilities (Eckert et al., 1986) and wide ranging migrations, the leatherback is considered the most pelagic of the sea turtles (Marquez, 1990).

Adult leatherback turtles reportedly occur in east Florida waters primarily during summer, although leatherback turtles were sighted during aerial survey programs conducted off northeast Florida from October through April as well (Schroeder and Thompson, 1987; Knowlton and Weigle, 1989; Continental Shelf Associates, Inc., 2002). During these surveys, leatherbacks were sighted on the mid shelf and inner shelf but not usually near shore (Continental Shelf Associates, Inc., 2002). However, historical data suggest that leatherbacks also may utilize inner shelf waters during periods of local thermal fronts that concentrate food resources (Thompson and Huang, 1993). Because of the cryptic behavior of hatchling and/or juvenile leatherback turtles, very little is known of their pelagic distribution. It is considered to be very rare in nearshore waters of the project area.

Leatherbacks nest on coarse grained, high energy beaches in tropical latitudes (Eckert, 1995). Florida is the only location in the continental U.S. where significant leatherback nesting occurs. Nests in Brevard County are relatively few in number when compared with Florida beaches to the south, especially Martin and Palm Beach Counties (NMFS and USFWS, 1992b; B. Brost, 2002, pers. comm.). Nesting along the east Florida coast occurs between late February through early September (Meylan et al., 1995). Densities of leatherback nests (recorded in units of nests per km) reported along the Mid-Reach area and Brevard County beaches south of the Mid-Reach during 2004 and 2005 are shown on **Figure 2-9**. Nests were reported from only three Mid-Reach locations (1 nest per km at each location) during 2004. No nests were reported from the Mid-Reach area during 2005. As in the case of loggerhead and green turtles, reported leatherback nests were more common along Brevard County beaches south of the Mid-Reach area than along the Mid-Reach area during both nesting seasons. Densities of nests recorded from Brevard County beaches south of the Mid-Reach area ranged from approximately 0 to 6 nests per km during the 2004 and 2005 nesting seasons.

No data on the feeding habits of hatchling and juvenile leatherbacks are available. Adult leatherbacks feed in the water column, primarily on cnidarians (*medusae, siphonophores*) and tunicates (*salps, pyrosomas*) (Eckert, 1995). The turtles are sometimes observed in association with jellyfishes, but actual feeding behavior has only occasionally been documented (Grant et al., 1996). Foraging has been observed at the surface, but considering their well developed deep diving capabilities, it also is likely to occur at depth (Eckert, 1995).

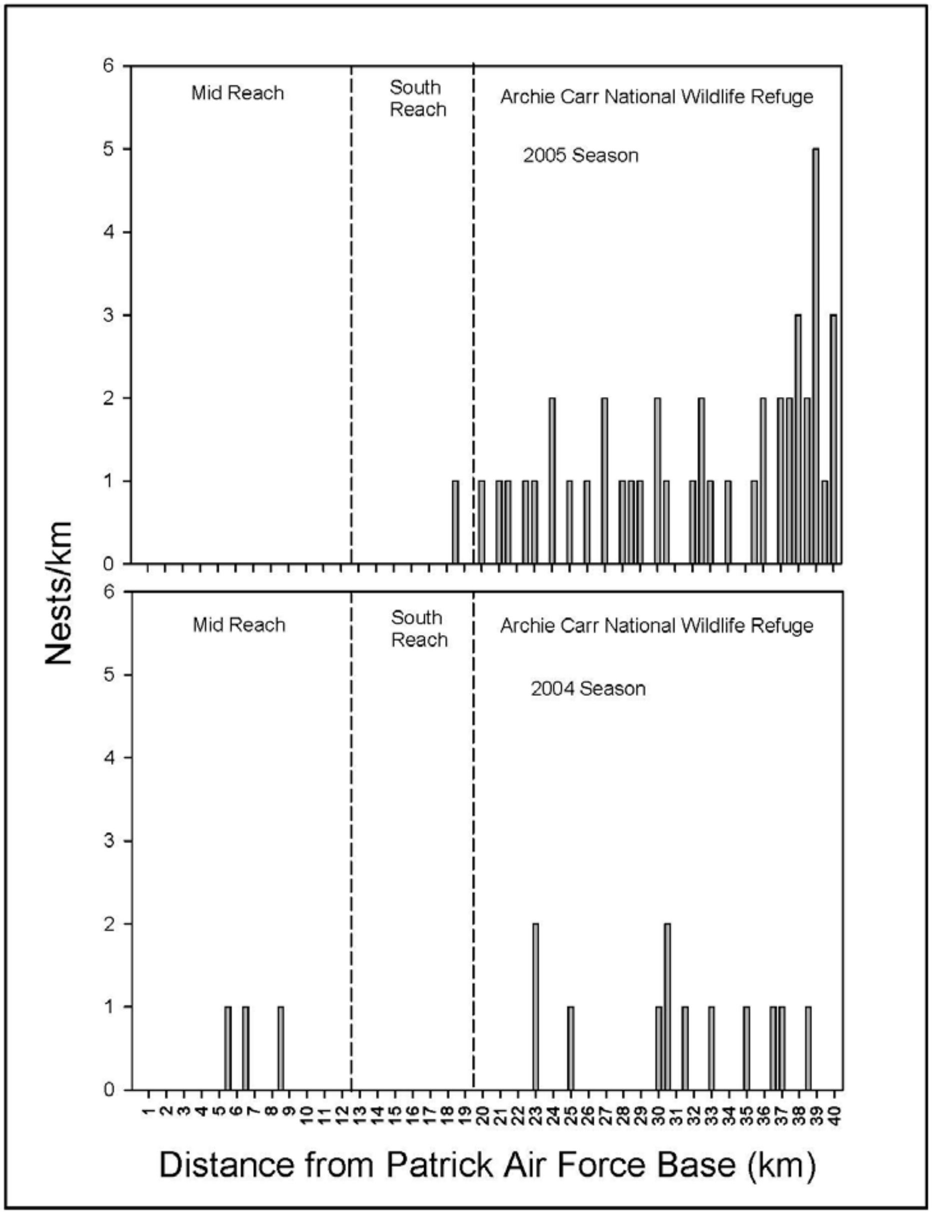

Figure 2-9. Densities of leatherback turtle nests (nests per km) reported within the Mid-Reach and South Reach areas of Brevard County during the 2004 and 2005 nesting seasons.

2.3.3.2 Birds

Birds that may be affected by the proposed action include primarily shorebird and seabird species that use outer beach and primary dune habitats within the project area for roosting, feeding, and/or nesting activities. Bird species that may occur within the project area and are currently federally listed by the U.S. Fish and Wildlife

Service (USFWS) or the Florida Fish and Wildlife Conservation Commission (FWC) as endangered or threatened species, or species of special concern (defined by the USFWS as a species that might be in need of conservation action) under the Endangered Species Act of 1973 are presented in **Table 2-8**.

Table 2-8. Bird species that may occur within the project area that are currently listed by federal and state agencies as endangered, threatened, or as species of concern (from: FWC, 2004).

Common Name	Genus/Species	Listing	
		Federal (USFWS)	State of Florida (FWC)
Piping Plover	*Charadrius melodus*	Threatened	Threatened
Snowy Plover	*Charadrius alexandrinus*	n/a	Threatened
American Oystercatcher	*Haematopus palliatus*	n/a	SSC (1,2)*
Brown Pelican	*Pelecanus occidentalis*	n/a	SSC (1)*
Black Skimmer	*Rynchops niger*	n/a	SSC (1)*
Least Tern	*Sterna antillarum*	n/a	Threatened
Roseate Tern	*Sterna dougallii dougallii*	Threatened	Threatened

a USFWS = US Fish & Wildlife Service

b FWC = Florida Fish and Wildlife Conservation Commission.

c Federally listed Species of Special Concern (SSC) are indicated by the number in parentheses under the following criteria:

(1) has a significant vulnerability to habitat modification, environmental alteration, human disturbance, or human exploitation which, in the foreseeable future, may result in its becoming a threatened species unless appropriate protective or management techniques are initiated or maintained; and

(2) may already meet certain criteria for designation as a threatened species but for which conclusive data are limited or lacking.

A Least Tern nest was recently reported on the Mid-Reach area beach. This species is known to move their nest sites frequently, especially when colony sizes are small (J. Rogers, 2005, personal communication, State of Florida, Florida Fish and Wildlife Conservation Commission). However, it is reasonable to assume that this nesting pair, and perhaps others, could return to the project area to nest during subsequent seasons.

2.3.3.3 West Indian Manatee

The West Indian Manatee (Trichecus manatus) is an endangered species that is found in the coastal and estuarine areas of Brevard County most of the year. Manatees are found within Canaveral Harbor and also utilize the harbor to transit between the ocean and the Indian/Banana River lagoon systems.

Acoustic sensors and controls installed by the Corps of Engineers on the navigation lock gates between Canaveral Harbor and the Banana River act successfully to reduce injury to manatees as they seek passage through the locks. Based upon data from 1998 through 2008 collected by the Corps, manatee sightings at the Canaveral Harbor locks ranged between 1446 and 5304 per year, or about 3805 on annual average. Manatee sightings were greatest from April through October (about

450/month on 10-yr average), least in January and February (about 50/month), and variable in November, December, and March (about 175/month). Peak manatee sightings occur in the months of May through July (about 525/month).

2.3.3.4 Whales

Whale species that may be found in the Atlantic coastal waters off Brevard County during certain times of the year include the endangered right whale (*Eubalaena glacialis*), sei whale (*Balaenoptera borealis*), sperm whale (*Physeter macrocephalus catodon*), finback whale (*Balaenoptera physalus*), and humpback whale (*Megaptera novaeangliae*). The right and humpback whale may be adversely impacted by dredging operation. Critical habitat for the right whale extends from Georgia to Sebastian Inlet and includes the project area. The calving season for the right whale occurs from December 1 through March 31. Humpback whales occur in Florida during annual migrations between their summer and winter ranges.

2.3.3.5 Southeastern Beach Mouse

The southeastern beach mouse (*Peromyscs polionitus niveiventris*) is a threatened species that inhabits coastal dune and scrub communities. The mouse is found along the Cape Canaveral Air Station (CCAS) and is potentially present within or near the west spoil area (Posiedon Dredged Material Management Area (DMMA)) north of Canaveral Harbor. Environmental staff at CCAS indicate that southeastern beach mouse are not considered relatively abundant in the DMMA (Angy Chambers, personal communication). The original field surveys by the USFWS along the project area shoreline indicated remnant mouse habitat; but no indication of mouse habitation. Subsequent surveys along Lori Wilson County Park, indicated as optimum remaining beach mouse habitat, did not reveal presence of the species.

2.3.3.6 Gopher Tortoise

In November, 2007, the gopher tortoise (*Gopherus polyphemus*) was “uplisted” as a state-listed threatened species in Florida. The gopher tortoise occurs throughout sandy and scrub habitats of Brevard County. Within the proposed project area, the gopher tortoise is known to be present at the west spoil area (Poseidon Dredged Material Management Area (DMMA)) north of Canaveral Harbor.

2.3.3.7 Indigo Snake

Presence of the threatened Eastern Indigo snake (*Drymarchon corias couperi*) is often associated with the burrows of the gopher tortoise and is potentially present in the vicinity of the DMMA and, less likely, along the dune and scrub habitat of the beach.

2.3.3.8 Smalltooth Sawfish

This species has become rare along the southeastern Atlantic and northern Gulf of Mexico coasts of the US during the past 30 years and its known primary range is now reduced to the coastal waters of Everglades National Park in extreme southern Florida. Fishing and habitat degradation have extirpated the smalltooth sawfish from much of this former range. The smalltooth sawfish is distributed in tropical and subtropical waters world-wide.

The smalltooth sawfish normally inhabits shallow waters (10 m or less) often near river mouths or in estuarine lagoons over sandy or muddy substrates, but may also occur in deeper waters (20 m) of the continental shelf. Shallow water less than 1 m appears to be important nursery area for young smalltooth sawfish. Smalltooth sawfish grow slowly and mature at about 10 years of age. Females bear live young and the litters reportedly range from 15 to 20 embryos requiring a year of gestation (NMFS, 2006).

Diet consists of macroinvertebrates and fishes such as herrings and mullets. The saw is reportedly used to rake surficial sediments in search of crustaceans and benthic fishes or to slash through schools of herrings and mullets (NMFS, 2006).

On 1 April 2003, NMFS published a final rule (50 Code of Federal Regulations [CFR] Part 224) listing the smalltooth sawfish (*Pristis pectinata*) Distinct Population Segment (DPS) as an endangered under the ESA. A DPS is a provision in the ESA that allows protection of an isolated subpopulation of an imperiled species with a broad geographic range. This DPS represents the northernmost population segment of a species distributed worldwide. The ESA listing was based on the present threatened destruction, modification, or curtailment of habitat or range; overutilization for commercial, recreational, scientific, or educational purposes; inadequacy of existing regulatory mechanisms; and other natural and manmade factors affecting the continued existence of the species.

The National Sawfish Encounter Database (Simpendorfer and Wiley, 2006) managed by the Florida Museum of Natural History, University of Florida revealed 9 encounters for Brevard County from as far back as 1895. Six of the observations occurred in the Indian River Lagoon and three occurred in the Atlantic coastal waters.

2.3.4 Hardgrounds

Nearshore rock features within the Mid-Reach Project Area are composed of coquina outcrops, formed from lithified shell fragments, quartz sand, and calcium carbonate. The outcrops parallel the shoreline, extending through the intertidal and subtidal zones, and range from wide expanses of tabular platforms with ledges to small isolated rocks. The outcrops extend from the southern half of Patrick Air Force Base southward through Indian Harbor Beach, and to a lesser extent southward to the south boundary of the Mid-Reach near Indialantic. The nearshore rock provides diverse habitat for shallow water marine flora and fauna (Continental Shelf Associates, Inc., 1990). The South Atlantic Fisheries Council of the National Marine Fisheries Service (NMFS) has designated the nearshore hardgrounds of the Mid-Reach as Habitat Areas of Particular Concern (HAPC).

The exposed rock outcrops occur irregularly between approximately the mean low water shoreline and up to about 300 feet seaward thereof, in water depths of between about 0 and 4 feet at mean low water.   See **Figure 2-10**. The width (and water depth) of occurrence decreases from north to south along the Mid-Reach: from about 300 feet at the north end (Reach 6), to about 80 feet or less at the south end (Reach 1) or within a band of about 180-feet seabed width on overall average. The rock is variously exposed above the sand seabed as both singular, isolated features and as large tabular ledges, where the latter are generally fractured, pitted, uplifted or otherwise irregular. See **Figure 2-11**. The vertical relief varies from about 0" (flush with the sand seabed) to 18", with some instances of up to 30" relief. The ledges typically are tipped up toward the beach, with exposed vertical faces and overhangs along the shoreward edges. The rock features exist in the highly turbulent and dynamic sedimentary environment of the inner surf zone, and the locations and extent of rock exposure vary significantly depending upon ambient beach and surf conditions. Surveys have indicated area-wide changes in exposed rock acreage of more than 36% over periods of several weeks   (Olsen, 2003).

Multiple years of historical shoreline surveys of the Brevard Mid Reach and adjacent areas have been analyzed for spatial and temporal trends in near shore hardbottom occurrence. The analysis confirms significant natural fluctuations in the aerial extent and cross-shore locations of exposed rock along the Mid Reach shoreline. Based on 1995 aerial photography, the U.S. Army Corps of Engineers (USACE, 1996) estimated approximately 31 acres of exposed nearshore rock acreage within the Mid-Reach project area. Multi-spectral image analysis of January 2001 aerial photography with ground truth transect surveys indicated an estimated 51.4 acres of rock within the Mid-Reach Project Area, plus an additional 9.3 acres along the southern mile of Patrick Air Force Base (Olsen 2003). Identical image analysis of June 2004 aerial photography and ground truth surveys indicated an estimated 31.3 acres of rock within the Mid-Reach Project Area, plus an additional 11.2 acres along the southern mile of Patrick Air Force Base. The alongshore abundance of exposed rock decreases significantly from north to south. Both the 2001 and 2004 mapping indicated that over 85% of the exposed rock in the Mid-Reach occurred along the northern half of the Mid-Reach (approximately), along Reaches 4-6 between monuments R-75.4 and R-99 (Olsen, 2005). Acreage estimates of rock within individual Mid-Reach Project Area sections are summarized in **Table 2-1**. The alongshore occurrence of exposed rock is illustrated in **Appendix K - Subappendix I.**

There are no quantitative surveys of nearshore rock along the study area prior to 1995 from which long-term changes in exposed hardbottom can be determined. Historical ground-level photographs and anecdotal reports indicate that rock outcrops have occurred along the Mid Reach shoreline since at least the early 1940's (Olsen 2003).

In order to quantify potential impacts to the nearshore hardbottom it was necessary to select a single survey data set for use during the plan formulation phase as opposed to an average of all the available surveys. After extensive coordination with resource agencies, the decision was made to use the most recent survey data as a baseline for the feasibility study. This decision is consistent with similar projects, wherein the resource agencies generally require the use of the most recent data on environmental resources, as opposed to a historical average. Based on the most recent survey data, a total area 31.3 acres of nearshore hardbottom was used as a baseline for assessing impacts. This surveyed area was analyzed relative to the toe of various beach fill designs. During this analysis, any rock landward of the beach fill toe was assumed to have been buried by beach fill activities thus requiring mitigation. Agreements have been made with resource agencies to conduct pre-construction surveys of the nearshore hardbottom in order to assure that proper mitigation measures are carried out based on expected impacts calculated using hardbottom extent present near the time of construction. Detailed discussion of rock outcrop impacts is included in **Appendix A - Section A-97** and additional discussion of mitigation and monitoring plans is provided in **Appendix J**.

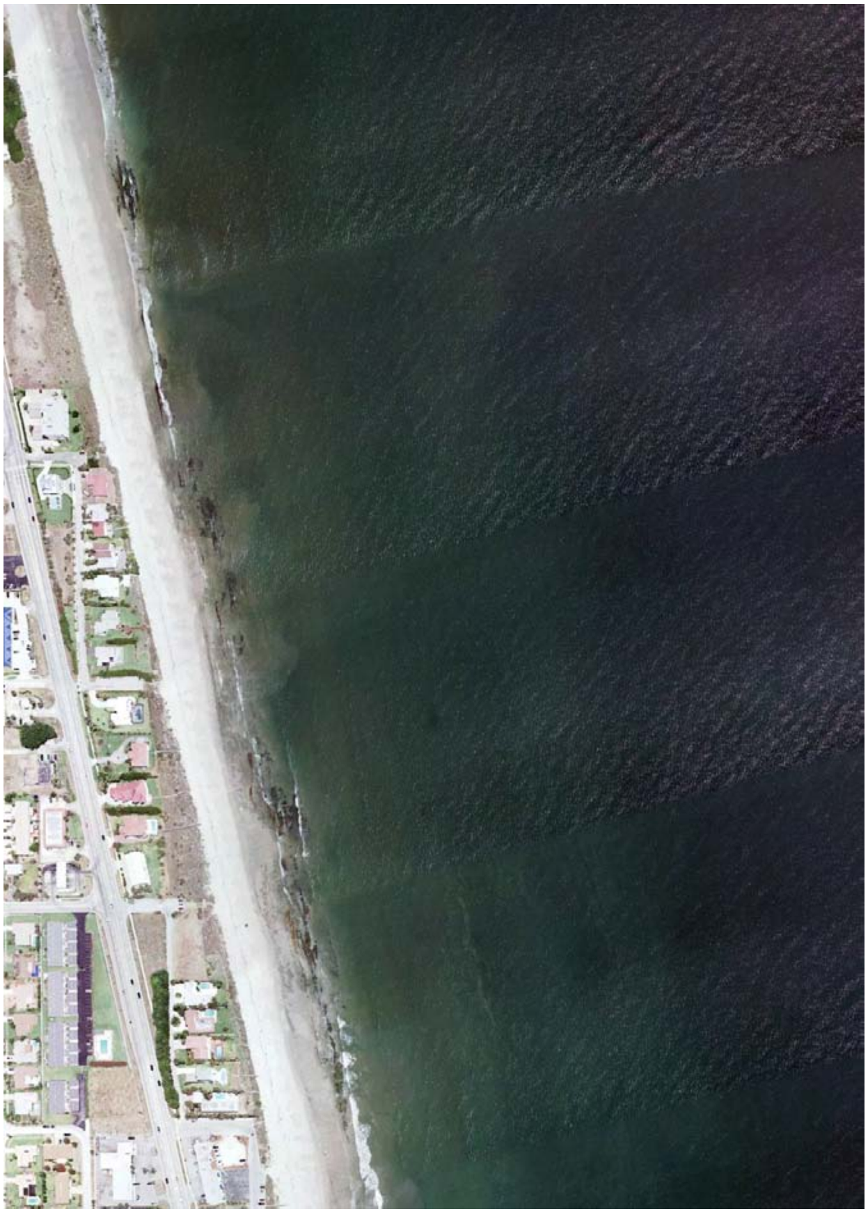

Figure 2-10. Aerial photograph of Mid-Reach exhibiting outcrops of exposed nearshore rock in June 2004 (vicinity of R-94 to R-97 within Reach 4).

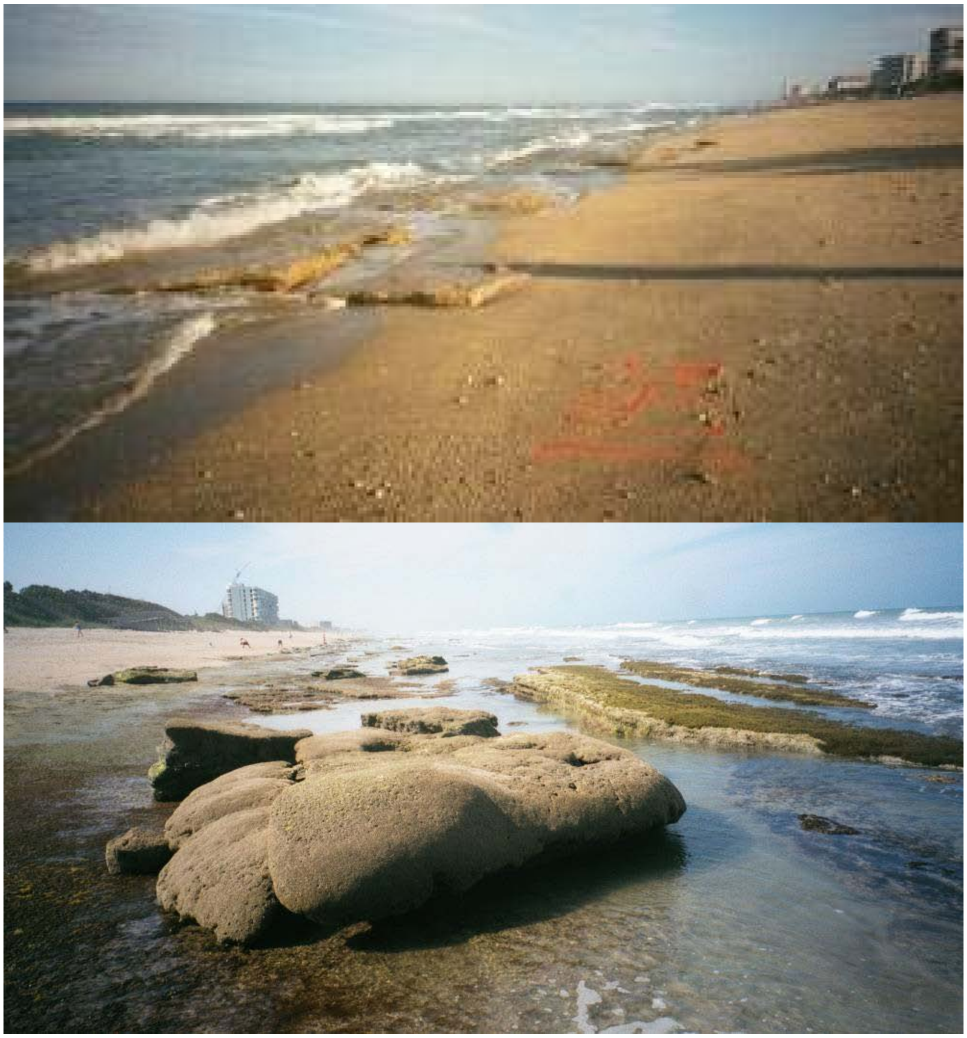

Figure 2-11. Ground-level photographs of nearshore rock outcrops at extreme low tide: upper – typical low-relief tabular ledges; lower – high-relief tabular ledges with algae and sabellariid tube worm structures in foreground.

Sub-bottom seismic profiling, jet-probing and diver surveys indicate that the nearshore rock drops sharply in elevation within less than 70 feet offshore of the exposed rocks' seaward edge, across sandy seabed in water depths ranging from 7 to 10 feet, MLW. These surveys indicate that there is little or no shallow, buried rock beyond the existing, mapped limits of rock that may readily become exposed in the future. Further seaward, in water depths between 10 and 26 feet MLW, no rock stratum was detected within 10-feet below the sand seabed surface (Olsen et al., 2005).

There are little or no substantial alongshore gaps in the exposed nearshore rock outcrops along the northern 6.5 miles of the Mid-Reach, north of monument R-111.5 (i.e., more than about 50 to 250 feet alongshore). Along the southern 1.28 miles of the Mid-Reach, south of R-111.5, the abundance of rock decreases significantly and the exposed outcrops are widely spaced (over 1000-ft alongshore), but with greater temporal variations in the rocks' spatial occurrence (Olsen, 2003).

The nearshore outcrops are colonized by a diverse algal community, the sabellariid tube worm *Phragmatopoma caudata* (= *P. lapidosa*), and other invertebrate groups including sponges, hydroids, mollusks, crustaceans, bryozoans, and ascidians (Kirtley, 1966; Young, 1975; Gore et al., 1978; Van Montfrans, 1981; Zale and Merrifield, 1989; Continental Shelf Associates, Inc., 1990, 2005). Various fish species also are an important component of these nearshore rock reefs (see Section 2.3.5).

Relatively high densities of the green alga *Caulerpa prolifera* and varying densities of unidentified green filamentous algae have been observed along the crests of these outcrops (Continental Shelf Associates, Inc., 1990). Surveys of the nearshore outcrops conducted at 15 sites along the Mid-Reach Project Area during the late summer of 2005 identified 22 species of marine algae (Continental Shelf Associates, Inc., October 2005). See Appendix K- Subappendix B. Percent cover analyses of diver-collected video data showed wide variability in algal distribution and density both within and between surveyed outcrops. Areas typically exhibiting higher percent algal cover included (a) low relief platforms in the lower intertidal and upper subtidal zone, where high abundances of red filamentous and branching algae and the green alga *Ulva lactuca* were noted (**Figure 2-12**), and (b) inshore edges of subtidal rock ledges and east-west breaks between these longshore ledges, both of which had the highest number of algal species and density within the project area.

The green alga *C. prolifera* was very abundant along the subtidal rock edges, in many areas occurring in wide dense bands covering 100% of the bottom (**Figure 2-13**). Larger, thin-branching red algae such as *Agardhiella subulata* and *Solieria filiformis* and the brown algae *Dictyota* sp. and *Padina gymnospora* also were fairly common along these margins. The red algae *Bryocladia cuspidata* was a widely distributed species, occurring on shallow intertidal platforms as well as on deeper subtidal ledges throughout the length of the Mid-Reach Project Area. Along the offshore margins of the tabular outcrops where the rock typically graded into the adjacent sand bottom, algal density generally declined with increasing amounts of sand overburden, with *C. prolifera* often observed protruding through the sand layer.

Total algal percent cover observed during these surveys within the Mid-Reach Project Area ranged from 16.3% to 54.5% at individual sampling sites, with green algae cover ranging from 0.0% to 30.4% and red algae cover from 4.7% to 47.0%. These algal percent cover ranges and species compositions are similar to those reported during previously described surveys of nearshore hard bottom in counties immediately south of the project area (see Appendix K- Subappendix B).

The sabellariid polychaete *P. caudata* is found throughout this area, building scattered mounds on nearshore rock outcrops south to Key Biscayne (Kirtley, 1966; Kirtley and Tanner, 1968; Young, 1975). The wormreef colonies typically are found in both the low intertidal and subtidal zones and are somewhat ephemeral, being negatively impacted by both storm waves and burial by sediments. Wormreef colonies were observed at 9 of 15 nearshore hard bottom sampling locations in the Mid-Reach Project Area (Continental Shelf Associates, Inc., 2005) (See **Figure 2-14** and **Figure 2-15**). Wormreef colony percent cover values at these sampling sites ranged from 0.0% to 27.2%, with an average of 5.2% cover for all sites. This value is consistent with estimates from image analysis of January 2001 aerial photography, which indicated a probable worm rock occurrence across 2.6% to 4.1% of the exposed rock outcrops (Olsen 2003). Eckelbarger (1976) collected gametes from worms during all months of the year, indicating they may be capable of spawning nearly year round. Sloan (2005) conducted sediment burial experiments on sabellariid worm colonies collected from the Mid-Reach Project Area and found increased mortality linked to both depth of burial and duration. Field observation, such as after Hurricane Floyd in September, 2000, indicates that severe storms may almost completely destroy the worm rock colony structures, after which they may re-form (Olsen 2003).

Wormreef reefs provide habitat for many other benthic invertebrates and juvenile fishes (Gore et al., 1978; Nelson, 1989; Lindeman and Snyder, 1999). The crabs *Menippe nodifrons* and *Pachygraspus transversus* have been noted as having some abundance in sabellariid wormreef areas north of Melbourne, along with limited occurrence of *Plagusia depressa* (Young, 1975). Van Montfrans (1981) collected eight decapod species on worm reef mounds in the intertidal zone and subtidally off Patrick Air Force Base in Satellite Beach. The sabellariid worms also are eaten by many of these crustacean species (Gore et al., 1978).

Figure 2-12. The green alga *Ulva lactuca* adjacent to a wormreef colony on an intertidal rock platform at Sunrise Avenue (Monument R-95.9).

Figure 2-13. The green alga *Caulerpa prolifera* on the western edge of a subtidal rock ledge at Sunrise Avenue (Monument R-95.3).

Figure 2-14. A colony of wormreef along with *Ulva lactuca* and unidentified red algae at Sunrise Avenue (Monument R-95.3).

Figure 2-15. Wormreef, *Ulva lactuca*, and other unidentified algae along an east-west break between subtidal ledges at Sunrise Avenue (Monument R-95.3).

2.3.5 Fish and Wildlife Resources

2.3.5.1 Infauna

The beaches off Brevard County have been described as high-energy beaches with medium to coarse quartz sand and shell hash (Tanner, 1960; Spring, 1981). Beach sediments within the Mid-Reach Project Area have a median diameter of about 0.4 mm for berm material and 0.26 mm or less for intertidal to subtidal sediments (+3 to -8 ft elevations) and an average carbonate or shell content of 39% (Olsen 2003). This corresponds to grain size data from Spring (1981) and Gorzelany and Nelson (1987) from study sites off Indialantic, where coarse to medium sand was identified intertidally and fine sand was observed in subtidal locations.

Beaches typically have been divided into three general vertical zones when describing macrofaunal distribution (Nelson, 1985). In tropical and subtropical areas, the upper beach area is typically dominated by the ghost crab genus *Ocypode*. Mole crabs (*Emerita*), *haustoriid* amphipods, and bivalves (*Donax*) are numerical dominants in the intertidal area, while polychaetes, other amphipod species, and bivalves increase in abundance in the subtidal nearshore areas (Pearse et al., 1942; Dahl, 1952).

Several surveys to describe the nearshore macroinfaunal community have been conducted in the vicinity of the Brevard County Mid-Reach Project Area. Spring

(1981) sampled intertidal and subtidal infaunal communities at quarterly intervals off Indialantic and Melbourne Beach, Florida. Samples were collected out to water depths of -2.9 m MLW in the vicinities of FDEP monuments R-123, R-128, and R-140. Benthic core samples were taken at the high tide line and at distances of 5, 27.5, 55, 73, and 91.5 m offshore relative to the high tide line. Spring identified a total of 37 taxa, composed of 24 species of arthropods, 7 annelids, and 6 mollusks. Common species, in order of decreasing abundance, included *Donax* spp. (juvenile coquina clams), *Bathyporeia parkeri* (amphipod), *Emerita talpoida* (mole crab), *Parahaustorius longimerus* (amphipod), *Donax variabilis* (coquina clam), juvenile *haustoriid* amphipods, *Paraonis fulgens* (polychaete worm), *Donax parvula* (coquina clam), *Protohaustorius deichmannae* (amphipod), and *Bowmaniella* sp. (mysid). Spring found the coquina clam *D. variabilis* and mole crab *E. talpoida* numerically dominated the upper intertidal zone, with juvenile *Donax* sp., *haustoriid* amphipods, and polychaetes more abundant in subtidal areas. During summer months, *D. variabilis* was common in the lower intertidal to subtidal zones, co-occurring with *D. parvula*. In spring and fall, *D. variabilis* moved inshore while *D. parvula* was most abundant offshore, and in winter both species were most commonly observed offshore. Overall species richness and abundance increased with distance from shore, and there was a significant decline in abundance during the winter sampling period.

Gorzelany (1983) and Gorzelany and Nelson (1987) studied the effects of beach nourishment on intertidal and subtidal infaunal communities in the same Indialantic and Melbourne Beach area. Sampling was conducted at the high tide line and at distances of 30.5, 61, 91.4, and 121.9 m from the high tide line using the same methods as Spring (1981). At least 99 taxa were identified during this study, with the numerically dominant group being juvenile *Donax* sp. followed by the polychaete *Happloscoloplos fragilis*, the amphipods *Parahaustorius longimerus* and *Bathyporeia parkeri*, and the polychaete *Paraonis fulgens*. Species richness and density decreased in winter, increased in spring and summer, and decreased in fall. These population shifts did not seem to be attributable to beach nourishment effects, but rather to natural seasonal variations.

Lacharmoise et al. (in preparation) sampled swash zone populations of *Donax* and Emerita on Brevard County beaches immediately south of the Mid-Reach before, during, and after a 2002 beach nourishment project. They found project area *Donax* populations did not exhibit the same peak abundance levels as reference area populations during April-May 2002, which was within the sand placement interval. Both reference and project area sites showed a similar peak abundance spike the following March with project site *Donax* abundance exceeding that of one of the two reference sites. They observed no significant difference in *Emerita* densities between reference and project area sites during the sampling period, with population peaks occurring from June through November 2002. During the period of highest *Emerita* density, the population was primarily juveniles, indicating a reproductive event had occurred.

2.3.5.2 Fishes and Essential Fish Habitat

The ichthyofauna of eastern Florida is one of the most taxonomically diverse in the Western Atlantic. This high diversity is the consequence of biogeographical and environmental factors operating on various spatial and temporal scales (Gilmore, 1995, 2001). Overlap between tropical, subtropical, and warm-temperate faunas underlies the transitional nature of the region's biogeography (Gilmore, 1995, 2001). Consequently, the resulting ichthyofauna is composed of species with differing ecological and evolutionary histories that can be subdivided into several assemblages and habitats (Gilmore, 2001). Habitat diversity in the region also contributes to the high fish diversity, and there are many connections among habitats that range from inside the Indian River Lagoon to the outer continental shelf.

On a broad scale, the primary environmental factor influencing fish distribution in the region is water temperature. Seasonal drops in temperature affect inshore and coastal waters and limit the distribution of tropical species in inshore waters to about Sebastian, Florida (winter sea surface temperatures seldom fall below 20ºC south of 27º50' [Gilmore et al., 1979]). Although Sebastian is just south of the Brevard County Mid-Reach, many tropical species still occur in the project area, particularly on a seasonal basis. The Gulf Stream brings warm water to the outer shelf of the region, but water temperatures on the outer shelf can decline rapidly as a result of periodic upwellings that originate along the shelf break (Smith, 1983). These oceanographic features of the outer shelf can influence nearshore waters if prevailing conditions promote inshore movement of water masses. As mentioned above, species inhabiting the region are often grouped by their relative temperature tolerance into tropical, subtropical, and warm temperate (Miller and Richards, 1979) or more detailed variations of these general categories (Gilmore, 1995). Other environmental factors important to the distribution and abundance of fishes in the area include salinity, dissolved oxygen, turbidity, and hydrodynamics.

The following describes fishes inhabiting waters of the Mid-Reach project area, which includes the nearshore shelf and surf zone (0 to 4 m). Demersal soft bottom, coastal pelagic, and demersal hard bottom are the three ichthyofaunal assemblages that are discussed. Within each category, broad species composition, movements, life history characteristics, and feeding habits are discussed, then federally managed species (including invertebrates) and Essential Fish Habitat (EFH) as described by the South Atlantic Fishery Management Council (SAFMC) (1998) are characterized. A formal EFH assessment is presented in Appendix K- Subappendix C.

2.3.5.2 (a) Demersal Soft Bottom

The demersal soft bottom fish assemblage that inhabits the open shelf off eastern Florida consists of 213 species and 53 families (Gilmore et al., 1981; Gilmore, 2001). The most speciose families recorded include skates (*Rajiidae*), stingrays (*Dasyatidae*), torpedo rays (*Torpedinidae*), cusk-eels (*Ophidiidae*), searobins (*Triglidae*), drums (*Sciaenidae*), left-eye flounders (*Bothidae*), sand flounders (*Paralichthyidae*), and soles (*Soleidae*). The coastal or nearshore segment of the open shelf, generally termed the surf zone, represents the landward extent of this open shelf assemblage. Gilmore et al. (1981) reported 91 species from the surf zone of the region; 26 of these were classified as demersal soft bottom species. Peters and Nelson (1987) collected fishes by seine at a site south of the Mid-Reach, R 140, at Melbourne Beach. Over a 14-month sampling period, they collected 22 species; 3 of the species collected, gulf kingfish (*Menticirrhus littoralis*), southern kingfish (*Menticirrhus saxatilis*), and sand drum (*Umbrina coroides*), were demersal soft bottom species.

Movements of demersal soft bottom species are not well known. Ross and Lancaster (1996) found that tagged juvenile gulf kingfish remained within discrete segments (≤10 km) of the coastline and did not make extensive migrations. Some demersal soft bottom species such as flounders may move along the coast or across the shelf in response to changes in temperature, salinity, dissolved oxygen, or high wave energy. These movements may occur at a variety of temporal scales ranging from daily to annual (Ross, 1983).

Little information is available on spawning of demersal soft bottom species. Generally these species spawn in shelf or coastal waters producing pelagic eggs and larvae. Some species use the surf zone only as juvenile habitat, whereas others spend much of their life cycle there. For example, all life stages of kingfishes are found within the surf zone; this taxon, especially the gulf kingfish, is found in surf zone habitats throughout the east coast (Peters and Nelson, 1987, Ross and Lancaster, 1996; Layman, 2000) and into the northern Gulf of Mexico (Ross, 1983). Although there is little available life history information, sand drum (Umbrina coroides) appears to be another resident of the demersal surf zone of east Florida (Gilbert, 1966).

Demersal soft bottom species have slender bodies with subterminal mouths that are adapted to feeding in the high-energy environment of the surf zone (Ross, 1983). Most species feed on infaunal or epifaunal invertebrates (Modde and Ross, 1983). Others such as flounder (*Paralichthys* spp.) will feed in the water column on fishes and decapods.

A total of 133 cast net samples, employing an 8-ft radius net with 1/8-inch mesh, were collected along the Mid-Reach (**Figure 2-16**) to identify surf zone ichthyofauna (Continental Shelf Associates, Inc., November 2005). While seine nets are most commonly used to sample surf zone fishes (e.g., Peters and Nelson, 1987), cast netting allows multiple samples in areas where emergent hard bottom would not allow conventional seine sampling and in the area's characteristically rough surf. Of the 13 total taxa collected, demersal soft bottom species ranked third (gulf kingfish), fourth (kingfish), and fifth (sand drum) in terms of abundance (**Table 2-9**). Federally managed species that inhabit demersal soft bottom in the region include penaeid shrimps and red drum.

Penaeid shrimps managed by the SAFMC potentially occurring in the project area are brown shrimp (*Farfantepenaeus aztecus*), pink shrimp (*F. duorarum*), and white shrimp (*Litopenaeus setiferus*). Other members of this management unit including rock shrimp (*Sicyonia brevirostris*), seabob shrimp (*Xiphopenaeus kroyeri*), and royal red shrimp (*Pleoticus robustus*) are found in waters much deeper than the project area.

EFH for penaeid shrimps encompasses the series of habitats used throughout their life history (SAFMC, 1998). This life history has two basic phases: the adult and juvenile benthic phase, and the planktonic larval and post-larval phase. Benthic adults aggregate to spawn in shelf waters over coarse calcareous sediments. Eggs attached to the females' abdomens hatch into planktonic larvae. These larvae and subsequent post-larval stages feed on zooplankton in the water column and make their way into inshore waters. During the inshore phase of the life history, post-larval stages settle to the bottom and resume a benthic existence in estuaries that provide rich food sources as well as shelter from predation. Young penaeid shrimps prefer shallow-water habitats with nearby sources of organic detritus such as estuarine emergent vegetated wetlands or mangrove fringe. Young shrimp occur in the Indian River Lagoon from April to June. It would be during cross-shelf migrations, either to or from inshore waters that penaeid shrimps would likely occur in the Mid-Reach project area.

Red drum (*Sciaenops ocellata*) is a member of the drum family *Sciaenidae* and a common inhabitant of inshore, coastal, and shelf waters. EFH for red drum includes tidal freshwater, estuarine emergent vegetated wetlands (flooded salt marshes, brackish marsh, tidal creeks), mangrove shorelines, seagrasses, oyster reefs and shell banks, unconsolidated bottom (soft sediments), ocean high salinity surf zones, and artificial reefs (SAFMC, 1998). The Mid-Reach project area includes ocean high salinity surf zone.

Adult and sub-adult red drum feed on benthic invertebrates and fishes. Larvae and early juveniles feed on zooplankton. Larger juveniles feed on benthic prey.

Habitat Areas of Particular Concern (HAPCs) for red drum are coastal inlets, all state designated nursery habitats of particular importance to red drum, documented sites of spawning aggregations, and habitats for submerged aquatic vegetation (SAFMC, 1998). In many areas throughout the geographic range of red drum, mature adults migrate from inshore areas offshore into shelf waters to spawn. This seems to be the case offshore of east central Florida, however, in the Indian River and Mosquito Lagoons, Gilmore (unpublished data) and others (Johnson and Funicelli, 1991) documented spawning by red drum. Tagging studies conducted in inshore waters of the area have documented that red drum will migrate to ocean inlets such as Sebastian or Ponce De Leon, presumably to spawn (Stevens and Sulak, 2001; Tremain et al., 2004). Currently the portion of the local red drum population spawning in shelf waters off Brevard County is unknown. However, during certain times of the year, adult and sub-adult red drum occur in nearshore waters of the region.

Table 2-9. Fishes collected by cast net from sites along the Mid-Reach in order of total abundance. Sites are ordered from south to north (**Figure 2-15**).

Common Name	Species	Site																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Total
False pilchard	*Harengula jaguana*					160					322	51			235					1,000	1,768
Florida pompano	*Trachinotus carolinus*	2		6	7	27	2	7	12	3		6		7	5	3	1	7	6		101
Gulf kingfish	*Menticirrhus littoralis*	16	1	3	19				4						3	2	3	8	1		60
Kingfish	*Menticirrhus* sp.	22			1											6		3	1		33
Sand drum	*Umbrina coroides*	2			1						2				1	1	2	2	6		17
White mullet	*Mugil curema*				2															6	8
Permit	*Trachinotus falcatus*					3			2	1											6
Dusky anchovy	*Anchoa lyolepis*										1	1								2	4
Lizardfish	*Synodus* sp.													4							4
Hairy blenny	*Labrisomus nuchipinnis*											2									2
Sergeant major	*Abudefduf saxatilis*										1										1
Sheepshead	*Archosargus probatocephalus*					1															1
Ladyfish	*Elops saurus*													1							1
Total individuals		42	1	9	30	191	2	7	18	4	326	60	0	12	244	12	6	20	14	1,008	2,006
Total species		4	1	2	5	4	1	1	3	2	4	4	0	3	4	4	3	4	4	3	13

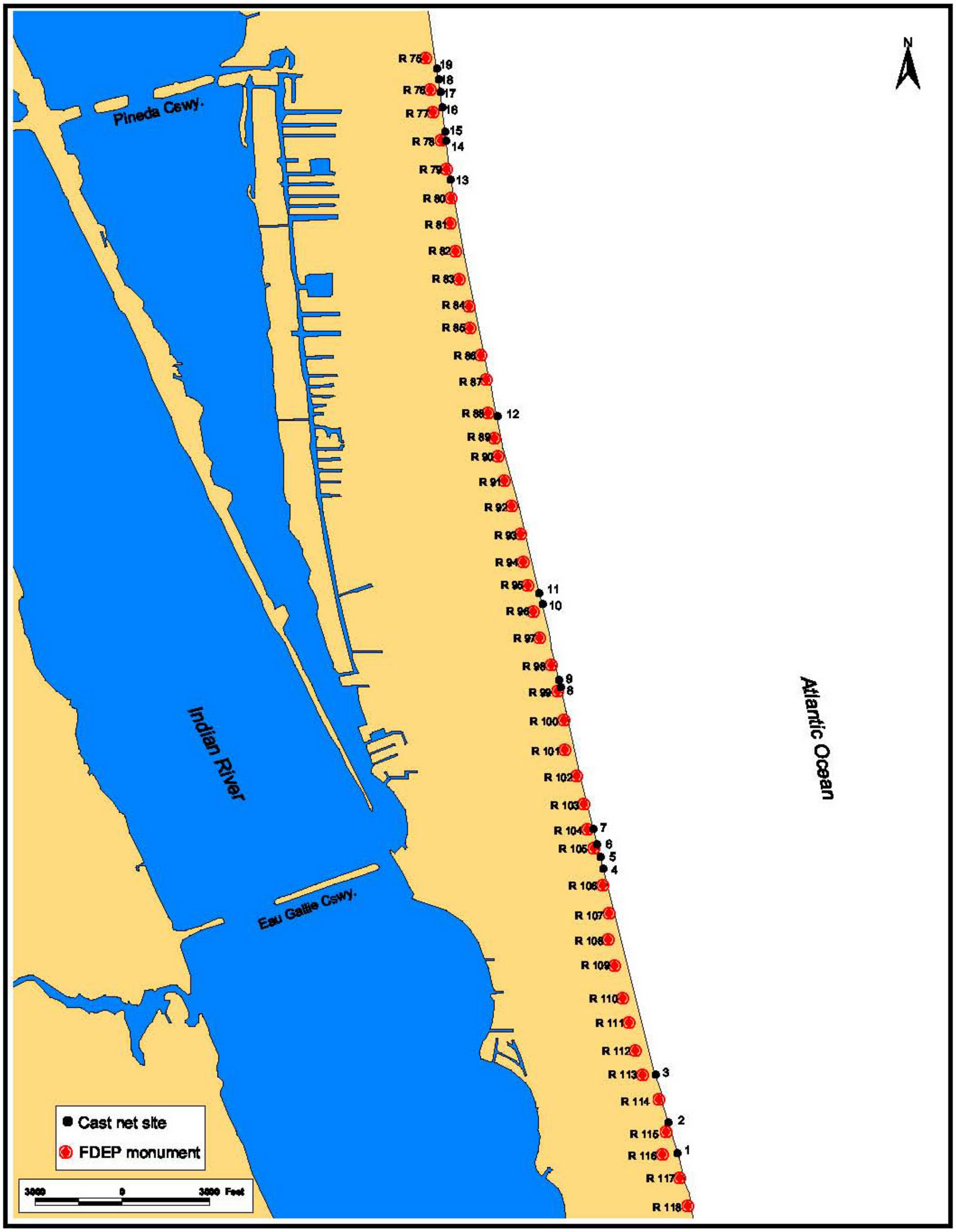

Figure 2-16. Field sampling sites along the Mid-Reach of Brevard County (2005) where fishes were collected with cast net.

2.3.5.2 (b) Coastal Pelagic

The major coastal pelagic families occurring in inshore and coastal waters of eastern Florida are requiem sharks (*Carcharhinidae*), eagle and cownose rays (*Myliobatidae*), ladyfish (*Elopidae*), tarpon (*Megalopidae*), anchovies (*Engraulidae*), herrings (*Clupeidae*), mackerels (*Scombridae*), jacks and pompanos (*Carangidae*), mullets (*Mugilidae*), bluefish (*Pomatomidae*), and cobia (*Rachycentridae*). Gilmore et al. (1981) reported 91 species from the surf zone habitat of the region; 62 of these species were coastal pelagic. At Melbourne Beach, Peters and Nelson (1987) collected 12 coastal pelagic species including anchovies *Anchoa hepsetus*, *A. lyolepis*, and *A. mitchilli*, false pilchard (*Harengula jaguana*), striped mullet (*Mugil cephalus*), white mullet (*M. curema*), and Florida pompano (*Trachinotus carolinus*).

Coastal pelagic species migrate over shelf (including nearshore and surf zone) waters of the region throughout the year, but fall and winter are generally the times of peak activity. Some species form large schools (e.g., cownose rays, anchovies, herrings, mullets, and Spanish mackerel [*Scomberomorus maculatus*]), while others travel singly or in smaller groups (e.g., tarpon [*Megalops atlanticus*]and cobia). Larger predatory species, particularly sharks, tarpon, bluefish (*Pomatomus saltatrix*), blue runner (*Caranx crysos*), jack crevalle (*Caranx hippos*), and Spanish mackerel, may be attracted to large aggregations of anchovies, herrings, and mullets that occur in nearshore areas, usually during late summer and fall. The local distribution of most species depends on water temperature and water quality (e.g., turbidity) that will vary spatially and seasonally. Rapid drops in air temperature (and atmospheric pressure) associated with passing cold fronts will often trigger southerly migrations of coastal pelagics such as Spanish mackerel and bluefish along the Florida coast.

Although coastal pelagic species are essentially water column dwellers, many will temporarily associate with natural or man-made structures including nearshore hard bottom. Within the Mid-Reach project area, smaller coastal pelagic species such as false pilchard occurred in the surf zone inside edge of the hard bottom, whereas larger species such as sharks and eagle rays were observed just outside of the hard bottom features.

Coastal pelagic fishes (not including sharks and rays) generally spawn in open shelf waters, resulting in planktonic eggs and larvae. When larvae transform into early juveniles, they may be attracted to flotsam (SAFMC, 1998) drifting in shelf waters or transform in the water column in response to physical-chemical gradients. Once transformed from the larval stage, some juvenile coastal pelagic species may enter inshore (estuarine) or shallow nearshore waters where they will remain until they reach a certain size/age. An example of this is the Florida pompano, which spawns offshore, but the young ranging in size from 10 to 80 mm (total length) inhabit shallow nearshore (surf zone) waters from mid-April to early December (Fields, 1962).

Most coastal pelagic fishes feed in the water column on nekton or plankton, using their vision to locate prey. Diets of individual species change with size and age of the individual and corresponding feeding morphology (body shape and jaw mechanism). Mackerels and jacks change from an early diet of zooplankton to adult fishes and larger nekton. Cobia change from zooplankton-feeding larvae to an opportunistic adult diet consisting of pelagic and benthic organisms (fishes and invertebrates). Most herrings and anchovies are planktivorous throughout their life history. Some coastal pelagic species such as juvenile and adult pompano feed mostly on benthic organisms such as clams, mole crabs, and other crustaceans. Sharks are opportunistic scavengers for much of their lives, feeding in both the water column and on the bottom.

Fish collections made by cast net along the Mid-Reach yielded several coastal pelagic taxa, including false pilchard, dusky anchovy (*Anchoa lyolepis*), white mullet, Florida pompano, and permit (*Trachinotus falcatus*) (**Table 2-10)**. These samples were collected in the surf zone between the shoreline and the landward edge of hard bottom in water depths of 1 m or less. Cast net sampling will undersample larger coastal pelagic species that normally occur outside the surf zone. For example, larger requiem sharks and eagle rays were caught by gill nets set for juvenile marine turtles just offshore of the hard bottom along the Mid-Reach (Holloway-Adkins and Provancha, 2005). See Appendix K- Subappendix A. More details on the fish collections may be found in the EFH assessment in Appendix K- Subappendix C.

Coastal pelagic species managed by the SAFMC are cobia (Rachycentron canadum), king mackerel (Scomberomorus cavalla), Spanish mackerel, and little tunny (Euthynnus alletteratus) (SAFMC, 1998). Life stages of all of these species may occur in the project area (**Table 2-10**).

EFH for coastal pelagic species includes sandy shoals of capes and offshore bars; high profile rocky bottom and barrier island ocean-side waters (from the surf zone to the shelf break zone), as well as all coastal inlets and all state designated nursery habitats of particular importance to coastal migratory pelagics (SAFMC, 1998).

Table 2-10. Coastal pelagic fishes and life stages with Essential Fish Habitat identified within the Mid-Reach project area (Source: South Atlantic Fisheries Management Council, 1998, National Marine Fisheries Service, 1999).

Common Name	Species	Eggs & Larvae	Juveniles/Subadults	Adults
Cobia	*Rachycentron canadum*	Shelf waters	Shelf waters; artificial and natural hard bottom; will associate with larger nekton (sharks, rays, sea turtles)	Shelf waters; artificial and natural hard bottom structures; will associate with larger nekton (sharks, rays, sea turtles)
King mackerel	*Scomberomorus cavalla*	Shelf waters	Shelf waters; will associate with artificial and natural hard bottom	Shelf waters; will associate with artificial and natural hard bottom
Spanish mackerel	*Scomberomorus maculatus*	Shelf waters	Shelf and inshore waters; will associate with artificial and natural hard bottom	Shelf and inshore waters; will associate with artificial and natural hard bottom
Little tunny	*Euthynnus alletteratus*	Shelf waters	Shelf waters; artificial and natural hard bottom	Shelf waters; artificial and natural hard bottom

Coastal sharks are those species (or life stages) commonly occuring in inshore and nearshore shelf waters. Several managed shark species occur in the project area, including blacknose (*Carcharhinus acronotus*), spinner (*C. brevipinna*), bull (*C. leucas*), dusky (*C. obscurus*), sandbar (*C. plumbeus*), tiger (*Gaelocerdo cuvier*), sand tiger (*Carcharias taurus*), bonnethead (*Sphyrna tiburo*), and lemon (*Negaprion brevirostris*). Sharks and rays reproduce via internal fertilization and bear live young or eggs in shelf or inshore waters, depending on the species. Female sharks and rays often seek shallow water before releasing live pups or depositing eggs (National Marine Fisheries Service [NMFS], 1999). The young of several of these species also utilize the nearby Indian River lagoon as nursery grounds (Snelson and Williams, 1981; Snelson et al., 1984). EFH identified by NMFS (1999) for coastal shark species is presented in **Table 2-11**. No HAPCs are available for coastal sharks.

Table 2-11. Coastal shark species and life stages with EFH identified within the Mid-Reach area (source: National Marine Fisheries Service, 1999).

Common Name	Species	Neonate/Early Juveniles	Late Juveniles/Subadults	Adults
Nurse shark	*Ginglymostoma cirratum*	--	Shallow coastal waters from the shoreline to the 25-m isobath off the east coast of Florida from Cumberland Island, GA (at 30.5ºN) to the Dry Tortugas	Shallow coastal waters from the shoreline to the 25-m isobath off the east coast of Florida from Cumberland Island, GA (at 30.5ºN) to the Dry Tortugas
Sand tiger shark	*Carcharias taurus*	Shallow coastal waters less than 25 m deep from Barnegat Inlet, NJ to Cape Canaveral, FL (27.5ºN)	--	Shallow coastal waters less than 25 m deep from Barnegat Inlet, NJ to Cape Canaveral, FL (27.5ºN)
Blacknose shark	*Carcharhinus acronotus*	Shallow coastal waters less than 25 m deep from the Georgia/Florida border to Cape Canaveral, FL	Shallow coastal waters less than 25 m deep from the Georgia/Florida border to Cape Canaveral, FL	--
Spinner shark	*Carcharhinus brevipinna*	Shallow coastal waters less than 25 m deep from Cape Hatteras, NC to around Florida	Shallow coastal waters less than 200 m deep from the Georgia/Florida border south to Cape Canaveral, FL (28.5 ºN)	Shallow coastal waters less than 100 m deep from Georgia/Florida border south to Cape Canaveral, FL (28.5 ºN)
Bull shark	*Carcharhinus leucas*	Shallow coastal waters, inlets, and estuaries in waters less than 25 m deep from just north of Cape Canaveral at 29ºN to just south of Cape Canaveral at 28ºN	Shallow coastal waters, inlets, and estuaries in water depths less than 25 m	n/a
Dusky shark	*Carcharhinus obscurus*	Shallow coastal waters, inlets, and estuaries in waters less than 25 m deep	Shallow coastal waters, inlets, and estuaries in waters less than 25 m deep	n/a
Sandbar shark	*Carcharhinus plumbeus*	Shallow coastal waters, inlets, and estuaries in waters less than 25 m deep from Montauk, NY to Cape Canaveral, FL (27.5ºN)	Shallow coastal waters, inlets, and estuaries in waters less than 25 m deep from Montauk, NY to Cape Canaveral, FL (27.5ºN)	n/a
Tiger shark	*Gaelocerdo cuvier*	Shallow coastal waters to the 200-m isobath from Cape Canaveral, FL (27.5ºN) to Montauk, NY	--	--
Lemon shark	*Negaprion brevirostris*	Shallow coastal waters, inlets, and estuaries less than 25 m deep from Bulls Bay, SC to West Palm Beach, FL	Shallow coastal waters, inlets, and estuaries less than 25 m deep from Bulls Bay, SC to West Palm Beach, FL	--
Bonnethead shark	*Sphyrna tiburo*	--	Shallow coastal waters, inlets, and estuaries less than 25 m deep from Cape Fear, NC to West Palm Beach, FL	--

-- = Life stage does not occur within the project area.
n/a = Information not available.

2.3.5.2 (c) Demersal Hard Bottom

Hard bottom habitats support the most diverse assemblages of fishes off eastern Florida. Gilmore et al. (1981) reported 255 species for offshore reefs and 109 species associated with nearshore hard bottom (surf zone reef) alone. Groupers (*Serranidae*), snappers (*Lutjanidae*), grunts (*Haemulidae*), porgies (*Sparidae*), spadefishes (*Ephippidae*), damselfishes (*Pomacentridae*), and wrasses (*Labridae*) are the most common families present. These groups are tropical and subtropical in origin. The most abundant species reported by Gilmore et al. (1981) for the region include black margate (*Anisotremus surinamensis*), porkfish (*Anisotremus virginicus*), spottail pinfish (*Diplodus holbrooki*), and hairy blenny (*Labrisomus nuchinipinnis*).

Many reef fishes migrate, but theirs are mostly developmental migrations that are an integral part of the life cycle. Reef fishes use a continuum of cross-shelf habitats to complete their life cycles. Many species migrate across the shelf from shallow nursery areas back to offshore spawning grounds. Hard bottom, including nearshore hard bottom, provides connections for young stages making developmental migrations from inshore areas to offshore spawning grounds

(Lindeman et al., 2000). Larval and early juvenile reef fishes use a variety of cues to locate adequate habitat for settlement.

Generally reef fishes spawn offshore, releasing eggs and larvae into the water column. In some species, such as gray snapper (*Lutjanus griseus*) and gag (*Mycteroperca microlepis*), larvae are transported through inlets into inshore areas where they settle on the bottom and occupy seagrass meadows or other structured habitats. As they grow, young move from seagrass areas to more structured areas including artificial hard bottom, mangrove fringe (prop roots), and nearshore hard bottom. Other reef fishes such as lane snapper (*L. synagris*) and grunts (*Haemulon* spp., *Anisotremus* spp., and *Orthopristis chrysoptera*) have similar life cycles, and their early life stages also may inhabit nearshore hard bottom (Lindeman and Snyder, 1999). Nearshore hard bottom provides an important connection among habitats for the cross-shelf developmental pathways undertaken by many reef species (Lindeman et al., 2000). Disruption of habitat connections can alter growth and ultimately reproduction of individuals that contribute to local demographic patterns. Other reef fishes such as damselfishes, blennies, and gobies settle onto reefs from the plankton and remain for their entire lives within a very small area of the habitat.

Reef fishes represent a variety of feeding types ranging from herbivory to carnivory. As with the other groups, most reef fishes begin life feeding on zooplankton and change diet with size and age. Some, such as snappers and groupers, are carnivorous from early stages, changing only the size of the food items as they grow (Sweatman, 1993). Grunts (*Haemulon* spp. and *Anisotremus* spp.) feed on zooplankton as early juveniles then switch to benthic prey as they grow. Some species, including porgies (*Diplodus* spp.), change their diet from zooplankton as juveniles to algae as adults. Thus, some reef fishes depend on the hard bottom for food, whereas many others depend on the import of plankton and nekton across the reef or surrounding soft bottom areas.

Visual surveys consisting of 10-minute swims (a modification of Kimmel's [1985] method) were conducted over nearshore hard bottom along the southern portion of Brevard's Mid-Reach. Locations of these censuses are provided in **Figure 2-17**. These censuses were made when the water clarity was marginal (less than 1 m), so the results should be considered underestimates of diversity and species composition. The surveys revealed 19 species (**Table 2-12**) and generally higher numbers of juveniles than of adults, indicating that the habitat is providing some nursery function. Species composition is consistent with the results of Gilmore et al. (1981) for nearshore hard bottom in the region. Of the 19 species observed, 6 (black margate, porkfish, lane snapper [*Lutjanus synagris*], gray snapper, Atlantic spadefish [*Chaetodipterus faber*], and sheepshead [*Archosargus probatocephalus*]) are members of the reef fish management unit (SAFMC, 1998). Another species, the nurse shark, is managed by the National Marine Fisheries Service (1999). Striped croaker (*Bairdiella sanctaeluciae*) is considered a species of special concern by the State of Florida (Gilmore and Snelson, 1992). Many reef fish species not managed by the SAFMC also utilize nearshore hard bottom in the project area. During field surveys, other species such as wrasses (*Halichoeres bivitattus*, *H. poeyi*), clingfish (*Gobiesox strumosus*), sergeant major (*Abudefduf saxatilis*), night sergeant (*Abudefduf taurus*), and hairy blenny (*Labrisomus nuchipinnis*) were observed in shallow tide pools. More details of the visual surveys are in the EFH assessment (Appendix K- Subappendix C).

The reef fish (snapper-grouper) management unit consists of 73 species from 10 families. Although the fisheries and adult habitat of most of these species exist well offshore of the project area, the young stages of several reef fishes utilize nearshore hard bottom (e.g., Gilmore et al., 1981; SAFMC, 1998; Lindeman and Snyder, 1999; Lindeman et al., 2000). SAFMC (1998) identified the following habitats as EFH for early life stages of reef fishes: attached macroalgae, seagrasses, salt marshes, tidal creeks, mangrove fringe, oyster reefs and shell banks, soft sediments, artificial reefs, coral reefs, and hard/live bottom. The Mid-Reach project area includes soft bottom and hard/live bottom. Nearshore hard bottom has been identified as an important habitat for many of the 73 members of the reef fish management unit (SAFMC, 1998). Reef fish species with EFH in the project area are listed in **Table 2-13**.

HAPCs for the reef fish management unit include localities of known or likely periodic spawning aggregations, nearshore hard bottom areas, mangrove habitat, seagrass habitat, oyster/shell habitat, all coastal inlets, all state designated nursery habitats of particular importance to snapper-grouper species, and artificial reefs (SAFMC, 1998). For the Mid-Reach project area, nearshore hard bottom is certainly present.

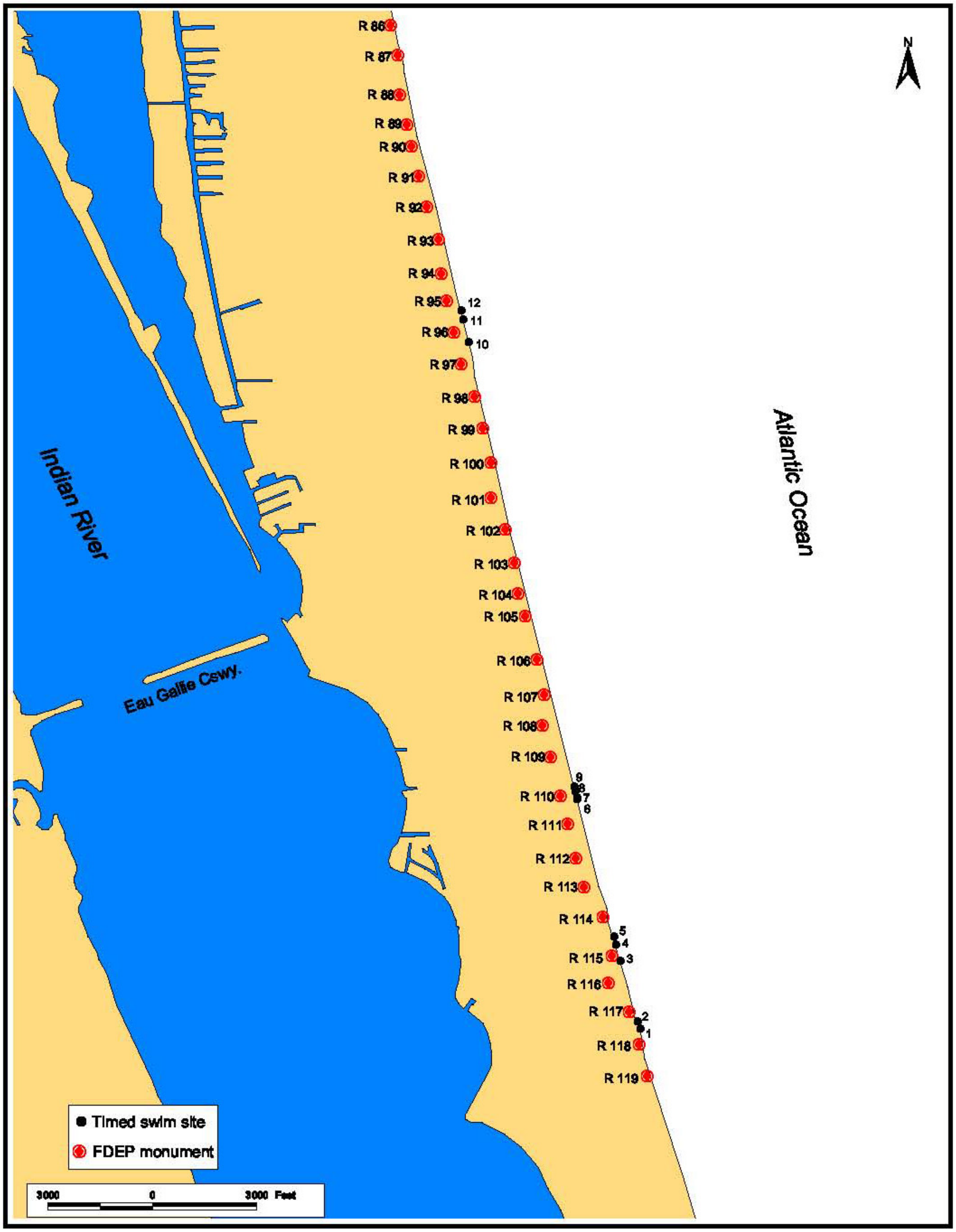

Figure 2-17. Field sampling sites along the Mid-Reach of Brevard County (2005) where reef fishes were censused by timed (10-min.) swims.

There are many species occurring in the project area that are not managed by the SAFMC but are nevertheless important economically or ecologically. Most notable of these species are tarpon, common snook (*Centropomus undecimalis*), striped croaker, Florida pompano, summer flounder (*Paralichthys dentatus*), and southern flounder (*Paralichthys lethostigma*). The Florida Fish and Wildlife Commission manages tarpon, snook, Florida pompano, and the two flounders. In addition, Florida pompano, flounder, and tarpon are considered to be Aquatic Resources of National Importance.

Table 2-12. Fishes observed during 10-minute swims over hard bottom features along the Brevard County Mid-Reach in order of total abundance. Sites are ordered from south to north (**Figure 2-16**).

Common Name	Species	Site												
		1	2	3	4	5	6	7	8	9	10	11	12	Total
Black margate	*Anisotremus surinamensis*	3	12		7	13	10	47	57	14	17	30	22	232
Hairy blenny	*Labrisomus nuchipinnis*	6	1	1	2	3	13	6	22	11	17	21	16	119
Silver porgy	*Diplodus argenteus*	7	5				8	4	10	11	8	5	10	68
Sheepshead	*Archosargus probatocephalus*		11			3		4	16	6	1	1	2	44
Atlantic spadefish	*Chaetodipterus faber*	6	9	2		3	5		1				2	28
Gray snapper	*Lutjanus griseus*		3			1				2		2	1	9
Slippery dick	*Halichoeres bivittatus*										1		5	6
Porkfish	*Anisotremus virginicus*				1							1	2	4
Molley miller	*Scartella cristata*										1		3	4
Sergeant major	*Abudefduf saxatilis*							1			1			2
Lane snapper	*Lutjanus synagris*								1		1			2
Striped croaker	*Bairdiella sanctaeluciae*											1		1
Nurse shark	*Ginglymostoma cirratum*					1								1
Blackear wrasse	*Halichoeres poeyi*										1			1
Pigfish	*Orthopristis chrysoptera*							1						1
Gulf flounder	*Paralichthys albigutta*												1	1
High-hat	*Paraques acuminatus*							1						1
Sand drum	*Umbrina coroides*								1					1
Razorfish	*Xyrichtys* sp.										1			1
Total Numbers		22	41	3	10	24	36	64	108	44	49	61	64	526
Total Taxa		4	6	2	3	6	4	7	7	5	10	7	10	19

Table 2-13. Species by family from the Reef Fish Management Unit with Essential Fish Habitat presence in the project area (South Atlantic Fishery Management Council [SAFMC], 1998).

Family	Common Name	Species	Spawning	Eggs	Larvae	Juveniles	Adults
Serranidae – Sea Basses and Groupers	Red grouper	*Epinephelus morio*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; hard bottom; inshore and shelf waters	Demersal; hard bottom; shelf waters
	Goliath grouper	*Epinephelus itajara*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; hard bottom; inshore and shelf waters	Demersal; hard bottom; shelf waters
	Gag	*Mycteroperca microlepis*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; hard bottom; inshore and shelf waters	Demersal; hard bottom; shelf waters
	Scamp	*Mycteroperca phenax*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; hard bottom; shelf waters	Demersal; hard bottom; shelf waters
	Black sea bass	*Centropristis striata*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; hard bottom; inshore and shelf waters	Demersal; hard bottom; shelf waters
Carangidae – Jacks	Blue runner	*Caranx crysos*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; inshore waters	Demersal; hard bottom; inshore and shelf waters
	Crevalle jack	*Caranx hippos*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; inshore waters	Demersal; hard bottom; inshore and shelf waters
Lutjanidae – Snappers	Gray snapper	*Lutjanus griseus*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; inshore waters	Demersal; hard bottom; inshore and shelf waters
	Lane snapper	*Lutjanus synagris*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; inshore and shelf waters	Demersal; hard bottom; inshore and shelf waters
	Vermilion snapper	*Rhomboplites aurorubens*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; shelf waters	Demersal; hard bottom; inshore and shelf waters
Haemulidae – Grunts	White grunt	*Haemulon plumieri*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; inshore waters	Demersal; hard bottom; inshore and shelf waters
	Porkfish	*Anisotremus virginicus*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; inshore waters	Demersal; hard bottom; inshore and shelf waters
	Black margate	*Anisotremus surinamensis*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; inshore waters	Demersal; hard bottom; inshore and shelf waters
	Sailors choice	*Haemulon parra*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; inshore waters	Demersal; hard bottom; inshore and shelf waters
Sparidae – Porgies	Sheepshead	*Archosargus probatocephalus*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; inshore waters	Demersal; hard bottom; inshore and shelf waters
Ephippidae – Spadefishes	Atlantic spadefish	*Chaetodipterus faber*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; inshore and shelf waters	Demersal; hard bottom; inshore and shelf waters
Balistidae – Triggerfishes	Gray triggerfish	*Balistes capriscus*	Shelf waters	Pelagic; shelf waters	Pelagic; shelf waters	Demersal; shelf waters	Demersal; hard bottom; inshore and shelf waters

2.3.5.3 Birds

Birds that may be affected by the proposed action include primarily shorebird and seabird species that use outer beach and primary dune habitats within the project area for roosting, feeding, and/or nesting activities. A list of birds known to occur as resident species or seasonal visitors within Brevard County, including the project area, is presented in **Table 2-14**, along with information pertaining to their seasonal abundance within Brevard County. Shorebird species listed as seasonally common residents in this area include Black-bellied Plover, Killdeer, Black-neck Stilt, Short-billed Dowitcher, Greater Yellowlegs, Lesser Yellowlegs, Willet, Ruddy Turnstone, Sanderling, Western Sandpiper, Least Sandpiper, and Dunlin. Seasonally common seabird species in this area include Brown Pelican, Double-crested Cormorant, Ring-billed Gull, Great Black-backed Gull, Herring Gull, Laughing Gull, Royal Tern, Forster's Tern, Least Tern, and Black Skimmer. A recent census survey of birds utilizing beach habitat in the vicinity of the project area (i.e., from Sea Gull Park near Patrick Air Force Base to US-192 in Indialantic) was performed on 31 July 2005 by volunteers from the local Audubon Society Chapter (Space Coast Audubon Society). These data are presented in **Table 2-15**.

Data from nearby South Melbourne Beach include a few outer shelf and pelagic seabird species that may seasonally range into near coastal waters of the project area but are not expected to be affected by beach nourishment activities. These species are as follows:

- Cory's Shearwater (*Calonectris diomedea*) – occasionally comes close to shore from June-November.
- Greater Shearwater (*Puffinus gravis*) – same
- Audubon's Shearwater (*Puffinus lherminieri*) – rarely comes close to shore in summer.
- Wilson's Storm-Petrel (*Oceanites oceanicus*) – rarely comes close to shore in summer.
- Northern Gannet (*Morus bassanus*) – common in winter close to shore.
- Brown Booby (*Sula leucogaster*) – rarely close to shore in summer.

In addition, many species of ducks migrate near the coast in fall starting with Blue-winged Teal in September (most are seen in November). Other species include Northern Pintail, American Wigeon, Northern Shoveler, Green-winged Teal, Lesser and Greater Scaup, Black, Surf, and White-winged Scoters, Bufflehead, and Red breasted Merganser. Peregrine Falcons and Merlins often migrate down the coast in winter months and feed on migrating/wintering shorebirds.

Table 2-14. Brevard shorebirds and near coastal seabirds (data and sequence of species from: Indian River Audubon Society, 2002).

Common Name	Genus/Species	Seasonal Abundance			
		Mar-May	Jun-Aug	Sep-Nov	Dec-Feb
SHOREBIRDS					
American Golden Plover	*Pluvalis dominica*			R	R
Black-bellied Plover	*Pluvalis squatarola*	C	O	C	C
Semipalmated Plover	*Charadrius semipalmatus*	O	R	U	C
Wilson's Plover	*Charadrius wilsonia*	R	R	R	R
Killdeer	*Charadrius vociferus*	C	C	C	C
Piping Plover	*Charadrius melodus*	O		O	O
Snowy Plover	*Charadrius alexandrinus*	A	A	A	A
American Oystercatcher	*Haematopus palliatus*	O	O	O	O
Black-necked Stilt	*Himantopus mexicanus*	C	C	U	
American Avocet	*Recurvirostra americana*	O		U	U
Common Snipe	*Gallinago gallinago*	O		U	U
Short-billed Dowitcher	*Limnodromus griseus*	U	O	C	C
Long-billed Dowitcher	*Limnodromus scolopaceus*	R		R	R
Hudsonian Godwit	*Limosa haemastica*	A	A	A	A
Bar-tailed Godwit	*Limosa limosa*	A	A	A	A
Marbled Godwit	*Limosa fedoa*	O		O	O
Whimbrel	*Numenius phaeopus*	O		O	O
Greater Yellowlegs	*Tringa melanoleuca*	C	O	C	C
Lesser Yellowlegs	*Tringa flavipes*	C	O	C	C

Common Name	Genus/Species	Seasonal Abundance			
		Mar-May	Jun-Aug	Sep-Nov	Dec-Feb
Solitary Sandpiper	*Tringa solitaria*	O		O	R
Spotted Sandpiper	*Actitis macularia*	O		U	U
Willet	*Catoptrophorus semipalmatus*	C	C	C	C
Ruddy Turnstone	*Arenaria interpres*	C	O	C	C
Red Knot	*Calidris canutus*	O	R	O	O
Sanderling	*Calidris alba*	C	O	C	C
Semipalmated Sandpiper	*Calidris pusilla*	U	O	U	
Western Sandpiper	*Calidris mauri*	C	O	C	C
Least Sandpiper	*Calidris minutilla*	C	O	C	C
White-rumped Sandpiper	*Calidris fuscicollis*	R		R	
Baird's Sandpiper	*Calidris bairdii*	A	A	A	A
Pectoral Sandpiper	*Calidris melanotos*	O	R	O	R
Dunlin	*Calidris alpina*	C	R	C	C
Purple Sandpiper	*Calidris maritima*			R	R
Stilt Sandpiper	*Calidris himantopus*	O	R	O	O
Buff-breasted Sandpiper	*Tryngites subruficollis*	A	A	A	A
Ruff	*Philomachus pugnax*	A	A	A	A
Wilson's Phalarope	*Phalaropus tricolor*		R	R	
Red-necked Phalarope	*Phalaropus lobatus*	R		R	R
Red Phalarope	*Phalaropus fulicaria*	R	O	O	R
SEABIRDS					
Brown Pelican	*Pelicanus occidentalis*	C	C	C	C
Double-crested Cormorant	*Phalacrocorax auritus*	C	C	C	C
Ring-billed Gull	*Larus delawarensis*	C	U	C	C
Great Black-backed Gull	*Larus marinus*	U	O	C	C
Herring Gull	*Larus argentatus*	C	O	C	C
Bonaparte's Gull	*Larus philadelphia*	O		O	C
Laughing Gull	*Larus atricilla*	C	C	C	C
Gull-billed Tern	*Sterna nilotica*	O	O	O	R
Caspian Tern	*Sterna caspia*	U	O	U	U
Sandwich Tern	*Sterna sandvicensis*	O	R	O	O
Royal Tern	*Sterna maxima*	C	C	C	C
Roseate Tern	*Sterna dougallii dougallii*	A	A	A	A
Common Tern	*Sterna hirundo*	R		U	R
Forster's Tern	*Sterna forsteri*	C	O	C	C
Least Tern	*Sterna antillarum*	C	C	U	
Bridled Tern	*Sterna anaethetus*	O	U	O	R
Sooty Tern	*Sterna fuscata*	R	R	R	
Black Tern	*Chlidonias niger*	R	O	O	
Black Skimmer	*Rhynchops niger*	C	C	C	C
WADING BIRDS					
Great Blue Heron	*Ardea herodias*	C	C	C	C
Great White Heron	*Ardea herodias*	A	A	A	A
Great Egret	*Ardea alba*	C	C	C	C
Reddish Egret	*Egretta rufescens*	O	O	U	U
Tricolored Heron	*Egretta tricolor*	C	C	C	C
Little Blue Heron	*Egretta caerulea*	C	C	C	C
Snowy Egret	*Egretta thula*	C	C	C	C
Cattle Egret	*Bubulcus ibis*	C	C	C	C
Green Heron	*Butorides virescens*	U	U	U	U

Common Name	Genus/Species	Seasonal Abundance			
		Mar-May	Jun-Aug	Sep-Nov	Dec-Feb
Black-crowned Night-Heron	*Nycticorax nycticorax*	U	U	U	U
Yellow-crowned Night-Heron	*Nyctanassa violacea*	O	O	O	O

C = Common – Present in large numbers and widespread. Certain to be seen in the right habitat.
U = Uncommon – Present in lower numbers or local in distribution. Should be seen with reasonable effort in the right habitat.
O = Occasional – Present in small numbers or local in distribution. Not expected to be seen without special effort.
R = Rare – In range but not expected to be seen every year. When present, usually in very low numbers or are secretive or very hard to find.
A = Accidental – Either very rare or out of their normal range.
Blank = Unknown or status not yet determined.

Table 2-15. Birds sighted within the project area during a 1-day (31 July 2005) survey by the Space Coast Audubon Society.

Common Name	Genus/Species	Numbers Sighted*
Sanderling	*Calidris alba*	345 (9)
Ruddy Turnstone	*Arenaria interpres*	47 (10)
Willet	*Catoptrophorus semipalmatus*	11 (1)
Laughing Gull	*Larus atricilla*	2 (6)
Brown Pelican	*Pelicanus occidentalis*	(14)
Royal Tern	*Sterna maxima*	(45)
Least Tern	*Sterna antillarum*	(22)
Snowy Egret	*Egretta thula*	2
Black Skimmer	*Rhynchops niger*	2

* Numbers in parentheses are birds that were seen flying by and not on the beach.

2.3.6 Essential Fish Habitat

In the SAFMC (1998) comprehensive EFH amendment, important habitats of the South Atlantic region were broadly divided into estuarine/inshore and marine/offshore with many subcategories under each heading. Marine/offshore habitats include coastal, open shelf, live/hard bottom, shelf edge, and lower shelf (SAFMC, 1998). Each of these habitats harbors a distinct assemblage of demersal fishes and invertebrates. The Brevard Mid-Reach project area encompasses only marine/offshore habitats and, of these, the project area includes three major habitats: hard bottom (nearshore hard bottom), soft bottom (open shelf), and the water column. These habitats were discussed previously relative to how they are utilized by managed species. Here they are discussed in terms of salient characteristics in the project area. See also the EFH assessment in Appendix K-Subappendix C.

2.3.6.1 Nearshore Hardbottom

Nearshore hard bottom is the primary EFH found in the project area. This habitat supports more species than the soft bottom or water column. Nearshore hard bottom outcrops along the eastern Florida shoreline are composed of beach rock (coquina) of the Anastasia limestone formation (Davis, 1997), usually formed as wind-blown sand dunes during the Pleistocene era. These features parallel the present-day shoreline and are subject to frequent burial and erosion caused by high wave energy of the surf zone. Unless the features have appreciable relief, they will be variously inundated by sand.

Despite this physically demanding environment, several sessile organisms are well adapted to the prevailing conditions and often cover high portions of the exposed rock. One such organism is the sabellarid polychaete *Phragmatopoma lapidosa*, which forms large gregarious colonies commonly referred to as wormreefs (Kirtley and Tanner, 1968; McCarthy., 2001). The wormreef colonies are composed of sand grains cemented together to form rugose structures that add relief and structural complexity to existing natural and artificial hard bottom. The growth of wormreef is dependent on a combination of available hard substrate, wave energy, sediment availability, and larval supply (McCarthy et al., 2003). Wormreefs south of Cape Canaveral have been designated as EFH by the SAFMC (1998). In addition to fish species, wormreef supports associated assemblages of organisms such as decapod crustaceans (Gore et al., 1978). Details of epibiota of the Mid-Reach hard bottom features are presented in Appendix K- Subappendix B.

There are approximately 42.5 acres of nearshore hard bottom in a band along the entire Brevard County coast based upon the June 2004 mapping, and approximately 31 acres along the Mid-Reach section. This band has been quantified by aerial photography then characterized by field verification of broad substrate categories (Olsen 2003). The areal extent of rock increases with increasing latitude. There are subtidal and intertidal portions of hard bottom along the Mid-Reach. The rock surface supported macroalgae and other epibionts that are important as food or shelter for fishes of varying life stages. Much of the epibiota is ephemeral and subject to extensive wave scour. Portions of the exposed rock are colonized by the sabellariid worm Phragmatopoma.

2.3.6.2 Nearshore Soft Bottom (Surf Zone)

Surf zone is the innermost portion of the open shelf habitat subcategory. Along the Mid-Reach the surf zone occurs landward of the hard bottom outcrop and the shoreline. The presence of infaunal invertebrates in the surf zone and nearshore soft bottom provides an important prey base for many of the benthic feeding fishes. Sediment characteristics in the nearshore soft bottom habitat change with latitude. Coarser shelly material is found in the southern portion of the Mid-Reach. Soft bottom species such as kingfish and sand drum feed extensively on infaunal invertebrates. In the surf zone, mole crab (*Emerita talpoida*) and beach clam (*Donax* sp.) are key invertebrate prey species. See Section 2.3.5.1 for further discussion of the infuana found along the Mid-Reach.

Soft bottom areas that are offshore of the surf zone include sandy patches within and just beyond the hard bottom feature.

2.3.6.3 Water Column

The water column of the area overlays the nearshore and surf zone portions of the project area. Important attributes of the water column include hydro-dynamics, temperature, salinity, and dissolved oxygen. The hydrodynamic regime is driven mostly by persistent ground swells generated by low pressure systems (tropical and extra-tropical cyclones). The persistent wave energy resuspends fine sediments into the water column for extended periods. A wave gauge at nearby Melbourne Beach recorded maximum wave heights for April, May, and June 2005 as 2.31, 1.57 and 1.61 m, respectively. As a result of the persistent waves, the water column of the project area is continually turbid. This problem chronically confounds complete visual sampling and aerial imagery of the Mid-Reach hard bottom.

Salinity data for the project area are not available. However, because coastal inlets are considerable distance from the Mid-Reach (13.5 miles from Canaveral Inlet to the northern Mid-Reach R-75.3 and 18.5 miles from Sebastian Inlet to the southern Mid-Reach R-119), the effects of inshore tidal water discharges on salinity are probably minimal during most seasons. With persistent wave energy and constant mixing, dissolved oxygen also is expected to be within normal ranges for supporting fish assemblages. Temperature should follow a seasonal pattern with peaks in summer and lows in winter. However, upwellings of cold water during summer could cause unseasonable changes in nearshore water temperature.

2.3.7 Cultural, Historic, and Archaeological Resources

2.3.7.1 Canaveral Shoal Borrow Area

The Canaveral Shoal Borrow Area is an existing previously used area developed for the Brevard County Shore Protection Project. This borrow area was used as recently as 2005. Underwater surveys and diver identifications have been conducted in the proposed borrow area. This effort is documented in a number of reports dating from 1994 all coordinated with the Florida State Historic Preservation Officer.

"*A Cultural Resources Survey of Proposed Borrow Area, Vicinity of Cape Canaveral, Brevard County, Florida* (DHR file No. 942533) this 1994 survey identified six potentially significant targets identified. The 1999 survey *A Submerged Cultural Resources Remote Sensing Survey of Four Proposed Borrow Areas and Archaeological Diver Identification and Evaluation of Eight Potentially Significant submerged Targets for the Brevard County Shore Protection Project, Brevard County, Florida* (DHR Nos. 992156 and 2000-02415) determined that the targets identified in 1994 were not significant and identified eight potentially significant targets in an expanded borrow area. In 2001 *Archaeological Diver Identification and Evaluation of Fourteen Potentially Significant Submerged Targets for the Brevard County Shore Protection Project* (DHR file No. 2001-316) identified eight anomalies as debris from the space program and potentially significant, avoidance was recommended. Additional areas were surveyed in 2002 which id documented in *A Cultural Resources Marine Remote Sensing Survey of the Offshore Borrow and Re-*

Handling Areas South Reach Brevard County Shore Protection Project, Brevard County, Florida (DHR file No. 2002-06980; no anomalies were identified.

2.3.7.2 Mid-Reach Beach Nourishment Area

Consultation with the Florida State Historic Preservation Officer (SHPO) for the Mid-Reach Nourishment Area identified the need to conduct a shoreline and underwater cultural resource survey in the project area (DHR file No. 2005-3278). From September 2006 to July 2007 the Jacksonville District contracted with Southeastern Archaeological Research, Inc. (SEARCH) to conduct a cultural resource investigation relative to the proposed beach nourishment activities within the Mid-Reach. In their report, *Historic Assessment and Cultural Resources Survey of the Shoreline and Submerged Remote Sensing Survey and Diver Evaluation of the NN (No Name) Shipwreck Site (8BR199) Brevard County, Florida,* SEARCH states that they investigated the NN Shipwreck and found that the site consisted of ballast stones and six or seven iron knees scattered in the rocks along the shoreline. The terrestrial cultural resources survey examined five proposed equipment staging areas and three alternate staging areas associated with the project. No cultural material was recovered or identified during the visual inspection and subsurface testing of the staging areas. A shoreline remote sensing survey utilizing a terrestrial magnetometer was also conducted and was centered on the reported location of the NN Shipwreck. The area of shoreline investigated consisted of a beach corridor 2,000 feet in length and 200 feet in width. This survey documented numerous anomalies, most of which were associated with shoreline buildings and structures or were small targets associated with beachgoers and isolated debris. Results of the nearshore magnetometer and side scan sonar survey identified a total of six anomalies which warranted investigation utilizing archaeological divers. With the exception of some metal objects at Targets BC-7/BC-8, the divers were not able to identify any of the anomalies indicating they were all deeply buried. The Corps determined that the Mid-Reach Beach Nourishment project would have no effect on cultural resources eligible for listing on the National Register of Historic Places. The SHPO concurred with this determination (DHR No. 2007-8113 and 2008-00032).

2.3.8 Aesthetics

The shorefront along the Mid-Reach project area features medium- to low-density, mixed-use commercial and residential development, interspersed among numerous public beach parks and undeveloped properties with substantial, mostly natural dune vegetation and tree canopy. Buildings are mostly 1- to 3-stories, with several higher-story hotels and condominiums. The natural beach dune (or bluff) habitat mostly exists along the shorefront, along with coastal hammock in many locations, excepting several properties that are armored by seawalls or for which the buildings/lawns are very close to the beach. Storm erosion of the beach results in significant scarping of the bluff, loss of vegetation, and damage to dune walkovers and other structures. There are 13 storm water drain outfalls located on the back-beach along the Mid-Reach shoreline, of which six are mostly or wholly buried in dune and are rarely seen, or known to flow onto the beach, except after severe hurricane impacts. At least two of the outfalls feature fairly significant flow after rainfall, creating some trenching of the beach (Jones-Edmunds, 2007; Brevard County NRMO, March 2008). One example is shown in **Figure 2-18**. The aesthetics of the beach area are not significantly changed relative to the original EIS document (USACE 1996).

The DMMA sand stockpile area is within U.S. military boundaries on the north side of Canaveral Harbor, which is associated with industrial, bulk-storage, cargo and military operations. Development of the facilities around the DMMA have permanently impacted the aesthetic quality of this area.

Figure 2-18. Existing storm water outfall drain near Howard Futch Park, south of Crowne Plaza hotel (monument R-109.2)

2.3.9 Recreation

Common beach- and water-related activities along the project area include sun-bathing, shell collecting, surf- and boat-fishing, swimming, surfing, wind- and kite-surfing, boating and kayaking and occasionally snorkeling when the water is clear. The public has substantial access to the Mid-Reach beaches through 30 public parks and beach access paths, along with access through extensive hotel facilities and rental condominiums, etc. At least seven large public parks include extensive parking and restroom facilities (Olsen 2003). Beach recreation is central to most local business interests in the area. There are no significant recreation activities associated with the DMMA. Jetty Park, a Brevard County Parks and Recreation Department facility operated by the Canaveral Port Authority, is located at the mouth of the harbor entrance on the opposite bank of the DMMA. This property is used for camping, fishing and other land-based and beach-related recreational uses.

2.3.10 Coastal Barrier Resources

The Coastal Barrier Resources Act (CBRA) of 1982 designated undeveloped private coastal barrier lands and associated aquatic habitat as part of the Coastal Barrier Resources System (CBRS). The Coastal Barrier Improvement Act of 1990 expanded the CBRS and created a new category of lands known as otherwise protected areas (OPAs). The project area does not include lands within CBRS units or within OPA units. The Spessard Holland Park Unit FL-13P is an OPA located about 3.5 miles south of the Mid-Reach. The Coconut Point unit P09A is a CBRS unit located about 5.5 miles south of the Mid-Reach. The approximate north boundary of the Archie Carr National Wildlife Refuge is likewise about 5 miles south of the Mid-Reach.

2.3.11 Water Quality

The waters off the coast of Brevard County and throughout the project areas, including Canaveral Harbor, are listed as Class III waters by the State of Florida. Class III waters are suitable for recreation and propagation by fish and wildlife. There are no known significant changes in water quality issues relative to the original EIS document (USACE 1996).

2.3.12 Hazardous, Toxic, and Radioactive Waste

There are no known sources of hazardous, toxic, or radioactive wastes within or adjacent to the beach project area, DMMA sand stockpile area, or offshore borrow areas.

2.3.13 Air Quality

Ambient air quality along coastal Brevard County and Canaveral Harbor is generally good due to prevalent ocean breezes from the northeast through the southeast, and due to the general lack of significant industrial development. Brevard County is classified as an attainment area for all Federal Air Quality Standards (USACE 1996).

2.3.14 Noise

Ambient noise levels along coastal Brevard County are typically low to moderate and are typical of recreational environments, with occasional exceptions related to military aircraft landing and take-off operations at Patrick Air Force Base, immediately north of the Mid-Reach. Otherwise, the major noise producers include the breaking surf, adjacent commercial and residential areas, and vehicular traffic along State Route A1A. Noise levels within Canaveral Harbor, adjacent to the DMMA, range from low to high levels, and are associated with localized stevedore activities, horns and passage of large ships through the harbor, and occasional rocket launches from the Cape Canaveral Air Station and Kennedy Space Center facilities.

2.3.15 Public Safety

Issues of public safety along the beach project area principally include those typically associated with beach- and water-related recreation, including sun exposure and injuries or drowning from high surf or run-outs. The submerged rock outcrops in shallow water along the Mid-Reach shoreline can also result in injuries to bathers. Most public beach parks are staffed by County or municipal lifeguards during periods of normal to high beach use. Crime and related activities are of a low to moderate nature and are not considered to be of a significant nature. There is no public access to, or near, the DMMA sand stockpile area.

2.3.16 Energy Requirements and Conservation

Dredge and truck-haul operations potentially associated with the project will require temporary investments of fuel energy that are not significant.

2.3.17 Natural or Depletable Resources

No natural energy or depletable resources occur within the beach project area or DMMA.

2.3.18 Scientific Resources

Excepting the environmental resources utilized by marine and related wildlife associated with the nearshore rock outcrops and adjacent beach substrate, and the scientific studies of these species' interaction with these resources, there are no significant scientific resources in the project area.

2.3.19 Native Americans

There are no known native American interests in the study area.

2.3.20 Reuse and Conservation Potential

Not applicable.

2.3.21 Urban Quality

The beach project area is a low- to moderate-density, mixed use environment of commercial and residential development. The DMMA is located within the commercial/industrial/military area of Canaveral Harbor and the Cape Canaveral Air Station. The beach project area includes 13 storm water outfalls that drain urban water from State Road A1A and the immediately surrounding areas (see Section 2.3.8).

2.3.22 Solid Waste

Solid waste is not known to be deposited in or adjacent to the beach project area or offshore borrow areas, and is not deposited within the DMMA sand stockpile area.

2.3.23 Drinking Water

No part of the project area is a direct or indirect source of drinking water. Potable water within the project area is supplied by the City of Cocoa and/or other municipal sources. There are no known potable wells in the project area.

2.4 Economic Conditions

Information on the existing economic condition was collected, including structure values and property ownership to support the economic benefit model. See **Table 2-16**. The information on the infrastructure of the shoreline of the Mid-Reach was collected from Brevard County, mapping resources, and site visits. Each parcel along the beach was identified as developed or undeveloped, and streets and parks noted. Corps of Engineers real estate specialists assisted in providing the value of the structural improvements on each property and calculating the replacement cost less depreciation of existing structures. The shoreline was inventoried for coastal armoring and each armoring unit categorized for the value and level of protection afforded. The beach along Brevard County is also an important recreational resource to the County. Public beach areas are scattered along the length of the shoreline. Recreational use of the beach is taken into account in a recreational benefit analysis. The recreational benefits of the project are limited by availability of parking within the project area.

Table 2-16. Summary of Total Structure Value by Reach

	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6
Value ($1,000s)	$99,396	$89,907	$156,163	$34,827	$143,155	$109,750
Length (miles)	1.8	0.6	1.2	1.1	1.7	1.4

3 FUTURE WITHOUT PROJECT CONDITION

3.1 General

The future without project condition is the most likely condition of the study area without construction of a Federal project over the next 50 years. It is projected that erosion in the study area will continue in the future and structural damage will occur due to storms.

In the event of an emergency incident requiring evacuation, a Brevard County Hurricane Evacuation Shelter Plan (December, 2007) has been developed by Brevard County to identify and classify evacuation areas, identify evacuation routes, establish shelter locations and to provide the comprehensive planning required in order to execute the proper preparedness actions to deal with the threat of hurricanes and tropical storms. Sheltering for others hazards such as tornado, flood, severe weather, radiological, HazMat or any other natural or man-made disaster is addressed in the Host Shelter Plan of the Brevard County Comprehensive Emergency Management Plan (CEMP). In the future, residents of Brevard County are expected to adhere to the county's established emergency and evacuation procedures.

3.2 Physical Conditions

Historical rates of shoreline erosion were projected to future years to locate the shoreline position 50 years from now. As the beach erodes, less beach will be available to protect against storm damages. The historical storm frequency versus recession relationship is also used in the future condition. Based on available measured sea level rise at Florida locations, the current rate of sea level rise for Brevard County is estimated to be 2.41 millimeters per year (mm/yr). The normalized projections estimate the extent to which future sea level rise will exceed what would have happened if current trends simply continued. The median (50% exceedance) and 1% (1% exceedance) normalized projection were 100mm and 350mm, respectively, during the period from 1995 to 2050. Adding the median projection to the 2.41 mm/yr current trend indicates that the most likely sea level rise is 3.87mm/yr (0.0125 ft/yr) for a total increase of .213 m (0.70 ft) by 2050. The 1% projection indicates that there is a 1 percent chance that sea level rise will exceed 8.38mm/yr (0.0275 ft/yr) for a total increase of .461 m (1.51 ft) by 2050.

3.3 Property Owner Response

At present, some locations include shore armoring, although most do not. As allowed by state law, it is projected that most homeowners will construct to a 5-year level of shore protection as erosion begins to threaten their property. The threshold for homeowners to construct the armor was selected as when the shoreline erodes to within 134 feet of the structure, or the erosion experienced by a 5-year storm. Vacant lots and public lands such as parks will not be protected by such shore armor. Structures that are located within 134 feet, the 5-year return period storm, are assumed to have already built a 5-year level of shore protection at year one. This assumption provides for the likelihood that the most endangered properties will construct their own protection after the structural inventory was completed (2005) in the case of beach erosion up to the private structures.

3.4 Economic Analysis

Information on the future without project condition is used as input to the Jacksonville District Storm Damage Model (SDM) for the economic analysis. The Windows based empirical computer model is used to simulate damages at existing and future years and compute average annual equivalent damages. The model was reviewed by the Center of Expertise for Coastal and Storm Damage and found to be appropriate for use in this project. Storm damage is defined as the damage incurred by the temporary loss of a given amount of shoreline as a direct result of wave attack caused by a storm of a given magnitude and frequency. Damages or losses to developed shorelines include buildings, pools, patios, parking lots, roads, utilities, seawalls, revetments, bulkheads, replacement of lost backfill, etc. The structure inventory and value are the same as the existing condition. This conservative approach neglects any increase in value due to future development. As there is a great uncertainty in future projections, using the existing condition is preferable. **Table 3-1** provides a summary of the results from the SDM for the future without project condition. An example input for the SDM is included as **Table 3-2**.

Table 3-1. Economic Damages in the Future Without Project Condition[1]

	Development	Coastal Armor	Backfill	Land Loss	Average Annual Damages
REACH 1	$531,617	$0	$77,147	$83,852	$692,616
REACH 2	$771,975	$0	$24,983	$28,109	$825,067
REACH 3	$4,569,891	$0	$48,083	$73,304	$4,691,278
REACH 4	$1,429,264	$4,281	$26,146	$55,761	$1,515,452
REACH 5	$4,446,759	$71,849	$72,158	$115,213	$4,705,979
REACH 6	$1,439,280	$12,923	$53,841	$49,351	$1,555,395

[1] Table 3-1 refers to sub-Reaches of the Brevard Mid-Reach project defined in the study report. The Development column provides the cost of replacement less depreciation of the structures damaged; the Coastal Armor column gives the cost of replacing coastal armor lost to storm damage; the Backfill column provides the cost for replacement fill behind coastal armor; the Land Loss column provides a price for land lost to erosion based on a cost per square foot property value; the Average Annual Damages column is a summation of the previous columns and represents the annual cost using the 5 1/8 percent water resources project evaluation interest rate for FY06.

Table 3-2. Example Input to Storm Damage Model

Reach 6 - Brevard Mid-Reach														
2010, 50 - Baseline Year, period of analysis														
1.8 - Shoreline position in Year Zero														
Year	Shoreline Position	Year	Shoreline Position	Year	Shoreline Position	Year	Shoreline Position	Year	Shoreline Position					
2010	2.4	2011	3.0	2012	3.6	2013	4.2	2014	4.8					
2015	5.4	2016	6.0	2017	6.6	2018	7.2	2019	7.8					
2020	8.4	2021	9.0	2022	9.6	2023	10.2	2024	10.8					
2025	11.4	2026	12.0	2027	12.6	2028	13.2	2029	13.8					
2030	14.4	2031	15.0	2032	15.6	2033	16.2	2034	16.8					
2035	17.4	2036	18.0	2037	18.6	2038	19.2	2039	19.8					
2040	20.4	2041	21.0	2042	21.6	2043	22.2	2044	22.8					
2045	23.4	2046	24.0	2047	24.6	2048	25.2	2049	25.8					
2050	26.4	2051	27.0	2052	27.6	2053	28.2	2054	28.8					
2055	29.4	2056	30.0	2057	30.6	2058	31.2	2059	31.8					
11 - Number of probabilities														
Probability	Recession (ft)	Return Period (yrs)												
0	500													
0.005	214	"200 year"												
0.007	209	"150 year"												
0.01	196	"100 year"												
0.013	184	"75 year"												
0.02	164	"50 year"												
0.04	156	"25 year"												
0.1	148	"10 year"												
0.2	134	"5 year"												
0.5	111	"2 year"												
1	24	"1 year"												
7 - Number of Armor Types														
Armor No.	Description of Armor			Unit Cost	Level of Protection	Erosion Halted?	% Replace							
1	"No Coastal Armor"			$0	0	0	0							
2	"CSP-Small"			$1,070	135	1	1							
3	"CSP-Medium"			$1,610	150	1	1							
4	"RR-Minimum"			$750	120	0	1							
5	"Geotextile Tubes"			$320	135	1	1							
6	"RR-Small"			$1,070	150	1	1							
7	"RR-Large"			$1,860	175	1	1							
$1.22 - Cost of Backfill per cubic yard														
Site Name		Total Value	Lot Width	Number Floors	Existing Armor	Replacem't Armor	Dist Armor	Dist Front	Dist Failure	Type Parcel	Land Value	Duplicate	DEP Monument	Condemn on/off
"Pineda Phase I"		$2,048,030	400	1	1	5	134	170	190	"VC"	-1	0	"R-75.4"	0
"Pineda Phase II"		$5,002,103	330	4	1	5	134	155	215	"VC"	-1	0		0
"Pineda Phase III"		$6,073,504	270	4	1	5	134	155	220	"VC"	-1	0	"R-76"	0
"Oceanus I"		$2,689,886	240	2	3	5	80	85	110	"VC"	-1	0		0
"Oceanus II"		$2,689,886	240	2	3	5	80	180	210	"VC"	-1	1		0
"Oceanus III"		$2,689,886	240	2	3	5	80	85	110	"VC"	-1	0		0
"Oceanus IV"		$2,689,886	240	2	3	5	80	180	210	"VC"	-1	1	"R-77"	0
"Sandpiper Towers I"		$7,808,395	250	6	3	5	40	60	215	"VC"	-1	0		0
"Flores de Playa"		$11,757,889	250	5	1	5	134	185	275	"VC"	-1	0		0
"Ocean Residence N"		$1,470,275	230	2	1	5	134	160	190	"VC"	-1	0		0
"Opal Seas"		$12,261,042	260	6	1	5	134	175	270	"VC"	-1	0	"R-78"	0
"Park - State of FL"		$14,016	150	1	1	1	134	183	189	"PC"	-1	0		0
"Sea Gull Park		$4,672	50	1	1	1	134	190	195	"PC"	-1	0		0
"Silver Sands I"		$8,310,786	350	5	1	5	90	190	260	"VC"	-1	0		0
"Silver Sands II"		$8,716,444	300	5	1	5	90	190	265	"VC"	-1	0		0
"Sea Breakers"		$1,808,959	200	2	2	5	110	135	190	"VC"	-1	0	"R-79"	0
"Horizon II"		$6,433,815	150	6	1	5	134	170	250	"VC"	-1	0		0
"Horizon I"		$5,778,748	220	6	1	5	134	165	245	"VC"	-1	0		0
"Horizon III"		$6,197,992	150	6	1	5	134	155	240	"VC"	-1	0		0
"Horizon IV"		$7,113,716	220	7	1	5	134	155	240	"VC"	-1	0		0
"SPRA Park		$119,045	200	1	1	1	125	130	131	"PC"	-1	0	"R-80"	0
"parking lot"		$119,045	75	1	1	1	125	150	190	"PC"	-1	1		0
"parking lot"		$119,045	75	1	1	1	125	150	190	"PC"	-1	1		0
"Las Brisas I"		$1,314,198	230	1	1	5	134	140	170	"VC"	-1	0		0
"Las Brisas II"		$1,354,957	190	1	1	5	134	140	170	"VC"	-1	0		0
"Monaco Condo"		$3,962,091	90	7	1	5	134	140	230	"VC"	-1	0		0
"Monaco Condo"		$3,962,091	150	7	1	5	134	140	230	"VC"	-1	0		0
"Monaco Condo"		$4,015,466	85	7	1	5	134	140	230	"VC"	-1	0		0
"Monaco Condo"		$4,015,466	110	7	1	5	134	140	230	"VC"	-1	0	"R-81"	0
"TIITF - State of FL"		$1	100	1	1	1	134	135	136	"PN"	-1	0		0
"City of Satellite Beach"		$1	1100	1	1	1	134	135	136	"PN"	-1	0	"R-82"	0
"Brevard County"		$1	135	1	1	1	134	135	136	"PN"	-1	0		0
"Brevard County"		$74,590	115	1	1	1	134	145	150	"PC"	-1	0		0
"City of Satellite Beach"		$1	440	1	1	1	134	135	136	"PN"	-1	0	"R-83"	0

3.5 Environmental Resources

3.5.1 General

With the exception of nearshore hard bottoms and endangered species, the majority of existing environmental and historic resources discussed in Chapter 2 were not predicted to significantly change during the 50 year period of analysis of the future without project condition. A major stressor in the future without project condition will be the continued erosion of the shoreline and projected responses from property owners. The beach width will be reduced and there will be an increase in shore armoring as structures are threatened by coastal storms. The projected reduction in beach width is most likely to adversely affect nearshore hard bottom communities and sea turtle habitat.

3.5.2 Nearshore Hardbottom

As the Mid-Reach shoreline recedes, the nearshore hardbottom will be further seaward in relation to the shoreline. It is reasonable to suggest that the hardbottom might attenuate a greater and greater percentage of destructive wave energy as time goes on, and thus potentially slow long-term shoreline recession rates. It is possible to test this hypothesis since there is a significant increase of hardbottom surface area and rock formation width from south to north within the Mid-Reach. By directly comparing data, it is possible to deduce whether the recession is related to hardbottom density. The mean high water line and bluff (+13-feet NGVD) changes from 1972 to 2005 were compared for each of the 44 FDEP monuments that are within the Mid-Reach and no correlation was found between the two variables. While it is possible that continued exposure of hardbottom might influence the future erosion rates, available data does not indicate a connection between hardbottom abundance and erosion rate. Therefore, the future without project condition assumes that the present rate of long-term shoreline recession will continue.

3.5.3 Endangered Species

In the future without project condition, it is projected that the beach will continue to erode. This will reduce the shoreline area available for nesting sea turtles and reduce the success of nests as there is a greater vulnerability to storm washout. As adjacent shores are available for nesting, it is unknown whether the overall nesting would be affected. In addition to the erosion itself, it is likely that the length of shoreline hardened by structures would increase, decreasing further the area available for nesting sea turtles.

4 PROBLEMS AND OPPORTUNITIES

4.1 Public Concerns

A public scoping meeting was held in Satellite Beach, Brevard County, Florida on September 8, 2005 in partial fulfillment of the requirements in the National Environmental Policy Act (NEPA). A meeting invitation was sent to adjacent property owners, U.S. Fish and Wildlife Service, National Marine Fisheries Service, Florida Department of Environmental Protection, Florida Fish and Wildlife Conservation Commission, other appropriate Federal and state agencies, and local city and county governments. The meeting presented the study area, initial alternatives, timeline for study, and solicited public comment. A wide variety of views were presented at the meeting including those in favor of, and against, a shore protection project. The most common concerns are listed below:

- loss of land and property due to erosion
- lack of protection from hurricanes
- loss of recreational beach
- protecting existing hardbottom for fishing
- environmental protection of the hardbottom (both pro and con)
- protecting surfing spots and the revenue they generate
- wasting Federal tax dollars
- considerable time since the first studies without positive results
- revetments and seawalls potential to harm sea turtle nesting

4.2 Problems and Opportunities

4.2.1 Problems

The greatest problem in the Brevard County Mid-Reach study area is a steep, narrow beach and continued erosion of the shoreline. This has been caused by both long-term erosion and storm-induced recession. Erosion has rendered upland development in the Mid-Reach area increasingly vulnerable to damages from tropical and extra-tropical storms. Shorefront structures have seen losses year after year in front of the structure, with little natural recovery. The structures closest to the shoreline have experienced damage to seawalls, pools, and in a few cases to the structure itself making it uninhabitable. Sea level rise and coastal storms continue to exacerbate the erosion pressures in the Brevard County Mid-Reach area. Additional problems associated with the eroding shoreline include impacts to tourism, recreation, and sea turtle nesting habitat loss.

4.2.2 Opportunities

Opportunities are positive conditions in the study area that may result from management measures. There is an opportunity to protect structures from storm damage by implementing some management measures. Coincident with expanding the beach berm and stabilizing the dune or bluff feature, sea turtle nesting habitat in the Mid-Reach may be protected. While sea turtle nesting may be disrupted during and following construction activities, there is an opportunity for long-term benefits in preserving the beach habitat. In addition, opportunities are present to preserve the natural resources that are available in the study area, through preserving the nearshore hardbottom resources and associated recreational opportunities.

4.3 Planning Objectives

4.3.1 Federal Objectives

The Federal objective, as stated in the Principles and Guidelines (P&G), is to contribute to national economic development (NED) consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. The three basic criteria used in the planning process are: (1) the project must be economically justified and environmentally acceptable, (2) Federal participation is warranted, and (3) the project must meet current Administration budget priorities.

4.3.1.1 Federal Environmental Objectives

The U.S. Army Corps of Engineers considers carefully and seeks to balance the environmental and development needs of the Nation in full compliance with the National Environmental Policy Act (NEPA) and other authorities provided by Congress and the Executive Branch. Public participation is encouraged early in the planning process to define environmental problems and elicit public expression of needs and expectations. Significant environmental resources and values that would likely be impacted, favorably as well as adversely, by an alternative under consideration are identified early in the planning process. All plans are formulated to avoid to the fullest extent practicable any adverse impact on significant resources. Significant adverse impacts that cannot be avoided are mitigated as required by Section 906(d) of WRDA 1986. The General Reevaluation Report describes the environmental impacts of the plan recommended and summarizes compliance with the Federal statutes and regulations.

4.3.1.2 Federal Project Purposes

Hurricane and storm damage reduction projects have been authorized for a variety of purposes: beach erosion control, shore/shoreline protection, hurricane/hurricane wave protection, and storm protection. The WRDA of 1986 assigns costs of Federal projects to appropriate project purposes, including flood control, non-structural flood control, and other purposes listed such as hydroelectric power, municipal and industrial water supply, agricultural water supply, recreation, hurricane and storm damage reduction, and aquatic plant control. The costs for construction associated with the Mid-Reach project are assigned to either hurricane and storm damage reduction or recreation. Costs assigned to privately owned, developed lands that are justified by hurricane and storm damage reduction benefits, provide incidental recreation benefits and meet the criteria for public access and public use of the shores are cost-shared 65% Federal and 35% non-Federal. Costs assigned to non-Federal public shores used for parks and recreation are cost-shared 50% Federal and 50% non-Federal. Project reaches that provide for separable recreation are not Federally cost shared. The Federal government does not participate in any work relating to recreation facilities at hurricane and storm damage reduction projects. Recreation is not considered to be a high priority output or primary project output under current Department of Army policy. This policy precludes Federal funds to support construction of shore or hurricane protection projects which depend on separable recreation benefits for economic justification, or for which incidental recreation benefits are greater than 50% of the total benefits unless the project is economically justified based on primary outputs alone, or based on the combination of primary benefits and an equivalent amount of incidental recreation benefits (ER 1105-2-100 section 3-4.b.(4)(a)).

4.3.1.3 Additional Federal Guidelines

Other general study objectives assure that any new project recommended for construction, or proposed modifications to existing hurricane and storm damage reduction projects are formulated to:

a. meet the specific needs and concerns of the general public within the project area;
b. be part of or developed in conjunction with a "systems approach." (alternative plans consider a broad range of possible impacts including impacts that occur on larger scale, the combined effectiveness and economic efficiency of the shore protection, navigation maintenance, and dredged material disposal programs can then be optimized);
c. respond to expressed public desires and preferences;
d. be flexible to accommodate changing economic, social, and environmental patterns and changing technologies;
e. integrate with and complement other related programs in the study area, and;
f. be implementable with respect to financial and institutional capabilities and public consensus.

4.3.2 State and Local Objectives

The State of Florida is empowered by the federal Coastal Zone Management Act and its implementing regulations at 15 CFR 930 to review Federal activities within or adjacent to its coastal zone to determine whether the activity complies with the requirements of the state's approved management program. Florida's Coastal Zone Management Program was established under the Coastal Management Act of 1978 (Chapter 380.20, Florida Statutes) and approved by the Federal Coastal Zone Management office in 1981. Florida does not regulate its coastal zone through one comprehensive law but rather through 28 state statutes. Through Florida's comprehensive planning act, local governments are also given the opportunity to determine whether these activities are consistent with their goals and policies. The Florida Department of Environmental Protection (FDEP) is the lead state agency for the implementation of the Federal Coastal Zone Management Act. The Beach and Shore Preservation Act (Chapter 161, Florida Statutes) is Florida's primary statute for developing and implementing the state's strategic beach management plan, regulating coastal construction seaward of the mean high water, and regulating activities seaward of the coastal construction control lines. The act, administered by the FDEP Bureau of Beaches and Coastal Systems (BBCS), was first passed in

1965 and has since been significantly amended. The objective of the Beach and Shore Preservation Act is to preserve and protect Florida's sandy beaches and adjacent beach and dune systems. The beach and dune system protects upland properties from storm damage, provides recreation for Florida residents and visitors, and provides habitat for wildlife. The following paragraphs describe programs which may have a bearing on the Brevard County Mid-Reach study.

4.3.2.1 Coastal Construction Control Lines

In the State of Florida Beach and Shore Preservation Act, the legislature asserted that Florida's beaches and coastal barrier dunes are among the state's most valuable natural resources and that these resources should be protected from "imprudent construction which can jeopardize the stability of the beach-dune system, accelerate erosion, provide inadequate protection to upland structures, endanger adjacent properties or interfere with public beach access" (Section 161.053, Florida Statutes). To ensure that such "imprudent construction" does not take place, the statute charged the FDEP to define and establish Coastal Construction Control Lines (CCCL). The CCCL represents the area of the beach and dune system that is expected to be subject to severe fluctuation from a 100-year storm surge. The specific location of the line is a function of the predicted storm surge and erosion resulting from a 100-year storm. The FDEP has established control lines on a county-by-county basis for Florida's 25 sandy beach counties (Section 161.053, Florida Statutes), including Brevard County. The CCCL defines the FDEP's jurisdictional area in which special design criteria are applied through the permit program, for construction and related activities. The primary purposes of this permitting program are to ensure that construction seaward of the control line is designed and sited to protect beaches and dunes from adverse impacts and to ensure that construction seaward of the line does not result in accelerated erosion on adjacent land. Coastal storm damage reduction alternatives such as beach restoration and nourishment, dune restoration and maintenance, seawalls, revetments, and groins would be included under the jurisdiction of this program. The BBCS has also implemented a coastal monitoring program for survey and documentation purposes. Control monitoring locations have been established approximately every 1,000 feet along the coastal shoreline of all beach front areas to serve as monument reference stations during surveying. FDEP regularly conducts post-storm surveys that provide Florida with a comprehensive pre- and post-storm database.

4.3.2.2 Joint Coastal Permit Program

The Beach and Shore Preservation Act regulates construction activities on sovereign lands of Florida below the mean high water line (Chapters 161.041, 373, 253 and 258, Florida Statutes) through the Joint Coastal Permit (JCP) program. This program is a combination of the CCCL regulatory program and the Environmental Regulatory Program, including the water quality certification, authorized under Chapters 373 and 403, Florida statutes. It also covers activities affecting inlets. The program is intended to protect the beach from further erosion, maintain water quality, protect threatened and endangered species habitat, and properly allocate public trust resources. The JCP program regulates activities that could have a material physical effect on coastal processes. Those activities primarily include beach restoration and nourishment projects, erosion control projects (including breakwaters and groins), and coastal inlet management projects (including navigational dredging, sand bypassing, and jetties). A JCP is necessary for any coastal construction or reconstruction or change to existing structures, or any construction or physical activity undertaken below mean high water.

4.3.2.3 Erosion Setbacks

The 1985 State Comprehensive Growth Management Act (Chapter 85-55, Laws of Florida) amended the Beach and Shore Preservation Act to include a construction setback provision for all sandy beach counties. The amendment prohibits the FDEP from granting most coastal construction permits on land that will be seaward of the seasonal high water line within 30 years (Section 161.053, Florida Statutes). The 30-year erosion projection cannot, however, extend landward of an established CCCL (Section 161.053, Florida Statutes). The FDEP uses long-term erosion rates to delineate the location of the 30-year erosion projection, considering also the presence of shore protection structures and beach restoration projects (Section 161.053, Florida Statutes). The FDEP can grant coastal construction and JCP permits for shore protection structures, piers, and minor structures seaward of the 30-year erosion projection. The FDEP can permit construction of a single-family residence seaward of the line only if the parcel was platted before adoption of the amendment, the landowner does not own another parcel adjacent to and landward of the parcel proposed for development, and the structure is located landward of the frontal dune and as far landward as practicable (Section 161.053, Florida Statutes). In addition, repairs or reconstruction of a building cannot "expand the capacity of the original structure seaward of the 30-year erosion projection" (Section 161.053, Florida Statutes). The department can, however, issue a permit for landward relocation of a damaged or existing structure if the relocation will not damage the beach-dune system (Section 161.053, Florida Statutes).

4.3.2.4 Coastal Building Zone

The 1985 Growth Management Act further amended the Beach and Shore Preservation Act to establish a coastal building zone extending landward of coastal construction control lines. Standards for structures within the coastal building zone are contained in the Florida Building Code. For mainland beaches, barrier spits, and peninsulas lying within Florida's sandy beach counties, the coastal building zone extends from the seasonal high water line to 1,500 feet landward of the CCCL. On barrier islands, the entire island or the area from the seasonal high water line to a maximum of 5,000 feet inland from the CCCL is included in the building zone (Section 161.54, Florida Statutes). All land areas within the Florida Keys, regardless of island size, also lie within the coastal building zone.

4.3.2.5 Erosion Control Program

In 1986, the Florida legislature amended the Beach and Shore Preservation Act to address the statewide problem of beach erosion through a "state-initiated program of beach restoration and beach nourishment" (Section 161.101, Florida Statutes). The legislature declared, "beach erosion is a serious menace to the economy and general welfare of the people of this state and has advanced to emergency proportions" (Section 161.088, Florida Statutes). The statute directs the FDEP to develop and maintain a comprehensive long-term management plan for restoration of Florida's critically eroding beaches (Section 161.091, Florida Statutes). The plan must 1) encourage the geographic coordination and sequencing of prioritized projects, 2) try to reduce equipment mobilization and demobilization costs, 3) maximize the quantity of beach-quality sand into the system, 4) extend the life of beach nourishment projects and reduce the frequency of nourishment, and 5) promote inlet sand bypassing to replicate the natural flow of sand interrupted by inlets and ports. The plan, known as the Strategic Beach Management Plan, is updated periodically to address changing conditions in the coastal system. State funds for erosion control projects are available from Florida's Ecosystem Restoration and Management Trust Fund (Section 161.091, Florida Statutes). The fund provides money for erosion control projects consistent with the Strategic Beach Management Plan. The state can pay up to 50% of the actual non-Federal cost of restoring a critically eroding beach, while the local government in which the project occurs must provide the balance of the funds (Section 161.101, Florida Statutes). The level of state funding is directly related to the amount of public beach access and parking located within the project area.

4.3.2.6 Erosion Control Line

Property rights of state and private upland owners in beach restoration project areas are set forth in Chapter 161.141, Florida Statute. The statute proclaims that the Legislature declares that it is the public policy of the state to cause to be fixed and determined, pursuant to beach restoration, beach nourishment, and erosion control projects, the boundary line between sovereignty lands of the state bordering on the Atlantic Ocean, the Gulf of Mexico, or the Straits of Florida, and the bays, lagoons, and other tidal reaches thereof, and the upland properties adjacent thereto; except that such boundary line shall not be fixed for beach restoration projects that result from inlet or navigation channel maintenance dredging projects unless such projects involve the construction of authorized beach restoration projects. Prior to construction of such a beach restoration project, the board of trustees shall establish the line of mean high water for the area to be restored; and any additions to the upland property landward of the established line of mean high water which result from the restoration project shall remain the property of the upland owner subject to all governmental regulations and shall not be used to justify increased density or the relocation of the coastal construction control line as may be in effect for such upland property. Such resulting additions to upland property shall also be subject to a public easement for traditional uses of the sandy beach consistent with uses, which would have been allowed prior to the need for such restoration project. It is further declared that there is no intention on the part of the state to extend its claims to lands not already held by it or to deprive any upland or submerged landowner of the legitimate and constitutional use and enjoyment of his property. If an authorized beach restoration, nourishment, and erosion control project cannot reasonably be accomplished without the taking of private property, then such taking shall be made by the requesting authority by eminent domain proceedings.

4.3.2.7 Inlet Management

In order to manage the erosion of adjacent beaches because of improved navigational inlets, the Florida Legislature passed the Declaration of Public Policy relating to improved navigation inlets (Section 161.142, Florida Statutes). In this statute, the Legislature recognized the need for maintaining navigation inlets to promote commercial and recreational uses of coastal waters and their resources. The Legislature further recognized that inlets alter the natural drift of beach-quality sand resources. The alteration often results in these sand resources being deposited around shallow outer-bar areas, instead of providing natural nourishment to the downdrift beaches. Therefore:

a. All construction and maintenance dredging of beach-quality sand should be placed on the downdrift beaches or, if placed elsewhere, an equivalent quality and quantity of sand from an alternate location should be placed on the downdrift beaches.

b. On an average annual basis, a quantity of sand should be placed on the downdrift beaches equal to the natural net annual longshore sediment transport.

4.3.2.8 Local Comprehensive Planning

The Local Government Comprehensive Planning Act of 1985 (Chapter 163) requires that all local governments prepare, adopt, and implement comprehensive plans that address community growth and development needs. It required that local, regional, and state comprehensive plans be consistent with each other and required coastal counties and cities to include a "coastal management element" in their local plans. This section of the plan must be based on an inventory of the beach-dune system and existing coastal land uses and an analysis of the effects of future land uses on coastal resources. Local governments must also address disaster mitigation and redevelopment, designation of coastal high-hazard areas, beach protection, and shoreline use. The Brevard County Comprehensive Plan’s Coastal Management Element prohibits new shoreline hardening structures south of Patrick Air Force Base, and encourages beach and dune restoration and vegetative cover.

4.4 Planning Constraints

The Brevard County Mid-Reach study is constrained by the following.

a. Avoid conflict with Federal and State regulations, as stated in Federal law, USACE regulations, executive orders and State of Florida statutes. While local and state policy is considered for consistency, the emphasis is on legal requirements.

b. Avoid, minimize and mitigate environmental impacts to the nearshore hardbottom caused by the implementation of a management measure, in and adjacent to the Mid-Reach study area, during construction and equilibration of the nearshore profile.

c. Constraints on the periodic nourishment include minimizing environmental impacts to the nearshore hardbottom and the economics of a minimum renourishment (the practicability of frequent nourishment by truck haul is constrained by the cost of mobilization/demobilization and construction windows for placement of material). More infrequent renourishments would require larger volumes of material to be placed which would increase the extent of nearshore hardbottom being covered. **Figure 4.1** shows the proximity of the hardbottom.

Figure 4-1. Nearshore hardbottom proximity.

4.5 Related Environmental Documents

The report presents the results of a feasibility level study in the Brevard County Mid-Reach study area integrated with the Environmental Impact Statement for the recommended plan. The Appendices include the Section 404(b) Evaluation, Coastal Zone Management Consistency, Pertinent Correspondence and Mailing List, Cumulative Effects Assessment, and Environmental Documentation. Section 1.6 lists pertinent previous studies. Additional environmental documents prepared in conjunction with this study are included in the references.

4.6 Decisions to be Made

The report serves as a decision document recommending authorization of a project for coastal storm damage reduction, with periodic nourishment over a 50-year period of Federal participation.

4.7 Agency Goal or Objective

The goal of the Brevard County Mid-Reach project is to reduce the damages caused by erosion and coastal storms to shorefront structures along the Mid-Reach study area. The following objectives were outlined based on the project problems, opportunities, goals, and Federal and state objectives and regulations.

1) Reduce storm damages to coastal structures within the Mid-Reach study area over the 50-year planning period starting in 2013.
2) Maintain the recreational beach in the Mid-Reach, including ensuring access to the public beach and a dry beach area free from man-made obstructions over the life of the project.
3) Maintain opportunities for recreational use of the nearshore areas in the Mid-Reach and adjacent areas, including surfing, fishing, and snorkeling over the life of the project.
4) Maintain environmental quality in the Mid-Reach and adjacent areas, for human and natural use, including air and water quality, habitat, and aesthetics over the life of the project.

4.8 Scoping and Environmental Issues

4.8.1 Issues Evaluated in Detail

The following environmental issues were identified during scoping and by the preparers of this document to be relevant to the proposed action and appropriate for detailed evaluation: threatened and endangered species and essential fish habitat.

4.8.2 Impact Measurement

The following provides the means and rationale for measurement and comparison of the proposed action and alternatives: acres of essential fish habitat impacted.

4.8.3 Issues Eliminated from Detailed Analysis

The following issues were not considered important or relevant to the proposed action based on scoping and the professional judgment of the preparers of this document: air quality, native American resources, urban quality, solid waste, and drinking water. These items are not likely to be affected by the alternatives under consideration.

4.9 Permits, Licenses, and Entitlements

This project would be performed in compliance with state of Florida water quality standards. In accordance with the Coastal Zone Management Act, the proposed work would also be reviewed by the state in order to determine if the project is consistent with the Coastal Zone Management Plan. This review is performed concurrently with the issuance of the state permit.

5 FORMULATION AND EVALUATION OF ALTERNATIVE PLANS

5.1 Plan Formulation Rationale

Four accounts are established in the Principles and Guidelines (P&G 1983) to facilitate the evaluation and display of effects of alternative plans. The national economic development (NED) account displays changes in the economic value of the national output of goods and services, the environmental quality (EQ) account displays non-monetary effects on ecological, cultural, and aesthetic resources including the positive and adverse effects of ecosystem restoration plans, the regional economic development (RED) account displays changes in the distribution of regional economic activity (e.g., income and employment), and the other social effects (OSE) account displays plan effects on social aspects such as community impacts, health and safety, displacement, energy conservation and others. The NED plan must also meet the test of four additional criteria: completeness, effectiveness, efficiency, and acceptability. The criteria are used in the building of alternatives; the four accounts are used in addition to the planning objectives and constraints in evaluating alternative plans.

5.2 Management Measures

5.2.1 Identification of Management Measures

Management measures were developed to address the problems and opportunities outlined for the project. Both Nonstructural (NS) measures and Structural (S) measures are included. All possible measures are considered, including those beyond the authority of the Corps to implement.

NS-1 – No-Action. The no-action plan is the continuation of existing conditions. Although this measure does not address any specific problems, it will provide a comparison to other measures. Information to describe this measure was collected during the inventory of existing conditions. The rate of shoreline change and current adjacent beach fill and sand bypassing operations will be assumed to continue over the 50-year period of analysis. Present structures and replacement costs will be used into the future.

NS-2 – Coastal Construction Control Line. A coastal construction control line (CCCL) that does not prohibit construction, but does provide stringent structural restrictions, has already been established by the State of Florida for all of the Brevard County study area. This management measure provides for potential changes to the CCCL or building regulations that could be implemented by the State of Florida. Such changes could include moving the CCCL landward, increasing the setback for construction, or increasing the standards for construction to reduce storm damages. The erosion of the shoreline would continue at the present rate, unabated by this measure.

NS-3 - Moratorium on Construction. This management measure would not permit new construction in the area vulnerable to storm damages adjacent to the study area. As properties are damaged, reconstruction would not be permitted. The erosion of the shoreline would continue at the present rate, unabated by this measure. Although, not a Congressionally authorized activity, this measure could be implemented by state or local governments.

NS-4 - Establish a No-Growth Program. This management measure would allow for existing structures and limited reconstruction following storm damage, but would not allow for an increased number of structures within the area vulnerable to storm damages adjacent to the study area. The erosion of the shoreline would continue at the present rate, unabated by this measure. Although, not a Congressionally authorized activity, this measure could be implemented by state or local governments.

NS-5 - Relocation of Structures. The relocation of the structures measure would allow the area to continue to erode and the land in this area would be lost. Structures would be identified within the study area which are vulnerable to storm damage. Where feasible, such structures would be moved further landward on their parcels to escape the vulnerable area.

NS-6 - Flood Proofing of Structures. Flood proofing of existing structures and regulation of flood plain and shorefront development are management measures that state and local governments could implement. This measure would require changes to the building codes to prevent flood damages associated with coastal storms. New construction and substantial reconstruction would be improved by regulation of new building codes. Existing structures could be improved through incentives and aid programs.

NS-7 - Condemnation of Structures and Land Acquisition. This measure would allow the shoreline to erode in the study area with a loss of land until the shoreline reached equilibrium. Structures within the area vulnerable to storm damage would be identified for acquisition. Structures on the parcels would be demolished and natural areas restored. Such parcels would become public property and would reduce the number of structures vulnerable to storm damages.

S-1 - Seawalls. The construction of additional concrete seawalls or improvements to and maintenance of the existing bulkheads/seawalls would provide a significant degree of protection. The seawalls would be constructed at the seaward edge of the existing bluff or vegetation line. Existing seawalls may be demolished in favor of a new seawall to provide a seamless wall over the entire study area or sub-reaches. This measure would stabilize the shoreline at the location of the bluff, allowing erosion to continue until the seawall becomes the water line. A concrete sheet-pile wall is proposed due to its stability in the salt environment and ability to withstand wave action. Construction would entail excavation into the bluff to install tie-back features. The seawall must be of sufficient depth underground to withstand projected scour by wave action and will require rock toe protection. Construction would be from the beach, with intermittent access from roads. Impacts to the nearshore hardbottom during construction would be avoided.

S-2 - Revetments. Revetments have been placed on similar beaches to protect critically damaged or eroding areas. This measure would involve placement of large rock, designed to withstand the wave environment, along the existing bluff line. The engineered structure would start at the elevation of the bluff, to tie in to existing elevations, and have a sloped profile. The structure would be imbedded under the beach elevation to a depth below expected scour and future erosion. In-place materials from the excavation would be used for backfill behind the structure. Along the shoreline, the revetment should be continuous to avoid erosional features at gaps and include tie back features at the ends. Existing armor can either be incorporated into the structure, or demolished to provide a seamless structure. Construction would be from the beach, with intermittent access from roads. Impacts to the nearshore hardbottom during construction would be avoided.

S-3 - Beach Nourishment. This management measure includes initial construction of a beach fill and future renourishments at regular intervals. Renourishment of the beach would be undertaken periodically to maintain the recreational and erosion control features within design dimensions. Dimensions of the beach fill would be based on the degree of protection desired or economically justified, storm damage protection of given widths of beach, and the environmental impact to the nearshore hardbottom. Beach nourishment material is available in adequate quantities from the Canaveral Shoals I or II borrow area used for the Brevard County North and South reaches. Advanced nourishment is added to the volume of beach fill to offset continued erosion between periodic nourishment events. As the project will be a modification of the South reach project, the periodic nourishment interval will be 6 years and the volume needed will be calculated from the annual with-project erosion rate which varies with the width of beach placed. At smaller widths, the rate is approximated by the historical erosion rate but will increase with increasing width.

S-4 - Groins. A series of groins in the problem area would help hold a beach in front of existing development and prevent further losses of land. The construction of groins would have to be supplemented with nourishment so that adjacent beaches would not be starved of sand. For this reason, groins are considered a method to help hold the fill in place and to reduce periodic nourishment requirements. The groins would be constructed of large size rock, designed to interlock together and with a foundation that would avoid subsidence. The groin would be placed perpendicular to the shoreline and would extend from above the mean high water line out into shallow water. The length, orientation, and head of the structure (T-head or not) would be designed based on wave conditions, storms and sediment transport. The beach fill material would come from the Canaveral Shoals I or II borrow area used for the Brevard County North and South reaches.

S-5 – Submerged Artificial Reefs. This management measure would use the perched beach concept to limit the amount of underwater fill and retain the dry beach for a longer period. This would be accomplished by placement of a submerged artificial reef in shallow water with beach fill material placed "perched" behind the reef structure. This measure may reduce initial fill quantities, reduce renourishment requirements and offer mitigation for the environmental impacts of nearshore hardbottom burial. The submerged artificial reef would be constructed out of large size rock with a foundation material to avoid subsidence. The beach fill material would come from the Canaveral Shoals I or II borrow area used for the Brevard County North and South reaches.

S-6 – Nearshore Placement. Dredged material would be placed in the nearshore to provide wave attenuation benefits, nourishment of the active profile, or a combination of both. This method allows placement in water depths 15 feet and deeper, avoiding direct placement covering the nearshore hardbottom. This management measure assumes that a portion of the sand placed in shallow water will move towards the beach under normal wave conditions. Over time following construction, the sand bar will migrate towards the beach, attach to the beach and shape into the normal equilibrium profile of the beach, thus adding material and enlarging the beach. The dredged material would come from the Canaveral Shoals I or II borrow area used for the Brevard County north and south reaches.

S-7 - Breakwaters. The construction of breakwaters offshore along the Brevard County study area is considered as a management measure to stabilize the beach. Such structures reduce the amount of wave energy reaching the shoreline in their lee. As a result, the rate of annual erosion would decrease. The breakwaters would be constructed of large size rock with foundation materials to prevent subsidence. The breakwaters would be trapezoidal in profile and would be placed parallel to the shoreline in shallow water. The breakwater would be constructed in segments, separated from each other, to prevent infilling between the beach and the breakwater. The elevation and length of each breakwater segment and the distance between segments would be designed using the wave and sediment transport characteristics.

S-8 - Dunes and Vegetation. The presence of dunes is essential if a beach is to remain stable and able to accommodate the vagaries wrought by unpredictable storms and extreme conditions of wind, wave, and elevated sea surface. Dunes maintain a sand repository that, during storms, provides sacrificial sand before structures would be damaged. In so doing, the dune system provides a measure of public safety and property protection. Proper vegetation on dunes increases sand erosion resistance by binding the sand together via extensive root masses penetrating deep into the sand. Further, such vegetation promotes dune growth through its sand trapping action when significant wind action transports substantial quantities of sand. This measure would include placement of beach compatible material, from either upland or offshore sources, in a dune feature adjacent to the existing bluff. The top elevation of the dune would be designed to tie into the bluff. The front slope of the dune would be a function of the material grain size and construction equipment. This measure consists of a single dune system, not a multiple dune system, due to limited space between structures on the ocean front parcels and the water line and anticipated environmental impacts of advancing the water line. Vegetation would be planted after placement of the dune material. The non-Federal sponsor would be responsible for watering until the plants become established.

S-9 – Feeder Beach System. A feeder beach system is placement of beach nourishment material updrift of the study area in quantities sufficient enough to allow for sediment transport into the study area. While the general sediment transport direction is from north to south, there are seasonal variations so both beaches north and south of the study area were evaluated. The quantity placed updrift will be determined by the sediment transport rate and the interval of periodic nourishment.

5.2.2 Evaluation of Management Measures

The management measures were evaluated for the potential to contribute to the project objectives and consistency with the project constraints. In this process interdependency between measures was identified as well as exclusivity. This assessment also determined if the management measures were consistent with current policy and authority. This process served to eliminate some measures from further consideration. Costs and benefits were not computed at this stage.

NS-1 – No-Action. The no-action plan is the continuation of existing conditions and provides no solutions to existing problems. This option is carried forward to compare to other plans.

NS-2 – Coastal Construction Control Line. This measure would be implemented by state or local governments. Changes to the coastal construction control line (CCCL) would not affect existing development and storm damages would continue to occur. As structures are destroyed, new construction would be better able to withstand storms. However, erosion of the shoreline is also expected to continue unabated by this management measure. Given the historical shoreline erosion in the area and the projected increase in sea level that contributes to shoreline erosion, erosion rates in future years are not expected to change significantly. Therefore, even as structures are lost, the shoreline erodes and threatens new structures. Continual erosion of the shoreline will produce a steep, narrow beach where sea turtle nests will be vulnerable to storms. This management measure has some improvement over the existing condition but does not fully meet project objectives 1 or 4. This measure will not be carried forward.

NS-3 - Moratorium on Construction. This measure would be implemented by State or local governments. A moratorium on construction offers no protection to existing development in the study area. As the shoreline erodes, structures will be destroyed and will not be allowed to rebuild. New construction within the vulnerable area will not be allowed. The desired growth of the area is oriented towards tourism and recreation, attracting retirees, and promoting a stable construction industry. By taking out structures, tourism will decline, affecting the regional economy. Storm damages may decrease somewhat if structures are not compensated or rebuilt, but erosion will continue and will threaten new structures. Continual erosion of the shoreline will produce a steep, narrow beach where sea turtle nests will be vulnerable to storms. This management measure does not meet project objectives 1 or 4. This measure is therefore excluded from further study.

NS-4 - Establish a No-Growth Program. This measure would be implemented by state or local governments. The establishment of a no-growth program would not allow new construction and would limit rehabilitation of existing structures. Erosion of the shoreline would continue unabated with this measure. Growth in the area, particularly that in connection with beach activities, is needed to provide economic depth to the communities. With an eroding shoreline, existing tourism may stagnate or decline as competing areas build bigger and better attractions. Further, this measure offers no protection to existing development in the study area. Compared to the no-action plan, storm damages will be the same because the no-action plan is based on existing structures not projected future growth. Continual erosion of the shoreline will produce a steep, narrow beach where sea turtle nests will be vulnerable to storms. This management measure does not meet project objectives 1 or 4. This measure is therefore excluded from further study.

NS-5 - Relocation of Structures. This measure would be implemented by the USACE. The relocation of the structures would allow the area to continue to erode and the land in this area would be lost. This measure is not practical for the very large condominiums in the study area or for the many structures on small parcels without available space to move landward. Structures within the area which cannot be economically or physically moved from the area would be lost due to erosion and residents would have to move. In addition, implementation of this measure would result in the loss of valuable recreational beach as shoreline recession continues. Continual erosion of the shoreline will produce a steep, narrow beach where sea turtle nests will be vulnerable to storms. Some environmental benefit can be obtained by moving structures landward that would otherwise be damaged by storms and place debris in the coastal system. Although some benefit may be obtained with this measure, it does not fully meet the project objectives 1 or 4 and is not carried forward.

NS-6 - Flood Proofing of Structures. Flood proofing of existing structures and regulation of floodplain and shorefront development are considered part of building code modifications regulated by state and local governments. Flood proofing would reduce storm damages from low severity storms. However, shoreline erosion would continue unabated by this measure. Over time, erosion would overtake structures even if flood proofed. A pile supported structure permanently surrounded by water is not usable even if it is still structurally sound. Continual erosion of the shoreline will produce a steep, narrow beach where sea turtle nests will be vulnerable to storms. This measure does not fully meet project objectives 1 or 4 and will not be carried to the next step.

NS-7 - Condemnation of Structures and Land Acquisition. This measure would be implemented by the project sponsor. This management measure would allow the shoreline to erode in the area with a loss of land. Structures within the area vulnerable to storm damage would be identified for acquisition, demolished and natural areas restored. Erosion of the shoreline would continue unabated with this measure, threatening new structures in time. This measure does not address the long-term erosion of the shoreline and does not offer any storm protection for remaining structures. Benefits are obtained by removing the most vulnerable structures thus reducing storm damages. The large condominiums may be outside the economic envelope for acquisition and would most likely remain with armor installed by the owner. As the shoreline is allowed to erode in some areas and stopped by armor in other areas, the shoreline would become irregular and may interrupt longshore sediment transport to adjacent beaches. In addition, such inequality is likely to meet local resistance to the acquisition program. Some environmental benefit may be obtained from the demolition of vulnerable structures that would otherwise be damaged by storms and contribute debris to the coastal system. Continual erosion of the shoreline will produce a steep, narrow beach where sea turtle nests will be vulnerable to storms. Additional recreational opportunities and environmental conservation may be obtained through the acquisition and subsequent environmental restoration of the parcels. As formulated the condemnation and acquisition management measure is not practical. This alternative is removed from further consideration as it does not fully meet project objectives 1 or 4 and is not implementable.

S-1 - Seawalls. This measure would be implemented by the USACE. The construction of additional concrete seawalls or improvements to and maintenance of the existing bulkheads/seawalls would provide a significant degree of upland protection. The height of the seawall would be designed to exceed the 50-year storm surge elevation, or that having a 2% chance of occurrence in any given year. The shoreline would be expected to erode in front of the seawall but stabilize at the location of the seawall, counteracting any further storm induced recession of the shoreline. The end effect is likely little, if any, dry beach in front of the seawall absent any restoration, and erosion of properties at either end. Environmental concerns with this measure include loss of sea turtle and shorebird nesting habitat and potential loss of nearshore hardbottom habitat as the nearshore beach profile adjusts to the new wave energy environment in front of the seawall. The two management measures, seawall and revetment, were discussed through email and phone calls with the US Fish and Wildlife Service (USFWS) to uncover potential issues with nesting sea turtles. The USFWS stated that landowners in Brevard County have been permitted to construct similar structures with a permit condition to maintain 5 feet of sand over the rock toe protection. The seawall measure will be modified to include maintenance of sand seaward of the seawall to provide a minimum width beach for sea turtle nesting of similar volume to the dune management measure. The addition of the minimum width beach also helps to alleviate concerns regarding loss of the recreational beach, economic loss to the area in tourism, changes to the offshore profile caused by erosion, changes to the surf breaks, and potential interruptions in the longshore sediment transport to adjacent beaches. Discussions with the Florida Department of Environmental Protection (FDEP) revealed that seawalls would likely be determined inconsistent with the Florida Coastal Zone Management Program (CZMP) and applicable state statutes. The objective of the CZMP is to preserve and protect Florida's sandy beaches and adjacent beach and dune systems thus providing protection to upland properties from storm damage, recreation for Florida residents and visitors, and habitat for wildlife. While seawalls are permitted in some cases to protect upland structures, they are considered methods of last resort, and are not encouraged as part of any long-term management strategy.

Structures built seaward of the CCCL are evaluated for consistency with the CZMP. Section 161.085 of the Florida Statutes governs rigid coastal armoring structures and outlines the conditions under which a permit or Federal consistency for construction of a seawall may be obtained. Pertinent requirements for approval include: 1) private structures or public infrastructures have been determined to be vulnerable to damage from frequent coastal storms, and 2) allowance to filling gaps to provide a continuous and uniform armoring structure is no more than 250 feet in length. The BBCS's rule, Chapter 62B-33, offers clarification of the statute. "Vulnerable" is defined as when a structure is subject to either direct wave attack or to erosion from a 15-year return interval storm. The rule also states that the armoring shall be authorized only for protection of eligible structures, adjacent structures shown by coastal models to become vulnerable following construction of the armoring, and to fill gaps between structures of 250 feet or less. Eligible structures include those defined as non-conforming or permitted for construction before March 1985 when a building code change was implemented.

Modeling in the Mid-Reach area using the USACE SBEACH model was used to determine which structures would experience erosion effects from a 15-year storm. Evaluation of the existing shoreline versus the vulnerability to the 15-year storm included comparison to both storm surge elevation and storm induced recession of the shoreline. The approximate 15-year storm surge elevation in Brevard County is 7 feet NGVD. As existing elevation of the landward edge of the beach are generally 10 to 15 feet NGVD, no structures are currently vulnerable to the 15-year storm surge. The 15-year storm induced recession from modeling results is approximately 151 feet, measured as the landward distance from the mean high water line to the point where vertical change from the pre-storm section to the post-storm section is less than 0.5 feet. The distance from the seaward face of structures to the mean high water line was measured and if found to be 151 feet or less, the structure was considered eligible. As the properties were scattered, only those situated to produce a contiguous length of armor were further evaluated. The result of the evaluation was two armor placement areas of 2760 feet and 560 feet in length, subtotaling 3320 ft or 8% of the whole Mid-Reach study length of 41,083 feet. Although this length technically may meet the requirements of the statute, construction of seawalls when other solutions are possible goes against the goals of the FDEP and is likely to be determined inconsistent. Furthermore, the project objective of storm damage reduction is reached in only 8% of the study area, which reduces the likelihood that this project could obtain a variance for this measure.

This management measure is eliminated from further consideration. This management measure does not meet constraint 1, only partially meets project objectives 1, 2, 3 and 4 and fully meets constraint 2.

<u>S-2 - Revetments</u>. This measure would be implemented by the USACE. This measure is mutually exclusive with the seawall measure, as both are constructed in the same location, the major difference being the seawall is a vertical structure and the revetment is a sloped structure. The revetment would be designed to protect against the 50-year storm event, or that having a 2% chance of occurrence in any given year. The shoreline would be stabilized against long-term erosion. Hardening of the shoreline by revetment would protect the upland structures, while reducing the impact of wave reflection as seen in seawalls to the nearshore profile. Erosion may continue and result in the loss of a beach for recreation and sea turtle nesting. While initial construction of this measure would avoid impacts to the nearshore hardbottom habitat, some adjustment of the nearshore profile may produce some increased scour around the hardbottom or increase the water depth. Changes to the nearshore beach profile may also affect the surfing community in the study area. The two management measures, seawall and revetment, were discussed through email and phone calls with the US Fish and Wildlife Service (USFWS) to uncover potential issues with nesting sea turtles. The USFWS stated that landowners in Brevard County have been permitted to construct similar structures with a permit condition to maintain 5 feet of sand vertically over the structure. Given the sloped seaward face of the revetment, the sand cover could amount to a considerable volume of material that would require frequent replacement. From a storm protection standpoint, both the seawall and revetment would be designed to withstand a 50-year storm. Both structures could be constructed from a variety of materials and would be placed in the same general location and shore parallel. The difference between a revetment and a seawall is the seaward slope of the structure. The sloped face

on the revetment requires more width of beach for construction. The seawall is preferable over the revetment as it takes up less space on the beach and requires less volume of sand for the sand cover; but the revetment is less reflective of wave energy and may result in less beach erosion than the seawall. This management measure partially meets objective 1 and 4 and constraint 2, but does not meet objective 2 or 3 or constraint 1. The revetment measure is eliminated from further consideration.

S-3 - Beach Nourishment. This measure would be implemented by the USACE. This measure includes initial construction of a beach fill of appropriate dimensions to serve as a buffer against wave attack and future renourishments at regular intervals. Dimensions of the beach fill would be designed to protect against the 50-year storm event in the first analysis, or that having a 2% chance of occurrence in any given year. Economics and environmental analysis of benefits and impacts of varying size widths of beach will optimize the measure. It is the flexibility of this measure to provide fill of varying widths and lengths is what makes it possible for further study. The construction method would also be optimized. Beach nourishment material is available in adequate quantities from the Canaveral Shoals II borrow area used for the Brevard County North and South reaches. Any substantial addition of material to the beach profile may have the effect of extending the mean high water line seaward, or shifting the entire profile of the beach seaward. While this is exactly the fact that provides additional storm damage protection, any extension of the mean high water line may cover nearshore hardbottom which exists only in the intertidal zone and very shallow water. Prolonged burial of the exposed nearshore hardgrounds by sand can destroy or displace the biologic community and ecologic function of the rock resource. The added beach width would provide additional recreational beach and potential growth to the tourism industry. There are also concerns over loss of nearshore hardbottom to other recreational activities such as fishing, and general changes to the nearshore beach profile for surfing. The beach nourishment measure has substantial benefits and potential impacts meeting objective 1 and 2 but not meeting objectives 3 or 4 nor constraint 2. The measure is carried forward into the next phase of analysis.

S-4 - Groins. This measure would be implemented by the USACE. A groin field would help hold a beach in front of existing development and prevent further losses of land. The construction of groins would have to be supplemented with nourishment so that adjacent beaches would not be starved of sand. For this reason, groins are considered a method to help hold the fill in place and to reduce periodic renourishment requirements. Some storm damages would be prevented by stabilizing the beach, but extension of the beach to add more benefit is not included in this measure. Beach nourishment material is available in adequate quantities from the Canaveral Shoals II borrow area used for the Brevard County North and South reaches. Groins have been successfully used in "hot-spots" that exhibit increased erosion over adjacent areas. As the entire area of the Mid-Reach has been experiencing significant erosion, the groin field may have to extend the entire 7.8 miles. As the adjacent areas to the north and south have both been historically nourished and may be presumed to continue in the future, the effects on longshore sediment transport may be minimized by extending the groin field through the entire study area. Concerns exist on potential placement sites to avoid impacts to the nearshore hardbottom. The groins extend from above the mean high water line into the water, and would pass directly over the nearshore hardbottom. The existing hardbottom does not have sufficient gaps for groin placement that avoids the hardbottom. While the rock used to construct the groins may offer some habitat mitigation, it is likely that additional mitigation would be required. The recreational beach would be stabilized, thus benefiting the tourism industry. A groin field would also impact the surfing industry in the area. Impacts to sea turtle nesting activities are not entirely known, but further study may be required to show that groins do not contribute to disorientation of nesting adults or emergent baby sea turtles. Groins do not fully address any project objective, only partially meets objectives 1 and 2 and does not meet objectives 3 or 4, nor constraint 2. Therefore groins are eliminated from further analysis.

S-5 – Submerged Artificial Reefs. This measure would be implemented by the USACE. This measure is mutually exclusive of the beach nourishment measure, as both occur in the same footprint. This measure would use the perched beach concept by placement of an artificial submerged reef in shallow water with beach fill material placed "perched" behind the reef structure. This measure may reduce initial fill quantities, reduce renourishment requirements and offer mitigation for the environmental impacts of nearshore hardbottom burial. However, the nearshore hardbottom in the study area located in shallow water depths would be covered by the new rock and beach fill. The location of the natural hardbottom would make avoidance unlikely. The constructed reef may be considered mitigation, but additional mitigation may also be required. The recreational beach would be stabilized, thus benefiting the tourism industry. Impacts to the nearshore profile will impact the surfing community. While this measurement may provide greater longevity of the fill and save some cost on periodic nourishments, the construction cost of the rock structure plus fill would be nearly triple that of the beach nourishment by itself for the same relative benefit (based on preliminary cost estimates).This management measure meets objective 1, partially meets objective 2 but does not meet objective 3 or 4 nor constraint 2. As this measure would impact the entire natural hardbottom and would not provide improved benefits over other measures, this measure is excluded from further consideration.

S-6 – Nearshore Placement. This measure would be implemented by the USACE. This measure is mutually exclusive of the beach nourishment measure, as both serve the same purpose but have differing construction technique. Dredged material would be placed in the nearshore to provide wave attenuation benefits, nourishment of the active profile, or a combination of both. This measure may have cost benefits compared to onshore disposal by hopper dredge as it would eliminate the need for pump-out facilities. Placement in the nearshore, if determined to be economically justified, would be handled in such a way as not to directly impact existing nearshore hardbottom. However, some of the material would be expected to migrate towards the shore, eventually attaching to the beach and extending the mean high water line seaward. This would provide added storm protection for coastal structures, but would also cover some or all of the nearshore hardbottom. This measure by itself would not provide onshore design elevations providing the same level of storm damage reduction as in the beach nourishment management measure. By placing material in the nearshore, some material may migrate to the beach, but some material may be lost offshore. This would necessitate dredging a greater volume of sand compared to the beach nourishment measure. The recreational beach would be stabilized or widened, thus benefiting the tourism industry. Impacts to the nearshore hardbottom could also impact fishing by covering rock and reducing habitat, and impacts to the nearshore profile could also impact the surfing community by changing how the waves break. This management measure partially meets objectives 1 and 2, but does not meet objectives 3 or 4, nor constraint 2. This measure provides less storm damage protection, greater environmental impacts, but potentially some cost savings over the beach nourishment measure. Given this comparison, this measure is not carried forward to the next phase of analysis.

<u>S-7 - Breakwaters</u>. This measure would be implemented by the USACE. The construction of breakwaters offshore along the Brevard County study area is considered as a measure to stabilize the beach. Such structures reduce the amount of wave energy reaching the shoreline in their lee. As a result, the rate of annual erosion would decrease. The breakwaters could be constructed seaward of the existing nearshore hardbottom, thus avoiding direct impacts during construction. Accretion of sand on the shoreline would occur if the breakwaters were of sufficient size. Any accretion of the shoreline would cause burial of the nearshore hardbottom. The breakwaters would also cause changes to the nearshore profile and may have effects on longshore sediment transport, effecting adjacent shores. A smaller sized breakwater to stabilize the shoreline but avoid accretion and sediment transport blockage would have limited effects on storm damage prevention. Combining breakwaters with beach nourishment would provide added beach elevations and beach width for storm damage reduction, but would substantially increase the costs. Even without beach nourishment, breakwaters may affect the nearshore profile such that some areas of hardbottom are buried and other areas experience increased scour. The recreational beach would be stabilized or widened, thus benefiting the tourism industry. Impacts to the nearshore hardbottom will also impact the fishing community and impacts to the nearshore profile will impact the surfing community. Impacts to sea turtle nesting activities are not entirely known, but further study may be required to show that breakwaters do not contribute to disorientation of nesting adults or emergent baby sea turtles. The breakwater would have an increased initial construction cost over beach nourishment alone

and is likely not justified versus any savings due to reduced erosion. As this measure only partially meets objectives 1 and 2, and does not meet objectives 3 or 4, nor constraint 2, this measure will not be considered further.

S-8 - Dunes and Vegetation. This measure would be implemented by the USACE or state or local governments. This measure is mutually exclusive with the seawall and revetment measures, as they occur in the same footprint. Storms with low surges are unable to reach the dune, leaving sand mostly intact. However, larger storms with attendant high waves and elevated water levels typically erode the dune. The dune sacrifices a portion of its sand during large storms to satisfy the erosion potential and protects the lands and property on its landward side. The level of protection offered by the dune will be determined during the analysis phase, although it is assumed that a dune will protect against some storms and be overtopped or eroded away by the largest storms. Frequent renourishment may be required to replenish the dune material following storms. The effect of the dune measure would be to offer some storm damage protection and to stabilize the beach at existing conditions. Vegetation on the dunes would be added to increase sand erosion resistance and promote dune growth through sand trapping. The vegetation also provides incidental environmental benefit by providing additional dune habitat where historically it has been eroded in the Mid-Reach area. Stabilizing the beach may also provide some incidental benefits to recreation and tourism, as well as some benefit by providing sea turtle nesting habitat. Construction sequencing would be necessary with the frequent renourishment to avoid sea turtle nesting season. This measure would have little, if any, impact on the nearshore hardbottom and may be implemented in combination with other plans. This measure meets objectives 3 and 4, and constraint 2, and partially meets objectives 1 and 2. It is the most environmentally positive measure of the structural measures. This measure will be carried into the next phase of analysis.

S-9 – Feeder Beach System. This measure would be implemented by the USACE or state or local governments. A feeder beach system is not likely to be implementable nor to produce much benefit. Beach nourishment projects already exist for the South Reach, adjacent to the study area on the south and to Patrick Air Force Base and beyond that the North Reach to the north. Natural transport already occurs from those projects, however, such feeder effects have not significantly negated the erosion occurring in the Mid-Reach. Additional sands to add to the feeder effect are denied by the water quality certificate for the South Reach, as creating a stockpile of material was initially discussed with Florida Department of Environmental Protection. The Mid-Reach is separated from the North Reach by Patrick Air Force Base, about 4 miles long, so added material to the North Reach is not likely to increase the feeder effects to the Mid-Reach. Even if implementable, a feeder effect would add sand to the nearshore and berm but would not provide any material to the dune, limiting the protection from larger storms. Added sand would be limited by the longshore current available so would likely not add enough material to provide protection in the berm volume for larger storms. This measure partially meets objectives 2 and 3 and constraint 1 and 2, however, this measure does not fully meet any objectives or constraints. This measure will not be carried into the next phase of analysis.

5.2.3 Screening Matrix

Table 5-1 presents an evaluation of the possible management measures considered in the first step of project formulation compared to the project objectives and constraints and Federal objectives represented by the four accounts. Objectives 1 and 2, storm damage reduction and maintaining recreational beach, were weighted higher than the other objectives to ensure the measures selected covered the basic needs of the project. Many of the measures did not fully address the project objectives and will not be carried forward to the next phase of analysis.

Table 5-1. Evaluation of Management Measures

	Possible Measures	Project Objectives				Project Constraints		Federal Objectives			
		Storm Damage Reduction	Maintain Recreational Beach	Maintain Nearshore Recreation	Maintain Environmental Quality	Consistent w/ Fed, State, Local Laws	Avoid, Minimize, Mitigate Impacts to Rock	NED /1	Environmental Quality	Other Social Effects	RED /2
	Nonstructural Measures (NS)	/3									
NS-1	No-Action	O	O	O	O	F	F	O	O	O	O
NS-2	Coastal Construction Control Line	P	O	F	O	F	F	P	O	O	O
NS-3	Moratorium on Construction	O	O	F	O	P	F	O	O	O	O
NS-4	Establish a No-Growth Program	O	O	F	O	P	F	O	O	O	O
NS-5	Relocation of Structures	O	O	F	P	F	F	O	P	O	O
NS-6	Flood Proofing of Structures	P	O	F	O	F	F	P	O	O	O
NS-7	Land Acquisition	P	P	F	P	P	F	P	P	O	O
	Structural Measures (S)										
S-1	Seawalls	P	P	P	P	O	F	P	P	O	P
S-2	Revetments	P	O	O	P	O	P	P	P	O	O
S-3	Beach Nourishment	F	F	O	O	F	O	F	O	P	P
S-4	Groins	P	P	O	O	P	O	P	O	O	O
S-5	Submerged Artificial Reefs	F	P	O	O	F	O	P	O	O	P
S-6	Nearshore Placement	P	P	O	O	F	O	P	O	O	P
S-7	Breakwaters	P	P	O	O	F	O	P	O	O	P
S-8	Dunes and Vegetation	P	P	F	F	F	F	P	F	O	O
S-9	Feeder Beach System	O	P	P	O	P	P	O	P	P	O

/1 NED - National Economic Development
/2 RED - Regional Economic Development
/3 F - Fully meets objective
P - Partially meets objective
O - Does not meet objective

5.2.4 Plans to be Studied Further

The previous paragraphs describing the possible solutions eliminated all but one nonstructural and two structural measures. The no-action plan (NS-1) is to be carried to the next phase of plan formulation for consideration and comparison. The structural measures to be carried into the next phase include beach nourishment (S-3) and dunes and vegetation (S-8). The beach nourishment measure includes a wide variety of scale and two possible methods of construction. For further refinement, the beach nourishment measure (S-3) is separated into two sub-measures: Beachface Fill (S-3A) and Conventional Fill (S-3B). The Beachface Fill would concentrate placement on the dry beach and intertidal zone and would be constructed using a truck haul. The Conventional Fill would be accomplished from a dredge over water, using either a pipeline or hopper dredge with pumpout facilities. These management measures will be developed into alternative plans in the next phase.

5.3 Issues and Basis for Choice

5.3.1 Formulation Strategy

Alternatives were developed by scaling the management measures in length and size and combining measures. As the alternatives were developed, the alternative evaluation criteria of completeness, effectiveness, efficiency and acceptability were considered. Completeness was satisfied by ensuring that the alternatives included all activities to implement the plan. Effectiveness is determined by how the alternatives addressed the project problems. Efficiency is determined by the cost effectiveness of a plan, which will be determined through the cost and benefit analysis. Acceptability is determined by evaluating the plan against local, state or Federal law and policy, environmental constraints and public willingness to support the plan. Each management measure is analyzed as an alternative by itself, with additional alternatives to indicate size variations. **Table 5-2** describes the alternatives developed from the management measures and scale variations, totaling 13 alternatives. Six increments of length over the 7.8 mile length of the Mid-Reach study area were evaluated. If the full range of combinations are considered, then there are over 4 million possible combinations. A screening methodology was developed to select alternatives for detailed analysis.

Table 5-2. Alternative Matrix

Management Measure	Number	Alternatives
NS-1 No-Action	NS-1	future without project
S-3A Beachface Fill	S-3A(1)	10 foot exten. of MHW + 10 ft adv. fill /1
	S-3A(2)	20 foot exten. of MHW + 10 ft adv. fill
	S-3A(3)	30 foot exten. of MHW + 10 ft adv. fill
S-3B Conventional Fill	S-3B(1)	20 foot exten. of MHW + adv. fill /2
	S-3B(2)	40 foot exten. of MHW + adv. fill
	S-3B(3)	60 foot exten. of MHW + adv. fill
	S-3B(4)	80 foot exten. of MHW + adv. fill
	S-3B(5)	100 foot exten. of MHW + adv. fill
	S-3B(6)	120 foot exten. of MHW + adv. fill
	S-3B(7)	140 foot exten. of MHW + adv. fill
	S-3B(8)	160 foot exten. of MHW + adv. fill
S-8 Dune and Vegetation	S-8	1 foot exten. of MHW

/1 The design fill is expressed in terms of feet extension of mean high water seaward. Additional advanced nourishment is placed seaward.
/2 Width of advanced nourishment for conventional fill alternatives increases with added width.

5.3.2 Screening Methodology

The screening process was developed through several iterations of alternative development and evaluation. It was essential to screen out impractical or redundant alternatives prior to doing any detailed analysis given the number of possible combination of alternatives. A brief description of the methodology is given here with further details to follow in subsequent paragraphs.

Step 1. A matrix was developed from the 13 alternatives and 6 reaches of shoreline length. The first steps consider each reach separately, however they are not independent of each other. In this first step nearshore hardbottom impact was calculated by reach and some alternatives eliminated due to unacceptable impacts.

Step 2. Unit costs were calculated for each management measure. Average annual equivalent (AAEQ) costs were calculated for each reach individually for costs that would not be shared between reaches, for example volume of sand placed times unit cost and mitigation cost. Model runs were conducted to calculate the AAEQ benefit for each alternative and net benefits calculated. Those plans with a net benefit less than 0 were eliminated. The highest net benefit in each reach was identified.

Step 3. The measures were screened based on the principle of domination and following the Federal objective to maximize net benefits while constrained to minimize hardbottom impacts.

Step 4. A combination plan was formulated adding reaches together by choosing the highest net benefit measure in each reach. Then alternative plans were added to improve consistency between reaches, address local concerns or desires, and reduce hardbottom impact. The result of this step was 72 plans with AAEQ costs and benefits and hardbottom impact numbers.

Step 5.   AAEQ costs and benefits for all 72 plans were tallied and the cost effective plans identified based on net benefit and hardbottom impact.

Step 6. The screened alternative plans were evaluated for engineering feasibility and environmental acceptability. And a final array of 5 plans was selected for further analysis. The analysis included construction details, renourishment cycles over the 50-year period of analysis, costs for mitigation, PED, lands, easements, rights-of-way, and mobilization/demobilization, and plan benefits.

Step 7. The selection of the recommended plan included comparing the final array of alternatives for maximum net benefit. The final result is the recommended plan.

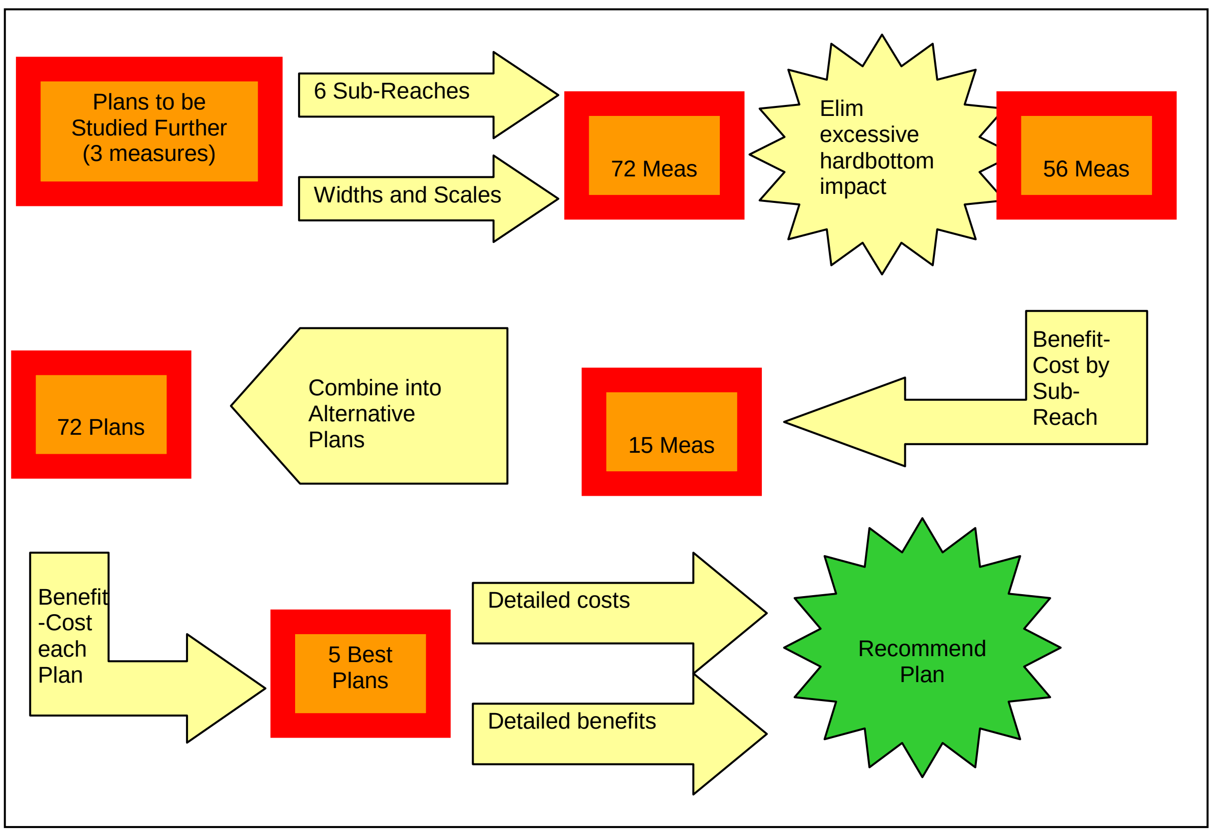

Figure 5-1. Screening Methodology Logic Diagram

5.4 Preliminary Array of Alternatives

5.4.1 Alternative Development

5.4.1.1 Hardbottom Impacts

Through the course of the study, several meetings were held with the Project Delivery Team (PDT), sponsor and environmental resource agencies to discuss the impacts of potential projects to the nearshore hardbottom resources. As additional information became available, it was evident that some levels of impact would be environmentally unacceptable regardless of mitigation potential (see Section 5.4.3.6 for additional detail). Initial analysis of the conventional fill alternatives revealed that hydraulic fill of sand would impact all the hardbottom regardless of the size of the fill, while the beachface fill placement by truck haul would be able to minimize impact by placement higher on the beach profile. This was due to the location of the hardbottom in the intertidal zone, the hydraulic fill pumpout equipment, and the liquefied nature of the pumped sand. **Table 5-3** shows the hardbottom acreage impacted by reach and by alternative including direct and indirect impacts. Additional impacts for each alternative will be evaluated for transitional areas and end effects. The engineering documentation in the Engineering Appendix includes information on how the hardbottom impact was determined for each alternative. In early meetings, discussions took place on the amount of hardbottom impact that would be environmentally unacceptable given the total hardbottom acreage of 31.3 acres. From the data, the conventional fill alternatives for Reaches 5 and 6 are eliminated due to excessive hardbottom impacts, with each reach containing almost one third of the hardbottom within the Mid-Reach. The remaining alternatives are carried forward for further evaluation. This completed Step 1.

Table 5-3. Initial Hardbottom Impact Screening (acres of hardbottom)

Management Measure	Number	Alternatives	Mitigation	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6
NS-1 No-Action	NS-1	future without project	No	0	0	0	0	0	0
S-3A Beachface Fill	S-3A(1)	10 foot exten. of MHW + 10 ft adv. fill /1	Yes	0.3	0.3	0.5	0.5	0.9	0.8
	S-3A(2)	20 foot exten. of MHW + 10 ft adv. fill	Yes	0.5	0.4	0.8	0.7	1.6	1.3
	S-3A(3)	30 foot exten. of MHW + 10 ft adv. fill	Yes	0.6	0.5	1.1	1.1	2.3	2.0
S-3B Conventional Fill	S-3B(1)	20 foot exten. of MHW + adv. fill	Yes	0.9	0.8	2.4	4.4	9.9	12.9
	S-3B(2)	40 foot exten. of MHW + adv. fill	Yes	0.9	0.8	2.4	4.4	9.9	12.9
	S-3B(3)	60 foot exten. of MHW + adv. fill	Yes	0.9	0.8	2.4	4.4	9.9	12.9
	S-3B(4)	80 foot exten. of MHW + adv. fill	Yes	0.9	0.8	2.4	4.4	9.9	12.9
	S-3B(5)	100 foot exten. of MHW + adv. fill	Yes	0.9	0.8	2.4	4.4	9.9	12.9
	S-3B(6)	120 foot exten. of MHW + adv. fill	Yes	0.9	0.8	2.4	4.4	9.9	12.9
	S-3B(7)	140 foot exten. of MHW + adv. fill	Yes	0.9	0.8	2.4	4.4	9.9	12.9
	S-3B(8)	160 foot exten. of MHW + adv. fill	Yes	0.9	0.8	2.4	4.4	9.9	12.9
S-8 Dune and Vegetation	S-8	1 foot exten. of MHW	No	0	0	0	0	0	0

/1 extension of mean high water. This is the design fill, additional advanced nourishment is placed seaward.

5.4.1.2 Economic Benefits and Costs

The economic analysis to determine the NED plan for the study area includes an inventory of potential damages, development of plans, and estimation of the costs for project implementation. The cost of mitigation measures was developed as part of the cost of each alternative. Monetary values are expressed in average annual equivalents by appropriate discounting and annualizing techniques based on the Fiscal Year 2008 water resource evaluation interest rate of 4 and 7/8%. The same 50-year period of analysis is used for all management measures. The period of analysis does not include the implementation or construction period (the period before the base year). Initial construction costs and subsequent benefits are expressed as of the beginning of the base year. The following steps are taken in the economic analysis:

a. for the future without project condition, assess the extent of damageable property through analysis of storm surge and wave damage, the loss of recreation, and the loss of land

b. determine damage reduction benefits to the coastal system for each alternative

c. evaluate all beneficial and adverse impacts for each project measure in accordance with Engineering Regulation 1105-2-100 (Principles and Guidelines).

5.4.1.3 Cost and Benefit Evaluation Methodology and Assumptions

The evaluation methodology for the economic benefits and costs follows established Corps of Engineers guidance. Construction costs were researched for similar projects in the recent past, and the MCACES construction cost estimating program used where information allowed. The economic database was compiled from field surveys of properties, assessments of tax appraiser information, survey measurements of distances and mean high water line location, and shoreline change data. The numerical model *S*torm-induced *BEA*ch *CH*ange Model (SBEACH) was utilized to predict the shoreline recession associated with tropical and extra-tropical storms throughout the project's 50-year life. The economic data was input into the Jacksonville District Storm Damage Model for calculation of recession and subsequent damages.

<u>NS-1 No-Action Plan</u>. The no-action plan is referred to in the economic analysis as the future without project condition. The future without-project condition assumes that short-term and long-term erosion will continue into the future at the same rates as they have over the period of record. Some coastal armoring activities, implemented by others, are included in the future without project condition in accordance with State of Florida coastal zone management regulations. The average annual equivalent damage predicted for the no-action plan is used as a benchmark in the comparison of alternatives. Predicted with-project damages are subtracted from the damages expected under the no-action plan to determine the benefits of each alternative. No costs are associated with the no-action plan.

S-3A - Beach Nourishment – Beachface Fill. The Beachface Fill measure focuses on placement of material on the dry beach and in the intertidal zone. Construction would be accomplished with truck haul from upland sources. Some impacts to the nearshore hardbottom would occur and mitigation costs were included in the analysis. Volumetric placements to achieve a 10-foot, 20-foot, and 30-foot extension of the mean high water line were analyzed to compute hardbottom impacts. The template includes a dune feature to maximize the volume placed on the upper beach, thereby decreasing the periodic nourishment and hardbottom impact. The benefits were computed using the Storm Damage Model's mean high water extension feature, wherein the beach fill widths were added as input parameters and the damages calculated. The damages were compared to the damages of the no-action plan to find the benefit of constructing each alternative. The benefits produced from the Storm Damage Model are for the design fill only and do not include time varying benefits from sacrificial advanced nourishment seaward of the design template.

S-3B - Beach Nourishment – Conventional Fill. The Conventional Fill measure is a larger beach nourishment project that would be constructed from a dredge. The same equipment and borrow source used in the Brevard County North and South Reaches were used in this analysis. The nearshore hardbottom was assumed 100% covered by this type of fill regardless of width and mitigation costs were included in the analysis. Volumetric placements to achieve a 20-foot to 160-foot mean high water line extension were analyzed in 20-foot increments to compute the costs. A dune feature is included at the 20 and 30 foot increments, matching the volume placed for S-3A, but the larger increments do not include a dune feature as there is no additional benefit from the Storm Damage Model Analysis. Mobilization/demobilization is not included in the project costs, following guidance from the Feasibility Scoping Meeting to assume that placement within the Mid-Reach would occur at the same time as additional future placement within the South Reach. The benefits were computed using the Storm Damage Model's mean high water extension feature, wherein the beach fill widths were added as input parameters and the damages calculated. The damages were compared to the damages of the no-action plan to find the benefit of constructing each alternative. The benefits produced from the Storm Damage Model are for the design fill only and do not include time varying benefits from sacrificial advanced nourishment seaward of the design template.

S-8 - Dunes and Vegetation. This management measure includes placement of approximately 5 cubic yards of fill per linear foot along the beach in the shape of a dune adjacent to the existing bluff line. Regular replacement of material may be required as storm action erodes the dune material. Construction would be accomplished by truck haul from an upland source. The benefits are derived from a stabilization of the existing shoreline, meaning the mean high water line will not be advanced but repeated nourishment of the dune would provide material to offset erosion. No impacts would be expected to the nearshore hardbottom, so no mitigation costs are included. The benefits were computed from the Storm Damage Model. As the dune measure would have the effect of stabilizing the shoreline at the existing condition, this was approximated by using the Storm Damage Model one-foot mean high water line extension. The model was run to compute damages and compared to the no-action plan to produce the benefits of each alternative.

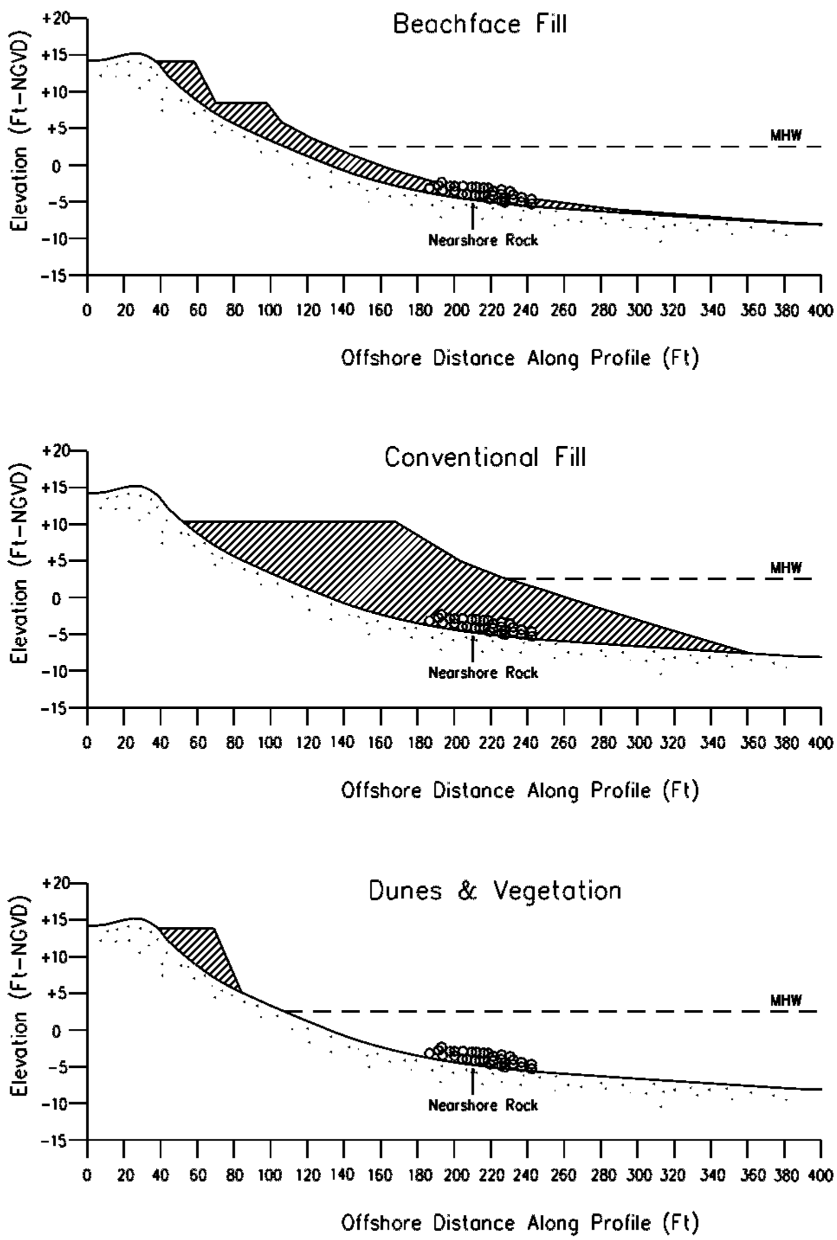

Figure 5-2. Typical Cross Sections

5.4.1.4 Sources of Material - Offshore

The likely source of material for construction of the conventional fill alternatives is an offshore borrow site called Canaveral Shoals II (**Figure 5-3**). The borrow area is located approximately 20 miles from the center of the study area. The size of the borrow area is approximately 6,000 x 6,500 feet with existing depths ranging from -11 to -42 feet. Adjacent to this site is Canaveral Shoals I, which is available for use; however, it requires an access channel to be dredged prior to a Hopper Dredge being able to use this area. For this reason, Canaveral Shoals II was developed. CSII lies within Federal waters, requiring a lease with Minerals Management Services for use. Canaveral Shoals II has been successfully leased and permitted for use in initial construction and renourishment of the Brevard County North and South Reaches. Approximately 21.3 million cubic yards of material are available from this site. The sediments encountered within the borrow area consist of light grey or light brown, fine to medium, poorly graded quartz sand with varying amount of whole and broken shell. The median grain diameter (D_{50}) of the composite sample for the entire borrow area is 0.34 mm. The silt contents (passing #230 sieve) is very low ranging from 0 to 0.14 percent, with an average of 0 percent. The gravel contents vary from 0 to 3.3 percent, with an average of 1.5 percent. A suitability analysis of this material compared to the native beach material in the Mid-Reach was completed. The borrow material is considered suitable for the Mid-Reach beach, because it is better sorted and contains less gravel and silt than the native beach does. An advantage of using coarser materials for beach nourishment is that the coarser materials could provide an improved resistance to storm-induced erosion. Given the low percentage of fines, turbidity during construction is not expected to be an issue. Although Canaveral Shoals II borrow area is proposed for use, Canaveral Shoals I borrow area contains similar material and could be further developed for use in the future.

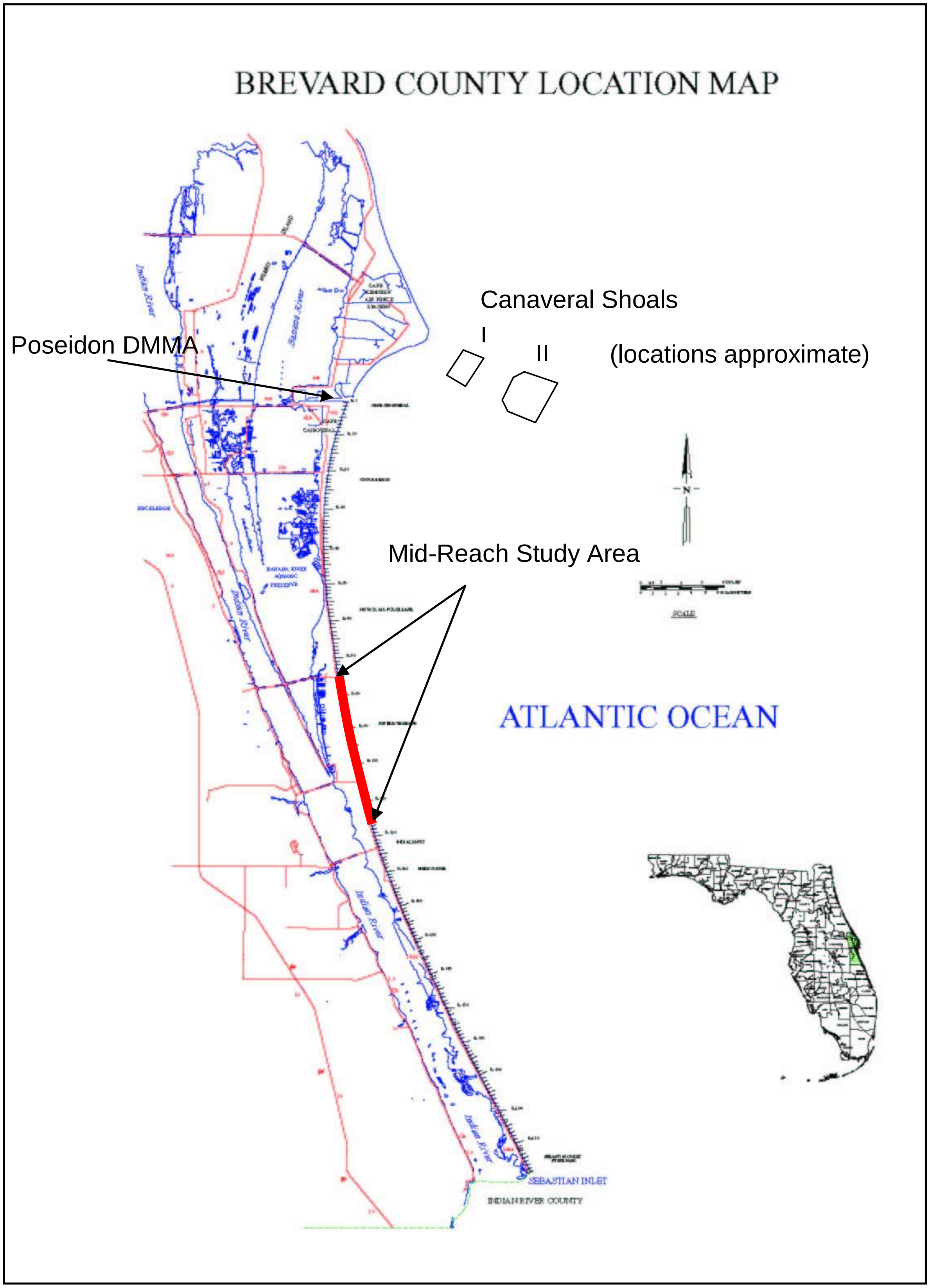

Figure 5-3. Canaveral Shoals II Borrow Site Map.

5.4.1.5 Sources of Material - Other

In addition to the previously described offshore source of sand, Canaveral Shoals, another potential supply of material for the Dune feature (S-8) and Beachface Fill (S-3A) is from upland sand sources. A value engineering study was conducted, due to the uncommon nature of using upland sand sources for shore protection projects and a desire to find an economical source of material. Several upland sources of sand were investigated during the value engineering study. Some basic parameters of the study were: the material must be dry (non-hydraulic) for a truck haul construction method, and the sand source must provide for the needs throughout the 50-year period of analysis. Stockpiled sand must be dry enough before transport such that sealed on-road trucks are not needed for transport to the placement site.

a) Poseidon Dredged Material Management Area (DMMA). This is the preferred upland sand source as it is the most practical and cost effective location to stockpile offshore sand. The method would include dredging sand from the offshore borrow site at CS-I or CS-II, offloading the material to the DMMA, allowing the material to dewater, loading the material into dump trucks, and truck hauling the material to the Mid-Reach. The dredging would occur on 6-year cycles to capitalize on the dredging activities of the adjacent Brevard County North and South reach shore protection project. The DMMA is owned by the Air Force and is managed by the Navy for use in maintenance dredging of the Navy’s Trident submarine basin located at Port Canaveral, although it has not been used for some time. The site is approximately 70 acres in size; preliminary designs include sufficient room for the 0.75 to 1.0 million cubic yards required capacity based on a 6-year cycle, if the site were improved. The site offers the advantages of an existing DMMA, deep water access for direct pumpout from a dredge, and an existing road network to truck sand to the Mid-Reach. Preliminary meetings and correspondence with Port Canaveral, the Air Force and the Navy indicate their willingness to participate in this plan. This option is used in the cost estimates for alternatives S-3A Beachface Fill and S-8 Dune and Vegetation.

b) Stockpile of offshore material on the beach. This plan has several challenges that prevent it from being practical. The alternative would use dredged material, capitalizing on the hydraulic fill of adjacent projects that occur on a 6-year cycle. Stockpiling hydraulic fill along the narrow beaches of the Mid-Reach would not provide adequate capacity without adversely increasing the project’s impacts to existing hardbottoms during initial construction and subsequent losses of sand from the stockpile. Stockpiling sand to the adjacent beaches is not included in prior project authorizations, permits, or easements and is contrary to the local interests and could likewise increase impacts to the adjacent hardbottoms due to losses and alongshore diffusion from the sand stockpile.

c) Stockpile of offshore sand on Patrick Air Force Base. This plan involves constructing a new DMMA on Air Force property just north of the Mid-Reach area. The advantage would be a closer stockpile area to the Mid-Reach than the stockpile at Poseidon DMMA. The disadvantages are that construction would start from scratch, including locating a suitable site. The primary difficulty with this option is devising a method by which sand could be pumped from the dredge or barge to the placement site. A pipeline could be constructed that would pass underneath the beach and Highway A1A to a site on the base. This option would require a very large initial construction outlay and likely would become prohibitively expensive when compared with other options. This plan is less desirable than the Poseidon DMMA.

d) Other Existing DMMA's. Similar plans were developed for alternate DMMAs that involved dredging material from CSII, placing the material in the DMMA, and then trucking the material to the Mid-Reach. None of these alternate plans were preferable to the Poseidon DMMA. Most contained material that was not suitable for beach placement, needed repairs to the DMMA, and were farther from both the dredge site and the Mid-Reach project area. DMMAs located in the Intracoastal Waterway also had added costs for transferring material from the dredge to small barges that would be able to transit the locks at Port Canaveral and the Intracoastal. The DMMAs investigated for this plan included CBC-DMMA 'Barge Canal', Navy Port West Dredge Disposal Area, BV-2C, BV-4B 'MIMS', BV-11, BV-R 'Rockledge', BV-40, BV-52, and BV-24.

e) Existing Commercial Quarries. Commercial quarries have been used in the past for small fill projects in Brevard County. The material is beach quality and suitable for truck haul. However, available sources of upland sand meeting the environmental quality required for this project are increasingly difficult to identify, and are unlikely to be able to provide for the quantity of material needed for 50 years of Federal participation. Temporary, interim use of upland sand sources may be considered in the event that other sources are immediately unavailable.

5.4.1.6 Construction Cost Estimates

Cost estimates were calculated for each of the alternatives and for each reach using the MCACES program. A summary table is presented below, with additional information provided in the Economics Appendix. It should be noted that for alternative S-3B, Conventional Fill, only four alternative beach widths were computed using the MCACES program (20, 40, 100 and 160 feet). To calculate intermediate beach widths for optimization of this alternative, the cost per cubic yard was used along with other costs pro-rated as needed based on volume. **Table 5-4** does not include the cost of mitigation. The supporting documentation for these cost estimates is the MCACES report dated October 2006, and is included as an attachment to the Economics Appendix (Appendix B).

Table 5-4. Construction Cost Estimates

		Reach						
Alternative		1	2	3	4	5	6	Total
Dune Fill		$1,655,708	$427,173	$807,231	$708,765	$1,134,956	$908,616	$5,642,449
Beachface Fill	20 ft MHW ext.	$3,814,123	$1,183,420	$2,158,315	$1,963,241	$3,144,728	$2,509,477	$14,773,305
Conventional Fill	20 ft MHW ext.	$3,822,121	$1,102,303	$1,733,873	$1,517,073	$2,379,083	$1,870,809	$12,425,263
Conventional Fill	40 ft MHW ext.	$6,424,217	$1,550,708	$2,175,265	$2,287,142	$3,898,057	$2,963,920	$19,299,310
Conventional Fill	100 ft MHW ext.	$12,247,051	$4,069,740	$5,347,935	$5,443,961	$9,403,227	$7,878,286	$44,390,199
Conventional Fill	160 ft MHW ext.	$19,032,245	$7,255,670	$11,021,653	$10,009,579	$17,635,865	$15,617,661	$80,572,673

5.4.2 Mitigation of Environmental Impacts

The plan formulation process up to this point has endeavored to avoid and minimize impacts to the nearshore hardbottom. However, in order to maximize storm damage reduction, some impact to the hardbottom is necessary and mitigation would be required. For complete analysis of the beach nourishment alternatives (S-3A and S-3B), the cost for mitigation of impacts to nearshore hardbottom needs to be included in the project costs. The other alternatives being considered do not impact the nearshore hardbottom. It is assumed that some acreage of impacts may be successfully permitted and mitigated, while impacts to the entire resource in the Mid-Reach study area are considered unacceptable. Areas of unimpacted hardbottom will remain where artificial mitigation reefs may be constructed seaward of the natural hardbottom. Intense discussion on multiple occasions took place between the Jacksonville District, Brevard County and their consultants, Florida Department of Environmental Protection, National Marine Fisheries Service, U.S. Fish and Wildlife Service and others.

5.4.2.1 Mitigation Calculation

In order to calculate the construction costs of the mitigation, a ratio of the acreage of mitigation required compared to the impact acreage of 1.6 to 1 was used. This draft mitigation ratio was calculated for plan formulation purposes and is subject to agency review and may be modified as additional information is available. The mitigation ratio was calculated following the State of Florida Uniform Mitigation Assessment Method (UMAM) method for calculating the mitigation ratio. Factors included in the calculation include risk, impact, and time lag. The UMAM calculation sheets are included in the Environmental Documentation Appendix. The mitigation ratio was verified using the Habitat Equivalency Analysis, which also resulted in a ratio of 1.6 to 1. A sensitivity analysis was conducted which determined selection of the NED plan was not sensitive to mitigation ratio. The Conventional Fill alternatives are assumed to cover 100% of the hardbottom within the construction area due to the hydraulic placement of material. The Beachface Fill alternatives were analyzed using coastal engineering principles of equilibrium and dispersion to quantify the impacts to the hardbottom in the cross-shore direction. Both direct and indirect impacts to the natural hardbottom are included in the impact acreage that requires mitigation.

5.4.2.2 Mitigation Options

Detailed studies of the natural hardbottom were conducted to provide a baseline. Research into similar projects and successfully permitted mitigation was gathered. The items of importance in selecting a viable mitigation plan were replacement of lost functions, a location in close proximity and similar water depth as that impacted, stability in the nearshore environment, avoiding additional impacts to the natural hardbottom by the mitigation reef, and the type of habitat that could be provided by the mitigation reef. Three main types of mitigation reefs have been either proposed for use on other projects or have been successfully permitted on other projects. The three types of artificial reef include pre-fabricated articulated concrete mats with coquina, limestone boulders constructed with no substratum material, and limestone boulders over a foundation mattress. The preferred mitigation plan is the articulated concrete mats with coquina. The units can be made on land, so they are cost effective for construction and implementation. The surface of the units is imbedded with natural coquina stone that is similar to the natural hardbottom in the area. And the habitat relief is similar to the low-lying natural hardbottom. The second option, the limestone boulders, requires a hard subsurface layer for implementation. The study area was investigated for subsurface hard layers underlying the sandy seabottom and nothing was found, outside of the hardbottom in the intertidal zone. The limestone boulders in the absence of a substratum layer are expected to subside into the sand such that no appreciable habitat will remain. Therefore construction of the limestone boulder reef without foundation materials is not practical. The third option combines limestone boulders with a foundation mattress. The mattress provides support for the limestone and prevents subsidence into the sand. Although this option is implementable, it is less desirable than the articulated concrete mats with coquina. Preliminary cost estimates show the boulders and foundation mattress to be the same or more expensive than the articulated concrete mats. And the boulders offer a differing habitat relief than the natural hardbottom. The location of the mitigation reef is also of primary importance. Proximity to the area of impact is desired and approximation of the shallow water depth. Considerations of the nearshore depths in which the mitigation reefs can be placed are discussed in **Appendix K – Subappendix F**. At numerous meetings with the environmental agencies to discuss the mitigation strategy, guidance from NMFS, USFWS, FDEP and others was to co-locate the mitigation reefs nearest the impacted resources in areas that would not be otherwise adversely impacted by beach fill or other activities.

5.4.2.3 Mitigation Construction
The preferred mitigation plan is the articulated concrete mats with coquina. Construction equipment is not capable of working from the beach and reaching past the nearshore hardbottom, so water based equipment is required. Such equipment must meet Coast Guard standards to operate in the wave environment experienced in Brevard County. Such fully loaded ocean-going barges on similar projects have been able to access only to the 15-foot contour. Use of a crane on a barge will not be able to appreciably reach shallower water to offload the mats. The mitigation reef must also maintain at least 6 feet of navigational clearance at low tide over the submerged reef. The proposed placement depths are from 14 to 16 feet mean lower low water (MLLW), or about 1000 feet offshore. Each articulated reef mat would consist of 18 cable-connected blocks. The blocks include 4 inch to 12 inch Florida coquina stone formed into the top surface of each concrete block. The coquina stone, spaces between the blocks, and spaces between each mat emulate the physical relief of natural hardbottom, crevices, and adjacent sand bottom. Each mat would be about 8-feet by 15-feet by 1-foot high, and when six are attached to form a row, they comprise a length of about 90 lineal feet of valleys/ridges between blocks and adjacent mats. Forty-two mats, in rows of six and seven offset columns, plus two mats layered on top of the landward mats to produce an overhanging ledge, would be placed adjacently to comprise one “set” of mats equal to 0.15 acres of hardbottom structure. Additional information is provided in the Engineering Appendix starting at paragraph A-59. The top surface of the finished mat structure would vary between 12 feet MLLW and 15 feet MLLW. Design details, placement locations and construction costs will be further refined during the PED phase. **Table 5-5** shows the construction cost estimate (October 2006 MCASES) used in the screening process for selected acreage of mitigation reef constructed of an articulated concrete mattress with imbedded coquina rock. Interpolation was used to calculate the cost of each alternative.

Table 5-5. Mitigation Reef Construction Costs

Alternative	Description	Unit Price	Unit of Measure	Subtotal
Articulated Concrete	1 acre	$1,508,786.00	acre	$1,780,410
Mitigation Reef	2 acre	$1,382,296.50	acre	$3,037,829
	3 acre	$1,340,133.67	acre	$4,293,637
	4 acre	$1,319,052.25	acre	$5,549,445
	5 acre	$1,306,403.40	acre	$6,805,253
	6 acre	$1,297,970.67	acre	$8,061,060
	7 acre	$1,291,947.43	acre	$9,316,868
	8 acre	$1,287,430.00	acre	$10,572,676
	9 acre	$1,283,916.44	acre	$11,828,484
	10 acre	$1,281,105.60	acre	$13,084,292
	11 acre	$1,278,805.82	acre	$14,340,100
	12 acre	$1,276,889.25	acre	$15,595,907

Figure 5-4. Mitigation Reef Prototype

5.4.3 Alternative Screening

In order to complete Step 2, the AAEQ costs and benefits were calculated for each reach individually and compared. For this analysis, the costs included things that were separable by reach, for example volume times unit cost and mitigation cost. Costs that could be shared between reaches, like mobilization/demobilization, are deferred for the next steps. Model runs were conducted to calculate the AAEQ benefit for each alternative and net benefits calculated. Those plans with a net benefit less than 0 were identified. The highest net benefit measure in each reach was identified.

Table 5-6. Initial Screening with AAEQ Costs and Benefits

			Reach 1					Reach 2				
Management Measure	Number	Alternatives	Total First Cost	AAEQ Cost	AAEQ Benefit	Net Benefits	Benefit-Cost Ratio	Total First Cost	AAEQ Cost	AAEQ Benefit	Net Benefits	Benefit-Cost Ratio
NS-1 No-Action	NS-1	future without project	$0	$0	$0	$0	0.00	$0		$0	$0	0.00
S-3A Beachface Fill	S-3A(1)	10 foot exten. of MHW /1	$4,950,833	$336,418	$741,327	$404,909	2.20	$2,784,511	$224,823	$550,283	$325,460	2.45
	S-3A(2)	20 foot exten. of MHW	$6,562,353	$434,857	$807,664	$372,807	1.86	$3,663,932	$283,944	$633,375	$349,431	2.23
	S-3A(3)	30 foot exten. of MHW	$8,139,266	$531,363	$849,890	$318,527	1.60	$4,371,777	$333,485	$687,069	$353,584	2.06
S-3B Conventional Fill	S-3B(1)	20 foot exten. of MHW	$10,467,886	$676,216	$807,664	$131,448	1.19	$8,047,458	$674,155	$633,375	($40,780)	0.94
NOT Cumulative	S-3B(2)	40 foot exten. of MHW	$13,600,436	$928,562	$879,004	($49,558)	0.95	$9,345,802	$868,642	$727,063	($141,579)	0.84
	S-3B(3)	60 foot exten. of MHW	$15,857,899	$1,132,641	$913,115	($219,526)	0.81	$11,269,758	$1,129,162	$778,761	($350,401)	0.69
	S-3B(4)	80 foot exten. of MHW	$18,077,766	$1,333,328	$926,657	($406,671)	0.69	$13,152,535	$1,384,099	$801,977	($582,122)	0.58
	S-3B(5)	100 foot exten. of MHW	$20,260,038	$1,530,625	$930,606	($600,019)	0.61	$14,994,131	$1,633,453	$808,161	($825,292)	0.49
	S-3B(6)	120 foot exten. of MHW	$23,102,155	$1,758,687	$931,454	($827,233)	0.53	$17,124,755	$1,905,746	$809,125	($1,096,621)	0.42
	S-3B(7)	140 foot exten. of MHW	$25,828,039	$1,977,371	$931,829	($1,045,542)	0.47	$19,255,169	$2,178,011	$809,238	($1,368,773)	0.37
	S-3B(8)	160 foot exten. of MHW	$28,437,690	$2,186,678	$932,777	($1,253,901)	0.43	$21,385,373	$2,450,250	$809,510	($1,640,740)	0.33
S-8 Dune and Vegetation	S-8	1 foot exten. of MHW	$1,231,477	$668,173	$648,200	($19,973)	0.97	$404,532	$219,625	$434,007	$214,382	1.98

/1 The design fill is expressed in terms of feet extension of mean high water seaward. Additional advanced nourishment is placed seaward.
The grayed out portions were eliminated as alternatives in prior steps. October 2006 Price Levels and FY07 discount rate of 4 7/8 was used for this screening.

Table 5-6 (continued). Initial Screening with AAEQ Costs and Benefits

			Reach 3					Reach 4				
Management Measure	Number	Alternatives	Total First Cost	AAEQ Cost	AAEQ Benefit	Net Benefits	Benefit-Cost Ratio	Total First Cost	AAEQ Cost	AAEQ Benefit	Net Benefits	Benefit-Cost Ratio
NS-1 No-Action	NS-1	future without project	$0		$0	$0	0.00	$0		$0	$0	0.00
S-3A Beachface Fill	S-3A(1)	10 foot exten. of MHW /1	$4,661,409	$528,074	$3,203,338	$2,675,264	6.07	$4,618,587	$598,880	$1,126,000	$527,120	1.88
	S-3A(2)	20 foot exten. of MHW	$6,292,529	$662,244	$3,828,257	$3,166,013	5.78	$6,406,432	$754,000	$1,259,913	$505,913	1.67
	S-3A(3)	30 foot exten. of MHW	$7,930,559	$796,799	$4,262,831	$3,466,032	5.35	$8,406,128	$920,949	$1,379,012	$458,063	1.50
S-3B Conventional Fill	S-3B(1)	20 foot exten. of MHW	$12,574,238	$990,464	$3,828,257	$2,837,793	3.87	$18,428,669	$1,340,857	$1,259,913	($80,944)	0.94
NOT Cumulative	S-3B(2)	40 foot exten. of MHW	$14,039,380	$1,218,284	$4,488,140	$3,269,856	3.68	$20,201,589	$1,583,515	$1,482,233	($101,282)	0.94
	S-3B(3)	60 foot exten. of MHW	$16,164,607	$1,487,162	$4,685,045	$3,197,883	3.15	$22,297,341	$1,847,415	$1,588,412	($259,003)	0.86
	S-3B(4)	80 foot exten. of MHW	$18,247,293	$1,750,645	$4,762,018	$3,011,373	2.72	$24,353,298	$2,106,291	$1,639,269	($467,022)	0.78
	S-3B(5)	100 foot exten. of MHW	$20,287,438	$2,008,733	$4,796,409	$2,787,676	2.39	$26,369,459	$2,360,144	$1,652,549	($707,595)	0.70
	S-3B(6)	120 foot exten. of MHW	$23,231,850	$2,324,332	$4,810,107	$2,485,775	2.07	$28,922,489	$2,650,502	$1,656,594	($993,908)	0.63
	S-3B(7)	140 foot exten. of MHW	$26,175,390	$2,639,837	$4,814,063	$2,174,226	1.82	$31,473,482	$2,940,628	$1,658,339	($1,282,289)	0.56
	S-3B(8)	160 foot exten. of MHW	$29,118,058	$2,955,248	$4,814,904	$1,859,656	1.63	$34,022,438	$3,230,523	$1,659,100	($1,571,423)	0.51
S-8 Dune and Vegetation	S-8	1 foot exten. of MHW	$710,722	$385,958	$2,402,874	$2,016,916	6.23	$634,216	$344,429	$909,963	$565,534	2.64

/1 The design fill is expressed in terms of feet extension of mean high water seaward. Additional advanced nourishment is placed seaward.
The grayed out portions were eliminated as alternatives in prior steps. October 2006 Price Levels and FY07 discount rate of 4 7/8 was used for this screening.

Table 5-6 (continued). Initial Screening with AAEQ Costs and Benefits

			Reach 5					Reach 6				
Management Measure	Number	Alternatives	Total First Cost	AAEQ Cost	AAEQ Benefit	Net Benefits	Benefit-Cost Ratio	Total First Cost	AAEQ Cost	AAEQ Benefit	Net Benefits	Benefit-Cost Ratio
NS-1 No-Action	NS-1	future without project	$0		$0	$0	0.00	$0		$0	$0	0.00
S-3A Beachface Fill	S-3A(1)	10 foot exten. of MHW /1	$6,690,152	$667,062	$3,339,136	$2,672,074	5.01	$5,595,636	$671,936	$1,195,219	$523,283	1.78
	S-3A(2)	20 foot exten. of MHW	$10,045,322	$901,783	$3,802,570	$2,900,787	4.22	$8,384,869	$886,055	$1,368,227	$482,172	1.54
	S-3A(3)	30 foot exten. of MHW	$13,770,457	$1,157,162	$4,102,446	$2,945,284	3.55	$11,657,999	$1,127,193	$1,471,241	$344,048	1.31
S-3B Conventional Fill	S-3B(1)	20 foot exten. of MHW										
NOT Cumulative	S-3B(2)	40 foot exten. of MHW										
	S-3B(3)	60 foot exten. of MHW										
	S-3B(4)	80 foot exten. of MHW										
	S-3B(5)	100 foot exten. of MHW										
	S-3B(6)	120 foot exten. of MHW										
	S-3B(7)	140 foot exten. of MHW										
	S-3B(8)	160 foot exten. of MHW										
S-8 Dune and Vegetation	S-8	1 foot exten. of MHW	$1,144,722	$618,353	$2,651,884	$2,033,531	4.29	$667,902	$363,353	$913,631	$550,278	2.51

/1 The design fill is expressed in terms of feet extension of mean high water seaward. Additional advanced nourishment is placed seaward.
The grayed out portions were eliminated as alternatives in prior steps. October 2006 Price Levels and FY07 discount rate of 4 7/8 was used for this screening.

Table 5-7. Initial Screening of Net Benefits Results

Management Measure	Number	Alternatives	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6
NS-1 No-Action	NS-1	future without project						
S-3A Beachface Fill	S-3A(1)	10 foot exten. of MHW /1	highest					
	S-3A(2)	20 foot exten. of MHW						
	S-3A(3)	30 foot exten. of MHW		highest	highest		highest	
S-3B Conventional Fill	S-3B(1)	20 foot exten. of MHW						
NOT Cumulative	S-3B(2)	40 foot exten. of MHW						
	S-3B(3)	60 foot exten. of MHW						
	S-3B(4)	80 foot exten. of MHW		B/C < 1		B/C < 1	Environmentally Unacceptable	
	S-3B(5)	100 foot exten. of MHW	B/C < 1					
	S-3B(6)	120 foot exten. of MHW						
	S-3B(7)	140 foot exten. of MHW						
	S-3B(8)	160 foot exten. of MHW						
S-8 Dune and Vegetation	S-8	1 foot exten. of MHW	B/C < 1			highest		highest

/1 extension of mean high water. This is the design fill, additional advanced nourishment is placed seaward.

5.4.3.1 Plan Formulation Strategy

As part of Step 3, the resulting AAEQ matrix from Step 2 was evaluated to identify the measure with the highest net benefit alternative in each reach **(Table 5-6)**. The highest net benefit measures are shown in **Table 5-7**. The highest net benefit measures were added together down the length of the Mid-Reach to create Plan 1, which has 4.4 acres of hardbottom impact. As one of the planning constraints was to avoid and minimize hardbottom impact, alternatives to Plan 1 were formulated to reduce the hardbottom impact. The plan formulation strategy was to vary the measure in each reach to both maximize net benefit and minimize hardbottom impact. In **Table 5-8** the rank of each measure relative to net benefit is indicated with number 1 being the highest net benefit, followed by number 2, and so on. Comparing **Table 5-8** to **Table 5-3**, any measure with less net benefit than number 1 but more hardbottom impact is contrary to the plan formulation strategy and is eliminated. It would make no sense to pursue a plan that increases the hardbottom impact and also reduces the net benefits as compared to Plan 1. It can be said that Plan 1 dominates any plan with less net benefit and more hardbottom impact. The measures that are dominated by the highest net benefit measure are grayed out in **Table 5-8**.

Table 5-8. Elimination of Dominated Plans

<table>
<tr><th>Management Measure</th><th>Number</th><th>Alternatives</th><th>Reach 1</th><th>Reach 2</th><th>Reach 3</th><th>Reach 4</th><th>Reach 5</th><th>Reach 6</th></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>NS-1 No-Action</td><td>NS-1</td><td>future without project</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>S-3A Beachface Fill</td><td>S-3A(1)</td><td>10 foot exten. of MHW /1</td><td>1</td><td>3</td><td>4</td><td>2</td><td>3</td><td>2</td></tr>
<tr><td></td><td>S-3A(2)</td><td>20 foot exten. of MHW</td><td>2</td><td>2</td><td>3</td><td>3</td><td>2</td><td>3</td></tr>
<tr><td></td><td>S-3A(3)</td><td>30 foot exten. of MHW</td><td>3</td><td>1</td><td>1</td><td>4</td><td>1</td><td>4</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>S-3B Conventional Fill</td><td>S-3B(1)</td><td>20 foot exten. of MHW</td><td>4</td><td rowspan="8">B/C < 1</td><td></td><td rowspan="8">B/C < 1</td><td rowspan="8" colspan="2">Environmentally Unacceptable</td></tr>
<tr><td>NOT Cumulative</td><td>S-3B(2)</td><td>40 foot exten. of MHW</td><td rowspan="7">B/C < 1</td><td>2</td></tr>
<tr><td></td><td>S-3B(3)</td><td>60 foot exten. of MHW</td><td rowspan="6">Dominated</td></tr>
<tr><td></td><td>S-3B(4)</td><td>80 foot exten. of MHW</td></tr>
<tr><td></td><td>S-3B(5)</td><td>100 foot exten. of MHW</td></tr>
<tr><td></td><td>S-3B(6)</td><td>120 foot exten. of MHW</td></tr>
<tr><td></td><td>S-3B(7)</td><td>140 foot exten. of MHW</td></tr>
<tr><td></td><td>S-3B(8)</td><td>160 foot exten. of MHW</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>S-8 Dune and Vegetation</td><td>S-8</td><td>1 foot exten. of MHW</td><td>B/C < 1</td><td>4</td><td>5</td><td>1</td><td>4</td><td>1</td></tr>
</table>

/1 extension of mean high water. This is the design fill, additional advanced nourishment is placed seaward.
Grayed out measures are eliminated from further consideration.

5.4.3.2 Alternative Plan Development

As Step 4, all possible alternative plans were developed using **Table 5-8**, resulting in 65 possible alternative plans. Plan 66 was added as a shorter alternative, with measures in reaches 1 to 4 but no action in reaches 5 and 6. Local options were also added to include the local sponsors permit plan, the plan presented at the Alternative Formulation Briefing and variations. **Table 5-9** tallies 72 alternatives that could be considered.

Table 5-9. Alternative Plan Development

Management Measure	Number	Alternatives	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Hardbottom Impact
S-3A Beachface Fill	1	tailored to highest net benefit	10 foot	30 foot	30 foot	dune	30 foot	dune	4.43
S-3A Beachface Fill	2	less impact reach 5	10 foot	30 foot	30 foot	dune	20 foot	dune	3.65
S-3A Beachface Fill	3	less impact reach 5	10 foot	30 foot	30 foot	dune	10 foot	dune	2.96
S-3A Beachface Fill	4	less impact reach 5	10 foot	30 foot	30 foot	dune	dune	dune	2.00
S-3A Beachface Fill	5	less impact reach 3	10 foot	30 foot	20 foot	dune	30 foot	dune	4.14
S-3A Beachface Fill	6	less impact reach 3 and 5	10 foot	30 foot	20 foot	dune	20 foot	dune	3.36
S-3A Beachface Fill	7	less impact reach 3 and 5	10 foot	30 foot	20 foot	dune	10 foot	dune	2.67
S-3A Beachface Fill	8	less impact reach 3 and 5	10 foot	30 foot	20 foot	dune	dune	dune	1.71
S-3A Beachface Fill	9	less impact reach 3 and 5	10 foot	30 foot	10 foot	dune	30 foot	dune	3.83
S-3A Beachface Fill	10	less impact reach 3 and 5	10 foot	30 foot	10 foot	dune	20 foot	dune	3.05
S-3A Beachface Fill	11	less impact reach 3 and 5	10 foot	30 foot	10 foot	dune	10 foot	dune	2.36
S-3A Beachface Fill	12	less impact reach 3 and 5	10 foot	30 foot	10 foot	dune	dune	dune	1.40
S-3A Beachface Fill	13	less impact reach 3 and 5	10 foot	30 foot	dune	dune	30 foot	dune	3.35
S-3A Beachface Fill	14	less impact reach 3 and 5	10 foot	30 foot	dune	dune	20 foot	dune	2.57
S-3A Beachface Fill	15	less impact reach 3 and 5	10 foot	30 foot	dune	dune	10 foot	dune	1.88
S-3A Beachface Fill	16	less impact reach 3 and 5	10 foot	30 foot	dune	dune	dune	dune	0.92
S-3A Beachface Fill	17	less impact reach 2	10 foot	20 foot	30 foot	dune	30 foot	dune	4.35
S-3A Beachface Fill	18	less impact reach 2 and 5	10 foot	20 foot	30 foot	dune	20 foot	dune	3.57
S-3A Beachface Fill	19	less impact reach 2 and 5	10 foot	20 foot	30 foot	dune	10 foot	dune	2.88
S-3A Beachface Fill	20	less impact reach 2 and 5	10 foot	20 foot	30 foot	dune	dune	dune	1.92
S-3A Beachface Fill	21	less impact reach 2, 3 and 5	10 foot	20 foot	20 foot	dune	30 foot	dune	4.06
S-3A Beachface Fill	22	less impact reach 2, 3 and 5	10 foot	20 foot	20 foot	dune	20 foot	dune	3.28
S-3A Beachface Fill	23	less impact reach 2, 3 and 5	10 foot	20 foot	20 foot	dune	10 foot	dune	2.59
S-3A Beachface Fill	24	less impact reach 2, 3 and 5	10 foot	20 foot	20 foot	dune	dune	dune	1.63
S-3A Beachface Fill	25	less impact reach 2, 3 and 5	10 foot	20 foot	10 foot	dune	30 foot	dune	3.75
S-3A Beachface Fill	26	less impact reach 2, 3 and 5	10 foot	20 foot	10 foot	dune	20 foot	dune	2.97
S-3A Beachface Fill	27	less impact reach 2, 3 and 5	10 foot	20 foot	10 foot	dune	10 foot	dune	2.28
S-3A Beachface Fill	28	less impact reach 2, 3 and 5	10 foot	20 foot	10 foot	dune	dune	dune	1.32
S-3A Beachface Fill	29	less impact reach 2, 3 and 5	10 foot	20 foot	dune	dune	30 foot	dune	3.24
S-3A Beachface Fill	30	less impact reach 2, 3 and 5	10 foot	20 foot	dune	dune	20 foot	dune	2.46
S-3A Beachface Fill	31	less impact reach 2, 3 and 5	10 foot	20 foot	dune	dune	10 foot	dune	1.77
S-3A Beachface Fill	32	less impact reach 2, 3 and 5	10 foot	20 foot	dune	dune	dune	dune	0.81
S-3A Beachface Fill	33	less impact reach 2	10 foot	10 foot	30 foot	dune	30 foot	dune	4.22
S-3A Beachface Fill	34	less impact reach 2 and 5	10 foot	10 foot	30 foot	dune	20 foot	dune	3.44
S-3A Beachface Fill	35	less impact reach 2 and 5	10 foot	10 foot	30 foot	dune	10 foot	dune	2.75
S-3A Beachface Fill	36	less impact reach 2 and 5	10 foot	10 foot	30 foot	dune	dune	dune	1.79
S-3A Beachface Fill	37	less impact reach 2, 3 and 5	10 foot	10 foot	20 foot	dune	30 foot	dune	3.93
S-3A Beachface Fill	38	less impact reach 2, 3 and 5	10 foot	10 foot	20 foot	dune	20 foot	dune	3.15
S-3A Beachface Fill	39	less impact reach 2, 3 and 5	10 foot	10 foot	20 foot	dune	10 foot	dune	2.46
S-3A Beachface Fill	40	less impact reach 2, 3 and 5	10 foot	10 foot	20 foot	dune	dune	dune	1.50
S-3A Beachface Fill	41	less impact reach 2, 3 and 5	10 foot	10 foot	10 foot	dune	30 foot	dune	3.62
S-3A Beachface Fill	42	less impact reach 2, 3 and 5	10 foot	10 foot	10 foot	dune	20 foot	dune	2.84
S-3A Beachface Fill	43	less impact reach 2, 3 and 5	10 foot	10 foot	10 foot	dune	10 foot	dune	2.15
S-3A Beachface Fill	44	less impact reach 2, 3 and 5	10 foot	10 foot	10 foot	dune	dune	dune	1.19
S-3A Beachface Fill	45	less impact reach 2, 3 and 5	10 foot	10 foot	dune	dune	30 foot	dune	3.09
S-3A Beachface Fill	46	less impact reach 2, 3 and 5	10 foot	10 foot	dune	dune	20 foot	dune	2.31
S-3A Beachface Fill	47	less impact reach 2, 3 and 5	10 foot	10 foot	dune	dune	10 foot	dune	1.62
S-3A Beachface Fill	48	less impact reach 2, 3 and 5	10 foot	10 foot	dune	dune	dune	dune	0.66
S-3A Beachface Fill	49	less impact reach 2	10 foot	dune	30 foot	dune	30 foot	dune	3.95
S-3A Beachface Fill	50	less impact reach 2 and 5	10 foot	dune	30 foot	dune	20 foot	dune	3.17
S-3A Beachface Fill	51	less impact reach 2 and 5	10 foot	dune	30 foot	dune	10 foot	dune	2.48
S-3A Beachface Fill	52	less impact reach 2 and 5	10 foot	dune	30 foot	dune	dune	dune	1.52
S-3A Beachface Fill	53	less impact reach 2, 3 and 5	10 foot	dune	20 foot	dune	30 foot	dune	3.66
S-3A Beachface Fill	54	less impact reach 2, 3 and 5	10 foot	dune	20 foot	dune	20 foot	dune	2.88
S-3A Beachface Fill	55	less impact reach 2, 3 and 5	10 foot	dune	20 foot	dune	10 foot	dune	2.19
S-3A Beachface Fill	56	less impact reach 2, 3 and 5	10 foot	dune	20 foot	dune	dune	dune	1.23
S-3A Beachface Fill	57	less impact reach 2, 3 and 5	10 foot	dune	10 foot	dune	30 foot	dune	3.35
S-3A Beachface Fill	58	less impact reach 2, 3 and 5	10 foot	dune	10 foot	dune	20 foot	dune	2.57
S-3A Beachface Fill	59	less impact reach 2, 3 and 5	10 foot	dune	10 foot	dune	10 foot	dune	1.88
S-3A Beachface Fill	60	less impact reach 2, 3 and 5	10 foot	dune	10 foot	dune	dune	dune	0.92
S-3A Beachface Fill	61	less impact reach 2, 3 and 5	10 foot	dune	dune	dune	30 foot	dune	2.78
S-3A Beachface Fill	62	less impact reach 2, 3 and 5	10 foot	dune	dune	dune	20 foot	dune	2.00
S-3A Beachface Fill	63	less impact reach 2, 3 and 5	10 foot	dune	dune	dune	10 foot	dune	1.31
S-3A Beachface Fill	64	less impact reach 2, 3 and 5	10 foot	dune	dune	dune	dune	dune	0.35
S-3A Beachface Fill	65	dune only	no action	dune	dune	dune	dune	dune	0.00
S-3A Beachface Fill	66	Plan 1 but shorter	10 foot	30 foot	30 foot	dune			2.00
Local Option 1	67	Hydraulic, beachface, dune	S-3B 90 foot	7 foot	7 foot	7 foot	7 foot	7 foot	2.95
Local Option 2	68	Hydraulic, beachface, dune	Tapered Con	10 foot	10 foot	10 foot	10 foot	dune	2.84
Local Option 3	69	Hydraulic, then plan 3	Tapered Con	30 foot	30 foot	dune	10 foot	dune	3.24
Local Option 4	70	AFB alt 55	10 foot	10 foot	10 foot	10 foot	10 foot	dune	2.56
Local Option 5	71	Plan 1 but smoothed	10 foot	20 foot	30 foot	10 foot	10 foot	dune	3.23
Local Option 6	72	Plan 1 but smoothed	10 foot	20 foot	20 foot	10 foot	10 foot	dune	2.97

5.4.3.3 Local Sponsor Alternatives

Alternative plans were developed to satisfy concerns or desires of the project sponsor, and are shown in **Table 5-9** as Local Option plans. They use the same management measures of conventional fill, beachface fill, and dune and vegetation developed through the study process. Local Option 1 includes construction of a berm the same width as the South Reach project in Reach 1 at 90 feet, tapering within Reach 1 to a 9 cubic yard per linear foot fill (approximately 7 feet design fill plus advanced nourishment) in Reaches 2 to 6. Reach 1 would be constructed by conventional fill at the same time as the South Reach renourishment. Reaches 2 to 6 would be constructed by truck haul fill from the upland sand source. Local Option 1 is the same as the plan submitted by the county for one-time construction in a permit application to the FDEP and Corps Regulatory. Local Option 2 differs in Reach 1 where construction would take place by conventional fill in a long taper from 90-foot mean high water extension to 10-foot wide mean high water extension at the start of Reach 2. The remainder is a 10-foot mean high water extension in Reaches 2 to 5 and a dune fill in Reach 6. Local Option 3 was added later, and has the conventional fill in a long taper in Reach 1 and then is the same as plan 3 in Reaches 2 to 6. Local Option 4 is the plan that was presented at the project AFB and is carried forward for comparison. Local Option 5 and 6 are based on plan 3 but reduced the beach width in reaches 2 and 3 and increased the beach width in reach 4 to improve consistency along the length of the project. The local options have similar hardbottom impacts to the other plans. Construction costs and mitigation costs were developed to the same level of detail as the other alternatives and annualized over the 50 year period of analysis. Benefits were derived from similar model runs within the capability of the model to approximate some of the construction features such as the taper.

5.4.3.4 Cost Effectiveness Analysis

As Step 5, the net benefit for the alternative plans was calculated by summing the net benefits for each measure shown in **Table 5-6**. Where the local option plans used new measures, the costs were calculated using the initial fill cost plus 50-year projected periodic nourishment cost and amortized over 50 years. Following the strategy to maximize net benefit and minimize hardbottom impact, combination plans were compared against each other on these two criteria. Cost effective plans were identified as those that dominate plans with less net benefit but greater hardbottom impact. **Table 5-10** shows all 72 plans in order of net benefit and identifies in gray those plans which are not cost effective and can be eliminated. In the graph in **Figure 5-5** it is evident that when one plan produces greater net benefit and less hardbottom impact than another plan, then the second plan can be eliminated. In this way, the 72 plans were screened to 31 plans, carrying forward the local sponsor options regardless of their cost effectiveness.

Table 5-10. Cost Effectiveness of Alternative Plans

Management Measure Bas	Number	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Net Benefits	Benefit-Cost Ratio	Hardbottom Impact
S-3A Beachface Fill	1	10 foot	30 foot	30 foot	dune	30 foot	dune	$8,285,620	3.49	4.43
S-3A Beachface Fill	17	10 foot	20 foot	30 foot	dune	30 foot	dune	$8,281,467	3.52	4.35
S-3A Beachface Fill	33	10 foot	10 foot	30 foot	dune	30 foot	dune	$8,257,496	3.56	4.22
S-3A Beachface Fill	2	10 foot	30 foot	30 foot	dune	20 foot	dune	$8,241,123	3.68	3.65
S-3A Beachface Fill	18	10 foot	20 foot	30 foot	dune	20 foot	dune	$8,236,970	3.72	3.57
S-3A Beachface Fill	34	10 foot	10 foot	30 foot	dune	20 foot	dune	$8,212,999	3.77	3.44
S-3A Beachface Fill	49	10 foot	dune	30 foot	dune	30 foot	dune	$8,146,418	3.53	3.95
S-3A Beachface Fill	50	10 foot	dune	30 foot	dune	20 foot	dune	$8,101,921	3.73	3.17
S-3A Beachface Fill	3	10 foot	30 foot	30 foot	dune	10 foot	dune	$8,012,411	3.82	2.96
S-3A Beachface Fill	19	10 foot	20 foot	30 foot	dune	10 foot	dune	$8,008,257	3.87	2.88
S-3A Beachface Fill	5	10 foot	30 foot	20 foot	dune	30 foot	dune	$7,985,601	3.50	4.14
S-3A Beachface Fill	35	10 foot	10 foot	30 foot	dune	10 foot	dune	$7,984,286	3.92	2.75
S-3A Beachface Fill	21	10 foot	20 foot	20 foot	dune	30 foot	dune	$7,981,448	3.54	4.06
S-3A Beachface Fill	37	10 foot	10 foot	20 foot	dune	30 foot	dune	$7,957,477	3.58	3.93
S-3A Beachface Fill	6	10 foot	30 foot	20 foot	dune	20 foot	dune	$7,941,104	3.70	3.36
S-3A Beachface Fill	22	10 foot	20 foot	20 foot	dune	20 foot	dune	$7,936,951	3.74	3.28
S-3A Beachface Fill	38	10 foot	10 foot	20 foot	dune	20 foot	dune	$7,912,980	3.79	3.15
S-3A Beachface Fill	51	10 foot	dune	30 foot	dune	10 foot	dune	$7,873,209	3.89	2.48
S-3A Beachface Fill	53	10 foot	dune	20 foot	dune	30 foot	dune	$7,846,399	3.54	3.66
S-3A Beachface Fill	54	10 foot	dune	20 foot	dune	20 foot	dune	$7,801,902	3.76	2.88
Local Option 5	71	10 foot	20 foot	30 foot	10 foot	10 foot	dune	$7,771,925	3.40	3.23
S-3A Beachface Fill	7	10 foot	30 foot	20 foot	dune	10 foot	dune	$7,712,392	3.85	2.67
S-3A Beachface Fill	23	10 foot	20 foot	20 foot	dune	10 foot	dune	$7,708,238	3.90	2.59
S-3A Beachface Fill	39	10 foot	10 foot	20 foot	dune	10 foot	dune	$7,684,267	3.96	2.46
S-3A Beachface Fill	55	10 foot	dune	20 foot	dune	10 foot	dune	$7,573,190	3.92	2.19
S-3A Beachface Fill	9	10 foot	30 foot	10 foot	dune	30 foot	dune	$7,494,851	3.45	3.83
S-3A Beachface Fill	25	10 foot	20 foot	10 foot	dune	30 foot	dune	$7,490,698	3.49	3.75
Local Option 6	72	10 foot	20 foot	20 foot	10 foot	10 foot	dune	$7,471,906	3.40	2.97
S-3A Beachface Fill	41	10 foot	10 foot	10 foot	dune	30 foot	dune	$7,466,727	3.53	3.62
S-3A Beachface Fill	10	10 foot	30 foot	10 foot	dune	20 foot	dune	$7,450,355	3.65	3.05
S-3A Beachface Fill	26	10 foot	20 foot	10 foot	dune	20 foot	dune	$7,446,201	3.70	2.97
S-3A Beachface Fill	42	10 foot	10 foot	10 foot	dune	20 foot	dune	$7,422,230	3.75	2.84
S-3A Beachface Fill	4	10 foot	30 foot	30 foot	dune	dune	dune	$7,373,867	3.64	2.00
S-3A Beachface Fill	20	10 foot	20 foot	30 foot	dune	dune	dune	$7,369,714	3.69	1.92
S-3A Beachface Fill	57	10 foot	dune	10 foot	dune	30 foot	dune	$7,355,649	3.49	3.35
S-3A Beachface Fill	36	10 foot	10 foot	30 foot	dune	dune	dune	$7,345,743	3.74	1.79
S-3A Beachface Fill	58	10 foot	dune	10 foot	dune	20 foot	dune	$7,311,153	3.71	2.57
S-3A Beachface Fill	52	10 foot	dune	30 foot	dune	dune	dune	$7,234,665	3.70	1.52
S-3A Beachface Fill	11	10 foot	30 foot	10 foot	dune	10 foot	dune	$7,221,642	3.81	2.36
S-3A Beachface Fill	27	10 foot	20 foot	10 foot	dune	10 foot	dune	$7,217,489	3.86	2.28
S-3A Beachface Fill	43	10 foot	10 foot	10 foot	dune	10 foot	dune	$7,193,518	3.92	2.15
Local Option 4	70	10 foot	10 foot	10 foot	10 foot	10 foot	dune	$7,155,104	3.63	2.56
Local Option 3	69	Tapered Con	30 foot	30 foot	dune	10 foot	dune	$7,083,597	2.83	3.24
S-3A Beachface Fill	59	10 foot	dune	10 foot	dune	10 foot	dune	$7,082,440	3.88	1.88
S-3A Beachface Fill	8	10 foot	30 foot	20 foot	dune	dune	dune	$7,073,848	3.66	1.71
S-3A Beachface Fill	24	10 foot	20 foot	20 foot	dune	dune	dune	$7,069,695	3.71	1.63
S-3A Beachface Fill	40	10 foot	10 foot	20 foot	dune	dune	dune	$7,045,724	3.76	1.50
S-3A Beachface Fill	56	10 foot	dune	20 foot	dune	dune	dune	$6,934,646	3.73	1.23
S-3A Beachface Fill	13	10 foot	30 foot	dune	dune	30 foot	dune	$6,836,504	3.34	3.35
S-3A Beachface Fill	29	10 foot	20 foot	dune	dune	30 foot	dune	$6,832,351	3.38	3.24
S-3A Beachface Fill	45	10 foot	10 foot	dune	dune	30 foot	dune	$6,808,380	3.42	3.09
S-3A Beachface Fill	14	10 foot	30 foot	dune	dune	20 foot	dune	$6,792,007	3.55	2.57
S-3A Beachface Fill	30	10 foot	20 foot	dune	dune	20 foot	dune	$6,787,854	3.59	2.46
S-3A Beachface Fill	46	10 foot	10 foot	dune	dune	20 foot	dune	$6,763,883	3.65	2.31
S-3A Beachface Fill	61	10 foot	dune	dune	dune	30 foot	dune	$6,697,302	3.39	2.78
S-3A Beachface Fill	62	10 foot	dune	dune	dune	20 foot	dune	$6,652,805	3.61	2.00
S-3A Beachface Fill	12	10 foot	30 foot	10 foot	dune	dune	dune	$6,583,098	3.61	1.40
S-3A Beachface Fill	28	10 foot	20 foot	10 foot	dune	dune	dune	$6,578,945	3.66	1.32
S-3A Beachface Fill	15	10 foot	30 foot	dune	dune	10 foot	dune	$6,563,295	3.70	1.88
S-3A Beachface Fill	31	10 foot	20 foot	dune	dune	10 foot	dune	$6,559,141	3.75	1.77
S-3A Beachface Fill	44	10 foot	10 foot	10 foot	dune	dune	dune	$6,554,974	3.71	1.19
S-3A Beachface Fill	47	10 foot	10 foot	dune	dune	10 foot	dune	$6,535,170	3.81	1.62
S-3A Beachface Fill	60	10 foot	dune	10 foot	dune	dune	dune	$6,443,896	3.67	0.92
S-3A Beachface Fill	63	10 foot	dune	dune	dune	10 foot	dune	$6,424,092	3.77	1.31
Local Option 2	68	Tapered Con	10 foot	10 foot	10 foot	10 foot	dune	$6,267,758	2.69	2.84
S-3A Beachface Fill	16	10 foot	30 foot	dune	dune	dune	dune	$5,924,751	3.49	0.92
S-3A Beachface Fill	32	10 foot	20 foot	dune	dune	dune	dune	$5,920,597	3.54	0.81
S-3A Beachface Fill	48	10 foot	10 foot	dune	dune	dune	dune	$5,896,627	3.59	0.66
S-3A Beachface Fill	64	10 foot	dune	dune	dune	dune	dune	$5,785,549	3.55	0.35
Local Option 1	67	S-3B 90 foot	7 foot	7 foot	7 foot	7 foot	7 foot	$5,413,326	2.56	2.95
S-8 Dune and Vegetation	65	no action	dune	dune	dune	dune	dune	$5,380,640	3.79	0.00
S-3A Beachface Fill	66	10 foot	30 foot	30 foot	dune			$4,790,059	3.64	2.00

Dominated or non-cost effective plans are grayed out, except local options carried forward.
October 2006 Price Levels and FY07 discount rate of 4 7/8 was used for this screening.

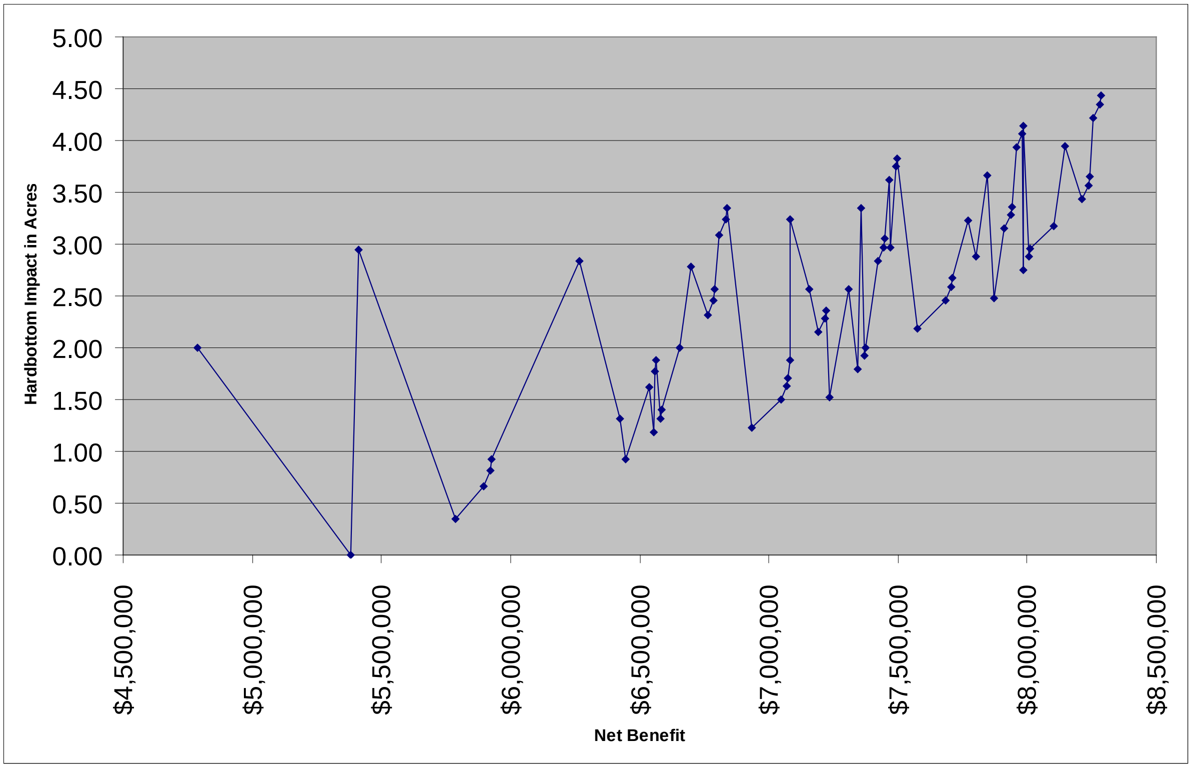

Figure 5-5. Cost Effectiveness of Alternative Plans

Table 5-11. Screened List of Alternative Plans

Management Measure Basis	Number	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Net Benefits	Benefit-Cost Ratio	TOTAL ROCK IMPACT	ELIMINATED (E) or CARRIED FORWARD (CF)
S-3A Beachface Fill	1	10 foot	30 foot	30 foot	dune	30 foot	dune	$8,285,620	3.49	4.43	E (Env[1]/Eng[2])
S-3A Beachface Fill	17	10 foot	20 foot	30 foot	dune	30 foot	dune	$8,281,467	3.52	4.35	E (Env/Eng)
S-3A Beachface Fill	33	10 foot	10 foot	30 foot	dune	30 foot	dune	$8,257,496	3.56	4.22	E (Env/Eng)
S-3A Beachface Fill	2	10 foot	30 foot	30 foot	dune	20 foot	dune	$8,241,123	3.68	3.65	E (Env/Eng)
S-3A Beachface Fill	18	10 foot	20 foot	30 foot	dune	20 foot	dune	$8,236,970	3.72	3.57	E (Env/Eng)
S-3A Beachface Fill	34	10 foot	10 foot	30 foot	dune	20 foot	dune	$8,212,999	3.77	3.44	E (Env/Eng)
S-3A Beachface Fill	50	10 foot	dune	30 foot	dune	20 foot	dune	$8,101,921	3.73	3.17	E(Env/Eng)
S-3A Beachface Fill	3	10 foot	30 foot	30 foot	dune	10 foot	dune	$8,012,411	3.82	2.96	CF
S-3A Beachface Fill	19	10 foot	20 foot	30 foot	dune	10 foot	dune	$8,008,257	3.87	2.88	CF
S-3A Beachface Fill	35	10 foot	10 foot	30 foot	dune	10 foot	dune	$7,984,286	3.92	2.75	CF
S-3A Beachface Fill	51	10 foot	dune	30 foot	dune	10 foot	dune	$7,873,209	3.89	2.48	E(NB[3])
Local Option 5	71	10 foot	20 foot	30 foot	10 foot	10 foot	dune	$7,771,925	3.40	3.23	E(Env/NB)
S-3A Beachface Fill	39	10 foot	10 foot	20 foot	dune	10 foot	dune	$7,684,267	3.96	2.46	E(NB)
S-3A Beachface Fill	55	10 foot	dune	20 foot	dune	10 foot	dune	$7,573,190	3.92	2.19	E(NB)
Local Option 6	72	10 foot	20 foot	20 foot	10 foot	10 foot	dune	$7,471,906	3.40	2.97	CF
S-3A Beachface Fill	4	10 foot	30 foot	30 foot	dune	dune	dune	$7,373,867	3.64	2.00	E(NB)
S-3A Beachface Fill	20	10 foot	20 foot	30 foot	dune	dune	dune	$7,369,714	3.69	1.92	E(NB)
S-3A Beachface Fill	36	10 foot	10 foot	30 foot	dune	dune	dune	$7,345,743	3.74	1.79	E(NB)
S-3A Beachface Fill	52	10 foot	dune	30 foot	dune	dune	dune	$7,234,665	3.70	1.52	E(NB)
Local Option 4	70	10 foot	10 foot	10 foot	10 foot	10 foot	dune	$7,155,104	3.63	2.56	E(NB)
Local Option 3	69	Tapered Con	30 foot	30 foot	dune	10 foot	dune	$7,083,597	2.83	3.24	E(Env/NB)
S-3A Beachface Fill	40	10 foot	10 foot	20 foot	dune	dune	dune	$7,045,724	3.76	1.50	E(NB)
S-3A Beachface Fill	56	10 foot	dune	20 foot	dune	dune	dune	$6,934,646	3.73	1.23	E(NB)
S-3A Beachface Fill	44	10 foot	10 foot	10 foot	dune	dune	dune	$6,554,974	3.71	1.19	E(NB)
S-3A Beachface Fill	60	10 foot	dune	10 foot	dune	dune	dune	$6,443,896	3.67	0.92	E(NB)
Local Option 2	68	Tapered Con	10 foot	10 foot	10 foot	10 foot	dune	$6,267,758	2.69	2.84	E(NB)
S-3A Beachface Fill	32	10 foot	20 foot	dune	dune	dune	dune	$5,920,597	3.54	0.81	E(NB)
S-3A Beachface Fill	48	10 foot	10 foot	dune	dune	dune	dune	$5,896,627	3.59	0.66	E(NB)
S-3A Beachface Fill	64	10 foot	dune	dune	dune	dune	dune	$5,785,549	3.55	0.35	E(NB)
Local Option 1	67	S-3B 90 foot	7 foot	7 foot	7 foot	7 foot	7 foot	$5,413,326	2.56	2.95	CF
S-8 Dune and Vegetation	65	no action	dune	dune	dune	dune	dune	$5,380,640	3.79	0.00	E(NB)

October 2006 Price Levels and FY07 discount rate of 4 7/8 was used for this screening.

[1] E(Env) means it was eliminated due to environmental concerns; specifically the impact to rock was greater than 3.0 acres.

[2] E(Eng) means it was eliminated due to engineering concerns; a transition between reaches 4, 5, and 6 of greater than 10 feet.

[3] E(NB) means it was eliminated due to the low Net Benefits as compared to the other alternatives.

5.4.3.5 Engineering Concerns

In the Step 5, the 72 plans that were formulated were screened down to 31 plans. The project delivery team reviewed the highest net benefit plans for engineering feasibility and environmental acceptability. The input assisted in screening the 31 plans down to a manageable level for comparison. Engineering concerns centered on the feasibility and reliability of constructing different measures in different reaches. In particular, the feasibility of constructing a dune in Reach 4, then out to 30-foot mean high water extension in Reach 5, then back to a dune for Reach 6, as in Plan 1. Concerns are that longshore diffusion of sand from Reach 5 to both the north and south will increase the hardbottom impacts, increase the need for renourishments, decrease the expected benefits, and increase the uncertainty in all of those numbers. Transition tapers can be constructed to alleviate rapid losses at the ends of the fill. These tapers mimic the shape of a naturally diffused beach fill and help to slow the loss of sediment from the ends of the project, alleviating the concern of decreased benefits. However, the tapers will increase the hardbottom impact in an area of higher density hardbottom. A plan with fewer or smaller transitions minimizes the issues associated with beach fill transition behavior. For these reasons, large transitions of fill should be avoided particularly in the northern reaches where additional hardbottom impacts will increase the cost of mitigation. Reach 1, 2, and 3 have less hardbottom impacts and diffusion south is blocked by the Brevard South Reach project. As Reaches 4 and 6 are economically optimized at the smallest fill, the dune fill, the greatest amount of fill that should be considered in reach 5 is the 10-foot mean high water extension. The final array focuses on those plans that reduce the concerns over losses in Reach 5, eliminating plans greater than the 10-foot extension in Reach 5.

5.4.3.6 Environmental Concerns

There are also environmental concerns with the 31 plans from the previous step, including Plan 1, which has the highest net benefits and 4.4 acres of hardbottom impact. A beach fill plan was presented by Brevard County in a permit application to FDEP in the spring of 2006 that included an impact of 6.4 acres. Corps regulatory, in a July 5, 2006 response, stated that the proposed project included unacceptable impacts and that the Corps would move forward with an unfavorable decision unless the impacts were eliminated or significantly reduced. Through multiple discussions Brevard County modified their proposal to a plan with 2.95 acres of impact. Although the permit still has not been issued, by discussion the level of impact has shown avoidance and minimization, while discussions continue on mitigation. These advance permit discussions on a similar project to the Federal plan formulation have offered insight into the level of impact wherein mitigation may be acceptable. Subsequent interagency discussions at a meeting on June 13, 2007 agreed that the level of impact (around 3 acres) was acceptable as showing avoidance and minimization. Plan 1 with 4.4 acres of impact would reopen the discussions and are likely to reverse the determination that the plan minimized impacts, as less impact plans were also found to be economically feasible. As Reach 5 is in the area of greater density of hardbottoms, minimizing the fill in Reach 5 as recommended by the project engineer is consistent with minimizing the hardbottom impact. Eliminating the top seven plans from **Table 5-11** makes Plan 3 the highest net benefit plan for the initial screening and is consistent with the level of impact discussed with the resource agencies.

5.4.3.7 Sensitivity Analysis on Mitigation Cost

The purpose of the sensitivity analysis was to evaluate the array of alternatives presented in **Table 5-11** using a range of mitigation ratios to determine if the plan selection is sensitive to mitigation cost. The method consisted of running the analysis with a range of mitigation ratios from 1.0, 2.0, 3.0, to 4.0. The net benefits ranged from $7,267,182 to $8,199,102 for Plan 1 based on the range of mitigation ratio, a 13% difference in values. The Benefit Cost Ratio (BCR) for all plans ranged from 2.5 to 3.5, indicating a confidence in the economic justification (BCR>1) of all plans. The same plans were consistently in the top 10, and no plans gained or lost more than one rank. The order of most plans was stable, meaning that plan selection is not very sensitive to mitigation ratio.

5.4.4 Alternatives Eliminated from Detailed Evaluation

Through the plan formulation process, multiple iterations assisted in the screening of possible alternatives in a logical way from a possible 4 million alternatives to a final array of 5 alternatives. The project objectives and constraints were closely followed during the screening, resulting in alternatives that maximized net benefit while minimizing the impact to the nearshore hardbottom.

5.4.5 Alternatives Not Within Jurisdiction of the Lead Agency

All alternative plans being considered were formulated to meet the project objectives, so they are in the Federal interest and all plans are within the jurisdiction of the US Army Corps of Engineers to construct.

5.4.6 Alternatives Carried Forward

From **Table 5-11**, a final array of alternatives was selected to update the project costs and benefits to the current year as part of Step 6. It should be noted that cost estimates performed at each step in this planning process used the current year and discount rate for evaluation. Each table has a note indicating the year and rate that the data represents and the supporting documentation is located in the Economics Appendix. Some of the local options remained in the final array at the request of the local sponsor for comparison. This produced the final array of 5 plans.

5.5 Comparison of Final Array of Alternatives

The final array is shown in **Tables 5-12** to **5-15** including pertinent factors like storm protection value and hardbottom impact acreage that are of interest in the selection of the recommended plan. Updated cost and benefits were calculated in June 2008 price levels. The supporting documentation for these cost estimates is the MCACES report dated June 2008, and is included as an attachment to the Economics Appendix (Appendix B). The analysis included construction costs, periodic nourishment costs over the 50 year period of Federal participation, mitigation costs, PED costs, costs of lands, easements, rights-of-way, mobilization/demobilization costs, and interest during construction. The benefits were calculated using the Jacksonville District Storm Damage Model and annualized using the FY08 discount rate of 4 7/8%. The Economic Appendix documents the methodology used in determining the cost and benefits used in this analysis. Attachment 1 of the Economic Appendix documents the cost effectiveness and incremental cost analysis of the mitigation measures. All the articulated concrete mattress alternatives are cost effective since the articulated concrete mattress alternatives cost less for the same level of outputs (habitat units) than the limestone marine mattress. The selected mitigation is the least cost articulated concrete mattress alternative that meets the target acreage.

Table 5-12. Fill Volumes for the Final Array of Alternatives

Alternative Plan	Number	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Initial Construction Design Fill Volume (cy)	Initial Construction Advanced Nourishment Fill Volume (cy)	Periodic Renourishment Volume (cy)	Renourishment Frequency (years)*
Highest NED plan feasible	19	10 foot	20 foot	30 foot	dune	10 foot	dune	438,300	101,250	155,950	2-3
Second highest NED	3	10 foot	30 foot	30 foot	dune	10 foot	dune	455,100	102,600	157,300	2-3
Third highest NED	35	10 foot	10 foot	30 foot	dune	10 foot	dune	422,900	99,900	154,600	2-3
Local Option 1	67	S-3B 90 foot	7 foot	7 foot	7 foot	7 foot	7 foot	618,078	265,278	265,278	2-6
Local Option 6	72	10 foot	20 foot	20 foot	10 foot	10 foot	dune	447,700	139,950	168,050	2-3

Table 5-13. Construction Cost of the Final Array of Alternatives

Management Measure	Number	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Subtotal Fixed Costs per Construction	Subtotal Mitigation Cost	Subtotal Fill Cost	Total Cost Initial Construction	Subtotal Periodic Nourishment
Highest NED plan feasible	19	10 foot	20 foot	30 foot	dune	10 foot	dune	$1,561,000	$7,947,000	$13,239,000	$22,747,000	$5,050,000
Second highest NED	3	10 foot	30 foot	30 foot	dune	10 foot	dune	$1,592,000	$8,475,000	$13,630,000	$23,697,000	$5,118,000
Third highest NED	35	10 foot	10 foot	30 foot	dune	10 foot	dune	$1,533,000	$7,683,000	$12,837,000	$22,053,000	$5,027,000
Local Option 1	67	S-3B 90 foot	7 foot	7 foot	7 foot	7 foot	7 foot	$2,345,000	$8,739,000	$22,166,000	$33,250,000	$8,209,000
Local Option 6	72	10 foot	20 foot	20 foot	10 foot	10 foot	dune	$1,777,000	$8,211,000	$14,320,000	$24,308,000	$5,260,000

*June 2008 Price Levels and FY08 discount rate of 4 7/8 was used for this screening.

Table 5-14. Net Benefits of the Final Array of Alternatives

Alternative Plan	Number	Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	Alternative Length (mi)	Range of Return Period of Erosion Protection	Total First Cost	AAEQ Cost	AAEQ Benefit	Net Benefits	Benefit-Cost Ratio
		1.82	0.65	1.18	1.06	1.71	1.36	7.78	* see table					
									below					
No Action Plan	0	no action	no action	no action	no action	no action	no action	0	1 - 5	$0	$0	$0	$0	0.00
Highest NED plan feasible	19	10 foot	20 foot	30 foot	dune	10 foot	dune	7.78	5 - 75	$22,748,000	$2,899,000	$11,672,000	$8,773,000	4.03
Second highest NED	3	10 foot	30 foot	30 foot	dune	10 foot	dune	7.78	5 - 75	$23,697,000	$2,974,000	$11,731,000	$8,757,000	3.94
Third highest NED	35	10 foot	10 foot	30 foot	dune	10 foot	dune	7.78	5 - 75	$22,053,000	$2,854,000	$11,581,000	$8,727,000	4.06
Local Option 1	67	S-3B 90 foot	7 foot	7 foot	7 foot	7 foot	7 foot	7.78	2 - 200	$33,249,000	$3,914,000	$10,534,000	$6,620,000	2.69
Local Option 6	72	10 foot	20 foot	20 foot	10 foot	10 foot	dune	7.78	5 - 75	$24,308,000	$3,050,000	$11,421,000	$8,371,000	3.74

*June 2008 Price Levels and FY08 discount rate of 4 7/8 was used for this screening.

Table 5-15. Level of Erosion Protection for the Final Array of Alternatives

Level of Erosion Protection based on Sbeach model *

		Reach 1	Reach 2	Reach 3	Reach 4	Reach 5	Reach 6	weighted average
Length of reach		1.82	0.65	1.18	1.06	1.71	1.36	
Existing Condition		50	25	10	5	2	5	17
Future Without Project		5	2	1	1	1	2	2
Highest NED plan	19	10 foot	20 foot	30 foot	dune	10 foot	dune	
		75	50	50	5	5	5	32
Second highest NED	3	10 foot	30 foot	30 foot	dune	10 foot	dune	
		75	75	50	5	5	5	34
Third highest NED	35	10 foot	10 foot	30 foot	dune	10 foot	dune	
		75	50	50	5	5	5	32
Local Option 1	67	S-3B 90 foot	7 foot	7 foot	7 foot	7 foot	7 foot	
		200	50	10	10	2	10	56
Local Option 6	72	10 foot	20 foot	20 foot	10 foot	10 foot	dune	
		75	50	50	25	5	5	35

From SBEACH Data

Recession	Storm Frequency
214 ft	"200 year"
209 ft	"150 year"
196 ft	"100 year"
184 ft	"75 year"
164 ft	"50 year"
156 ft	"25 year"
148 ft	"10 year"
134 ft	"5 year"
111 ft	"2 year"
24 ft	"1 year"

5.5.1 Tradeoff Analysis

The final array of alternatives was evaluated using the Four Accounts in order to trade off benefits. The Four Accounts are National Economic Development (NED), Regional Economic Development (RED), Other Social Effects (OSE), and Environmental Quality (EQ). Each alternative was qualitatively assessed and identified with an F for fully consistent, a P for partially consistent, and an O for not consistent. While this evaluation is qualitative and subjective, it does identify those alternatives that are in balance the best plans. Per EC 1105-2-409, any plan may be selected and recommended for implementation if it has, on balance, net beneficial effects after considering all plan effects, beneficial and adverse, in the four accounts. The final array is shown in **Table 5-16**. All 5 plans indicate an improvement over the future without project condition. Local option 1 is the least favorable, but the other 4 plans are equal. The tradeoff analysis confirms that all of the plans have a net beneficial effect.

Table 5-16. Four Accounts Tradeoff Analysis

		NED	RED	OSE	EQ
Management Measure	Alternative Number	NED Benefits	Local Tourism Economy	Storm Protection, Consistency, Sellability, Recreation (Fishing, Surfing, Snorkeling, Beaching), Risk of Funding	Essential Fish Habitat (Rock), Endangered Species in the water, Endangered Species on the Beach
Existing Condition		P	P	P	F
Future Without Project	0	O	O	O	P
S-3A Beachface Fill	19	F	F	P	P
S-3A Beachface Fill	3	F	F	P	P
S-3A Beachface Fill	35	F	F	P	P
Local Option 1	67	P	F	P	P
Local Option 6	72	F	F	P	P

F - fully consistent with the objectives or positive impact from the alternative
P - partially consistent with the objectives or neutral impact from the alternative
O - not consistent with the objectives or negative impact from the alternative

5.5.2 Environmental Operating Principles

The U.S. Army Corps of Engineers-Environmental Operating Principles (EOPs) were considered during each step of the plan formulation process. Early on, the District and the local sponsor recognized the high quality of the hardbottom habitat within the project area and the diverse marine life that it supports, including threatened and endangered species. Accordingly, detailed discussions were held with key personnel from the Florida Department of Environmental Protection, National Marine Fisheries Service, U.S. Fish and Wildlife Service, Florida Fish and Wildlife Conservation Commission; the local sponsor and their environmental consultants; and the District's Regulatory Division. Taking into consideration the views expressed by all the stakeholders, and in conformity with the EOPs, the PDT selected a plan which provides the best balance of environmental sustainability and storm damage reduction. How the EOPs were considered during the plan formulation process is summarized below.

1. Strive to achieve environmental sustainability. An environment maintained in a healthy, diverse and sustainable condition is necessary to support life.

Achieving environmental sustainability within the Mid-Reach has been a primary consideration throughout the history of this study, especially during the plan formulation process. For example, as stated in section 5.4.1 (p. 99), conventional fill alternatives for Reaches 5 and 6 were eliminated due to excessive hardbottom impacts. Section 5.4.3.1 further states that the plan formulation strategy was to vary shore protection measures in order to reduce environmental impacts, which led to the selection of a plan that would affect less than 3 acres of hardbottom habitat. Based on the most recent survey data, a total area of 31.3 acres was used as a baseline for assessing impacts. The tentatively selected plan should result in a healthy, diverse and sustainable environment fully capable of supporting marine life.

2. Recognize the interdependence of life and the physical environment. Proactively consider environmental consequences of Corps programs and act accordingly in all appropriate circumstances.

The interdependence of marine life and the hardbottom, as well as the interdependence of other biota and other habitats within the project area, have been well documented in Chapter 2 and Appendix K. This information was used in the plan formulation process to better understand, and to explain to stakeholders, the need to proactively consider impacts and the need to protect these resources.

3. Seek balance and synergy among human development activities and natural systems by designing economic and environmental solutions that support and reinforce one another. The plan formulation strategy (Section 5.4.3.1, p. 99) sought to balance environmental impacts with shore protection benefits. This resulted in the selection of a tentative plan that minimizes impacts and yet provides acceptable benefits (Section 6.1, p. 138).

4. Continue to accept corporate responsibility and accountability under the law for activities and decisions under our control that impact human health and welfare and the continued viability of natural systems.

This study was conducted in accordance with the Water Resources Development Acts of 2000 and 2007 (Section 1.2, p. 1). Compliance with environmental requirements is described in Section 7.2.35, p. 224.

5. Seeks ways and means to assess and mitigate cumulative impacts to the environment; bring systems approaches to the full life cycle of our processes and work.

Unavoidable impacts to the hardbottom resource shall be mitigated as described in Sections 5.4.2-5.4.2.3. Bringing systems approaches to the full life cycle of our processes and work is programmatic in nature, and is beyond the scope of this study.

6. Build and share an integrated scientific, economic, and social knowledge base that supports a greater understanding of the environment and impacts of our work.

The environmental study reports (Appendix K) have been provided to relevant stakeholders, including all appropriate resource agencies. This information has resulted in a greater understanding of the Mid-Reach environment, and impacts of the proposed work.

7. Respect the views of individuals and groups interested in Corps activities, listen to them actively, and learn from their perspective in the search to find innovative win-win solutions to the nation's problems that also protect and enhance the environment.

A public scoping meeting (Section 8.4.2, p. 233), public workshop (Section 8.4.4, p. 234) as well as interagency meetings (Section 8.2, p. 229) were conducted. Coordination between the agencies has resulted in the selection of a tentative plan that minimizes impacts and still provides storm reduction benefits.

5.5.3 USACE Campaign Plan

USACE Vision – A great engineering force of highly disciplined people working with our partners through disciplined thought and action to deliver innovative and sustainable solutions to the Nation’s engineering challenges.

USACE Mission – Provide public engineering services in peace and war to strengthen our Nation’s security, energize the economy, and reduce risks from disasters.

Commander’s Intent – The Corps will be one disciplined team, in thought, word, and action. We will meet our commitments, with and through our partners, by saying what we will do and doing what we say. The USACE will, through execution of this Campaign Plan, become a GREAT organization as evidenced by the following in all mission areas: Delivering superior performance, Setting the standard for the profession, Making a positive impact on the Nation and other nations, Being built to last by having a strong “bench” of educated, trained, competent, experienced, and certified professionals.

The recommended plan for this project is consistent with these themes. The project team took the latest policy and planning guidance and worked with professionals familiar with the local coastal system to design a project that will work in tandem with adjacent projects to help protect the project area. Extensive reviews were performed to ensure quality and consistency. The team worked with stakeholders on the State and Federal level and reached out and provided feedback to the public.

5.5.4 Summary of Direct and Indirect Impacts

Table 5-17. Summary of Direct and Indirect Impacts

ALTERNATIVE ENVIRONMENTAL FACTOR	Proposed Action	Net Impact of Proposed Action	Mitigation for Proposed Action	No Action (Status Quo)
PROTECTED SPECIES, Sea turtles	Truck-haul (mechanical) placement of beach-compatible sand along the 7.8-mile Mid Reach shoreline with periodic 3-yr renourishment. Along the northern 1.4-miles (Reach 6), fill placement would be limited to the dune above the wave zone. Along the remainder (Reaches 1-5), fill placement would be to the dune and beachface, widening the beach between 0 and 30 feet at the shoreline. The source of beach fill material will be the Canaveral Shoals I or II offshore borrow areas*, excavated by hopper dredge in 6-year intervals and temporarily stockpiled in the Poseidon Dredged Management Disposal Area (DMMA)	Direct adverse impacts - 1) alteration of the beach face, resulting in potential adverse impact to nesting and hatching success, (including effects from grade changes, sediment material, over-compaction, escarpment formation, artificial lighting during construction), resulting in potential for incidental "take" of sea turtles 2) potential taking of sea turtles with hopper dredge at Canaveral Shoals* Direct positive impacts - 1) nesting areas would increase in areas with nourishment activities, providing a potential positive impact. Indirect adverse impacts – 1) Burial of nearshore hardbottom habitat and associated macroalgae food source for juvenile turtles.	Construction activities on the beach will be limited to Nov. 1 through April 30. Construction in early nesting season (March 1 – April 30) and late nesting season (Nov 1-30) shall require daily monitoring for nesting activity and relocation if warranted. Tilling of the beach prior to early nesting season shall be undertaken if measurements show that the beach is overly compact. Monitoring per USFWS and NMFS requirements shall be implemented, in addition to surveys for nesting acitivity and success and lighting. Beach construction will be by truck-haul with little or no night-time construction and minimum or no lighting requirements. Beach fill design will follow turtle-friendly slopes. Monitoring and sand quality requirements will assure compatibility of sand with native beach and suitable nesting substrate. Foraging habitat for juvenile green turtles (macroalgae and turf algae impacts) will be mitigated by placement of artificial reef structures.	Nesting will continue in the area without direct or cumulative effects on either nesting or hardbottom feeding and refuge by young green turtles. Sea turtle nesting areas would continue to decrease as beaches erode.

ALTERNATIVE ENVIRONMENTAL FACTOR	Proposed Action	Net Impact of Proposed Action	Mitigation for Proposed Action	No Action (Status Quo)
	at Cape Canaveral Air Station.		Hopper dredging within Canaveral Shoals* will utilize a rigid draghead deflector, inflow and outflow screening and shipboard observers for both sea turtle and marine mammal identification Dredge pumps shall remain disengaged when dragheads are not firmly on bottom.	
Birds	See above.	Direct adverse impacts - 1) destruction of nests. 2) disturbance to nesting adults and hatchlings. Indirect adverse impacts – 1) alteration of intertidal feeding habitat by burial.	Surveys for shorebird nesting behavior will identify areas and corridors requiring marking and avoidance during construction activities.	Local habitat use (feeding, resting, nesting) by listed birds is expected to continue
Manatees	See above.	Direct adverse impacts – 1) Possible encounters with manatees by dredge and support vessels during dredge and disposal operations.	Marine mammal observers would be used as appropriate; signs would be posted on crew vessels and work stations informing the crew of possible whale and manatee encounters; no-wake speeds would be observed at all times in shallow waters; and logs of encounters for all species will be maintained.	Local habitat use by manatees is expected to continue
Whales	See above.	Direct adverse impacts –	Requirements stipulated in the	Local habitat use by

ALTERNATIVE ENVIRONMENTAL FACTOR	Proposed Action	Net Impact of Proposed Action	Mitigation for Proposed Action	No Action (Status Quo)
		1) Possible encounters with whales by dredge and support vessels during dredge and disposal operations, especially at Canaveral Shoals*.	NMFS Regional Biological Opinion will be followed, including use of whale observers aboard dredge vessels, and reductions of vessel speed as warranted.	whales is expected to continue
Southeastern Beach Mouse	See above.	Direct adverse impacts -- 1) Possible burial or impact by disposal and truck-haul activity at DMMA upland disposal area. Indirect impacts -- Potential loss or interference with habitat or burrows	Monitoring for, and relocation of, southeastern beach mouse would be implemented per the existing SEBM Management Plan for Cape Canaveral Air Station.	Local habitat use by southeastern beach mouse in the vicinity of the DMMA is expected to continue
Gopher Tortoise	See above.	Same as above	Surveys for, and relocation of, gopher tortoise within work areas would be implemented per existing protocols by permitted staff at Cape Canaveral Air Station.	Local habitat use by gopher tortoise in the vicinity of the DMMA is expected to continue
Indigo Snake	See above.	Same as above	Surveys for, and relocation of, indigo snake within work areas would be implemented per existing protocols by permitted staff at Cape Canaveral Air Station.	Local habitat use by indigo snake in the vicinity of the DMMA is expected to continue
HARD GROUND	See above.	Direct adverse impacts 1) burial of inshore margin (approximately 3 acres) of nearshore hardbottom feature by direct placement and subsequent cross-shore equilibration and longshore diffusion, including through sedimentation. Indirect adverse impacts -- 1) loss of ecological functions	Lost hard bottom (3.0 acres) will be replaced with artificial reefs (4.8 acres). Artificial reefs will be low relief modules consisting of natural Coquina rock embedded in concrete. Biological and physical monitoring program will assess impacts to hard ground and performance of mitigation reef relative to project expectations.	Natural hardground exposure will fluctuate, and might increase with continued beach erosion.

ALTERNATIVE ENVIRONMENTAL FACTOR	Proposed Action	Net Impact of Proposed Action	Mitigation for Proposed Action	No Action (Status Quo)
		important to local flora and fauna including substrate for attachment, nesting sites, spawning sites, and feeding sites.		
SHORELINE EROSION	See above.	Would maintain or improve the sand dune and beach, and storm protection, habitat and recreation provided by the beach.	N/A.	Shoreline would continue to erode at its present rate.
FISH AND WILDLIFE RESOURCES	See above.	Direct adverse impacts- 1) burial and therefore eliminate portions of the hardbottom including attached invertebrates and plants as well as less mobile fishes and crustaceans. 2) Burial of softbottom areas along the surf zone, or disturbance of softbottom areas at Canaveral Shoals* will temporarily eliminate infaunal assemblages. 3) Suspended sediment (turbidity) will negatively affect filter feeding invertebrates and fishes. Suspended sediment can abrade gill tissues on fishes and invertebrates. Indirect adverse impacts- 1) feeding by visually oriented predators will be affected.	Turbidity will be monitored during construction with appropriate triggers (29 NTUs) in place to modify and/or cease operations if threshold levels are exceeded. Material from the borrow site will be meet all state required standards with respect to grain size and beach compatibility. With high quality sediment placed as fill infauna will naturally recolonize soft bottom areas. Lost hardbottom (3.0 acres) will be replaced with 4.8 acres of artificial reefs. These reefs should restore about 75% of the lost ecological functions.	Local habitat use by fishes and invertebrates will continue in relation to natural variability of the physical environment.

ALTERNATIVE ENVIRONMENTAL FACTOR	Proposed Action	Net Impact of Proposed Action	Mitigation for Proposed Action	No Action (Status Quo)
		2) organisms directly affected by high turbidity would be unavailable to other consumers. 3) Direct burial of hardbottom habitat will reduce the amount of foraging habitat for grazing and browsing fishes and motile invertebrates. 4) Loss of infaunal forage base for fishes and motile invertebrates.		
VEGETATION	See above.	Direct adverse impacts – 1) Potential for damage to existing dune vegetation during construction. Direct positive impacts - 1) Existing exotic and invasive species within DMMA will be removed. Indirect positive impacts – 1) Density of existing dune grass would be maintained and/or improved by increased dune/beach stability. 2) Spread of exotic and invasive species existing within DMMA will be abated.	Construction activities on beach will be limited to beach/dune seaward of existing vegetation. Native vegetation disturbed by construction access will be replaced.	Existing dune vegetation would be impacted by continued beach and dune erosion. Existing exotic and invasive species within DMMA shall continue or spread.
WATER QUALITY	See above.	Direct adverse impacts-- Temporary increases in turbidity adjacent to the offshore borrow, DMMA disposal, and beach fill areas. Indirect positive impacts –	State requirements for turbidity monitoring and management shall be followed.	No effects.

ALTERNATIVE ENVIRONMENTAL FACTOR	Proposed Action	Net Impact of Proposed Action	Mitigation for Proposed Action	No Action (Status Quo)
		Improvement in water quality by decreasing storm water effluent to beach required by State as requisite permit condition (non-federal responsibility).		
HISTORIC PROPERTIES	See above.	Direct adverse impacts -- Potential but unlikely impacts to undocumented submerged archaeological sites at the borrow area. Indirect adverse impacts– Decreased sediment volume at borrow area could lead to exposure of undocumented artifacts.	None proposed. Offshore borrow areas have been investigated for archaelogical sites and previously coordinated with State Historic Preservation Officer (SHPO). Any discovery of resources during construction shall be coordinated with SHPO.	No effects.
RECREATION	See above.	Direct adverse impacts – 1) Temporary disruption and/or localized suspension of recreation at beach and at offshore dredging locations during construction activities. Direct positive impacts - 1) Improve existing recreational opportunities associated with dry beach by maintaining or increasing beach area.	N/A.	Continued loss of recreational opportunities associated with erosion of dry beach.
AESTHETICS	See above.	Direct adverse impacts – 1)Temporary aesthetic impacts associated with construction activities. Direct positive impacts - 1) Maintain existing beach aesthetics by maintaining or improving sand dune and	N/A.	Aesthetic impacts associated with unabated beach erosion and attendant damage to existing shorefront structures.

ALTERNATIVE ENVIRONMENTAL FACTOR	Proposed Action	Net Impact of Proposed Action	Mitigation for Proposed Action	No Action (Status Quo)
		beach conditions.		
NAVIGATION	See above.	Direct adverse impacts – Temporary and localized increase in vessel traffic through Canaveral Harbor navigation channel associated with transit of dredge and support vessels between DMMA and offshore borrow area during dredge activities.	N/A.	No effects.
ECONOMICS	See above.	The total annualized storm damage and land loss reduction benefits from the proposed activity are between $10.5 and $12 million.	N/A.	Continued erosion of existing beach would result in increased potential of storm damage and a likely reduction in beach-related tourism revenues, property tax revenues and associated jobs.
ENERGY REQUIREMENTS AND CONSERVATION	See above.	Expenditure of energy resources is required for project construction through dredging and truck-haul transfer of sand for placement to the beach.	N/A.	Energy requirements associated with clean-up after storm events would continue to increase concurrent with realized damages.
ESSENTIAL FISH HABITAT	See above.	-Direct adverse effects 1)Turbidity will affect feeding and respiration in all life stages of federally managed species. Effects will be more severe for early life stages. 2) Direct burial of hardbottom habitat	Turbidity will be monitored during construction with appropriate triggers (29 NTUs) in place to modify and/or cease operations if threshold levels are exceeded. Lost hardbottom (3.0 acres) will be replaced with 4.8 acres of artificial	Local habitat use by managed fish and invertebrate species will continue in relation to natural variability in the physical environment.

ALTERNATIVE ENVIRONMENTAL FACTOR	Proposed Action	Net Impact of Proposed Action	Mitigation for Proposed Action	No Action (Status Quo)
		3) Direct burial of softbottom infaunal assemblages -Indirect adverse effects 1) Sedimentation and burial of hardbottom will eliminate feeding, sheltering, and nesting sites for various managed species. 2) Loss of infauna will affect feeding of some managed species and their prey.	reefs. These reefs should restore about 75% of the lost ecological functions.	

*A separate Environmental Assessment was prepared for the Canaveral Shoals borrow area in 1999, and can be made available upon request.

5.6 Plan Selection

Based on the economics and environmental evaluation, Alternative 19 is selected as the best plan that maximizes NED benefits, achieves the project objectives and is environmentally acceptable.

5.6.1 The National Economic Development (NED) Plan

The plan that maximizes the project net benefits and is environmentally acceptable is the National Economic Development (NED) plan. The results of our analysis over the 50-year economic period shows that the NED plan is Alternative 19 and consists of a 10-foot extension of the mean high water line plus advanced nourishment to maintain that design fill volume in Reach 1; a 20-foot extension of the mean high water line plus advanced nourishment in Reach 2; 30-foot extension of the mean high water line plus advanced nourishment in Reach 3; a dune fill in Reach 4; a 10-foot extension of the mean high water line plus advanced nourishment in Reach 5; and a dune fill in Reach 6 **(see Figure 5-6)**. The plan includes rehabilitation of the Poseidon Dredged Material Management Area (DMMA) at Port Canaveral, dredging material at 6 year intervals from Canaveral Shoals with placement into the Poseidon DMMA, and hauling by dump truck to the Mid-Reach for placement on the beach at approximately 3 year intervals. The width of the beach face fill was optimized by comparing 10, 20, and 30-foot berm widths; however, the renourishment intervals are severely limited by the presence of the rock outcrops. The NED plan has been optimized based on Economic, Engineering, and Environmental considerations. Sections A-79 through A-104 of the engineering appendix provide detail on the engineering and environmental considerations addressed in selecting the NED plan. The NED plan offers storm protection ranging from a 5-year storm level to a 75-year storm, varying along the length of the Mid-Reach. The plan includes 3 acres of environmental impact to the nearshore hardbottom, following minimization of the impacts as much as possible while still offering maximum storm damage reduction. Project costs include mitigation for these hardbottom impacts.

5.6.2 The Locally Preferred Plan (LPP)

The NED plan described above is the plan that maximizes the net benefits for the project area while minimizing environmental impact. Should the project sponsor decide that another plan is better suited to their needs, the team will be required to abide by the current policy guidance regarding locally preferred plans (LPPs). If the LPP has a greater total project cost than the NED plan, the difference will be paid at 100% non-Federal cost. If the LPP has a lesser total project cost than the NED plan, the total project cost will be cost shared at the same percentage as the NED plan. All LPPs must have a cost to benefit ratio greater than one. The Brevard County Board of County Commissioners notified the Jacksonville District that they request consideration of Local Option 6 as the LPP **(see Figure 5-7)**. As the two plans are very similar in construction technique, fill volume, and environmental impact, the Jacksonville District supports construction of the LPP.

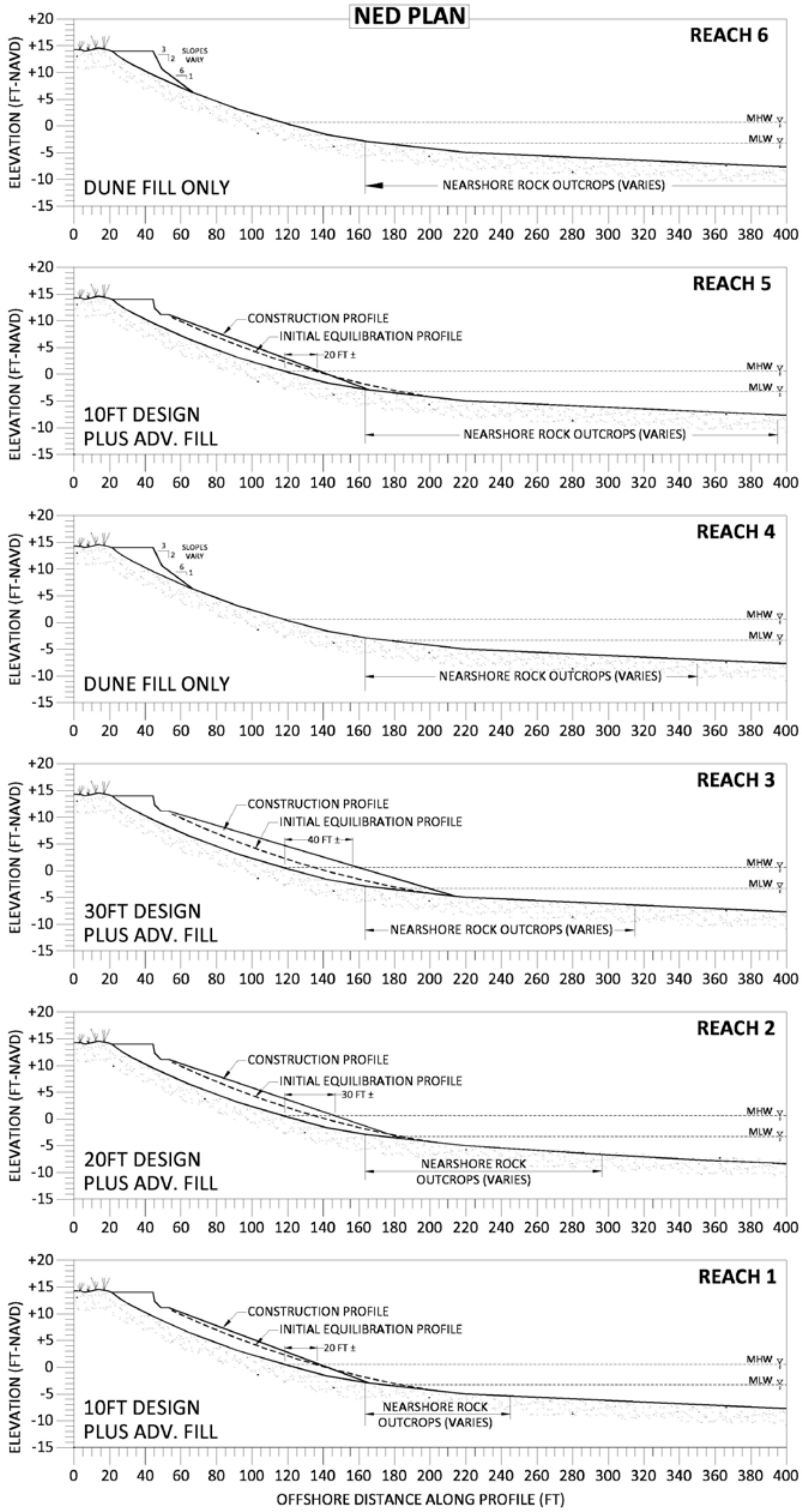

Figure 5-6. Schematic illustration of typical project beach fill in the NED Plan relative to the existing beach profile and nearshore hardgrounds.

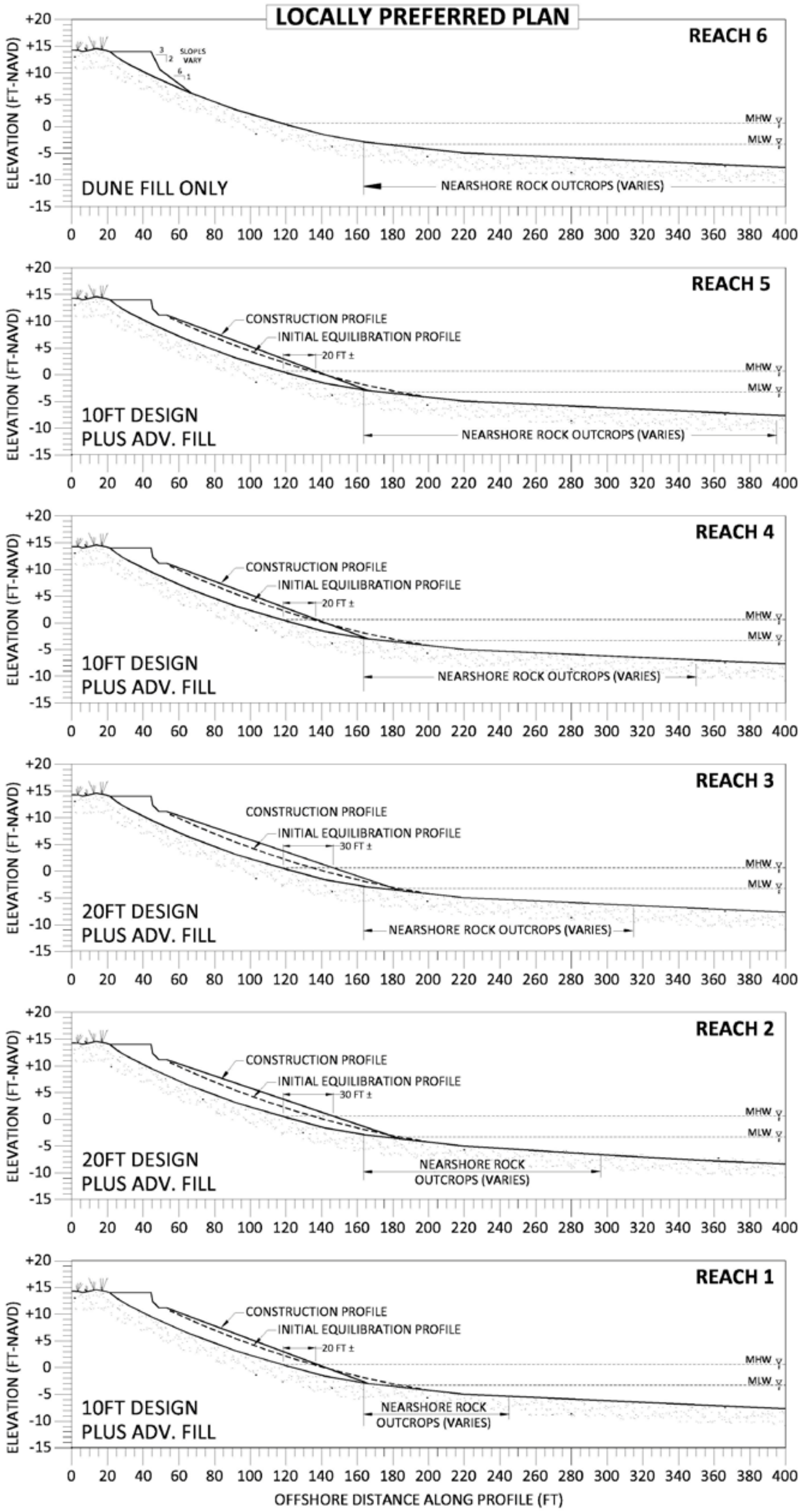

Figure 5-7. Schematic illustration of typical project beach fill in the LPP relative to the existing beach profile and nearshore hardgrounds.

6 THE RECOMMENDED PLAN

6.1 Description of the Recommended Plan

The District recommends the LPP as the recommended plan, shown in the alternative analysis as Local Option 6. The plan consists of a 10-foot extension of the mean high water line plus advanced nourishment to maintain that design fill volume in Reach 1 (R-119 to R-109), a 20-foot extension of the mean high water line plus advanced nourishment to maintain that design fill volume in Reaches 2 and 3 (R-109 to R-99), a 10-foot extension of the mean high water line plus advanced nourishment to maintain that design fill volume in Reaches 4 and 5 (R-99 to R-83), and a dune fill consisting of advanced nourishment in Reach 6 (R-83 to R-75.4). The approximate volume of sand to be placed, as calculated from the 2005 survey, includes an initial design fill of 445,000 cubic yards plus an advanced nourishment fill of 210,000 cubic yards for a total fill of 655,000 cubic yards at initial construction. The project's design baseline as defined for all economic benefit and damage calculations and plan formulation steps, is the mean high water line from the year 2005. MHW in the project area is defined as elevation +2.0 feet NGVD 29. The coordinates of the 2005 MHW line are included in **Appendix A, Table A-12.**

6.1.1 Project Design Template

The project design template is defined based on an advancement of the 2005 MHW shoreline by 10 feet (Reaches 1, 4, and 5) or 20 feet (Reaches 2, and 3). Reach 6 consists of a dune feature that is entirely sacrificial advance fill (placed as part of the construction template) meant to protect the native dune, but not provide any permanent advancement of the dune—thus there is no design template defined for Reach 6. The design template shape conforms closely to the native slope of the beach, so that the design template may be used for assessment of the condition of the project once it has matured and the construction template beach fill has taken a natural shape. For the purposes of formulating a simplified design template, the native beach template is divided into three cross-shore regions: upper beach face, lower beach face, and the submerged profile. The upper beach face extends seaward from a berm height of +10.6 to +6.0 feet NGVD29; the lower beach face extends seaward from +6.0 to the MHW elevation of +2.0 NGVD29; the submerged profile extends from MHW elevation seaward. For the sake of the design template, the only the upper and lower beach face slopes are defined, whereas the submerged profile is expected to take a shape that is equivalent to the native submerged beach, albeit at a position 10 to 20 feet seaward of the native profile.

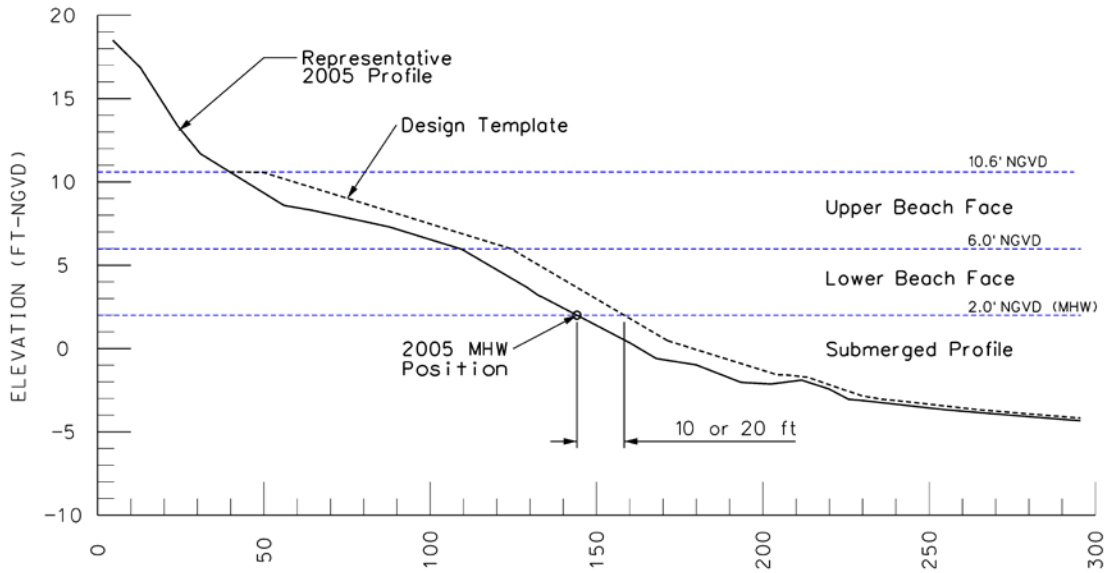

Figure 6-1. Project design template.

The upper and lower beach face slopes are not always equal with the upper being less steeply sloped than the lower beach in reaches 1 and 2, as shown in **Figure 6-1.** The native beach face slopes generally become steeper toward the north end of the project area, thus the design slopes become steeper from Reach 1 to Reach 5 as shown in **Table 6-1**.

Table 6-1. Beach fill design template slopes

Reach	Upper Beach Face Slope	Lower Beach Face Slope
1	1V:17H	1:10
2	1:15	1: 10
3	1:10	1:10
4	1:10	1:10
5	1:8	1:8
6	NA	NA

6.1.2 Project Construction Template

To account for the erosion that will occur between renourishment events 210,000 cubic yards of material will be placed as advanced fill (equivalent to -70,000 cy/yr over a 3-year renourishment interval). The construction template includes a wider overall berm fill with a steeper seaward slope than the design template along with a dune fill element above the berm height, as illustrated in **Figure 6-2**. During maturation of the beach fill the dune and beach face fill will be transported seaward through storm induced erosion of the dune and the long-term equilibration process until the fill material regains a shape that is equivalent to the natural beach profile shape, albeit seaward of the existing beach profile. Due to the presence of the dune feature, the construction template is referenced from the berm elevation of +10.6 feet NGVD29.

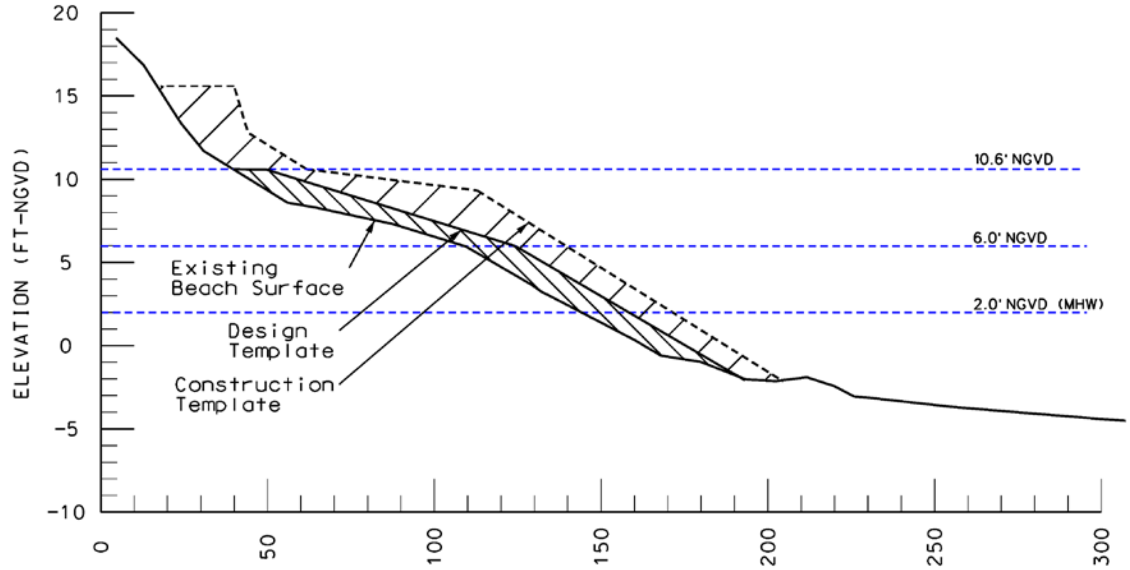

Figure 6-2. Typical project design template and construction template

The width of the construction template elements (dune and berm widths) are designed to accommodate the full volume of sand that would be required to advance the 2005 shoreline by 10 feet (Reaches 1,4, and 5) or 20 feet (Reaches 2 and 3) from berm height (+10.6 feet) to depth of closure (-17 feet NGVD29). This volume is calculated as 445,000 cubic yards. Further detail on the formulation of the design volume is included in Appendix A. In addition to design fill, the construction template includes 210,000 cubic yards of advance fill for a total of 655,000 cubic yards of fill to be placed in the project area at initial construction. The project baseline for the construction template is the +10.6 foot elevation of the 2005 beach profile at each FDEP monument in Reaches 1-5, which corresponds with the natural berm height elevation of the project area. In Reach 6 the baseline for construction is the +12.8 foot contour from 2005, which corresponds to the position of the existing dune face at that time.

Due to local variations in native beach width and dune width, the construction template widths vary from one reach to the next as outlined in **Table 6-2** below. All widths are referenced to the 2005 +10.6/+12.8 NGVD29 contour positions (Table A.11).

Table 6-2. Construction template dune and berm width

	Dune Fill Width (ft)	Berm Fill Width (ft)
Reach 1	27	75
Reach 2	43	80
Reach 3	38	80
Reach 4	20	55
Reach 5	23	30
Reach 6	10	NA

The construction template slopes are consistent throughout Reaches 1-5 and are illustrated in **Figure 6-3**. The dune portion of this fill template begins at the height of the native dune crest seaward on a 1V:1.5H slope to the elevation +12.8, then seaward at a 1V:8H slope to elevation +10.6. The berm then slopes 1V:40H until the design berm width (**Table 6-2**), then slopes seaward on a 1V:8H slope until intersection with the existing bottom.

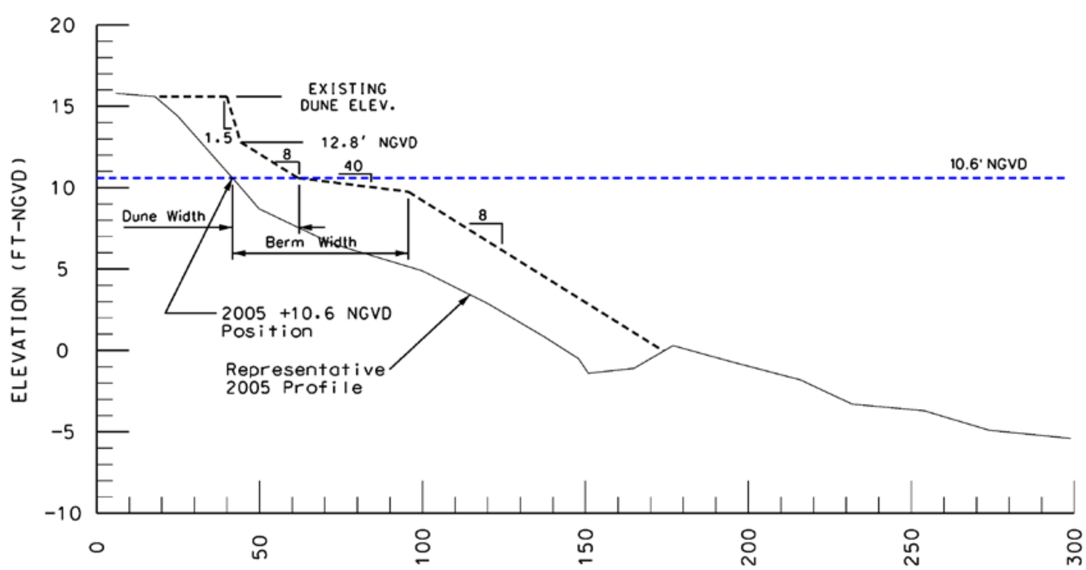

Figure 6-3. Construction template for dune and beach face fills in Reaches 1-5.

The construction template for Reach 6 is shown in **Figure 6-4**. The position of this template at each monument location is referenced to the +12.8 foot NGVD29 elevation. The template extends from the native dune height seaward on a 1V:1.5H slope until elevation +12.8, then seaward at a 1V:6H slope until intersection with the existing bottom. The width of the template as measured at the +12.8 foot elevation is 10 feet.

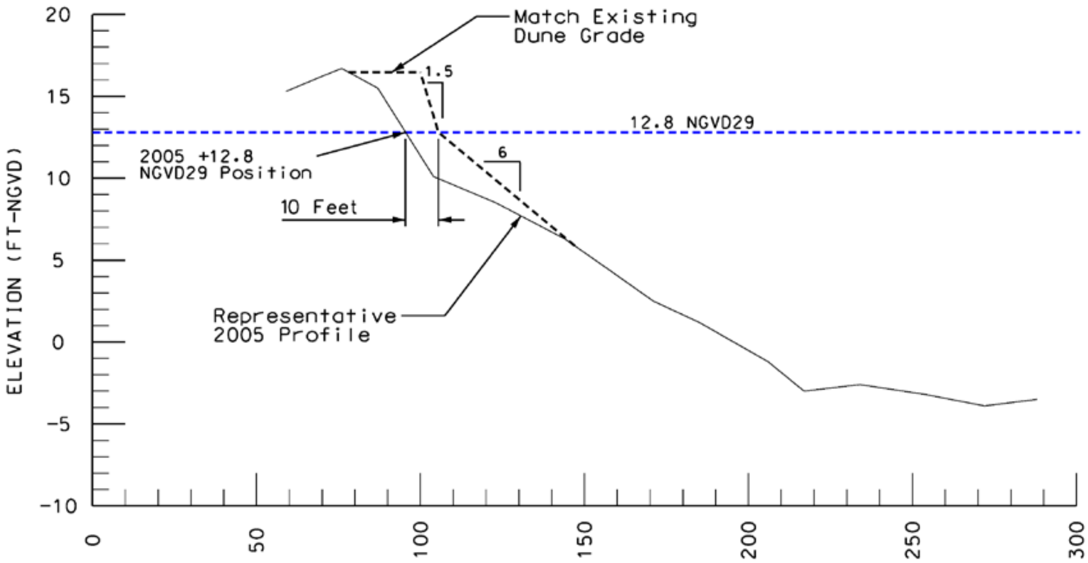

Figure 6-4. Reach 6 dune fill template.

6.2 Project Construction

Construction of the project will include several distinct steps. First, rehabilitating the Poseidon dredged material management area (DMMA) at Port Canaveral, then dredging material from Canaveral Shoals with placement into the Poseidon DMMA approximately every 6 years, and finally, hauling by dump truck to the Mid-Reach for placement on the beach at approximately 3 year intervals. The renourishment volume, with placement occurring every 3 years, is an estimated 210,000 cubic yards. The recommended plan offers erosion protection ranging from a 5-year storm level to a 75-year storm, varying along the length of the Mid-Reach.

The plan includes 3.0 acres of environmental impact to the nearshore rock resources, following minimization of the impacts as much as possible while still offering maximum storm damage reduction. Mitigation for impacts due to direct and indirect cover of the nearshore rock is included in the 3.0 acre impact, however, 1.4 acres is expected to include some temporal variation as the advanced nourishment erodes. The recommended plan includes impacts in Reaches 1 to 5 and no impact in Reach 6. The area impacted is on the landward edge of the nearshore rock, resulting in the small width of rock impacted but over the whole length of Reach 1 to 5. The calculated impact acreage is 3.0 acres out of the total of 31.3 acres of nearshore rock in the Mid-Reach study area. The nearshore rock seaward of the fill area will not be impacted. The mitigation quantity is calculated from the UMAM ratio of 1.6 mitigation acres required for every acre of natural rock impacted, resulting in a mitigation of 4.8 acres.

With this recommendation the Brevard County project would then include the previously authorized North Reach, extending from the south jetty of Canaveral Harbor to the north boundary of Patrick Air Force Base; the Mid-Reach from the south boundary of Patrick Air Force Base to FDEP R-119; and the South Reach from FDEP R-119 to Spessard Holland Park.

6.3 Detailed Cost Estimates (MCACES)

The MCACES for the LPP and the NED plan was updated to reflect 2010 price levels. A detailed cost estimate for the recommended plan is included in the Engineering Appendix. As the cost sharing of the LPP is dependent on the Federal participation in the NED plan, summary costs of both plans are shown later in this section.

6.4 Design and Construction Considerations

The major items of work, in sequence, include rehabilitation of the Poseidon DMMA, dredging of material from the offshore Canaveral Shoals borrow area and placement into the Poseidon DMMA, removal of the material by truck from the DMMA with placement on the Mid-Reach beach, and construction and placement of the mitigation reef in the nearshore. These activities require different pieces of equipment, so may be constructed using separate construction contracts. This approach may also provide flexibility for construction schedules and funding availability.

Hydraulic dredging of the offshore borrow area(s) and replenishment of the DMMA upland stockpile, by hopper dredge, would be in approximate 6-year cycles to correspond with hydraulic-fill renourishment of the North or South Reach portions of the federal shore protection project. Hydraulic dredging and discharge to initially construct and subsequently replenish the DMMA stockpile is anticipated to require between about 60-90 days and 30-40 days, respectively. While construction activities upon the beach shall be limited to November 1 through April 30 (with specific restrictions from March 1 through April 30 and from November 1 through November 30, per **Section 7.2.34**), no calendar restrictions on dredging and disposal activities to the DMMA are proposed. Additional design will also be completed on the Poseidon DMMA in order to advance to construction.

Beach fill placement and grading will be by truck-haul, excavator, bulldozer and similar mechanical equipment, with placement mostly (but not wholly) above the mean low water line. One-way transit distances between the DMMA upland stockpile and beach fill areas are between about 18 and 24 miles. Initial construction (placing approximately 655,000 cubic yards of sand) is anticipated to require between 160 and 180 calendar days. Periodic renourishment would be in approximately 3-year cycles, with each event anticipated to place approximately 210,000 cubic yards and to require between 45 and 60 days for construction. Due to the dynamic nature of the coastal environment, there is expected to be continued erosion in the Mid-Reach from the time of this report writing until construction. This report references the 2005 mean high water line and all templates and volumes are relative to that line. During the PED phase, new surveys shall be conducted and a determination made as to the erosion or accretion of the shoreline.

Placement and subsequent equilibration of the placed beach fill sediment will result in burial or sedimentation of a portion of approximately 3.0 acres of existing nearshore rock hardgrounds. As compensatory mitigation for these impacts, the project will construct approximately 4.8 acres of nearshore hardbottom (reef). The reef structure will consist of articulated concrete mats with an integral coquina-rock surface, intended to emulate physical features of the existing nearshore rock. An example structure is illustrated in **Figure 6-5** consisting of nine experimental blocks constructed during prototype development by the local sponsor.

Final details and dimensions of the mitigation reef structure will vary as determined through detailed engineering design. Each articulated reef mat will consist of approximately 18 cable-connected concrete blocks with coquina surface. Each mat would be about 8-ft x 15-ft x 1-ft and comprise about 90 lineal ft of valleys (ridges) between blocks and adjacent mats. In total, about 42 mats (in 6 rows and 7 offset columns) would be placed adjacently – along with two additional “top-layer” mats along the landward edge to form an overhanging ledge. This would constitute one “set” of 44 mats. Each set of mats would create about 0.15 to 0.16 acres of hard bottom structure. Approximate alongshore locations of reef “sets” are illustrated in **Figures 6-6 and 6-7**. Final alongshore locations of reef structures and the number and dimensions of mats within each set (or group) will be determined through the reef structure’s final design.

Each set of mats would be placed on the sand seabed at ambient depths between about -14.4 ft and -15.6 ft mean low water (MLW) (i.e., approximately centered along the -15-ft MLW contour). At 12-in. nominal relief (and 24-in. maximum relief along the landward edge), the coquina surface of the reef units would lay in water depths between -12.4 ft MLW and -14.6 ft MLW. The mitigation sites are typically located about 1000 ft seaward of the project area’s MLW shoreline, and at least 800-ft seaward of the existing rock outcrops.

Between three and five sets of mats would be spaced 50 to 60 ft apart along the approximate 15-ft depth contour to form a reef-group, comprising between 0.45 and 0.75 acres of hardbottom per group. These reef-groups would be spaced on the order of 400 to 9000 ft apart to create the requisite total area of reef mitigation along the shoreline.

The reef mats will be constructed (cast) at an upland yard, transported overland (by rail or truck) to a barge, and then transported over water to the installation sites. It is anticipated that construction would be staged through Canaveral Harbor, located about 14 to 22 miles north-northwest of the mitigation reef sites. Placement of the mats from barges to the seabed will be by crane located upon floating and/or jack-up barges. The barges will utilize anchors and/or spuds upon the sand seabed. Ancillary vessels will include crew boats, survey vessels, and ocean certified tugboat. Seabed installation of the reef mats will require 4 to 8 months (for two or one crane barge set-ups, respectively), spanning more than one year. It is anticipated that installation will occur in months of May through September, owing to favorable seas, but will not be limited to those times. Design details, placement locations and construction costs will be further refined during the PED phase.

Figure 6-5. Articulated Concrete Mattress

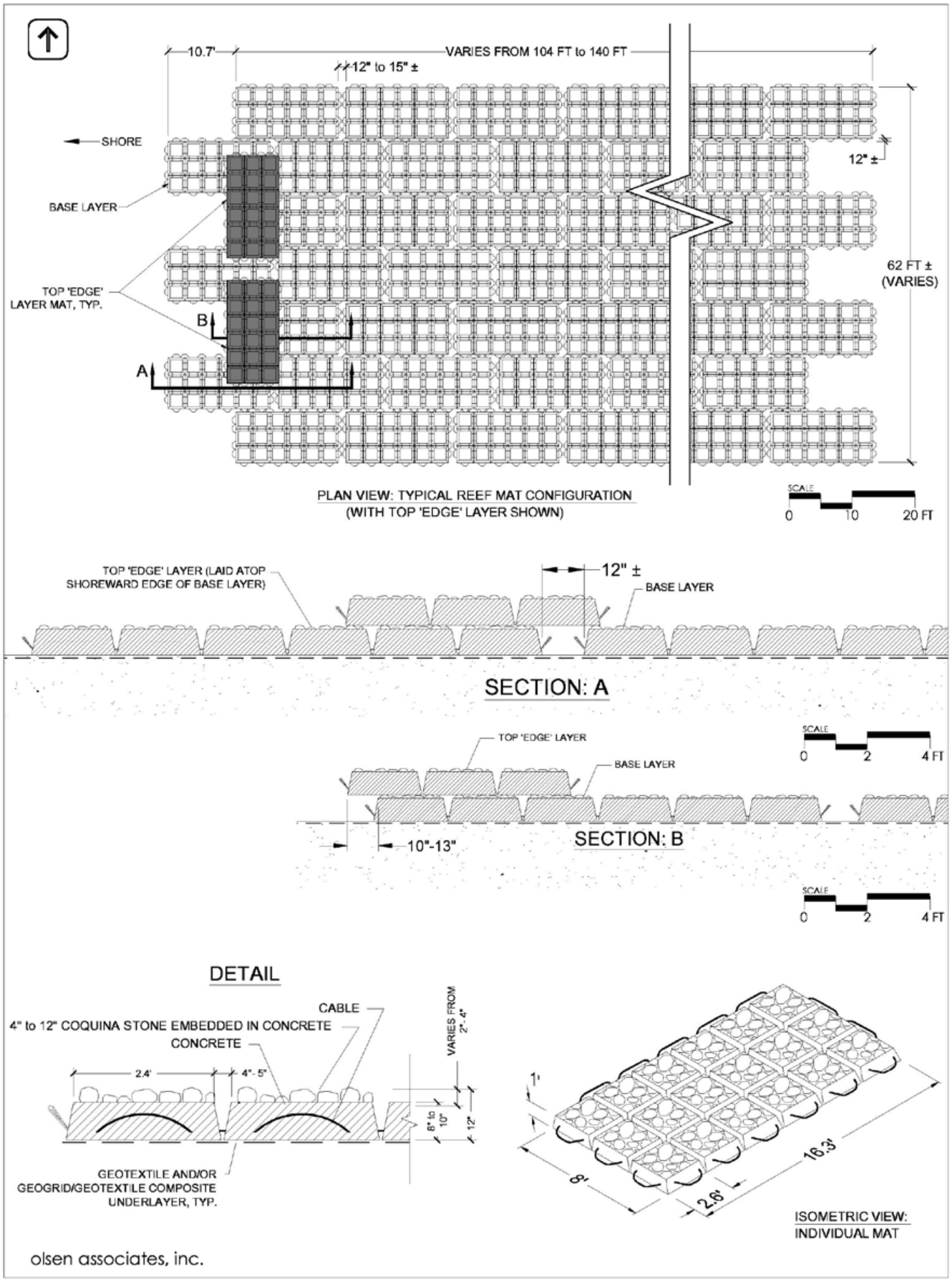

Figure 6-6. Plan and elevation view of typical articulated reef-mat mitigation structure.

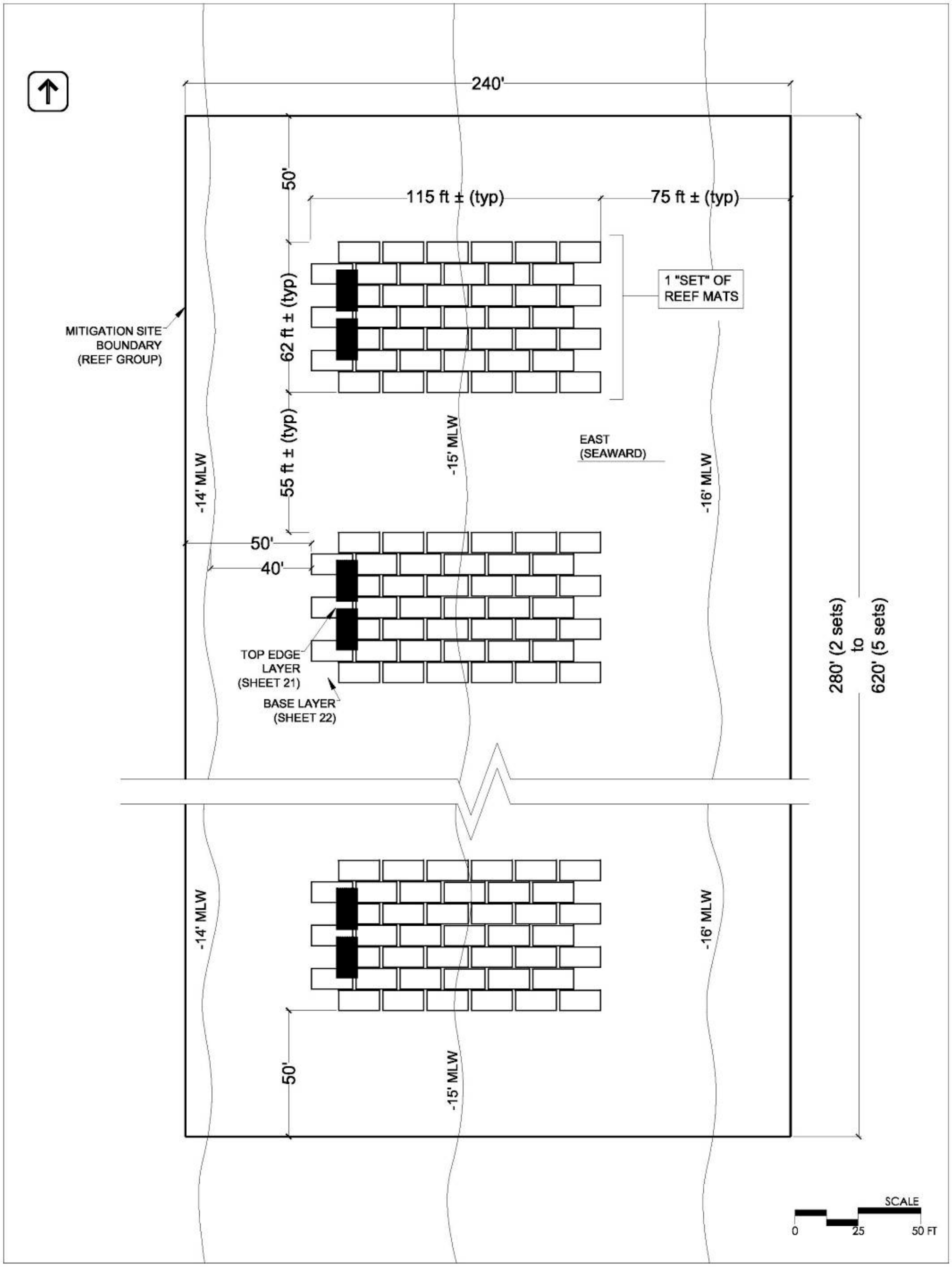

Figure 6-7. Plan view of several sets of reef-mat mitigation structures within one reef group.

6.5 LERRD Considerations

In accordance with the “Interagency Coordination Agreement for Civil Works Projects between Florida Department of Environmental Protection and the United States Army Corps of Engineers Jacksonville District” dated February 2006, it requires our non-Federal sponsors to obtain all real estate permissions required from the State of Florida. Material placed upon public lands seaward of the proposed ECL will require a Consent of Use from the State of Florida. Also included in this document is the use of any submerged borrow areas and/or pipeline corridors. As the borrow areas, Canaveral Shoals I and Canaveral Shoals II, are located in Federal waters, a lease would be required by United States Mineral Management Service. The proposed Poseidon DMMA (stockpile area) is owned by Patrick Air Force Base. Permits from the Department of the Air Force will be required for use of the Poseidon DMMA located near Canaveral Harbor. An automatic renewal of this permit is requested, so that it will continue for period of analysis. The non-Federal sponsor must acquire the perpetual storm damage reduction easement estate for all placement areas landward of the proposed ECL, dune/vegetation areas and all accesses to the beach. Addition information is found in the Real Estate Appendix.

6.6 Operations and Maintenance Considerations

6.6.1 Beach Nourishment

By Public Law 826 dated 1956 (a.k.a. Beach Nourishment), periodic nourishment is considered construction and not maintenance, so is cost shared. Items of operations and maintenance include beach inspections, beach profile surveys, photography, revegetation, etc. The operations and maintenance required for the recommended plan is similar in nature and scale to similar projects. Operations and maintenance is born 100% by the non-Federal sponsor and is detailed in the Project Partnership Agreement. An Operations and Maintenance Manual will be completed by the USACE and provided to the sponsor following completion of initial construction.

6.6.2 Project Monitoring

A complete monitoring plan of the mitigation reef is included in the Environmental Documentation Appendix. The general objectives of the project monitoring plan are to indicate

a) physical beach fill performance,

b) changes at the offshore borrow areas,

c) physical impacts to the existing nearshore hardgrounds vis-à-vis changes in exposure (sand burial) of the hardgrounds,

d) extent of impacts to epibiota, fishes, and turtles associated with nearshore hardgrounds subject to sand fill from the project;

e) physical performance of the mitigation reef vis-à-vis changes in exposure and substrate, and

f) extent of biological recruitment and activity at the mitigation site – both in an absolute sense and relative to the existing nearshore rock reef (hardgrounds) in specific terms of macroalgae, invertebrates, juvenile and adult fishes, and marine turtles.

The primary objectives of the biological elements of the monitoring plan are to assess potential impacts to the existing reef in the Mid-Reach project area; and to evaluate the degree to which the mitigation reef replicates the ecological functions of the existing nearshore reef in terms of habitat for the major taxonomic groups listed above. Criteria for measurement and success of the mitigation reef shall be based upon the degree to which the reef is sufficiently exposed to serve these ecological functions relative to the predictions made in the project formulation. The design of the monitoring program must take into account the challenging physical conditions at the site. These include typically turbid water with little or no visibility, and consistently energetic surf. Conditions at the existing reef site are further complicated by the very shallow water and breaking waves. Practical consideration of these conditions is necessary in order to develop a monitoring program and measurement criteria that are realistically achievable and which result in meaningful data. Sea state and visibility shall be monitored daily during the summertime to ensure that surveys are conducted on days with ideal weather and visibility conditions. The monitoring program shall include the physical performance of the beach fill and borrow area, by traditional surveys, to assess the longevity and movement of the beach fill (volume and shoreline change) and bathymetric/volume changes at the offshore borrow area. The monitoring program shall include the physical and biological components of both the existing reef and the mitigation reef.

6.7 Summary of Accounts

Per EC 1105-2-409, any plan may be selected and recommended for implementation if it has, on balance, net beneficial effects after considering all plan effects, beneficial and adverse, in the four accounts (NED, RED, EQ and OSE). The recommended plan was shown to have a net improvement over the future without project condition and has positive net benefits. The recommended plan is the LPP, which has similar benefits in all four accounts to the NED plan.

6.8 Risk and Uncertainty

The risk of storm damages is lessened by the recommended plan, however, residual risk will remain. The risk was evaluated as part of the economic evaluation. The model that was used in the economic evaluation uses a risk relationship between shoreline recession and storm frequency. Such erosion would include loss of material due to waves, tides, and other forces. The recommended plan is designed to offset erosion from a 5-year to 75-year storm depending on the shoreline location. However, the risk to structures from flooding, wind damage, or wave damage other than loss of material is not included in the modeling, so this risk is unknown. Another source of risk is related to the periodic nourishment cycle. Any beach nourishment project depends on continuing nourishments over the life of the project to replace erosional losses. While there is risk associated with any similar project, the recommended plan will require periodic nourishments every 2 to 4 years in order to realize the benefits. And while the nourishment cycle is designed to maintain the beach width, it is possible to have several severe storms in a row that would reduce the protection offered by the beach. The uncertainties in the evaluations that led to the recommended plan were also identified. The model used to evaluate the economics allows for variations based on the uncertainty in the input data and returns the average benefits, maximum, minimum and standard deviation. Each data input value to the economics analysis was evaluated for the range of uncertainty and incorporated into the model. Another source of uncertainty is the quantity of hardbottom impact. Coastal engineering techniques and experience with similar projects led to the quantifications, however, it is known that the exposed acreage of hardbottom changes over time making the accuracy of the predicted impact less certain. A sensitivity analysis was performed as part of the study to evaluate the uncertainty in the cost of mitigation, and it was determined that plan selection is not sensitive to the cost of mitigation. A complete explanation of the risk and uncertainty analysis performed for the Brevard Mid-Reach is provided in **Appendix B.**

6.9 Implementation Requirements

Pending approval of this document by higher headquarters, and funding in an Appropriations Act, the next phase would be drafting and review of a Project Partnership Agreement (PPA). As there already exists a PPA for the north and south reach of the Brevard County Shore Protection Project, the Mid-Reach area may be added by amendment or a new PPA may be executed. Concurrent with the PPA, plans and specifications will be developed following execution of the PED agreement with the non-Federal sponsor.

6.9.1 Federal Implementation Responsibilities

The U. S. Army Corps of Engineers is responsible for budgeting for the Federal share of construction costs for all future work for Federal projects. Federal funding is subject to budgetary constraints inherent in the formation of the national civil works budget for a given fiscal year. The USACE would perform the necessary preconstruction engineering and design needed prior to construction. The USACE would obtain any necessary permits for the use of Federal lands at the Poseidon DMMA and would construct the project. Cost sharing of initial construction and periodic nourishment will be in accordance with WRDA 1986, as amended, subject to the availability of appropriations and concurrence with the coastal zone consistency determination.

6.9.2 Non-Federal Implementation Responsibilities

The non-Federal sponsor for the shore protection project will be Brevard County. The non-Federal project sponsor would provide an up-front cash contribution for initial construction costs of the proposed project. The amount of the non-Federal up-front cash contribution would be based on cost sharing principles reflecting shoreline use, ownership and public access in existence at the time of construction. The non-Federal sponsor shall provide the entire cost of all material placed on undeveloped lands and developed private lands (which are inaccessible to the public), including the cost of material placed seaward of the ECL. The non-Federal sponsor shall provide lands, easements, and rights-of-way and bear a portion of the administrative costs associated with land requirements. Any additional costs in excess of the NED plan cost will be a non-Federal responsibility. The non-Federal sponsor shall provide the water quality certification from the State of Florida and a lease agreement from the Mineral Management Service for the use of Canaveral Shoals borrow area. Requirements of the water quality certification not included in the project costs, such as removal or modification of storm water outfalls, shall be a non-Federal sponsor responsibility. Other general non-Federal responsibilities, such as continuing public use of the project beach for which benefits are claimed in the economic justification of the project, and controlling water pollution to safeguard the health of bathers, must also be assumed by the non-Federal sponsor before the project can be constructed. The non-Federal project sponsor will be responsible for all costs of operation, maintenance, repair, rehabilitation and replacement of project features. Section 402 of the 1986 Water Resources Development Act (33 USC 701b-12) as amended by Section 14 of the 1988 Water Resources Development Act states that "Before construction of any project for local flood protection or any project for hurricane or storm damage reduction, the non-Federal interests shall agree to participate in and comply with applicable Federal flood plain management and flood insurance programs." The non-Federal sponsor and communities must be enrolled in and in compliance with the National Flood Insurance Program to receive Federal funding for a recommended storm damage reduction project.

6.9.3 Cost Sharing

Federal participation in shore protection projects is limited to shorelines open to public use. Guidance is provided in ER 1105-2-100 wherein user fees, parking, access, beach use by private organizations, and public shores with limitations are addressed (E-24.d). Federal participation is further defined by project purpose, either hurricane and storm damage reduction or recreation, and by shoreline ownership. Shoreline ownership is separated into lands that are Federally owned, publicly and privately owned, and privately owned with limited use, as shown in **Table 6-3**. More specific guidance is provided in ER 1165-2-130 on what constitutes sufficient parking. The total number of required parking spaces is the lesser of that required to meet peak hour demand or beach capacity per current policy guidance. At the time of construction in 2013, the lesser of peak hour demand and beach capacity is 744 spaces. The current number of parking spaces of 830 meets the current demand. In order to evaluate the Brevard County Mid-Reach study area, available information was gathered from existing reports, aerial photography, Brevard County sources and field reconnaissance. The public use of the shoreline was addressed first to determine the level of Federal participation, then secondly the shoreline ownership, and then the cost sharing percentage was calculated (**Table 6-4)**. The majority of the Mid-Reach included in the recommended plan is open and accessible to the public with only 3,985 feet in four segments out of 41,083 feet that are not open. This length is incidental to the whole project and cannot be avoided without jeopardizing the integrity of the recommended plan or incurring extra costs.

An adjustment is included in the cost allocation to remove that portion from Federal participation. See the Public Use Determination Appendix for more information.

Table 6-3. Shore Ownership and Levels of Federal Participation

Shore Ownership and Project Purpose or Benefits	Maximum Level of Federal Participation in Initial Construction	Maximum Level of Federal Participation in Periodic Nourishment	Maximum Level of Federal Participation in OMRR&R
I. Federally Owned			
A. HSDR on Developed Lands	100%	100%	100%
B. HSDR on Undeveloped Lands	100%	100%	100%
C. Separable Recreation	100%	100%	100%
II. Publicly and Privately Owned (public benefits)			
A. HSDR on Developed Lands	65%	50%	0%
B. HSDR on Undeveloped Lands			
(1) Public Lands	50%	50%	0%
(2) Private Lands	0%	0%	0%
C. Separable Recreation	50%	50%	0%
III. Privately Owned (limited use)			
A. HSDR on Developed Lands	0%	0%	0%
B. HSDR on Undeveloped Lands	0%	0%	0%
C. Separable Recreation	0%	0%	0%

Table 6-4. Brevard County Mid-Reach NED Cost Sharing Percentage

Initial Construction			
Shore Ownership and Project Purpose (as defined in ER 1105-2-100, Table E-22)	Maximum Level of Federal Participation in Construction Costs	Shoreline Length (feet)	Federal Participation (feet)
I. Federally Owned	100%	0	0
II. Publicly and Privately Owned (public benefits)			
A. HSDR on Developed Lands	65%	26,834	17,442
B. HSDR on Undeveloped Lands			
(1) Public Lands	50%	4,415	2,208
(2) Private Lands	0%	815	0
C. Separable Recreation	50%	5,034	2,521
III. Privately Owned (limited use)			
A. HSDR on Developed Lands	0%	3,695	0
B. HSDR on Undeveloped Lands	0%	85	0
C. Separable Recreation	0%	205	0
	Total Distance	41,083	22,171
Federal share = 22,171 divided by 41,083 =			54.0%
Periodic Nourishment			
Shore Ownership and Project Purpose (as defined in ER 1105-2-100, Table E-22)	Maximum Level of Federal Participation in Construction Costs	Shoreline Length (feet)	Federal Participation (feet)
I. Federally Owned	100%	0	0
II. Publicly and Privately Owned (public benefits)			
A. HSDR on Developed Lands	50%	26,834	13,417
B. HSDR on Undeveloped Lands			
(1) Public Lands	50%	4,415	2,208
(2) Private Lands	0%	815	0
C. Separable Recreation	50%	5,034	2,521
III. Privately Owned (limited use)			
A. HSDR on Developed Lands	0%	3,695	0
B. HSDR on Undeveloped Lands	0%	85	0
C. Separable Recreation	0%	205	0
	Total Distance	41,083	18,146
Federal share = 18,146 divided by 41,083 =			44.2%

6.9.4 Project Costs

As the recommended plan is the LPP, Federal participation in the project costs is limited to the Federal participation in the NED plan if the LPP total project cost is greater than the NED plan; or the Federal cost share percentage if the LPP total project cost is less than the NED plan. Total projects costs in 2010 price levels are tabulated below (**Tables 6-5 and 6-6**) and confirm the LPP has a lower total project cost than the NED plan. The summary cost table shows the costs for both the LPP and the NED plan.

Table 6-5. Brevard County Mid-Reach Cost Sharing Table

The NED Plan				The Locally Preferred Plan (LPP)		
Alternative 19				Local Option 6		
Reach 1	10 foot			Reach 1	10 foot	
Reach 2	20 foot			Reach 2	20 foot	
Reach 3	30 foot			Reach 3	20 foot	
Reach 4	dune			Reach 4	10 foot	
Reach 5	10 foot			Reach 5	10 foot	
Reach 6	dune			Reach 6	dune	
	Sum				Sum	
First Cost:	$32,413,704			First Cost:	$32,199,272	
Nourishment Cost:	$8,217,706	every 3 years		Nourishment Cost:	$8,216,773	every 3 years
16 Nourishments over 50 years				16 Nourishments over 50 years		
$8,217,706 x 16 =	$131,483,290			$8,216,773 x 16 =	$131,468,364	
Total Cost = First Cost + Periodic Nourishments				Total Cost = First Cost + Periodic Nourishments		
	$163,896,994				$163,667,636	
Federal participation in the NED plan				The Locally Preferred Plan is limited to the same		
				Federal cost share as the NED Plan		
Initial Construction				Initial Construction		
Federal		54%		Federal		54%
Non-Federal		46%		Non-Federal		46%
Periodic Nourishment				Periodic Nourishment		
Federal		44.2%		Federal		44.2%
Non-Federal		55.8%		Non-Federal		55.8%
NOTE: Total project cost does not include inflation. Locally Preferred Plan uses the same cost sharing percentage as the NED plan because the LPP has a lower total project cost.						

Table 6-6. Brevard County Mid-Reach Summary of Project Costs

Brevard County Storm Damage Reduction Project, Mid-Reach Segment — Summary of Project Costs (Mar 2010 price levels)	NED Plan - Alternative 19			LPP - Local Option 6		
	Total Cost	Federal Cost (54%)	Non-Federal Cost (46%)	Total Cost	Federal Cost (54%)	Non-Federal Cost (46%)
Mob/Demob	$2,031,975	$1,097,266	$934,708	$2,031,975	$1,097,266	$934,708
LERRD	$86,100	$46,494	$39,606	$86,100	$46,494	$39,606
PED	$384,990	$207,895	$177,095	$384,990	$207,895	$177,095
Engineering Monitoring	$778,836	$420,571	$358,265	$778,836	$420,571	$358,265
Beach Nourishment Fill	$19,578,659	$10,572,476	$9,006,183	$19,381,026	$10,465,754	$8,915,272
Construction Management (S&I)	$2,441,402	$1,318,357	$1,123,045	$2,424,603	$1,309,286	$1,115,317
Mitigation	$7,111,742	$3,840,341	$3,271,401	$7,111,742	$3,840,341	$3,271,401
Total First Cost	**$32,413,704**	**$17,503,400**	**$14,910,304**	**$32,199,272**	**$17,387,607**	**$14,811,665**
	NED Plan - Alternative 19			LPP - Local Option 6		
	Total Cost	Federal Cost (44.2%)	Non-Federal Cost (55.8%)	Total Cost	Federal Cost (44.2%)	Non-Federal Cost (55.8%)
Mob/Demob	$708,422	$313,123	$395,300	$708,294	$313,066	$395,228
LERRD	$86,100	$38,056	$48,044	$86,100	$38,056	$48,044
PED	$384,990	$170,166	$214,824	$384,990	$170,166	$214,824
Engineering Monitoring	$140,835	$62,249	$78,586	$140,835	$62,249	$78,586
Periodic Nourishment Fill	$6,301,514	$2,785,269	$3,516,245	$6,300,782	$2,784,946	$3,515,836
Construction Management (S&I)	$595,845	$263,363	$332,481	$595,771	$263,331	$332,440
Total Each Periodic Nourishment (3 yrs)	**$8,217,706**	**$3,632,226**	**$4,585,480**	**$8,216,773**	**$3,631,814**	**$4,584,959**
Annual OMRR&R	$133,968	$0	$133,968	$133,968	$0	$133,968
Total Project Cost	$163,896,994	$75,619,014	$88,277,979	$163,667,636	$75,496,624	$ 88,171,012
Interest During Construction	$34,343			$34,147		
AAEQ Cost (4 3/8%)	**$4,255,529**			**$4,244,408**		
Primary AAEQ Benefit	$11,830,208			$11,566,324		
Incidental AAEQ Benefit (Recreation)	$1,013,900			$1,013,900		**Note:** Total project cost does not include inflation.
Total AAEQ Benefit	**$12,844,108**			**$12,580,224**		
Net Benefits	**$8,588,579**			**$8,335,816**		
Benefit-Cost Ratio	**3.02**			**2.96**		

6.9.5 Financial Analysis of Non-Federal Sponsor's Capabilities
A financial analysis is required for any plan being considered for USACE implementation that involved non-Federal cost sharing. The ultimate purpose of the financial analysis is to ensure that the non-Federal sponsor understands the financial commitment involved and has reasonable plans for meeting that commitment. By memorandum dated April 24, 2007 the Assistant Secretary of the Army (Civil Works) granted approval of the self-certification of non-Federal sponsors for their ability to pay the non-Federal share of projects. The self-certification is required prior to submission of the Project Cooperation Agreement, typically during the PED phase of the project. Included with the self-certification, the financial analysis shall include the non-Federal sponsor's statement of financial capability, the non-Federal sponsors financing plan, and an assessment of the sponsor's financial capability. The Brevard County Board of Commissioners provided a letter, dated 12 August 2009, certifying Brevard County's willingness and ability to pay the non-Federal share of this Federal Shore Protection Project. The letter is included as an attachment in **Appendix I,** pertinent correspondence.

6.9.6 Views of Non-Federal Sponsor
Brevard County is the non-Federal sponsor for the Brevard County Mid-Reach Shore Protection Project. They have been an integral part of the PDT from the conception of the project. At each step of the process, Brevard County has contributed to the available information, participated in the formulation, and reviewed the products. Brevard County is in support of the recommended plan. The Board of County Commissioners selected this plan on August 28, 2008. This memorandum referencing this selection is found in **Appendix I**.

7 ENVIRONMENTAL CONSEQUENCES

7.1 Environmental Evaluation Methodology

The environmental resources that characterize the project area and the anticipated impacts of the project to those resources were researched and evaluated through numerous site-specific field studies and analysis. These efforts likewise included the development and field studies of prototype reef structures proposed as compensatory mitigation of project impacts to nearshore rock resources, along with subsequent detailed evaluation of the anticipated ecological function of the mitigation structures. Additionally, the views of, and guidance from, relevant Federal, State, and local environmental agencies (as well as other interested persons and organizations) were incorporated to the evaluation, through cooperative meetings and other means, in order to identify those project alternatives that adequately minimized and mitigated potential adverse environmental impacts while achieving the project's shore protection objectives.

In formulation and evaluation of the project, specific input from environmental agencies and the public were developed through numerous means, including the following. A scoping letter was mailed out to all Federal, State, and local agencies and all adjacent homeowners on April 1, 2005; and a Notice of Intent to prepare a Draft Supplemental Environmental Impact Statement was published in the Federal Register on April 26, 2005. A public scoping meeting was held in Satellite Beach, Brevard County, Florida on September 8, 2005 in partial fulfillment of the requirements in the National Environmental Policy Act (NEPA), at which a wide variety of views were presented including those for and against a shore protection project.

The National Marine Fisheries Service (NMFS) provided response to the NEPA scoping meeting by letter dated October 7, 2005. NMFS stressed the "ecological importance" and "uniqueness" of the nearshore coquina rock outcroppings in the Brevard County Mid-Reach study area, which has been designated as Essential Fish Habitat and a Habitat Area of Particular Concern, and the need to avoid and then minimize impacts to the rock. NMFS noted that its policy states that where compensatory mitigation is required, the mitigation should be local, upfront, in-kind and monitored.

A Project Delivery Team meeting was held in conjunction with Brevard County, Indian River County, Jacksonville District Regulatory staff, and Florida Department of Environmental Protection (FDEP) to discuss the project, similarities with a non-Federal Indian River County project, and possible mitigation alternatives on October 18, 2005. Information was collected on the permitting process and mitigation constructed for the Indian River County project, which impacted 3.8 acres of nearshore coquina rock outcroppings of a very similar nature to that occurring in Brevard County.

A meeting with the team, Brevard County, U.S. Fish and Wildlife Service (USFWS), NMFS, Florida Fish and Wildlife Conservation Commission (FWC), and FDEP was held in Jacksonville, Florida on December 8, 2005 to present findings of intensive field research efforts to characterize the nearshore rock outcroppings and the selected mitigation plan, and to receive feedback from the agencies. In letters dated March 16 and 21, 2006, respectively, NMFS and USFWS stated that they would each participate as a cooperating agency on this study.

Pursuant to Section 7 of the Endangered Species Act, consultation with the USFWS and NMFS is required; the status is discussed in section 7.2.35.2. In compliance with the Fish and Wildlife Coordination Act, a Coordination Act Report was prepared.

The Feasibility Scoping Meeting, held in Jacksonville, Florida on February 15, 2006 (with video conferencing to USACE South Atlantic Division and Headquarters) included representatives of Brevard County and phone conferencing to NMFS, USFWS, FWC, and FDEP; during which, these agencies were provided opportunity to add their views to the official documentation of the meeting. A subsequent meeting held in Jacksonville, Florida on June 13, 2007 discussed the selection and the environmental acceptability of the tentatively selected plan, at which attendees included representatives of the Jacksonville District, Brevard County, NMFS, USFWS, NOAA Fisheries, FWC, and FDEP. Agency representatives provided comments regarding the project's mitigation and related monitoring requirements, and expressed general support for the direction in which the plan formulation was developed in terms of minimizing project impacts relative to the requirements for shore protection.

A meeting among staff from the Jacksonville District, Canaveral Port Authority, Brevard County, and U.S. Air Force was held at Port Canaveral, Florida on March 14, 2007 to discuss the requirements and potential impacts associated with the use of the Poseidon Dredged Material Disposal Area for temporary stockpiling of dredged material for purposes of the project. On June 18, 2006, the local sponsor (the lease holder of the Outer Continental Shelf borrow area) apprised the Minerals Management Service (MMS) of the Tentatively Selected Plan in order to gauge the Service's acceptance of temporary stockpiling of dredged material from Canaveral Shoals II for subsequent placement to the Mid-Reach project area over a multi-year period. All future lease agreements shall be made between the MMS, federal and non-federal sponsors.

In addition to the important input gained from these inter-agency meetings and correspondence, specific evaluation and guidance from the environmental agencies in regard to the project's environmental impacts, mitigation and monitoring was developed through the agencies' review of a Joint Coastal Permit (JCP) application for shore protection along the Mid-Reach project area, prepared and submitted by the local sponsor (Brevard County) in September 2005. The physical scope, anticipated impacts to nearshore rock resources (approximately 3.0 acres), and mitigation and monitoring plans of the final, revised project, as described in the permit application, are very similar to those of the selected project alternatives described herein. (The principal difference is that the County's project includes hydraulic placement of large-scale beach fill along Reach 1 and slightly smaller-scale truck-haul beach fill along Reaches 2 through 6 than that described herein, with the truck-haul fill material being temporarily stockpiled along Reach 1 in lieu of use of the Dredged Material Management Area.)

Comments and evaluation of the County's permit application by the Corps Regulatory Division and other federal agencies (including USFWS, NMFS, EPA, NOAA Fisheries), and FDEP and FWC, from late 2005 through 2008, provided valuable, project-specific information relating to the agencies' concerns and requirements to avoid and/or minimize, mitigate and monitor the project. It likewise provided opportunity for the agencies to evaluate, in detail, the studies of the environmental resources, mitigation and monitoring plans, and anticipated environmental impacts of the project. Comments and requests for additional information from these agencies, in large part, provided a specific framework for the environmental studies and analysis that are described in the present report. These comments also aided in the identification of those project alternatives that were judged to reasonably avoid, minimize, and mitigate adverse environmental impacts. In this regard, the agencies specifically indicated that the anticipated impacts to nearshore rock (6.4 acres) and proposed mitigation (rock boulders) associated with the County's originally proposed project were unacceptable and that reduction of impacts and an improved mitigation scheme were required. In response, the County modified the project and permit application to reflect lesser impacts (approximately 3.0 acres) and to include an innovative compensatory mitigation reef structure that better emulates the existing nearshore rock outcrops. The modified project's impacts and mitigation plans are essentially identical to those evaluated herein. The modified project was viewed more favorably by the agencies, along with subsequent development and evaluation of a monitoring plan for the project.

Upon anticipated receipt of permits for its proposed project, it is the intent of Brevard County to seek modification of the permits to reflect the scope of the selected, authorized federal plan. Through these means, the environmental studies and agencies' review attendant to the County's permit application substantially aided in the evaluation of the environmental resources, impacts, compensatory mitigation, and monitoring of shore protection alternatives along the Mid-Reach, conducted in parallel with the formulation of the selected plan.

The environmental evaluation included numerous investigations and activities undertaken by the local sponsor, Brevard County to identify the environmental resources of the project area and toward development of the Plan's mitigation element, SEIS and NEPA documentation. These include the studies and tasks described below.

Brevard County mapped the nearshore rock resource using aerial photography and multi-spectral image classification in 2001 and 2004, along with comparative ground-truth survey transects in April and May, 2001, supplemented with ground-truth survey transects conducted by the Jacksonville District in December, 2002 at 50 locations (Olsen 2003, Morgan & Eklund 2003, Olsen 2005). **See Appendix K – Subappendix I**. A portion of these ground-truth transects were repeated by the County in 2007 and in 2008. These surveys have been used to identify the extent and nature of the exposed nearshore hardbottom along the project area and adjacent Patrick AFB shoreline. Preliminary results from these transect surveys, from 2001 through 2008, indicate the significant, natural dynamic fluctuation in the amounts and locations of exposed nearshore hardbottom along the project area. There is no indication of temporal trend in the amounts or locations of the natural hardbottom exposure (see **Appendix K - Subappendix I**). This survey period includes the effects of beach fill placement along the adjacent shorelines (Patrick AFB and South Reach) and placement of sand for post-storm dune restoration along the Mid-Reach.

Additionally, the effect upon the Mid-Reach rock resource of existing beach fill projects immediately adjacent to the Mid-Reach (at Patrick Air Force Base to the north, and the Brevard County Shore Protection Project South Reach to the south) has been examined by the County's consultants through annual comparative transect surveys from 2005 through 2008 (Olsen 2005a, 2006a, 2006b, 2006c, 2007a, 2008a, 2008b, 2008c). These surveys and subsequent analysis have been conducted at the request of, and after coordination with, NMFS pursuant to correspondence between NMFS, the Corps, and the US Air Force in December 2004 (see Olsen 2005a, 2006a). The annual surveys have indicated no significant change in the net amount of exposed nearshore rock, nor fluctuations in beach profile elevation beyond historically measured norms, to-date, along the northern and southern 1-1/2 miles of the Mid-Reach, immediately adjacent to existing shore protection projects renourished in 2005.

Through bathymetric survey, sub-bottom seismic sounding, jet-probing, and diver transects, Brevard County mapped the apparent elevation of the existing rock stratum along the Mid-Reach shoreline (Olsen et al., 2005), as described in **Section 2.3.4**.

The sedimentary characteristics of the proposed beach fill material, from the Canaveral Shoals borrow area were examined in an "as-built" condition by analysis of sediment samples placed from this borrow area upon the Brevard County Shore Protection Project (North and South Reach) and Patrick Air Force Base in 2000-03 and in Spring, 2005 (Olsen 2005d). Grain size and carbonate characteristics of the in-place beach fill material, sampled every 2000 feet alongshore, were compared with the sediment from the initial 2000-03 beach nourishment construction, borrow area cores, and the native (pre-nourishment) beach. See **Section 7.2.5.1** (Infauna).

The baseline biologic features of the existing nearshore rock resource were identified by the local sponsor's consultants through a variety of environmental field studies. These studies are briefly outlined below.

Field studies of abundance and foraging activity of marine turtles along the Mid-Reach nearshore rock were undertaken in 2005 and supplemented with previous data (Holloway-Adkins & Provancha, 2005). See **Appendix K - Subappendix A**. Using visual boat transects, net and hand captures, lavage, and acoustic tracking devices attached to turtles, the study examined the relative abundance and spatial distribution of marine turtles about the nearshore rock, along with the size class structure and condition of the turtles, foraging (diet) and movement habits, and compared the results with similar marine turtle studies on Florida's east coast.

Existing epibiota assemblages along the nearshore rock outcrops were characterized in additional field studies conducted in 2005 (Continental Shelf Associates, 2005a). See **Section 2.3.4** and **Appendix K - Subappendix B**. Digital video data were collected from transects along and across the rock, above and below water, at about 15 representative locations in the Mid-Reach, from which images were captured for point count identification of taxa and percent cover (abundance). The investigation identified 22 species of marine algae along with sponges, hydroids, mollusks, crabs, and ascidians, and worm rock (*Phragmatopoma caudata / P. lapidosa*) and describes their abundance along the study area.

A field survey of fishes along the existing Mid-Reach nearshore was conducted in April through August of 2005 (Continental Shelf Assoc., 2005b). As described in **Section 2.3.5.2** and **Appendix K - Subappendix C**, the survey collected a total of 133 cast net samples from 19 locations and timed swims at 12 locations along the Mid-Reach. The survey identified the relative abundance, species richness/diversity, and size class of surf zone and reef fishes.

In addition to these baseline field studies of existing biota, Brevard County developed and installed test platforms upon the seabed to study the recruitment of rock-building worms (*P. lapidosa*) on structures offshore of the Mid-Reach (McCarthy & Holloway-Adkins 2007). See **Appendix K - Subappendix D**. The study likewise investigated the recruitment of algae upon the structures (Holloway-Adkins & McCarthy 2007). See **Appendix K - Subappendix E**. The platforms were placed in water depths of approximately 15 feet, similar to those proposed for the project's mitigation element, offshore of the central Mid-Reach shoreline near FDEP reference monument R-97. The study, referred to as "Propagule and Larval Measurement (PALM)", deployed three 24.7-cubic feet boxes for periods of 45 days and 300 days, respectively, on May 24, 2006 and July 8, 2006. All four sides of each box were equipped with 60 limestone plates at various elevations above the seabed, along with additional limestone/coquina plates on the top of each box. The plates were removed after each deployment to examine the recruitment (abundance) and species of worm settlement and algae growth.

The PALM study found significant recruitment of *Phragmatopoma lapidosa* on the structures deployed in 15-ft water depth offshore of the Mid-Reach. The measured worm coverage on the boxes' plates was about 34% and 4%, on average, during the two sampling periods, respectively (**Appendix K - Subappendix D**). These results compare favorably with the observed occurrence of worm coverage across the existing nearshore rock along the Mid-Reach – previously estimated as between 2.6% and 4.1% in 2001, where the occurrence of “worm rock” along the nearshore area is known to vary significantly between seasons and years. (Olsen 2003). The study likewise found that macroalgae can successfully recruit on concrete, coquina, and limestone surfaces deployed near the seabed in about 15 ft water depth offshore of the Mid-Reach. The total percent cover of algae measured across the test plates was 24.7%, dominated by red, then green algae. Observed algae included six of fifteen red algal species and three of five green algal species previously observed on the existing nearshore rock along the Mid-Reach (Continental Shelf Assoc. 2005a). Twenty-two motile and sessile invertebrate species were additionally found on the PALM surfaces, in addition to incidental observations of about a dozen fish species on and around the structures during one examination (**Appendix K - Subappendix E**). Eleven of the macroalgae and four of the invertebrate species that recruited on the PALM settlement plates were previously identified in the diets of juvenile green turtles captured over the nearshore reef (Holloway-Adkins and Provancha, 2005).

Brevard County developed the mitigation element that is included in the project plan and constructed a small-scale prototype of the structure in April 2006. This mitigation feature is composed of articulated concrete mats with a coquina rock surface, arranged in 0.15-acre parcels, as described herein. This design was developed in response to prior comments from the environmental regulatory agencies which sought a mitigation component that more closely emulated the existing nearshore rock resource (in lieu of conventional placement of limestone boulders atop a foundation structure). Prototype reef-mat blocks were deployed offshore of the Mid-Reach in seabed depths of about -14 ft MLLW. The biotic colonization upon the blocks was subsequently examined by the County’s consultants (Holloway-Adkins 2006) and presented through photographs and video to FDEP.

Practical, physical requirements for the deployment of the project’s compensatory mitigation reef structures were evaluated by Olsen (2007b). See **Appendix K - Subappendix F**. This evaluation included consideration of geotechnical data, spatial density and location of existing nearshore rock, storm impacts and hydrodynamic seabed stability of the reef structures, structure effects upon littoral processes, wave climate and constructability, natural fluctuations of the seabed profile, and public safety. In sum consideration of these factors, the study concluded that the appropriate minimum depth for the deployment of reef mitigation structures along the Mid-Reach shoreline is approximately -14.1 ft MLLW or deeper.

In northern Indian River County, immediately south of Brevard County, 5.24 acres of nearshore reef were constructed between May 24, 2004 and July 27, 2005 to mitigate anticipated impacts to 3.8 acres of nearshore hardbottom associated with a non-federal beach nourishment project. The mitigation structure consists of 4.96

acres of high-relief, high-complexity (HRHC) reef consisting of stacked limestone boulders in water depths of -12 to -16 ft MLLW, and 0.28 acres of low-relief, low-complexity (LRLC) reef consisting of single-layer limestone boulders placed in water depths of -11 to -14 ft MLLW. Annual monitoring of the biotic recruitment associated with these mitigation reefs was completed in the summers of 2006, 2007 and 2008 (Coastal Eco-Group 2007, 2008). While there are differences between the affected environments of the Brevard County and Indian River nearshore rock and mitigation reefs, monitoring data from the Indian River project provided potential insight to the ability of constructed limerock reef structures, in -11 to -16 ft water depths, to replicate the ecological functions of nearshore rock along the central east Florida coastline. Monitoring indicated abundant macroalgal coverage, dominated by red algaes, with greater algal cover across the lower-relief reef, and similar abundance of fishes and juvenile green turtles across the mitigation reef and natural nearshore hardbottom. The presence of silt/mud accumulation adversely affected the presence of reef biota (Coastal Eco-Group 2008).

Detailed Mitigation Assessment Analyses were prepared that address the scale of anticipated impacts to the nearshore rock resources and the compensatory mitigation function of the selected project alternatives. The assessments are fundamentally based upon those originally prepared for the proposed (revised) project and permit application presented by Brevard County. See **Appendix K - Subappendix G** and **Appendix K - Subappendix H**. As noted above, the project described in the County's JCP permit application very closely approximates the nearshore-rock impacts, and replicates the mitigation reef structures, described for the presently proposed project.

The assessments employed both the Uniform Mitigation Assessment Method (UMAM) and Habitat Equivalency Analysis (HEA) (Continental Shelf Associates (CSA) et al. 2006, CSA 2007). The assessment outlines the specific evaluation of the impact and mitigation sites in terms of seven key ecological functions: habitat corridor, water quality, substrate, cover, nesting/reproduction, feeding, and nursery. Each of these seven functions was considered in regard to four major taxonomic groups: macroalgae, invertebrates, fishes (juvenile and adult, separately), and marine turtles. The ecological functions of both the impact and mitigation sites, with particular regard to the hard bottom habitat, were evaluated for both pre- and post-project conditions. When viewed in average-aggregate (grand means), the net gain in ecological function at the mitigation site was found to represent between about 64% and 86% of the net loss at the impact site, with the range in value being associated with the assumption of risk. The UMAM and HEA assessments concluded requisite mitigation ratios of approximately 1.58 and 1.4 acres of compensatory mitigation reef per 1.0 acre of anticipated impacts to nearshore reef, respectively (CSA et al. 2006 and CSA 2007). The summary reports of the analysis were submitted to the regulatory agencies for review. Additional analysis requested by FDEP, and provided by Brevard County, described the anticipated temporal fluctuations in impacts to the nearshore rock associated with the proposed project along with descriptions of prior successful applications of articulated mat structures on the nearshore seabed (Olsen 2008d). Subsequent independent evaluation by FDEP using UMAM, per Rule 62-345 F.A.C., concluded a similar mitigation ratio requirement of approximately 1.6 acres of compensatory mitigation reef per 1.0 acre of anticipated impacts for the County's proposed project; i.e., requiring 4.8 acres of mitigation reef for an anticipated total impact of 2.95 acres (FDEP, 2008). This mitigation ratio of 1.6:1 is accordingly adopted in the evaluation of the selected project evaluation alternatives.

A detailed plan for physical and biological monitoring of the beach fill project area and the mitigation reefs was prepared by Brevard County and submitted to FDEP and the Corps Regulatory Division, on April 30, 2008, in regard to its proposed permit application for shore protection along the Mid-Reach which, as described above, is very similar to that of the selected project alternatives (Olsen 2008d). The principal elements of this plan, modified pursuant to subsequent review and minor revisions by FDEP, are incorporated to the monitoring plan described herein for the selected project alternatives.

Brevard County additionally completed a feasibility study of removing, increasing the treatment of, or decreasing the flow volume from 17 existing storm water outfalls along its shoreline, of which 13 are located along or immediately adjacent to the Mid-Reach study area, and of which most are FDOT owned and operated (Jones Edmunds 2007). Removal or modification of these outfalls (a non-federal responsibility) is a stated concern of the FDEP in its issuance of permits for shore protection projects. In April 2008, the County submitted to FDEP a summary of existing conditions and proposed plan of improvements, and capital expenditure plan, to implement storm water outfall improvements (Brevard County NRMO 2008).

7.2 Effects on Significant Resources

This section describes anticipated changes to the existing environment from the considered and selected project alternatives. See **Table 5-17** for a summary of direct and indirect impacts.

The nature and scope of the recommended project and its effects upon environmental resources does not significantly differ between the NED and Locally Preferred Plan (LPP) presented above. Accordingly, the following discussion does not materially differentiate between the scope or effects of the two projects except in regard to specific numerical discrimination of beach widths or anticipated acreage impacts to nearshore hardground resources, where warranted.

The nature and scope of various project alternatives to the NED and LPP, including these alternatives' effects upon environmental resources, are described in **Section 5**. These alternatives include no-action, shoreline retreat, seawalls and revetments, conventional-scale hydraulic beach fill, coastal structures, larger- and smaller-scale dune- and beach-face fill, and various combinations thereof. Because these alternatives are concluded to have unacceptable adverse impacts to environmental resources and/or do not meet the project objectives, for reasons described in

Section 5, their effects upon significant environmental resources are not specifically described in this section, excepting the No Action alternative, as appropriate.

7.2.1 General Environmental Effects

7.2.1.1 Principal Elements of Proposed Actions (NED and Locally Preferred Plans)
Both the NED Plan and Locally Preferred Plan (LPP) include the following principal project elements:

(a) hydraulic excavation of beach-quality sediment, by hopper dredge, from the Canaveral Shoals I or II offshore borrow areas;
(b) transit of the hopper dredge between the borrow area and Canaveral Harbor;
(c) hydraulic placement of the dredged sediment from the hopper dredge to the Poseidon Dredged Material Management Area (DMMA), via pipeline, to create a temporary upland sand stockpile;
(d) truck-haul transfer of stockpiled sediment from the DMMA to the 7.8-mile long Mid-Reach project area shoreline;
(e) mechanical (truck-haul) placement of the sediment as dune and/or beach face fill along the shoreline;
(f) construction of nearshore mitigation reef structures; and
(g) project monitoring.

The beach fill consists of initial construction and periodic nourishment of limited dune- and/or beach-face sand placement, as summarized below and indicated in **Table 7-1** and **Figure 7-1**:

NED Plan:
Reach 6: dune-only fill
Reach 5: 10-ft design widening of the beach plus advance nourishment;
Reach 4: dune-only fill;
Reach 3: 30-ft design widening of the beach plus advance nourishment;
Reach 2: 20-ft design widening of the beach plus advance nourishment;
Reach 1: 10-ft design widening of the beach plus advance nourishment.

LPP:
Reach 6: dune-only fill
Reach 5: 10-ft design widening of the beach plus advance nourishment;
Reach 4: 10-ft design widening of the beach plus advance nourishment;
Reach 3: 20-ft (design widening of the beach plus advance nourishment;
Reach 2: 20-ft design widening of the beach plus advance nourishment;
Reach 1: 10-ft design widening of the beach plus advance nourishment.

Advance nourishment, where indicated, consists of an approximate additional 10-ft widening of the beach beyond the design width. Beach fill placement for the NED and LPP is identical except along Reaches 3 and 4. Periodic nourishment would be accomplished in approximately 3-year cycles. Replenishment of the DMMA upland stockpile, by hopper dredge, would be accomplished in approximate 6-year cycles to correspond with hydraulic-fill nourishment of the North or South Reach portions of the federal shore protection project. Additional information is included in **Section 6.3**.

In the event that there is insufficient stockpiled material within the DMMA site for project nourishment, then use of beach-compatible sand from alternate upland sources may be used as a temporary, supplemental source of beach fill material. This instance is not anticipated, but it could arise in the event of emergency, post-storm conditions whereby storm erosion requires prompt replenishment of at least a portion of the project's dune and beach-face fill. Use of supplemental upland sand sources would require that the material conforms to all applicable State of Florida standards and that its use is specifically pre-approved by the FDEP.

Table 7-1: Summary of beach fill plans and anticipated nearshore rock impacts.

Reach Limits				Dist. to stockpile site (miles)	NED PLAN					
								Impacts to Nearshore Rock (Acres)		
Reach	FDEP Monuments		Length (ft)		Design Fill Template	Initial Nourishment Volume (cy)	Periodic Renourishment Volume (cy)	Design Template	Advance Template	Total*
1	R119 -	R109	**9,599**	**24**	10'	148,000	34,000	0.2	0.2	0.3
2	R109 -	R105.5	**3,406**	**22.7**	20'	84,000	16,000	0.4	0.2	0.5
3	R105.5 -	R99	**6,239**	**21.7**	30'	162,000	28,000	0.8	0.3	1.1
4	R99 -	R93	**5,603**	**20.7**	dune	15,000	15,000	0.1	0.1	0.2
5	R93 -	R83	**9,029**	**19.4**	10'	103,000	43,000	0.3	0.6	0.9
6	R83 -	R75.4	**7,207**	**18**	dune	18,000	18,000	0.0	0.0	0.1
TOTAL	R119 -	R75.4	41,083			**530,000**	**154,000**	**1.8**	**1.2**	**3.0**

Reach Limits				Dist. to stockpile site (miles)	LOCALLY PREFERRED PLAN					
								Impacts to Nearshore Rock (Acres)		
Reach	FDEP Monuments		Length (ft)		Design Fill Template	Initial Nourishment Volume (cy)	Periodic Renourishment Volume (cy)	Design Template	Advance Template	Total*
1	R119 -	R109	**9,599**	**24**	10'	148,000	34,000	0.2	0.2	0.3
2	R109 -	R105.5	**3,406**	**22.7**	20'	84,000	16,000	0.3	0.1	0.4
3	R105.5 -	R99	**6,239**	**21.7**	20'	135,000	28,000	0.5	0.3	0.8
4	R99 -	R93	**5,603**	**20.7**	10'	85,000	25,000	0.3	0.2	0.5
5	R93 -	R83	**9,029**	**19.4**	10'	103,000	43,000	0.3	0.6	0.9
6	R83 -	R75.4	**7,207**	**18**	dune	18,000	18,000	0.0	0.0	0.1
TOTAL	R119 -	R75.4	41,083			**573,000**	**164,000**	**1.6**	**1.4**	**3.0**

* The total predicted impact represents the maximum (seaward extent) of the anticipated toe of beach fill after cross-shore equilibration and alongshore diffusion. For this reason, and likewise due to rounding, the numeric sum of impacts from the design and advance templates are in some cases different from the numeric value of the anticipated total impacts.

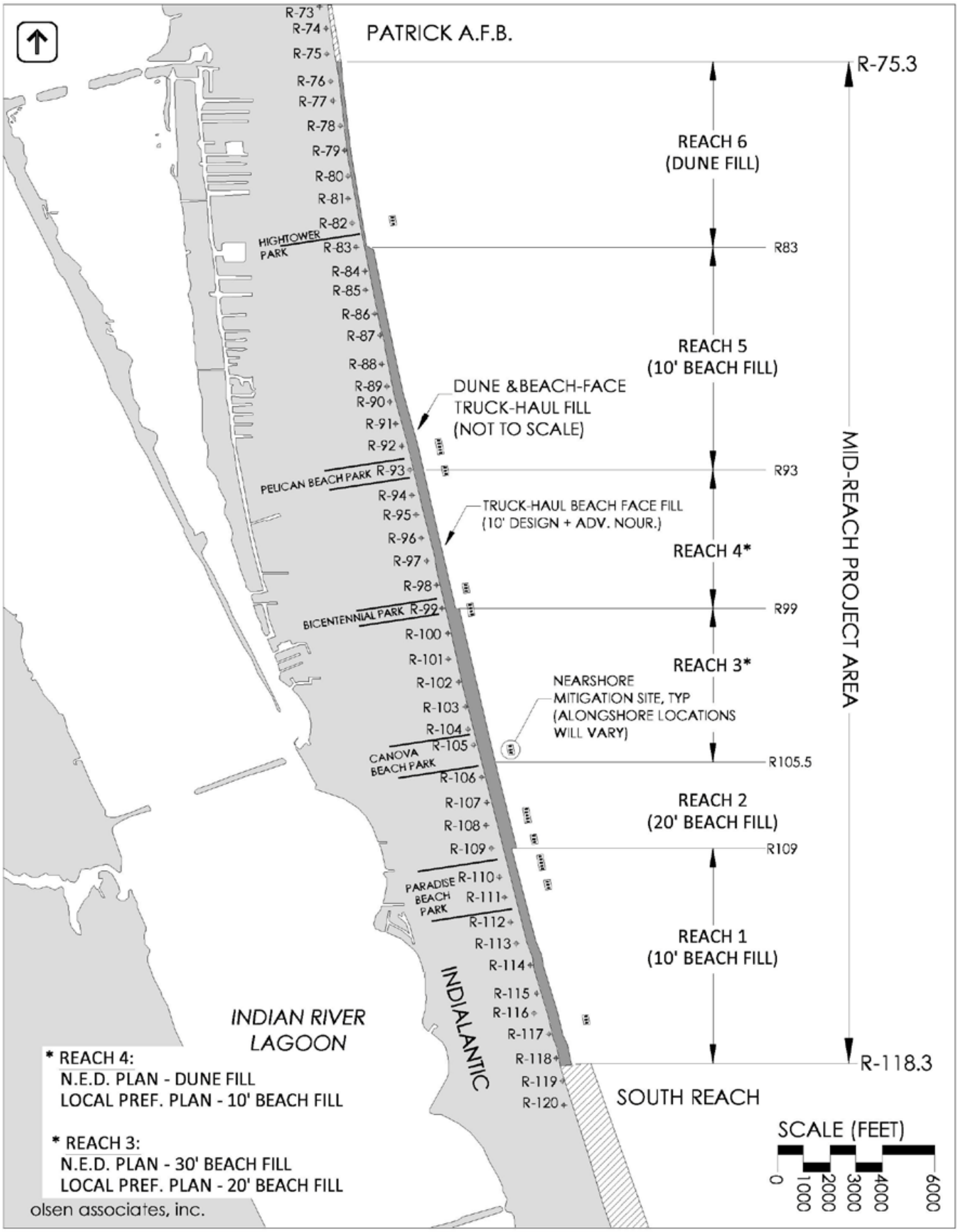

Figure 7-1: Proposed plan along the Mid-Reach project shoreline for the NED Plan and LPP. The beach fill plans (not drawn to scale) are identical for the two plans except along Reaches 3 and 4.

The proposed project monitoring plan is described in **Appendix K - Subappendix J**, which additionally describes the mitigation plan. The monitoring plan takes into practical consideration the challenging physical conditions of the project area in order to develop means and criteria of measurement that are realistically achievable and will result in meaningful data. These conditions include typically turbid water with little or no visibility and consistently energetic surf, in addition to very shallow water and breaking waves that characterize the existing nearshore hardbottom.

A primary objective of the biological monitoring is to assess potential impacts to the existing reef in the Mid-Reach project area and to evaluate the degree to which the mitigation reef replicates the ecological functions of the existing nearshore reef in terms of habitat for the major taxonomic groups, as described in **Appendix K - Subappendix G**. Criteria for measurement and success of the mitigation reef shall be based upon the degree to which the reef is sufficiently physically exposed to serve these ecological functions relative to the predictions made in the project formulation. The monitoring program likewise includes the physical performance of the beach fill and borrow area, by traditional surveys, to assess the longevity and movement of the beach fill (volume and shoreline change) and bathymetric/volume changes at the offshore borrow area. The plan includes measurement of pre-project conditions in order to establish an improved understanding of the natural (baseline) variability of the nearshore rock exposure in existing conditions. Project monitoring shall also includes requisite monitoring of turbidity during hydraulic dredge and discharge activities, observation for marine animals during marine construction activities, daily surveys for marine turtle nesting activity and shorebird activity during and after construction, compaction measurement, and tilling and escarpment removal as necessary.

7.2.1.2 General Effects (NED Plan)

The beneficial effects from the placement of sand fill along the proposed project areas include the establishment of a buffer area for protection against storms and flooding and creation of additional dry beach for recreational activities. The placement of sand may increase sea turtle nesting habitat provided that the sand is highly compatible with naturally occurring beach sediments and that compaction and escarpment remediation measures are incorporated into the project.

Potential negative effects to sea turtles include possible destruction of nests deposited within the boundaries of the proposed project, harassment in the form of disturbing or interfering with female turtles attempting to nest within the construction area or on adjacent beaches, disorientation of hatchlings on beaches adjacent to the construction area as they emerge from the nest and crawl to the water as a result of project lighting, and behavior modification of nesting females due to escarpment formation within the project area during a nesting season, resulting in false crawls or situations where they choose marginal or unsuitable nesting areas to deposit eggs. The quality and color of the sand could 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. However, prior experience with placement of beach fill from the offshore sand sources identified for the present project has indicated sediment quality and nesting success that is equivalent to the natural beach conditions; and the elevation of the dune feature and modest, seaward-sloping berm widths associated with the proposed beach fill are not reasonably anticipated to increase hatchling disorientation associated with beach lighting. Protective measures can additionally alleviate the potential for some of these negative impacts (i.e. nest monitoring and relocation, using minimum and/or shielding construction lighting, compaction monitoring and tilling activities to reduce sand compaction, leveling escarpments prior to nesting season, conducting construction outside of the main nesting season, and conducting daily surveys and avoidance of nesting activities for construction during early or late nesting season).

Adverse effects to shorebirds may occur by harassment during construction and physical impacts to nesting or fledgling animals, and from temporary loss of benthic macroinfauncal invertebrates along areas of beach-face fill, and relocation (concentration) of waterbird feeding to non-affected areas of the shoreline. These impacts are typically temporary, and will be lessened by monitoring during construction and the fact that portions of the project area will include only dune fill placement (versus inter-tidal or sub-tidal placement).

The presence of construction equipment and personnel will temporarily detract from the aesthetics of the beach and temporarily limit recreational beach activity by the public within areas of construction activity. Best management practices will be implemented to ensure efficient construction and the minimization of extended presence of equipment and personnel on project area habitats. Aesthetic impacts due to temporary discoloration of the beach fill sand after placement is not anticipated in the proposed project.

Truck-haul transfer of the sand from the upland stockpile area to the beach project area will increase traffic, add to air pollution, and pose potential additional traffic safety hazards. These impacts will occur in approximate 3-year intervals associated with initial construction and subsequent periodic nourishment of the project, and will require traffic safety management and daylight construction.

Adverse effects to marine mammals and sea turtles from hopper dredging and dredge transit between the borrow area and upland stockpile area at Canaveral Harbor. Avoidance of these impacts will require use of turtle exclusion devices and adherence to other operational practices and limitations on incidental take that are presently mandated by the National Marine Fisheries Service and/or Corps of Engineers.

Adverse effects to southeastern beach mouse, gopher tortoise, indigo snake, and loafing shorebirds may occur from activities attendant to rehabilitation and use of the DMMA upland stockpile area. These impacts may be minimized or avoided through monitoring and relocation.

No significant adverse effects to water quality are anticipated from turbidity associated with offshore dredging, pump-out to the DMMA upland stockpile area, and/or placement of beach fill. Prior dredging and hydraulic discharge associated with the borrow source has not resulted in turbidity measurements that exceed State water quality standards during dredging, open water discharge for seabed rehandling, or hydraulic beach fill placement. The proposed project will place beach fill by mechanical (not hydraulic) means, mostly above the waterline. There are no natural hardgrounds or seagrass resources near the dredge or stockpile areas that would be affected by dredge activities. Effects of hopper dredging at the offshore borrow areas, and placement of sediment to and removal from the upland stockpile area, will be equivalent to prior identical, permitted activities at these sites.

Placement of beach-face fill along Reaches 1, 2, 3, and 5 of the Mid-Reach (comprising 5.4 miles of the 7.8-mile long project area) is anticipated to result in quasi-temporal impacts to the landward edge of existing hardgrounds, through sedimentation or burial, of approximately 3.0 acres of exposed nearshore rock outcrops. This represents approximately 7% of the 42.5-acres of exposed rock along the Mid-Reach and adjacent southern mile of Patrick AFB in 2004 (or, 9.6% of the 31.3 acres of exposed rock along the Mid-Reach only). This predicted impact includes approximately 1.8 acres of long-term (residual) burial of rock associated with the minimum design-fill template that is to be maintained through the period of analysis, plus an additional 1.2 acres of temporal impacts associated with the placement and diffusion of advance fill. As such, the predicted impacts are anticipated to vary from about 1.8 acres to 3.0 acres between 3-year project nourishments. The actual impacts are expected to vary owing to (1) the highly dynamic, natural variations in sediment movement and exposure of the nearshore rock reef, and (2) natural variations in rock relief relative to the thickness of beach fill sand that is transported seaward. Estimated impacts include both cross-shore and alongshore equilibration of the sand fill placement (see **Table 7-1**). No impacts to hardbottom areas are anticipated from pipeline corridors or other elements of hydraulic dredge activities, because all beach fill placement will be by truck-haul from the upland.

The existing nearshore rock hardgrounds occur along and immediately seaward of the beach's mean low water shoreline. The biotic community associated with the rock is therefore acclimated to very high levels of sedimentation and ephemeral burial/exposure of the rock. Chronic sedimentation of a portion of the existing nearshore rock resources by beach fill placement will result in significant, adverse impacts to benthos, epifauna, fishes and waterbirds, and juvenile green turtles (which utilize the rock for foraging and shelter).

The proposed project's construction of 4.8 acres of mitigation reef seaward of the beach fill project area is anticipated to provide compensatory mitigation for environmental impacts to the existing nearshore rock resources. Measurement of macroalgae and worm-rock recruitment in addition to observations of other epifaunal and fish assemblages on prototype structures deployed in the depths and general locations of the proposed mitigation reef, and the proximate ("corridor") location of the reef structures relative to the existing rock resources, provide evidence that the proposed mitigation reef can serve ecological functions of the impacted resource – including those attendant to epifauna and infauna, sea turtles and fishes. These observations are likewise supported by those of somewhat analogous reef structures in nearshore waters in Indian River County, located south of the project area. A comprehensive monitoring program will be employed to assess the physical and biological performance of the mitigation reef as well as the physical performance of the beach fill and its impacts to the existing hardgrounds.

Anticipated project effects to recreational resources are mixed. As noted above, the beach fill placement will increase or maintain recreational beach use along the shoreline area, but with temporary impacts associated with restrictions or interruptions during construction activity. Impacts to the landward edge of the nearshore rock may adversely affect surf fishing; however, the slight landward advance of the beach planform toward the unimpacted rock may partly or wholly obviate these impacts. No significant adverse impacts to surfing are anticipated because of the limited width of the beach fill placement along the shoreline which will not otherwise affect the development of surfable wave conditions which are naturally created further from shore, beyond the effects of the direct placement or equilibration of the sand fill. Likewise, no significant adverse impacts to bathing or swimming are anticipated. The quality of shell collection may be temporarily impeded after initial construction and periodic nourishments. Limited increased opportunities for snorkeling or fishing may occur along the nearshore reef sites (mainly by kayak or boat), for which reasons, the mitigation reef locations are principally proposed seaward of established public beach park areas.

7.2.1.3 General Effects (LPP)

The effects of the LPP are identical to those described above for the NED Plan, with one minor exception. The total impacts to nearshore rock of both the NED and LPP are predicted to be approximately 3.0 acres; however, the long-term (permanent) impacts of the LPP – associated with the design template – are 0.2 acres less than the NED Plan; i.e., 1.6 acres versus 1.8 acres (see **Table 7-1**). Thus, the project's impacts are anticipated to nominally vary from approximately 1.6 to 3.0 acres between nourishment activities. This numeric difference is not considered significant. The principal physical difference between the NED and LPP is that the LPP provides a slightly more uniform planform and profile to the project beach from Reaches 2 through 5, with its quasi-uniform design beach width of 10- to 20-feet along those reaches. This contrasts with the slightly greater discontinuity (perturbation) and attendant diffusion in beach width represented by the NED Plan, which varies from dune-only to 30-ft design beach width along these reaches.

7.2.1.4 General Effects (No Action Alternative)

The no-action alternative would result in neither increased shore protection nor direct impacts to nearshore hardgrounds. Based upon historical measurements, the beach (particularly the dune-bluff) would continue to erode in response to storm activities and result in future losses of upland land and improvements, as well as probable increases in emergency construction of temporary or permanent shoreline armoring for eligible properties. The latter is known to result in progressive loss of recreational beach and habitat, including for marine turtle nesting and shorebird activities. Observation and measurement of the Mid-Reach shoreline subsequent to recent storm impacts since 2004, alongshore transport of sediment from significant sand bypassing and inlet sand management activities at Canaveral Harbor since 1992 and additional significant beach restoration along the adjacent shorelines since 2000-03 – and as supported by other coastal engineering analyses (Kriebel et al, 2003) – present no indication that chronic beach and dune erosion along the Mid-Reach project shoreline will naturally abate in the near future under a No-Action alternative. The degree to which the net, long-term exposure of nearshore rock would change in the future, in a No-Action alternative, is not certain. While it is anecdotally recognized that nearshore rock outcrops existed along the project area during or prior to the 1940's, there are no long-term data by which to quantitatively assess long-term historic changes in the rock exposure or trends thereof.

7.2.1.5 Prior Related Permitted Activities

Placement of dune fill, similar to that proposed for Reaches 6 and 4 in the NED Plan, and for Reach 6 in the LPP, has been previously constructed along most of the Mid-Reach shoreline (and elsewhere along the County shoreline) by Brevard County on three prior occasions; viz., 2005, 2006, and 2008. These were permitted activities pursuant to Dept. of the Army Nationwide Permit 3 [file numbers: Jeanne-IFS-2004-200 (October 27, 2004 amended December 29, 2004, February 28, 2005, March 25, 2005, February 3, 2006, and June 6, 2006); and SAJ-2008-00103(NW-IS) February 1, 2008], and FDEP permits BE-1134 E (March 24 2005), BE-1158 (2006), BE-1210 (Feb. 2008); for which USFWS Biological Opinions were prepared [FWS Log No.: 05-773 (February 24, 2005), FWS Log No.: 05-1054 (May 19, 2005), FWS Log No. 41910-2006-F-0189 (Feb 1, 2006) and 05-1054 (January 6, 2006)]. These activities were constructed in response to erosion from severe storms with partial funding by the Federal Emergency Management Agency (FEMA). Prior, analogous dune-fill activities by Brevard County along Reach 6 included approximately 34,400 cy in 2005, 11,900 cy in 2006, and 16,000 cy in 2008, typically comprising between 3 and 6 cy/ft, more or less, where placed. The scope, methods, and effects of these activities were essentially identical to that proposed in the present activity, except that the source of sand fill was from upland sources.

Similar dune restoration and limited beach face fill has been likewise constructed by the Air Force in 2005, pursuant to shoreline erosion by severe hurricanes in 2004, along the southern 2 miles of Patrick AFB, immediately north of Reach 6. This activity consisted of truck-haul placement of between 5 and 10 cy/ft of sand fill. The sand was dredged from the Canaveral Shoals II offshore borrow area and temporarily stockpiled along the adjacent Patrick AFB shoreline. Annual monitoring along the southern mile of the Base and the adjacent 2000-ft of the northern Mid-Reach, have indicated no net adverse impacts (burial) of the existing nearshore rock resource pursuant to this activity, relative to natural pre-project variations in rock exposure (Olsen Associates Inc, 2008b.)

Both Canaveral Shoals I and II offshore borrow areas are already included as sand sources within the existing authorized Brevard County Federal Shore Protection Project, per the project's original Environmental Impact Statement (USACE, 1996), and subsequent Environmental Assessment and Finding of No Significant Impact (USACE, October 14, 1999). The National Marine Fisheries Service re-evaluated the final EA/FONSI in April 2001 in regard to Essential Fish Habitat and concluded that there were no EFH Conservation Recommendations required (NMFS, April 19, 2001). Subsequent project evaluations in 2005 identified EFH Conservation Recommendations regarding beach fill impacts to nearshore rock but added no recommendations regarding the offshore borrow areas (NMFS, January 13, 2005).

The Canaveral Shoals II (CS-II) borrow area has been previously dredged as a source for beach fill placed along the Brevard County shoreline. This includes initial construction and nourishment of the Brevard County Federal Shore Protection Project, North and South Reaches, in 2000-2003 and 2005, respectively; and, it includes initial construction and maintenance of beach nourishment along the federal shoreline of Patrick AFB in 2000-01 and 2005. These beach fill projects are located immediately adjacent to the Mid-Reach project shoreline. Dredging of CS-II for these projects included a lease agreement between the Minerals Management Service (MMS) and Brevard County, and a Memorandum of Agreement between MMS and the Corps of Engineers, and between MMS and the U.S. Air Force 45th Space Wing. The Canaveral Shoals I (CS-I) borrow area has not been previously dredged.

As of a May 2005 survey, there are approximately 22 million cubic yards of sand available within the permitted limits of the CS-II borrow area (Olsen 2006d). There are at least 16 million cubic yards of sand available within the permitted limits of the CS-I borrow area (USACE 1996). An estimated 573,000 cubic yards would be required for initial nourishment of the Mid-Reach, and an estimated 164,000 cubic yards would be required every three years to renourish the beach (573,000 cubic yards plus 164,000 cubic yards every 3 years, or 17 renourishment events over 50 years totals 3,361,000 cubic yards). These quantities, alone or together, are more than sufficient to meet the 50-year requirements of the existing Brevard County shore protection project, in addition to the proposed Mid-Reach project, along with Patrick AFB. There are no new features or changes in project construction, or other known changes in environmental factors regarding the use of these borrow areas, relative to that described in the existing EIS/EA documentation or prior construction activities.

The Poseidon Dredged Material Management Area (DMMA) has been previously utilized for stockpiling of hydraulically-dredged material (from Canaveral Harbor) and as a subsequent source of sand for beach fill placement along Brevard County (viz., along Patrick AFB). The Poseidon DMMA (also known as the Trident Basin West Spoil Area) is located within a federal facility at the Cape Canaveral Air Station and Naval Ordinance Test Unit. The DMMA is managed by the Corps of Engineers for use as a disposal facility for material dredged from the Canaveral Harbor Federal Navigation Project. Beach-quality material within the DMMA was previously excavated and truck-hauled for placement as beach fill material along Patrick AFB by the U.S. Air Force, in 1998, pursuant to Department of the Army permit 199603789 (IP-TB) (February 1997) and FDEP permit 0176167-001-JC, for which a Biological Opinion was prepared by USFWS on October 24, 1996 (FWS Log No. 97-112).

7.2.2 Vegetation

Beach fill placement activities will occur seaward of existing beach and dune vegetation, which is consistent with anticipated requirements by State and Federal resource protection agencies to limit, to the greatest extent practical, disturbance to existing beach and dune vegetation. Protective measures to be included in the plans and specifications shall limit construction activities primarily to areas seaward of the existing dune vegetation line. Construction access through several locations along the shoreline will result in temporary removal or disturbance of dune and upland vegetation. Project construction will require and include the planting of vegetation, in equivalent density and type (limited to naturally occurring native coastal species), to replace that vegetation that was disturbed for the construction activity. The DMMA (upland stockpile area) includes extensive coverage of invasive exotic species that would be removed, representing a beneficial environmental effect at that location. There are no seagrass communities that would be subject to direct or secondary impacts from the project activities. No significant adverse impacts to vegetation are expected from the proposed activity (NED or LPP). The No-Action Alternative would result in increased or continued erosion of the beach and dune, consequently resulting in increased or continued loss of dune vegetation.

7.2.3 Threatened and Endangered Species

Sections 7.2.3.1 through **7.2.3.7**, following, describe impacts to threatened and endangered species associated with the proposed action. This description includes both the NED Plan and LPP, for which impacts are essentially identical unless otherwise noted. **Section 7.2.3.8**, at the end of this section, describes impacts associated with the no-action alternative.

7.2.3.1 Sea Turtles

7.2.3.1(a) Nesting Habitat

Sea turtles that may occur within the project area are listed in **Section 2.3.3.1**. All sea turtle species are currently listed as endangered or threatened by the USFWS and FWC (**Table 2-6**).

The project area is not identified or labeled as critical habitat for sea turtles. Beaches within the project do, however, provide nesting habitat for loggerhead, green, and leatherback turtles (Meylan et al., 1995). Erosion rates on beaches in many coastal areas are increased by inlets, jetties, and groins, which disrupt normal long shore patterns of sand transport (Pilkey, 1991; Finkl, 1993). This sand loss poses a threat to nesting sea turtles, with most nesting beaches in Florida currently seriously affected by erosion (NMFS and USFWS, 1991). Beach nourishment becomes an important technique for the restoration of sea turtle nesting beaches (Greene, 2002; Crain et al., 1995).

Impact-producing factors associated with the beach nourishment activities affecting sea turtles include the following:

- Disturbance of nesting female turtles by beach nourishment activities;
- Damage to or burial of existing nests during nourishment activities; and
- Effects to nesting females, eggs, and hatchlings from changes in the physical and chemical characteristics of the nourished beach.

Nourishment projects conducted during the nesting season can cause decreased nesting success (Brock et al., 2008; Crain et al., 1995). Gravid female turtles may avoid or be deterred from suitable nesting sites by the presence of equipment during nourishment activities (e.g., trucks, bulldozers, dredge pipelines, etc.), noise from operations, and human activity (NRC, 1995). Existing nests can be covered with excess sand fill during nourishment activities. This compaction may crush eggs or inhibit hatchling emergence by physically impeding their upward crawl through the upper sand layer, though most studies find no adverse effect of nourishment on hatchling emergence (Crain et al., 1995).

Physical and chemical changes induced by nourishment activities can have a detrimental effect on the nesting success of gravid female turtles as well as the survival of and future reproductive contribution of developing embryos and emerging hatchlings. Steep sand scarps may form on nourished beaches when an abrupt transition occurs between the steep fill slope and a flatter, natural offshore slope (Nelson and Dickerson, 1989). Scarping may occur following nourishment while the beach readjusts to a more natural profile. A scarp can prevent female turtles from reaching preferred nesting sites, increasing the numbers of false crawls on the nourished beach (Nelson et al., 1987; Steinitz et al., 1998; Herren, 1999; Rumbold et al., 2001). However, studies have shown that nesting turtles' responses to a beach scarp vary considerably (Nelson et al., 1987). The turtle may dig through the scarp or resort to digging the nest closer to the water where the eggs may be swept away by tides (Bagley et al., 1994; Steinitz et al., 1998). Brock et al. (2008) observed reduced nesting success in loggerhead and green turtles on artificially nourished beaches. This decrease in nesting success was a result of the altered beach profile, which subsequently improved in later seasons (one year for loggerheads and at least one season for greens) as the beach equilibrated to a more natural slope. Nourished beaches are often harder (having increased shear resistance or ability to penetrate the sand) than natural beaches, primarily from the use of angular, finer grain sand dredged from stable offshore borrow sites (Nelson and Dickerson, 1989). This physical change can cause female turtles to abandon attempts at digging nests, leave behind unsuccessful nest cavities (false digs), and prevent nesting females from concealing the nest with a disguising mound of sand, leading to increased nest predation by predators such as raccoons (Ryder, 1991). According to Steimitz et al. (1998), a nourished beach may not become suitable again for turtle nesting in the middle beach zone until 2 to 3 years after project completion, which allows sufficient time for the beach surface to become more penetrable. Other studies have documented times of up to 7 years for the beach sand to return to its normal density (Moulding and Nelson, 1988; Nelson and Dickerson, 1989).

Sea turtles assess potential nesting beaches prior to emerging from the water to nest (Crain et al., 1995). However, the quality of the nesting habitat (e.g., sand grain size, density, shear resistance, color, gas diffusion rates, organic composition, and moisture content) is not an important factor in a turtle's choice of nesting beach. Sediments of finer grain size or those with a high clay or silt content may affect nesting success because of beach compaction or concretion from the drying of newly laid sediments. Compaction also may occur from the use of construction equipment on the beach. Increased compaction has been found to decrease the proportion of crawls resulting in nests, alter nest chamber geometry, and affect nest concealment (Byrd, 2004). Compacted sediments on nourished beaches also may affect gas diffusion and available moisture to sea turtle eggs and have a tremendous impact on egg survival (Crain et al., 1995; Herren, 1999). Increased elevation or width of a nourished beach can potentially increase exposure of the beach and turtles to artificial lighting from the upland and increase disorientation of hatchlings seeking the surf.

When nourished sand is taken from offshore borrow sites, it may have a very dark gray color that could affect ambient sand temperature (as darker sands absorb more radiation than lighter sands). Byrd (2004) found nourished beach temperatures on Hunting Island, South Carolina to be significantly higher than temperatures on a control beach. In sea turtles, sex is determined by temperature during the second trimester of egg incubation; high incubation temperatures during this period produce primarily females and low temperatures typically produce males (Mrosovsky and Ynetema, 1980). Therefore, abnormal sex ratios can be expected if the thermal parameters of a sand fill on a nourished beach differ from the natural beach.

Results of prior annual monitoring of sea turtle nesting activity in Brevard County on beaches nourished in 2000-03 and 2005 with offshore borrow sand from Canaveral Shoals, as proposed for this project, indicate that the fill material is suitable for sea turtle nesting purposes and compatible with sea turtle nesting behavior and hatching success. Along the Brevard County Federal Shore Protection Project, data obtained from nests inventoried during the 2007 season showed excellent loggerhead hatching (83.8%) and hatchling emergence (81.9%) success in the North Reach study area (Geomar 2008). The hatchling success ratio in the South Reach study area was similar and reasonably high for loggerheads (78.25%), green turtles

(70.55), and leatherbacks (66.23%) (Ehrhart and Hirsch 2008). These results were reported to be comparable to many Florida beaches and exceeded documented statewide means of 50.77% for hatching and 48.03% for hatchling emergence success for loggerhead sea turtles (Geomar 2008). These and prior-year data provide evidence of the overall high quality of the fill material as an incubation medium (Ehrhart and Hirsch 2008) which may be attributed to the relatively coarse sand grain size of the fill material that includes well-graded shell fragments which may have prevented the hydraulically placed fill material from excessive compaction that would otherwise adversely affect sea turtle nesting success (Geomar 2008).

Both the NED Plan and LPP include mechanical (truck-haul) placement of beach fill, in approximately 3-year intervals, from the Canaveral Shoals offshore borrow areas that is stockpiled in the DMMA upland disposal site. The material will be placed as dune and beach-face fill as described in **Section 7.2.1** above. Initial project construction is anticipated to require between 160 and 180 calendar days. Subsequent nourishments, at approximately 3-year intervals, will require a much shorter period, most likely between approximately 60 and 90 days.

Collectively, the beach fill activity will result in the increase of current exposed dunes and beach face habitats that will be available for nesting sea turtles. The physical characteristics of the proposed offshore sand source material conform to those of the native beach. Median grain size of sand fill material is estimated to be as coarse or coarser than the native material, with similar carbonate/small-shell content (~ 40%) and fine-sediment content equal to or less than the fine-sediment content of the native beach material. Prior monitoring of nesting activity and success in the beach fill material placed along the adjacent shorelines of Brevard County in 2000-03 and in 2005 indicate that the material is suitable for sea turtle nesting behavior and hatching success as noted above.

Activities associated with the placement, spreading, and grading of beach fill are expected to occur only during daylight hours. These activities may periodically disturb gravid female turtles in the project area that are inspecting suitable beach habitat from offshore. Daylight construction, however, will minimize or mostly eliminate the need and potential adverse effects of construction-related lighting along the beach. At night, construction equipment will be moved to the landward edge of the beach or to the upland off of the beach.

Beach fill placement along portions of the Mid-Reach will result in a finite seaward advance of the beach face and mean high water line (i.e., Reaches 1-3 & 5 in the NED plan and Reaches 1-5 in the LPP). Consequently, there may be some scarping of the beach face by wave action after deposition and grading. This scarp may impede nest building for some nesting females. Because of the small scale of the placed fill, post-construction scarping is anticipated to occur rapidly after construction, and as a mostly acute occurrence, and can be eliminated through post-construction grading before the main nesting season after construction. The similar physical characteristics of the sand fill to natural sand within the project area should minimize effects of beach hardening, concretion, and compaction after deposition.

The project activity will avoid and minimize adverse impacts to sea turtle nesting activity by following recommendations and requirements by USFWS and FWC established for analogous, prior beach fill activities along the adjacent shorelines, including the North and South Reach of the Brevard County Federal Shore Protection Project and Patrick AFB. These measures are summarized in **Section 7.2.34** (Environmental Commitments) and include the following.

Beach fill and construction activities on the beach shall be limited to a 6-month window between 1 November and 30 April. Construction on the beach after 1 March will require that daily early morning surveys for turtles be conducted commencing 1 March and continuing throughout the construction period. Construction activities between 1 and 30 November will require daily early morning surveys for late nesting turtles conducted 65 days prior to project initiation and continued through 30 September. Nests found during these surveys for early- or late-season construction will be marked and avoided, or the eggs will be removed and relocated. Studies by Burney and Mattison (1992) found no significant differences between hatching success of relocated and natural nests, suggesting that this is a viable measure for reducing nest failure on beaches scheduled for nourishment activities. Compaction measurements of the placed fill will be made annually after construction and areas found to exceed stipulated compaction criteria shall be tilled prior to nesting season. Escarpments that interfere with marine turtle nesting activity shall be leveled prior to nesting season, and if observed, may be leveled during nesting season after concurrence of USFWS and FWC. It is anticipated that annual monitoring of nesting activity and success along the affected area will be conducted pursuant to requirements by USFWS and/or FWC.

Collectively, these mitigation methods (i.e., nesting season avoidance and daylight operations), combined with turtle surveys before and during the proposed activity and the relocation of established nests will minimize impacts from the proposed activity on nesting adults (disturbance and avoidance of nesting beaches) and established nests within the project area.

There are no significant differences between the anticipated effects of the NED and LPP to sea turtle nesting activity. Along Reach 3 (6239 ft), potential escarpment formation from the NED Plan (30-ft design fill) is relatively greater than from the LPP (20-ft design fill). This effect may be partly offset along Reach 4 (5603 ft), whereby potential escarpment formation from the NED Plan (dune fill) is relatively lesser than from the LPP (10-ft design fill).

In summary, the placement of fill on dune and beach face habitats associated with the NED Plan and LPP will largely occur outside of the turtle nesting period, thus reducing potential direct impacts to nesting females and nests from nourishment activities. These activities may, however, disturb some early or late season nesting females, during which daily beach surveys will locate existing nests within the project area. The nests will be excavated and the eggs removed and transferred to a suitable alternate location. The deposited fill may subsequently form a scarp on the beach face until the nourished slope readjusts to the natural profile. The scarp may turn away some females during the subsequent nesting season. Lastly, the physical characteristics of the deposited fill may require a season to adjust to levels of the natural beach sand. These negative impacts are considered adverse, but not significant to individual nesting sea turtles, and are not likely to adversely affect or jeopardize the existence of a listed turtle species. The activity will, however, ultimately result in a substantial increase in suitable nesting habitat for sea turtles species within the project area.

7.2.3.1(b) Nearshore and Offshore Habitat
Marine turtles are present in the open ocean, in and around the project area, year-round (see **Section 2.3.3**). Relatively warm temperatures and hard bottom habitat provide suitable foraging and shelter grounds for several marine turtle species. The most frequently encountered species are green (*Chelonia mydas*) and loggerhead (*Caretta caretta*) sea turtles. The leatherback sea turtle (*Dermochelys coriacea*) is occasionally observed in waters beyond the hard bottom substrate and juvenile hawksbill turtles (*Eretmochelys imbricata*) have stranded in the area.

Several nearshore hard bottom areas on the east coast of Florida have been identified as juvenile green turtle developmental habitat in Brevard (Holloway-Adkins and Provancha 2005), Indian River (Ehrhart et al. 2001b), St. Lucie (Bresette et al. 1998), Stuart (Inwater Research Group 2005a), Palm Beach (Makowski et al. 2006b), and Broward (Wershoven and Wershoven 1992a, Makowski et al. 2006a) counties. Studies conducted in Brevard County since 2003, clearly identify the nearshore rock resources in the Mid-Reach area as important habitat for a relatively large population of small size-class juvenile green turtles (Holloway-Adkins 2005a, Holloway-Adkins and Provancha 2005, Holloway-Adkins 2006)

Juvenile green turtles utilize the project area as developmental habitat in which they forage, rest and seek protection from predators. Their main food resource, macroalgae is locally and temporally abundant in this area. Green turtles forage mostly on red algae, which are the most abundant algae on the nearshore reefs (Holloway-Adkins and Provancha, 2005). Juvenile green turtles were observed sleeping or hiding under ledges. Relief as low as 6 inches appeared to provide a reprieve for turtles whereby they could periodically take shelter from high-energy waves while foraging for macroalgae in extremely shallow waters. This activity would also serve to provide protection from large predators.

Juvenile green turtles in this area are unique in that they represent the smaller size-class end of juvenile green turtle populations on the east coast of Florida (mean 35.8 SCL). Additionally, no individuals captured from this area have been found with fibropapillomatosis or FP; a potentially debilitating disease. FP is found in nearly all juvenile green turtle populations on the east coast of Florida, especially in estuarine environments.

Both the NED Plan and LPP will place beach fill along the beach face, below the dune line, along portions of the project area; specifically Reaches 1-3 and 5 in the NED Plan, and Reaches 1-5 in the LPP. The placement and subsequent cross-shore equilibration of this sand fill will result in sedimentation and/or partial burial of the portions of the existing nearshore rock resources along the beach, anticipated to be mostly along the landward edge. This will result in a loss of intertidal habitat and will impact the growth of macroalgae and certain life history stages of invertebrates, fish, and marine turtles. Placement of dune fill along Reach 6 is not anticipated to result in significant impacts to the nearshore hard bottom resources along the majority of that 7200-ft long shoreline. Placement of only dune fill along Reach 4 (in the NED Plan) versus limited 10-ft wide design beach-face fill (in the LPP) will not wholly eliminate impacts to the nearshore rock along Reach 4, comprising about 5600-ft of shoreline. This is due to subsequent, anticipated migration of sand from beach-face fill along the adjacent reaches. (Specifically, net impacts to the nearshore rock in Reach 4 are predicted as about 0.1 acres in the NED Plan versus 0.2 acres in the LPP. See **Table 7-1**.)

The subsequent equilibration of sand from the beach fill will not interfere with the activities of adult female loggerhead (*Caretta caretta*), green (*Chelonia mydas*) or leatherback (*Dermochelys coriacea*) turtles. The nearshore area appears to function strictly as a corridor to the adjacent nesting beach for these animals. Marine turtles are infrequently associated with open sand bottom habitat and are predicted to avoid the project areas where sand will be deposited.

Connections between adjacent hard bottom segments will be severed in some isolated areas where the existing exposed rock occurs very close to shore and where a sandy void is created by the placement or drift of sand over hard bottom habitat. Burial of hard bottom habitat results in the burial of attached macroalgae, the predominant food resource for juvenile green turtles in the Mid-Reach. Hard bottom acreage and relief will be reduced in the intertidal areas of Reaches 1 through 5 (Reaches 1 through 5 in NED alternative). Additionally this burial removes the shelter once provided by the hard bottom outcrops.

Soft bottom habitat created at the site of impact through dredge and fill activities can potentially increase some loggerhead turtle food resources (e.g., soft bottom invertebrates) at the impact site. Immature loggerhead turtles may forage at the impacted site on soft bottom benthic organisms that recruit to the area. However, given that these areas are relatively shallow and loggerhead sightings were altogether infrequent in the Mid-Reach, it is unlikely that the shallow intertidal waters will be used by loggerheads in this capacity.

Juvenile green turtles recruit to nearshore habitats at approximately 20.0 to 30.0 cm SCL (Carr, 1987; Hirth, 1997). The average size class (35.8 SCL) and size distribution of turtles in the Mid-Reach indicate these animals represent a relatively smaller-sized population of juvenile green turtles when compared to other population studies on the east coast of Florida (Bresette et al., 1998; Wershoven and Wershoven, 1992; Ehrhart et al., 2001; Ehrhart et al., 1996). Shallow, nearshore habitats may prove more beneficial to these relatively small juvenile green turtles than to the larger ones (Redfoot, 1997). Accessibility to resources in this nearshore habitat is easier for smaller animals with the ability to maneuver in the shallows, and may provide a competitive advantage over larger animals.

7.2.3.1(c) Mitigation

The mitigation reef poses little to no change to the nesting corridor for adult marine turtles in the Mid-Reach area nor does it promulgate increased hatchling mortality from predation when placed in 4.6 m (15 feet) water depths (Whelan and Wyneken 2007). The reef will provide additional habitat and close connectivity to adjacent habitats for immature loggerhead and green sea turtles. Many of the same macroalgal species present at the subtidal zone of the Mid- Reach are expected to grow at the mitigation site (Holloway-Adkins and McCarthy, 2007; see also **Appendix K - Subappendix E**). However, the new habitat will provide resources in deeper, relatively calmer waters and may influence juvenile green turtle recruitment size. The structural design of the mitigation reef was planned to create small crevasses specifically for small turtles to hide and rest in, and may help offset potential intraspecies competition.

The materials and structural design for the proposed mitigation reef emulate the nearshore hard bottom habitat (see **Section 7.2.4**). However, the location and depth of the mitigation reef is not expected to replicate all of the impacted intertidal habitat functions (see **Appendix K - Subappendix G and Subappendix H,** Mitigation Assessment Analyses). This assessment was incorporated in the development of the mitigation plan. Research and monitoring of structure placed seaward of the Mid-Reach and Indian River County, to the south, indicates that several of the same species of macroalgae found in the diet of juvenile green turtles grew on artificial substrates placed at proposed mitigation depths (Holloway-Adkins and McCarthy 2007; Coastal Eco-Group Inc. 2008). Differences in macroalgal species composition between natural intertidal and mitigation reef sites are expected to be similar to differences between the existing intertidal and subtidal hard bottom areas.

7.2.3.2 Birds

Bird species that are currently listed as endangered or threatened species by the USFWS and FWC and may occur within the project area are listed in **Section 2.3.3.2**. The project area is not identified or labeled as a critical habitat for listed birds. Critical habitat is defined by the USFWS as “specific geographic areas, whether occupied by a listed species or not, that are essential for its conservation and that have been formally designated by rule published in the Federal Register.” Further, there are no reports of nesting of listed bird species within the project area.

Impact producing factors associated with the proposed project plans (NED Plan and LPP) to listed birds include:

- disturbance from ongoing dune and beach-face fill placement, pumpout, and grading activities, and
- the loss of benthic macroinfaunal invertebrates within the beach-face fill placement areas that are used as a food source for certain listed species.

Listed species that may visit the project area during the beach nourishment period are likely to be displaced from the target beach(es) by disturbance from ongoing activities. These disturbances may result in temporary displacement, or may result in the abandonment of the target beach area by individual birds.

The assemblage(s) of benthic macroinfaunal invertebrates that will be buried during beach nourishment activities will be unavailable to listed birds as a source of food until the recolonization of the habitat. A study on the effects of beach nourishment on waterbirds and shorebirds in Brunswick County, North Carolina found no significant effect from replenishment on mean bird abundances. Conversely, study data suggested that habitat use by these birds might have actually increased at replenished beaches. Waterbird feeding activity, however, declined significantly after replenishment, but overall there was no strong evidence that either shorebird or waterbird feeding activity was altered by replenishment (Grippo et al., 2007).

A study of the effects of beach nourishment activities on the intertidal zone at Bogue Banks, North Carolina (Reilly and Bellis, 1983) found that intertidal and subtidal benthic fauna density and community structure were affected both during and after nourishment activities. Species densities on the nourished beach became zero at the onset of nourishment activities, and recovery largely depended on recruitment from pelagic larval stocks. High turbidities in adjacent nearshore waters associated with these activities may prevent or retard this recruitment.

The recovery of beach benthic fauna within renourished beach habitats occurs through mechanisms such as the vertical migration of existing beach fauna through the sediment overburden, and recruitment of pelagic larvae, juveniles, and adult organisms to the target beach from adjacent areas (Greene, 2002). Historic data suggest that recovery of these areas should occur within one to two seasons following the project, assuming the nourishment material is compatible with the natural beach sediments.

Both the NED and LPP involve the deposition of sand fill to enlarge and/or maintain the dune along the entire 7.8-mile length of the Mid-Reach project shoreline, and to advance the mean high water shoreline (widen the beach face) along portions of the Mid-Reach. The material will be placed and spread mechanically by truck-haul at approximately 3-year intervals.

In the NED Plan, sand fill within Reach 6 and Reach 4 will be limited to dune placement, above the mean high water line. Sand fill along Reaches 1, 2, 3 and 5 will result in the placement of fill along the dune and beach face to produce a 10- to 40-ft seaward advance of the mean high water line (varying in time and location).

In the LPP, sand fill within Reach 6 will be limited to dune placement, above the mean high water line. Sand fill along Reaches 1 through 5 will result in the placement of fill along the dune and beach face to produce a 10- to 20-ft seaward advance of the mean high water line (varying in time and location).

Collectively, either or both activity will ultimately result in the increase of current exposed dune and beach-face habitats that will be available for resting and foraging birds.

Activities associated with the placement and spreading and grading of beach fill are expected to periodically disturb listed birds that are present in the project area. These disturbances are likely to result in the temporary displacement of individual birds from discrete areas of beach fill activities. Since these activities involve noisy and relatively slow-moving machinery that follow somewhat predictable patterns in space and time (activities limited to daylight hours), their impacts to listed birds are expected to be negligible and temporary.

The placement of sand fill on beach-face habitat (Reaches 1, 2, 3, and 5 in the NED Plan and Reaches 1 through 5 in the LPP) will bury and, thus, temporarily destroy benthic fauna on this length of shoreline and may increase turbidity within adjacent nearshore waters. These potential foraging habitats will be made unavailable for listed shorebirds and seabirds that feed within the intertidal zone or within shallow waters. Significant turbidity is not anticipated due to the mechanical (non-hydraulic) nature of the placement and the coarse nature of the fill material (see **Section 7.2.5.1**). Potential turbidity within nearshore waters will subside following completion of the placement of fill. It is anticipated that the sand fill overburden will be rapidly colonized by benthic fauna, and should be restored to background within a season or two.

In summary, the placement of fill on dune and beach-face habitats associated with the NED Plan and/or LPP will temporarily reduce available foraging habitat for listed birds within the project area, and activities associated with this plan may potentially disturb resting or foraging birds. These impacts are considered negligible and temporary, and are not likely to adversely affect or jeopardize the existence of a listed bird species.

7.2.3.3 West Indian Manatee

Mortality data published by the Fish and Wildlife Research Institute indicate a total of 552 manatee deaths in Brevard County from 1998 through 2007, or 17.3% of all Florida counties during this period. Of deaths in Brevard during this period, 20.8% were attributed to watercraft and one death (0.2 %) was attributed to locks/gates, with the number of injuries and fatalities associated with manatees' passage through the Canaveral Harbor locks having been greatly reduced by the introduction of acoustic sensors and manatee protection in the late 1990’s. These values are lower than the corresponding State-wide values (24.7% and 1.7%, respectively).

Manatees are present through the project area waters but are most likely to be encountered or impacted by project activities within the Canaveral Harbor basin. Manatees are most likely to be impacted by support boats moving between the basin and the hopper dredge; and, to a lesser degree, to the movement of the hopper dredge associated with temporary mooring and/or discharge to the DMMA on the north bank of the Harbor.

No significant adverse impacts to manatees are anticipated with proper mitigative precautions that generally include the standard manatee protection requirements, during construction, outlined in **Section 7.2.34** Environmental Commitments.

7.2.3.4 Whales

The presence of whales is described in **Section 2.3.3.4**. One of the primary human caused sources of injury and mortality for right and humpback whales is collisions with vessels. Use of the hopper dredge in approximate 6-year intervals, between the offshore borrow area and the DMMA upland stockpile site, will result in increased vessel traffic and increased likelihood of whale/vessel interactions. To best ensure that adverse impacts to whales are avoided during construction activities, the requirements and recommendations in the NMFS Regional Biological Opinion will be followed, as outlined in **Section 7.2.34** Environmental Commitments.

7.2.3.5 Southeastern Beach Mouse

No significant adverse impacts to southeastern beach mouse along the beach fill project area are anticipated (see **Section 2.3.3.5**). While southeastern beach mice are encountered at Cape Canaveral Air Station (CCAS), the DMMA upland stockpile site is located along the north bank of the harbor and substantially separated from the beach and dunes. Environmental staff at the facility familiar with management of the species at the CCAS indicate that no significant effects to the southeastern beach mouse are anticipated in conjunction with the proposed use of the DMMA.

7.2.3.6 Gopher Tortoise

Gopher tortoise will be impacted by construction activities associated with the DMMA at the Cape Canaveral Air Station (CCAS). Measures to minimize impacts to gopher tortoises shall include monitoring and relocation, conducted by permitted CCAS personnel, as outlined in **Section 7.2.34** Environmental Commitments. The affected area will be surveyed for the presence of gopher tortoises approximately 60 days prior to construction activities. Gopher tortoises that are determined to be potentially impacted would be avoided or relocated at CCAS in accordance with the Air Force’s existing tortoise relocation permit (No. WR01103) and the current CCAS Gopher Tortoise Conservation Plan.

7.2.3.7 Indigo Snake

The Eastern Indigo snake, of which presence is often associated with the burrows of gopher tortoises, may be impacted by construction activities at the DMMA. Measures to minimize impacts to this snake shall include monitoring and relocation, conducted by CCAS personnel, in conjunction with related actions for the gopher tortoise as described above (**Section 7.2.3.6**).

7.2.3.8 Smalltooth Sawfish

Smalltooth sawfish (*Pristis pectinata*) is currently listed as endangered by the NMFS and may rarely occur within the project area (**Section 2.3.3.8**). Currently, the core of the smalltooth sawfish Distinct Population Segment is surviving and reproducing in the waters of southwest Florida and Florida Bay, primarily within the jurisdictional boundaries of Everglades National Park where important habitat features are still present and less fragmented than in other parts of the historic range. Maintenance and protection of habitat is an important component of the recovery plan (NMFS, 2006). Recent studies indicate that key habitat features (particularly for immature individuals) nominally consist of shallow water, proximity to mangroves, and estuarine conditions. These attributes are found within the Indian River Lagoon, but not along the Brevard County Mid-Reach shore.

Impact producing factors associated with the proposed project plans (NED Plan and Locally Preferred Plan) to smalltooth sawfish include noise and turbidity generated by the construction activities. These activities may affect, but are not likely to adversely affect smalltooth sawfish individuals in the project area.

Smalltooth sawfish that may visit the project area during the construciton period are likely to be displaced by disturbance from ongoing activities. These disturbances may result in temporary movement or avoidance of the area.

7.2.3.9 No-Action Alternative

The no-action alternative would not result in significant increased or changed effect to threatened and endangered species listed above, beyond natural existing occurrences, with the exception that the no-action alternative would allow for continued erosion of the beach along the Mid-Reach shoreline. This would potentially result in the reduction of dry beach habitat suitable for successful sea turtle nesting, including increased potential for overwash and inundation of nests, and resultant injury or mortality.

7.2.4 Hardgrounds

Nearshore hardground resources within the project area are discussed in **Section 2.3.4**. These coquina outcrop features of the Anastasia formation parallel the shoreline within the intertidal and subtidal zones, and range from wide expanses of tabular platforms to small, isolated rock mounds that support diverse algae and invertebrate fauna, as well as associated fish species.

Based upon June 2004 mapping, there are approximately 31.3 acres of nearshore hard bottom in a band along the Mid-Reach shoreline, plus an additional 11.2 acres along the adjacent mile of Patrick Air Force Base to the north (see **Section 2.3.4**). **Appendix K – Subappendix I** includes images of the rock coverage along the project shoreline. The extent of the exposed rock area increases with increasing latitude. There are subtidal and intertidal portions of hard bottom along the Mid-Reach. The rock surface supports macroalgae and other epibionts that are important food sources or shelter for fishes of varying life stages. Much of the epibiota is emphemeral and subject to extensive wave scour. Portions of the exposed rock are colonized by the sabellariid worm *Phragmatopoma lapidosa*.

7.2.4.1 Effects (NED Plan and LPP)

Impact producing factors associated with the beach nourishment activities to nearshore hardground resources in the beach fill project area include turbidity and sedimentation. There are no impact producing factors to nearshore or other hardground resources associated with dredging, pipeline placements, or construction of the mitigation reef. This is because (1) there are no hardgrounds in the vicinity of the borrow (dredge) areas or temporary upland sand stockpiling area, (2) placement of the fill material to the beach will be from the upland, by truck-haul, and (3) construction of the mitigation reef structures will be by marine vessels that access the reef area from deepwater, well seaward of and removed from the existing nearshore hardground.

7.2.4.1(a) Turbidity

Turbidity is the cloudiness or haziness of a fluid caused by individual particles, termed suspended solids. Components of beach fill, particularly fine grained sediments of fill deposited along the beach front, may become suspended within nearshore waters due to wave action, creating a visibly turbid plume which may reduce available light to algae for photosynthesis and may physically and/or behaviorally impact invertebrate fauna, particularly sessile (attached) species on the nearshore hard bottom features.

The level of turbidity created during beach nourishment activities will depend greatly on the nature of the sediment removed from the borrow areas (Wanless and Maier, 2007). The physical characteristics of sediment within the offshore borrow areas conforms closely to those of the native beach (fine to medium grain size sand with variable content of carbonate material and coarse shell). The typical composite profile median grain size of native beach sediment is approximately 0.3 to 0.35 mm, with carbonate material fractions ranging from 16% to 54%, with an average of approximately 38%. In comparison, the median grain size of sediment within the CS-I borrow area ranges from about 0.18 to 0.3 mm, with an average of approximately 0.27 mm. The median grain size of sediments within the CS-II borrow area ranges from about 0.3 to 0.4 mm, with an average of approximately 0.34 mm. Borrow area cores and samples of in-place fill material from the CS-II borrow area exhibit less than 1% fine sediment fraction.

Turbidity measured within visible plumes during previous hydraulic beach nourishment activities along Brevard County beaches (including the North and South Reaches of the federal shore protection project and along Patrick AFB), from 2000 through 2005, never exceeded State of Florida water quality standards; viz., 29 NTU above background. These turbidity measurements included both the dredge and beach fill placement areas (as well as nearshore seabed sand rehandling areas in 2000-03). Because of the similarities in beach fill and native beach sediment, with fill material generally as coarse or coarser than native material, it is expected that the fill material will not be suspended within nearshore waters from wave action and so contribute to chronic turbidity on nearshore hard bottom resources to any extent greater than existing beach and nearshore sediments. Placement of the fill material to the beach by truck-haul, rather than by dredge pump-out, eliminates hydraulic effluent and therefore likewise minimizes turbidity.
Visual monitoring of the turbidity levels of nearshore waters will be made during the mechanical (truck-haul) placement and spreading of beach fill material. Quantitative turbidity monitoring shall be conducted in the event that elevated levels of nearshore turbidity are visually observed. This approach is consistent with that employed during truck-haul transfer and placement of sand along the southern two miles of Patrick AFB, in 2005, from an adjacent, temporary stockpile of hydraulically dredged sand upon the beach, for which no instances of elevated nearshore turbidity were observed.

7.2.4.1(b) Sedimentation

Sedimentation is the deposition or settling of sediment by mechanical means from a state of suspension in water. Sedimentation caused by the proposed activity will result from the physical placement of sand along the inshore margin of beach face and within nearshore waters along the entire Mid-Reach project area. Sedimentation or direct burial of nearshore hardbottom following the placement, mechanical spreading, and subsequent diffusion of sand will result in an adverse and significant impact.

The approximate seaward limit of the equilibrated sand fill, relative to the exposed nearshore rock, is schematically illustrated in profile view in **Figures 5-6 and 5-7** and in planform view in the plates following the main report. After initial equilibration of the placed fill, the potential impact to exposed nearshore rock alongshore is predicted to be about 3.0 acres, based on June 2004 resource mapping. As the advance fill erodes and the beach width retreats over the anticipated 3-year nourishment interval, nearshore rock buried by sand fill placement will become increasingly re-exposed. When the sand fill recedes to the design condition along Reaches 1 through 5 (up to 10- to 30-ft advance of the high water line, depending upon the alternative and reach location), the anticipated impact to the rock resource is predicted to be on the order of 1.8 acres (NED Plan) to 1.6 acres (LPP).

In order to limit the effects of sedimentation (burial) impacts to the exposed nearshore hardgrounds, placement of beach fill along the project shoreline will be limited to, and/or measured by, a finite prescribed volume of sand per alongshore length of shore; e.g., a specified number of cubic yards of sand per specific 100-ft subreach of shore, etc. This will act to ensure that the volume of sand placed during each construction event does not inadvertently exceed the event's design/contract volume by compensating (replacing) fill material that is eroded during construction.

7.2.4.2 Mitigation

To offset the adverse impacts to nearshore hardgrounds expected through sedimentation, artificial reefs will be constructed. A detailed process was undertaken to determine the necessary mitigation. The proposed reef structure will consist of articulated concrete mats with an integral coquina-rock surface (see **Section 6.3**). The mitigation reef is designed to replicate the physical appearance, texture, relief, and function of the existing nearshore rock resource as closely as practical, while respecting aspects of constructability, hydraulic stability, and geotechnical considerations.

The top surface of the reef mat structures will feature essentially 100% coquina cover with 1" to 4" deep crevices between the coquina stones that emulate the existing nearshore rock. The valleys between blocks, and the overhanging "ledge" on the landward end of a set of units, emulate the physical relief of crevices and ledges within the existing reef. In addition, 16" gaps between the ends of reef mats would provide resting areas appropriately sized for juvenile green turtles observed to rest and forage in similarly-sized crevices on the existing Mid-Reach rock resource.

The specific geometry of the mats within and between each set will be determined by considerations of marine construction equipment, seabed depth and tides, and the objective of installing the reef as shallow as practical. The geometry and alongshore spacing of reef units considers the natural patch dynamics of nearshore hard bottom. The alongshore spacing is similar to that of the existing hard bottom along the southern Mid-Reach. It is intended to create a corridor of readily traversed (yet semi-isolated) reef patches proximate to the existing non-impacted rock.

Jointly, considerations of hydrodynamic stability, construction access, historical sea conditions, natural seabed profile fluctuation, and potential hazards to public safety indicate that seabed depths of about -14 ft mean low water (MLW) or deeper (equating to approximately -17.3 ft North American Vertical Datum) represent the shallowest practical limit of reef construction at this location (Olsen, 2007; **Appendix K - Subappendix F**). Through these detailed considerations, construction of the mitigation reef in shallower water, equivalent to that of the existing, impacted nearshore rock resource, was concluded to be infeasible.

The seabed at the mitigation sites, and generally seaward of the nearshore rock hardgrounds, is typically fine sand with no underlying rock stratum within at least 10-ft beneath the seabed (Olsen et al. 2005). There are no known existing hard-bottoms at or near the proposed mitigation sites, excepting the nearshore rock reefs along the project shoreline. The articulated mat structure serves as the requisite foundation for the sand bottom. Use of such articulated mats (without the special coquina surface) is a standard marine construction practice employed to establish hydraulically stable structures on sand seabeds prone to scour. Successful prior use of similar mattress foundations to stabilize sand seabeds, in conditions of swift currents and high wave energy, include Rudee Inlet, VA; Tybee Island, GA; Ft. Clinch and Amelia Island State Parks, FL; among others (Olsen 2008d).

The efficacy of the proposed mitigation reefs in providing substrata for sessile organisms was assessed through field investigations known as the "Propagule and Larval Measurement (PALM)" study. McCarthy and Holloway-Adkins (2007) found significant recruitment of *Phragmatopoma lapidosa* on limestone and coquina plates deployed on structures in approximately 15-ft water depth offshore of the Mid-Reach near FDEP reference monument R-97. See **Appendix K - Subappendix D**. The study deployed three 24.7-cubic feet boxes in 15-ft water depths offshore of the central Mid-Reach for periods of 45 days and 300 days, respectively, on May 24, 2006 and July 8, 2006. All four sides of each box were equipped with 60 limestone plates at various elevations above the seabed, along with additional limestone/coquina plates on the top of each box. The measured worm coverage on the boxes' plates was about 34%, on average, during the first period sampled (May-July, 2006) and about 4% during the second period sampled (July 2006-May 2007). These results compare favorably with the observed occurrence of worm coverage across the existing nearshore rock along the Mid-Reach – previously estimated as between 2.6% and 4.1% in 2001, for which the occurrence of "worm rock" along the nearshore area is observed to vary significantly between seasons and years (Olsen 2003).

P. lapidosa was the dominant encrusting organism during the first period, among additional encrusting species such as bryozoans, hydrozoans, ascidians and barnacles. During the second period, the PALM boxes were partially buried with sediment and there was high mortality of recruits of various species of encrusting organisms, including bivalves and barnacles. For both time periods, *P. lapidosa* recruitment was greatest on the lowest plates, nearer the seabed. Otherwise, *P. lapidos*a recruitment occurred equally on plates regardless of chemical treatment and plate orientation. It was generally concluded that fluctuations in local hydrodynamic and/or turbidity conditions at the PALM site are "likely creating continual favorable conditions for the settlement of *P. lapidosa* larvae regardless of the effect of plate orientation, height and chemical treatment."

Corollary analysis of the PALM experiment by Holloway-Adkins and McCarthy (2007) indicated that macroalgae can successfully recruit on concrete, coquina, and limestone surfaces deployed near the seabed in about 15 ft water depth offshore of the Mid-Reach. See **Appendix K - Subappendix E**. The total percent cover of algae measured across the test plates was 24.7%. Overall, red algae cover on the plates was 17.8%. Green algae cover was 8.9% (of which 2% overlapped with coverage of red algae). No brown algal species were observed. Recruitment of the macroalgae was not significantly different between the substrate materials tested.

Macroalgae observed on the plates were generally small in size, which may be attributable to (1) new spore settlement and insufficient time to grow, (2) impact by herbivorous animals (suggested by examination of some algae), and/or (3) sedimentation.

In addition to macroalgae, twenty-two motile and sessile invertebrate species were found on the settlement plate and box surfaces. These represented eight species of arthropods, two annelids, three cnidarians, three bryozoans, and six mollusks. The study was not designed to measure fish species; however, notation is made of about a dozen fish species incidentally observed on and around the PALM boxes during one examination, including by common name: sand perch (*Diplectrum formosum*), sea bass (Centropristis striatus), drum (Pareques sp.), molly miller (*Scartella cristata*), hairy blenny (adult and juvenile) (*Labrisomus nuchipinnis*), clingfish (*Gobiesox* sp.), saddled blenny (*Malacoctenus triangulatus*), Atlantic spadefish (*Chaetodipterus faber*), porkfish (*Anisotremus virginicus*), leopard sea robin (*Prionotus scitulus*), white grunt (*Haemulon plumieri*), tomtate (*Haemulon aurolineatum*), and lane snapper (*Lutjanus synagris*).

Algal species identified on the PALM plates included six of fifteen red algal species previously observed on the existing nearshore rock along the Mid-Reach (CSA, 2005), and three of five green algal species. Common species between the species observed on the PALM and nearshore rock included *Ulva* sp., *Bryocladia cuspidata*, *Centroceras* sp., *Gelidium pusillium*, and *Gracilaria* sp. Eleven of the macroalgae and four of the invertebrate species that recruited on the PALM settlement plates were previously identified in the diets of juvenile green turtles captured over the nearshore reef. (Holloway-Adkins and Provancha, 2005).

A detailed evaluation of the anticipated extent to which the mitigation reef will replicate or serve the ecological functions of the impacted nearshore hardgrounds is described in **Appendix K - Subappendix G** (Mitigation Assessment Methodology). This assessment evaluated the impact and mitigation sites in terms of seven key ecological functions: habitat corridor, waer quality, substrate, cover, nesting/reproduction, feeding, and nursery. Each of these seven functions was considered in regard to four major taxonomic groups: macroalgae, invertebrates, fishes (juvenile and adult, separately), and marine turtles. The ecological functions of both the impact and mitgation sites, with particular regard to the hard bottom habitat, were evaluated for both with- and without-project conditions. In grand sum, the net gain in ecological function at the mitigation site was assessed to represent roughly 85% of the value of the pre-project impact site, excluding risk. With considerations of time lag and risk factor included, net gains in ecological function at the mitigation site are expected to be on the order of about 64% (or 1/1.6) of the losses at the impact site. This assessment is reflected in the proposed plan to construct about 4.8 acres of mitigation reef in anticipation of 3.0 acres of impacts to nearshore rock (i.e., a ratio of approximately 1.6:1) which is likewise in numeric accord with the results of independent assessment concluded by the Florida Dept. of

Environmental Protection for a project activity with similar impacts that was proposed, but not constructed, along the Mid-Reach (FDEP 2008).

7.2.4.3 LPP versus NED Plan

As described above, the nature and scope of anticipated impacts to nearshore hardgrounds from the Locally Preferred Plan (LPP) are essentially identical to those from the NED Plan. Both plans are anticipated to result in a nominal approximate impact of 3.0 acres to the existing nearshore rock resource. The principal difference is that the temporal impact to hardgrounds associated with the NED Plan is anticipated to vary between 3.0 and 1.8 acres between beach nourishment events, and the impact associated with the LPP is anticipated to vary between 3.0 and 1.6 acres between beach nourishment events. This small difference is associated with the plans' proposed beach fill design along Reaches 3 and 4. The NED Plan includes a 30-ft design fill along Reach 3 (6,240 feet) and dune-fill along Reach 4 (5,600 feet). The LPP includes a 20-ft design fill along Reach 3 and 10-ft design fill along Reach 4.

7.2.4.4 No Action Alternative

The no-action alternative would result in no, or uncertain, effect to the presence of nearshore hardgrounds. As described in **Section 7.2.1.4**, above, it is somewhat likely that future (continued) erosion of the Mid-Reach shoreline in the no-action alternative may result in increased exposure of existing nearshore rock outcrops; but there are no long-term historic data by which to affirm or quantify this presumption.

7.2.5 Fish and Wildlife Resources

7.2.5.1 Infauna

Infauna of the project area were characterized and discussed in **Section 2.3.5.1**. Principally important elements of the infauna are surf clams *Donax* spp. and mole crab *Emerita talpoida*. These species are ecologically significant as forage for shorebirds and surf zone fishes such as pompano (*Trachinotus carolinus*), sand drum (*Umbrina coroides*), and Gulf kingfish (*Menticirrhus saxatilis*). The key impact producing factors affecting the infauna are turbidity and sedimentation.

Turbidity expected for this project was discussed above in **Section 7.2.4**. Turbidity has been shown to affect the growth of mole crabs in mesocosm experiments (Peterson and Manning, 2001) and is assumed to be detrimental in areas where nourishment projects use unsuitable (finer than native beach sand) material. Due to the nature of the dredged material from the Canveral Shoals Borrow area for which prior beach-fill use and analyses have indicated fine sediment fractions of less than 1%, (see below and **Section 7.2.4.1**), turbidity is expected to present a potentially adverse but not significant (long-term) effect on the infuanal assemblage.

Sedimentation caused by the proposed project will result from the physical placement of sand along the inshore margin of beach face and within nearshore waters along the entire Mid-Reach project area. Sedimentation or direct burial of the sandy swash zone in areas where hard bottom is less prevalent (mostly the southern portion of the project area) following the placement, mechanical spreading, and subsequent diffusion of sand will result in an adverse impact to infauna, particularly surf clams and mole crab. Reduction in numbers of these species can affect local populations of surf zone fishes and shorebirds that feed upon them (Peterson and Manning, 2001).

Direct effects of beach nourishment on surf clams and mole crabs have been documented along the North Carolina coast (Versar, 2003; Lindquist and Manning, 2001; Peterson and Manning, 2001; Peterson et al, 2000). These studies (reviewed by Greene, 2002) showed that when grain size decreases and sorting increases as a result of using fill sand that is incompatible with native beach sand, numbers of surf clams and mole crab were substantially reduced in nourished areas relative to control areas. Although population numbers recovered in some areas, other areas neither species populations had recovered after two years (duration of the study). In addition the body sizes of both species in recovered populations on nourished beaches were reduced (Peterson and Manning, 2001).

The “in-place” sedimentary characteristics of the proposed beach fill material, from the Canaveral Shoals borrow area were examined by analysis of sediment samples placed from this borrow area upon the Brevard County Shore Protection Project (North and South Reach) and Patrick AFB in 2000-03 and in early 2005 (Olsen 2005c). Through collection of samples of placed nourishment material every 2000 feet alongshore, the report contrasted the grain size distributions of the borrow source material from the 2005 nourishment, prior 2000-03 beach nourishment construction, and the native (pre-nourishment) beach. The analysis found that (a) the fine-sediment fraction of both the 2005 and prior fill material was less than 1%, (b) the in-place sediment sample gradations closely matched the composite grain-size distributions of the borrow area core borings, (c) the material was slightly coarser than the native beach berm material, and (d) the placed material was homogeneous with little deviation among the in-place beach fill sediment samples.

Thus because of these sedimentary characteristics described above the effects of the project on infauna particularly surf clams and mole crabs will be adverse but not significant leaving potentially small areas unsuitable for shorebird and surfzone fish foraging for less than one season. Recovery should occur in phase with normal seasonal recruitment patterns documented for the project area (Lacharmoise et al., in preparation).

As previously mentioned, a separate Environmental Assessment was prepared for Canaveral Shoals in 1999. In summary, the report concluded that the use of Canaveral Shoals as a borrow site for beach nourishment projects would adversely affect nonmotile invertebrates. However, as dredging would be limited to a relatively small area, species inhabiting bottom areas adjacent to dredged furrows will provide a local recruitment stock. As these organisms are very fecund, the dredged site is expected to quickly recolonize.

7.2.5.2 Fishes

Existing ichthyofauna resources of the affected environment are described in **Section 2.3.5.2**. A complete discussion of project-related effects on fishes is presented in **Appendix K - Subappendix C** (Essential Fish Habitat) and **Appendix K - Subappendix G** (Mitigation Assessment Analysis).

As previously mentioned, a separate Environmental Assessment was prepared for Canaveral Shoals in 1999. In summary, the report concluded that the use of Canaveral Shoals as a borrow site for beach nourishment projects would adversely affect populations of fossorial fish species such as eels, jawfish and gobies. However, with a reasonably anticipated rapid benthic recovery, these impacts are expected to be temporary. More motile species of fish are expected to flee the active dredging site.

7.2.5.3 Birds

Bird species that may occur within the project area are presented in **Section 2.3.5.3**. Impact producing factors associated with the proposed project plans (NED Plan and LPP) include those described in **Section 7.2.3.2**, above.

Bird species that are resident to or those that may visit the project area during the beach nourishment period are likely to be displaced from the target beach(es) by disturbance from ongoing activities. These disturbances may result in temporary displacement, or may result in the abandonment of the target beach area by individual birds. Migratory species depend on winter months to gather and store energy reserves for the breeding season. However, birds that use the target beach for breeding and nesting are more likely to be affected by beach nourishment than those species that use the area for feeding and resting during migration. Repeated disturbances may result in adult nesting birds abandoning nests or nesting sites. Sand placement and grading activities have the potential to crush eggs or hatchlings on or near nests (Greene, 2002).

Impacts from the loss of benthic resources during beach nourishment are discussed in **Section 7.2.3.2** and **Section 7.2.5.1**. The loss of natural, undisturbed shoreline habitat from beach replenishment activities in some areas, such as North Carolina, has resulted in the concentration of many nesting waterbird species at fewer discrete sites, increasing the risk of catastrophic nesting failures (Grippo et al., 2007). Generally, waterbird feeding activity may decline significantly after replenishment. Recovery, however, should occur within one to two seasons following the project, assuming the nourishment material is compatible with the natural beach sediments. Ultimately, habitat use by waterbirds may increase at replenished beaches.

The specific impacts to shorebirds and waterbirds from both the NED and LPP include those described in **Section 7.2.3.2**. Potential impacts will be avoided and/or minimized by daily surveys for shorebirds along the beach fill and DMMA construction sites, during construction, if construction occurs between April 1 through September 1. Buffer zones shall be established around locations where shorebirds have been observed to engage in courtship or nesting behavior, in which construction activities or stockpiling of equipment shall be suspended.

7.2.6 Essential Fish Habitat

Both the NED Plan and LPP will impact Essential Fish Habitat. The placement and subsequent equilibration of beach fill placement below the dune line will result in sedimentation or burial that is predicted to affect approximately 3.0 acres of the 31.3 acres of existing exposed nearshore rock hardgrounds along the Mid-Reach (per June 2004 measurement). As the placed “advance” fill erodes through cross-shore and/or alongshore transport out of the nearshore rock zone, the impact is predicted to reduce from about 3.0 acres to between approximately 1.6 acres (LPP) and 1.8 acres (NED Plan), between 3-year nourishment events. The anticipated extent to which the project’s mitigation reef structure shall serve the ecological functions associated with the displaced nearshore reef structure, as applicable to fish habitat, is described in **Appendix K - Subappendix C** (Essential Fish Habitat (EFH) Assessment) and in **Appendix K - Subappendix G and Subappendix H** (Mitigation Assessment Analysis).

7.2.7 Cultural, Historic and Archaeological Resources

Eight potentially significant magnetic targets (C2-01, C2-02, C2-08, C2-12, C2-13, C2-14, C2-16, and C2-17) associated with the space program, were identified in the proposed Canaveral Shoals I and II borrow area. The targets are divided in two clusters, one in the northwest corner and the other in the south central section of the borrow area. A 300 foot radius “no work zone” will be established around each of the two clusters to protect potentially significant historic properties from the effects of dredging. Because “no work zones” will be established, dredging in this borrow area will not have an adverse effect on potentially significant historic properties. Only two of the anomalies, BC-7 and BC-8, identified within the Mid-Reach are likely to represent a historic shipwreck. Due to the depth of the materials and the nature of the proposed project, the work will have no effect on BC-7 and BC-8. The No Name Shipwreck, 8BR199, was not relocated. The State Historic Preservation Officer concurred with the Jacksonville District’s determination that the proposed project will have no effect on cultural resources listed or eligible for listing in the National Register of Historic Places, or otherwise of historical, archaeological, or architectural value.

7.2.8 Socio-Economic Effects

The principal potential effects to socio-economic resources in the project area are two-fold: (1) socio-economic losses resulting from potential storm damages to buildings and land along the Atlantic coastline, as well as losses in tourism revenue and recreational opportunities resulting from diminishing beach area; and (2) losses in tourism revenue and recreational opportunities resulting from diminished nearshore hardbottom area.

Both the NED and LPP would result in decreased storm damages and increased (or stabilized) beach recreational area, and would likewise result in some loss in nearshore hardbottom area. The latter may adversely impact recreational activities such as surf fishing; but it is not reasonably anticipated to impact snorkeling, diving, boating, surfing or similar activities because the impacts are associated with a small area of the rock along its shoreward, shallowest edge. Swimming and wading may be slightly improved to the extent that there is less relief (hazard) along the shoreward edge of rock; but the net effect is not considered significant. There are no known site-specific studies of the number of persons that utilize the project area for surf-fishing versus other forms of beach recreation.

The use of offshore sand from Canaveral Shoals, temporarily stockpiled to the upland disposal site (DMMA), obviates the requirement to identify and remove acceptable, beach-compatible sources of sand within the uplands. Sand within local upland deposits is limited in availability and it is of important value to other societal uses, such as construction aggregates, drainage, etc. Use of the offshore sand therefore minimizes the diversion of upland sand resources for non-construction activities.

7.2.9 Aesthetics

The presence of construction equipment and personnel will temporarily detract from the aesthetics of the beach. Best management practices will be implemented to ensure efficient construction and the minimization of extended presence of equipment and personnel on project area habitats.

Temporary aesthetic discoloration of the beach fill sand after placement is not anticipated in the proposed project because the hydraulically dredged sand will have previously dewatered and lightened in the upland stockpile area before transfer to the beach. Further, prior experience with placement of the fill material upon the adjacent shorelines of Brevard County has indicated only minor, temporary discoloration, relative to the existing sand, immediately after project construction. (See **Figure 7-2**)

Figure 7-2: Beach fill material from Canaveral Shoals II borrow area (toward right of photograph) placed upon native Brevard County beach (toward left), several days after initial, hydraulic construction in 2001. (Brevard County Shore Protection Project, North Reach.)

7.2.10 Recreation

Anticipated project effects to recreational resources are mixed. As noted above, the beach fill placement will increase or maintain recreational beach use along the shoreline area, but with temporary impacts associated with restrictions or interruptions during construction activity. Impacts to the landward edge of the nearshore rock may adversely affect surf fishing; however, the slight landward advance of the beach planform toward the unimpacted rock may partly or wholly obviate these impacts.

No significant adverse impacts to surfing or related water sports are anticipated because of the limited width of the beach fill placement immediately along the shoreline. The location of the fill placement (above the waterline and/or in very shallow intertidal water), and the small volume of placed fill, will not affect the development of surfable wave conditions. Those conditions are naturally created further from shore, beyond the effects of the direct placement or equilibration of the sand fill. Likewise, no significant adverse impacts to bathing or swimming are anticipated. Where the exposure of nearshore rock is decreased by sedimentation, there will be slightly decreased impediment to bathers that wade below the waterline or swim/body-surf nearshore; however, this benefit to bathers is anticipated to be minor because only a minor fraction of the rock is affected by the sand. The quality of shell collection may be temporarily impeded after initial construction and periodic nourishment events.

Limited increased opportunities for snorkeling or fishing may occur along the nearshore mitigation reef sites (mainly by kayak or boat). For this reason, the mitigation reef locations are principally proposed seaward of established public beach park areas. There is a minor possibility that the presence of the reef structures may affect local wave and surfing conditions (positively or negatively); but this is anticipated to be a nearly negligible, or non-significant, effect because of the depths and modest scale of the constructed, low-relief reef structures.

The no-action alternative will result in increased (or continued) beach erosion and consequent decreased recreation opportunity along the beach. Otherwise, no significant effect to recreation is anticipated.

7.2.11 Coastal Barrier Resources

The project area does not include lands within units identified as part of the Coastal Barrier Resources System (CBRS) or Otherwise Protected Areas. See **Section 2.3.10**.

7.2.12 Water Quality

Impact producing factors to water quality from either the NED or LPP principally include turbidity associated with hydraulic dredging and disposal activities. These activities specifically include hopper dredging at the Canaveral Shoals offshore borrow areas and discharge to the west spoil area (Poseidon Dredged Material Management Area (DMMA)) on the north bank of Canaveral Harbor, both of which affect Class III waters. Both activities have been previously permitted and conducted as part of the Brevard County Federal Shore Protection Project, Patrick AFB shore protection project, and Canaveral Harbor Federal Navigation Project.

Measures shall be taken to measure and minimize turbidity during hydraulic dredging and discharge activities. Hydraulic discharge of the sand to the DMMA will result in seawater effluent from the disposal area to Canaveral Harbor, through water control structures designed to minimize turbidity and sediment entrainment. Monitoring for turbidity shall be as described in **Section 7.2.34** (Environmental Commitments).

The low content of fine sediment (<2%) in the borrow material, and prior experience with hydraulic dredging and discharge of the material, indicates that no significant adverse impacts to water quality are anticipated. Measured turbidity levels in visible plumes associated with dredging and discharge of Canaveral Shoals II borrow material for initial construction and periodic nourishment of the Brevard County Federal Shore Protection Project and Patrick AFB shore protection project, in 2000-03 and 2005, respectively, never exceeded nor approached State threshold levels of

29 NTU above background. Significant turbidity in the waters adjacent to the beach fill project area is not anticipated because (1) the material features a low content of fine sediment, and (2) placement will be by mechanical (not hydraulic) means from an upland stockpile.

Potential impacts to water quality are essentially identical for both the NED and LPP. The no-action alternative would not create situations to cause these potential impacts.

7.2.13 Haxardous, Toxic, and Radioactive Waste

There are no known hazardous, toxic or radioactive wastes in the project areas that would be affected by the chosen alternative actions. There is a potential for hydrocarbon spills with dredging and construction equipment in the area, but accident and spill prevention plans delineated in the contract specifications should prevent most spills. The no-action alternative would not create situations to cause these potential impacts.

7.2.14 Air Quality

The short-term impact from emissions by the dredge and other construction equipment associated with the project will not significantly impact air quality. Exhaust emissions of the construction equipment, both onshore and offshore, would have a temporary effect on the air quality, but no permanent impacts are expected. The no-action alternative would have no impact upon air quality.

7.2.15 Noise

Construction based on the recommended alternatives would temporarily raise the noise level in the areas of the dredge and the beach fill activity on the beach. Construction equipment would be properly maintained to minimize these effects in compliance with local laws. The areas affected by the dredge are several miles offshore and within the Canaveral Harbor. The former is removed from public activity, and the latter is within an existing industrial setting. Noise associated with the beach fill activity includes the transport of sand by truck-haul along the roadways and beach, in addition to mechanical grading equipment and back-up alarms. Beach fill construction activity and the attendant noise impacts would be limited to daylight hours. There would be no noise impacts from the no-action alternative.

7.2.16 Public Safety

Water related activities near dredge operations will be restricted at both the borrow and discharge areas. The borrow areas are located several miles offshore. The dredge discharge area (i.e., the DMMA upland stockpile) is within the boundaries of Canaveral Harbor and the Cape Canaveral Air Station (CCAS) wherein public activity/access is regulated and restricted, respectively. Likewise, public activity/access is restricted from operations associated with removal of sand from the DMMA stockpile area. Accordingly, no significant impacts to public safety are anticipated in relation to the dredging and discharge activities.

The truck-haul transport of sand from the DMMA stockpile area at CCAS to the beach project site, in addition to the transport and placement of sand along the beach project area, presents a potential increased hazard to public safety. This hazard includes both increased truck traffic along the public roadways, the presence of truck transit along the beach, and the placement/grading of the sand. These impacts will be temporary and will occur in conjunction with the initial construction and periodic (3-year) nourishment activities.

As a public safety measure, recreational (public) access to the beach shall be temporarily restricted in the immediate vicinity of (1) beach fill placement and grading activities and (2) points of truck-access (ingress/egress) to the beach. Along those segments of the beach where trucks are transiting between access points and placement points, warnings and flagging shall be placed, operational speeds shall be limited, all equipment operators will provide paramount vigilance for public activity, and public recreational activity that conflicts with the equipment transit will be limited. The number and locations of truck-access points will seek to minimize the length and frequency of required truck-transit along the shoreline.

Identical operations and public safety measures have been previously undertaken in Brevard County during construction of emergency, post-storm dune reparations in 2005 through 2008, and previously by the U.S. Air Force for truck-haul beach fill along Patrick AFB. No accidents or injuries associated with these activities are known to have occurred.

Sand fill from the project is anticipated to partly cover a portion of the exposed nearshore hardgrounds, mostly along the shoreward-most edge (see **Section 7.2.4**). This effect would potentially reduce hazards (injuries) to bathers that result from impact with the rock; however, it is not a significant consideration because only a very small fraction of the existing rock is anticipated to be affected. The hazards (injuries) to bathers associated with the nearshore rock will still exist. The potential attraction for persons to snorkel, dive or kayak amidst the constructed, nearshore mitigation reef may present a safety hazard to those persons, commensurate with similar activities on natural sites. The mitigation reefs are to be placed about 1000 feet from shore, in water depths of about 15 feet more or less, so that persons would have to make a specific or purposeful effort to reach the reef sites, and would not encounter them incidentally. The depths of the mitigation reefs are such that they are anticipated to lay below (and/or seaward of) depths typically reached by surfers.

The no-action alternative would assume continued erosion, allowing the surf zone to advance landward, with the potential of negative impacts to public safety due to storm damage.

7.2.17 Energy Requirements and Conservation

Energy requirements for the proposed alternatives would be confined to fuel for the dredge, truck-haul transport from the DMMA to the Mid-Reach beach fill area, and related labor and construction equipment. Over the period of analysis, the use of sand from the proposed borrow areas would require less energy expenditure than obtaining sand from other anticipated, available sources (see **Section 7.2.21** below). The no-action alternative would allow erosion to continue, and may require significant energy expenditure of on-site preventative measures and post-storm clean-up in the event of a storm event.

7.2.18 Natural or Depletable Resources

The beach quality sand obtained from the borrow areas is a depletable resource. The proposed alternative will result in a permanent removal, or transfer, of sand from the offshore seabed to the nearshore littoral zone along the project beach area. The amount of beach quality sand in the borrow areas will be reduced. Prior surveys have demonstrated volumetric recovery of the borrow area after dredging. This includes deposition of about 653,000 cubic yards of sand within Canaveral Shoals II between May 2003 and August 2004, subsequent to prior dredging of approximately 5,150,000 cubic yards from the borrow area in 2000-2003 (Olsen 2005d). This deposition, however, likely includes sand transported into the dredged area from the adjacent ocean seabed. Given the required volume of the sand over the 50-year period of analysis (on the order of 3 million cubic yards) relative to the available volume remaining in the existing, permitted borrow areas (well over 35 million cubic yards), this impact is not considered to be significant.

The proposed use of sand from the offshore borrow areas for beach fill, in lieu of sand from upland borrow areas, reduces impacts to the depletable sand resources within the upland. That is, local deposits of suitable, available sand from upland sources are much more limited in volume than the local offshore deposits of sand identified for the project. The use of offshore sand therefore increases the likelihood that upland sand sources remain available for other traditional, upland uses.

The no-action alternative will allow the sand in the borrow areas to remain relatively intact, although redistribution will occur with natural cycles and storm events. The no-action alternative will likewise allow sand along the beach area to be eroded and redistributed, reducing the storm protection, recreation and habitat value of the resource along the project area.

7.2.19 Scientific Resources

There are no known impacts to scientific resources associated with the proposed project or the no-action alternative.

7.2.20 Native Americans

None of the proposed project activities occur on land belonging to Native Americans. Therefore implementation of the proposed project will not result in any impacts to Native Americans or land belonging to Native Americans.

7.2.21 Reuse and Conservation Potential

There is no potential for reuse associated with the proposed project activities, therefore this is not applicable to the proposed nourishment project. Energy requirements for the proposed alternatives would be confined to fuel for the dredge, labor transportation, and other construction equipment. The energy conservation potential of the use of sand from the proposed borrow areas – whereby the sand is dredged and placed to the DMMA stockpile area, and subsequently truck-hauled to the beach fill area -- is probably lesser (requiring greater energy expenditure) than obtaining sand directly from other distant upland sources. However, the prevailing experience of Brevard County in 2005 through 2008 has demonstrated that the availability of suitable, beach-compatible beach fill sand from upland sources for beach-fill placement is extremely limited. Additionally, sand of suitable quality for habitat and related State-mandated environmental requirements is limited or inconsistent, located at distances that are significantly further from the DMMA stockpile site, and/or requires mechanical screening that entails additional energy expenditure beyond truck-haul requirements from the DMMA site. While some environmentally-acceptable sand for beach fill placement exists in Brevard County at truck-haul distances that are equivalent to that of the proposed DMMA site (where high-quality offshore dredged sand is proposed to be stockpiled for the project), and which could be used to supplement placement to the Mid-Reach in requisite or emergency conditions, there is no indication that the quality or quantity of such sand resources will meet the long-term requirements of the proposed activity.

7.2.22 Urban Quality

No direct permanent impacts related to urban quality are expected as a result of the proposed project. Implementation of the proposed project would indirectly, positively impact urban quality by (a) conservation of land that would be otherwise lost by storm erosion and (b) an increase in the capacity for recreational beach activity, which would then lead to potential increase in tax revenue and tourism commerce. The commercial business and residential properties along State Road A-1-A would benefit from the storm protection afforded by the project and incur less risk of property damage. The presence of construction equipment would temporarily detract from the aesthetics of the environment, thereby possibly temporarily affecting the visual aesthetics associated with urban quality. The no-action alternative would assume continued shoreline erosion and reduction of storm protection, and continued loss of recreational beach area with repercussions to tax revenue and tourism commerce.

7.2.23 Solid Waste

No impacts related to solid waste are expected as a result of this project. Precautionary measures will be included in the contract specifications for proper disposal of solid wastes. These precautionary measures include proper containment and avoidance of overflow conditions by emptying containers on a regular schedule. Disposal of any solid waste material into Atlantic waters will not be permitted.

7.2.24 Drinking Water

No municipal or private water supplies are located in or near the project site, therefore drinking water supplies will not be impacted by the implementation of the proposed project.

7.2.25 Cumulative Impacts

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" (40 CFR 1508.7). **Table 7-2** summarizes the impact of such cumulative actions by identifying the past, present, and reasonably foreseeable future condition of the various resources which are directly or indirectly impacted by the proposed action and no-action alternatives. **Appendix J** contains more detailed information of how the cumulative impacts were examined using the 11 steps identified by the Council on Environmental Quality, 1997. ["Considering Cumulative Effects Under the National Environmental Policy Act," January, 1997, Executive Office of the President, Washington, D.C.]

The proposed action, in addition to past projects and any future actions, primarily impacts the sand beach, marine turtle and nearshore hardbottom epibenthic and fish communities, and the offshore sand borrow areas and confined-area upland disposal site, located along the Atlantic Ocean shoreline of central Brevard County, Florida. Of these, beach and nearshore hardbottom are identified as being of greatest (or priority) potential significance from a standpoint of cumulative effects, as described in **Appendix J**.

The geographic scope of the cumulative effects analysis includes the coastline from Cape Canaveral to Sebastian Inlet; viz., about 45 miles of ocean coastline. This includes the coastline comprising the offshore and beach borrow areas (near the north end of this reach), the Mid Reach project area, and the previous, ongoing, and future anticipated beach nourishment activities within the littoral zone that influences – or is influenced by – the Mid Reach shoreline. This likewise includes all of the nearshore hardground area along Brevard County, which encompasses all of the Mid Reach project area and approximately one mile north thereof. The nearest exposed hardground resources occur 18.5 miles or more to the south of the Mid Reach (south of Sebastian Inlet) and well over 22 miles to the north of the Mid Reach (north of Cape Canaveral, or north of Brevard County).

The proposed action will allow for an expansion, or extension, of ongoing beach nourishment and erosion control measures in Brevard County. Specifically, beach-compatible sediment from offshore sand sources will be placed along the 7.8-mile long Mid Reach shoreline in periodic renourishment of about 3 year intervals. The adjacent 13.6-miles of shoreline to the north, comprising Patrick Air Force Base (PAFB) and the North Reach of the Brevard County Federal Shore Protection Project (BCSPP) have been likewise nourished with sand from the same offshore borrow sources since 2000. The adjacent 4-miles of shoreline to the south, comprising the South Reach of the BCSPP have been likewise nourished with sand from the same offshore borrow source (and another offshore source) since 2002. The BCSPP project is authorized through the year 2053, more or less. In contrast to these projects, placement of sand along the Mid Reach, in the proposed action, will be by truck-haul (not by hydraulic discharge) and of significantly less volume and width than that associated with the authorized North and South Reaches of the BCSPP and shore protection along the northern two miles of Patrick Air Force Base.

Directly along the Mid Reach, sand fill has also been previously placed to restore the dune pursuant to severe storm impacts from Hurricanes Charley, France, Jeannie, Wilma and Noel in 2005-08. The source of this sand fill has included upland sources, from which it is increasingly difficult to identify environmentally suitable, beach-compatible sediment. In addition, periodic bypassing of sand across Canaveral Harbor, as well as nearshore disposal of maintenance-dredged sand from Canaveral Harbor Entrance, has been conducted since 1995 and 1992, respectively. These activities (in addition to the construction of jetty improvements at the Entrance in 1995-2005) are anticipated to continue into the indefinite future. These activities are intended to mitigate ongoing and future littoral impacts of the Harbor upon the beaches to the south, but are neither intended nor anticipated to mitigate historical, present or future beach erosion along the Mid Reach project area (Kriebel et al., 2002). Prior and anticipated future sand placement activities along all of Brevard County are summarized in **Table 7-3**.

The scope of the proposed action along the Mid Reach is consistent with these prior and adjacent actions with the exception that the proposed action will result in impact (sedimentation or sand burial) to about 3 acres of existing nearshore hard bottom. Specifically, prior placement of sand to restore the eroded dune along the Mid Reach (and adjacent southern shore of PAFB) was limited to placement above the high water line, so as to not to impact the nearshore rock resource. Additionally, the fill to be placed along the Mid Reach, through the proposed actions, shall be from the same offshore sand sources utilized for the prior (and ongoing) BCSPP and PAFB beach nourishment projects. The northern 1.4 miles (approximately) of the Mid Reach shoreline ("Reach 6") will receive sand placement only above the wave zone, along the dune. The remaining 6.2 miles (approximately) will receive sand placement and/or anticipated diffusion of sand, both above and below the high water line, resulting in temporal impacts to the existing nearshore rock. Mitigation reefs shall be constructed to compensate for losses associated with these impacts. Prior mitigation reefs have not been required, nor constructed, in Brevard County for these purposes.

With-project effects to the borrow area and upland disposal area will be identical to those of past, ongoing, and future activities. The proposed offshore sand source(s) for the proposed activity is (are) identical to those included in the project descriptions and permits for the existing projects along the North and South Reach of the BCSPP and Patrick Air Force Base. Future dredging (beach fill) requirements for these two projects -- through the 50-year life of the former -- are anticipated to total about 10 to

12 million cubic yards, more or less. The anticipated total dredging (beach fill) requirement for the proposed project along the Mid Reach, over its 50-year life – is about 3 million cubic yards. The total, future combined dredging (beach fill) requirement for the existing and proposed projects is about 13 to 15 million cubic yards, more or less.

There are currently about 22+ million cubic yards of sand remaining in the Canaveral Shoals II permitted area, plus an additional 16 million cubic yards of sand available in the Canaveral Shoals I permitted area. Both amounts reflect beach-compatible material with little or no requirement for overfill. The total permitted sand quantity in the borrow areas (38 mcy) is about 3 times greater than anticipated, present requirements – leaving ample contingency. All prior dredging activity has occurred at CS-II, totaling on the order of 6.9 Mcy from 2000 through 2005, which includes the construction of nearshore sand rehandling areas for initial construction of the BCSPP in 2000-03. (In addition, about 0.8 Mcy were dredged from Space Coast Shoals II, offshore of southern PAFB, for initial construction of the South Reach in 2002-03. Further dredging of sand from the Space Coast Shoals area, for beach nourishment, is not anticipated.) The abundance of high quality sand in the existing borrow areas, particularly that remaining within the CS-II borrow area, indicates that spatial impacts of future dredging will remain essentially unchanged. Viewed cumulatively, the proposed action will increase the volume of dredging activity, in anticipated (approximate) six year intervals, by about 23%, relative to the existing, estimated requirements of the BCSPP and PAFB beach renourishment projects; however, it will not require changes (expansion) in the limits of the existing sand borrow areas. Dredging-related impacts to the offshore borrow area(s) for the proposed activity is anticipated to occur commensurate and equivalently with other present and future foreseen dredging activities. That is, the gross volume of sand removed from the borrow areas will be increased by the proposed action; but the nature, spatial and temporal extents of the environmental impacts will not be significantly different or greater than the impacts from past, present, and foreseen future activities.

Unlike the existing BCSPP and PAFB beach nourishment projects (which receive the beach fill directly from the offshore borrow area, via dredge placement), the proposed project for the Mid Reach calls for the dredged material to be placed to an upland disposal area, and then transferred and placed to the beach by truck-haul. This action is intended to avoid and minimize burial/sedimentation impacts to the existing nearshore rock hardgrounds along the Mid Reach. (Hydraulic dredge discharge to the beach would result in greater fill placement and nearshore rock impacts than is identified in the selected project alternative.)

In the proposed action, the dredged material will be placed to an existing, confined upland disposal area; i.e., the Poseidon Dredged Material Management Area (DMMA). This area was developed, permitted, and previously utilized for the purposes of receiving and storing hydraulically dredged material. In the past (1998), beach-quality sediment within the DMMA has been removed and placed by truck-haul to the beach adjacent to the Mid Reach – along Patrick AFB – in an activity analgous to that proposed in the selected project alternative. The Poseidon DMMA has not been otherwise recently utilized for the disposal or removal of dredged material. The Corps of Engineers has determined that its use as a temporary stockpile area for the Mid Reach shore protection project will not compromise dredged management storage requirements for the Canaveral Harbor federal navigation project. Expansions to existing dredged material management areas are therefore not expected to be required as an incremental result of the proposed action.

The developed shoreline in Brevard County, between the Canaveral Harbor Entrance and Sebastian Inlet, is about 40-miles long and is currently managed by non-federal and/or federal interests. Brevard County, with cost-share from the Federal Emergency Management Agency (FEMA) and the State of Florida, has previously placed sand along the Mid Reach, above the high water line, in emergency actions to repair dune erosion caused by hurricanes. In the proposed action, the placement of beach fill to maintain the dune and/or beach face along the Mid Reach will increase the length of shoreline that is actively managed by federal interests (the Corps of Engineers and Patrick AFB) from 17.6 miles to 25.2 miles. The proposed action does not add to the length of shoreline that is managed; but it modifies the scope and responsibilities of the management. It increases the length of shoreline upon which sand is placed upon (or affects) the intertidal beach face, below the wave zone, by about 6.2 miles (viz., Reaches 1 through 5 of the Mid Reach) and it likewise increases the volume of sand that is placed to the Brevard County shoreline, via initial construction, sand bypassing and periodc renourishment. Excluding emergency post-storm dune restoration, current bypassing and periodic renourishment volumes along Brevard County, south of Canaveral Harbor, total about 388,000 cy/yr. (This is comprised of about 238,000 cy/yr for North Reach BCSPP (which includes sand bypassing), 50,000 cy/yr for Patrick AFB (estimated), and 100,000 cy/yr for South Reach BCSPP). After initial construction of between 530,000 and 573,000 cy (approximate), the proposed activity would increase periodic renourishment by between 51,000 and 55,000 cy/yr, more or less; or, by about 10% above current requirements.

Monitoring of previously constructed beach renourishment projects since 2005, immediately along and adjacent to the nearshore rock hardgrounds of the Mid Reach and Patrick AFB, has indicated no net impact to the exposed rock resource. (**See Appendix K – Subappendix I**.) The measured locations of exposed rock fluctuate at levels equivalent to the pre-nourishment [baseline] conditions, and there has been no apparent trend in changes to the spatial occurrence or net amount of exposed rock hardgrounds, relative to pre-renourishment [baseline] conditions. These results are based upon monitoring surveys and analyses conducted pursuant to EFH conservation recommendations by the National Marine Fisheries Service in December 2004, in regard to the placement of beach fill material along Patrick AFB and the South Reach BCSPP, immediately adjacent to existing nearshore hardgrounds in Spring, 2005. Similar monitoring of exposed nearshore rock occurrence along the Mid Reach has indicated no apparent or significant change in rock exposure subsequent to post-storm dune restoration, by the County, in 2005-08. (**See Appendix K – Subappendix I**.)

Excepting the Corps of Engineers' mapping estimates of rock exposure along the Mid Reach in 1995 (USACE 1996), comprehensive (systematic) and quantitative surveys of the occurrence of exposed nearshore rock outcrops are not available prior to 2001. The amount of exposed rock along the Mid Reach, based upon aerial photographic surveys varies from about 32 acres in 1995 (USACE 1996) to 51.4 acres in 2001 (Olsen 2003) to 31.3 acres in 2004 (Olsen 2005). The earliest of these three surveys, in 1995, was prior to the inception of the BCSPP and coincident with the first sand bypass project, which occurred over 10 miles north of the Mid Reach. Repeated transect surveys along the Mid Reach, beginning in 2001, exhibit significant natural fluctuation in the amount and locations of exposed rock along each transect (Olsen 2003). The available, existing data do not indicate that prior or existing beach nourishment/sand bypassing activities are significantly affecting the amounts or locations of exposed nearshore rock outcrops relative to naturally occurring fluctuations. The estimated area of nearshore hard bottoms that may be impacted by the proposed action presume the presence of, and take into account, existing and future anticipated beach nourishment and sand bypassing activity in the County.

The proposed action shall include physical and biological monitoring of the beach profiles, nearshore rock hardgrounds and mitigation reef to assess the impacts to the existing reef and performance of the mitigation reef. (**See Appendix K – Subappendix J.**) The baseline condition will reflect the typical, naturally occurring beach profile and nearshore rock exposure along the Mid Reach (and adjacent 5000-ft of shoreline). The baseline condition will indicate the mean and expected (natural) fluctuation of the beach profiles along the fill-placement area and nearshore rock area, and it will indicate natural, without project fluctuation of nearshore rock exposure.

The no-action alternative will allow for continued erosion of beaches, increasing the potential for storm related property damage and decreasing property values. No adverse environmental impacts to nearshore hardbottom habitats and fish or related communities are anticipated in the no-action alternative. Continued beach erosion could increase the exposure of nearshore hardbottom in the future, which could provide increased habitat for surf zone fishes and other marine biota. Long-term trends in the amount of natural rock exposure (relative to long-term beach erosion) have not yet been identified. Continued erosion of the beach will impact the existence of existing dune vegetation and associated habitat. Continued beach erosion will also reduce the amount of dry beach available for sea turtle nesting and may result in poor site selection by nesting females. Additional detailed discussion of the anticipated cumulative effects of the proposed action is presented in **Appendix J**.

Table 7-2: Summary of Cumulative Impacts					
ALTERNATIVE ENVIRON-MENTAL FACTOR	Boundary (Same for all)	Past	Present (existing conditions)	Future without project	Future with proposed action
PROTECTED SPECIES	The geographic scope of the area considered includes the coastline from Cape Canaveral south to Sebastian Inlet. The project area is the Mid-Reach shoreline of Brevard County, FL proposed for truck-haul beach fill, encompassing approximately 7.8 miles between Patrick Air Force Base and the South Reach segment of the Brevard County Federal Shore Protection Project. The Canaveral Shoals borrow areas are located between about 2 and 6 miles offshore (southeast) of Cape Canaveral.	Beach fill has been placed along the dune and above the waterline during non-nesting seasons. Turtle nesting (loggerhead, green, and leatherback) on Mid-Reach area beaches has been significantly lower than on South Reach and the South beaches. Seven species of birds listed as threatened or species of special concern may occur along the project area only one nest of one species (least tern) has been reported on the Mid-Reach area beach. Smalltooth sawfish occur in the coastal waters of the area but have rarely been observed.	Turtle nesting by loggerhead, green, and leatherback turtles occurs on Mid-Reach beaches. Juvenile green turtles are commonly observed on the nearshore hard bottom where they feed upon macroalgae. Juvenile green turtles utilize the shallow limestone ledges and relief for resting areas. Tucked away on the inside of ledges, small turtles are able to avoid the pounding surf in the intertidal zone. Many of the ledges are narrow and afford protection from large predators.	Nesting will continue in the area without any direct, secondary, or cumulative effects on either nesting or hardbottom feeding and refuge by young green turtles. Conventional scale beach nourishment will occur north and south of the project area in approx. 6-year cycles (North Reach/PAFB and South Reach) with sand dredged from Canaveral Shoals and bypassed across Canaveral Harbor; and dune fill may be placed from upland sources in response to storm impacts along the remainder of the shoreline.	Potential “take” of sea turtles by alteration of the beach face resulting in impact to nesting and hatching success. Nesting habitat increased and/or maintained after a period of approximately one year (grading of sand fill to a more natural consistency and reduction or elimination of scarping). Relocation of nests in the project area will minimize impacts to hatchlings. Burial and habitat alteration of intertidal zone may reduce available prey (infauna) to a listed birds for a period of up to one season.

Table 7-2: Summary of Cumulative Impacts					
ALTERNATIVE ENVIRON-MENTAL FACTOR	Boundary (Same for all)	Past	Present (existing conditions)	Future without project	Future with proposed action
HARD GROUND		**P**lacement of beach-fill sand resulting in direct impact to the existing nearshore rock hardgrounds of the Mid Reach has not been previously constructed. However, beach fill has been placed along the dune and above the waterline immediately along the rock hardground areas by both the Air Force (2005) and Brevard County (2005-08). Large-scale beach fill has also been placed adjacent to the rock hardgrounds along Patrick AFB (2001, 2005) and the South Reach of the Brevard County Fed. Shore Protection Project (in 2003, 2005). Annual monitoring since 2005 indicates that exposure of the nearshore rock along and adjacent to these beachfill activities – at the south end of Patrick AFB and at the north end of the South Reach – has varied within the range of natural, pre-project fluctuations and has not been adversely impacted by the beach fill activities (Olsen 2008b, c).	Anastasia limestone outcroppings, sabellariid worm rock, and compressed coquina rocks form the substrate on which an abundant and diverse number of macroalgae thrive in the intertidal and subtidal areas of the nearshore. Brown, green, and primarily red algae represent the primary producers in this marine community. Sessile invertebrates including sponges, hydroids, sabellariid worms, and tunicates attach to the coquina limestone substrate. Sabellariid worms form extensive colonies that can spatially dominate the coquina substrate, providing another layer of complexity to the nearshore hard bottom.	No direct or secondary or cumulative effects from sedimentation or turbidity associated with beach fill operations would occur. Ongoing shoreline protection activities will continue in the area, but these have not adversely affected the extent of nearshore hardbottom. Nearshore hardbottom exposure would vary naturally. Organisms would respond accordingly to the natural fluctuations. Dune fill will occur following storms along the Mid-Reach shoreline. Hard grounds do not occur south of the Mid-Reach or significantly beyond 1 mile north of the Mid Reach (along Patrick AFB).	Approximately 3 acres of exposed nearshore hardbottom would experience sedimenta-tion or burial. The absence of substrate after impact will eliminate algal growth in those areas of the nearshore. Direct burial of hard bottom by the proposed project will eliminate hard substrate and its sessile assemblage and replace it with level sand bottom. The new sand substrate will be utilized by infaunal (e.g., polychaete worms, bivalves, and gastro-pods) and epifaunal invertebrates (e.g., swimming crabs, shrimps, and echinoderms), but with no hard bottom substratum, hard bottom sessile species will not be present in the impacted area.

Table 7-2: Summary of Cumulative Impacts					
ALTERNATIVE ENVIRON-MENTAL FACTOR	Boundary (Same for all)	Past	Present (existing conditions)	Future without project	Future with proposed action
FISH AND WILDLIFE RESOURCES		See above	Fishes utilize the hard bottom structure for shelter at several spatial scales. Small solitary individuals use small (ca. 1-10 cm) holes, cracks, and ledges. Larger reef fishes seek shelter under ledges (approx. 10 cm to 1 m in relief) and overhangs formed by the tabular outcrops that occur along the Mid Reach hard bottom. It appears that adult and juvenile fishes congregate under ledges and overhangs seeking shelter not only from predators but also from the constant wave surge. The life stage composition of near-shore hard bottom fish assemblages is generally skewed toward immature individuals. The intertidal and subtidal soft bottom areas support infuanal assemblages dominated by surf clam and mole crab. These species are important as food for soft bottom and migratory fishes. Canaveral shoals borrow area supports benthic invertebrate and fish assemblages.	No direct or secondary or cumulative effects from sedimentation or turbidity associated with beach fill operations would occur. Nearshore hardbottom exposure would vary naturally. Organisms would respond accordingly to the natural fluctuations. Similarly, soft bottom fishes and invertebrates would only be subjected to existing stressors and natural variation in turbidity and sedimentation. Hydraulic dredging and beach fill will occur in approx. six-year cycles immediately north and south of the project area. Dune fill from upland sources may be placed along the project area and South Beaches to repair erosion due to storms. Periodic dredging of Canaveral Shoals and for sand bypassing at Canaveral Harbor will displace benthic fishes and invertebrates.	Following the impact, the approximate 3 acre impacted portion of the nearshore hard bottom cover will be lost to the local system, and fishes utilizing the impact area will mostly be soft bottom and coastal pelagic species. Hard bottom species would be displaced following sand burial of the project site. Depending on mobility of individual species and life stages these fishes will either migrate to adjacent hardbottom areas or perish. Dredging of Canaveral Shoals will displace bottom feeding fishes and invertebrates. Invertebrates will re-colonize dredged areas, but the assemblages formed will differ in species composition from those in adjacent un-dredged areas.

Table 7-2: Summary of Cumulative Impacts					
ALTERNATIVE ENVIRON-MENTAL FACTOR	Boundary (Same for all)	Past	Present (existing conditions)	Future without project	Future with proposed action
WATER QUALITY		The Canaveral Shoal sand source proposed for this project has been utilized previously with no turbidity problems.	Water quality parameters under the present scenario include turbidity, salinity, dissolved oxygen, leachate from septic tanks, and chemical contamination. Upland runoff including leachates from stormwater outfalls may slightly degrade marine water quality during heavy rains. Persistent waves make high turbidity the norm in the Mid Reach area. Eddies and turbulence around rocks may increase turbidity; nevertheless, there is no reason to expect that the current water environment is anything other than optimal for the extant organisms.	Project related turbidity, both acute and chronic would be avoided in the Mid-Reach area. Natural turbidity levels would be maintained and will fluctuate with wave action, tides, currents, and rainfall. Some elevated turbidity could occur following the existing dune fill activities in the Mid-Reach. Storm-related shoreline protection by beach and dune fill north and south of the Mid-Reach as well as hydraulic dredging for these projects will continue to influence turbidity. The Canaveral Shoals borrow site will continue to be used as a sand source for other ongoing shoreline protection projects.	A wider beach may provide better filtering for upland run off, and slightly coarser sediment may reduce turbidity. Elevated turbidity can be temporary or chronic, depending on the sedimentary characteristics of the material placed on the beach. The sand source proposed for this project has been utilized previously with no turbidity problems. With use of a sand source that does not contain higher fractions of fine sediment than the native material, water quality should be the same as pre-construction levels once construction related turbidity recedes. Turbidity at Canaveral Shoals borrow site will temporarily increase during exacavation.

Table 7-2: Summary of Cumulative Impacts					
ALTERNATIVE ENVIRON-MENTAL FACTOR	Boundary (Same for all)	Past	Present (existing conditions)	Future without project	Future with proposed action
ESSENTIAL FISH HABITAT		Placement of beach-fill sand resulting in direct impact to the existing nearshore rock hardgrounds of the Mid Reach has not been previously constructed. However, beach fill has been placed along the dune and above the waterline immediately along the rock hardground areas by both the Air Force (2005) and Brevard County (2005-08). Large-scale beach fill has also been placed adjacent to the rock hardgrounds along Patrick AFB (2001, 2005) and the South Reach of the Brevard County Fed. Shore Protection Project (2003, 2005). Annual monitoring since 2005 indicates that exposure of the nearshore rock along and adjacent to the beachfill activity – at the south end of PAFB and at the north end of the South Reach – has varied within the range of natural, pre-project fluctuations and has not been adversely impacted by the beach fill activities (Olsen 2008b, 2008c).	Species groups managed by the SAFMC and NMFS under EFH include penaeid shrimps, coastal pelagic fishes, red drum, reef fishes, and coastal sharks. Members of these groups occur in the project area for at least a portion of their life history. EFH in the area includes the seafloor and the water column The water column of the area overlays the nearshore and surf zone portions of the project area. Important attributes of the water column include hydro-dynamics, temperature, salinity, and dissolved oxygen. The hydrodynamic regime is driven mostly by persistent ground swells. The primary feature of the seafloor is the nearshore hardbottom area described above under hardgrounds and fish and wildlife resources. Canaveral shoals borrow area supports benthic invertebrate and fish assemblages,	There would be no effect of turbidity and sedimentation on the water column or hardground areas as described above. Project-related turbidity, both acute and chronic would be avoided. Ongoing shoreline protection projects within and adjacent to the Mid-Reach will continue to influence turbidity. The seafloor of Canaveral Shoals will continue to be affected by ongoing dredging projects. Loss of soft bottom habitat used by bottom feeding fishes will continue, as will turbidity elevated during dredging.	Following the impact, hard bottom cover will be lost to the local system, and fishes utilizing the impact area will mostly be soft bottom and coastal pelagic species. There will be few, if any, reef fishes that regularly seek or use cover provided by the hard bottom features remaining in the impact area. Increased requirement for dredged material from the the Canaveral Shoals borrow sites will increase the length of time that seafloor areas (used by bottom feeding fishes) will be disturbed and turbidity will be elevated.

Table 7-3: Prior beach fill activities in Brevard County

Date	Location		Volume cu. yds.	Sand Source
	Description	FDEP R-Monuments		
1972	City of Cape Canaveral	0-14	200,000	Beach north of Canaveral Harbor
1974	City of Cape Canaveral	0-14	2,850,000	Excavation of Trident Basin
1980	Indialantic/Melbourne	126-136	540,000	Upland [truck-haul]
1992	Cocoa Beach *	28-31	79,000	Canaveral Channel – maint. dredging
1993	Cocoa Beach *	28-31	50,000	Canaveral Channel – maint. dredging
1994	City of Cape Canaveral	5-11	100,000	Port Canav. – terminal constr. [truck-haul]
1994	Cocoa Beach *	28-31	68,000	Canaveral Channel – maint. dredging
1995	City of Cape Canaveral Sand Bypass I	0-8	783,000	Beach north of Canaveral Harbor (CCAS)
1995	Cocoa Beach *	28-31	122,000	Canaveral Channel – maint. dredging
1980 - 95	Patrick AFB	53-75	380,000	Various upland sources [truck-haul]
1996	Cocoa Beach	34-38	40,000	Upland quarry [truck-haul]
1998	City of Cape Canaveral Sand Bypass II	3-14	1,035,000	Beach north of Canaveral Harbor (CCAS)
1996 - 98	Patrick AFB	53-75	250,000	Poseidon DMMA (West Spoil Area CCAS)
2000 - 01	Patrick AFB	53-75	541,000	Canaveral Shoals II
2000 - 01	North Reach	3-54	2,798,000	Canaveral Shoals II
2002 - 03	South Reach	118-139	1,346,000	Space Coast Shoals II & Canav. Shoals II
2005	Patrick AFB	54.5-65	258,300	Canaveral Shoals II
2005	Patrick AFB	65-75.4	63,200	Canaveral Shoals II [truck-haul]
2005	North Reach	8-19 33-54	353,000 401,600	Canaveral Shoals II
2005	South Reach	118.3-139	578,910	Canaveral Shoals II
2005	Dune Reconstruction (Hurr. Frances & Jeannie)	75.4-118.3 138-213	307,300 252,200	Various upland sources [truck-haul]
2006	Dune Reconstruction (Hurricane Wilma)	75.4-118.3 138-213	127,478 47,145	Various upland sources [truck-haul]
2007	City of Cape Canaveral Sand Bypass III	4-10	750,000	Beach north of Canaveral Harbor (CCAS)
2008	Dune Reconstruction (T.S. Noel)	75.4-118.3 138-213	97,000 31,000	Various upland sources [truck-haul]
FUTURE ANTICIPATED ACTIVITIES IN THE WITH-PROJECT CONDITION				
2013 and 6-yr intervals	Canaveral Sand Bypass	3-18	~156,000 cy/yr	Beach north of Canaveral Harbor (CCAS)
2010 and 6-yr intervals	South Reach	118-139	~100,000 cy/yr	Canaveral Shoals I and/or II
2012? and >6-year intervals	North Reach	3-54	~82,000 cy/yr	Canaveral Shoals I and/or II
2010? and ~ 6-yr intervals	Patrick AFB	55-75	~50,000 cy/yr	Canaveral Shoals I and/or II, and Upland beach north of Canaveral Harbor landward of bypass borrow area (CCAS)
2009 and varying intervals	Dune Reconstruction – South Beaches (storm erosion response)	138-213	Varies: ~40,000 cy/yr	Principally upland borrow areas

* Nearshore Disposal (18-22 ft water depth). Indicated volume is “effective” placement; about 1/3 x disposal vol.

7.2.26 Irreversible and Irretrievable Commitment of Resources

7.2.26.1 Irreversible

An irreversible commitment of resources is one in which the ability to use and/or enjoy the resource is lost forever. Cyclical coverage and exposure of nearshore hardbottom and seasonal beach profile cycles illustrate that the effects from the proposed project alternatives are reversible, particularly provided appropriate mitigation to compensate for temporal loses. In view of the natural, highly dynamic fluctuations in exposure and burial of the nearshore rock resource and the modest scale of the proposed beach fill activity, abandonment of the project at any point during or after the proposed life of the period of analysis, for example, is reasonably anticipated to result in the near or wholly complete recovery of existing conditions within a very short period of time (i.e., less than one or two years).

The use of sand from the proposed offshore borrow areas would irreversibly deplete the immediate suitable sand reserves for future nourishment projects; however, the proven sand resources of the offshore borrow areas (over 35 million cubic yards) indicate that there is amply sufficient material for the life of the presently proposed project (on the order of 3 million cubic yards) in addition to the long-term authorized requirements of other existing and reasonably foreseen shore protection projects in Brevard County that depend upon this offshore sand resource (on the order of 10 million cubic yards). There will likewise be sufficient sand reserves remaining for recolonization of benthic organisms both within and adjacent to the borrow areas.

7.2.26.2 Irretrievable

An irretrievable commitment of resources is one in which, due to decisions to manage the resource for another purpose, opportunities to use or enjoy the resource as they presently exist are lost for a period of time. Irretrievable loss of nearshore resources resulting from the project will be mitigated through the implementation of a program of nearshore artificial reef construction (see below). The mitigative reef program reflects extensive agency and local sponsor coordination to identify the physical and ecological scope of the nearshore rock resources that would be lost and the probable ability of the proposed reef to serve the ecological functions of the impacted resources. (See **Appendix K - Subappendix G and Subappendix H**.)

7.2.27 Unavoidable Adverse Environmental Effects

Most of the infauna inhabiting the borrow area and fill site will be unavoidably lost as a result of dredging and sand placement activities. However, these losses are not expected to have a long-term, significant adverse impact on the surrounding environment since infauna outside of the fill areas and borrow areas will recolonize the disturbed sandy areas within one to three seasons after construction, respectively, and changes in macroinfaunal community assemblages should result in a minimal loss of productivity. These impacts are associated with dredging and beach fill placement activities that are identical to those which have been previously undertaken in Brevard County.

The natural, exposed nearshore hardbottom at the project area occurs immediately proximate to the beachface, along and just below the low tide shoreline. It is mostly low in relief and scattered, with few substantial alongshore gaps. This configuration means that there is an unavoidable potential for sedimentation (or partial burial) of any exposed hardbottom by the placement of beach fill below the wave zone. Restricting the beach fill placement to only above the wave zone was determined to not meet the minimum project requirements for shore protection. Accordingly, some level of beach fill is required below the wave zone (along the beach face) and this will lead to unavoidable anticipated impact to exposed nearshore rock. Formulation of the project, as described in this document, sought to avoid and minimize the impact to the rock while maintaining the requisite level of shore protection, and to mitigate unavoidable impact through construction of reef habitat.

Approximately 3.0 acres of nearshore hardbottom habitat will be impacted by the placement and subsequent equilibration of the beach fill during initial project construction and periodic nourishment activities. This impact is temporal and is anticipated to potentially decrease to between 1.6 and 1.8 acres between construction activities; however the analysis of project impacts and mitigation requirements presumes a long-term impact of approximately 3 acres.

The project will construct 4.8 acres of mitigation reef structure along the project area, consisting of articulated concrete mats with embedded coquina stone surface and featuring gaps and ledges. The relief and surface of the mitigation reef structure will physically emulate that of the impacted reef; however, the mitigation reef will be located in deeper water (about 15 feet) and further from shore (about 800 to 1000 feet) than the impacted reef. Numerous physical considerations practically and unavoidably limit the reef construction to these depths and locations (see **Appendix K - Subappendix F**). Nonetheless, evaluation of the proposed mitigation reef, including observed results of biotic recruitment upon experimental reef prototypes placed in identical depths and locations – in addition to observed results from similar reef structures in the adjacent county – support the expectation that the proposed mitigation reef will provide on the order of 75% of the ecological services that are lost at the impact site (see **Appendix K - Subappendix D, Subappendix E, Subappendix G, and Subappendix H**). This considered the probable changes at the proposed impact and mitigation sites in terms of habitat corridor, water quality, susbstrate, cover, nesting/reproduction, feeding, and nursery; wherein each of these functions were considered in specific regard to macroalgae, invertebrates, juvenile and adult fishes, and marine turtles. The project's mitigation plan will compensate for unavoidable impacts to nearshore hardbottom habitat located inshore of the project equilibrium toe of fill.

7.2.28 Local Short-Term Uses and Maintenance/Enhancement of Long-Term Productivity

Shoreline protection using beach fill with periodic nourishment is an ongoing effort. Beach nourishment projects have a temporary and short-term impact on local offshore and nearshore biological resources. Most motile organisms (fishes, crabs, and some sand dwelling organisms) within the borrow area and nearshore zone should be able to escape these areas during construction. Some less-motile individuals that are unable to escape from construction will be lost, but are expected to recolonize after project completion. Short-term reductions in primary productivity and reproductive and feeding success of invertebrate species and fish are expected. The sustainability of these populations should not be negatively affected given the minority scale of impacts relative to the remaining resource and provided the creation of suitable replacement habitat as associated with the project's mitigation reef.

7.2.29 Indirect Effects

Prior studies have concluded that beach nourishment projects frequently lead to greater development, tourism, investment, and subsequently greater long-term requirement for shore protection along the project shoreline (National Research Council 1995, Pilkey and Dixon 1996, Dean 1999); though other studies claim no evidence that beach nourishment projects induce development (Cordes and Yezer 1995). Overall, shoreline erosion control measures can potentially create an upward spiral of protective measures that result in more expensive development which leads to the need for more and larger protective measures, etc. Increased shoreline development may adversely affect sea turtle nesting success by supporting larger populations of mammalian predators, such as foxes and raccoons, and can also result in greater adverse effects due to increased artificial lighting.

In the present project, the existing project shoreline is already developed with a mix of commercial (lodging), residential, and public beach park facilities. There is relatively limited opportunity for future densification of development, however the presence of shore protection and decreased storm losses would conceivably act to at least maintain the density of existing development and improve investments therein. The studies describing growth in development associated with beach nourishment have typically examined or presumed beach nourishment projects that are large in scale. These cases do not necessarily characterize the present project, wherein the proposed beach fill placement is relatively small in scale (i.e., dune-only and 10- to 30-ft advances in beach width). Accordingly, the degree to which project indirectly affects the nature or growth of development along the shoreline can be anticipated to be relatively small.

In the no-action alternative, losses to property and land will continue due to storm erosion. This may lead to a tempering or reduction of future development, and/or abandonment or dereliction of existing development (i.e., decreased or lessened investment). Alternatively, this may lead to increased demand for shoreline armoring by private interests as developed properties become imperiled by storm erosion.

7.2.30 Compatibility with Federal, State, and Local Objectives

The Federal objective is to contribute to national economic development consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. Federal planning concerns other than economic include environmental protection and enhancement, human safety, social well being, and cultural and historical resources. Federal, State and County objectives include (1) the reduction of expected storm damages through beach nourishment and other project alternatives; (2) maintaining beaches as suitable recreational areas; (3) maintaining suitable beach habitat for nesting sea turtles, invertebrate species, and shorebirds; (4) maintaining commerce associated with beach recreation in Brevard County, and (5) avoidance or minimization of adverse impacts to sensitive environmental marine resources, including habitat associated with the nearshore rock hardgrounds along the project area. The proposed project activity is consistent with Federal and Local objectives and with the State's Coastal Zone Management Plan.

7.2.31 Conflicts and Controversy

Through the plan formulation process efforts were made to minimize adverse effects to environmental resources. The NED Plan and LPP represent the result of intense cooperation and coordination. Additional opportunity for comment is afforded in the public comment period for the draft report.

7.2.32 Uncertain, Unique, or Unknown Risks

All activities associated with the proposed project have been previously undertaken during past shore protection and navigation activities performed in Brevard County, with the specific exceptions of (1) construction and monitoring of the nearshore mitigation reef and (2) placement of beach face fill directly along the nearshore rock resources. Both of these activities are described below.

Some specific project elements are new to the Brevard County Federal Shore Protection Project, but have been otherwise conducted in Brevard County by the Corps, County or the Air Force through other activities in the recent past. These specific activities include (1) the temporary hydraulic stockpiling of sand to the DMMA and (2) subsequent removal and beach-fill placement of sand from the DMMA by truck-haul. Hydraulic discharge and storage of sediment into the DMMA has been accomplished by the Corps in the past, for purposes of dredge disposal at Canaveral Harbor. Mechanical removal of sand from the DMMA, and truck-haul transport and placement to the beach immediately north of the Mid-Reach, along Patrick Air Force Base, has been previously accomplished by the Air Force in 1998. Truck-haul transport and placement of sand as dune-fill along the Mid-Reach, from upland sources, has been accomplished by Brevard County in 2005, 2006 and 2008. Experience gained from these successful prior activities has been incorporated to development of the proposed plan.

Construction of the proposed mitigation reef is unique and its performance offers some uncertainty and risk. The reef is an adaption of an existing marine technology; i.e., articulated-concrete marine mats, with coquina rock incorporated to the surface. Articulated concrete mats have been successfully deployed as seabed foundation structures on sandy and silty substrates, for many years, in conditions similar to the present. However, their direct use as a reef structure (with coquina-rock surface) is new. Their use was specifically developed for this project in response to the environmental agencies' request for alternative mitigation structures that would more closely emulate the impacted resource. There is some risk that the mitigation reef structures may subside and/or become covered with sediment, thus compromising their intended ecological function. There is additionally some risk that the mitigation reef structures will not provide the predicted level of ecological function. Consideration of these risks has been included in the formulation of the mitigation plan, including the proposed construction of 1.6-acres of mitigation reef per 1.0-acres of anticipated impact to existing hardgrounds. (See **Appendix K - Subappendix G** and **Appendix K - Subappendix H**.)

Placement of beach-fill sand resulting in direct impact to the existing nearshore rock hardgrounds of the Mid-Reach has not been previously constructed. However, beach fill has been placed along the dune and above the waterline immediately along the rock hardground areas by both the Air Force (2005) and Brevard County (2005-08). Additionally, large-scale beach fill has been placed adjacent to the rock hardgrounds along Patrick AFB (in 2001, 2005) and the South Reach of the Brevard County Federal Shore Protection Project (in 2003, 2005). These activities were designed and predicted to have minimal impact to the nearshore rock. Annual monitoring since 2005 indicates that exposure of the nearshore rock along and adjacent to these beachfill activities – at the south end of Patrick AFB and at the north end of the South Reach – has varied within the range of natural, pre-project fluctuations and has not been adversely impacted by the beach fill activities (Olsen 2008b, 2008c).

7.2.33 Precedent and Principle for Future Actions

As described above, the proposed activities are consistent with, and/or adaptions of, prior permitted activities conducted by the Corps of Engineers, Brevard County and the U.S. Air Force. These include prior beach nourishment and periodic nourishment along the North Reach and South Reach of the Brevard County Federal Shore Protection Project (2000-03, 2005), Patrick Air Force Base (1998, 2000-01, 05) and limited emergency dune restoration along the Mid-Reach by Brevard County (2005-08).

7.2.34 Environmental Commitments

The U.S. Army Corps of Engineers and Brevard County are committed to avoiding, minimizing, and/or mitigating for adverse effects during construction activities by including the following commitments in the contract specifications or attendant pre- and post-project monitoring plans.

7.2.34.1 Gopher Tortoise Relocation

Mitigation measures that would be employed during project activities involving or affect the Poseidon Dredged Management Material Area (DMMA) include the following:

a) Approximately 60 days prior to any land disturbing activities associated with the proposed project, project areas would be surveyed to determine the number of gopher tortoises occupying the site and the number of individuals that would require relocation. If the surveyor cannot determine whether a burrow is active or not, the burrow would be assumed active.

b) Tortoises slated for relocation would be captured using the bucket trap method. If tortoises must be removed quickly, or evade bucket traps, a backhoe would be used to excavate the burrow. Only experienced backhoe operators would be used for this activity, with trained tortoise observers providing oversight throughout the operation.

c) Tortoises would be captured and/or relocated only on days when the overnight low temperature is forecast to be above 50 degrees F and the two following overnight lows are forecast to exceed 50 degrees F.

d) Tortoises would be measured and permanently marked using the scute drilling method. Since a unique numbering system already exists on CCAS and the adjacent Kennedy Space Center, the Air Force would continue to utilize the existing system.

e) Blood samples would be taken from tortoises for analysis for Upper Respiratory Tract Disease (URTD). Samples would be drawn from the brachial vein of the restrained tortoise using 25 gauge needles and monoject syringes. Blood would be immediately transferred via pipette to lithium heparin separator tubes for preservation. Samples would be kept cold and then centrifuged, for plasma separation. Samples would be frozen at minus 20 degrees C until shipment to the University of Florida for analysis. To ensure risk reduction for cross contamination and spread of disease, including URTD, individual tortoises would be kept separate during holding and processing periods. All processing equipment would be cleaned with a 10% bleach solution between uses and tortoises would be held in clean, separate containers.

f) Recipient sites would be chosen and surveyed to determine the presence/absence of tortoises occupying that site. If the proposed recipient site already contains a dense population of tortoises, an alternate site would be selected.

g) Whenever possible, a number of tortoises removed from a single site would be treated as a “group or neighborhood” and would be relocated to a common recipient site. Tortoises would be relocated on CCAS as close to the donor site as possible.

h) Areas to be disturbed would be inspected days prior to project activities to ensure no new active burrows have been dug in the area. If active burrows are observed, gopher tortoises would be removed prior to project activities in that area.

7.2.34.2 Turbidity

The following measures shall be implemented to avoid/minimize turbidity related impacts. Turbidity in Nephelometric Turbidity Units (NTUs), shall be monitored every six hours during daylight hours during dredging. For hopper dredge use, samples shall be taken approximately every six hours midway through a fill cycle while the dredge is actively dewatering or discharging overflow. Should daytime measurements of the turbidity show an increase to a level approaching 29 NTU limits, then more frequent, or nighttime measurements, shall be resumed (29 NTUs above background is a state water quality standard). The samples shall be analyzed on site within two hours of collection at the following locations. Samples shall be collected from the surface and one meter above the bottom.

a. Borrow Sites

Background: 500 meters from the dredge in the opposite direction of the prevailing current flow, clearly outside the influence of any turbid plume.

Compliance: No more than 150 meters downcurrent from the dredge, within the densest portion of any visible turbidity plume.

b. Discharge Sites

Background: 500 meters from the point where discharge water is re-entering waters of the State (Canaveral Harbor) in the opposite direction of the prevailing current flow, clearly outside the influence of any turbid plume.

Compliance: No more than 150 meters downcurrent from the point where discharge water is re-entering waters of the State (Canaveral Harbor), within the densest portion of any visible turbidity plume.

If monitoring shows turbidity at any of the compliance stations exceeds the counterpart background station by more than 29 NTUs, construction activities shall cease immediately and not resume until corrective measures have been taken and turbidity has returned to acceptable levels.

7.2.34.3 Sea Turtles

Considering that hopper dredging will be utilized in Brevard County, compliance with all recommendations of the 1997 NMFS Biological Opinion regarding hopper dredging will be required to assure that incidental take of sea turtles are minimized during hopper dredging operations. The sea turtle deflecting draghead is required for all hopper dredging projects during the months that turtles may be present, unless a waiver is granted by the USACE in consultation with NMFS. The 1997 amended Biological Opinion mandates that year round, one-hundred percent observer coverage is necessary for beach nourishment project in southeast Florida. One hundred percent inflow screening is required, and one-hundred percent overflow screening is recommended when observers are required on hopper dredges. If conditions prevent one hundred percent inflow screening, inflow screening can be reduced, but one hundred percent outflow screening is required, and an explanation must be included in the preliminary dredging report. Preliminary dredging reports which summarize the results of the dredging and any sea turtle take must be submitted within 30 working days of completion of any given dredging project. Logs of any sea turtle injuries or deaths due to hopper dredging activities will be maintained, with immediate notification to the USACE, Jacksonville District, the USFWS and NMFS as appropriate, and the FWC.

The Corps and Brevard County agree to comply with the reasonable and prudent measures and non-discretionary terms and conditions stated in the U.S. Fish and Wildlife Service Biological Opinion for the proposed Brevard County Shore Protection Project. The reasonable and prudent measures and terms and conditions as stated in the Biological Opinion will be implemented to minimize take of loggerhead, green and leatherback sea turtles. Based on similar documents, these may include, in abbreviated summary:

a) Use of beach quality sand suitable for sea turtle nesting, sucubation and hatchling emergence.

b) No construction activity or equipment on the beach from May 1 through October 31.

c) Daily early morning nesting surveys and restricted nest relocation and/or avoidance beginning March 1 if beach construction activities occur between March 1 and April 30.

d) Daily early morning nesting surveys beginning 65 days prior to construction, through September 30 for beach construction activity from November 1 through 30.

e) Measurement of sand compaction and tilling of the nourished beach if required, prior to March 1, after construction and for three subsequent years.

f) Visual surveys for escarpments after construction and for three subsequent years, and removal of escarpments prior to March 1 (and thereafter, pursuant to coordination with the USFWS and FWC) that interfere with sea turtle nesting.

g) Requisite meetings between the construction contractor, USFWS, FWC and marine turtle State permit holder.

h) Minimization of storage of construction equipment upon the beach from March 1 through April 30 and from November 1 through 30.

i) Avoidance and minimization of lighting of the beach and nearshore waters, and upon offshore equipment, from March 1 through April 30 and from November 1 through 30.

j) Annual surveys and reports of marine turtle nesting activities and success for at least three years after each construction event.

Additionally, a survey of lights and light sources visible from the renourished beach berm shall be conducted after each construction event and prior to May 10 and a summary report prepared.

7.2.34.4 Manatees

The following standard protection measures will be implemented to minimize potential impacts to manatees:

a) The contractor will instruct all personnel associated with the construction of the project about the presence of manatees in the area and the need to avoid collisions with manatees. All construction personnel shall be responsible for observing water-related activities for the presence of manatees and shall implement appropriate precautions to ensure the protection of manatees.

b) All construction personnel shall be advised that there are civil and criminal penalties for harming, harassing or killing manatees which are protected under the Marine Mammals Protection Act of 1972, the Endangered Species Act of 1973, and the Florida Sanctuary Act. The contractor shall be held responsible for any manatee harmed, harassed, or killed as a result of the construction of the project.

c) Prior to the commencement of construction, the construction contractor shall construct and install at least two temporary signs concerning manatees. These signs shall read "Caution: Manatee Habitat. Idle Speed is Required if Operating a Vessel in the Construction Area" and "Caution: Manatee Habitat. Equipment Must be Shutdown Immediately if a Manatee Comes Within 50 Feet of Operation".

d) All vessels associated with the project will be required to operate at "no wake" speeds at all times while in waters where the draft of the vessel provides less than four feet of clearance from the bottom. All vessels shall follow routes of deep water whenever possible.

e) If a manatee is sighted within a hundred yards of the construction area, appropriate safeguards will be taken, including suspension of construction activities, if necessary, to avoid injury to manatees. These precautions shall include the operation of all moving equipment no closer than 50 feet of a manatee.

f) The contractor shall maintain a log detailing sightings, collisions, or injuries to manatees should they occur during the contract. Any collision with and/or injury to a manatee shall be reported immediately to the Florida Marine Patrol at 1-800-DIAL-FMP (1-800-342-5367) and U.S. Fish and Wildlife Service in Vero Beach.

7.2.34.5 Whales

The following protection measures will be implemented to minimize potential impacts to whale species:

a) From December 1 through March 31, dredge vessels moving through the southeastern right whale critical habitat area (from 31^{o}15’N to 30^{o}15’N out 15 miles offshore and from 30^{o}15’N to 28^{o}0’N out 5 miles offshore) shall post a dedicated, qualified observer to spot whales. If a whale is seen, and/or during evening hours or when there is limited visibility due to fog or sea states of greater than Beaufort 3, the vessel must slow to 5 knots or less when traversing between areas if whales have been spotted within 15 nm of the vessels’s path within the previous 24 hours. In addition the vessel operator shall maintain a 500 yard buffer zone between the vessel and any whale.

b) From December 15 through February 15, vessles shall proceed at reduced speeds (suggested 8 knots) in the southeastern right whale critical habitat area.

7.2.34.6 Shorebirds

The following standard measures shall be taken to protect shorebirds:

a) Areas of construction activity shall be surveyed daily for shorebirds if construction occurs between April 1 through September 1. Nesting surveys shall begin on April 1 or one week prior to construction, whichever is later and be conducted daily through September 30 until shorebird nesting activity is no longer observed.

b) Each shorebird species observed, a rough estimate of numbers of each species, the location of the birds, and their activity (e.g., foraging, resting, nesting, courtship behavior) shall be logged and reported to the FWC monthly.

c) Within the project area, a buffer zone shall be established around any location where shorebirds have been engaged in courtship or nesting behavior, or around areas where piping plovers occur or winter migrants congregate in significant numbers. Construction activities, including stockpiling of equipment and movement of vehicles, shall be prohibited in the buffer zone.

d) Tilling and scarp removal shall be conducted outside the shorebird nesting season or outside areas being utilized by shorebirds.

7.2.34.7 Southeastern Beach Mouse

Mitigation measures that would be employed during project construction involving or affecting the Poseidon Dredged Management Material Area (DMMA) will include those monitoring and relocation activities undertaken in accordance with the existing habitat conservation plan for the southeastern beach mouse at Cape Canaveral Air Station.

7.2.34.8 Nearshore Hardgrounds

Biological and physical monitoring of the existing nearshore rock resource and the project’s mitigation reef feature shall be conducted as described in **Appendix K - Subappendix J**.

7.2.34.9 Physical Monitoring of the Beach and Borrow Area
Topographic and hydrographic surveys of the borrow area and the beach fill area shall be conducted as described in **Appendix K - Subappendix J**, and in accordance with current standards of the FDEP Bureau of Beaches and Coastal Systems.

7.2.34.10 Quality Assurance for Beach Fill Sediment and Dredging Activities
Dredging and quality of the beach fill material shall be established and monitored per the following minimum requirements:

a) Beach fill material shall be beach compatible and meet the specifications required by Florida Administrative Codes 62B-41.007 (j), 62B-33.002 (8) and 62B-33.0015. Beach fill material shall be clean sand from a permitted source, free of construction debris, asphalt, gravel, rocks, clay balls, branches, leaves and other organics, oil, pollutants and any other non-beach-compatible materials. The sand shall be similar to the existing beach sediments in color and texture. Sand fill shall be free of components prone to cause cementation.

b) The grain size of the fill material shall conform to the following, by weight measure: (1) not more than 5% finer than the No. 230 U.S. Std. sieve; (2) not more than 5% coarser than the No. 4 sieve, and (3) not more than 0.5% coarser than 3/4-inch sieve. The mean grain size shall be between 0.25 and 0.45 mm. Maximum carbonate content shall be 45%. Sand color, based upon the Munsell Scale and when graded on the 7.5YR or 10YR Hues, shall have a Value of at least 6.0 or higher and a Chroma of 2.0 or less in moist sample conditions.

c) Per requirements of the construction contract, the dredging contractor shall continuously operate electronic positioning equipment approved by the government to monitor the draghead (“intake”) locations and depths. A Differential Global Positioning System (DGPS) or equivalent shall be used to determine the horizontal position of the intake(s) and shall be interfaced with an appropriate depth measuring device to determine the intake depth(s). The horizontal positioning equipment shall maintain an accuracy of ±3 feet. No dredging shall take place outside of the specified horizontal and vertical limits of the borrow area. The dredge contractor shall certify on each Daily Report that all dredging has been performed within the permitted limits of the borrow area, and shall be required to operate the electronic positioning equipment continuously, record, plot, and report the position of the dredge intakes during dredging and disposal activities. The intake positioning devices shall maintain a vertical accuracy of ±0.5 feet with continuous applicable tidal corrections measured proximate to the project site. The dredge contractor shall install and maintain a properly-functioning radio-transmitting tide gage in the project area and shall verify daily that the tide corrections are properly applied to the vertical position of the intake(s) on a continuous basis, and/or shall apply continuously-correcting GPS elevation data to the vertical position of the intake(s).

d) The dredge contractor shall monitor the nature of the material filled to the hopper dredge (where applicable) and shall continuously monitor the sediment discharged to the stockpile area. If rock, clay, or excessive turbidity/shell content/dark-colored material is encountered in the borrow area, the contractor shall raise the intake(s) and the location of the dredging shall be immediately changed. Should undesirable sediments continue to be encountered, the contractor shall cease excavation, move the dredge to another location within the permitted borrow area, and notify the Corps Contracting Officer immediately.

e) A hopper-barge load with material judged to be non-beach compatible material shall be replaced to the borrow area at the area from which it was removed, and subsequently avoided; or, shall be replaced to the borrow area at an area that will be unaffected by future dredging; or, shall be placed to the existing ODMDS site subject to federal requirements for disposal to that site.

f) Non-beach compatible material deposited on the beach shall be removed from the site of the work and disposed of in permitted areas. Sediment sampling during construction will consist of a 300-500 g physical sample at not greater than every 500-ft alongshore shall be collected, labeled with time/date/location, examined promptly for approval by the government inspector, and archived for subsequent examination and/or analysis as warranted. For any placed material that visually appears to differ in texture, color or content from the specifications herein, and which is placed to the beach and not rejected prior to placement, samples shall be promptly analyzed for compliance. Samples will be processed to determine grain size distribution between U.S. Standard Sieve sizes 4 (4.76 mm) and 230 (0.625 mm) in addition to the weight fraction retained on the ¾" sieve and categorized as PASS or FAIL with regard to the sand specification. The analysis shall utilize standard sieve sizes at half-phi intervals between U.S. Std. No. 4 and No. 230 (inclusive), , and including the ¾" sieve and pan. Should non-compliant material be detected after placement, additional testing will be conducted to determine its extent, and all non-compliant fill will be removed and subsequently replaced with compliant fill.

g) Construction observation will be performed during beach fill placement. Site inspectors shall have prior experience in beach nourishment and construction inspection and testing and shall be knowledgeable of the permit conditions and requirements for acceptable sediment quality. Site inspectors shall retain a physical sample ("standard") of the sediment that is expected to be placed upon the beach, and shall notify the contractor if the material placed to the beach substantially deviates from that of the standard sample. The construction contractor shall prepare and provide, for government approval, a Quality Control Plan that addresses requirements for sediment quality assurance. The contractor shall provide daily reports which characterize the nature of the sediments encountered at the borrow area and/or placed along the project shoreline, including occurrences of non beach compatible material.

h) Should rocks or excessive amounts of large shell or other non-beach compatible material be identified in excess of 50% of background in any 10,000 square ft area, then the non-compatible material shall be removed from the beach fill. This assessment shall take into account the potential occurrence of non-compatible materials below the surface. Acceptable fill shall be replaced as required to meet construction requirements.

i) Post-construction sediment sampling shall consist of two sand samples that are representative of the placed fill material at approximately 1000-ft spacing along the project fill area. Samples shall be taken at approximately 1 ft below the surface of the dry construction dune or berm. At each 1000-ft station, one sample shall be collected from near the landward toe of the dune and one sample shall be midway across the berm, as applicable. Sample analyses will include grain size distribution (including fines content) and color grading at half-phi intervals between U.S. Std. No. 4 and No. 230 (inclusive), , and including the ¾" sieve and pan. Up to one-third of the samples, randomly selected, will additionally be analyzed for carbonate fraction. A summary report shall be submitted to FDEP and shall also indicate the volume, areal extent and location of any unacceptable beach areas, and remediated areas or areas determined to be subject to remediation.

j) Methods of remediation in the event of non-beach-compatible material placed to beach are subject to approval by the Corps of Engineers and FDEP. Remediation may include, but not limited to (i) excavating the non-beach compatible material and mixing it with compatible material to achieve a sand mixture that acceptably complies with the project sand requirements, (ii) excavating the non-beach compatible material, transporting the material to a permitted upland location, and replacing the material with sand that complies with the project sand requirements, and/or (iii) screening the non-beach compatible material from the fill, on-site, and removing the non-compatible material for placement to a permitted upland location.

k) In the event that there is an insufficient quantity of stockpiled sand within the upland DMMA site for beach fill placement (viz. in the event of emergency post-storm requirements), and interim use of alternate, permitted upland sand sources is required, then all applicable stipulations for sediment quality and monitoring shall apply, and the beach fill material shall be additionally subject to specific approval of the FDEP.

7.2.35 Compliance with Environmental Requirements

7.2.35.1 National Environmental Policy Act of 1969.

In formulation and evaluation of the project, specific input from environmental agencies and the public were developed through numerous means, including the following. A scoping letter was mailed out to all Federal, State, and local agencies and all adjacent homeowners on April 1, 2005; and a Notice of Intent to prepare a Draft Supplemental Environmental Impact Statement (SEIS) was published in the Federal Register on April 26, 2005. A public scoping meeting was held in Satellite Beach, Brevard County, Florida on September 8, 2005, a Notice of Availability for the Draft SEIS was mailed out to stakeholders on October 30, 2009 which provided an electronic link to the Draft SEIS, copies of the draft report were also placed in a local library within the Mid-Reach area, a Notice of Availability for the Draft SEIS was also published in the Federal Register on November 13, 2009, a public workshop was held in Melbourne, Brevard County on February 10, 2010 in fulfillment of the requirements in the National Environmental Policy Act (NEPA), at which a wide variety of views were presented including those for and against a shore protection project. The project is in compliance with the National Environmental Policy Act.

7.2.35.2 Endangered Species Act of 1973.
Pursuant to Section 7 of the Endangered Species Act, consultation with the USFWS has been completed and is on-going with NMFS. The Corps has determined that the project may affect nesting sea turtles as well as juvenile green sea turtles, and may affect, but is not likely to adversely affect the West Indian manatee, eastern indigo snake, piping plover, southeastern beach mouse, and the smalltooth sawfish. As specified in Section 7 (b) (1) of the Act, biological assessments were prepared and issued to the USFWS and NMFS on October 6, 2008. The USFWS concurred with the Corps determinations, and issued a biological opinion on this project dated April 22, 2009 (see Appendix I). The use of a hopper dredge may affect the green, loggerhead, Kemp's ridley, and leatherback sea turtles as well as the northern right whale and humpback whale; however, the use of a hopper dredge has been previously coordinated with the NMFS and is covered under the 1997 regional biological opinion (RBO). The Corps has also determined that the loss of 3 acres of hard bottom due to beach placement may affect green sea turtles which forage on algae growing on the rocks. This effect would not be covered by the RBO. Section 7 consultation with NMFS regarding this impact is still ongoing.

7.2.35.3 Fish and Wildlife Coordination Act of 1958.
This project has been coordinated with the U.S. Fish and Wildlife Service. A Final Coordination Act Report (CAR) was submitted to the Corps in November 2008. A copy of the Final CAR is included in Appendix H. This project is in full compliance with the Act.

7.2.35.4 National Historic Preservation Act of 1966. (As Amended)
Archival research, field work, and coordination with the Florida State Historic Preservation Officer (SHPO), has been conducted in accordance with the National Historic Preservation Act, as amended; the Archeological and Historic Preservation Act, as amended, Executive Order 11593, and Advisory Council's revised 36 CFR Part 800 Regulations. The project is consistent with the goals of this chapter. Pertinent SHPO correspondence is included in Appendix I. The project will be in compliance with each of these Federal laws.

7.2.35.5 Clean Water Act of 1972.
Application for a Section 401 water quality certification shall be submitted to the FDEP. All State water quality standards will be met. A Section 404(b) evaluation is included in this report as Appendix F. The project will be in compliance with this Act.

7.2.35.6 Clean Air Act of 1972.
No air quality permits would be required for this project. Exhaust emissions from labor transport, including trucks hauling sand to the beach, and dredge equipment would likely be well under the *de minimus* levels for criteria air pollutants. The proposed action may result in small, localized, temporary increases in concentrations of NO2, SO2, CO, VOC, and PM. Since the project is located in an attainment area, there is no requirement to prepare a conformity determination. The total increases are relatively minor in context of the existing point and nonpoint and mobile source emissions in Brevard County. Emissions from the proposed action would not adversely impact air quality given the relatively low level of emissions and the likelihood for prevailing offshore winds. With the proposed action, the criteria pollutant levels would be well within the national ambient air quality standards. Any indirect emissions as a result of the proposed action are beyond the control and maintenance of the USACE.

This project has been coordinated with the U.S. Environmental Protection Agency (EPA) and will be in compliance with Section 309 of the Act. The Draft EIS has been reviewed by EPA, and EPA issued a letter on this project dated November 30, 2009.

7.2.35.7 Coastal Zone Management Act of 1972.
Federal consistency determination in accordance with 15 CFR 930 Subpart C is included in this report as Appendix G. State consistency review shall be performed during the coordination of the Draft EIS to ensure that the project is consistent with the Florida Coastal Zone Management. The project will be in compliance with this act.

7.2.35.8 Farmland Protection Policy Act of 1981.
No prime or unique farmland would be impacted by implementation of this project. This act is not applicable.

7.2.35.9 Wild and Scenic River Act of 1968.
No designated Wild and Scenic river reaches would be affected by project related activities. This act is not applicable.

7.2.35.10 Marine Mammal Protection Act of 1972.
Incorporation of the safe guards used to protect threatened or endangered species during dredging, disposal, and truck-haul beach operations would also protect any marine mammals in the area, therefore, this project is in compliance with the Act. The Corps does not anticipate the take of any marine mammal during any activities associated with the project. A trained and government certified sea turtle and marine mammal observer will be stationed on the dredge during all water-related

construction activities. Appropriate actions will be taken to avoid listed sea turtle and marine mammal species effects during project construction. If a marine mammal is identified within the project boundaries, they will be provided protections equal the ESA species that have had consultations completed, and as a result of this the project sponsor is in compliance with the Act.

7.2.35.11 Estuary Protection Act of 1968.
No designated estuary would be affected by project activities. This act is not applicable.

7.2.35.12 Federal Water Project Recreation Act.
The principles of the Federal Water Project Recreation Act, (Public Law 89-72) as amended, have been fulfilled by complying with the recreation cost sharing criteria as outlined in Section 2 (a), paragraph (2). Another area of compliance includes the public beach access requirement on which the nourishment project hinges (Section 1, (b)).

7.2.35.13 Fishery Conservation and Management Act of 1976.
Coordination with the National Marine Fisheries Service (NMFS) shall be accomplished during review of the Draft EIS. The project will be in compliance with this Act.

7.2.35.14 Submerged Lands Act of 1953.
The project will occur on submerged lands of the State of Florida. The project shall be coordinated with the State and will be in compliance with the act.

7.2.35.15 Coastal Barrier Resources Act and Coastal Barrier Improvement Act of 1990.
There are no project areas as undeveloped coastal barriers as defined by the Coastal Barriers Resources Act. This act is not applicable.

7.2.35.16 Rivers And Harbors Act of 1899.
The proposed work would not obstruct navigable waters of the United States. The proposed action shall be subject to the public notice, public hearing, and other evaluations normally conducted for activities subject to the act. The project will be in full compliance.

7.2.35.17 Anadromous Fish Conservation Act.
Anadromous fish species would not be affected. The project will be coordinated with the National Marine Fisheries Service and will be in compliance with the act.

7.2.35.18 Migratory Bird Treaty Act and Migratory Bird Conservation Act.
Migratory birds are not anticipated to be significantly adversely affected by project activities. Protective measures for shorebirds are described in **Section 7.2.34** and shall additionally be in accordance with stipulations of project permit requirements. The project will be in compliance with these acts.

7.2.35.19 Marine Protection, Research and Sanctuaries Act.
The term "dumping" as defined in the Act (3[33 U.S.C. 1402](f)) does not apply to the disposal of material for beach nourishment or to the placement of material for a purpose other than disposal (i.e. placement of material as an artificial reef or the construction of artificial reefs as mitigation). Therefore, the Marine Protection, Research and Sanctuaries Act does not apply to this project. The disposal activities addressed in this Draft EIS have been evaluated under Section 404 of the Clean Water Act.

7.2.35.20 Magnuson-Stevens Fishery Conservation and Management Act.
This act requires preparation of an Essential Fish Habitat (EFH) Assessment and coordination with the National Marine Fisheries Service (NMFS). Pursuant to the Magnuson-Stevens Act, Essential Fish Habitat (EFH) consultation with the National Marine Fisheries Service has been completed and a letter was issued by NMFS on January 22, 2010. The project will be in full compliance with this act.

7.2.35.21 E.O. 11990, Protection of Wetlands.
No wetlands would be affected by project activities. This project is in compliance with the goals of this Executive Order.

7.2.35.22 E.O. 11988, Flood Plain Management.
The project is in the base flood plain (100-year flood) and is being evaluated in accordance with this Executive Order. Project will be in compliance with this Act.

7.2.35.23 E.O. 12898, Environmental Justice.
The District has determined that there are no minority or low-income populations present in the study area, therefore, the proposed work would not result in adverse impacts to any populations specified in E.O. 12898. Additionally, the proposed project would not result in adverse human heath or environmental effects, nor would the activity impact subsistence consumption of fish and wildlife within the region. The project is in compliance with this executive order.

7.2.35.24 E.O. 13089, Coral Reef Protection.
This EO refers to "those species, habitats, and other natural resources associated with coral reefs." The existing coquina outcrops (nearshore hardgrounds) affected by the project activity are not those associated with hermatypic coral reefs. The project area is outside of the geographic range of threatened acroporid species. Due to the shallow water depths and other environmental factors, living corals are not known to occur upon hardbottom along the Mid-Reach; however, in areas, the natural structural complexity of the hardbottom is enhanced by colonies of living and structural worm rock associated with the polychaete *Phragmatopoma lapidosa (caudata)*. Observations of recruitment of *P. lapidosa*, on a prototype structure deployed offshore of the Mid-Reach (McCarthy and Holloway-Adkins 2007; **Appendix K - Subappendix D**), indicated that the project's mitigation reef structure

will create favorable conditions for the development of worm rock in similar coverage to that of the existing hardbottom

7.2.35.25 E.O. 13112, Invasive Species.
The proposed activity does not include actions that would introduce invasive species. The source of beach fill material to be placed along the project area will be from offshore borrow sources proximate to the local coastal waters, and this source has been previously used in prior, permitted federal beach restoration activities in 2000 through 2005. Requisite repairs to and preparation of the west spoil area (Poseidon Dredged Material Management Area (DMMA)) at Cape Canaveral Air Station, to be used as an upland stockpile for the dredged, beach fill material, will include the removal of invasive and exotic species such as cat tails (*Typha spp*.) and Brazilian pepper (*Schinus terebinthefolius*) that cover the interior berm slopes and floor of the DMMA. This action is consistent with ongoing removal of invasive, exotic species by the U.S. Air Force at Cape Canaveral Air Station.

8 PUBLIC INVOLVEMENT, REVIEW AND CONSULTATION

8.1 Public Involvement Program

The public involvement program included the following items to contact or directly involve the public in the planning process by: sending a scoping letter to interested parties, conducting a public scoping meeting, sending a Notice of Availability on the draft report to interested parties, and holding a public workshop in order to obtain comment on the draft report.

8.2 Institutional Involvement

By letter the Jacksonville District invited the National Marine Fisheries Service (NMFS), U.S. Fish and Wildlife Service (USFWS), U.S. Environmental Protection Agency (USEPA), and Florida Department of Environmental Protection (FDEP) to be cooperating agencies. The NMFS in a letter dated March 16, 2006 stated that they would participate as a cooperating agency on this study (see Appendix I). The USFWS in a letter dated March 21, 2006 also accepted the District's invitation to participate as a cooperating agency (see Appendix I). FDEP and USEPA did not respond. The above agencies were invited to participate in public and non-public meetings on the project which occurred on September 8, 2005, December 8, 2005, February 15, 2006, and June 13, 2007.

8.3 Required Coordination

8.3.1 USFWS and NMFS: Endangered Species Act-Section 7 Consultation

Pursuant to Section 7 of the Endangered Species Act, consultation with the USFWS has been completed and is on-going with NMFS. The Corps has determined that the project may affect nesting sea turtles as well as juvenile green sea turtles, and may affect, but is not likely to adversely affect the West Indian manatee, eastern indigo snake, piping plover, southeastern beach mouse, and the smalltooth sawfish. As specified in Section 7 (b) (1) of the Act, biological assessments were prepared and issued to the USFWS and NMFS on October 6, 2008. The USFWS concurred with the Corps determinations, and issued a biological opinion on this project dated April 22, 2009 (see Appendix I). The use of a hopper dredge may affect the green, loggerhead, Kemp's ridley, and leatherback sea turtles as well as the northern right whale and humpback whale; however, the use of a hopper dredge has been previously coordinated with the NMFS and is covered under the 1997 regional biological opinion (RBO). The Corps has also determined that the loss of 3 acres of hard bottom due to beach placement may affect green sea turtles which forage on algae growing on the rocks. This effect would not be covered by the RBO. Section 7 consultation with NMFS regarding this impact is still ongoing.

8.3.2 USFWS: Fish and Wildlife Coordination Act

In compliance with the Fish and Wildlife Coordination Act, a Fish and Wildlife Coordination Act Report (CAR) was finalized by the USFWS in November 2008, and is included in Appendix H.

8.3.3 NMFS: Magnuson-Stevens Fishery Conservation and Management Act

In accordance with the Magnuson-Stevens Fishery Conservation and Management Act, the NMFS provided a letter dated October 7, 2005 stating their concerns on how the proposed work may impact Essential Fish Habitat. NMFS stressed the "ecological importance" and "uniqueness" of the nearshore coquina rock outcroppings in the Brevard County Mid-Reach study area. The nearshore hardbottom has been designated as Essential Fish Habitat and a Habitat Area of Particular Concern. Numerous species have been observed on or near the rock, including several managed fisheries. Two of these fisheries, red drum and shrimp, are considered to be aquatic resources of national importance. Specific concerns were also stressed in the letter for avoiding and then minimizing impacts to the rock. Concerns were also expressed over the temporary relief from erosion that may result from some alternatives and the need for a more complete sand bypassing system to address erosion caused by Canaveral Inlet. NMFS suggested examining again the non-structural alternatives presented in the 1996 Feasibility Study for Brevard County. Finally NMFS policy states that where compensatory mitigation is required, the mitigation should be local, upfront, in-kind and monitored. A copy of the letter is included in Appendix I. These items of concern shaped the plan formulation process and are stressed in the project constraints. The report includes detailed discussion on avoidance, minimization, mitigation and non-structural alternatives. In the course of the study, discussions also took place with NMFS regarding the jetties at Canaveral Inlet and what affect they have on the erosion of the Mid-Reach. Evidence indicates that the jetties have little or no influence on the Mid-Reach because the distance separating the two is too great. Through intense effort and coordination, the Project Delivery Team sought to recommend a solution while satisfactorily addressing these issues.

In compliance with the Magnuson-Stevens Fishery Conservation and Management Act, an Essential Fish Habitat (EFH) Assessment has been prepared and is included in Appendix K. The assessment has been coordinated with the NMFS, and recommendations on the proposed work were issued by NMFS in a letter dated January 22, 2010 (see Appendix I). The recommendations are as follows:

• The SEIS should include a discussion of the importance of the Mid-Reach's mature worm rock colonies as a source of larvae for maintaining sabellariid worm rock reefs outside the project area.

Response: The worm rock located within the project area does not differ from worm rock located outside the project area, i.e. adjacent to Patrick AFB or Indian River County. The 3 acres (or <10%) of hardgrounds predicted to be affected by the project activity are composed of coquina rock outcrops of which only a portion consists of worm rock. Olsen (2003) concluded that between 2.6% and 4.1% of the total exposed rock outcrop area along the project area shoreline in January 2001 contained some level of probable sabellarriid worm rock. The Corps and its local sponsor assume that recruitment of Phragmatoma lapidosa within the project area is similar to recruitment levels found outside the project area. It appears that the level of recruitment is more correlated with the distance of the rock from the shoreline, intertidal vs. sub-tidal (McCarthy et. al., 2003), rather than location of the rock along the coastline. As stated in the GRR/SEIS, McCarthy and Holloway-Adkins (2007) observed and concluded that conditions for successful worm recruitment and settlement were available in 4.6 m (mitigation site) which should offset the potential loss of worm rock among the 3 acres of coquina rock outcrops predicted to be affected by the project activity. McCarthy et al. (2003) found that sub-tidal worms were more fecund than intertidal worms. Because the project will mitigate the loss of intertidal worms by creating a sub-tidal population, it is logical to expect the mitigation will produce an adequate (perhaps improved) source of sabellariid worm larvae. Therefore, the Corps and its local sponsor do not expect this loss of natural outcrops, as mitigated, to indirectly or cumulatively affect sabellariid worm populations in other areas.

• The SEIS should evaluate a hybrid of the National Economic Development (NED) plan and Locally Preferred Plan (LPP) for Reaches 3 and 4. This evaluation should specifically address whether it would meet the project's objective and quantify the differences in direct and indirect impacts to worm rock reef and hard bottom between the hybrid, NED plan, and LPP designs. If this evaluation shows hybrid design would meet the project purpose and impact less hard bottom habitat, it should be adopted as the recommended plan.

Response: A total of 72 plans were evaluated for potential storm reduction benefits and each plans impacts to hard bottom habitat. The project was fully coordinated with all regulatory agencies, and as a result of this coordination the project was redesigned or scaled back in order to minimize hard bottom impacts. The LPP in Reach 3 actually has a 20 ft design plus advance fill versus the NED plan which has a 30 ft design plus advance fill. The LPP in Reach 4 has a 10 ft design plus advance fill, while the NED plan recommended dune fill only. The LPP offers more storm reduction benefits within in this reach, but would result in a slight increase in impacts to the hard bottom resource. Additional sub-reaches, or multiple transitions from a 10' design to dunes, could be added to the Reach 4 design, but this would result in a sawtooth beach template. This would not last very long as the ocean would very quickly straighten out the shoreline. The Corps sees little or no benefit to the hard bottom resource in doing this. As the natural processes straighten the shoreline the sand will move along the beach, potentially impacting the hard bottom. The recommended plan should not result in a sawtooth beach template. The Mid-Reach was divided into sub-reaches for planning purposes, and transitions between sub-reaches would be tapered. The length of each sub-reach, and the tapers, would reduce the chance of a sawtooth pattern.

•Construct and monitor the mitigation reefs for at least one year before beginning the beach fill.

Response: The Corps plans to construct the mitigation reefs concurrent with the planned rehabilitation of the dredged material management area (upland site) at Cape Canaveral Air Force Station, and both of these tasks would be completed prior to any beach fill. This should provide some time to monitor and evaluate the mitigation site before any impacts occur to the existing hard bottom resource.

• Placement of the mitigation reefs closer to shore and in closer proximity to the existing hard bottom.

Response: As described in the study (SEIS Sub-appendix F), placing the mitigation reefs in shallower water entails risks and practical limitations. While limitations of constructability in shallower water might be overcome, to some limited extent, through use of specialized construction equipment (e.g., jack-up barges), the potential for sand burial of the reefs increases significantly as reefs are placed shallower than the -15 ft (approximate) seabed depths that are proposed. Pragmatically, placement of some reef materials in shallower water must be accompanied by a reduction in the minimum amount of exposed mitigation reef substrate that is to be consistently maintained.

•A monitoring program should be undertaken that examines utilization of the mitigating reefs by fishery species and their prey and also examines the recovery of the infauna communities within the borrow areas. Results from both monitoring efforts should be incorporated into an adaptive management program aimed at meeting the project's purpose while minimizing impacts to fishery resources.

Response: Per the monitoring plan, macroalgae, invertebrates, juvenile and adult fishes, and marine turtles will be assessed at the mitigation reefs and nearshore hardgrounds. Data shall be collected annually, and shall be evaluated after the Year-5 post-construction survey to assess the project's impacts to the nearshore hardgrounds and the performance of the mitigation reef. Should the Average with Project Acreage (AWPA) be less than the Threshold Mitigation Acreage (TMA) after the Year-5 survey, or should annual assessments of the AWPA or nearshore rock surveys indicate significant trends that are adverse or inconsistent with the project's predicted performance, then adaptive actions shall be taken. These actions may consist of additional monitoring, analysis, and/or modifications to the project plan, subject to coordination between the Corps, local sponsor and the relevant regulatory agencies. The Corps believes this plan meets the NMFS request. However, in regard to the borrow site (Canaveral Shoals), the monitoring plan calls for surveys to assess bathymetric/volume changes only. The Corps is not proposing to monitor infauna communities at the borrow site as requested. As stated in the report, "dredging (within the borrow area) would be limited to a relatively small area, species inhabiting bottom areas adjacent to dredged furrows will provide a local recruitment stock. As these organisms are very fecund, the dredged site is expected to quickly recolonize."

8.3.4 Florida Department of Environmental Protection: Clean Water Act

The non-Federal sponsor has agreed to apply for the Joint Coastal Permit from the Florida Department of Environmental Protection, also known as the water quality certificate (WQC).

8.3.5 State Historic Preservation Officer: National Historic Preservation Act

The State Historic Preservation Officer (SHPO) stated in a letter dated May 20, 2005 that the NN Shipwreck is located in the vicinity of the project. Therefore, the location of the wreck needs to be addressed and the area avoided by project activities. The SHPO further indicated that the 7.8 miles of the Mid-Reach have never been surveyed for cultural resources. A survey of the shipwreck and beach placement area was completed and coordinated with the SHPO. The survey determined that the NN Shipwreck is located approximately 300 feet off shore and less than a mile north of the old Canova Beach Pier, which is within Reach 3 of the Mid-Reach (see Figure 2-2, Reaches Associated with the Mid-Reach Study). The SHPO concurred that the proposed project will have no effect on cultural resources listed or eligible for listing in the NRHP, or otherwise of historical, archaeological, or architectural value.

8.4 Scoping

8.4.1 Scoping Letter

A scoping letter was mailed out to Federal, State, and local agencies, other relevant stakeholders, as well as adjacent property owners on April 1, 2005. In conjunction with the scoping letter, a Notice of Intent to prepare a DSEIS was published in the Federal Register on April 26, 2005. The Notice of Intent described the study area; outlined the proposed action, alternatives, and scope; and laid out the scoping process utilized to involve Federal, State, and local agencies, affected Indian tribes, and other interested persons and organizations. Numerous replies were received, whereafter the team decided to hold a public scoping meeting to allow all interested parties a chance to participate.

8.4.2 Public Scoping Meeting

A public scoping meeting was held in Satellite Beach, Brevard County, Florida on September 8, 2005 in partial fulfillment of the requirements in the National Environmental Policy Act (NEPA). A meeting invitation was sent to adjacent property owners, U.S. Fish and Wildlife Service, National Marine Fisheries Service, Florida Department of Environmental Protection, Florida Fish and Wildlife Conservation Commission, other appropriate Federal and State agencies, and local city and county governments. The meeting presented the study area, initial alternatives, timeline for study, and solicited public comment. A wide variety of views were presented at the meeting including those for a shore protection project and those against. The most common concerns are listed below.

- loss of land and property due to erosion
- lack of protection from hurricanes
- loss of recreational beach
- concern over protecting existing rock for fishing
- environmental protection of the rock (both pro and con)
- concern over protecting surfing spots and the revenue therefrom
- concern over wasting Federal tax dollars

- too much time since the first studies without positive results
- concern that revetments and seawalls harm turtle nesting

8.5 Notice of Availability of Draft Supplemental Environmental Impact Statement (DSEIS)

Notification that the DSEIS was available for public review and comment was mailed out to Federal, State, and local agencies, other relevant stakeholders, as well as adjacent property owners on October 30, 2009. This Notice of Availability (NOA) provided an electronic link to the report, and also informed stakeholders that copies of the DSEIS had been placed in a public library near the location of the proposed project. In conjunction with the NOA that was mailed out, a second NOA on the DSEIS was published in the Federal Register on November 13, 2009.

8.5.1 Public Workshop on DSEIS

A public workshop was held in Melbourne, Brevard County, Florida on February 10, 2010 in order to provide additional opportunity for stakeholders to discuss and comment on the DSEIS. A workshop invitation was sent to adjacent property owners, other interested parties, U.S. Fish and Wildlife Service, National Marine Fisheries Service, Florida Department of Environmental Protection, Florida Fish and Wildlife Conservation Commission, other appropriate Federal and State agencies, and local city and county governments.

8.5.2 Comments on the DSEIS from the General Public

Comments and questions on the DSEIS from the general public in response to the NOA, as well as those that were obtained during or after the public workshop, represented a wide variety of views (see Appendix L, Public Comments on the DSEIS). These comments and concerns are summarized below:

- Project should not be constructed

Response: This report shall be sent to the Secretary of the Army for further review, and if presented to the U.S. Congress, the U.S. Congress shall decide whether this project is to be funded for construction.

- Local stakeholders have been left out of the (scoping) process, and have the most to lose

Response: The level of scoping for this project has met the requirements of 40 CFR 1501.7 as well as our guidance in ER 200-2-2. In addition, the local sponsor for this project, Brevard County, held several meetings during this time frame in order to further discuss the proposed work with local stakeholders.

- The project hurts the local economy

Response: The project was formulated to maximize national economic benefits, primarily hurricane and storm damage reduction. During the course of this study, the Corps looked at the local economy as part of the regional economic development planning account. Local economics were qualitatively evaluated; however, no major differences between the alternatives were noted.

• The project will have detrimental effects on a valuable and federally protected reef, and should not be impacted at all

Response: The proposed project has been fully coordinated with the Florida Department of Environmental Protection, U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Environmental Protection Agency, Florida Fish and Wildlife Conservation Commission as well as other government agencies. As a result of this coordination, the project was redesigned in order to avoid and minimize adverse impacts to the hard bottom resource while still providing hurricane and storm damage reduction. The selected plan will impact approximately 3 acres of hard bottoms, and this impact shall be mitigated as described in the DSEIS.

• The mitigation reef is unproven and may not be effective

Response: The 4.8 acres of compensatory mitigation shall be comprised of articulated concrete mattress with coquina, and its design has been fully coordinated with the agencies listed above. Mitigation sites will be monitored, and the monitoring results shall be provided to the relevant regulatory agencies. In the event that monitoring shows that the mitigation is not performing as expected, then the project shall be re-evaluated and re-coordinated with the agencies.

• The models used to justify this project are flawed

Response: The models used for this study have been approved by USACE for use on this project. The uses of the models, the data used as inputs for the models, as well as the model outputs have all been reviewed by an independent (non-government) group, the USACE Planning Center of Expertise, and USACE Division and Headquarters.

• Cost of the project is indefensible in today's economic and budget climate

Response: The economic analysis found the benefits of the project in damages averted outweigh the costs of implementation. The final report will be sent to Congress for their decision to fund it for construction or not. It is also the decision of the local sponsor, Brevard County for this project, that the project is not only defensible but it is necessary.

• Why are the property owners not held responsible for building in the dune system? Irresponsible zoning, permitting, and construction are the issue.

Response: Zoning, permitting, and construction decisions are made at the local and state government levels. Many of the properties in the Mid-Reach were constructed decades ago under differing regulations.

• There must be better solutions than what is being proposed, such as (more) reef

Response: The report outlines all of the possible solutions that were considered during the planning process and the selected plan best satisfies the objectives considering the constraints given. The creation of the artificial reef in this project was the selected method of mitigation for the project construction and does not necessarily help solve the project areas problems of storm damages.

• Recreational activities such as surfing and fishing would be immediately and perhaps irrepairably crushed by the project

Response: The project was formulated to minimize impacts to the nearshore hardbottom, and the attendant recreational opportunities, as well as provide storm damage reduction. As stated earlier, the project would impact approximately 3 acres of the adjacent hard bottom resource, which is estimated to be less than 10 % of the total resource along the Mid-Reach. This impact shall be mitigated.

• Consider buying oceanfront property before destroying the reef

Response: Land acquisition (buying the oceanfront property) was one of the alternatives that was studied. The project study found that this alternative did not assure the protection of surrounding property from storm damages. For example if the erosion were allowed to continue that Highway A1A would become susceptible to storm damage. In addition the cost of land acquisition was prohibitive.

• The effects of the study are not well documented

Response: Environmental consequences are detailed in Chapter 7 of this report, and as mentioned earlier, have been fully coordinated with federal and state resource agencies.

• Beach nourishment is a never-ending cycle, and a bad idea

Response: The selected plan was identified as the plan that maximized net benefits of storm damages averted compared to cost over a 50-year period of analysis, including periodic nourishment costs. The decision to approve the project will be made by the Assistant Secretary of the Army (Civil Works) with funding provided by the U.S. Congress.

• Small areas of the Mid-Reach should be built first to test effectiveness before the entire project is built

Response: The costs and benefits were evaluated for a complete project covering the entire 7.8 miles. If built in segments, the costs would increase due to multiple construction contracts and increase loss of materials at the project ends. The benefits would also be reduced by not affording the same reduction in storm damages, thus producing a less cost effective project. Project monitoring will be continued after initial construction to ensure the effectiveness to maintain the beach profile, the impacts to the nearshore hardbottom, and the required periodic nourishment interval.

• The project may be dangerous to human lives

Response: There have been no studies documenting the loss of human lives caused by beach renourishment. The project team took many design templates into consideration before selecting the best one for this project. The slope of the template is based on the natural forces seen at this project site, including waves, tides, currents, and sand grain size.

• Continue with the dune restoration, but do not place any sand lower on the beach or in the intertidal

Response: Dune restoration was considered in the planning process, however the plan was selected to maximize the reduction in damages to the shore and upland structures for each reach. In one reach of the selected plan dune restoration is proposed, while the other reaches include additional sand beyond the dune.

• Concern that construction of jetties at Port Canaveral causes the Mid-Reach to erode

Response: Several studies have been completed on the effects of the navigation channel and jetties at Port Canaveral on the shorelines to the south. As shown in Section 1.6 of this report, the prior studies concluded that the effects were limited to the area 10 to 15 miles south of the inlet. As the Mid-Reach study area begins 14 miles south of the Port, and bypassing and nourishment activities north of the Mid-Reach preclude any additional erosion from occurring, it is unlikely the erosion at the Mid-Reach is caused by the jetty construction.

• Proposed project should be constructed

Response: This report shall be sent to the Secretary of the Army for further review, and if presented to the U.S. Congress, the U.S. Congress shall decide whether this project is to be funded for construction.

• Rocks on the beaches are dangerous, beach nourishment should proceed

Response: While this project would provide hurricane and storm damage reduction, it also has been designed to minimize adverse impacts to the hard bottom resource.

As stated earlier, approximately 3 acres of this resource would be impacted, which is less than 10 % of the total amount of hard bottom along the Mid-Reach.

• Concern over loss of land and property due to erosion

Response: Loss of land and storm damages to property were included in the benefits calculated for the project. The project was formulated to maximize storm damage reduction.

• Proposed beach nourishment is too limited, a wider beach should be constructed like the North and South Reach Beaches

Response: The project team considered many variations of nourishment volumes, however, the selected plan was chosen to reduce storm damages to the extent possible while also restricting the impact to the nearshore hardbottom.

• Too much time since the first studies without positive results

Response: The planning process is rigorous, with the effect being the plan recommended to the Assistant Secretary of the Army for approval has been vetted through numerous stakeholders, agency reviews, and USACE reviews.

• Hard bottom habitat is there because of erosion

Response: The hard bottom habitat is influenced by erosion; however, hard bottom habitat is a naturally occurring feature that has been documented over time along the Mid-Reach.

• Concern over recreational access to nourished beach

Response: Brevard County maintains public parks which provide access to the Mid-Reach. Assurances will be made in the project agreements for the continued public use of the shoreline.

8.5.3 Comments on the DSEIS from Agencies

Additional comments and questions on the DSEIS were received from various agencies (see Appendix I). These comments and concerns are as follows:

Letter from the US Environmental Protection Agency (EPA) dated 11 November 2009 (Appendix I, pp. 71-74)

• EPA previously reviewed Feasibility Report with Final Environmental Impact Statement (FEIS) for Brevard County (1996), and we noted that that the Mid-Reach segment was removed from the recommended plan due to environmental concerns.

Response: No response.

• EPA concurs with the Corps' subsequent inclusion of the Mid-Reach within the overall Brevard County Hurricane and Storm Damage Project. EPA also concurs with the Corps' decision to assess impacts from all proposed construction and dredging, as well as addressing potential effects at borrow areas, offshore areas, and the ocean bottom. EPA also supports the Corps' efforts to assess impacts from future beach maintenance, as well as requiring pre- and post-environmental monitoring efforts.

Response: No response.

• In general, the DSEIS adequately addresses all issues associated with the Brevard County Mid-Reach project, which has been proposed for construction to "reduce the damages caused by erosion and coastal storms to shorefront structures along the Mid-Reach study area." Project objectives have appropriately focused on "reducing storm damages to coastal structures, maintaining recreational beach, maintaining opportunities for recreation beach use of the nearshore areas, and maintaining environmental quality."

Response: No response.

• EPA recommends that if the comprehensive post-construction monitoring indicates any changes occurring to the beaches and the near-shore environment (e.g. unexpected erosion is detected), the project should be halted for a re-evaluation of the long term shoreline maintenance plan conducted. EPA recommends that any loss of material during construction should be thoroughly investigated, and appropriate remedies enacted.

Response: The project shall be monitored per the plan described in the report, and any changes to the beach and the near-shore environment shall be evaluated. Monitoring reports will be coordinated with the appropriate agencies, and the project shall be re-evaluated if necessary. Loss of material during construction shall be investigated, and appropriate remedies shall be enacted if practicable.

• EPA strongly recommends the use of adaptive management measures to address potential problems with fish populations and turtle/shore bird nesting. If necessary, the maintenance plan should be modified.

Response: Per the monitoring plan, macroalgae, invertebrates, juvenile and adult fishes, and marine turtles will be assessed at the mitigation reefs and nearshore hardgrounds. Data shall be collected annually, and shall be evaluated after the Year-5 post-construction survey to assess the project's impacts to the nearshore hardgrounds and the performance of the mitigation reef. Should the Average with Project Acreage (AWPA) be less than the Threshold Mitigation Acreage (TMA) after the Year-5 survey, or should annual assessments of the AWPA or nearshore rock surveys indicate significant trends that are adverse or inconsistent with the project's predicted performance, then adaptive actions shall be taken. These actions may consist of additional monitoring, analysis, and/or modifications to the project plan, subject to coordination between the Corps, local sponsor and the relevant regulatory agencies. Shore bird nesting activities shall also be monitored during construction activities, and protective measures (i.e. buffer zones around nests) shall be implemented to avoid take of eggs, chicks, or adult birds.

• The EIS adequately addressed a number of alternatives, including both structural and non-structural alternatives. These alternatives adequately addressed beach nourishment while seeking to minimize impact to the nearshore hardbottom.

Response: No response.

• EPA recommends that the Corps' future development efforts should consider potential sea level rise.

Response: Sea level rise was considered during plan formulation for this project (see Sections 2.2.8, 3.2).

• EPA notes that the locally preferred plan consists of a 10-foot extension of the mean high water line plus advanced nourishment to maintain that design fill volume in Reach 1 (R-119 to R-109), a 20-foot extension of the mean high water line plus advanced nourishment to maintain that design fill volume in Reaches 2 and 3 (R-109 to R-99), a 10-foot extension of the mean high water line plus advanced nourishment to maintain that design fill volume in Reaches 4 and 5 (R-99 to R-83), and a dune fill with no added advanced nourishment in Reach 6 (R-83 to R-75.4).

Response: No response.

• EPA recommends that if project construction is delayed for more than a year, an updated survey (to calculate sand volumes) should be initiated.

Response: A survey shall be performed prior to completion of the plans and specifications for the construction contract.

• EPA notes that the Corps plans to rehabilitate the Poseidon dredged material management area (DMMA) at Port Canaveral, with dredged material from Canaveral Shoals then placed into Poseidon DMMA every 6 years. The Corps proposes to haul this sand by dump truck to the Mid-Reach for placement on the beach at approximately 3 year intervals. As the renourishment volume is approximately 164,00 cubic yards, EPA notes that this equates to about 16,400 fully loaded trips with a 10 yard dump truck or 8,200 fully loaded trips with a 20 yard truck. The highway haul route for this major sand hauling project should carefully be considered, with particular attention to any load rated bridges on the route and other safety issues. Coordination with local highway officials is needed to ensure that the hauling is accomplished in a safe manner with minimal effects to road and bridge structures.

Response: The Corps will continue to coordinate with the local sponsor, Brevard County, on this issue. The County has considerable experience with routing of trucks for beach nourishment purposes, e.g. a dune has been constructed along the Mid-Reach on multiple occasions, and the sand was hauled by trucks from upland sources.

• EPA notes that the recommended plan appropriately offers erosion protection ranging from a 5-year storm level to a 75-year storm, varying along the length of the Mid-Reach.

Response: No response.

• EPA supports the Corps' goal "to avoid, minimize and mitigate environmental impacts to the nearshore hardbottom. " EPA notes that the project impacts 3.0 acres of hard bottom out of a total of 31.3 acres of nearshore rock in the Mid-Reach study area. The mitigation quantity has been calculated from the ratio of 1.6 mitigation acres required for every acre of natural rock impacted, resulting in a mitigation of 4.8 acres. EPA does have some environmental concerns regarding the long term consequences of inundating this hard bottom habitat, especially since this will not be the last beach nourishment project in the Mid-Reach. Therefore, EPA has identified cumulative impacts as being an issue of concern.

Response: The Corps, and its local sponsor, also identified cumulative impacts to hard bottom habitat as being an issue of concern. Discussion of these impacts is presented in Appendix J of this report. Also, the project shall be monitored per the plan outlined in this report, and if necessary, adaptive actions shall be undertaken.

• EPA believes that these hard bottom communities are the premier communities in the local marine environment, and the Final SEIS should therefore document all activities that will prevent detrimental impacts to these communities. The final mitigation decision and final monitoring plans should demonstrate, therefore, that the project will be conducted in an ecologically sustainable manner.

Response: In accordance with federal law requirements, this project has been fully coordinated with the Florida Department of Environmental Protection, U.S. Fish and Wildlife Service, National Marine Fisheries Service, U.S. Environmental Protection Agency, Florida Fish and Wildlife Conservation Commission as well as other government agencies. As a result of this coordination, the project was redesigned in order to avoid and minimize adverse impacts to the hard bottom resource while still providing hurricane and storm damage reduction. The selected plan will impact approximately 3 acres of hard bottoms, and this impact shall be mitigated as described in the DSEIS. Per the Environmental Operating Principles of the Corps, this project will be conducted in an ecologically sustainable manner.

• The Corps' documents appropriately discuss and address project economics, including cost sharing (e.g. the overall Federal participation in cost for the project is reported to be 54% of the NED plan, with the remainder to be non-Federal). EPA notes that some of the structural valuations used by the Corps (Table 2-15) may no longer be valid based upon recent significant decreases (since 2008) in home prices in the local real estate market, and we recommend that the Corps review these numbers for accuracy before inclusion in the Final SEIS.

Response: The structure values used in our benefit analysis are based on replacement value less depreciation. The Corps believes that the replacement value has not changed significantly.

• EPA concurs with the Corps' decision to select the project alternative that is the most "economically feasible, environmentally acceptable, and soundly engineered" out of the range of alternatives considered. EPA requests the Corps' continued coordination with our Agency to resolve any issues that may arise after the Final SEIS is issued.

Response: The Corps will continue to coordinate with EPA to resolve any issues that may arise after the Final SEIS is issued.

Letter from the Florida State Clearinghouse dated 18 December 2009 (Appendix I, pp.75-77).

• The state has determined that, at this stage, the proposed activity is consistent with the Florida Coastal Management Plan (FCMP).

Response: No response.

• The East Central Florida Regional Planning Council has not identified any significant or adverse effects to regional resources or facilities, nor have any extra-jurisdictional impacts been identified that would adversely affect neighboring jurisdictions. The proposed project is found to be consistent with the goals, objectives and policies of the East Central Florida Regional Planning Council.

Response: No response.

• The Florida Fish and Wildlife Conservation Commission had no comment on the report.

Response: No response.

• The Florida Department of State had no comment on the report.

Response: No response.

• The Florida Department of Environmental Protection's Bureau of Beaches and Coastal Systems is currently processing a state Joint Coastal Permit/Water Quality Certification for the proposed project and is working with the applicant on mitigation for nearshore hard bottom habitat.

Response: This is in reference to the state permit issued to the local sponsor, and agreement has been reached on mitigation for near-shore hard bottom habitat.

• The St. Johns River Water Management District had no comments on the draft report.

Response: No response.

• Florida Division of Historic Resources had no comment on the draft report.

Response: No response.

Letter from the US Department of Interior-Office of Environmental Policy and Compliance dated 22 December 2009 (Appendix I, pp. 78).

• The Department of Interior had no comment on the draft report.

Response: No response.

Email from the Department of Interior-Minerals Management Service (MMS) dated 10 March 2010 (Appendix I, pp. 79-80).

• The MMS requests that they be a cooperating agency for the environmental review of the proposed project.

Response: Since the SEIS is nearing completion, the Corps has determined that the addition of the MMS as a cooperating agency at this time would not be appropriate. The MMS may still choose to adopt the Final GRR/EIS to facilitate future leasing decisions on Canaveral Shoals, or the MMS and Corps can coordinate on the preparation of an Environmental Assessment on the use of Canaveral Shoals which would tier off of the SEIS.

• The potential impacts to air quality were dismissed during alternative and plan formulation. The MMS believes the potential for air quality impacts related to truck loading, hauling, and dumping, including those associated with fugitive dust, should be evaluated in the GRR/SEIS.

Response: Air emissions were evaluated for the Brevard County (South Reach) Hurricane and Storm Damage Reduction Project, and that evaluation indicated that the total increases would be relatively minor in the context of the existing point, nonpoint, and mobile source emissions in Brevard County. Projected emissions from the South Reach project would not adversely impact air quality given the relatively low level of emissions and the likelihood for prevailing offshore winds. With the South Reach project, the criteria pollutant levels would be well within the national ambient air quality standards. For the proposed Mid-Reach project, the Corps believes that project (including truck) emissions would also be relatively minor in the context of local conditions. As previously stated, an Environmental Assessment can be prepared for the use of Canaveral Shoals, and the assessment can further evaluate this concern.

• The draft GRR/EIS mischaracterizes the non-federal sponsor's lease status. Brevard County does not have current approval for the use of Canaveral Shoals II for the proposed action. In contrast, both federal and non-federal sponsors will be required to enter into a new negotiated agreement with the MMS for the use of either proposed OCS borrow area.

Response: The report will be changed to state that the federal and non-federal sponsor will coordinate with MMS.

• The MMS recommends that the Corps include a robust discussion of the potential impacts to prehistoric resources in proposed borrow areas and placement sites, either providing new information or incorporating existing analysis by reference.

Response: The Corps proposes to use an existing borrow area under consultation that pre-dates consideration of underwater prehistoric resources. Based on the prior use of this borrow area, there is no evidence of the presence of prehistoric cultural resources. This is an accreting shoal and therefore, prehistoric cultural resources are not expected at the depth of the borrow area. The Mid-Reach has been surveyed for cultural resources and the results of the survey can be found in Section 2.3.7.2 of the report.

8.6 List of Statement Recipients

A complete and specific list of recipients is included in the appendices.

9 RECOMMENDATIONS

I have given consideration to all significant aspects in the overall public interest including engineering feasibility, economic, social, cost and risk analysis, and environmental effects. The selected plan described in this report, including mitigation for environmental impacts, provides the optimum solution for shore protection benefits within the study area that can be developed with the framework of the formulation concepts. Implementation of the shore protection project for Brevard County, Florida, Mid-Reach segment is recommended at this time, with such modification as in the discretion of the Commander, HQUSACE, may seem advisable.

9.1 Draft Items of Local Cooperation

Recommendations for provision of Federal participation in the selected plan described in this report would require the project sponsor to enter into a written Project Cooperation Agreement, as required by Section 221 of Public Law 91-611, as amended, to provide local cooperation satisfactory to the Secretary of the Army. Such local cooperation shall provide the following non-Federal responsibilities:

a. Provide 35 percent of initial project costs assigned to hurricane and storm damage reduction, 50 percent of initial project costs assigned to protection of recreational public lands, 100 percent of initial project costs assigned to protecting undeveloped private lands and other private shores which do not provide public benefits, and 100 percent of total project costs exceeding the NED Plan, as well as 50 percent of periodic nourishment costs assigned to hurricane and storm damage reduction plus 100 percent of periodic nourishment costs assigned to protecting undeveloped private lands and other private shores which do not provide public benefits and as further specified below:

(1) Enter into an agreement which provides, prior to execution of the project partnership agreement, 25 percent of design costs;

(2) Provide, during the first year of construction, any additional funds needed to cover the non-Federal share of design costs;

(3) Provide all lands, easements, and rights-of-way, including those required for relocations, the borrowing of material, and the disposal of dredged or excavated material; perform or ensure the performance of all relocations; and construct improvements required on lands, easements, and rights-of-way to enable the disposal of dredged or excavated material that the Government determines to be necessary for the construction, operation, maintenance, repair, replacement, and rehabilitation of the project;

(4) Provide, during construction, any additional funds necessary to make its total contribution equal to 35 percent of initial project costs assigned to hurricane and storm damage reduction, 50 percent of initial project costs assigned to protection of recreational public lands, 100 percent of initial project costs assigned to protecting undeveloped private lands and other private shores

which do not provide public benefits, and 100 percent of total project costs exceeding the NED Plan, as well as 50 percent of periodic nourishment costs assigned to hurricane and storm damage reduction plus 100 percent of periodic nourishment costs assigned to protecting undeveloped private lands and other private shores which do not provide public benefits.

b. For as long as the project remains authorized, operate, maintain, repair, replace, and rehabilitate the project, or functional portions of the project, including mitigation, at no cost to the Federal Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and state laws and regulations and any specific directions prescribed by the Federal Government;

c. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal sponsor, now or hereafter, owns or controls for access to the project for the purpose of inspecting, operating, maintaining, repairing, replacing, rehabilitating, or completing the project. No completion, operation, maintenance, repair, replacement, or rehabilitation by the Federal Government shall relieve the non-Federal sponsor of responsibility to meet the non-Federal sponsor's obligations, or to preclude the Federal Government from pursuing any other remedy at law or equity to ensure faithful performance;

d. Hold and save the United States free from all damages arising from the construction, operation, maintenance, repair, replacement, and rehabilitation of the project and any project-related betterments, except for damages due to the fault or negligence of the United States or its contractors;

e. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project, for a minimum of 3 years after completion of the accounting for which such books, records, documents, and other evidence is required, to the extent and in such detail as would properly reflect total costs of construction of the project, and in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal Regulations (CFR) Section 33.20;

f. Perform, or cause to be performed, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 96-510, as amended (42 U.S.C. 9601-9675), that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for the initial construction, periodic nourishment, operation, and maintenance of the project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-Federal sponsor with prior specific written direction, in which case the non-Federal sponsor shall perform such investigations in accordance with such written direction;

g. Assume, as between the Federal Government and the non-Federal sponsor, complete financial responsibility for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be necessary for the initial construction, periodic nourishment, operation, or maintenance of the project;

h. Agree that, as between the Federal Government and the non-Federal sponsor, the non-Federal sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, and repair the project in a manner that would not cause liability to arise under CERCLA;

i. Comply with all applicable provisions of the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended (42 U.S.C. 4601-4655), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way necessary for the initial construction, periodic nourishment, operation, and maintenance of the project, including those necessary for relocations, borrow materials, and dredged or excavated material disposal, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act.

j. Comply with all applicable Federal and state laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and ActivitiesAssisted or Conducted by the Department of the Army," and all applicable Federal labor standards and requirements, including but not limited to 40 U.S.C. 3141- 3148 and 40 U.S.C. 3701 – 3708 (revising, codifying, and enacting without substantial change the provisions of the Davis-Bacon Act (formerly 40 U.S.C. 276a et seq.), the Contract Work Hours and Safety Standards Act (formerly 40 U.S.C. 327 et seq.) and the Copeland Anti-Kickback Act (formerly 40 U.S.C. 276c et seq.) Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12), requiring non-Federal preparation and implementation of flood plain management plans; [CHECk]; and

k Provide the non-Federal share of that portion of the costs of mitigation and data recovery activities associated with historic preservation, that are in excess of 1 percent of the total amount authorized to be appropriated for the project;

l. Participate in and comply with applicable Federal floodplain management and flood insurance programs;

m. Not use funds provided by a Federal agency under any other Federal program, to satisfy, in whole or in part, the non-Federal share of the cost of the project unless the Federal agency that provides the funds determines that the funds are authorized to be used to carry out the study or project;

n. Prevent obstructions of or encroachments on the project (including prescribing and enforcing regulations to prevent such obstruction or encroachments) which might reduce ecosystem restoration benefits, hinder operation and maintenance, or interfere with the project's proper function, such as any new developments on project lands or the addition of facilities which would degrade the benefits of the project;

o. Not less than once each year, inform affected interests of the extent of protection afforded by the project;

p.   Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in preventing unwise future development in the floodplain, and in adopting such regulations as may be necessary to prevent unwise future development and to ensure compatibility with protection levels provided by the project;

q.   For so long as the project remains authorized, the Non-Federal Sponsor shall ensure continued conditions of public ownership and use of the shore upon which the amount of Federal participation is based;

r. Not use project or lands, easements, and rights-of-way required for the project as a wetlands bank or mitigation credit for any other project;

s.   Provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms;

t. Comply with Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended (42 U.S.C. 1962d-5), and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended (33 U.S.C. 2213), which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element;

t. At least twice annually and after storm events, perform surveillance of the beach to determine losses of nourishment material from the project design section and provide the results of such surveillance to the Federal Government.

9.2 Disclaimer

The recommendations contained herein reflect the information available at this time and current Departmental policies governing formulation of individual projects. They do not reflect program and budgeting priorities inherent in the formulation of a national Civil Works construction program nor the perspective of higher review levels within the Executive Branch. Consequently, the recommendations may be modified before they are transmitted to higher authority as proposals for project modification and/or implementation funding. The recommendations herein for provision of a shore protection project for Brevard County, Florida, do not include any provisions for work which would result in any new Federal expenditures or financial assistance prohibited by the Coastal Barrier Resources Act (Public Law 97-348); nor were funds obligated in past years for this project for purposes prohibited by this Act.

9.3 Certification of Public Accessibility

As part of the obligations established in the project cooperation agreement for the Brevard County, Florida, Shore Protection Project, the non-Federal sponsor shall assure continued conditions of public ownership and public use of the shore upon which Federal participation is based during the economic life of the project. The non-Federal sponsor shall also provide and maintain necessary access roads, parking areas and other public use facilities, open and available to all on equal terms. In the determination of the Federal interest in cost sharing, Federal participation was limited to areas where adequate parking and access are available. For shoreline reaches further than ¼ mile from public parking and/or beach access points, Federal participation was not provided. The maximum Federal participation allowable for each land use category is applied for cost sharing. I therefore conclude that there is reasonable public availability of the project beaches in all areas where Federal participation is provided.

Al Pantano
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11 LIST OF ACRONYMS

AAEQ	Average Annual Equivalent
ACR	Acre
AFB	Air Force Base
BBCS	Bureau of Beaches and Coastal Systems
BCR	Benefit to Cost Ratio
CAR	Coordination Act Report
CBRA	Coastal Barrier Resources Act
CBRS	Coastal Barrier Resources System
CCAS	Cape Canaveral Air Station
CCCL	Coastal Construction Control Line
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CS-II	Canaveral Shoals II borrow area
CSA	Continental Shelf Associates
CY	Cubic yard
CZMP	Coastal Zone Management Program
DGPS	Differential Global Positioning System
DMMA	Dredged Material Management Area
EA	Environmental Assessment
EC	Engineering Circular
ECL	Erosion Control Line
EFH	Essential Fish Habitat
EIS	Environmental Impact Statement
EO	Executive Order
EOP	Environmental Operating Principles
EPA	Environmental Protection Agency
EQ	Environmental Quality
ER	Engineering Regulation
FCCE	Flood Control and Coastal Emergency
FDEP	Florida Department of Environmental Protection
FDOT	Florida Department of Transportation
FEMA	Federal Emergency Management Agency
FONSI	Finding of No Significant Impact
FP	Fibropapillomatosis
FWC	Florida Fish and Wildlife Conservation Commission
FY	Fiscal Year
GPS	Global Positioning System
GRR	General Re-evaluation Report
HAPC	Habitat Areas of Particular Concern
HEA	Habitat Equivalency Analysis
HQUSACE	Headquarters, United States Army Corps of Engineers
HR	Hour
HRHC	High relief, high complexity
HSDR	Hurricane and Storm Damage Reduction

HTRW	Hazardous, Toxic, and Radioactive Waste
JCP	Joint Coastal Permit
LERRD	Lands, easements, relocations, rights-of-way, disposal
LPP	Locally Preferred Plan
LRLC	Low relief, low complexity
LS	Lump Sum
MCACES	Micro-Computer Aided Cost Estimating System
MHW	Mean high water
MHWL	Mean high water line
MLLW	Mean lower low water
MLW	Mean low water
MMS	Minerals Management Service
NED	National Economic Development
NEPA	National Environmental Policy Act
NGVD	National Geodetic Vertical Datum
NMFS	National Marine Fisheries Service
NN	No Name (Shipwreck)
NOAA	National Oceanic and Atmospheric Administration
NRC	National Research Council
NRHP	National Register of Historic Places
NRMO	Natural Resources Management Office
NS	Non-Structural
NTU	Nephelometric Turbidity Units
O&M	Operations and Maintenance
ODMDS	Offshore Dredged Material Disposal Site
OMRR&R	Operations, maintenance, replacement, repair and rehabilitation
OPA	Otherwise Protected Area
OSE	Other Social Effects
P&G	Principles and Guidelines
PAFB	Patrick Air Force Base
PALM	Propagule and Larval Measurement
PCA	Project Cooperation Agreement
PDT	Project Delivery Team
PED	Preconstruction, engineering, and design
PPA	Project Partnership Agreement
RED	Regional Economic Development
S	Structural
SAFMC	South Atlantic Fishery Management Council
SBEACH	Shore and Beach Change Model
SCL	Straight Carapace Length
SDM	Storm Damage Model
SEARCH	Southeastern Archaeological Research, Inc.
SEIS	Supplemental Environmental Impact Statement
SHPO	State Historic Preservation Officer
SPP	Shore Protection Project
SY	Square Yard

UMAM	Uniform Mitigation Assessment Method
URTD	Upper Respiratory Tract Disease
USACE	United States Army Corps of Engineers
USC	United States Code
USEPA	United States Environmental Protection Agency
USFWS	United States Fish and Wildlife Service
WRDA	Water Resources Development Act

12 INDEX

13 REFERENCES

Bagley, D., T. Cascio, R. Owen, S. Jonson, and L. Ehrhardt. 1994. Marine turtle nesting Patrick Air Force Base, Florida: 1987-1993: Trends and issues. Pp. 180-181, In: K.A. Bjorndal, A.B. Bolten, D. Johnason, and P. Elizar (compilers), Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation, Technical Memorandum NMFS-SEFC-351, National Oceanic and Atmospheric Administration, Washington, D.C.

Bagley, Dean A. Sea Turtle Biologist for UCF and Inwater Research Group, Inc. Unpublished data concerning satellite tracking. Indications that large subadult green turtles (>71.0 cm SCL) migrate from nearshore habitats into the southeastern Caribbean.

Balazs, G.H. 1985. Impact of ocean debris on marine turtles: entanglement and ingestion, pp. 387-489. In: Shomura, R.S. and H.O. Yoshida (eds.), Workshop on the Fate and Impact of Marine Debris. U.S. Department of Commerce, Honolulu, Hawaii.

Bowen, B., J.C. Avise, J.I. Richardson, A.B. Meylan, D. Margaritoulis, and S.R. Hopkins Murphy. 1993. Population structure of loggerhead turtles (Caretta caretta) in the northwestern Atlantic Ocean and Mediterranean Sea. Conservation Biology 7(4):834-844.

Bresette, M.J., J. Gorham, and B. Peery. 1998. Size fidelity and size frequencies of juvenile green turtles (Chelonia mydas) utilizing near shore reefs in St. Lucie County, Florida. Marine Turtle Newsletter 82:5.

Bresette, M.J., J.C. Gorham, and B.D. Peery. 2000. Initial assessment of sea turtle in the southern Indian River Lagoon system, Ft. Pierce, Florida, pp. 271-273. In: A. Mosier, A. Foley, and B. Brost (eds.), Twentieth Annual Symposium on Sea Turtle Biology and Conservation. NOAA Tech. Memo. NMFS-SEFSC-477, Orlando, FL.

Brevard County NRMO. 2008. Summary of Brevard County Outfalls: Existing conditions and proposed plan of improvements. Report prepared by Brevard County Natural Resources Management Office and Olsen Associates, Inc. Response to FDEP RAI#6A, JCP File No. 0254479-001-JC, Att. B1. March 31, 2008.

Brevard, misc. Annual turtle nesting studies of the Brevard County North and South Reach Shore Protection Project. Brevard County, Florida. 2001 through 2007.

Brock, K.A., J.S. Reece, and L.M. Ehrhart. 2008. The effects of artificial beach nourishment on marine turtles: Differences between loggerhead and green turtles. doi:10.1111/j.1526-100X.2007.00337.x

Burke, V.J., S.J. Morreale, P. Logan, and E.A. Standora. 1992. Diet of green turtles (Chelonia mydas) in the waters of Long Island, New York, pp. 140 142. In: M. Salmon and J. Wyneken (eds.), Proceedings of the Eleventh Annual Workshop on Sea Turtle Biology and Conservation, NOAA Tech. Mem. NMFS SEFC 302.

Burke, V.J., E.A. Standora, and S.J. Morreale. 1993. Diet of juvenile Kemp's ridley and loggerhead sea turtles from Long Island, New York. Copeia 1993:1,176 1,180.

Burney, C. and C. Mattison. 1992. The effects of egg relocation and beach renourishment on the nesting and hatching success of Caretta caretta in Broward County, Florida, 1991. Pgs 395-407, In: L.S. Tait (compiler), Proceedings of the Fifth Annual National Conference on Beach Preservation Technology: New directions in beach management. Florida Shore and Beach Preservation Association, Tallahassee, Florida.

Byles, R.A. 1988. Satellite Telemetry of Kemp's Ridley Sea Turtle, Lepidochelys kempii, in the Gulf of Mexico. National Fish and Wildlife Foundation. 40 pp.

Byrd, J.I. 2004. The effect of beach nourishment on loggerhead sea turtle (Caretta caretta) nesting in South Carolina. Master’s thesis. College of Charleston, South Carolina. 97 pp.

Carr, A. 1987. New perspectives on the pelagic stage of sea turtle development. Conservation Biology 1:103 121.

Coastal Eco-Group Inc. 2007. Indian River County biological monitoring of the Ambersand (Sectors 1 and 2) mitigation reef; baseline survey summer/fall 2006. 40 pp. plus appendices. Prepared by Coastal Eco-Group, Inc., 808 East Las Olas Blvd., Suite 101, Ft. Lauderdale, FL 33301 under contract to Applied Technology & Management, Inc., West Palm Beach, FL. Prepared for Indian River County, 1840 25th Street, Vero Beach, FL. May 2007.

Coastal Eco-Group Inc. 2008. Indian River County biological monitoring of the Ambersand (Sectors 1 and 2) Mitigation Reef. Summer/Fall 2007 Monitoring Event. Prepared by Coastal Eco-Group, Inc., 808 East Las Olas Blvd., Suite 101, Ft. Lauderdale, FL 33301 under contract to Applied Technology & Management, Inc., West Palm Beach, FL. Prepared for Indian River County, 1840 25th Stree, Vero Beach, FL. May 2008.

Continental Shelf Associates, Inc. 1990. Environmental impact assessment for beach restoration, Brevard County, Florida. Prepared for Olsen Associates, Inc. 57 pp.

Continental Shelf Associates, Inc. 2002. Summary report on aerial surveys (1996/97, 1997/98, 1998/99) of northern right whales and other listed species in Atlantic waters from Charleston, South Carolina to Cape Canaveral, Florida. Department of the Navy, Southern Division, Charleston, South Carolina. 47 pp. + app.

Continental Shelf Associates, Inc. 2005. Survey of fishes along the Brevard County Mid Reach. Continental Shelf Associates, Inc. 759 Parkway Street, Jupiter, FL 33477. 11 pp. 14 November, 2005.

Continental Shelf Associates, Inc. 2005. Results of epibiotic surveys of nearshore rock outcrops in the Mid Reach project area in Brevard County, Florida. Prepared for Olsen Associates, Inc. 15 pp.

Continental Shelf Associates, Inc. 2007. "Habitat Equivalency Analysis (HEA): Proposed Mitigation Reef for Brevard County Mid Reach Shore Protection Project." CSA International Inc. 759 Parkway St., Jupiter FL 33477. February 2007.

Continental Shelf Associates, Inc., East Coast Biologists Inc., and Olsen Associates Inc. 2006. "Brevard County Mid Reach Shore Protection Project: Mitigation Assessment Analysis" Prepared for Brevard County Natural Res. Mgt. Office. Prepared by Continental Shelf Associates, Inc., Jupiter FL; East Coast Biologists, Inc., Indialantic, FL; Olsen Associates Inc., Jacksonville, FL. 28 August 2006.

Continental Shelf Associates, Inc., East Coast Biologists Inc., and Olsen Associates Inc. 2008. "Brevard County Mid Reach Shore Protection Project: Mitigation Assessment Analysis" Prepared for Brevard County Natural Res. Mgt. Office. Prepared by Continental Shelf Associates, Inc., Jupiter FL; East Coast Biologists, Inc., Indialantic, FL; Olsen Associates Inc., Jacksonville, FL. August 2008.

Coastal Eco-Group 2007. "Indian River County Biological Monitoring of the Ambersand (Sectors 1 and 2) Mitigation Reef. FDEP Permit No. 0166929-001-JC." Report prepared for Indian River County. Prepared by Coastal Eco-Group, Inc. 808 East Las Olas Blvd., Suite 101, Ft. Lauderdale, FL 33301. 2007.

Cordes, J. J. and A. M. Yezer. 1995. Shore Protection and Beach Erosion Control Study: Economic Effects of Induced Development in Corps Protected

Beachfront Communiities. U. S. Army Coprs of Engineers, Water Resources Support Center. IWR Report 95-PS-1, 106 pp.

Crain, D. A., A. B. Bolton, and K. A. Bjorndal. 1995. Effects of beach nourishment on sea turtles: Review and research initiatives. Restoration Ecology 3(2):95-104.

Dahl, E. 1952. Some aspects of the ecology and zonation of the fauna on sandy beaches. Oikos 4:1-27.

Davis, R A., Jr. 1997. Geology of the Florida Coast, pp. 155-168. In: A.F. Randazzo and D.S. Jones (eds.) Geology of Florida. University Press of Florida, Gainesville, FL.

Dean A. Bagley. Sea Turtle Biologist for UCF and Inwater Research Group, Inc. Unpublished data concerning satellite tracking. Indications that large subadult green turtles (>71.0 cm SCL) migrate from nearshore habitats into the southeastern Caribbean.

Dean, C. 1999. Against the tide: the battle for America's beaches. Columbia University Press. New York, NY.

Dodd, C.K. Jr. 1988. Synopsis of the biological data on the loggerhead sea turtle Caretta caretta (Linnaeus 1758). U.S. Fish and Wildlife Service Biological Report 88(4). 110 pp.

Eckelbarger, K.J.. 1976. Larval development and population aspects of the reef-building polychaete Phragmatopoma lapidosa from the east coast of Florida. Bull. Mar. Sci. 26:117-132.

Eckert, K.L. 1995. Leatherback sea turtle, Dermochelys coriacea. In: P.T. Plotkin (ed.), National Marine Fisheries Service and U.S. Fish and Wildlife Service Status Reviews for Sea Turtles Listed Under the Endangered Species Act of 1973, Silver Spring, MD.

Eckert, S.A., D.W. Nellis, K.L. Eckert, and G.L. Kooyman. 1986. Diving patterns of two leatherback sea turtles (Dermochelys coriacea) during internesting intervals at Sandy Point, St. Croix, U.S. Virgin Islands. Herpetologica 42(3):381 388.

Ehrhart, L.M. 1983. Marine turtles of the Indian River lagoon system. Florida Scientist 46:337-346

Ehrhart, L.M. and B.E. Witherington, 1987. Human and natural causes of marine turtle nest and hatchling mortality and their relationship to hatchling production on an important Florida nesting beach. Florida Game and Fresh Water Fish Commission, Non Game Wildlife Program, Tech. Rep. 1.

Ehrhart, L.M. 1992. Turtles of the worm-rock reefs. The Florida Naturalist. 65:9-11.

Ehrhart, L.M. and W.E. Redfoot. 1996. Assessment of green turtle relative abundance in the Cape Canaveral AFS Port area, Trident Submarine Basin. Final Report to USAE Waterways Experiment Station, Coastal Ecology Group, Environmental Laboratory., Vicksburg, Mississippi.

Ehrhart, L.M., W.E. Redfoot, and D.A. Bagley. 1996. A study of the population ecology of the in-water marine turtle populations on the east-central Florida coast from 1982-96, p. 164. NOAA/NMFS/SEFC, Miami, FL.

Ehrhart, L.M., D.A. Bagley, W.E. Redfoot, S.A. Kubis, and S. Hirama. 2001a. In-water population studies of marine turtles on the East-Central Florida coast; September, 1999 through December, 2000. NOAA/NMFS.

Ehrhart, L. M., D. A. Bagley, W. E. Redfoot, S. A. Kubis, and S. Hirama. 2001b. In-water population studies of marine turtles on the East-Central Florida coast; September, 1999 through December, 2000. NOAA/NMFS, Silver Spring, MD. pp 53.

Ehrhart, L. M. and S. Hirsch 2008. Marine turtle nesting monitoring: Brevard County Shore Protection Project; South Reach 2007. Department of Biology, University of Central Florida, P.O. Box 162368, Orlando, FL 32816. 21 pp. 15 February, 2008.

Ernst, C., J. Lovich, and R. Barbour. 1994. Turtles of the United States and Canada. Smithsonian Institute Press, Washington, DC. 578 pp.

FDEP 2008. Correspondence from Michael Barnett, Chief, Bureau of Beaches and Coastal Systems, FDEP, to Ernest Brown, Director, Brevard County Natural Res. Management Office. June 16, 2008.

Fields, H.M. 1962. Pompanos of the south Atlanic Coast of the United States. Fish. Bull. 62:189-222.

Finkl, C.W. Jr. 1993. Pre-emptive strategies for enhanced sand bypassing and beach replenishment activities in southeast Florida: A geological perspective. Journal of Coastal Restoration, Special Issue No. 18:59-89.

Florida Fish and Wildlife Conservation Commission. 2004. Florida's Endangered Species, Threatened Species, and Species of Special Concern. 29 January 2004. 6 pp.

Geomar 2008. An assessment of sea turtle nesting success – Brevard County Federal Shore Protection Project, North Reach, 2007. Geomar Environmental Consultants, Inc., 130 Belmont Avenue, Cocoa, FL 32927. 17 pp. March, 2008.

Gilbert, C.R. 1966. Western Atlantic sciaenid fishes of the genus Umbrina. Bull. Mar. Sci. 16:230-258.

Gilbert, E.I. 2005. Juvenile green turtle (Chelonia mydas) foraging ecology: feeding selectivity and forage nutrient analysis. Masters thesis. University of Central Florida, Orlando, FL.

Gilmore, R.G., Jr. 1995. Environmental and biogeographic factors affecting ichthyofaunal diversity: Indian River Lagoon. Bull. Mar. Sci. 57(1):153-170.

Gilmore, R.G., Jr. 2001. The origin of Florida fish and fisheries. Proc. Gulf Carib. Fish. Inst. 52:713-731.

Gilmore, R.G. and F.F. Snelson. 1992. Striped croaker, Bairdiella sanctaeluciae (Jordan), pp 218-222. In: C.R. Gilbert (ed.) Rare and endangered biota of Florida, Volume II. Fishes. University Press of Florida, Gainesville, Florida.

Gilmore, R.G., Jr., L.H. Bullock, and F.H. Berry. 1979. Hypothermal mortality in marine fishes of south-central Florida: January 1977. NE Gulf Sci. 2(2):77-79.

Gilmore, R.G., Jr., C.J. Donohoe, D.W. Cooke, and D.J. Herrema. 1981. Fishes of the Indian River Lagoon and adjacent waters. Harbor Branch Tech. Rep. No. 41. 64 pp.

Gitschlag, G.R. 1996. Migration and diving behavior of Kemp's ridley (Garman) sea turtles along the U.S. southeastern Atlantic coast. Journal of Experimental Marine Biology and Ecology 205:115 135.

Gore, R.H., L.E. Scotto, and L.J. Becker. 1978. Community composition, stability, and trophic partitioning in decapod crustaceans inhabiting some subtropical sabellariid wormreefs. Bull. Mar. Sci. 28(2):221-248.

Gorzelany, J.F. 1983. The effects of beach nourishment on the nearshore benthic macrofauna of Indialantic and Melbourne Beach, Florida. Masters Thesis, Florida Institute of Technology, Melbourne, FL 114 pp.

Gorzelany, J.F. and W.G. Nelson. 1987. The effects of beach replenishment on the benthos of a sub-tropical Florida beach. Marine Environ. Res. 21:75-94.

Grant, G., H. Malpass, and J. Beasley. 1996. Correlation of leatherback turtle and jellyfish occurrence. Herpetological Review 27(3):123 125.

Greene, Karen. 2002. Beach nourishment: A review of the biological and physical impacts. Atlantic States Marine Fisheries Commission, ASMFC Habitat Management Series #7, November 2002.

Grippo, M., S. Cooper, and A. Massey. 2007. Effect of beach replenishment projects on waterbird and shorebird communities. Journal of Coastal Research 23(5):1088-1096.

H.D. 352. House Document No. 352, 90th Congress, 2nd Session, Brevard County, Florida. 1968.

Henwood, T.A. 1987. Movements and seasonal changes in loggerhead turtle Caretta caretta aggregations in the vicinity of Cape Canaveral, Florida (1978 84). Biological Conservation 40:191 202.

Herren, R.M. 1999. The effect of beach nourishment on loggerhead (Caretta caretta) nesting and reproductive success at Sebastian Inlet, Florida. Master's thesis. University of Central Florida, Orlando. 138 pp.

Hirth, H.F. 1997. Synopsis of the biological data on the green turtle Chelonia mydas (Linnaeus, 1758). U.S. Fish and Wildlife Service Biological Report 97(1). 120 pp.

Holloway-Adkins, K.G. 2001. A comparative study of the feeding ecology of Chelonia mydas (green turtle) and the incidental ingestion of Prorocentrum spp. Master's thesis, Department of Biology. UCF, Orlando, FL. 168 pp.

Holloway-Adkins, K.G., M.J. Bresette, and L.M. Ehrhart. 2002. Juvenile green turtles of the Sabellariid Worm Reef. In: J.A. Seminoff (ed.), Twenty-Second Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-503, Miami. FL.

Holloway-Adkins, K.G., and J.A. Provancha. 2005. Abundance and foraging activity of marine turtles using nearshore rock resources along the Mid Reach of Brevard County, Florida. Dynamac Corporation, 100 Spaceport Way, Cape Canaveral, FL 32920. October 18, 2005. 45 pp.

Holloway-Adkins, K. G. 2005a. Green Turtles Using Nearshore Reefs in Brevard County, Florida as Developmental Habitat; a Preliminary Investigation. in 25th Annual Symposium on Sea Turtle Biology and Conservation. NOAA-SENMFS, Savannah, GA.

Holloway-Adkins, K. G. 2005b. In press: Green Turtles Using Nearshore Reefs in Brevard County, Florida as Developmental Habitat; a Preliminary Investigation. in 25th Annual Symposium on Sea Turtle Biology and Conservation. NOAA-SENMFS, Savannah, GA.

Holloway-Adkins, K. 2006. Juvenile green turtle (Chelonia mydas) foraging on a high-energy, shallow reef on the east cost of Florida. Pages 193 in M. Frick, P. A., R. A. F., and K. Williams, editors. Twenty-Sixth Annual Symposium on Sea Turtle Biology and Conservation. International Sea Turtle Society, Athens, Greece.

Holloway-Adkins, K. 2006. "Palm & Prototype Observations: 10-13-2006." East Coast Biologists Inc., PO Box 33715, Indialantic FL 32903. October 13, 2006.

Holloway-Adkins, K. and D. McCarthy 2007. "The Recruitment of Macroalgae on Subtidally Deployed Structures off the Coastal Waters of Brevard County, Florida." East Coast Biologists Inc., PO Box 33715, Indialantic FL 32903. August 30, 2007.

Inwater Research Group, I. 2005. Final report on sea turtle sampling in the Key West National Wildlife Refuge, Florida, July 2005. FWC Marine Research Institute, St Petersburg, Florida.

Inwater Research Group. 2005a. Abundance and Distribution of Marine Turtles Within Nearshore Hardbottom and Associated Habitats. Florida Fish and Wildlife Conservation Commission, St Petersburg, FL. pp 39.

Inwater Research Group, I. 2005b. Abundance and distribution of marine turtles within nearshore hardbottom and associated habitats. Grant Florida Fish and Wildlife Conservation Commission, St Petersburg, FL. pp.

J. Rogers, 2005, personal communication, State of Florida, Florida Fish and Wildlife Conservation Commission.

Johnson, D.R. and N.A. Funicelli. 1991. Spawning of the red drum in Mosquito Lagoon, East-central Florida. Estuaries 14(1):74-79.

Jones Edmunds 2007. "Brevard County Beach Outfalls Removal, Feasibility Study; Final Report." Report prepared for Brevard County Stormwater Utility Dept., by Jones Edmunds, 3910 S. Washington Ave., Suite 210, Titusville, FL 32780. October 19, 2007.

Kimmel, J. 1985. A new species-time method of visual census of fishes and its comparison with established methods. Environ. Biol. Fishes 12:23-32.

Kirtley, D.W. 1966. Intertidal reefs of sabellariidae (Annelida, Polychaeta) along the coasts of Florida. M.S. Thesis. Florida State University, Tallahassee.

Kirtley, D.W. and W.F. Tanner. 1968. Sabellariid worms: builders of a major reef type. J. Sed. Petr. 38:73-78.

Knowlton, A.R. and B. Weigle. 1989. A note on the distribution of leatherback turtles Dermochelys coriacea along the Florida coast in February 1988. In: S.A. Eckert, K.L. Eckert, and T.H. Richardson (comps.), Proceedings of the Ninth Annual Workshop on Sea Turtle Conservation and Biology, NOAA Tech. Mem. NMFS SEFSC 232, pp. 83 85.

Kriebel, D., R. Weggel, and R. Dalrymple 2002. "Independent Study Report, Brevard County, Florida Shore Protection Project." 2002. Also known as the Brevard County Independent Coastal Expert (ICE) Report.

Lacharmoise, F., V. Barrailler, T. Horwell, V.H. Barker, and M.B. Bush. In Preparation. Beach nourishment on invertebrate population densities.

Layman, C.A. 2000. Fish assemblage structure of the shallow ocean surf-zone on the eastern shore of Virginia barrier islands. Est. Coast Shelf Sci. 51:201-213.

Lindeman, K.C. and D.B. Snyder. 1999. Nearshore hardbottom fishes of southeast Florida and effects of habitat burial caused by dredging. Fish. Bull. 97:508-525.

Lindeman, K.C., R. Pugliese, G.T. Waugh, and J.S. Ault. 2000. Developmental patterns within a multispecies reef fishery: Management applications for essential fish habitats and protected areas. Bull. Mar. Sci. 66(3):929-956.

Lindquist, N. and L. Manning. 2001. Impacts of beach nourishment and beach scraping on critical habitat and productivity of surf fishes. Final Report-Project #98-EP-05. North Carolina Sea Grant Fisheries Resource Grant Program. 107. pp.

Lutcavage, M. and J.A. Musick. 1985. Aspects of the biology of sea turtles in Virginia. Copeia 1985(2):449-456.

Magnuson, J.J., K.A. Bjorndal, W.D. DuPaul, G.L. Graham, F.W. Owens, C.H. Peterson, P.C.H. Pritchard, J.I. Richardson, G.E. Saul, and C.W. West. 1990. Decline of Sea Turtles: Causes and Prevention. National Academy Press, Washing, D.C. 259 pp.

Makowski, C., R. Slattery, and M. Salmon. 2002. "Shark fishing": a technique for estimating the distribution of juvenile green turtles (Chelonia mydas) in shallow water developmental habitats, Palm Beach County, Florida USA, p. 241. In: J.A. Seminoff (ed.), Twenty Second Annual Symposium on Sea Turtle Biology and Conservation. NOAA Technical Memorandum NMFS-SEFSC-503, Miami, FL.

Makowski, C. 2004. Home range and movements of juvenile Atlantic green turtles (Chelonia mydas L.) on shallow reef habitats in Palm Beach, Florida, USA. Department of Biology. Florida Atlantic University, Boca Raton, FL.

Makowski, C., L. Fisher, and C. J. Kruempel. 2006a. Green turtle (Chelonia mydas L.) population estimate for the nearshore reefs of Broward County:a summary after three years of pre-construction monitoring. Shore and Beach 72:26-28.

Makowski, C., J. A. Seminoff, and M. Salmon. 2006b. Home range and habitat use of juvenile Atlantic green turtles (Chelonia mydas L.) on shallow reef habitats in Palm Beach, Florida, USA. Marine Biology 148:1167-1179.

Marine Turtle Expert Working Group. 1996a. Status of the Loggerhead Turtle Population (Caretta caretta) in the Western North Atlantic. 50 pp.

Marine Turtle Expert Working Group. 1996b. Kemp’s Ridley Sea Turtle (Lepidochelys kempii) Status Report. 49 pp.

Marine Turtle Expert Working Group. 2000. Assessment Update for the Kemp's Ridley and Loggerhead Sea Turtle Populations in the Western North Atlantic. U.S. Department of Commerce, NOAA Tech. Mem. NMFS SEFSC 444. 115 pp.

Marquez, R.M. 1990. Sea Turtles of the World. FAO Species Catalogue, Volume 11. FAO, Rome. 81 pp.

McCarthy, D.A. 2001. Life-history patterns and the role of disturbance in intertidal and subtidal populations of the polychaete Phragmatopoma lapidosa (Kinberg 1867) in the tropical Western Atlantic. Ph.D. dissertation. King’s College, London. 237 pp.

McCarthy, D.A., C.M. Young, and R.H. Emson. 2003. Influence of wave-induced disturbance on seasonal spawning patterns in the sabellariid polychaete Phragmatopoma lapidosa (Kinberg 1867). Marine Ecology Progress Series 256:123 133.

McCarthy, D. A. and K. Holloway-Adkins 2007. “Assessing larval recruitment of the polychaete Phragmatopoma lapidosa on subtidally deployed structures off Satellite Beach, Florida.” Dept. of Biology and Marine Science, Jacksonville University, 2800 University Blvd North; Jacksonville, FL 32216. August 20, 2007.

Mendonca, M.T. 1983. Movements and feeding ecology of immature green turtles (Chelonia mydas) in a Florida lagoon. Copeia 1983:1,013-1,023.

Meylan, A.B. and K.A. Bjorndal. 1983. Sea turtles nesting at Melbourne Beach, Florida, II. Post nesting movements of Caretta caretta. Biological Conservation 26:79 90.

Meylan, A. 1988. Spongivory in hawksbill turtles: a diet of glass. Science, 239: 393 395.

Meylan, A. 1992. Hawksbill turtle Eretmochelys imbricata, pp. 95 99. In: P. Moler (ed.), Rare and Endangered Biota of Florida, University Press of Florida, Gainesville, FL.

Meylan, A., B. Schroeder, and A. Mosier. 1995. Marine turtle nesting activity in the State of Florida, 1979 1992, p. 83. In: K.A. Bjorndal, A.B. Bolten, D.A. Johnson, and P.J. Eliazar (comps.), Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation, Hilton Head, SC, U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Miami, FL.

Meylan, A., B. Schroeder, and A. Mosier. 1995. Sea turtle nesting activity in the State of Florida 1979-1992. Florida Marine Research Publication 52:19 pp.

Meylan, A., and A.Redlow. 2006. Eretmochelys imbricata- Hawksbill Turtle. Chelonian Research Monographs 3:105–127.

Miller, G.C. and W.J. Richards. 1979. Reef fish habitat, faunal assemblages, and factors determining distributions in the South Atlantic Bight. Proc. Gulf Carib. Fish. Inst. 32:114-130.

Modde, T. and S.T. Ross. 1983. Trophic relationships of fishes occurring within a surf zone habitat in the northern Gulf of Mexico. NE Gulf Sci. 6:109-120.

Morgan & Eklund Inc. 2003. “Conventional Survey, Field Investigation - Brevard County, South Reach Segment II Coastal Project, Satellite Beach, FL” US Army Corps of Engineers, Jacksonville District Survey No. 02-146. Morgan & Eklund, Inc., 8745 US Hwy 1, Wabasso, FL 32970. January, 2003.

Mortimer, J.A. 1982. Feeding ecology of sea turtles, pp. 103 109. In: K.A. Bjorndal (ed.), Biology and Conservation of Sea Turtles, Smithsonian Institution Press, Washington, DC.

Moulding, J. and D. Nelson. 1988. Beach nourishment issues related to sea turtle nesting. Pp. 87-93. In: Lyke, W. and T. Hoban (compilers), Proceedings of the Symposium of Coastal Water Resources. Technical Publication Series TPS-88-1. American Water Resources, Bethesda, Maryland.

Mrosovsky, N. and C.L. Yntema. 1980. Temperture dependence of sexual differentiation in sea turtles: Implications for conservation practices. Biological Conservation 18:271-280.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 1991. Recovery Plan for U.S. Population of Atlantic Green Turtle. National Marine Fisheries Service, Washington, DC. 52 pp.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 1992a. Recovery Plan for the Kemp's Ridley Sea Turtle (Lepidochelys kempii). National Marine Fisheries Service, St. Petersburg, FL. 40 pp.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 1992b. Recovery Plan for Leatherback Turtles in the U.S. Caribbean, Atlantic, and Gulf of Mexico. National Marine Fisheries Service, Washington, DC. 65 pp.

National Marine Fisheries Service and U.S. Fish and Wildlife Service. 1993. Recovery Plan for Hawksbill Turtles in the U.S. Caribbean Sea, Atlantic Ocean, and Gulf of Mexico. National Marine Fisheries Service, St. Petersburg, FL, 47 pp.

National Marine Fisheries Service. 1999. Fishery Management Plan for Atlantic tunas, swordfish, and sharks, Volume II . National Marine Fisheries Service Division of Highly Migratory Species, Office of Sustainable Fisheries, Silver Spring, MD. 302 pp.

National Marine Fisheries Service (NMFS). 2006. Draft recovery plan for smalltooth sawfish (*Pristis pectinata*). Prepared by the Smalltooth Sawfish Recovery Team for the National Marine Fisheries Service, Silver Spring, Maryland.

National Research Council (NRC). 1995. Beach Nourishment and Protection. National Academy Press. Washington, D.C.

Nelson, D.A., K. Mauck, and J. Fletemeyer. 1987. Physical effects of beach nourishment on sea turtle nesting, Delray Beach, Florida. Technical Report EL 87-15, U.S. Dept. of the Army, U.S. Army Corps of Engineers, Jacksonville, FL. 56 pp.

Nelson, D.A. 1988. Life History and Environmental Requirements of Loggerhead Turtles. U.S. Fish and Wildlife Service Biological Report 88(23). U.S. Army Corps of Engineers Tech. Rep. EL 86 2(Rev.). 34 pp.

Nelson, D.A. and D.D. Dickerson. 1989. Effects of beach nourishment on sea turtles, pp. 125-127. In: Eckert, S.A., K.L. Eckert, and T.H. Richardson, eds., Proceedings of the Ninth Annual Workshop on Sea Turtle Conservation and Biology, 7-11 February 1989. NOAA Technical Memorandum NMFS SEFC 232.

Nelson, W.G. 1985. Physical and biological guidelines for beach restoration projects. Part I, Biological guidelines. Florida Sea Grant College, Report No. 76. 65 pp.

Nelson, W.G. 1989. Beach nourishment and hard bottom habitats: the case for caution. In S. Tait (ed.), Proc. 1989 National Conf. Beach Preserv. Tachnol., p. 109-116. Fl. Shore and Beach Preserv. Assoc., Tallahassee, FL.

Olsen Associates, Inc. 2003. Assessment of nearshore rock and shore protection alternatives along the Mid Reach of Brevard County, FL. Report prepared by Olsen Associates, Inc., 4438 Herschel Street, Jacksonville, FL 32210, for Brevard County Natural Resources Management Office. 187 pp. January 2003.

Olsen Associates, Inc., Morgan & Eklund, Inc., and Sonographics Inc. 2005. Sub-bottom mapping of nearshore rock along the Mid Reach shoreline of Brevard County, FL. Report prepared by Olsen Associates, Inc., 4438 Herschel Street, Jacksonville, FL 32210, for Brevard County Natural Resources Management Office. October 16, 2005.

Olsen Associates, Inc. 2005. Aerial mapping and wading transects of nearshore rock outcrops along the Brevard County, Florida Mid Reach (2002-04). Report prepared by Olsen Associates, Inc., 4438 Herschel Street, Jacksonville, FL 32210, for Brevard County Natural Resources Management Office. November 1, 2005.

Olsen 2005a. “Patrick AFB, Florida: Post-Storm Emergency Beach Restoration (2005) Nearshore Rock Mapping.” Letter Report to Mr. Patrick Giniewski 45 CES/CECC, PAFB. Prepared by K. Bodge, Olsen Associates, Inc., 4438 Herschel Street, Jacksonville, FL 32210. 15 December 2005.

Olsen 2005c. “Brevard County Shore Protection Project; Patrick AFB Beach Fill; Brevard County, Florida, 2005 Post-Storm Beach Renourishment; As-Built Beach Fill Sediment Sampling.” Report prepared for Brevard County Natural Res. Mgt. Office, Patrick AFB 45 CES/CEV, FDEP Bureau of Beaches & Coastal Systems. Olsen Associates, Inc., 4438 Herschel Street, Jacksonville, FL. 2005.

Olsen 2005d. “Brevard County, Florida: Federal Shore Protection Project (North Reach) and Patrick AFB Beach Fill: Three-Year Post-Construction Physical Monitoring Report – 2004.” Report prepared for Brevard County Natural Res. Mgt. Office, Patrick AFB 45 CES/CEV, FDEP Bureau of Beaches & Coastal Systems. Olsen Associates, Inc., 4438 Herschel Street, Jacksonville, FL. July 2005.

Olsen 2006a. “Brevard County Shore Protection Project, South Reach; Nearshore Rock Mapping North of Project Limits (R110 to R118)”. Letter Report to Mr. Mike McGarry, Brevard County Nat. Res. Mgt. Office. Prepared by K. Bodge, Olsen Associates, Inc., 4438 Herschel Street, Jacksonville, FL 32210. 01 February 2006.

Olsen 2006b. “2005 Post-Storm Beach Renourishment, Patrick AFB; Year-1 Post-Construction Nearshore Rock Survey”. Letter Report to Mr. Jeffrey Skupien 45 CES/CECC, PAFB. Prepared by K. Bodge, Olsen Associates, Inc., 4438 Herschel Street, Jacksonville, FL 32210. 29 September 2006.

Olsen 2006c. “Brevard County Shore Protection Project, South Reach; Year-One Post-Construction Nearshore Rock Mapping (R110 to R118)”. Letter Report to Mr. Mike McGarry, Brevard County Nat. Res. Mgt. Office. Prepared by K. Bodge, Olsen Associates, Inc., 4438 Herschel Street, Jacksonville, FL 32210. 9 October 2006.

Olsen Associates Inc. 2006d. Brevard County, Florida Federal Shore Protection Project, North Reach and Patrick Air Force Base Beach Fill: 2005 Project Renourishment -- Post Construction Physical Monitoring Report (2005). Report prepared for Brevard County, Natural Res. Mgt. Office, FDEP, and PAFB 45 CES/CEV, by Olsen Associates, Inc., 4438 Herschel Street, Jacksonville, FL 32210. February 2006.

Olsen 2007a. “Brevard County Shore Protection Project, South Reach; Year-Two Post-Construction Nearshore Rock Mapping (R110 to R118)”. Letter Report to Mr. Mike McGarry, Brevard County Nat. Res. Mgt. Office. Prepared by K. Bodge, Olsen Associates, Inc., 4438 Herschel Street, Jacksonville, FL 32210. 23 August 2007.

Olsen 2007b. “Practical Consideration of Depth for the Construction of Nearshore Mitigation along the Mid Reach Coastline of Brevard County, FL”. Report submitted to Florida Dept. of Environmental Protection as included in Response to RAI #5 to FDEP, per JCP File No. 0254479-001. Olsen Associates, Inc. 4438 Herschel Street, Jacksonville, FL 32210. September 26, 2007, 21 pp.

Olsen 2008a. “2005 Post-Storm Beach Renourishment, Patrick AFB; Year-Two Post-Construction Nearshore Rock Survey - 2007”. Letter Report to Mr.

Richard Peters, Amec Earth & Environmental Inc., Knoxville TN. Prepared by S. Howard, Olsen Associates, Inc., 4438 Herschel Street, Jacksonville, FL 32210. 21 April 2008.

Olsen 2008b. "2005 Post-Storm Beach Renourishment, Patrick AFB; Year-Three Post-Construction Nearshore Rock Survey - 2008". Letter Report to Mr. John McGann, Amec Earth & Environmental Inc., Cocoa FL. Prepared by S. Howard, Olsen Associates, Inc., 4438 Herschel Street, Jacksonville, FL 32210. 07 August 2008.

Olsen 2008c. "Brevard County Shore Protection Project, South Reach; Year-Three Post-Construction Nearshore Rock Mapping (R110 to R118)". Letter Report to Mr. Mike McGarry, Brevard County Nat. Res. Mgt. Office. Prepared by S. Howard, Olsen Associates, Inc., 4438 Herschel Street, Jacksonville, FL 32210. (In preparation.)

Olsen 2008d. Correspondence from Kevin Bodge, Olsen Associates Inc., to Caitlin Lustic, Bureau of Beaches and Coastal Systems, FDEP. April 30, 2008.

Patricia Bargo, NMFS Observer for Marine Mammal and Marine Turtle Species. Current: East Coast Observers, Executive Director. Unpublished results of turtle trawling conducted by REMSA (Norfolk, VA) during the dredging of the Port Canaveral Shipping Channel in 2001 and 2004.

Pearse, A.S., H.J. Humm, and G.W. Wharton. 1942. Ecology of sand beaches at Beaufort, North Carolina. Ecol. Monogr. 12:135-140.

Perkins, T.H., et al.1997. "Distribution of hard-bottom habitats on the continental shelf off the northern and central east coast of Florida." Southeast Area Monitoring and Assessment Program (SEAMAP), National Marine Fisheries Service. 1997.

Peters, D.J. and W.G. Nelson. 1987. The seasonality and spatial patterns of juvenile surf zone fishes of the Florida East coast. Fla. Sci. 50(2):85-99.

Peterson, C.H., D.H.M. Hickerson, and G.G. Johnson. 2000. Short-term consequences of nourishment and bulldozing on the dominant large invertebrates of a sandy beach. Journal of Coastal Research 16(2): 368-378.

Peterson, C.H. and L. Manning. 2001. How beach nourishment affects the habitat value of intertidal beach prey for surf fish and shorebirds and why uncertainty still exists. Proceedings of the Coastal Ecosystem and Federal Activities Technical Training Symposium.

Pilkey, O.H. 1991. Coastal erosion. Episodes 14:46-51.

Pilkey, O. H. and K. L. Dixon. 1996. The Corps and the Shore. Island Press. Washington D.C.

Provancha, J.A., R.H. Lowers, D.M. Scheidt, M.J. Mota, and M. Corsello. 1998. Relative abundance and distribution of marine turtles inhabiting Mosquito Lagoon, Florida, pp. 78-79. In: 17th Annual Sea Turtle Symposium. S.P. Epperly and J.A. Braun (eds.), NOAA Technical Memorandum NMFS-SEFSC-415.

Provancha, J.A., M.J. Mota, K.G. Holloway-Adkins, E.A. Reyier, R.H. Lowers, D.M. Scheidt, and M. Epstein. 2005. Mosquito Lagoon sea turtle cold stun event of January 2003, Kennedy Space Center/Merritt Island National Wildlife Refuge. Florida. Florida Scientist 68:114-121.

Redfoot, W.E. 1997. Population structure and feeding ecology of green turtles utilizing the Trident Submarine Basin, Cape Canaveral, Florida as developmental habitat. Department of Biology. University of Central Florida, Orlando, Florida. 72 pp

Reilly, F. Jr. and V. Bellis. 1983. The ecological impact of beach nourishment with dredged materials on the intertidal zone at Bogue Banks, North Carolina. U.S. Army Corps of Engineers, Coastal Engineering Research Center, Miscellaneous Report No. 83-3. 74 pp.

Richardson, J.I. and P. McGillivary. 1991. Post-hatchling loggerheads turtles eat insects in Sargassum community. Marine Turtle Newsletter 55:2-5.

Ross, S.T. 1983. A review of surf zone ichthyofauna in the Gulf of Mexico, pp. 25-34. In: S.V. Shabicam, N.B. Cofer, and S.V. Cake, Jr. (eds.), Estuaries and Barrier Islands Conference. U.S. Department of the Interior, National Park Service, Southeast Regional Office, Atlanta, GA.

Ross, S.W. and J.E. Lancaster. 1996. Movements of juvenile fishes using surf zone nursery habitats and the relationship of movements to beach nourishment along a North Carolina beach: Pilot project. Final report to National Oceanic and Atmospheric Administration Office of Coastal Resource Management and the U.S. Army Corps of Engineers, Wilmington District. NOAA Award No. NA570Z0318. 31 pp.

Rumbold, D.G., P.W. Davis, and C. Perretta. 2001. Estimating the effect of beach nourishment on Caretta caretta (loggerhead sea turtle) nesting. Restoration Ecology 9(3):304-310.

Ryder, C.E. 1991. The effect of beach renourishment on sea turtle nesting and hatch success. Sebastian Inlet State Recreation Area, East-Central Florida. Sebastian Inlet Tax District Commission, Sebastian Inlet, Florida.

Ryder, T.S., E. Standora, M. Eberle, J. Edbauer, K. Williams, S. Morreale, and A. Bolten, 1994. Daily movements of adult male and juvenile loggerhead turtles (Caretta caretta) at Cape Canaveral, Florida, p. 131. In: K.A. Bjorndal, A.B. Bolten, D.A. Johnson, and P.J. Eliazar (comps.), Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation, NOAA Tech. Mem. NMFS SEFSC 351.

SAFMC - South Atlantic Fishery Management Council. 1998. Comprehensive Amendment Addressing Essential Fish Habitat in Fishery Management Plans of the South Atlantic Region. South Atlantic Fishery Management Council, Charleston, SC.

Schmid, J.R. 1995. Marine turtle populations on the east central coast of Florida: results of tagging studies at Cape Canaveral, Florida, 1986 1991. Fishery Bulletin 93:139 151.

Schmid, J.R. and L.H. Ogren. 1992. Subadult Kemp's ridley sea turtles in the southeastern U.S.: Results of long term tagging studies, pp. 102 103. In: M. Salmon and J. Wyneken (comps.), Proceedings of the Eleventh Annual Workshop on Sea Turtle Biology and Conservation. NOAA Tech. Mem. NMFS SEFSC 302.

Schroeder, B.A. and N.B. Thompson. 1987. Distribution of the loggerhead turtle, Caretta caretta, and the leatherback turtle, Dermochelys coriacea, in the Cape Canaveral, Florida area: Results of aerial surveys, pp. 45 53. In: W.N. Witzell (ed.), Ecology of East Florida Sea Turtles, Proceedings of a Cape Canaveral, Florida Sea Turtle Workshop, Miami, Florida, February 26 27, 1985, NOAA Tech. Rep. NMFS 53.

Shaver, D.J. 1991. Feeding ecology of wild and headstarted Kemp's ridley sea turtles in South Texas waters. Journal of Herpetology 25(3):327 334.

Shoop, C.R., C.A. Ruckdeschel, and N.B. Thompson. 1985. Sea turtles in the southeast United States: Nesting activity as derived from aerial and ground surveys, 1982. Herpetologica 41(3):252 259.

Simpfendorfer, C.A. and T.R. Wiley. 2006. National smalltooth sawfish encounter database. Mote Marine Laboratory Technical Report 1071. A final report for NOAA Purchase Order No. GA133F04SE1439. 13 pp.

Sloan, N.J.B. 2005. Burial tolerances of reef-building sabellariid worms from the east coast of Florida. M.S. Thesis, Florida Institute of Technology, Melbourne, Florida. 63 pp.

Smith, N.P. 1983. Temporal and spatial characteristics of summer upwelling along Florida's Atlantic shelf. J. Phys. Oceanogr. 13(9):1,709-1,715.

Snelson, F.F. and S.E. Williams. 1981. Notes on the occurrence and biology of elasmobranch fishes in the Indian River Lagoon system, Florida. Estuaries 4(2):110 120

Snelson, F.F., T.J. Mulligan, and S.E. Williams. 1984. Food habits, occurrence, and population structure of the bull shark, Carcharhinus leucas, in Florida coastal lagoons. Bull. Mar. Sci. 34(1):71-80.

Spring, K.D. 1981. A study of the spatial and temporal variation in the nearshore macrobenthic populations of the central Florida east coast. Masters thesis, Florida Institute of Technology, Melbourne, FL. 67 pp.

Steinitz, M.J., M. Salmon, and J. Wyneken. 1998. Beach renourishment and loggerhead turtle reproduction: A seven year study at Jupiter Island, Florida. Journal of Coastal Restoration. 14(3):1,000-1,013.

Stevens, P.W. and K.J. Sulak. 2001. Egress of adult sportfish from an estuarine reserve within Merritt Island National Wildlife Refuge, Florida. Gulf of Mexico Science. 2:77-89.

Sweatman, H.P.A. 1993. Tropical snapper (Lutjanidae) that is piscivorous at settlement. Copeia 1137-1139.

Tanner, W.F. 1960. Florida coastal classification. Trans. Gulf Coast Assoc. Geol. Soc. 10:259-266.

Teas, W.G. 1993. 1992 Annual Report of the Sea Turtle Stranding and Salvage Network. Atlantic and Gulf Coasts of the United States. January – December 1992. Contribution No. MIA-92/93-73 from the Miami Laboratory, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Center, Miami, FL. 43 pp.

Thompson, N.B. and H. Huang. 1993. Leatherback turtles in southeast U.S. waters. U.S. Department of Commerce, National Oceanic and Atmospheric Administration, National Marine Fisheries Service, Southeast Fisheries Science Center, Miami, FL. NOAA Technical Memorandum NMFS-SEFSC-318. 11 pp.

Tremain, D.M., C.W. Harnden, and D.H. Adams. 2004. Multidirectional movements of sportfish species between a no-take zone and surrounding waters of the Indian River Lagoon, Florida. Fish Bull. 102:533-544.

U.S. Water Resources Council. “Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies,” known as the Principles and Guidelines, February 1983.

USACE 1972. “General and Detail Design Memorandum: Brevard County, Florida.” US Army Corps of Engineers, Jacksonville District, Jacksonville, 1972.

USACE 1978. “General and Detail Design Memorandum Addendum: Brevard County, Florida.” US Army Corps of Engineers, Jacksonville District, Jacksonville, Florida. 1978.

USACE 1991. “Supplement to the General Design Memorandum, Sand Bypass System, Canaveral Harbor, Florida.” US Army Corps of Engineers, Jacksonville District, Jacksonville, Florida. 1991.

USACE 1992a. “Reconnaissance Report, Brevard County, Florida.” US Army Corps of Engineers, Jacksonville District, Jacksonville, Florida. 1992.

USACE 1992b. “Design Memorandum, Canaveral Harbor, Florida.” US Army Corps of Engineers, Jacksonville District, Jacksonville, Florida. 1992.

USACE 1996. “Feasibility Report with Final Environmental Impact Statement, Brevard County, Florida Shore Protection Project.” US Army Corps of Engineers, Jacksonville District, Jacksonville, Florida. September 1996.

USACE 1999. ”Limited Reevaluation Report, Brevard County, Florida, Shore Protection Project.” US Army Corps of Engineers, Jacksonville District, Jacksonville, Florida. 1999.

USACE 2003. “Limited Reevaluation Report and Environmental Assessment, North Jetty Sand-Tightening and Jetty Extension, Canaveral Harbor, Florida.” US Army Corps of Engineers, Jacksonville District, Jacksonville, Florida. 2003.

USACE. 2007. USACE Sea Turtle Data Warehouse. in. USACE, Vicksburg, MS.

Van Montfrans, J. 1981. Decapod crustaceans associated with worm rock (Phragmatopoma lapidosa Kinberg) in southeastern Florida. M.S. Thesis, Florida Atlantic University, Boca Raton, Florida. 290 pp.

Versar, Inc. 2003. Effects of dredge material beach disposal on surf zone and nearshore fish and benthic resources on Baldhead Island, Caswell Beach, Oak Island, and Holden Beach, North Carolina: interim study findings. A report prepared for U.S. Army Corps of Engineers,Wilmington, NC. Contract No. DACW54-00-D-0001.

Weber, M. 1995. Kemp's Ridley Sea Turtle, Lepidochelys kempii. In: P.T. Plotkin (ed.), National Marine Fisheries Service and U. S. Fish and Wildlife Service Status Reviews for Sea Turtles Listed under the Endangered Species Act of 1973, Silver Spring, MD.

Werner, S.A. and A.M. Landry, Jr. 1994. Feeding ecology of wild and head started Kemp's ridley sea turtles (Lepidochelys kempii), p. 163. In: K.A. Bjorndal, A.B. Bolten, D.A. Johnson, and P.J. Eliazar (comps.), Proceedings of the Fourteenth Annual Symposium on Sea Turtle Biology and Conservation, NOAA Tech. Mem. NMFS SEFSC 351.

Wershoven, J.L. and R.L. Wershoven. 1992a. Juvenile green turtles in their nearshore habitat of Broward County, Florida: a five year review, pp. 121-123. In: M. Salmon and J. Wyneken (eds.), Eleventh Annual Workshop on Sea Turtle Biology and Conservation, Jekyll Island, GA.

Wershoven, R.W. and J.L. Wershoven. 1992b. Stomach Content Analysis of Stranded Juvenile and Adult Green Turtles in Broward and Palm Beach Counties, Florida, pp. 124-126. In: M. Salmon and J. Wyneken (eds.), Eleventh Annual Workshop on Sea Turtle Biology and Conservation, Jekyll Island, GA.

Whelan, C. L., and J. Wyneken. 2007. Estimating predation levels and site-specific survival of hatchling loggerhead sea turtles (*Caretta caretta*) from south Florida beaches. Copeia 2007:745-754.

Witherington, B.E. 2002. Ecology of neonate loggerhead turtles inhabiting lines of downwelling near a Gulf Stream front. Marine Biology 140:843-853.

Witzell, W.N. 1998. Long term tag returns from juvenile Kemp's ridley turtles. Marine Turtle Newsletter 79:20.

Young, D.K. (ed.). 1975. Indian River coastal zone study, second annual report. Harbor Branch Consortium, Fort Pierce, Florida. 180 pp.

Zale, A.V. and S.G. Merrifield. 1989. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (south Florida) - reef building tube worm. U.S. Fish Wildl. Serv. Biol. Rep. 82(11.115). U.S. Army Corps of Engineers, TR EL-82-4. 12 pp.