BIOLOGICAL ASSESSMENT OF THE IMPACTS OF THE PROPOSED INDIAN RIVER COUNTY SECTOR 7 BEACH RESTORATION PROJECT ON COASTAL ENVIRONMENTS

MARCH 2003

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1.0 EXECUTIVE SUMMARY

The Indian River County Board of County Commissioners has submitted an application to the U.S. Army Corps of Engineers and the State of Florida to request regulatory authorization to construct a beach restoration project along a portion of the County's Atlantic shoreline. In order to comply with provisions of Federal law, the Corps of Engineers must consult with Federal wildlife agencies regarding the potential impacts of the proposed project on protected species and fishery resources. This Biological Assessment reviews the expected impacts of the proposed project and project alternatives on a wide variety of biological resources, including invertebrates, fishes, sea turtles, mammals and birds. The Biological Assessment is intended to serve as a summary of existing biological resources and anticipated potential impacts and is provided to the Federal agencies that must issue a biological opinion on the proposed project, ant to the state for state environmental regulatory review.

A brief introduction describes the regulatory and jurisdictional background of the reviewing Federal agencies, followed by an overview of the proposed project. Background information on the environments that may potentially be impacted by the project is found in section four, followed by a section summarizing the Federally protected species that may be impacted by the project. The remainder of the assessment outlines the anticipated effects of the project on sea turtles, sand beach environments, nearshore reef environments, offshore areas, and the anticipated impacts on fisheries and fish populations.

The proposed project is expected to impact sea turtle nesting, but the impacts are expected to be largely limited to the first sea turtle nesting season following project construction. The effect of the project on nesting turtles may be reflected primarily in a reduction of sea turtle nesting success (the proportion of turtles coming ashore that successfully nest) rather than hatch success (the proportion of eggs laid that hatch). Effects on sea turtle developmental habitat (the nearshore reef feeding areas for green turtles) are not expected to be significant due to the small percentage of the available feeding habitat that will be impacted by the proposed project.

The impacts of projects of this type on the biological communities of the sandy beach and the offshore sand borrow areas were reviewed. The prevailing opinion in the literature is that the most of such impacts are temporary in nature and limited in scope. Therefore no significant project impacts in these areas are expected.

However, the preferred alternative project will have a direct impact on an estimated 5.3 acres of nearshore reef habitat. There may also be indirect impacts on reef habitat outside the direct impact area from turbid water resulting from project construction. Construction plans will include a fill containment dike and dewatering system to minimize the extent of this impact. This indirect impact is difficult to quantify, but is expected to be limited by the high tolerances of nearshore reef organisms to turbidity and the resilient nature of the major reef species. While the direct impact on 5.3 acres of reef habitat is not negligible, it is estimated that this amount of reef represents less than 0.2% of the approximately 4,000 acres of total habitat of this type in Indian River County. Since direct impacts are limited to a small percentage of the total reef environment, there is not expected to be an adverse impact on the structure and function of the nearshore reef environment at an ecosystem level.

Direct and indirect effects on fish and fisheries were also reviewed. In some cases it was possible to generate quantitative estimates of the level of impact. From these estimates it was concluded that the proposed project would not result in a significant effect on the fish resources of Indian River County, or on recreational or commercial fisheries.

In summary, the proposed Indian River County beach restoration project will result in some adverse biological impacts that must be weighed against the project benefits to the mitigation of historical erosion losses, coastal property protection, preservation of endangered species habitat, recreational use, and tourism. In cooperation with State and Federal agencies, and with public input, it is expected that reasonable measures to minimize or mitigate unavoidable project impacts can be developed.

2.0 INTRODUCTION

2.1 Events Leading to this Assessment

The Indian River County Board of County Commissioners, in accordance with its Beach Preservation Plan, has made application to the Florida Department of Environmental Protection (FDEP) and the U.S. Army Corps of Engineers (USACOE) for a beach restoration projects along a portion of the County's Atlantic coastline. The project location has experienced well-documented severe erosion and unless corrective measures are implemented, the County's coastal resources will continue to diminish. The County's immediate coastal area provides sea turtle nesting and southeastern beach mouse habitat (beaches and dunes), sea turtle foraging habitat (nearshore reefs), and ecologically important reef formations. Therefore, the County has prepared this Biological Assessment to submit to the USACOE in order to initiate consultation with the relevant Federal agencies responsible for evaluating the environmental impacts of the proposed project.

2.2 Purpose

This Biological Assessment was prepared for the USACOE for submission to the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS). The Assessment provides information necessary for compliance with Section 7 of the Endangered Species Act of 1973 (as amended) and the Essential Fish Habitat (EFH) provisions of the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA).

2.3 Endangered Species Act

Section 7 of the Endangered Species Act provides for interagency cooperation in that, "… each federal agency shall, in consultation with and with the assistance of the Secretary, insure that any action authorized, funded, or carried out by such agency does not jeopardize the continued existence of any endangered species or threatened species or result in destruction or adverse modification of habitat of such species…"

2.4 Essential Fish Habitat

The EFH provision of the MSFCMA requires that Federal agencies consult with NMFS when any activity proposed to be permitted, funded, or undertaken by a Federal agency may have adverse impacts on designated EFH.

2.5 Jurisdiction of the National Marine Fisheries Service

Under a memorandum of agreement with USFWS, the NMFS Office of Protected Resources has jurisdiction over all species of sea turtles within the waters of the United States. In the context of this assessment, potential adverse and beneficial impacts to foraging turtles and their developmental habitats are the purview of NMFS. The Habitat Conservation Division of NMFS is the lead agency for EFH consultation. This consultation consists of an assessment of the impacts of a proposed action on federally managed fisheries and fish habitats.

2.6 Jurisdiction of the U.S. Fish and Wildlife Service

USFWS has jurisdiction when sea turtles move from the water on to land, and during the incubation and hatching of eggs. In the context of this assessment, USFWS will evaluate potential impacts of the proposed project that may affect sea turtle nesting, incubation and hatching.

3.0 PROJECT DESCRIPTION

This section is intended to provide a brief overview of the nature and extent of the proposed project. Detailed information is available in the documents cited herein. This section also contains a description of the project alternatives that are evaluated for potential impacts in Sections 6 through 10.

3.1 Project Areas

The proposed project area is located in Indian River County, Florida (Figure 1). The Indian River County shoreline was characterized and subdivided into seven distinct shoreline segments, or Sectors, numbered from north to south, for the purpose of shoreline evaluation. This Biological Assessment pertains to the proposed beach project along the shoreline contained within Sector 7. Sector 7 is located in southern Indian River County, from FDEP Reference monument R-94 to monument R-113. The Florida DEP Bureau of Beaches and Wetland Resources (BBWR) has designated the shoreline segment from R-103 to R-107 as a Critically Eroded Area.

The shoreline designated for restoration in Sector 7 extends from 95 feet north of Indian River County DEP Reference monument T-100 south to 105 feet south of T-107. The Sector 7 project area is 1.35-miles in length and is characterized by developed single-family properties and vacant single-family zoned parcels. The shoreline segment proposed for restoration has experienced recent volumetric erosion rates averaging 2.8 cubic yards per foot per year (CY/ft/yr) and shoreline erosion rates averaging 5.6 feet per year, based on shoreline change analyses conducted between 1986 and 1999. Sector 7 contains the highest erosion rates identified anywhere in Indian River County. A summary the proposed project design features are provided in the following table. The Evaluation of Alternative Designs for Sector 7 Report (Applied Technology and Management 2002) and the Evaluation of Alternative Designs for Sector 7 Indian River County, Florida Addendum (Applied Technology and Management 2003) provides detailed information on the project design and rationale, including quantities and distribution of beach fill material.

PROJECT DESIGN SUMMARY

PROJECT SECTOR	SHORELINE LENGTH (FEET)	FILL AMOUNT (CUBIC YARDS) *	FILL AMOUNT (CUBIC YARDS/FT) *	AVERAGE DRY BEACH WIDTH AT EQUILIBRIUM (FEET) *
7	7,138	459,700	62.4	75

* Preferred Alternative

3.2 Offshore Sand Source

The location of the proposed offshore borrow area is shown in Figure 1. The criteria used for borrow area selection included: beach sand compatibility, adequate available volume, absence of hardbottom habitats or cultural resources, and proximity to the fill areas. Extensive core sampling was conducted to determine the sedimentary characteristics of the site. The designated sites will be used only if sediment grain size analysis results indicate the sand is compatible with the native beach material. Analysis of a composite of the sediment cores indicates that the proposed primary borrow area could potentially provide 1.4 million cubic yards of beach quality sand (Applied Technology and Management 2001). The mean grain size of the proposed borrow area is 0.52 mm and the expected fine fraction of the borrow material is only 0.97 percent. Side scan sonar and magnetometer surveys have been completed and have revealed no hardbottom features or cultural resources in or immediately adjacent to the proposed borrow areas. Additionally, a towed video survey was conducted of the entire borrow area and a 400 foot buffer zone around the area in the summer of 2002. These surveys revealed no hardbottom, submerged aquatic vegetation, or other resources of concern (Dial-Cordy 2002).

3.3 Project Schedule

Restoration of beach Sector 7 is scheduled to begin in November 2004. All construction activities are scheduled to take place outside of the main part of the marine turtle nesting season. The preferred alternative project design fill volume has a projected life (the time interval before renourishment is needed) of six years.

3.4 Socioeconomic Studies

Socioeconomic and project cost and benefit analyses were conducted to assess the economic merits of the proposed project. These studies and analyses are contained in the documents "Indian River County Beach Preservation Plan Economic Analysis and Cost Allocation Plan" (Applied Technology and Management 1998) and "Indian River County Beach Preservation Plan Economic Analysis- Phase II: Funding Sources and Financing Plan" (Applied Technology and Management 1999b).

The storm protection benefit resulting from the beach nourishment project was computed for each parcel of property over a 30-year project horizon. The following factors were taken into consideration: 1) anticipated acreage and value of land loss if no action is taken to control erosion, and 2) construction and maintenance cost of erosion control structures which would be required if no action is taken. The aggregate net present value of the storm protection benefit for all properties within the project area is estimated at $7.64 million.

Recreation benefits associated with the proposed beach nourishment project were determined based on surveys of beach users on the Indian River County beaches. The total recreational benefit value is estimated as the average value of a day at the beach multiplied by the number of days spent on average at the beach. Over the projected 30-year project horizon, the net present value of the recreational benefits to the Sector 7 beaches is estimated at $2.53 million.

The total 30-year net present worth benefit associated with storm protection and recreational use of the nourished beach in Sector 7 is $10.17 million.

3.5 Project Alternatives Considered

This Assessment will evaluate the anticipated impacts of the preferred alternative design of the project and also the potential adverse and beneficial impacts for a full range of alternatives. The "no-action" alternative, a "reduced fill" alternative, a"six groin" alternative, and a "twelve groin" alternative will be discussed for anticipated impacts in Sections 6 through 10.

3.5.1 The Preferred Alternative

The Preferred Alternative was designed to restore the beaches to a dynamic equilibrium along the project shoreline within Sector 7. Historic shoreline change data indicate that between 1972 and 1986, the project area shoreline was eroding at a rate of approximately 0.8 CY/ft/yr. More recent shoreline data show a trend of increasing erosion rates. Between 1986 and 1999 the project area shoreline was eroding at a rate of approximately 2.8 CY/ft/yr.

The Preferred Alternative calls for a project design to provide a storm protective berm sufficient to sustain erosion-induced damages from a 15-year design storm event, advance fill to allow for expected post-construction erosion losses, an additional 10-year storm loss, and expected end losses. The 7,138-foot project length is based on a 6-year renourishment schedule, which was sought for cost effectiveness and realistic sand placement volumes.

A uniformly shaped fill area was designed resulting in a total fill (nourishment) volume of 459,700 cubic yards. The design calls for renourishment when the fill has been reduced to the amount expected to erode during a 15-year period storm event (i.e. 137,800 cubic yards). This is considered the minimum buffer to protect the existing upland structures. The renourishment volume was calculated to be 321,900 cubic yards (end losses + 10-year storm + annual erosion * 6-year maintenance interval). The results of the longshore sediment transport study conducted by ATM confirmed that a renourishment interval of 6years is appropriate to meet design goals with respect to remaining volume (storm buffer). Continued monitoring of the area following project construction will be the best indicator of project performance and hence the optimal renourishment interval.

The volume of sand in the proposed beachfill template averages 62.4 cubic yards per foot which was determined according to design criteria as outlined herein as well as in the Beach Preservation Plan (BPP) (1988), the BPP Update (1998), the IRC Economic Analysis Reports (ATM, 1998 and 1999), and the Evaluation of Alternative Designs for Sector 7 Report (ATM, 2002), and Addendum (ATM 2003). The proposed beach fill project will result in an initial average dry beach width (from the toe of the dune feature to MHW) of 75 feet after equilibrium.

The uniform berm elevation of +9 feet NGVD was determined based on the existing berm elevations, the need for volume contained within the prescribed berm, and other successful beach nourishment projects along the east coast of Florida with similar seasonal high water and storm impact characteristics. The proposed beach design includes a beach face slope of 1 vertical to 10 horizontal (1V:10H) between the +9 feet NGVD berm crest and mean low water (MLW). This slope was chosen because it closely approximates the natural slope of the beach in the project area, and because the borrow area sand characteristics indicate the material can reasonably be expected to adjust to this geometry.

The sediment along the seaward edge of the construction profile will adjust seaward during the project construction and subsequent to placement of the fill. Profile geometry will adjust to a more natural equilibrium profile approximately coincident with the grain size characteristics of the nourishment material and based on the wave climate of the area. The profiles will naturally redistribute the initial sand placement/construction profiles to balance the constructive and destructive forces of the waves and currents acting on the beach. The mean grain size of the beachfill used in this analysis of the beach in Sector 7 was 0.52 mm, corresponding to the primary borrow area, the South Sub–Area 1 borrow area, which is found on the Indian River Shoal complex in the southern portion of the County.

A dune enhancement feature is also proposed to mitigate for historic dune losses, enhance protection of the upland areas, and preserve the coastal environment. The dune feature will tie into the natural backshore elevations with a landward slope of 1 vertical to 3 horizontal to the existing backshore where the existing dune elevation is below the proposed dune crest elevation. The seaward slope of the dune feature will also be 1V:3H from the designated dune crest elevation to the +9 feet NGVD design berm contour. The crest elevation of the proposed dune feature in Sector 7 is +12 feet NGVD. The average horizontal dune footprint will be 38 feet with an average volume of 2.4 CY/ft. The restored dune feature will provide a greater diversity of habitats for beach-associated flora and fauna, including the southeastern beach mouse, and will provide additional storm protection to the upland properties.

Numerous design iterations were performed to balance the minimization of hardbottom coverage impacts and the effectiveness of the resulting profile’s ability to meet the project goals. Applying the characteristics of the South borrow area material, the natural shape of the nearshore area corresponds extremely well to the predicted shape of the equilibrium profile in most of the project area. Due to the breadth and low relief of the hardbottom and its proximity to the shoreline, if a significant volume of sand is added to the profile, some of the added material will naturally settle on the hardbottom. While any reduction of the proposed design volume reduces hardbottom coverage, it also results in significant reduction of the design fill volume and berm width. This reduction in fill volume increases the frequency of renourishments in order to maintain the desired level of storm protection, and increases adverse environmental impacts due to the more frequent renourishment events.

The total estimated construction cost for the Preferred Alternative is $6.5 million. This total includes the estimated cost of the construction of an artificial reef to mitigate for an expected direct impact of 5.3 acres to the nearshore hardbottom. Based on a project horizon of 30 years, it is estimated that the project will incur 4 renourishments at 6-year intervals each at a cost of $3.5 million. The total 30-year net present worth cost of the Preferred Alternative is $15.55 million. The total volume of sand placement over the 30-year planning period for the Sector 7 project under the Preferred Alternative is 1,747,300 cubic yards.

3.5.2 The No-Action Alternative

The Indian River County Beach Preservation Plan Economic Analysis conducted in 1998 (Applied Technology and Management, 1998) examined the overall economic viability of the proposed beach nourishment project and quantified the expected 30-year costs if no action is taken. This analysis of storm damage and land losses determined the anticipated land loss from erosion if no additional sand, other than the sediment that is placed by the Sebastian Inlet Tax District, is placed into the system. This economic study quantified the value of land that would be lost, the construction cost of erosion control structures that would be required if the project is not built, and the maintenance costs of the erosion control structures. The study determined that without action to prevent the loss of upland property along the Sector 7 shoreline, oceanfront property owners will suffer direct economic losses. Those properties impacted by storm damage and land losses are:

- Privately owned, undeveloped, unprotected property (1,837 feet or 25.5 percent of project frontage) experiencing continued land loss;
- Privately owned, developed, unprotected, property (4,510 feet or 62.5percent project frontage) experiencing continued land loss due to erosional losses and storm damage, some requiring new seawall/revetment construction;
- Privately owned, developed, protected property, (682 feet or 9.5 percent project frontage) requiring rehabilitation and/or replacement of existing shoreline armor; and,
- Roadways (185 ft or 2.6 percent project frontage) threatened or damaged as the result of continued land loss.

If the present sediment deficit is not corrected, the beaches will continue to erode and it is assumed that the oceanfront property owners will take whatever actions are in their own economic interest to protect their properties. If the major habitable structures on the property are in jeopardy of significant structural damage from yearly landward erosion or a 15-year storm event, it can be assumed that the property owners will armor the shoreline (i.e. construct an erosion control structure). However, seawalls alone do not alleviate the erosion problems and may transfer the problems to adjacent properties, whereby the entire shoreline in erosional areas will eventually be armored – thus fixing the shoreline position and potentially reducing marine turtle nesting habitat.

The Economic Analysis concluded that over the next 30 years, 7.1 percent of the project shoreline would be armored, costing $6.17 million (net present worth). Without the implementation of a beach nourishment plan, historical sand losses will not be mitigated and thereby the following results were determined to likely occur:

- Existing, recent erosion trends and shoreline armoring at Sector 7 will continue;
- Owner group litigation is likely; and,
- State of Florida cost share contribution from the Erosion Control Trust Fund will be lost.

As the beaches continue to erode in this State-designated Critical Erosion Area, beaches will narrow due to the presence of seawalls and development, as well as the beach's encroachment on dune and upland vegetation. As erosion threatens waterfront properties, the anticipated result will be a proliferation of shoreline armoring structures and emergency stopgap measures to protect property. It is estimated that no action to control this erosion will result in additional shoreline armoring over what is expected with the project. As a result of this beach narrowing, sea turtle nesting habitat will be degraded, and in some areas, completely lost. While very narrow beaches are expected to still support nesting, under conditions where high tides reach the dune line on a daily basis, hatchling success would decrease dramatically due to inundation and nest washout.

3.5.3 The Reduced Fill Alternative

The design for the reduced fill alternative calls for the placement of 376,100 cubic yards of sand along the 7,138 ft project area within Sector 7. The average unit sand placement is 50.5 cubic yards per foot of shoreline, which includes a dune feature at +12 feet above mean sea level (NGVD) and material placement for upland structure protection from a 15-year return period storm event. Applying the same design principles as with the Preferred Alternative, the project is expected to require renourishment every 4 years. Thus the remaining sand quantity prior to each maintenance event is approximately equal to the 15-year design storm event (i.e. 137,800 cubic yards). This is considered the minimum buffer to protect the upland structures. The renourishment volume is 238,300 cubic yards. The average additional dry beach width is estimated at 55 feet following initial adjustment of the profile following restoration.

Smaller sand placement quantities in the beachfill template associated with this alternative would be expected to result in less coverage of juvenile turtle foraging habitat, will make possible sedimentation of feeding areas and interstitial spaces in the reef structure less likely. In addition, this alternative is expected to require a slightly shorter construction window to accomplish the initial restoration. Cumulative impacts to sea turtle nesting over the 30-year project life would be greatly increased due to the short 4-year renourishment interval. Beachfill template configuration with this alternative would not be expected to deviate from other alternatives considered herein.

The total estimated construction cost for the 376,100 cubic yards Alternative is $5.2 million. Based on a project horizon of 30 years, it is estimated that the project will incur 7 renourishments at 4-year intervals each at a cost of $2.9 million. The total 30-year net present worth cost of the Reduced Fill Alternative is $18.15 million. The total sand volume anticipated to be placed under the reduced fill alternative over the 30-year planning period is 2,044,200 cubic yards. It should be noted that, due to the short renourishment interval associated with this alternative, the total sand volume placement is actually higher than for the preferred alternative, even though a smaller beach is being constructed and maintained.

The reduced fill volume would result in a reduction of direct impact to nearshore hardbottom habitat, estimated at 3.2 acres.

3.5.4 The Six Groin Alternative

The six groin alternative specifies 459,700 cubic yards of sand placement, in the same template as the Preferred Alternative, but with the addition of six shore-perpendicular groins spaced strategically throughout the project area. Groin design and placement locations are optimized to trap sand being transported along the shoreline, while allowing some natural sand bypassing to occur. The Sector 7 Evaluation of Alternative Designs for Sector 7 Indian River County, Florida Addendum (Applied Technology and Management 2003) provides figures showing the proposed groin locations and details of groin materials and design. Groins would vary in length from 80 to 132 feet. The landward terminus of the groins would be at the dune line or erosion control structure, and the seaward terminus of the groins would be landward of the construction Mean High Water (MHW) shoreline, but somewhat seaward of the predicted equilibrium shoreline. Groins would be constructed of natural limestone rock, with a crest width of about 12 feet, a crest elevation of about 10 feet, and side slopes of 3:1.

The total estimated construction cost for the six groin alternative is $8.0 million. Annual groin maintenance will likely be necessary, with costs estimated to be approximately $35,000 per year. Based on a project horizon of 30 years, it is estimated that the project will incur 4 renourishments, at 7-year intervals, each at a cost of $3.5 million. The total 30-year net present worth cost of the six groin alternative is $17.20 million. The total sand volume requirement over the 30-year planning period for the six groin alternative is 1,747,300 cubic yards.

Impacts to nearshore hardbottom areas would be approximately 5.3 acres, equal to the impacts for the Preferred Alternative. The increase in the renourishment interval in the six groin alternative, from 6 to 7 years, would decrease the cumulative impacts of repeated beach fills to nesting sea turtles; however, the groins themselves would eliminate some nesting habitat and possibly interfere with nesting behavior and/or hatchling dispersal.

3.5.5 The Twelve Groin Alternative

The twelve groin alternative specifies 459,700 cubic yards of sand placement, in the same template as the Preferred Alternative, but with the addition of twelve shore-perpendicular groins spaced strategically throughout the project area. Groin design and placement locations are optimized to trap sand being transported along the shoreline, while allowing some natural sand bypassing to occur. The Sector 7 Alternative Design Report (ATM 2002) provides figures showing the proposed groin locations and details of groin materials and design. Groins would vary in length from 65 to 154 feet. The landward terminus of the groins would be at the dune line or erosion control structure, and the seaward terminus of the groins would be landward of the construction Mean High Water (MHW) shoreline, but somewhat seaward of the predicted equilibrium shoreline. Groins would be constructed of natural limestone rock, with a crest width of about 12 feet, a crest elevation of about 10 feet, and side slopes of 3:1.

The total estimated construction cost for the twelve groin alternative is $10.2 million. Annual groin maintenance will likely be necessary, with costs estimated to be approximately $85,000 per year. Based on a project horizon of 30 years, it is estimated that the project will incur 3 renourishments at 8-year intervals each at a cost of $3.5 million. The total 30-year net present worth cost of the twelve groin alternative is $18.58 million. The total sand volume requirement for the twelve groin alternative over the 30 year planning period is 1,425,400 cubic yards.

Impacts to nearshore hardbottom areas would be approximately 5.3 acres, equal to those of the Preferred Alternative. The increase in the renourishment interval in the twelve groin alternative, from 6 to 8 years, would decrease the cumulative impacts of repeated beach fills to nesting sea turtles, but the groins themselves would eliminate some nesting habitat and possibly interfere with nesting behavior and/or hatchling dispersal.

4.0 DESCRIPTION OF ENVIRONMENTS

This section characterizes the nature of the environments found near the proposed project area, which may be impacted by the project.

4.1 Location

Indian River County is located on the east central coast of Florida. The oceanfront portion of the County is a barrier island (Orchid Island) separated from the mainland by the Indian River Lagoon. The County has 22.4 miles of Atlantic Ocean coastline, consisting of high-energy sand beaches with extensive shallow reef formations immediately offshore. A coastal inlet (Sebastian Inlet) defines the northern boundary of the County. Typical of most inlets, the interruption of longshore sand transport has resulted in severe erosion of the downdrift beaches.

4.2 The Beach Environment

4.2 .1 Geological

Indian River County beaches are composed of unconsolidated sediments deposited along the Atlantic Beach Ridge in recent times (less than 12,000 years before present). Beaches are geologically very dynamic environments, with sand moving inshore and offshore seasonally. Sand is transported parallel to the coast by longshore currents, and influenced by the migration of ephemeral natural inlets through the barrier island (Zarillo and Liu 1990). Recent stabilization of inlets along the barrier island coast, including Sebastian Inlet, have resulted in significant adverse impacts on sand transport quantities and shoreline erosion along the coastline, contributing to beach losses "downstream" of the inlet.

4.2.2 Biological

The high-energy beach is a challenging environment for animal and plant life. Species diversity is typically low, although species adapted to sandy beaches may be highly abundant. Typical beach fauna in the proposed project area includes the mole crab (*Emerita talpoida*), surf clam (*Donax variabilis*) and ghost crab (*Ocypode quadrata*). These and other beach infauna provide forage for a wide variety of shorebirds such as plovers (*Charadrius spp*.), willets (*Catoptrophorous semipalmatus*), and ruddy turnstones *(Arenaria interpres*). Drift algae and sargassum stranded on the beach may support large numbers of insect and other invertebrate life. As elevation increases, conditions become less severe for the establishment of plant life. Tendrils of various plants extend down the beach, notably the beach morning glory *Ipomoea pes-capre*. As the dune crest is approached, other salt tolerant plants are found such as sea oats (*Uniola paniculata*), sea rocket (*Cakile sp.)* and beach elder (*Iva imbricata*). Sparsely vegetated beaches are preferred nesting habitat for the least tern (*Sterna antillarum*), listed as a threatened species by the Florida Fish and Wildlife Conservation Commission. Although there is no positive evidence of their occurrence in the Sector 7 project area, the sea oat zone high on the dune provides habitat for another threatened species, the southeastern beach mouse (*Peromyscus polionotus niveiventris*).

Beaches in Indian River County also provide nesting habitat for at least three species of sea turtles, as will be discussed in Section 5.

4.3 Offshore Borrow Areas

4.3.1 Geological

The area selected as the sand source for the proposed project (Figure 1) is located on an offshore sand shoal in about 25 to 30 feet of water three miles or less offshore. This sand shoal was formed in the recent geologic past by the migration of relic inlets through the barrier island (Moody 1964). As a tidal inlet migrates, its ebb shoal becomes elongated and eventually detaches from the shoreline due to rising sea level and the landward retreat of the shoreline. There are a number of these shoal formations along the local coast, including St. Lucie, Pierce, and Capron Shoals in St. Lucie County, and Indian River Shoal located offshore of southern Indian River County and northern St. Lucie County. The shoal sediments are mostly beach-compatible sands, as might be expected from their geological origins. Deposits consist of deep layers of high quality sands (core samples from Indian River Shoal indicate unconsolidated sand over 15 feet deep), making this shoal a viable sand source for beach restoration.

4.3.2 Biological

These offshore sand habitats support a diverse fauna, although there has been comparatively little research attention in this environment. There are several studies of invertebrates and fishes from the open sand habitat in the general proposed project area. Johnson (1982) collected over 188 species of invertebrates in benthic grab samples from the Capron Shoal area off Fort Pierce Inlet. In a study offshore of Hutchinson Island in St. Lucie County, Futch and Dwinell (1977) collected lanclets (sand dwelling chordates in the subphylum Acrania) in densities as high as 1,750 per square meter. Gilmore et al. (1981) collected 194 species of fishes from open shelf sand habitats in the Indian River County area. Flatfishes, searobins, and cusk eels, along with an assortment of batfishes and skates, dominated the fish fauna.

There is some information on the extent to which offshore sand shoals like the proposed borrow areas differ from the open sand habitat in general. In the early 70's, extensive baseline ecological monitoring was conducted offshore of Hutchinson Island in St. Lucie County in conjunction with the licensing of the St. Lucie Nuclear Power Plant. These studies included physical and chemical analyses, and phytoplankton, zooplankton, invertebrate, and fish studies. The results were published in a series of Florida Department of Natural Resources publications. The offshore stations established for these studies included one station on Pierce Shoal, an offshore sand shoal similar in origin, depth, and offshore position to the proposed borrow areas on Indian River Shoals. Three other stations were located in sand habitats off the shoal. Phytoplankton studies (Tester and Steidinger 1979) showed that of the four offshore stations, the shoals station had the lowest chlorophyll a levels, the lowest rate of primary productivity, and the lowest phytoplankton diversity. The shoals station ranked third out of four in total zooplankton abundance (Walker et al. 1979). Arthropod populations were sampled extensively over a three year period using both grabs and trawls and including both day and night samples (Camp et al.

1977). The 34 species collected at the shoals station had arthropod populations less than half of any of the other offshore stations. The arthropod density in the grab samples was significantly lower at the shoal station than at the other stations. Fishes were also sampled over a three-year period at the same stations, using a 3.7m otter trawl capable of sampling both benthic and water-column fishes. The shoal site had the lowest number of species and the lowest fish density of any of the offshore stations. The authors attributed the paucity of fishes at the shoals site to the relative lack of invertebrate prey on the shoals (Futch and Dwinell 1977).

4.4 Nearshore Hardbottom Reefs

4.4.1 Geological

The underlying material of the nearshore reef system off Indian River County is coquina rock limestone of lithified sands and shell typical of the Anastasia formation found along much of the east central coast of Florida. Like the Atlantic Coastal Ridge and the offshore reef tracts, this formation was created during periods of sea level change and parallels the present day coastline.

Some of the present nearshore reef system was uncovered by the recession of the shoreline in historic time. Beach profile measurements from 1972 show that some present day well developed reef areas closest to shore were buried under the beach/dune system in 1972, and in some cases more recently.

Apart from its biological value, the reef structure itself may help protect the coastline from erosion and traps sediments, providing for the actual progradation of beaches in some instances (Kirtley and Tanner 1968). Perkins et al. (1997) produced maps of the nearshore hardbottom habitat offshore of Indian River County as part of the SEAMAP program. They characterize the reef habitat as being essentially continuous and up to ½ mile wide. Calculations based on digital analysis of SEAMAP aerial photography taken in the summer of 1993 yield an estimate of approximately 3,740 acres for total nearshore reef habitat in Indian River County.

4.4.2 Biological

The keystone species for the nearshore reef community is the reef building tube worm *Phragmatopoma caudata* (= *lapidosa*). These animals construct much of the reef habitat, using coquinoid rock outcroppings as substrate. Zale and Merrifield (1989) provide a review of the species and its ecology. Both the rock substrate and the worm reef provide the foundation for a diverse community of algae, invertebrates, and fishes. Nelson (1989) found 62 species of algae and 263 species of invertebrates on the nearshore reefs near Sebastian Inlet, and suggested that this number may be conservative. Nelson also found extraordinary densities of invertebrates associated with the *Phragmatopoma* community, with densities of 40,000 to 50,000 individuals per square meter of isopods and amphipods. More extensive sampling by Gore et al. (1978) focused on crustaceans on reefs adjacent to the proposed project area. They found 96 species of decapod and stomatopod crustaceans within or adjacent to the worm rock reef. The Nelson study found species richness ranged from 45-93 on the most inshore reefs, from 36-83 in the intermediate zone, and 53-119 on the most offshore reefs. Nelson concluded that while considerable biodiversity was present in all areas, greater sediment movement and increased turbidity may keep the inshore an intermediate reefs somewhat less developed than those of higher relief located farther offshore.

Environmental surveys in the Indian River County nearshore area have identified four distinct hardbottom habitat classification types (Applied Technology and Management 2001). The types include:

- Type 1 – Non-hardbottom sand habitat in the mapping areas
- Type 2 – Algal community with low relief rock
- Type 3 – Inshore worm rock
- Type 4 – High relief algal/sponge community
- Type 5 – High relief algal/sponge community with worm rock

It is likely that the hardbottom habitat subsets have different habitat values for fish and invertebrate fauna. For example, the high relief Type 5 community may be the most appropriate for adult fishes and spiny lobster, while the lower relief communities may be ecologically important primarily as juvenile fish and invertebrate settling and developmental habitat.

Gilmore et al. (1981), Futch and Dwinell (1977), and Lindeman and Snyder (1999) studied fish communities on nearshore hardbottom habitat in the general area of the proposed project. The most comprehensive study is Gilmore et al. (1981), who used a variety of methods, including ichthyocides, to develop a comprehensive inventory of species. Gilmore et al. found a total of 107 species of fishes on “surf zone” reefs (coquinoid-sabellariid reefs 0-3m deep, equivalent to those adjacent to the project area) between Sebastian and St. Lucie Inlets. Five species dominated the total number of individuals. These include two blennys, *Labrisomus nuchipinnis* and *Scartella cristata,* two grunts, *Anisotremus virginicus* and *Haemulon parrai,* and one porgy, *Diplodus holbrooki.* Species were tabulated semi-quantitatively, with each species ranked as unknown, rare, occasional, frequent, common, or abundant. The seventy-six species that were ranked as frequent, common, or abundant are listed in Table 1.

4.5 Water Column Habitat

4.5.1 Oceanographic

The water column, or neritic, habitat consists of the waters overlying benthic habitats to the edge of the continental shelf. Coastal waters offshore of central Florida are an admixture of shelf waters and Florida Current (Gulf Stream) water, and variations in the path of the Florida Current dramatically affect water column habitats (South Atlantic Fishery Management Council 1998). Upwelling of deep water along Florida Current frontal boundaries is an important source of nutrients to continental shelf waters (SAFMC 1998).

4.5.2 Biological

Since most marine species spawn pelagic eggs, the neritic habitat is important to a wide variety of fish and invertebrate species at some point in their life history. The Florida Current serves as an important source of continual replenishment for local waters, as many larval and juvenile fishes and invertebrates are transported into the neritic zone from tropical waters to the south. There are also large numbers of species that inhabit the water column as adults. 200 species of adult fishes have been documented from neritic habitats off the east central Florida coast (Gilmore et.al. 1981). Many of the larger species, such as mackerels, tunas, and billfishes, make seasonal migrations north and south along the coast in the neritic zone.

5.0 BIOLOGICAL INFORMATION ON PROTECTED SPECIES

This section summarizes available information on the biology of protected species potentially affected by the proposed project, both generally and specifically to the project area.

5.1 Sea Turtles

Five species of sea turtles are found in the waters off Indian River County, and three species have been documented as nesting on Indian River County beaches. The loggerhead is responsible for the vast majority of the nesting, although recent data shows an increasing statewide trend for nesting by the green turtle and particularly by the leatherback.

5.1.1. Loggerhead Sea Turtle (*Caretta caretta*)

5.1.1.1 General Information

The loggerhead sea turtle has been Federally listed as a threatened species since 1978. Loggerheads are circumglobal in distribution in tropical and temperate waters. The southeast U.S. coast, and particularly Florida, is considered to be the most important rookery in the western hemisphere for loggerheads (NMFS and USFWS 1991a). Recent studies have revealed three genetically distinct nesting populations in the southeast U.S.: the northern nesting population (North Carolina to Cape Canaveral), the South Florida population (Cape Canaveral to Collier County), and the Florida Panhandle population (Franklin to Escambia Counties, Florida) (Bowen et al. 1993). Trends in Florida nesting were assessed by Witherington and Koppel (in press), who analyzed loggerhead nesting for thirty nesting beach sites in Florida, included in the Florida Index Nesting Beach program, and concluded that loggerhead nesting appeared to be stable or increasing over the period from 1989-1998.

Loggerheads nest in the southeast U.S. from April through September, with the peak nesting in June and July (NMFS and USFWS 1991a). The nesting process is remarkably stereotyped, and is described in Bustard et al. (1975). Hatchlings emerge primarily at night, and swim offshore in a “frenzy” until they arrive at offshore weed and debris lines (Carr 1986) (Wyneken and Salmon, 1992). Post hatchling turtles from the Florida coast enter the currents of the North Atlantic Gyre, eventually returning to the western Atlantic coastal waters (Bowen et. al. 1993). When loggerheads reach a carapace length of approximately 40-60 cm, they leave the pelagic environment and move into various nearshore habitats (Carr, 1986). In the United States, developmental habitats for loggerheads are found from Texas to Nova Scotia (Turtle Expert Working Group 1998). As they approach adult size of about 83 cm carapace length (Ehrhart et al. 1996) loggerheads leave the developmental habitats. Adult loggerhead foraging grounds for the South Florida nesting population are found in the Caribbean basin, the Gulf of Mexico, and along the eastern seaboard of the U.S. (Meylan et al. 1983). Abundances of adult loggerheads in Florida coastal waters are much lower in months outside of the nesting season (Magnuson et al. 1990).

5.1.1.2 Site Specific Information

Juvenile and subadult loggerheads are found throughout the year in the Indian River Lagoon and the offshore reef areas of Indian River County. In 1989, Dr. Llewellyn Ehrhart with the University of Central Florida (UCF) began conducting turtle netting during the summer over a sabellariid worm reef near Sebastian Inlet. In the ongoing netting study by the University of Central Florida marine turtle research program (Ehrhart et al. 1996) very few loggerhead turtles have been captured on the nearshore wormrock reefs. However, large numbers of captures at the Florida Power and Light Company St. Lucie Nuclear Power Plant (Quantum Resources, Inc. 1999), suggest that juvenile loggerheads use the nearshore habitat in this general area.

There is no countywide sea turtle nesting survey in Indian River County, but the Florida Fish and Wildlife Conservation Commission (FFWCC) Statewide Nesting Beach Survey (SNBS) program has data collected from a variable number of kilometers of beach in the County since 1980. In the last decade (1990-1999) the average number of loggerhead nests per kilometer of beach surveyed in the County was 154 nests/km. With 35.6 km of Indian River County shoreline, this figure yields an estimate of mean annual loggerhead nesting within the County of 5,482 nests. As discussed in Section 6.1.1, the limited data available for the Sector 7 project area suggest an average annual nesting level for loggerheads in Sector 7 of 127 nests.

5.1.2 Green Sea Turtle (*Chelonia mydas*)

5.1.2.1 General Information

The green turtle was listed under the Endangered Species Act (ESA) in 1978, and the Florida nesting population is currently listed as endangered. Green turtles are found worldwide in tropical and subtropical waters. Major green turtle rookeries in the Western Hemisphere occur on South Atlantic islands and the Caribbean basin. Most continental U.S. nesting of the green turtle takes place on the Florida East Coast south of Cape Canaveral (NMFS and USFWS 1991b). Green turtles show a similar life history pattern as loggerheads, but they leave the pelagic phase and enter developmental habitats at a considerably smaller size, about 20-25 cm carapace length (Magnuson et al. 1990). Typical developmental habitats are shallow, protected waters where seagrasses are prevalent (Carr et al. 1978), but small green turtles are also commonly found in reef environments were attached algae is present (Ehrhart et al. 1996) (Coyne 1994). It has been suggested that green turtles in foraging habitats may tend to specialize in either algae or seagrass forage, as individual turtles with intestinal microbial flora adapted to aid in seagrass digestion would digest algae less efficiently, and vice versa (Bjorndal 1985).

Green turtles nesting in Florida have a minimum size of 83.2 cm carapace length, but they appear to leave Florida developmental habitats by about 60-65 cm carapace length (Witherington and Ehrhart 1989), perhaps migrating to the southeastern Caribbean. The majority of green turtle nesting in Florida takes place in July, August, and early September. Witherington and Koppel (in press) reviewed green turtle nesting on thirty beach sites included in the Florida Index Nesting Beach program. They concluded that green turtle nesting in Florida was stable or increasing over the period from 1989-1998.

5.1.2.2 Site Specific Information

Indian River County contains two significant developmental habitats for green turtles, the Indian River Lagoon and the nearshore reef system (Ehrhart et al. 1996). In 1989, Dr. Llewellyn Ehrhart with the University of Central Florida (UCF) began conducting turtle netting during the summer over a sabellariid worm reef near Sebastian Inlet. More juvenile green turtles were caught per unit effort (CPUE) on the reef than at a nearby site in the Lagoon. CPUEs recorded on the nearshore reef were the highest recorded for any capture program on record (L. Ehrhart, pers. comm.).

It should be noted that there are no truly comparable capture programs in Atlantic coastal waters, and there is no particular reason to believe that the one site at which UCF samples turtles is in any way unique. These data suggest that there might be a higher number of turtles inhabiting the reef than the lagoon, at least during the summer. An alternative explanation is that capture rates on the reef may be higher because the foraging area is more concentrated over the reef and therefore capture techniques are more effective. Statistically significant differences in CPUE were found between years in the reef turtle captures, but the authors suggested that differences among years might reflect differences in surf conditions and water clarity, which affect netting success, rather than differences in actual turtle abundance. Although turtles captured on the reef were similar in size to those captured in the lagoon, migration between the two habitats appears to be minimal, despite the presence of a nearby inlet (D. Bagley, unpublished data).

Some limited dietary analysis has been done on green turtles captured on the reef by Karen Holloway-Adkins of UCF. The major food of these turtles was found to include marine algae of the genera *Bryothamnion, Gelidum, Gigartina, Hypnea, Rhodymenia, Bryocladia,* and *Soliera* (red algae) and *Caulerpa* and *Ulva* (green algae).

There is no data available on the seasonality of use of this habitat by juvenile green turtles. The Florida Power and Light Company St. Lucie Power Plant, located approximately 60 km south of the UCF study site, also samples turtles from the nearshore ocean environment. FPL data show juvenile green turtle captures tend to be distributed more or less evenly throughout the year (Quantum Resources, Inc. 1999). The UCF researchers also capture juvenile green turtles at the Trident submarine basin in Port Canaveral (approximately 100 km to the north of Sebastian Inlet). This area is thought to be an adjunct of the nearshore developmental habitat. Juvenile green turtles are present in the Trident basin all year.

There is some indirect evidence that suggests that the suitability of nearshore reefs in the proposed project area for juvenile green turtle foraging may be limited to part of the year. Nelson (1989) noted a great seasonal reduction in algal species richness (56 summer vs. 16 winter) on the nearshore hardbottom reefs at Sebastian Inlet. Also, the hardbottom mapping and characterization study conducted for this proposed project showed a considerable reduction in algal standing crop in the winter months (B. Baca, pers. comm.). An examination of Sea Turtle Stranding and Salvage Network (STSSN) data might be used to infer seasonal use patterns, but variations in stranding levels may be confounded by seasonal variation in wind patterns, fishing seasons and patterns of recreational use of beaches, which affects reporting levels.

Nesting activity of the green turtle in Indian River County was estimated from FFWCC Statewide Nesting Beach Survey data in the same manner as that reported in Section 5.1.1.2 for loggerheads. Data for 1990-1999 yields a mean nesting density of 4.2 nests per kilometer of beach surveyed, for an overall countywide annual nesting estimate of 150 nests. As discussed in Section 6.1.1, the limited data available for the Sector 7 project area suggest an average annual nesting level for green turtles in Sector 7 of three nests.

5.1.3 Leatherback Sea Turtle (*Dermochelys coriacea*)

5.1.3.1 General Information

The leatherback sea turtle was Federally listed as endangered in 1970. Leatherbacks are found worldwide in pelagic waters from the tropics to near the Arctic and Antarctic Circles. Nesting primarily occurs on the Pacific coast of Mexico and the Caribbean coast of South America, with some continental US nesting in Florida. During the period from 1979 to 1992, over 90% of Florida leatherback nesting occurred in St. Lucie, Martin, and Palm Beach counties (Meylan et al. 1995). An analysis of Florida Index Nesting Beach Survey data indicates a statistically significant increase in Florida leatherback nesting over the period from 1989-1998 (Witherington and Koppel in press).

5.1.3.2 Site Specific Information.

Leatherback turtles are virtually unknown from the inshore waters of Indian River County, apart from nesting females. FFWCC statewide nesting beach survey data for 1990-1999 show a mean leatherback nesting density of 0.23 nests per kilometer. This yields an estimate for annual leatherback nesting in Indian River County of 8 nests. As discussed in Section 6.1.1, the limited data available for the Sector 7 project area suggest an average annual nesting level for leatherbacks in Sector 7 of one nest.

5.2 Other Protected Species

Other protected marine turtle and marine mammal species potentially found in Indian River County either occur in very low abundances or cannot reasonably be expected to be significantly impacted by the proposed project, and are not reviewed here. A search of the US Fish and Wildlife Service GIS database for occurrence of protected species in the proposed project sectors revealed no protected plants or terrestrial animals, and 4 species of non-listed shorebirds (T. Adams, pers. comm.). Five protected species of vertebrates, the piping plover, the least tern, the southeastern beach mouse, the northern right whale, and the West Indian manatee, may potentially occur in the proposed project area and will be discussed briefly herein.

5.2.1 Piping Plover (*Charadrius melodus*)

The piping plover is listed as a threatened species at both the state and Federal level. The piping plover is also protected under the Migratory Bird Treaty Act. Piping plovers are migratory, and are found in Florida from September through March (USFWS 1995). Piping plovers use the sandy shore as a feeding area, appearing to prefer more sheltered beach environments rather than the high-energy Atlantic coast beaches. Surveys have found that the plover is most often observed at the accreting ends of barrier islands, along sandy peninsulas, and near coastal inlets (USFWS 1995). Piping plovers have been observed by rangers at the Sebastian Inlet State Recreation Area on the beach south of the inlet (Gayle Stewart, SISRA, pers. comm.).

5.2.2 Least Tern (*Sterna antillarum*)

The least tern is a small member of the gull family (Laridae) that is listed by the state as a threatened species and is federally protected under the Migratory Bird Treaty Act. The least tern winters in South America and nests in Florida in the summer. Terns arrive in Florida each year in late March or early April and nesting usually begins in late April. Least terns are colonial nesters and traditionally choose open sandy areas on beaches and sand spits, although they may also use flat, gravel-topped roofs in many areas. Terns feed diurnally on small fish near the surface by diving, and, as a result, require reasonably clear water for successful foraging. As a ground nesting bird, least terns are impacted by high levels of human activity on beaches and predation from wild and domestic animals. Locally, least terns are known to nest on sandbars and spoil areas in Sebastian Inlet State Recreation Area.

5.2.3 Southeastern Beach Mouse (*Peromyscus polionotus niveiventris*)

The southeastern beach mouse is listed as a threatened species at both the Federal and state levels. The species has been found on barrier islands on the Florida East Coast from Palm Beach through Volusia Counties. Preferred habitat for the mouse appears to be the dune crest and backdune habitat dominated by the sea oat *Uniola paniculata*. The decline of the beach mouse has been attributed to loss of habitat from beach erosion and coastal development, as well as from predation by domestic pets. Southeastern beach mice have historically been documented within the primary dune area in several locations in the County, including Sebastian Inlet State Recreation Area, Treasure Shores Park, and several private properties. Populations have declined steadily throughout the 1990’s in most areas of the County. Annual trap surveys conducted in the Indian River County portion of the Sebastian Inlet State Recreation Area from 1995 through 1999 have fluctuated between 1 and 6 individuals (Alice Bard, pers. comm). It appears that the species may have become recently extirpated in the beach habitat throughout much of its local range, presumably due to erosional habitat loss (L. Ehrhart, pers. comm.). There is no information specific to the Sector 7 project area on the possible presence of the beach mouse. The fact that the area is largely built out, and little native pioneer dune vegetation remains due to erosion and seawalling, reduces the likelihood that the southeastern beach mouse occurs in Sector 7.

5.2.4 Northern right whale (*Eubalaena glacialis*)

The northern right whale is a Federally listed endangered species, and is also protected under the Marine Mammal Protection Act. This is a highly migratory species, summering in the Canadian Maritime Provinces and wintering in the Southeastern Atlantic and Caribbean. Adults and dependant calves routinely travel close to shore off the Florida coast (Schmidly 1981). The time of peak occurrence in the waters off Indian River County (December through March) corresponds to the construction period of the proposed project.

5.2.5 West Indian Manatee (*Trichechus manatus*)

Manatees are Federally protected under both the Endangered Species Act and the Marine Mammal Protection Act, as well as under Florida law. Manatees are generally restricted to the Florida peninsula and Georgia coast, although they occasionally wander as far as Louisiana and Virginia (Geraci and Lounsbury 1993). Manatee habitat includes shallow, protected lagoons and freshwater systems. Manatee use of the open ocean is infrequent and generally limited to travel between favored habitats (Hartman 1979). In summer months, manatees range widely between habitats (particularly on the Florida East Coast), while from November to April, they are generally concentrated in areas near warm water refuges (Reid et al. 1991). Manatee presence in nearshore ocean areas off Indian River County during the November through April period is unlikely (John Morris, Florida Tech, pers. comm.).

6.0 ANTICIPATED EFFECTS ON MARINE TURTLES

This section provides a general discussion of the nature of potential effects of beach restoration projects on marine turtles, and a specific discussion of the anticipated effects of the proposed projects and the alternatives.

Nature of potential effects

Restored beaches often differ from natural beaches in several important features that affect their suitability for sea turtle nesting. If sands used for restoration differ markedly from natural beach sands in grain size distribution and color, then sediment temperature, moisture content, and gas exchange may be affected, all of which affect the nest incubation environment. Renourished beaches may show high levels of sand compaction, which affects the ability of turtles to nest, the incubation environment, and hatchling emergence success. These changes in physical characteristics, together with the unnatural "as-built" profile of the restored beach, may result in reduced reproductive success during one or more nesting seasons following construction.

As restored beaches equilibrate to a more natural profile, steep vertical escarpments often form along the seaward edge of the constructed beach berm. These "scarps" present a physical barrier to nesting turtles. Additionally, as beach profiles equilibrate, losses of nests laid in the seaward portions of the renourished beach due to erosion may be high. A review of these potential impacts is provided by Crain et al. (1995). Steinitz et al. (1998) have postulated a cyclical trend of impacts on nesting based on long-term observations from a renourished beach at Jupiter Island, Florida. They found that nesting densities were low on highly eroded beaches, as might be expected. Following the construction of a beach restoration project, although the number of crawls increased, low nesting success caused the nest density to remain low. After two years post construction, nesting density was considerably higher than pre-construction levels and was similar to the nesting density found for a non-eroded control beach. As the renourished beach eroded and narrowed, nest densities declined until they approached pre-construction levels. The next renourishment episode began the cycle again.

Most of the detrimental effects of beach renourishment projects have been limited to effects on nesting success (the proportion of turtles emerging from the sea that successfully nest) (Nelson and Dickerson 1988). Reductions in hatching success (the proportion of eggs laid that hatch or result in emergent hatchlings) have been reported less frequently (Ehrhart 1995; Ecological Associates 1998). Trindell et al. (1998) provide a comprehensive review of sea turtle monitoring data associated with 27 beach restoration projects constructed in Florida since 1987. Where appropriate, data were pooled for statistical comparison with available background nesting data. Overall, they found that nesting success was significantly reduced in the first post construction nesting season, but a significant difference was absent in the second nesting season post-construction. No significant differences in hatching success levels were evident in either the first or second year post construction between background levels and pooled project beaches.

6.1 Effects of Proposed Project on Nesting Success

6.1.1 Estimates of Nesting in the Project Sector

Two different approaches can be used to estimate the levels of marine turtle nesting that occur in the proposed project sector. Countywide estimates include a number of survey years but do not reflect variation in nesting between different areas of the County. The proposed Sector 7 project area is not regularly surveyed for sea turtle nesting. The only systematic nesting surveys in the area were conducted in 1997 and 1998. Basing estimates of nesting on just two survey years is less than ideal, but this represents the best available data for the area. Using this best available data for Sector 7, the proposed project (2.17 km of shoreline) will affect an amount of nesting habitat that would be expected to support 127 loggerhead nests, 3 green turtle nests, and 1 leatherback nest. In the County's Habitat Conservation Plan for sea turtles, Ecological Associates Inc. (EAI) have compiled and summarized the best available nesting data broken down into 8 segments covering the entire County (EAI 2002). Estimates of nesting in the proposed project area was generated by converting EAI nesting density data into nests per linear foot, then multiplying by the number of linear feet of project sector contained in that EAI beach segment.

LOGGERHEAD NESTING ESTIMATES BY PROJECT SECTOR

BEACH SECTOR	EXTENT (KM)	NESTING DENSITY (NESTS/KM)	ANNUAL ESTIMATED NESTS	SURVEY YEARS IN ANALYSIS
Countywide mean	35.6 km	154	5482	1990-1999
Sector 7	2.17 km	47	127	1997-1998

GREEN TURTLE NESTING ESTIMATES BY PROJECT SECTOR

BEACH SECTOR	EXTENT (KM)	NESTING DENSITY (NESTS/KM)	ANNUAL ESTIMATED NESTS	SURVEY YEARS IN ANALYSIS
Countywide mean	35.6 km	4.2	150	1990-1999
Sector 7	2.17 km	1.2	3	1997-1998

LEATHERBACK NESTING ESTIMATES BY PROJECT SECTOR

BEACH SECTOR	EXTENT (KM)	NESTING DENSITY (NESTS/KM)	ANNUAL ESTIMATED NESTS	SURVEY YEARS IN ANALYSIS
Countywide mean	35.6 km	0.23	8	1990-1999
Sector 7	2.17 km	0.51	1	1994-1998

From the three previous tables it is apparent that, due to differences in nesting densities, the proposed Sector 7 supports much lower nesting levels than the County average for loggerheads and green turtles and thus predicted nesting using best available data is less than would be expected from considering countywide data. Leatherback nesting levels using best available data for Sector 7 are higher than the countywide mean, but this is quite possibly a statistical artifact resulting from the rarity of leatherback nests and from just two sample years.

6.1.2 Review of Effects of Relevant Projects

There are two specific studies that have particular relevance to the proposed project. Ecological Associates Inc. of Jensen Beach, Florida conducted a comprehensive assessment of the effects of a 1.2 million cubic yard beach restoration project in Martin County (EAI 1999). Herren (1999) studied the effects of sand transfer renourishment on loggerhead nesting and reproductive success along the shoreline adjacent to Sebastian Inlet. Both these studies include pre- and post-nourishment data at the treatment sites and proper control sites. The fact that the two studies come to rather different conclusions regarding the impact of the respective projects on turtle nesting reflects the variable nature of beach restoration project impacts on marine turtles. Differences in design, management, and objectives between the two projects may have been in large part responsible for the differences in the observed effects on marine turtles. The Martin County beach restoration was carefully designed and managed to result in a natural beach profile.

In contrast, the Sebastian Inlet project was not a beach restoration project *per se,* but rather a sand transfer operation designed to replace the sand deficit caused by the inlets interruption of longshore sand transport. There was little design effort to create a beach, and relatively little regulatory oversight of the project. The 1999 Herren study also came to different conclusions than an earlier study by Ryder (1993) who examined the 1989-1990 sand transfer renourishment at Sebastian Inlet. While Herren found a substantial reduction in nesting that was attributable to the 1997 project, Ryder found no reduction in nesting success attributable to the 1989-1990 project. Thus, even successive renourishments of the same beach may have different project effects.

In the Sebastian Inlet study, Herren (1999) found nesting success was reduced by 33 percentage points and the total number of nests in the renourished treatment area reduced by 81% the first nesting season after construction, with both parameters recovering by the second nesting season. The EAI study found nesting success was reduced significantly in the first post construction season in one of the two treatment areas (EAI 1999).

The two studies found different project effects on the total number of turtles emerging on renourished beaches. At Sebastian Inlet, Herren found a 53% reduction in loggerhead emergences in the first post-construction nesting season, while EAI found no reduction in the number of emergences attributable to the Martin County renourishment project. Since there was no effect on emergences, but there was reduction in nesting success, EAI concluded that the project reduced the relative attractiveness of the beach to post emergent turtles. EAI found no evidence to suggest that scarp formation was responsible for reducing nesting success in the Martin County project, and felt that differences in overall beach profile may have been responsible. In contrast, Herren (1999) concluded that scarp formation played a significant role in reducing nesting success at Sebastian Inlet. Scarp formation at the Sebastian Inlet site was probably exacerbated by the manner of sand placement on the beach in that project.

A reduction in nesting in a project area does not imply that those nests are lost. Bagley et al. (1994) and Ehrhart et al. (1994) have noted increased nesting on beaches adjacent to badly scarped beaches, suggesting that turtles deterred from nesting on one portion of beach are able to successfully nest on nearby beaches. It is important to note that this displacement is not without impact, since the metabolic cost of even a short non-nesting emergence is not trivial. This metabolic cost may lower the overall reproductive output over the season (fewer eggs per clutch or fewer clutches). Frequently deterred turtles may finally place their nests in sub-optimal environments. The extent of occurrence of these effects has never been quantified, yet are logical consequences of nest site deterrence.

6.1.3 Anticipated Effects of the Preferred Alternative on Nesting Success

The proposed project has several features that are expected to minimize impacts on turtle nesting success. The modest fill template of the preferred alternative is designed to change the shoreline profile as little as possible, while remaining consistent with shoreline protection goals. The fill volume also allows for a design renourishment interval of six years. A smaller volume fill template might reduce initial impacts on turtle nest success, but reducing the fill schedule reduces the design life of the project. Since nourishment effects are most prominent in the first year following construction, a smaller fill volume that would result in additional rounds of construction over the project lifespan would likely result in more total impact than a design with a larger placement volume which would require less renourishments.

Selection of fill material that resembles native beach sand as closely as possible minimizes adverse impacts. The sand source for the proposed projects will come from an offshore site. Offshore borrow sites are generally the most suitable for beach fill (Crain et al.1995). Sediment contained within the proposed borrow area has been found to be suitable in terms of grain size and percentages of very fine and very coarse material. Results of grain size analysis of the proposed sand sources indicate an average percentage of fine material of only 0.97 percent, indicating excellent quality beach material. Compaction monitoring and tilling (if warranted) and scarp reduction will be included in the construction and monitoring plans.

Overall, most project impacts on sea turtle nesting success are expected to be limited to the first year, with some measurable effect persisting into the second year. Since any turtles deterred from nesting in the project areas can be expected to nest elsewhere nearby, no measurable negative effect of the project on total nesting within Indian River County is expected.

There are also significant positive potential effects of the proposed projects on marine turtle nesting success. The Sector 7 project area is prone to a proliferation of coastal armoring in the absence of a beach restoration project. As a part of the County's Habitat Conservation Plan for take associated with coastal armoring (seawalls), the County and its consultant, Ecological Associates Inc. have calculated the potential for new armoring structures in the County both with and without the proposed beach restoration project. It is anticipated that the construction of the Sector 7 project will result in 1,044 fewer feet of armoring being constructed under emergency permitting in Sector 7 over the next 30 years (EAI 2002). This total does not include an unknown number of eligible structures whose owners would choose to apply for seawall permits through the standard permitting procedure, and who would be enjoined from doing so by Statute if the project were to be built. Although results from a recent study must be considered preliminary, (Mosier 1998) has documented a clear reduction in nesting success in front of seawalled properties. The Mosier study also found that as the proportion of the total available shoreline that is armored increases, the cumulative effects become more and more severe. Thus, the proposed project will have a documented and quantifiable long-term positive impact on marine turtle nesting success in Indian River County.

The positive potential effect of increasing available nesting habitat for marine turtles has often been cited for beach restoration projects. Although it is generally felt that the temporary negative effects largely offset these benefits, where nesting habitat was nonexistent before restoration, restoration projects clearly have a net positive effect. (Lebuff et al. 1990) (Flynn 1992).

6.2 Effects of the Preferred Alternative on Hatching and Emergence Success

Nelson and Dickerson (1988) found that nests laid on restored beaches generally hatched successfully. In the Sebastian Inlet sand transfer renourishment area, Herren (1999) found no significant difference in hatching success in the renourished area in the first or second season after renourishment compared to pre-renourishment levels. EAI (1999) found lower overall hatch success on nourished beaches following construction compared to controls, but the differences were not statistically significant. When nests lost due to erosion were excluded from the statistical analysis, reproductive success on nourished beaches equaled or exceeded values for the control beach in both post construction years. The EAI study did find changes in the incubation environment on the nourished beaches, but there was no apparent effect on the percentage of eggs laid that hatched or the emergence success of hatchlings. In the EAI study, there were significant differences between renourished and natural beaches in terms of grain size, carbonate content, moisture content, and sand color. Despite these clear differences, reproductive success, exclusive of washouts, was not significantly different on renourished beaches. This indicates that, within rather wide parameters, differences in sand characteristics between natural and renourished beaches do not affect their suitability as marine turtle incubation substrates.

Both the Martin County study and the Sebastian Inlet study point to erosional losses of nests laid low on the newly constructed berms as a primary source of impact from the construction project. A proper relocation program could largely eliminate this impact. EAI recommended that consideration be given to relocating nests, located on seaward portions of nourished beaches, which would be expected to be lost in the first post construction nesting season as the beach equilibrates to a more natural profile. Herren (1999) recommended that nests seaward or within 5 meters landward of beach scarps in project areas be relocated.

With all construction occurring outside the nesting season and careful selection of appropriate fill material, the effects of the proposed project on sea turtle nest hatching success will be minimal. To eliminate potential impacts from erosional losses, we propose that during the first nesting season after construction, nests laid in vulnerable areas of the restored beach be allowed to be relocated landward by properly trained and permitted individuals.

6.3 Effects of the Preferred Alternative on Marine Turtle Developmental Habitat

Effects of the proposed projects on the juvenile green turtles that have been documented to use nearshore reefs as foraging habitat will be limited to the indirect effect of a minor reduction in available foraging habitat. It is assumed, for impact assessment purposes, use of this habitat is Countywide and that the habitat is used year-round.

Hardbottom habitats with high algae abundance provide the most valuable habitat for foraging green turtles. Of the specific hardbottom types identified in the 1999 hardbottom mapping and characterization effort (ATM 2001), Types 2, 4, and 5 are dominated by algae and share algal genera with reported diet items from juvenile green turtles in this habitat (Ehrhart et al. 1996). Type 3 hardbottom is dominated by the sabellariid worm *Phragmatopma* and would not be expected to be as suitable for green turtle foraging. The Sector 7 proposed project area contains only Type 2 habitat. The following table summarizes the direct impact on hardbottom habitat for the project as proposed. It is estimated that the preferred alternative of the project will directly impact a total of 5.3 acres of potential juvenile green turtle foraging habitat.

HARDBOTTOM HABITAT IMPACT BY HABITAT TYPE

PROJECT	TYPE 2	TYPE 3	TYPE 4	TYPE 5	TOTAL
SECTOR 7	5.3 acres	None	none	none	5.3 acres

The sampling methodology of the UCF turtle study does not allow for turtle density calculations, and there is currently no estimate of the amount of nearshore hardbottom needed to support a foraging turtle, so no quantitative assessment of the magnitude of impact is possible. Based on the estimate of total nearshore hardbottom habitat from Section 4.4.1, the proposed project is estimated to directly impact less than 0.2% of the total hardbottom habitat in Indian River County. Direct impacts to green turtle foraging habitat are not expected to be significant, due to the small proportion of total available foraging habitat that will be directly affected.

The proposed project will also cause indirect effects on juvenile green turtle foraging habitat. The primary indirect effect anticipated will be elevated turbidity levels associated with fill placement and the subsequent sorting out of fine material as the fill weathers. Elevated turbidity decreases light penetration, limiting algal primary production, in turn limiting available forage for juvenile green turtles. The extent and duration of this impact depends on many factors, some of which are unpredictable, but the most intense impacts can reasonably be expected in the months immediately following fill placement (in winter). As noted in Section 5.1.2.2, the winter season is when algae biomass and diversity in this habitat are at a minimum, and background turbidity is typically much higher than in the summer. The construction plans for the projects include a fill containment dike and dewatering system to minimize the release of turbid water. The expected fine fraction in the borrow material is 0.97 percent, which will limit the extent and severity of turbidity effects. Together, these factors minimize the anticipated indirect effect of the proposed projects on foraging habitat. Indirect impacts to marine turtle foraging habitat are not expected to be significant, due to their restricted extent in both space and time.

UCF data provide some indications of the potential for beach restoration projects to affect foraging turtles. UCF has collected data and calculated the CPUE for juvenile green turtles each year since 1989. The sampling area has presumably been subject to the influence of the Sebastian Inlet sand transfer renourishments, as it is quite nearshore and just south of the beach segment where over 850,000 cubic yards of sand have been placed over the last 10 years. The following table presents green turtle CPUE data for the nearshore reef from 1989-1999 (Holloway-Adkins et al. 2000). Years in boldface type represent the years (summers) immediately following a sand transfer renourishment project.

GREEN TURTLE CATCH PER UNIT EFFORT (TURTLES PER KM-NET/HOUR)

Year	**1989**	**1990**	1991	1992	**1993**	1994	1995	1996	**1997**	1998	**1999**
CPUE	5.44	0.72	4.32	7.97	20.42	0.29	8.55	23.78	12.58	7.02	43.81

The mean CPUE in summers following a sand transfer renourishment was not statistically different from the mean CPUE in summers not following a sand transfer renourishment (where statistical significance was determined through use of the two tailed t-test).

6.4 Anticipated Effects of Project Alternatives

6.4.1 The No-Action Alternative

The no-action alternative would eliminate the negative impacts of the proposed project on nesting and hatching success. However, as the beaches continue to erode in the critical erosion areas selected for restoration, the nesting habitat will be degraded, and in some areas completely lost. While very narrow beaches will be expected to still support nesting, under conditions were high tides reach the dune line on a daily basis, hatch success may decrease dramatically due to inundation and nest washout.

As erosion threatens waterfront properties, the inevitable result will be a proliferation of shoreline armoring structures and emergency, stop-gap measures to protect property that will have negative impacts on turtle nesting and hatching success. As noted in Section 3.5.1, failure to build the proposed beach nourishment project will result in an estimated 1,044 feet of additional shoreline armoring over the next 30 years, more than the armoring expected if the project were to be built, under emergency permitting rules alone.

The proliferation of seawalls has a documented negative effect on sea turtle nesting. In Volusia County, nesting turtles were found to encounter armoring structures on 16.7 percent of all emergences in 1999 (EAI, 2000). Fully 91% of those encounters resulted in a false crawl (the turtle failing to nest). Overall, armoring was responsible for nearly a third of all recorded false crawls, and the false crawl percentage was particularly high in the portions of the County where armoring was most prevalent. Quantitative data for the impact of armoring structures is only available for loggerheads. From FFWCC data from 1990-1999, the "background" nesting success in Indian River County is 54%. Mosier (1998) reported that nesting success was, on average, 69% lower at sites with seawalls than at sites without seawalls. The reduction in nesting success attributable to 1,044 shoreline feet of seawalls (0.317 km), results in a displacement of

13 nests every year in Sector 7 (EAI, 2002). Unlike the effects of beach nourishment, this effect is permanent and does not decrease over time.

When high tides reach the base of armoring structures, nests deposited in front of these structures are often subject to tidal inundation. This and other negative effects of seawalls become more pronounced the closer the seawalls are to the surf zone. Thus, in the absence of beach restoration, the impacts that both existing and future seawalls will have on nesting habitat are exacerbated.

The no-action alternative would result in no impacts to marine turtle foraging habitat. No adverse effects to marine turtle foraging habitat are anticipated under the no-action alternative.

6.4.2 The Reduced Fill Alternative

The effects of reducing the fill volume on marine turtle nesting and hatch success is difficult to quantify. The resulting beach berm as constructed would be narrower and the number of non-nesting emergences and would be expected to decrease somewhat, slightly increasing nesting success. A narrower berm is not expected to affect the incidence or average height of scarps. Aspects of the nest incubation environment that are influenced by renourishment such as compaction, water content, and temperature shall be the same as the preferred alternative given that characteristics of the sand are the same. Thus, a decrease in fill volume will have no effect on the influence of these factors on hatching and emergence success.

The reduced fill volume will result in cumulative adverse effects on marine turtle nesting from a decrease in the renourishment interval. Since the negative effects of beach renourishment on turtle nesting for the first and sometimes second year following construction are well documented, projects with a long lifespan are preferred over projects that require more frequent reconstruction. A consequence of the cyclical pattern of nesting impacts, observed by Steinitz et al. (1998) (see Section 6.0), is that the shorter the renourishment interval, the longer the unattractive, low density nesting periods become relative to the more attractive state that is more conducive to successful nesting. The decreased fill alternative is calculated to have a renourishment interval of 4 years, whereas the preferred alternative has a renourishment interval of 6 years. Decreases in fill volumes that require more frequent renourishment also significantly increase the total costs of the project over the 30-year lifespan.

The reduced fill alternative would decrease the extent of direct impacts to juvenile green turtle foraging habitat (see Section 8.2 for anticipated changes in direct hardbottom habitat impacts). Indirect impacts to foraging habitats would be decreased due to the reduced fill volume which will minimize the extent and severity of turbidity plumes associated with the project construction. However, the shortened renourishment intervals associated with the decreased fill alternative would increase the frequency of turbidity related impacts to marine turtle foraging habitat. The total cumulative indirect effects of the reduced fill alternative on marine turtle foraging habitat may actually be greater than for the preferred alternative, since the reduced fill alternative would actually result in the placement of slightly more sand on the Sector 7 beaches over the 30 year planning period, as discussed in Sections 3.5.1 and 3.5.3.

6.4.3 The Six Groin Alternative

The six groin alternative would result in the same beach widths as the preferred alternative considered, and beach characteristic related affects on sea turtle nesting and hatching success are expected to be similar. This alternative is associated with a 7-year renourishment interval, as opposed to the 6-year renourishment interval of the preferred alternative. The beneficial effect of a reduction in the demand for coastal armoring would be approximately the same as for the preferred alternative. There would however, be a permanent loss of some nesting habitat as a result of the area of dry beach occupied by the groins themselves. The "footprint" of each groin is approximately 42 feet alongshore, and it is assumed that the groin would occupy all the dry beach area between the dune or seawall and the tide line for that 42-foot width.

The potential magnitude of this impact may be estimated by totaling the beach width occupied by the six groins (252 feet), and dividing that quantity into the nesting density estimate for Sector 7 provided in Section 6.1.1. This calculation indicates that the six groin alternative would permanently remove a quantity of sea turtle nesting habitat that would be expected to support 3.6 loggerhead nests, 0.1 green turtle nests, and 0.04 leatherback turtle nests annually. There is also the distinct possibility that the presence of groins on a nesting beach may interfere with nesting behavior or the sea-finding ability of sea turtle hatchlings.

6.4.4 The Twelve Groin Alternative

The twelve groin alternative would result in the same beach widths as the preferred alternative considered, and beach characteristic related affects on sea turtle nesting and hatching success are expected to be similar. This alternative is calculated to have an 8-year renourishment interval, as opposed to the 6-year renourishment interval of the preferred alternative. The increased renourishment interval of the six groin alternative would result in less cumulative disruption to sea turtle nesting habit over the 30 year planning period, as one fewer renourishment episode is anticipated. The beneficial effect of a reduction in the demand for coastal armoring would be approximately the same as for the preferred alternative. There would however, be a permanent loss of some nesting habitat as a result of the area of dry beach occupied by the groins themselves. The "footprint" of each groin is approximately 42 feet alongshore and it is assumed that the groin would occupy all the dry beach area between the dune or seawall and the tide line for that 42-foot width.

The potential magnitude of this impact may be estimated by totaling the beach width occupied by the twelve groins (504 feet), and dividing that quantity into the nesting density estimate for Sector 7 provided in Section 6.1.1. This calculation indicates that the twelve groin alternative would permanently remove a quantity of sea turtle nesting habitat that would be expected to support 7.2 loggerhead nests, 0.2 green turtle nests, and 0.08 leatherback turtle nests annually. There is also the distinct possibility that the presence of groins on a nesting beach may interfere with nesting behavior or the sea-finding ability of sea turtle hatchlings.

7.0 EFFECTS ON SAND BEACH COMMUNITIES

This section summarizes the anticipated effects of the proposed project on animals residing on or in the beach itself, or that use the beach as a foraging habitat.

7.1 Effects of the Preferred Alternative on Infaunal Communities

Nelson (1985) reviewed the literature on the effects of beach renourishment projects on sand beach fauna and concluded…"Minimal biological effects result from beach nourishment. Some mortality of organisms may occur where grain size is a poor match to existing sediments, however, recovery of the beach system appears to be rapid". Nelson reviewed several studies on the most common beach invertebrates of the southeastern US, including the mole crab, *Emerita talpoida*, the surf clam, *Donax sp*, and the ghost crab *Ocypode quadrata*. None of the studies cited in Nelson showed significant or lasting impacts to any of these species resulting from beach nourishment. Hackney et al. (1996) provide a more recent review of the effects of beach restoration projects on beach infauna in the southeastern US. They also reviewed studies on the above species and agree with the conclusions in the Nelson study, with the caveats that construction should take place in the winter months to minimize impacts, and that the sand used should be a close match to native beach sands. In most of the studies reviewed by these authors, there was a considerable short-term reduction in the abundance of mole crabs, surf clams, and ghost crabs attributable to direct burial. Recruitment and immigration were generally sufficient to reestablish populations within one year of construction.

The proposed project will be constructed in the winter season, outside the recruitment window for these species, and the sand source is of high quality with a small percentage of fine material. These features operate to minimize adverse effects on most beach infauna (Hackney et al. 1996). We therefore do not expect the proposed project to have significant, long lasting impacts on sand beach infaunal communities.

7.2 Effects of the Preferred Alternative on Other Beach Associated Fauna

In addition to marine turtles, three beach associated protected species, the piping plover, least tern, and the southeastern beach mouse, discussed in Sections 5.2.1, 5.2.2, and 5.2.3, have the potential to be affected by the proposed project. The piping plover may be displaced to other feeding habitats during construction. The wider beach berm resulting from the project may make the restored beaches more favorable habitat for the plover in the short term, but this effect will diminish as the beach equilibrates and assumes a more natural profile.

Potential least tern nesting will not be affected by project construction since construction will occur in winter and the tern nests in summer. There may be some interference with least tern foraging immediately following construction if turbid water persists through April, when terns arrive from South America.

Any remnant population of the southeastern beach mouse in the project areas will not be adversely affected by the proposed projects. Existing back dune habitat will not be disturbed, and unlike beach restoration using terrestrial sand sources, extensive equipment access points through back dune habitats will not be necessary. Although there is no positive evidence the species occurs in Sector 7, the result of the proposed project will be a substantial improvement in habitat suitability for the southeastern beach mouse.

7.3 Anticipated Effects of Project Alternatives

7.3.1 The No-Action Alternative

The no-action alternative would not impact beach-associated infauna. There may be some adverse effects on the least tern, piping plover, and other shorebird populations, as continued beach erosion reduces the total habitat area available.

7.3.2 The Reduced Fill Alternative

A decreased fill volume of approximately 376,100 cubic yards would result in incrementally lesser impacts to the sand beach communities, however the 4-year renourishment interval associated with this option would increase the frequency of these impacts, when compared to the 6-year renourishment interval for the preferred alternative. The total cumulative effects of the reduced fill alternative on sand beach communities may actually be greater than for the preferred alternative, since the reduced fill alternative would result in the placement of slightly more sand on the Sector 7 beaches over the 30 year planning period, as discussed in Sections 3.5.1 and 3.5.3. The reduced fill alternative would have the same benefits for the southeastern beach mouse as the preferred alternative.

7.3.3 The Six Groin Alternative

The six groin alternative would have approximately the same impacts from the initial beach fill as the preferred alternative considered in Section 7.3.1, there would, however, be less cumulative impacts to beach associated fauna over the 30 year planning period due to the increase in the renourishment interval from 6 to 7 years. There would be the additional impact on the loss of open beach habit from the presence of the groins themselves. The six groin alternative would result in the loss a total of 252 feet of open beach habitat, from the dune line or erosion control structure to slightly seaward of the water line.

7.3.4 The Twelve Groin Alternative

The twelve groin alternative would have approximately the same impacts from the initial beach fill as the preferred alternative considered in Section 7.3.1. There would be less cumulative impacts to beach associated fauna over the 30 year planning period, for the twelve groin alternative due to the increase in the renourishment interval from 6 to 8 years, when compared to the preferred alternative. Additionally, an additional impact of the loss of open beach habit from the presence of the groins themselves will be realized. The twelve groin alternative would result in the loss of what, cumulatively, may be considered a strip of open beach habitat totaling 504-feet wide, from the dune line or erosion control structure to slightly seaward of the water line.

8.0 EFFECTS ON NEARSHORE HARDBOTTOM COMMUNITIES

This section summarizes the anticipated effects of the preferred alternative project and the project alternatives on nearshore reefs and their associated biotic communities.

Nature of potential effects

Direct effects on nearshore reef habitats are due to physical burial by the dredged material and to a lesser extent by the potential physical damage to reefs from dredge pipelines and other equipment operating in the nearshore environment. Potential indirect effects are related to the impacts of turbidity resulting from construction of the project and from the subsequent weathering of the material by rain and waves.

Direct effects

The preferred alternative design (459,700 cubic yards) would result in the direct burial of a total of 5.3 acres of nearshore hardbottom habitat. Direct hardbottom impacts of the project alternatives are summarized in the following table.

DIRECT HARDBOTTOM HABITAT IMPACT

ALTERNATIVE	TYPE 2	TYPE 3	TYPE 4	TYPE 5	TOTAL
NO ACTION	none	none	none	none	none
PREFERRED	5.3 acres	none	none	none	5.3 acres
SIX GROIN	5.3 acres	none	none	none	5.3 acres
TWELVE GROIN	5.3 acres	none	none	none	5.3 acres
REDUCED FILL	3.2 acres	none	none	none	3.2 acres

In assessing the impacts associated with these projects, the ephemeral and resilient nature of this habitat should be considered. To a large extent, the reefs impacted by the proposed projects were formed on substrate exposed by the recession of the beach over the last few decades, and reef habitat very near shore typically covers and uncovers with sand seasonally or in response to storm events. The major species in this immediate nearshore environment is the reef building tube worm *Phragmatopoma caudata. Phragmatopoma* is capable of rapid colonization and recovery. Gore et al. (1978) reported that 6 months after settlement, new colonies of *Phragmatopoma* were indistinguishable from long established colonies. However, *Phragmatopoma* reefs also support a diverse community of invertebrates (Nelson 1989) (Gore et al. 1978), which may not be able to recover as rapidly as *Phragmatopoma* itself. Although eventual recovery is likely, we assume for impact assessment that the directly impacted habitat and all associated fauna are permanently lost. Using the estimate of total nearshore hardbottom in the County given in Section 4.4.1, we estimate that the preferred alternative project will cause a direct loss of less than 0.2% of Indian River County nearshore hardbottom habitat. The hardbottom habitats that will be directly impacted will obviously be those closest to shore. As noted in Section 4.4.2, these areas, although diverse, are significantly less so than the high relief offshore reefs.

Indirect effects

The major potential indirect effect of the proposed projects on nearshore hardbottom habitat is increased turbidity and siltation, which may impact habitats at some distance from the project site itself. The most important variable controlling the duration and severity of turbidity impacts is the fine material content of the fill material. Analysis of the material from the candidate sand source borrow areas yields an estimated fine fraction of only 0.97 percent. This high quality fill material will limit the potential for adverse turbidity effects from the proposed projects. Release of turbid water associated with project construction will be minimized by the use of a fill containment dike and dewatering system.

Abundant references exist on impacts of turbidity to corals and impacts to corals from dredging and beach renourishment (Dodge and Vaisnys 1977, Marszalek 1981) but there is very little specific information on the turbidity tolerances of members of the coquinoid rock–sabellariid reef community. Main and Nelson (1988) report that *Phragmatopoma* is tolerant of extremely high silt loads over the short term (6 grams per liter for 4 days, over 100 times typical background levels). Although specific information for other species is unavailable, most reef fauna inhabiting a high-energy beach environment would be expected to have high tolerances for turbidity. The algal component of the nearshore reef community may be more sensitive. Algal species are a major component of the reefs, and may be particularly affected by reduced light penetration associated with increased turbidity. Nelson (1989) noted a great reduction in algal species richness (56 summer vs. 16 winter) on wormrock reefs at Sebastian Inlet, possibly due to increased turbidity typical of winter months. The most intense turbidity effects associated with these projects will take place in the winter due to construction timing, when algal diversity is low and background turbidities are high.

Another possible indirect effect of the proposed projects relates to changes in the position of the shoreline. The projects will cause a temporary seaward shift of the shoreline. This shift may change the physical conditions (wave exposure etc.) that hardbottom habitats very near shore, but outside the area of direct impact, are exposed to. This may change the ecological development of those areas, for example, favoring worm rock over algal communities. It should be noted that this potential effect is purely conjectural and is undocumented.

Unlike tropical coral reef communities that are predicated on long-term stability in environmental conditions and community structure, nearshore reefs are adapted to a continual cycle of distrbance and recovery. The nearshore reef structure closest to the beach repeatedly covers and uncovers with sand. The algal and fouling communities change radically seasonally and in response to scour associated with storm events. This community is adapted to periodic catastrophic disturbance as a consequence of the exposed high-energy beach environment. Nearshore reef communities are adapted to the precise sorts of impacts associated with beach restoration projects (turbidity and siltation). This increased tolerance minimizes the ecological effects from project impacts. Overall, it is expected that the projects will have some limited adverse indirect effects on nearshore hardbottom habitat adjacent to the project area.

Cumulative impacts

The erosional history of the project area must be evaluated as part of the cumulative impact assessment. To a large extent, the reef structure nearest the shoreline that is subject to direct burial was exposed in the last few decades by the recession of the beaches. Since beach recession is at least in part an artifact of modern inlet management practices, the amount of habitat existing today is greater than what would be expected under natural conditions. This does not reduce the level of direct impact, since these extreme nearshore reefs, whatever their origin, support significant biological communities. However, the assessment of cumulative impacts requires a longer-term perspective and focuses on larger scale ecosystem effects. At this level of analysis, the erosional origin and history of the extreme nearshore reefs must be taken into account. Since the total amount of nearshore reef habitat has been, in essence, artificially enhanced, the cumulative impacts of beach restoration are considerably less than would be estimated from a consideration of the acreage of habitat impacted alone.

8.1 Anticipated Effects of Project Alternatives

8.1.1 The No-Action Alternative

The no-impact alternative eliminates all direct and indirect impacts to the nearshore hardbottom habitat. Continued recession of the beach in the absence of restoration is expected to result in the exposure of additional bedrock, which may develop into a reef community. It is possible that the extensive seawall construction that will be the inevitable result of not restoring the beaches may affect the nearshore wave dynamics and sand transport to a degree that nearshore reef environments could be affected.

8.1.2 The Reduced Fill Alternative

A primary objective in the consideration of fill alternatives was the reduction of direct impacts to nearshore hardbottom habitats. The reduced fill alternative, while resulting in a narrower beach and substantially decreasing the renourishment interval, does result in a large decrease of direct hardbottom habitat impacts.

Decreases in fill volumes are expected to decrease indirect effects on nearshore hardbottom habitat caused by turbidity and siltation to some extent, since the total amount of sediment placed on the beaches will be less.

Potential adverse impacts to nearshore hardbottom habitats, as a result of the reduced fill alternative, are expected to be present, but small, relative to the positive factor of directly burying less acreage. As a result of the decreased renourishment interval, construction impacts will occur more often, increasing the cumulative impacts, particularly the cumulative indirect impacts of repeated siltation and turbidity events that may interrupt community recovery in areas adjacent to the direct impact areas. The total cumulative indirect effects of the reduced fill alternative on nearshore hardbottom may actually be greater than for the preferred alternative, since the reduced fill alternative would result in the placement of slightly more sand on the Sector 7 shoreline over the 30 year planning period, as discussed in Sections 3.5.1 and 3.5.3. In addition, as projects are renourished more often, there is increased opportunity for damage to the reef from dredge pipelines and grounding of construction vessels.

8.1.3 The Six Groin Alternative

Direct and indirect impacts to hardbottom communities at initial construction from the six groin alternative are expected to be the same as those for the preferred alternative discussed in Section 8.1.1. As a result of the increase in the renourishment interval from 6 to 7 years, construction impacts will occur less often, decreasing the cumulative impacts, particularly the cumulative indirect impacts of repeated siltation and turbidity events that may interrupt community recovery in areas adjacent to the direct impact areas. In addition, as projects are renourished less often, there is decreased opportunity for damage to the reef from dredge pipelines and grounding of construction vessels.

8.1.4 The Twelve Groin Alternative

Direct and indirect impacts to hardbottom communities at initial construction from the twelve groin alternative are expected to be the same as those for the preferred alternative discussed in Section 8.1.1. As a result of the increase in the renourishment interval from 6 to 8 years, construction impacts will occur less often, decreasing the cumulative impacts, particularly the cumulative indirect impacts of repeated siltation and turbidity events that may interrupt community recovery in areas adjacent to the direct impact areas. In addition, as projects are renourished less often, there is decreased opportunity for damage to the reef from dredge pipelines and grounding of construction vessels.

9.0 EFFECTS ON OFFSHORE BORROW AREA COMMUNITIES

This section addresses the direct and indirect effects of the removal of sand from the offshore sand sources on offshore biological resources.

9.1 Anticipated Effects of the Preferred Alternative

The removal of large quantities of sand from offshore borrow areas results in a disturbance of the sand bottom animal communities as a fraction of the existing habitat is removed and the bottom topography is changed. However, most studies on the infauna of sand borrow areas have shown little lasting impact in terms of species diversity and total abundance or density. Johnson and Nelson (1985) found that abundance and species richness returned to near normal between 9 and 12 months after dredging off Fort Pierce Inlet in the same general location as the proposed project. Similar results were reported by Saloman et al. (1982) off Panama City Beach, Florida and by Tuberville and Marsh (1982) in Broward County. Wilber and Stern (1992) have criticized the limited focus of these studies on species richness or diversity and total numbers of individuals. They reviewed several studies and concluded that impacts on community structure, particularly impacts on larger deeper burrowing species, were not properly documented and that these impacts may last 2-3 years or longer.

More recently, Schaffner et al. (1996) have applied a more comprehensive assessment technique, the Benthic Index of Biotic Integrity (B-IBI) to a borrow area in Chesapeake Bay. The B-IBI takes into account abundance, biomass, species diversity, and Guild parameters such as the percentage of deposit feeders and compares them in a weighted scale between impacted and reference communities. It was concluded that the sand mining activities in the Chesapeake Bay study did not have negative or adverse impacts on benthic biotic integrity.

Properly sited projects will not have any direct impacts on reef environments, but there can be indirect effects from turbidity and siltation that may extend away from the borrow site. Extensive side scan sonar surveys in the proposed borrow sites have not revealed any discernable reef structure within or immediately adjacent to the sites. No direct impacts on reef habitat in the offshore borrow area are expected, and indirect effects will be minimal due to the remote location of significant reef structure.

Significant effects on fishes are not considered likely, due to the mobile nature and low site fidelity typical of fishes native to open sand habitats. Courtney et al. (1974) and Applied Biology (1979) found no negative impacts to fishes in offshore dredge areas off Broward and Duval Counties, respectively.

Dredging in harbors and channels has been documented to cause mortalities to sea turtles, with an estimated annual mortality of 50-500 turtles annually (Magnuson et al. 1990). While turtles often concentrate in harbors and entrance channels, the open unvegetated, non-reef habitat of offshore sand borrow areas has little attraction for sea turtles. Nelson and Dickerson (1988) conclude that sea turtle mortalities associated with sand source dredging either do not occur or are very rare. A few mortalities have been documented in Florida despite requirements for 24 hour a day hopper dredge observers that have been included in NMFS Biological Opinions for beach restoration projects.

Collisions between large vessels and right whales are a major concern. In this vein, there is some potential for the proposed project to affect the northern right whale, due to offshore operation of hopper dredges.

In areas near Jacksonville, Florida where northern right whale abundance is seasonally high, hopper dredge vessels are required to limit their speed to five knots. It is believed that vessels moving at five knots or slower pose little threat to right whales (Scott Kraus, New England Aquarium pers. comm.)

No impacts to the West Indian manatee are expected in the offshore or nearshore project areas due to the lack of manatees in these habitats in the winter months, when construction is scheduled.

Overall, no significant, long-lasting effects on benthic fauna in the borrow areas are expected from the preferred alternative. No impact to fishes, marine turtles, or marine mammals as a result of operations in the offshore borrow areas are expected.

9.2 Anticipated Effects of Project Alternatives

9.2.1 The No-Action Alternative

This alternative eliminates all direct and indirect impacts on offshore borrow area communities.

9.2.2 The Reduced Fill Alternative

Decreasing the amount of sediment dredged from the borrow areas by approximately 20% from reduced fill alternative is expected to proportionately decrease the amount of direct and indirect impact from initial construction to borrow area communities. The total cumulative effects of the reduced fill alternative on borrow area communities may actually be greater than those of the preferred alternative, since the reduced fill alternative would result in the excavation of slightly more sand from the borrow area over the 30 year planning period, as discussed in Sections 3.5.1 and 3.5.3. The reduced fill alternative would also increase the frequency of disturbance to benthic communities in the borrow areas due to the shorter renourishment interval. However, no significant effects on benthic fauna in the borrow areas are expected from the reduced fill alternative. Under the reduced fill alternative, there would be an increased opportunity for sea turtles and marine mammals to encounter dredge equipment due to more frequent renourishment intervals, but no impact to fishes, marine turtles, or marine mammals as a result of operations in the offshore borrow areas are expected.

9.2.3 The Six Groin Alternative

The anticipated impacts of the six groin alternative on borrow area communities at initial construction are expected to be the same as those of the preferred alternative, since both alternatives call for the excavation of the same volumes of sand from the borrow areas. The increase in the expected renourishment interval for the six groin alternative, from 6 to 7 years, will result in less frequent disturbances to borrow area benthic communities and less total volume excavated over the 30 year planning period, reducing the cumulative impacts.

9.2.4 The Twelve Groin Alternative

The increase in the expected renourishment interval for the twelve groin alternative, from 6 to 8 years, will result in less frequent disturbances to borrow area benthic communities and less total volume excavated over the 30 year planning period, reducing the cumulative impacts.

10.0 EFFECTS ON FISH AND FISHERIES

This section summarizes the anticipated effects of the proposed project on fish and fishery resources. Potential direct and indirect effects on reef fish population levels and reef fish recruitment potential are considered, and a discussion of ecosystem level effects on fish habitat is included. This section also contains a consideration of potential project effects on recreational and commercial fisheries in the local area.

10.1 Anticipated Effects of the Preferred Alternative on Reef Fishes

Direct effects

The elimination of reef habitat clearly has an impact on reef-associated fishes. An example is found in Lindeman and Snyder (1999), who conducted pre- and post- impact censuses of fishes in similar nearshore hardbottom habitat where 12-14 acres of reef were buried by a beach renourishment project near Jupiter Inlet. After the renourishment, they found very little hardbottom remaining and very few fish remaining. Before renourishment fish abundance averaged 38 individuals per transect and after renourishment the mean abundance was less than 1 individual per transect. It was assumed that mortality was high on displaced fishes as there was little other suitable habitat within 0.8km and 80% of fishes censused were juveniles, expected to suffer high losses to predation.

We expect survival of displaced fishes to be much higher in the proposed project, since abundant habitat will remain in the immediate vicinity of the impact area, both along adjacent non-nourished beaches and offshore of the fill placement area. Since there is no reliable estimate of percent survival, it will be assumed for impact assessment that mortality is total. With this assumption, a loss of 5.3 acres nearshore hardbottom habitat will result in the loss of the fish biomass that 5.3 acres of such habitat can support. In order to quantify the impact, an estimate of fish biomass density is required, but biomass estimates are not available for project area reefs. On hard bottom habitats in South Carolina, Sedberry and Van Dolah (1984) estimated fish biomass density at 168 kilograms per hectare. This estimate can be applied to reefs in the proposed project area. The preferred alternative project directly impacts 2.14 hectares, giving a potential loss of 360 kg of fish biomass, with the highly conservative assumption of zero survival of displaced fishes. Given the magnitude of commercial and recreational fish landings, this level of impact is unlikely to be significant.

Indirect effects

Indirect effects on fish populations are difficult to predict or quantify. Increased turbidity on the reefs surrounding the project area may decrease the foraging efficiency of visual oriented predators. Fish displaced by direct impacts may increase competition for space or food resources on nearby reefs where they attempt to relocate. Physical stress from elevated turbidity is a possibility for less mobile fishes that will not move to escape turbidity. Many prey items for fishes, particularly small and juvenile fishes, are the small inconspicuous crustaceans often associated with macroalgae (Nelson 1989). Accordingly, a loss of algae biomass due to turbidity increases may affect foraging of even non-herbivorous species of fishes. The high quality fill material proposed for these projects and the use of fill containment dikes and dewatering systems in the construction process will minimize potential adverse indirect effects on fish populations.

10.2 Effects of the Preferred Alternative on Reef Fish Recruitment Potential

Direct effects

The permanent loss of habitat due to the proposed projects implies a permanent loss of the fish, invertebrates, and plants supported by that habitat. Thus the project impacts not only the existing fauna, but also the entire fauna the habitat could be expected to support in the future (or in practice until the beach erodes and the habitat is uncovered again and reestablishes itself). In order to quantify the magnitude of this impact, information on the density of reef fish recruitment and the number of potential recruits to impacted habitat that could be expected to settle successfully elsewhere is required. The percentage of recruits to impacted habitat that will successfully settle elsewhere is likely considerable, given the mechanics of recruitment from the plankton. This assessment is based on the extremely conservative assumption that all potential recruits to impacted habitats are lost.

Shulman and Ogden (1987) provide recruitment rates in individuals per square meter for 48 species of coral reef fish in the Caribbean and Australia. Fourteen families were included in the study, 13 of which are also found on the project area reefs. The mean recruitment rate for the 48 species in Shulman and Ogden is 17.5 individuals/m^2/yr. Applying this mean to the direct reef impact area of the preferred alternative project, (5.3 acres = 21,400 m^2) gives a potential loss of 374,500 fish recruits per year, applying the unrealistic assumption that none of the recruits are able to settle elsewhere. Using a survival rate to first reproduction of 0.01% given for the grunt *Haemulon flavolineatum* by Shulman and Ogden (1987), the proposed projects would, in total, result in a yearly equivalent loss to the fishery of 37.4 adult fish.

The potential loss of larval fish recruits may be considered in the context of power plant entrainment effects. Although the numbers are not directly comparable because planktonic larvae rather than settling larvae are considered, fish larvae mortality due to the operation of the nearby St. Lucie Nuclear Power Plant was estimated at 650 million per year (Applied Biology Inc. 1977).

There are a few caveats to consider in this analysis. The recruitment rate estimates used were taken from coral reef ecosystems and may not be the same as local recruitment rates. There is also considerable debate on whether adult fish population levels are controlled by the amount of available habitat (including settling habitat) or by fluctuations in the availability of larval recruits. In the latter view, termed the “recruitment limitation hypothesis” or “supply-side ecology” (Victor 1983, Doherty 1991), the amount of habitat available for settling recruits is less important than the variations in the size of recruitment classes in determining adult fish populations.

Ruple (1984) provided some data on the occurrence of 69 larval fish taxa in surf zone areas in the Gulf of Mexico that Courtney et al. (1996) felt was applicable to Atlantic coast habitats as well. Ruple found clear differences between the inner surf zone (less than 1 meter deep) and the outer surf zone (between 4 to7 meters deep). More larval fishes occurred in the outer surf zone, with a peak in May and June. The inner surf zone had a lower abundance and a peak in December. Two species commonly found in the surf zone as juveniles and adults (Florida pompano and whiting) were absent or uncommon as larvae. The winter construction window for the proposed projects is expected to minimize potential effects on recruitment of both reef and non-reef fishes in nearshore habitats.

Indirect effects

A potential indirect effect of the proposed project on reef fish recruitment is related to the possible impact of turbidity on algae abundance. If turbidity from the project reduces algae cover on reefs outside the area of direct impact, fish recruitment may be reduced in those areas. In an algae dominated reef system in New Zealand, it was demonstrated that algal abundance was crucial in the recruitment of juvenile fish, providing both shelter and epifaunal food resources. When all algae were experimentally completely removed, recruitment was decreased by 87% (Jones, 1984). The extent of this potential effect is unknown, but the duration is expected to be short (less than one year following construction).

10.3 Anticipated Effects of the Preferred Alternative on Non-Reef Fishes

Hackney et al. (1996) reviewed biological data on the common species of surf zone sand dwelling fish in the South Atlantic Bight and the potential impacts from beach restoration projects. They were not able to document significant impacts to surf zone fishes as a result of beach restoration projects, which they attribute mostly to a lack of studies that addressed the issue. Their general conclusion was that the diversity and abundance of surf zone fishes reaches a minimum in winter and diversity reaches a maximum in late summer. They found the peak in abundance most often occurs in the fall when large schools are migrating along beaches. The major recruitment period for juveniles to surf zone habitats was in late spring to early summer.

The Sebastian Inlet Tax District has commissioned long-term studies on surf zone fishes near Sebastian Inlet. Those studies, using monthly beach seines, also found a very pronounced peak in fish population in mid to late summer and a minimum in winter (Irlandi 1999).

The general lack of strong site fidelity of non-reef fishes lessens the potential for direct impacts, since these fish can more successfully relocate to avoid unfavorable conditions. The well-documented short-term negative impacts of beach restoration projects on important prey items for surf zone fishes (for example mole crabs and surf clams) may be transmitted to the fish community through the food chain. Hackney et al. (1996) recommend that beach construction take place in the winter (November through March) to minimize effects on surf zone fish communities and their invertebrate prey. They also recommend beach fill with a small percentage of fine-grained material to minimize turbidity related effects. The proposed project incorporates both these features. No significant or long lasting effects of the proposed project are anticipated for non-reef fishes.

10.4 Anticipated Ecosystem Level Effects of the Preferred Alternative on Fish Habitat

The nearshore reef within the project area may have important overall ecosystem roles. A nearly continuous stretch of reef habitat just off the coastline may be an important “corridor” for the movement and dispersal of reef fishes up and down the coast. Such a corridor may also provide important resources for non-reef species, such as bluefish, *Pomatomus saltatrix* and Spanish mackerel *Scomberomorus maculates*, which regularly migrate up and down the coast in the immediate offshore zone. Lindeman and Snyder (1999) postulate that the nearshore hardbottom plays an important role due to its cross shelf positioning, lying between estuarine developmental habitats and adult marine habitats. The effects of the proposed project on these large scale ecological roles is expected to be minimal and not significant, due to the small amount of total available hardbottom habitat that will be impacted.

10.5 Anticipated Effects of Project Alternatives

10.5.1 The No-Action Alternative

This alternative would eliminate all direct and indirect effects on fish and fisheries. Some negative effect on recreational fisheries will accrue from the no-action alternative, as eroded beaches become less attractive for surf fishermen and divers.

10.5.2 The Reduced Fill Alternative

The reduction in the amount of affected nearshore reef habitat associated with the reduced fill alternative decreases the magnitude of the estimated direct effects on fish populations. The same calculations used previously may be applied to the acreage resulting from the reduced fill alternative (3.2 acres of direct impact). The estimate for anticipated loss of fish biomass becomes 217kg. The estimated potential loss of fish recruits per year is also decreased proportionately to the decrease in acreage of habitat directly impacted. The reduced fill alternative results in an annual recruitment loss of 225,750 larval fish.

Although more difficult to quantify, indirect effects of initial construction of the proposed project on fish and fisheries are expected to be decreased by the reduced fill alternative roughly proportionally to the decrease in fill volumes. The total cumulative indirect effects of the reduced fill alternative may actually be greater than for the preferred alternative, since the reduced fill alternative would result in the placement of slightly more sand on the Sector 7 beaches over the 30 year planning period, as discussed in Sections 3.5.1 and 3.5.3.

10.5.3 The Six Groin Alternative

The magnitude of the direct and indirect impacts resulting from initial construction under the six groin alternative is expected to be the same as experienced with the preferred alternative discussed in Sections 10.2, 10.3, and 10.4. The increase in the renourishment interval provided by the six groin alternative would decrease the frequency of impacts, and reduce the total volume of sand placement over the 30 year planning period.

Groins that extend somewhat into the nearshore zone may themselves provide significant habitat for reef-associated fishes. Hay and Sutherland (1988) reviewed the ecology of rocky structures, including groins, jetties, and breakwaters, in the southeast U.S. They concluded that these rocky structures support diverse fish communities typical of the area in general, and noted that these structures often support exceptionally high densities of juveniles. The design for the groin elements specifies that they will be entirely above water at first construction, but as the beachfill equilibrates and the project erodes over time, the groins will extend farther into the nearshore waters, providing some variable amount of habitat that is difficult to quantify.

10.5.4 The Twelve Groin Alternative

The magnitude of the direct and indirect impacts resulting from initial construction under the twelve groin alternative are expected to be the same as those for the preferred alternative discussed in Sections 10.2, 10.3, and 10.4. The increase in the renourishment interval provided by the twelve groin alternative would decrease the frequency of impacts, and reduce the total volume of sand placement over the 30 year planning period.

Groins that extend somewhat into the nearshore zone may in themselves provide significant habitat for reef-associated fishes. Hay and Sutherland (1988) reviewed the ecology of rocky structures, including groins, jetties, and breakwaters, in the southeast U.S. They concluded that these rocky structures support diverse fish communities typical of the area in general, and noted that these structures often support exceptionally high densities of juveniles. The design for the groin elements specifies that they will be entirely above water at first construction, but as the beachfill equilibrates and the project erodes over time, the groins will extend farther into the nearshore waters, providing some variable amount of habitat that is difficult to quantify.

10.6 Anticipated Effects on Fisheries

Nearshore habitats in the proposed project areas contain members of three Fishery Management Plans (FMPs) administered by the South Atlantic Fishery Management Council (SAFMC 1998).

The South Atlantic Snapper-Grouper complex is a group of 73 species of primarily reef fishes. Twenty-four of those species are listed in Table 1 as being frequent, common, or abundant in local nearshore hardbottom habitats. Species in common are listed here

Serranidae – Groupers and Sea Basses
Centropristis striata
Epinephelus itajara
Epinephelus morio
Mycteroperca microlepis

Ephippidae – Spadefishes
Chaetodipterus faber

Lutjanidae – Snappers
Lutjanus analis
Lutjanus apodus
Lutjanus griseus
Lutjanus jocu
Lutjanus mahogoni
Lutjanus synagris
Ocyurus chrysurus

Pomadasyidae – Grunts
Anisotremus surinamensis
Anisotremus virginicus
Haemulon aurolineatum
Haemulon chrysargyreum
Haemulon parrai
Haemulon plumeri

Carangidae – Jacks and Pompanos
Caranx bartholomaei
Caranx crysos
Caranx hippos
Caranx rubber

Sparidae – Porgies
Archosargus probatocephalus
Calamus bajonado

The sole member of the Spiny Lobster FMP is the spiny lobster, *Panulirus argus*. This species is found in nearshore hardbottom habitats in the proposed project areas.

As has been discussed at length, considerable live rock (living marine organisms attached to a hard substrate) is found in the proposed project areas, which falls under the Coral, Coral Reefs, and Live/Hard Bottom Habitat FMP. There are also some scleractinian corals present in low abundance in the proposed project areas that would fall under this Management Plan.

Neritic habitats in the vicinity of the proposed offshore borrow areas may be expected to contain all six species comprising the Coastal Migratory Pelagics FMP, except possibly the dolphin, *Coryphaena hippurus*, which occurs at very low abundance in such shallow water.

The proposed project areas are included in Habitat Areas of Particular Concern (HAPCs) for two Fishery Management Plans administered by SAFMC. HAPCs for the snapper-grouper complex FMP include nearshore hard bottom areas (with no other geographic references). HAPCs for the coral, coral reefs, and live/hard bottom FMP includes *Phragmatopoma* reefs off the east central Florida coast, and nearshore hard bottom (0-12 feet depth) from Cape Canaveral to Broward County. The proposed project area does not contain any HAPC for the spiny lobster FMP.

10.6.1 Local Commercial Fisheries

The only commercial fishery in the nearshore zone is a minor hook and line fishery for pompano (*Trachinotus carolinus)*, supporting mostly part time fishermen. Short-term effects from local increases in turbidity will affect this fishery, but no long-term effect is expected, as the pompano is not a reef-associated species. No significant impact to commercial fisheries is expected to result from the proposed project.

10.6.2 Local Recreational Fisheries

Significant shoreline recreational fisheries exist for pompano and whiting (*Menticirrhus spp*.) in the general project areas. Impacts to this fishery are expected to be limited to short-term turbidity effects, since neither is a reef-associated species. The abundance of the sand flea *Emerita talpoida*, a favored live bait for this fishery, may be negatively impacted by the proposed project over the short to mid term. There is a significant recreational fishery for spiny lobster on the nearshore reefs. Indian River County is one of the few areas where beach diving for lobster is productive which becomes particularly important to divers without access to boats. Increases in turbidity over the short term in and around the project areas may limit diving opportunities immediately adjacent to discreet fill areas. Long-term effects are expected to be minimal, due to the small proportion of available habitat affected by the proposed project.

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TABLE 1. LIST OF FISHES FROM NEARSHORE HARDBOTTOM HABITATS
(Modified from Gilmore et al. 1981)
Abundance classes – F= Frequent, C= Common, A= Abundant
Fishery status – C= Commercial fishery value, S= Sport fishery value

SPECIES	ABUNDANCE CLASS	FISHERY STATUS
Muraenidae – Moray Eels		
Gymnothorax funebris	F	
Gymnothorax moringa	C	
Clupeidae – Herrings		
Harengula jaguana	A	C
Opisthonema oglinum	A	C
Sardinella aurita	A	C
Engraulidae – Anchovies		
Anchoa cubana	C	
Anchoa hepsetus	A	
Anchoa lyolepis	A	
Gobiesocidae – Clingfishes		
Gobisox strumosus	C	
Hemiramphidae – Halfbeaks		
Hyporhamphus unifasciatus	C	C
Hyporhamphus sp.	C	
Scorpaenidae – Scorpionfishes		
Scorpaena plumieri	C	
Serranidae – Groupers and Sea Basses		
Centropristis striata	C	
Epinephelus itajara	C	S
Epinephelus morio	C	C,S
Mycteroperca microlepis	C	C,S
Serranus subligarius	C	
Grammistidae- Soapfishes		
Rypticus maculatus	C	
Apogonidae – Cardinalfishes		
Apogon maculatus	C	
Apogon pseudomaculatus	C	
Pomatomidae – Bluefishes		
Pomatomus saltatrix	C	C,S
Carangidae – Jacks and Pompanos		
Caranx bartholomaei	C	S
Caranx crysos	C	S
Caranx hippos	C	S
Caranx latus	C	

Caranx ruber	C	S
Chloroscombrus chrysurus	C	
Carangidae – Jacks and Pompanos (continued)		
Oligoplites saurus	C	S
Selene setapinnis	F	C
Selene vomer	C	S
Lutjanidae – Snappers		
Lutjanus analis	C	C,S
Lutjanus apodus	C	C,S
Lutjanus griseus	C	C,S
Lutjanus jocu	C	C,S
Lutjanus mahogoni	F	C,S
Lutjanus synagris	C	C,S
Ocyurus chrysurus	F	C,S
Gerridae – Mojarras		
Eucinostomus argenteus	C	
Eucinostomus gula	C	
Gerres cinereus	C	C,S
Pomadasyidae – Grunts		
Anisotremus surinamensis	A	C,S
Anisotremus virginicus	A	S
Haemulon aurolineatum	C	C,S
Haemulon chrysargyreum	C	S
Haemulon parrai	C	C,S
Haemulon plumeri	C	C,S
Sparidae – Porgies		
Archosargus probatocephalus	C	C,S
Calamus bajonado	C	S
Diplodus holbrooki	A	S
Sciaenidae – Drums		
Odontoscion dentex	C	S
Pareques acuminatus	C	
Equetus umbrosus	C	
Ephippidae – Spadefishes		
Chaetodipterus faber	F	C,S
Pomacanthidae – Angelfishes		
Holacanthus bermudensis	C	S
Pomacanthus arcuatus	C	S
Pomacentridae – Damselfishes		
Abudefduf saxatilis	C	
Abudefduf taurus	F	
Eupomacentrus dorsopunicans	F	
Eupomacentrus variabilis	C	
Labridae – Wrasses		
Halichoeres bivittatus	C	
Halichoeres maculipinna	C	

Halichoeres poeyi	F	
Halichoeres radiatus	F	
Labridae – Wrasses (continued)		
Thalassoma bifasciatum	C	
Scaridae – Parrotfishes		
Scarus coelestinus	F	
Scarus guacamaia	F	
Sparisoma chrysopterium	F	
Sparisoma rubripinne	C	
Sphyraenidae – Barracudas		
Sphyraena barracuda	C	S
Sphyraena guachancho	F	
Dactyloscopidae – Sand Stargazers		
Dactyloscopus crossotus	F	
Clinidae – Clinids		
Labrisomus nuchipinnus	A	
Starksia ocellata	C	
Blenniidae – Combtooth Blennies		
Scartella cristata	A	
Acanthuridae – Surgeonfishes		
Acanthurus bahianus	C	S
Acanthurus chirurgus	C	S
Monacanthidae – Filefishes		
Stephanolepis hispidus	F	

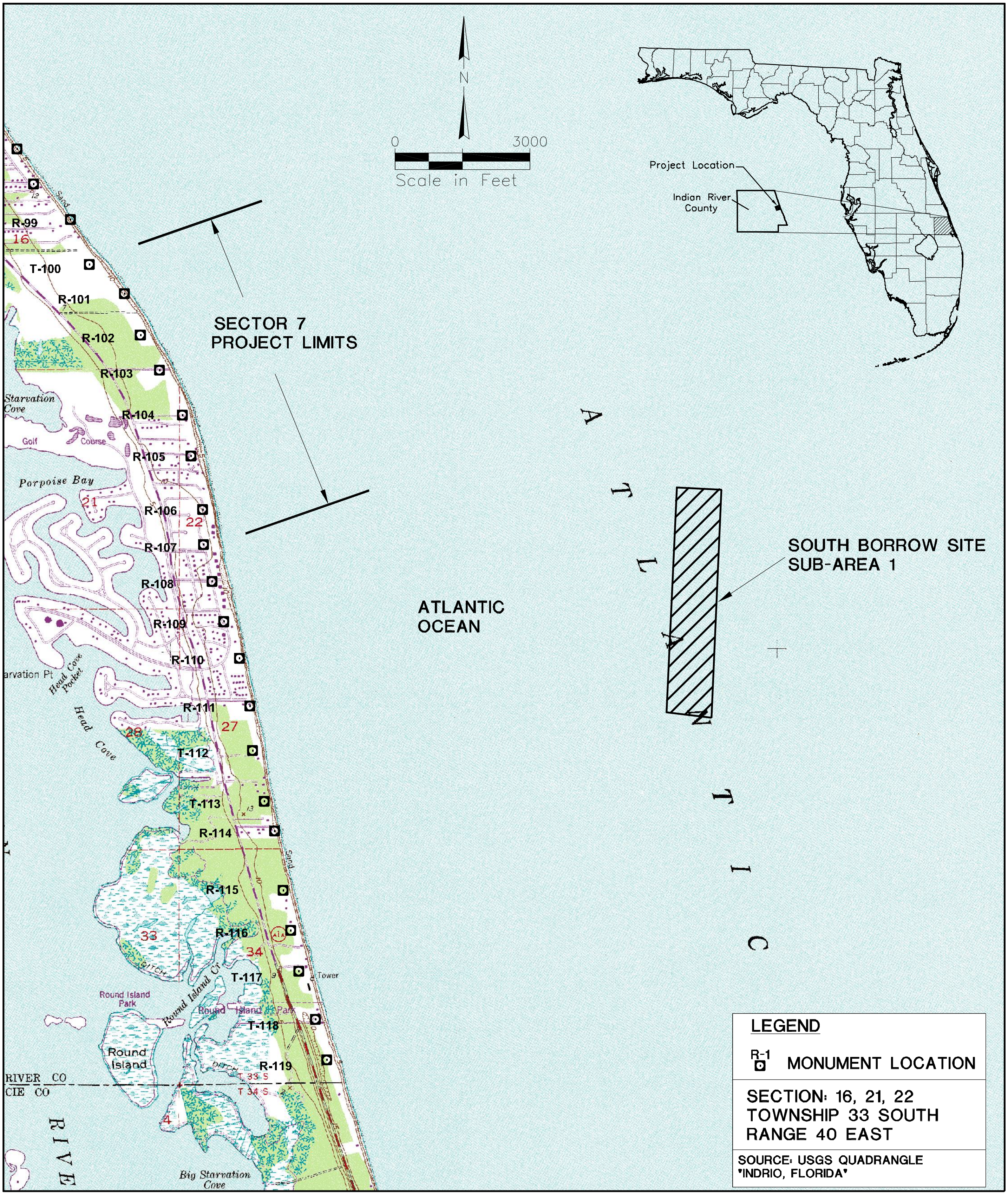

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Figure 1
Indian River County – Sector 7
Location Map

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