APPENDIX R

CUMULATIVE EFFECTS ASSESSMENT

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Acronyms

ATM	Applied Technology and Management, Inc.
CBRS	Coastal Barrier Resource System
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
Coastal Tech	Coastal Technology Corporation, Inc.
CPE	Coastal Planning and Engineering, Inc.
CSA	CSA International, Inc.
DEIS	Draft Environmental Impact Statement
EAI	Ecological Associates, Inc.
EFH	Essential Fish Habitat
ESA	Endangered Species Act
F.A.C.	Florida Administrative Code
F.S.	Florida Statutes
FDEP	Florida Department of Environmental Protection
FMRI	Florida Marine Resources Institute
FPL	Florida Power and Light, Inc.
FWC	Florida Fish and Wildlife Conservation Commission
FWRI	Fish and Wildlife Research Institute
HAPC	Habitat Area of Particular Concern
HB	relatively persistent hardbottom (a hardbottom habitat type)
IPCC	Intergovernmental Panel on Climate Change
MMS	United States Department of the Interior Minerals Management Service
MSL	Mean Sea Level
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
NRC	National Research Council
NTU	nephelometric turbidity units
PEHB	partially exposed hardbottom (a hardbottom habitat type)
SAFMC	South Atlantic Fisheries Management Council
SARBO	Southeast Atlantic Regional Biological Opinion
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service

CUMULATIVE EFFECTS ASSESSMENT
ST. LUCIE COUNTY SOUTH BEACH AND DUNE RESTORATION PROJECT
ST. LUCIE COUNTY, FLORIDA

INTRODUCTION

Council on Environmental Quality's (CEQ) regulations (40 CFR §§ 1500 – 1508) implement the procedural provisions of the National Environmental Policy Act (NEPA) of 1969, as amended (42 U.S.C. §§ 4321 et seq.). Those regulations define *cumulative effects* as:

> *The impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions (40 CFR § 1508.7).*

CEQ (1997) further characterizes cumulative impacts and describes the cumulative impact analysis process. Cumulative impacts

> *…result from spatial (geographic) and temporal (time) crowding of environmental perturbations. The effects of human activities will accumulate when a second perturbation occurs at a site before the ecosystem can fully rebound from the effect of the first perturbation…Cumulative effects analysis, an iterative process, repeatedly assesses consequences following incorporation of avoidance, minimization, and mitigation measures into the alternatives to achieve a particular goal.. Monitoring is the last step in determining the cumulative effects that ultimately results from the action. The significance of cumulative effects depends upon the ecosystem, resource baseline conditions, and relevant resource stress thresholds).*

This cumulative effects analysis uses the methods, rationale, and basic presentation arrangement structure recommended in CEQ (1997).

1. SIGNIFICANT CUMULATIVE EFFECTS ISSUES AND ASSESSMENT GOALS

CUMULATIVE EFFECTS ASSESSMENT GOALS

The broad goals of this assessment are to identify, avoid, minimize, and mitigate adverse environmental impacts associated with the project objectives of providing storm protection along the south St. Lucie County shoreline. This assessment focuses on potential cumulative effects to the sandy beach and nearshore hardbottom resources along the beaches of south St. Lucie County, and offshore sand shoal habitats three to six miles offshore of the project shoreline.

CULMULATIVE EFFECTS ASSESSEMENT ISSUES

With the exception of the No-Action alternatives, all project alternatives considered in detail would increase the St. Lucie County shoreline width to mitigate beach erosion and decrease property losses due to storms. Project alternatives to provide protection generally include beach nourishment or beach nourishment with T-head groins. These alternatives would provide continued shoreline protection, recreational opportunities, and wildlife habitat along South St. Lucie County beaches, albeit at different levels dependent upon the specific design considered.

All but one of the alternatives would nourish the shoreline of south St. Lucie County from Florida Department of Environmental Protection (FDEP) R-monument (R)-87.7 – R-90.3 (north segment); each of the alternatives would nourish the shoreline between R-98 – R-115+1,000 feet (south segment - the St. Lucie County / Martin County line), placing beach compatible sand on the beach within those boundaries (Figure 1). The applicant's plan as described in its application for project authorization by the USACE included a preferred alternative that would construct dune and beach berm in both north and south segments, impacting an estimated 2.73 acres of hardbottom habitat requiring mitigation. On January 5, 2012, after substantial completion of the Cumulative Effects Assessment, the applicant provided a letter to the USACE deleting the project segment from R87-7 to R-90.3. This reduced the project hardbottom impacts to 0.57 acres requiring mitigation of 0.78 acres of hardbottom. This change, however, does not substantively alter the assessment below. The USACE has revised this document in to reflect the changed boundaries of the applicant's preferred project and mitigation area requirement.

Other alternatives include different levels of beach fill, increasing or decreasing the amount of protection and impact; one alternative would include T-head groins with beach fill.

Project construction would require 3-4 months outside the peak turtle nesting season (May through October).

Priority habitats and species within or associated with the St. Lucie County South Beach and Dune Restoration Project area potentially subject to cumulative impacts include:

- Beach upland, shoreline, and intertidal area (beach sediments and berm rock)
- Nearshore hardbottom reefs along the shoreline within the direct and/or indirect area of influence of beach nourishment (sand placement) activities
- Benthos, fish, birds, marine turtles, and marine mammals and the related biotic community along shoreline areas subject to periodic sand burial and/or turbidity associated with beach nourishment activities
- Benthos, fish, marine mammals, and related resources within offshore sand borrow areas subject to dredging

The significant cumulative impacts associated with the alternatives considered in detail include:

- Burial and/or alteration of the beach and berm sediment and associated faunal community by placement of beach fill sediment and cover with rock for T-head groin construction
- Direct and indirect sedimentation (burial) and/or turbidity on the nearshore hardbottom resources
- Loss of offshore shoal elevation and/or bathymetric elevation gradients due to borrow area excavation activities. Offshore sand borrow areas, poorly understood in terms of their habitat functions, may incur significant cumulative impacts as a result of dredging, particularly if dredging deflates (eliminates) shoals (Gilmore, 2009).

The relative values of the potentially affected resources have significant influence on the level of concern associated with impacts to those resources and the likelihood of mitigating impacts. The U.S. Fish and Wildlife Service (USFWS, 2010a) defined several habitat value categories. The proposed includes no Resource Category 1 habitats (unique, irreplaceable resources on a national basis or in the ecoregion section). USFWS usually considers nearshore hardbottom habitat as Resource Category 2 (relatively scarce or becoming scarce on a national basis or in the ecoregion section) with mitigation goals of “no net loss of in-kind habitat value” (USFWS, 2010a). The beach shoreline / intertidal area and offshore borrow areas could fall into USFWS Category 3 (high to medium value for evaluation species), for which the USFWS recommends a mitigation goal “no net loss of habitat value while minimizing loss of in-kind habitat value (USFWS, 2010a)”.

Beach Upland and Intertidal Habitats

The finally selected project would fulfill future requirements for beach and dune restoration (in terms of both maintenance and storm protection) using high quality, beach compatible sand from proven sources and potentially include hard structure (T-head groins). The project would increase the beach upland and dune resources available in the project area.

Local, short-term impacts related to turbidity will occur adjacent to the beach fill sites during project construction. Future projects would also create similar short-term impacts, but can avoid and minimize long-term effects by using sand of appropriate quality and best management practices at dredging and placement locations

Maintenance efforts associated with beach nourishment projects could keep the natural resources of the barrier island ecosystems from re-establishing a natural equilibrium with the dynamic coastal forces of the area (USACE 2007). The repeated impacts of these nourishment and dredging actions on macroinvertebrate, fish, shorebird, and sea turtle species that inhabit or use the beach upland and intertidal habitats could accumulate to the level of a cumulative impact. As a beach fill project evolves, locations adjacent to areas with large shoreline extensions receive sediment from lateral spreading of the fill. However, beach fill planform shoreline change rates of other projects that have experienced repeated beach nourishments have indicated that erosion decreases with each successive beach fill. The location of the erosion and the diminishing erosion rate follow standard coastal engineering theory (e.g., Dean, 2002).

Placement of rock for T-head groins would permanently impact the beach by eliminating nesting habitat with the T-head groins footprint above mean high water) and potentially create and impediment to nesting (if turtles contact the rock material either in moving onto the beach to nest or when constructing a nest).

St. Lucie County beaches serve as important nesting habitat for threatened and endangered sea turtle species. The applicant's preferred alternative and others like it have the cumulative potential to adversely affect nesting females, nests, and hatchlings within the proposed project area.

<u>Nearshore Hardbottom Habitat</u>

CSA International, Inc. (2010a) surveyed cross-shelf (shore perpendicular) transects to quantify the physical and biological characteristics of nearshore hardbottom and ground truth aerial imagery shot in the project area. The field survey was based on 22 permanent transects installed at FDEP range monuments R-77.7, R-78.7, R-80.4, R-82.8, R-85, R-86.3, R-88.7, R-90.4, R-92, R-93.5, R-100, R-101, R-102, R-103.2, R-104.5, R-105.9, R-109.2, R-110, R-110.5, and R-112 in St. Lucie County and R-1 and R-3 in Martin County. Each transect extended from the landward edge of exposed nearshore hard bottom to the easternmost extent of exposed hard bottom along the transect, but did not exceed 150 m in total length. The transects covered water depths from 0 to 7 m (0 to 23. ft). Transects were sampled with diver-held video, in-situ quadrats, and point intercept assessments to quantify biota and physical habitat attributes.

Physical structure of the hardbottom included larger shore-parallel features with low to medium relief, isolated low-relief ledges, and large flat boulders (the latter found only along the offshore extent of the existing hardbottom features). Algae dominated the recorded biota, but the community also included sessile invertebrates such as hydrozoans, sponges, and wormrock (*Phragmatopoma lapidosa*). Divers observed very few octocoral colonies and these located outside of the project area along Transect R-78.7. The only stony corals observed were solitary cup corals (*Phyllangia americana americana*). These were recorded in a single quadrat along transect R-110.5.

Based on the spatial distribution of the biota, CSA International (2010a) recognized three hardbottom communities. These community distinctions do not identify bounded discrete "communities" but rather assemblages of differing biotic composition that likely reflect the effects of location and differing levels of physical disturbances.

The landward edge of hardbottom is relatively close to shore (within 10 to 20 meters (33 to 66 ft) of the mean high water line – MHWL). Hardbottom continues seaward as a series of well-exposed, shore-parallel ledges with vertical relief of 0.5 to 1.0 meters (1.6 to 3.3 ft), alternating with partially-exposed, pavement-like platforms

Community One (HB1) and Community Two (HB2) occur primarily from the intertidal to depths of about 2 meters (6.5 ft). In the northern section of the project area, between transects R-87.7 and R-90.3, HB1 occurred on an often discontinuous, low- to medium-relief (up to 1 meter (3.3 ft)) landward hardbottom. HB1 is composed of hydroids, encrusting sponges, macroalgae, and turf algae. The physical characteristics and location of this community type facilitate the establishment and proliferation of wormrock, while also supporting a large percent cover of canopy-forming red algae. HB1 provides shelter and nutrient source to many invertebrate, fish, and turtle species. Additionally, wormrock builds reef and contributes to the habitat complexity and biological diversity of the nearshore environment (CSA International 2010a).

Community Two (HB2) consists of less biologically complex, low relief, consolidated coquina rock ledges. The well-defined, undercut ledges include exposed coquina rock with little or no biotic cover. The habitat mostly provides physical refuge space (CSA International 2010a). This community did not have the wormrock component or robust macroalgae evident in HB1. The applicant concluded that HB2 represented hardbottom substrate located in areas subject to the relatively constant physical dynamics of the nearshore environment, specifically sand movement, scouring, and alternating sand burial and subsequent re-exposure.

Data from the first 50 meters seaward of the shore along each of two monitoring transects surveyed (located at R-88.7 and R-90.4) during summer 2009 (CSA International 2010a) provided detailed estimates of biological benthos within the footprint of the northern section of the project area. Percent cover of macroalgae ranged from 10% to 70% at individual sampling locations (*in situ* 0.5 square meter quadrats), with an average cover of 35.8%. Red algae dominated the algal community with an average cover of 20.3%, followed by turf algae at 9.5%. Dominant species of red algae included *Laurencia* sp., *Bryothamnion seaforthii*, *Chondria* sp., and *Hypnea musciformes*. Cover of sessile macroinvertebrates ranged from 0% to 15% at individual sampling locations, with an average cover of 1.3%. *P. lapidosa* dominated the invertebrate community, although other observed invertebrates included hydroids, solitary (*Cinachyra* sp.) and encrusting sponges, encrusting tunicates, holothuroids (*Holothuria grisea*), and various small crabs and other mollusks.

In the southern section of the project area, between R-99.5 and R-107, hardbottom occurs as a discontinuous landward edge (CSA International 2010a). The landward edge of hardbottom in this region generally occurs as an undercut coquina rock ledge with low relief (of 0.25 to 1.0 meters (0.8 to 3.3 ft) vertical rise) and relatively less biotic cover than HB2 (CSA International, 2010a).

Between R-98.5 to just north of R-104, the landward edge of hardbottom is located approximately 40 meters (131 ft) from the MHWL, whereas from just south of R-104 to R-107, the landward edge of hardbottom lies approximately 17 to 40 meters (56 to 131 ft) from the MHWL. Hardbottom continues seaward as a series of low-relief ledges with a vertical relief of 0.25 to 1.0 meters (0.8 to 3.3 ft), alternating with partially exposed pavement-like platforms. Worm rock occurs in the intertidal zone near R-101, R-104.5, and R-105.9; hardbottom (including worm rock) in this section showed more evidence of sand-scouring and a dynamic sedimentary environment with minimal to moderate algal cover dominated by turf algae. Cover of sessile macroinvertebrates at transects R-104.5 and R-105.9 ranged from 0% to 100% due to localized abundance of worm rock in the intertidal zone. Other invertebrates observed along these transects included barnacles, hydroids, solitary (*Cinachyra* sp.) and encrusting sponges, encrusting tunicates, holothuroids (*Holothuria grisea*), and various small crabs and other mollusks.

Community Three (HB3) locates in deeper (3 - 4 m (9.8 to 13 ft)) water farther offshore (100 – 300 meters (328 – 984 ft) with medium (up to 2 m (6.5 ft)) vertical relief. HB3 includes large (1 to 3 meters (3.3 to 9.8 ft) diameter), flat rock structures. HB3 consists of faunal species not observed in the more nearshore hard bottom areas including spiny lobster (*Panulirus argus*), octocorals (*Leptogorgia* sp.), holothuroids, and a variety of encrusting sponges. HB3 does not occur in the areas potentially impacted by project construction or turbidity and thus will not receive mention in further sections of the document.

The USACE has estimated that the applicant's preferred alternative (as of January 5, 2012) would impact 0.57 acres of HB2. The 0.57-acre impact area comprises about 4% of the hardbottom along and adjacent to the project shoreline.

The third hardbottom habitat type (HB3) could incur indirect impacts if nourishment resulted in chronically increased turbidity (from introduced sand with higher fines or other turbidity-producing materials) and the transport of additional (new) sand into the nearshore environment. These hardbottom resources are therefore potentially subject only to cumulative impacts from the proposed activity and similar future activities.

Other nourishment alternatives would result in varying levels of impacts. Increases in the amount of sand placed on the beach, would increase the permanent impacts, and lesser amounts of sand would result in lesser impacts of the same type as created by the applicant's preferred alternative. Placement of T-head groins would add 0.2 acres of hardbottom impact to the ephemeral hardbottom habitat when compared to the applicant's preferred alternative.

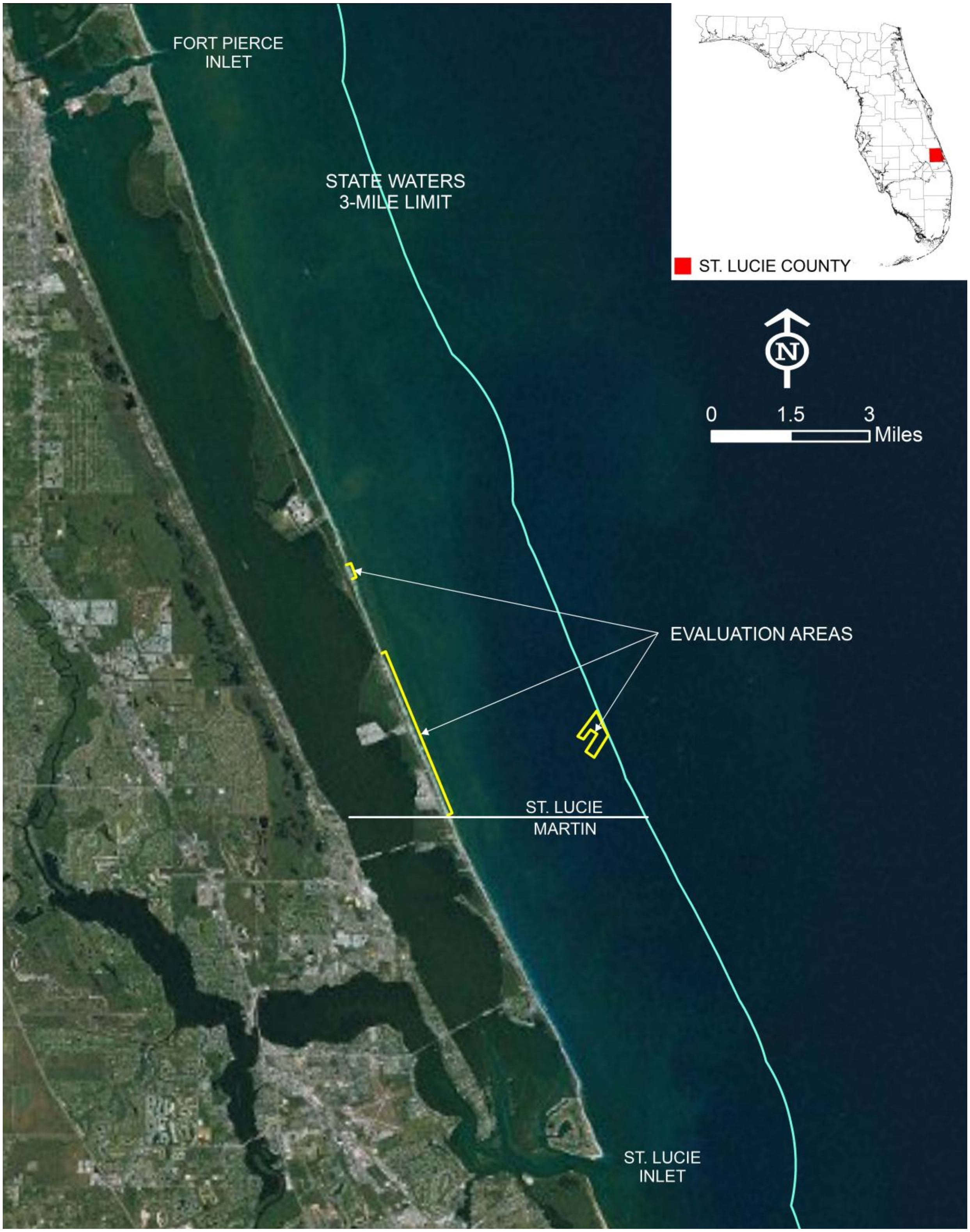


Figure 1 Project Location, St. Lucie County South Beach and Dune Restoration Project, St. Lucie County, Florida

Offshore Sand Shoal Borrow Area

The alternatives considered in detail include dredging of the southeastern-most corner of the offshore sand shoals generally described as the St. Lucie Shoal, located in the Atlantic Ocean beginning about three miles east of the project area and extending northeast from there. The National Marine Fisheries Service (NMFS 2010) identifies the borrow area as the coastal continental shelf marine habitat extending from the shoreline to 200 meter (656 ft) depth (NMFS 2010). The NMFS identifies much of this area as essential fish habitat (EFH) for a variety of fishes, marine turtles, and mammals. Potential physical effects of dredging may include alternation of the wave climate on adjacent shorelines, creation of pits or furrows in the ocean floor, and exposure of sediments with different physical characteristics (grain size distribution, chemical composition, etc.) than the mined material.

CSA International (2011, Appendix Q in St. Lucie County South Beach and Dune Restoration EIS) sampled benthic infauna in the proposed offshore dredge area. A Summary Table also in that appendix provides overall statistics for the 42 benthic samples collected in and adjacent to the proposed offshore borrow area.

Biological effects may include temporary and permanent impacts to the benthic invertebrate community and to the benthic, pelagic, and migratory fish communities. These effects may result from reduction of habitat complexity (lowering or elimination of the shoal elevations), changes in the biological community as responses to changed sediment characteristics, bottom elevations, and bathymetry, particularly in mining-created depressions

Upland Sand Mines

Upland sand mines may also provide a long-term source of beach fill. The sand from these upland sources may require significant sieving and washing to achieve a sand size distribution similar to the existing beach. If not carefully monitored for quality, sand from this source could have significant long-term impacts on the beach sand for turtle nesting and recreational uses.

2. GEOGRAPHIC SCOPE

The geographic scope of this analysis includes shoreline of St. Lucie County and Martin County between Ft. Pierce Inlet and St. Lucie Inlet (about 22 miles of shoreline) and Atlantic Ocean sand shoals between about three and six miles offshore of the central Florida coastline (Figure 1). Coastal jurisdictions within the geographic scope of the assessment generally include unincorporated areas of St. Lucie County and Martin County and the towns of Ft. Pierce and Jensen Beach. St. Lucie County is located on the east central coast of Florida and includes approximately 22 miles of Atlantic Ocean coastline along Hutchinson Island. Ft. Pierce Inlet to the north and St. Lucie Inlet to the south (in Martin County) provide physical boundaries to longshore currents and associated sand transport. The immediate project impact area comprises about 3.9

miles of beach-fill placement shoreline and the offshore borrow areas in the Atlantic Ocean approximately three to six miles east of the project area. The borrow area for the alternatives lies in state waters (within the 3-mile line). The borrow areas proposed for the full project life lie largely within waters under federal jurisdiction (between 3 and 12 miles offshore).

The potentially affected nearshore hardbottom area for the project alternatives encompasses all of the project impact area and a mixing area approximately 1/2 mile north and south of the project footprint. The cumulative impact area for nearshore hardbottom extends, like the beach area, along the 22 mile length of Hutchinson Island between the two inlets. The nearshore hardbottom habitats occur within about a 300-meter (1,000-foot) wide band from the shoreline.

Past, present and future actions that would potentially affect the project impact area principally include beach management activities (including beach nourishment) that may occur along the St. Lucie County and Martin County beaches between Ft. Pierce Inlet and St. Lucie Inlet. At the north end of this zone, Ft. Pierce Inlet acts as a barrier to littoral sediment transport excepting sand bypass activities that commenced in 1978. At the south end of this zone, St. Lucie Inlet divides the littoral system and inhibits the natural drift of alongshore sediment transport, except for sand bypassing activities that began in 1974. Changes to the inlets themselves (structural modifications, dredging, etc.) could also affect the project area.

Other nourishment projects along the central Florida coastline could affect the proposed offshore borrow area and other regional sand resources that future nourishment projects might use. These regional areas, in federal jurisdiction, may be available for mining on a first-come basis.

3. CUMULATIVE EFFECTS ANALYSIS TIME FRAME

The applicant anticipates project construction of the its preferred plan to start in late 2011 or early 2012 with a construction period of 3-4 months (including some delay time for mobilization, dredging, inclement weather, and other, unanticipated events that would require construction to cease temporarily). Construction of nearshore mitigation reefs may require several additional months. Project activities will include hopper dredge operation to collect the sand that lies approximately three miles offshore and transfer it to the beach. After discharge on the beach, large earth-moving machinery will form the sand into the approved and permitted template.

For consideration of project effects, the applicant's preferred plan and the other alternatives considered in detail assume periodic renourishment of the project beach fill at nominal 10-year intervals after initial construction. This cumulative effects analysis considers a 50-year project period.

4. OTHER ACTIONS AFFECTING THE RESOURCES, ECOSYSTEMS, AND HUMAN COMMUNITIES OF CONCERN

Cumulative effects analysis not only considers the impacts of past, present, and future actions on the resources, ecosystems, and human communities related specifically to this project, but also the impacts from unrelated actions occurring in the vicinity of the project area such as:

- Development along the coastline
- Population growth
- Recreational uses
- Past and future beach nourishments and other coastal construction activities
- Inlet dredging and maintenance projects
- Weather conditions/storms
- Sea-level rise

Development Along the Coastline and Population Growth

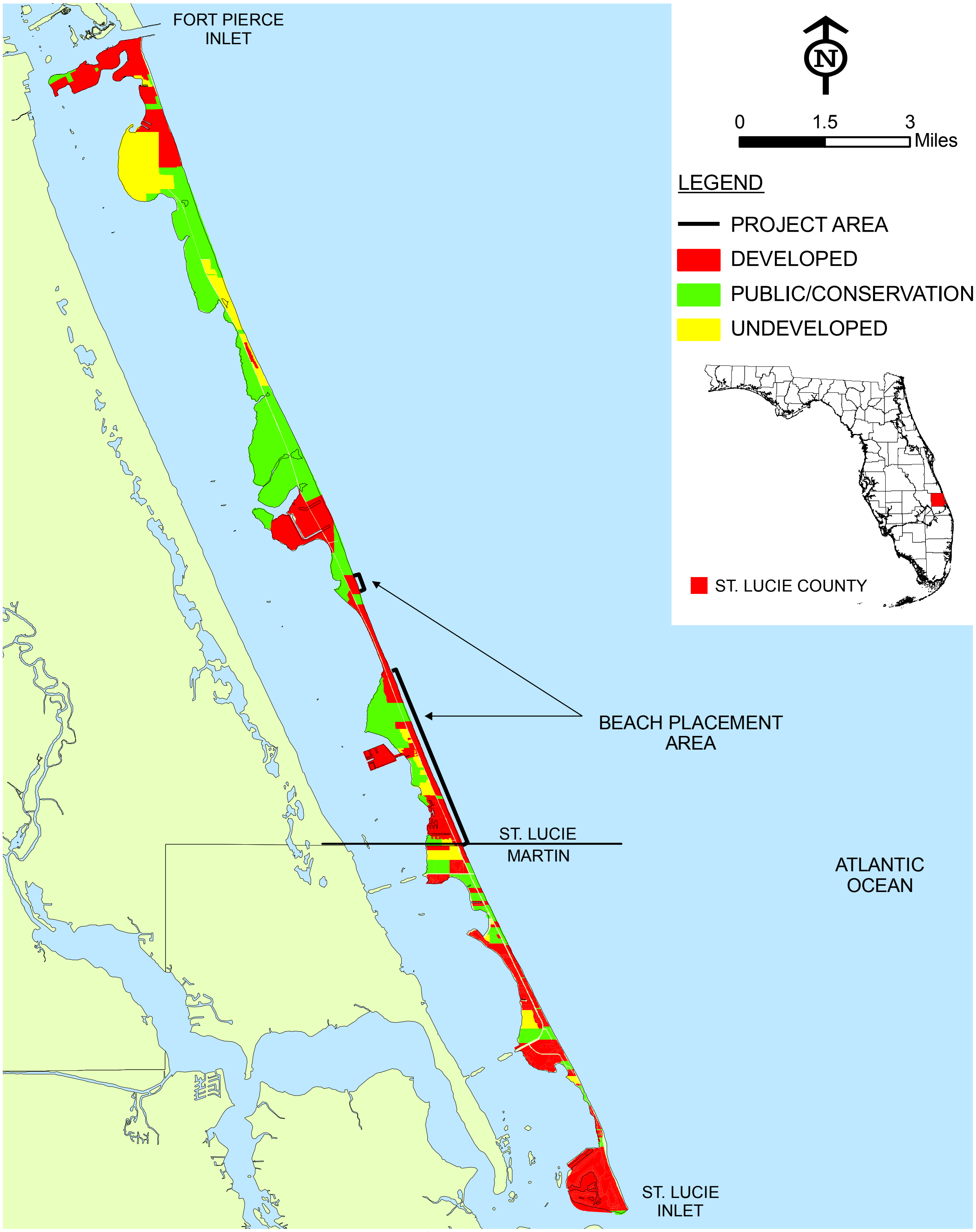
Hutchinson Island, the barrier island between Ft. Pierce and St. Lucie inlets (including the project area), has little remaining area (about 7.3% of the available upland) for development (Figure 2). Rapid growth in St. Lucie and Martin Counties (Table 1) has filled most of Hutchinson Island not protected as conservation area. Most future growth in the counties will occur on the mainland. Much of the remaining undeveloped private lands on Hutchinson Island are currently in development, although the recent economic recession has slowed the development process. In a letter to the U.S. Army Corps of Engineers (USACE), USFWS (2010b) has expressed concern regarding four private developments in Coastal Barrier Resources System Unit P11 north of the project area that have applied for state and federal environmental resource permits. The USFWS summarizes its concerns with the following statement: “cumulative impact of the residential proposals in Coastal Barrier Resource System (CBRS) Unit P-11 will cause multiple alterations of the floodplain over time, and will result in a significant degradation of floodplain values and functions”. The letter describes a potential sequence of storm damage resulting in loss of the beach and dune features seaward of the developments resulting in the need to protect structures by nourishment and ultimately by hardening the shoreline.

Table 1 Population Growth 2000 – 2009 in St. Lucie and Martin Counties

Population	St. Lucie County	Martin County
Population 2000	192,695	126,731
Population 2009	266,502	139,794
Population Growth	38.3%	10.3%

Source: U.S. Census Bureau: http://quickfacts.census.gov/qfd/states.html

In the absence of the proposed action and/or the absence of continued or future, similar beach fill actions in the project area, new development will not likely decrease (or increase) significantly. The use of shoreline armoring could provide protection for property and infrastructure; property values and maintenance may decrease. Thus, in regard to upland development and related trends, adverse cumulative effects may associate with not implementing proposed active beach management activities.



TAYLOR ENGINEERING INC.
10151 DEERWOOD PARK BLVD
BLDG 300 SUITE 300
JACKSONVILLE, FL 32256

Figure 2
Land Development Status
St. Lucie County Beach and
Dune Restoration Project
St. Lucie County, Florida

PROJECT	C2010-018
DRAWN BY	AC
DATE	NOVEMBER 2010

Recreational and Cultural Resources

Recreational activities also impact beach and hardbottom resources. As resident populations increase and the number of tourists visiting the area increase, recreational uses of the project beach and nearshore reefs will likely increase. Increased beach recreation increases traffic, air, and surface water pollution, and increases required beach and beach facility maintenance (assuming the desire to maintain the beach in the current condition). A socioeconomic study of reefs in adjacent Martin County (Hazen and Sawyer 2004) estimated that in 2003, visitors spent 529,000 person-days using artificial reefs and natural hardbottom habitats in Martin County. Recreational uses result in damage to the biotic community (e.g. from touching and bumping the living community, scraping it with equipment and gear, etc.). As recreational activity increases, the level of impact likely will increase correspondingly.

Temporary increases in water column turbidity and burial of hardbottom areas may affect diving and snorkeling in the area. However, increases in turbidity and sediment transport are likely temporary and localized. Elevated turbidity will cease after construction and increased sediment transport will cease after equilibrium of the new beach fill. Ongoing and repetitive dredging of offshore borrow areas for additional proposed nourishment projects may impact archeological resources (i.e., shipwrecks, if present) within and adjacent to borrow areas without appropriate and thorough desktop and field investigations and, as necessary, appropriate mitigations.

Development, population growth, weather conditions/storms, and degradation of water quality can also impact recreational resources. Continued urbanization and population growth in Martin and St. Lucie Counties contributes to general degradation of coastal water quality. Water quality may deteriorate due to unrelated anthropogenic sources such as stormwater runoff resulting in increased nutrients and inputs to nearshore waters from impacted estuarine waters.

Past and Future Beach Nourishments

A Conditions Assessment of the project area prepared for St. Lucie County (Coastal Tech 2007, 2008) summarized historical shoreline changes from Monuments R-77 through R-115. Except for the segment from Monuments R-103 to R-109, the shoreline within the study area predominantly retreated from 1972 to 2006. A volumetric study conducted by the USACE (2007a) indicated that from 1997 to June 2004, the beaches of the study area experienced slight erosion. The period from June 2004 to November 2004, which including the landfalls of Hurricanes Frances and Jeanne, exhibited a much higher erosion rate.

More than a decade ago, the USACE recommended a “feasibility study” for a study area extending from just south of Blind Creek (R-77) to the Martin County line. However, due to limited funding, the USACE only partially completed that Feasibility Study, which until recently remained without sufficient funding for completion. The USACE is currently completing the feasibility study but will not likely complete its project feasibility study and implementation process prior to 2012. The applicant has initiated its project to address the deteriorated shoreline and emergency conditions as soon as possible with parallel development of a future federal Shore Protection Project to provide for future renourishment of south St. Lucie County beaches.

To provide for future project renourishment, the applicant has described a conceptual 50-year borrow area dredge plan based upon the report titled “St. Lucie County Sand Search – Geotechnical Investigations – Reconnaissance Level Investigations” by Coastal Tech (2010). At ten-year intervals after the initial construction, the applicant would renourish the beach with about 200,000 cubic yards of beach quality sand. The applicant’s proposed borrow areas for project renourishment include St. Lucie Shoal offshore St. Lucie County which lies in reasonable proximity to the project fill area and could easily yield the 50-year total estimated volume of beach compatible sand. Sources of renourishment sand also include upland sand mines. St. Lucie County currently has contracts with a least two mines that supply beach quality sand.

The proposed Martin County Beach Erosion Control Project (USACE 2008) would authorize construction of a protective and recreational beach along 4 miles of shorefront south from the St. Lucie County line to near the limit of Stuart Public Beach Park (R-1 to R-25). The USACE initially constructed that authorized project in 1996 with a planned periodic renourishment interval of 11 years. Federal participation (cost-sharing) is authorized for 50 years from the date of initial construction; authorization expires in 2046. Earlier nourishments have depleted the approved borrow area for that project. Therefore, the USACE is now assessing the use of one or more of three portions of the St. Lucie Shoal complex located approximately 3 to 7 miles offshore Martin and St. Lucie Counties. The USACE has estimated a total Martin County project sand need for the remainder of the 50-year life of the Martin County project of between 2.4 and 4.0 million cubic yards. The next renourishment phase, scheduled for 2011, will involve the placement of approximately 589,600 cubic yards of material along the 4-mile project area (ANAMAR 2011).

Beach nourishment programs typically include construction and long-term maintenance of a berm and dune profile. As the number of permitted beach nourishment projects on the east coast of Florida increases, the degree of cumulative impacts may increase proportionally with the total length of beach nourishment projects constructed. FDEP (2010), which identifies “critically eroded beaches”, provides one measure of the possible long-term level of nourishment activity along the central Florida coastline. Critically eroded beaches are eligible for beach nourishment permits under the Florida Joint Coastal Permit Program. Updates of the original (1989) critically eroded beaches evaluation have typically added additional beachfront to the list of critically eroded areas (FDEP 2010). Beach nourishment projects already permitted along the central east coast of Florida include all those areas of Brevard, Indian River, St. Lucie and Martin Counties designated as critical erosion areas (Table 2). In the future, as is now occurring, beach nourishment projects may likely follow recognition of new critical erosion areas. Note that the reaches described as critically eroded in Table 2 may or may not have received nourishment along their entire lengths. However, in most cases nourishment has included a considerable (majority) portion of the critically eroded area.

Table 2 Locations of FDEP-Designated Beach Erosion Areas, Permitted and Proposed Projects, Central Florida Beaches. Adapted from FDEP (2010)

County	Location (R-Monument)	Critical Erosion (miles)	Non-Critical Erosion (miles)	Permitted Projects
St. Lucie	R-1 to R-10	1.8	0	Yes
	R-34 to R-46	2.3	0	Yes
	R-46 to R-80	0	6.4	No
	R-88 to R-90	1.9	0	Yes
	R-90.3 to R-98	0	1.5	No
	R-97.7 – R-114	3.1	0	Yes
	R-87.7 to R-90.3 and R-98 to R-115+1000 feet	3. 8	0	Proposed
	Total Miles	**9.4**	**7.9**	--
Martin	R-1 to R-37.6	6.3	0	Yes
	R-45 to R-111	11.5	0	No
	R-126 to R-127.4	0.2	0	Yes
	Total Miles	**18**	**0**	--
Brevard	V-020 to V-066	0	8.7	No
	V-117 to V-136	0	3.6	No
	R-1 to R-202	36.5	0	Yes
	Total Miles	**36.5**	**12.3**	--
Indian River	R-1 to R-51.3	9.5	0	Yes
	R-70 to R-86	3.1	0	No
	R-97 to R-115.7	3.1	0	Yes
	Total Miles	**15.7**	**0**	--
Total		**79.6**		

Numerous beach nourishment projects on Hutchinson Island have included most of the critically-eroded areas on the island (Table 3). Sand sources have included upland mines, Ft. Pierce Inlet, and offshore shoals.

The historical beach nourishments and likely future beach nourishment adjacent to (particularly north of) the project area could potentially result in cumulative impacts to the sand beach habitat, nearshore hardbottom, and offshore sand shoal habitat in the project area and beyond. USACE (1996) estimated that in southeast Florida alone, an area 4 miles wide by 140 miles long (Dade, Palm Beach, and Martin County beaches) about 100 beach nourishments and associated dredging could occur between 1969 and 2050. These nourishments would use at least 100,000,000 cubic yards of sediment. Greene (2002) summarized more than 30 nourishment projects along 86 miles of beach between 1995 and 2002. Many past beach nourishment projects have, and future projects likely will use offshore central Florida offshore sand sources (Taylor Engineering 2009a).

Beach and dune restoration projects that could affect the existing south St. Lucie County shoreline include the large scale nourishment projects that commenced in 1990 or thereafter. These projects typically place large volumes (100,000 cubic yards or more sand) in a single project. About nine miles north of the project area, the Ft. Pierce Shore Protection Project (a federal project) includes beach nourishment along a 1.3-mile section immediately south of Ft. Pierce Inlet. Immediately south of the proposed project, shoreline restoration activities include beach nourishment along the adjacent 4-mile long Martin County Shore Protection Project (R-1 to R-22) and recent small nourishment projects (35,000 - 50,000 cubic yards) at Bathtub Beach and Sailfish Point (Table 3). Sands from large nourishment activities could, over time, increase the amount of sand in the nearshore area and result in total or more frequent burial of hardbottom habitat. Depending on location and physical structure, hardbottom exposure at any particular location may vary from almost always to very rarely. Additional sand in the system could change the period of exposure for much of the hardbottom and in some areas result in the relatively permanent burial of habitat.

The proposed project location has experienced only one sand placement — an emergency fill project after severe storms in 2004. Following hurricanes Frances and Jeanne (September 2004), dune restoration was conducted by St. Lucie County – including placement of about 162,000 cubic yards of sand along the dune from R-98.4 to R-101.5, and from R-103.3 to R115+1,000 feet (St. Lucie County/Martin County line) (PBS&J 2005). The project purpose included partial restoration of sand eroded from the dune above the high water line. These activities did not advance the beach or shoreline relative to pre-storm conditions. The sand fill came from upland sources. Poor sand quality (PBS&J 2005) resulted in the required removal and replacement of much of the sand placed during the emergency fill project.

Beach nourishment in the region will likely continue and increase in the coming years, compounding opportunities for recurring impacts. Frequent maintenance efforts associated with beach nourishment projects could keep the natural resources of the barrier island ecosystems from re-establishing a natural equilibrium with the dynamic coastal forces of the area (USACE 2007a). Nourishment and dredging actions may also have significant direct, indirect, and cumulative impacts on macroinvertebrate, shorebird, sea turtle, fish, and mammal species that use the nourishment and sand source areas.

Table 3 Beach Nourishment Projects on Hutchinson Island in St. Lucie and Martin Counties

Project	Volume (cubic yards)	Location	Fill Source	Dates
Ft. Pierce SPP Initial Beach Nourishment	718,000	Ft. Pierce Inlet to R-41	Nearshore Sand Source	July 1971
Ft. Pierce Inlet Channel Maintenance	49,800	Shoreline just south of Ft. Pierce Inlet	Channel	July 1978
Ft. Pierce SPP First Beach Renourishment	346,000	Ft. Pierce Inlet to R-41	Nearshore Sand Source	1980
Ft. Pierce Inlet Channel Maintenance	29,800	Adjacent Beach (Ft. Pierce Inlet)	Channel	December 1987
Ft. Pierce Inlet Channel Maintenance	47,800	Adjacent Beach (Ft. Pierce Inlet)	Channel	January 1989
Ft. Pierce Inlet Channel Maintenance	55,700	Adjacent Beach (Ft. Pierce Inlet)	Channel	March 1990
Ft. Pierce Inlet Channel Maintenance	7,200	Adjacent Beach (Ft. Pierce Inlet)	Channel	November 1993 – January 1994
Upland Truck Haul Project	14,400	South Beach (Ft. Pierce Inlet)	Upland Truck Haul	1992 – 1994
Ft. Pierce Inlet Channel Maintenance	166,700	Adjacent Beach (Ft. Pierce Inlet)	Channel	1995
Upland Truck Haul Project	54,400	Ft. Pierce Beach (Longard Tube Backfill)	Upland Truck Haul	March 1995
Ft. Pierce Inlet Channel Maintenance	23,300	Beach South of Ft. Pierce Inlet Jetty	Channel	January 1998

Table 3 Beach Nourishment Projects on Hutchinson Island in St. Lucie and Martin Counties

Project	Volume (cubic yards)	Location	Fill Source	Dates
Ft. Pierce SPP 2^{nd} Beach Renourishment	830,000	Ft. Pierce Inlet to R-41	Capron Shoal	March 1999
Ft. Pierce SPP 3^{rd} Beach Renourishment - Phase 1	336,000	Ft. Pierce Inlet to T-36	Capron Shoal	April 2003
Ft. Pierce SPP 3^{rd} Beach Renourishment - Phase 2	406,000	Ft. Pierce Inlet to T-36.5	Capron Shoal	April 2004
Ft. Pierce SPP 4^{th} Beach Renourishment	616,000	Ft. Pierce Inlet to R-41	Capron Shoal	May 2005
Ft. Pierce SPP 5^{th} Beach Renourishment	503,800	Ft. Pierce Inlet to R-41	Capron Shoal	April 2007
Ft. Pierce SPP 6^{th} Beach Renourishment	189,600	Ft. Pierce Inlet to R-35	Capron Shoal	May 2009
Ft. Pierce SPP Emergency Beach Restoration	62,000	Ft. Pierce Inlet to R35-	Upland Truck Haul	April 2011
St. Lucie County South Beach Emergency Dune Restoration	162,000	R-98.4 to R-101.5, R-103.3 to R115+1,000 feet	Upland Truck Haul	2005
Martin County SPP Initial Beach Nourishment	1,340,000	R-1 to R-25	Gilbert Shoal	December 1995 – April 1996
Martin County SPP 1^{st} Beach Renourishment – Phase I	178,000	R-16.2 to R-22.3	Gilbert Shoal	Winter-Spring 2001
Martin County SPP 1^{st} Beach Renourishment – Phase II	126,000	R-13.5 to R-16.2	Gilbert Shoal	Winter-Spring 2002
Martin County SPP 2^{nd} Renourishment	885,000	R-1 to R-25.6	Gilbert Shoal	Spring 2005

Table 3 Beach Nourishment Projects on Hutchinson Island in St. Lucie and Martin Counties

Project	Volume (cubic yards)	Location	Fill Source	Dates
Bathtub Beach Nourishment	35,000	R34.5 to R35.5	St. Lucie Inlet Flood Shoal	Spring 2010
Sailfish Point Nourishment	25,000	R-36 to R37.5	St. Lucie Inlet North Channel	Winter/Spring 2005
Sailfish Point Renourishment	50,000	R36 to R37.5	St. Lucie Inlet North Channel	Winter/Spring 2009

For future project nourishments, the applicant has proposed a conceptual 50-year borrow area dredge plan (Coastal Tech 2010), with a renourishment of about 200,000 cubic yards every 10 years. The proposed borrow areas for project renourishment lie offshore St. Lucie County in reasonable proximity to the project fill area. These borrow areas can likely yield the required 50-year total estimated volume of beach compatible sand.

The proposed Martin County Beach Erosion Control Project (USACE 2008) would provide another renourishment of a protective and recreational beach along 4 miles of shoreline extending from the St. Lucie County line (the southern border of the proposed project) south to Martin County R-1 to R-25 near Stuart Public Beach Park. Construction of the Martin County project around the same time (within a year or two) as construction in the proposed project area could benefit both projects, as sand from the St. Lucie project would "feed" the beach to the south while the sand placed for the Martin County project would slow erosion of the more northerly project. However, construction of the two projects so close in time could also result in greater impacts to nearshore hardbottom and offshore sand shoal resources.

Inlet Development and Maintenance

Inlet development and maintenance, as well as related channel protection activities are among the leading causes of beach erosion in Florida (Florida Coastal Management Program 1996). Structure placement and inlet development have contributed to the interruption of natural littoral processes within the study area, resulting in erosional "hot spots" on the downdrift sides of inlet entrances (Hammer et al. 2005). Potential sources of cumulative beach impacts in the project area include inlet activities related to maintenance of Ft. Pierce Inlet. St. Lucie County beaches already receive sand dredged during Ft. Pierce Inlet channel maintenance. St. Lucie County has approved design and permitting of a sand impoundment structure for regular bypassing activity (Taylor Engineering 2010), as generally recommended in the Ft. Pierce Inlet Management Plan (FDEP 1997). This structure, constructed by digging a pit on the northwest edge of the inlet, would capture sand now entering the inlet rather than passing from north to south with the predominant longshore currents along the barrier island. Periodic pumping of this sand to the beaches south of the inlet would reduce the amount of sand required from other (offshore and upland) sources to nourish the same beaches. In the long-term, this high quality sand will also work its way down to the south end of Hutchinson Island and the proposed project beach.

Construction of the Ft. Pierce Inlet (1921) and St. Lucie Inlet (1892), inlet improvements, and maintenance activities since that time (Table 4), and prior beach restoration activities along the St. Lucie County and Martin County coastlines have had and continue to affect the project area.

Inlet management activities and beach nourishment projects along the central east coast of Florida will result in localized, short-term turbidity plumes adjacent to the beach fill sites and offshore borrow areas during project construction. Implementing protective measures and monitoring before and during project construction should result in avoidance of cumulative impacts from localized turbidity plumes.

Previous studies conducted by Van Dolah et al. (1992, 1994) found that dredging appeared to have little impact on bottom turbidities at various borrow sites. However, potential long-term effects of turbidity from these nourishment and dredging actions are unknown.

Storms

Factors such as natural population cycles as a result of favorable or negative weather conditions including droughts, floods, La Niña, El Niño, and major storms and hurricanes, unrelated to placement of sand on the beach, may affect beach and nearshore resources such as hardbottom, benthic assemblages, turtle nesting, shorebird populations, and ocean fish stocks. In recent years, several hurricanes making landfall in or near the St. Lucie County project area and storms with strong, sustained northeasterly onshore winds have resulted in significant damage and shoreline erosion throughout the area of interest (Table 5).

Table 5 Recent Hurricanes and Major Storms Affecting the Project Area

Event	Event Date
Northeaster	March 1996
Hurricane Dennis	August 1999
Hurricane Floyd	September 1999
Hurricane Irene	October 1999
Hurricane Frances	August 2004
Hurricane Jeanne	September 2004
Hurricane Dennis	July 2005
Hurricane Katrina	August 2005
Hurricane Wilma	September 2005
Northeasters	August – September 2008

Table 4 Ft. Pierce and St. Lucie Inlets Development and Improvement Activities

Activity	Ft. Pierce Inlet	St. Lucie Inlet
Initial Development	1920 to 1921 – inlet and coquina rock jetty construction	1892 Initial channel construction
Structural Improvements	1926 – Reconstruction and extension of jetties 1938 – Dredging of entrance channel, interior channel, and turning basin 1955 – Channel enlarged, deepened	1926 to 1929 – 3,325-foot stone jetty constructed along the northern side of the inlet 1982 – Extensions of the north and south jetties, construction of a 450-foot detached breakwater, and partial excavation of an impoundment basin inside the Inlet adjacent to the north jetty 1997 – 200-ft spur jetty attached to the south jetty 2002 – impoundment basin deepened to 20 ft
Maintenance Dredging and Sand Bypassing	1938 – Initial inlet channel dredging 1974 and ongoing – channel maintenance dredging conducted on a biannual basis 1994 – Three geotextile erosion control tubes placement south of the south jetty 1996 – Inlet channel deepened	1982 – Current federally-authorized features completed 1982 and ongoing – Maintenance dredging conducted at approximately 4-year intervals 2007 – Navigation Channel restored to 12-foot depth
Beach Nourishment South of Inlet	Periodically since 1974 for disposal of inlet material	Periodically since 1974 - dredged material placement within a 1 mile segment of beach

Sources: Ft. Pierce Inlet – FDEP (1997); Rodriguez and Dean (2005)
St. Lucie Inlet – FDEP (1995); http://martin.fl.us/portal/page?_pageid=73,276034&_dad=portal&_schema=PORTAL

Sea-level Rise

Sea level rise was modeled in accordance with USACE Circular No. 1165-2-211 (USACE 2009). USACE (2009) specifies the use of three sea level rise rates for all civil works program – “low”, “intermediate”, and “high”. Low rates use the historic rate of sea-level change and are best determined from tide gauges. The nearest NOS tide stations to the project area with sufficient historical data to measure sea level rise occur at Mayport and Daytona Beach to the north and Miami Beach to the south. The Mayport station shows an average sea level rise of 2.40 millimeters per year with high confidence. The Daytona Beach station shows a rise of 2.32 millimeters per year with lower confidence. The Miami Beach station shows a rise of 2.39 millimeters per year with high confidence. Therefore, this analysis used data from Mayport and Miami Beach to estimate sea level rise for the St. Lucie County project area.

NOAA (http://www.co-ops.nos.noaa.gov) publishes mean sea level (MSL) trends for the Atlantic coast of Florida. Using data (1928 – 1999) from Station 8720220 Mayport and data (1931 – 1981) from Station 8723170 Miami Beach, MSL rises 0.238 meters and 0.244 meters (0.80 and 0.78 feet) per century. These rates correspond to 2.38 and 2.44 millimeters per year. Adjusting the rate for the project location with respect to the two tide gauges provide a project area low (baseline) total local sea level rise of 155 millimeters over a 50-year period.

Gross sea level rise includes changes in land elevation, which vary around the globe. At this time, research located no local land elevation change data. In 2007, the Intergovernmental Panel on Climate Change (IPCC) published a global MSL rise of 1.7 ± 0.5 millimeters per year in the twentieth century. Therefore, in the absence of definitive local data, this analysis estimates a vertical land movement of -0.7 millimeters per year in St. Lucie County (2.4 millimeters per year – 1.7 millimeters per year).

Intermediate and high rates use the modified NRC-I and NRC-II curves (USACE 2009) to predict a sea level rise of 0.5 meters and 1.5 meters over 114 years (1986 to 2100). These data applied in the following equation (from USACE 2009) provided the intermediate and high sea level rise rates:

$$E(t) = 0.0017t + bt^2$$

Where $E(t)$ is the amount of eustatic sea-level rise since 1986 in meters, t is the time in years since 1986, and b is a constant. Taylor Engineering formulated this equation to eliminate the constant b given that $E(t)$ is known when t = 114 (in 2100).

$$E(t_2) = (t_2/t_1^2) * [0.0017*t_1*(t_1-t_2) + E(t_1)*t_2]$$

Where t_1 always equals 114 years, and $E(t_1)$ equals 0.5 meters for scenario NRC-I and 1.5 meters for NRC-III. The analysis period begins in 2011 (t_2 = 25 years) and ends in 2061 (t_2 = 75 years).

Table 6 presents the results of the sea level rise calculation. The low rate represents the historic rate of sea level rise. The 2011 Sea Level and 2061 Sea Level come from the calculations above. Then, the Average Sea Level Rise equals the difference between these two levels divided by 50 years. The Total Local Sea Level Rise incorporates the estimated vertical land movement (0.7 millimeters per year).

Table 6 Estimated Sea Level Rise in South St. Lucie County, FL

Rate	Average Sea Level Rise m/yr (ft/yr)	Total Local Sea Level Rise m/yr (ft/yr)	50-yr Total Local Sea Level Rise m (ft)
Low	0.0017 (0.0056)	0.0024 (0.0078)	0.12 (0.39)
Intermediate	0.0041 (0.013)	0.0048 (0.016)	0.24 (0.79)
High	0.012 (0.038)	0.013 (0.041)	0.63 (2.1)

The worst-case scenario for sea level rise adds about 2.1 ft to average sea elevation over the next 50 years.

Sutherland (2004) summarizing other authors, predicted potential effects of sea level rise including:

- Loss of dry land without protection
- Loss of wetlands without protection
- Loss of exclusive economic rights over extensive areas
- Destruction of existing economic infrastructure and existing human settlements
- Damage to subsistence and commercial fisheries production
- Saline intrusion that adversely affects freshwater resources
- Negatively affected economies

Sea level elevation is an additive component of storm wave calculations, one basis for design of beach nourishment templates and elevations. A sea level rise of 0.62 feet (Table 6: High Rate, 50-year Projection) will increase sand volumes required for beach nourishment projects.

Titus et al. (2009 SAP 4.1), developed for the U.S. Climate Change Science Program, details both how sea-level change affects coastal environments and what planners should address to protect the environment and sustain economic growth. SAP 4.1 represents the most current knowledge on implications of rising sea levels and possible adaptive responses. Many options are available for protecting land from inundation, erosion, and flooding ("shore protection"), or for minimizing hazards and environmental impacts by removing development from the most vulnerable areas ("retreat"). However, policymakers have not decided whether the practice of protecting development should continue as sea level rises, or be modified to avoid adverse environmental consequences and increased costs of shore protection. Most shore protection structures are designed for the current sea level, and retreat policies that rely on setting development back from the coast are designed for the current rate of sea-level rise. Those structures and policies would not necessarily accommodate a significant acceleration in the rate of sea-level rise.

Flick and Ewing (2009) estimated effects of sea level rise on sand volume needs for beach nourishment in southern California. Using the same approach and assuming sea level rise rates described in Table 6, over a 50-year period, sand fill requirements for the applicant's preferred alternative may increase from current projections by about 172,000 cubic yards per mile (for the applicant's preferred plan) to 682,000 cubic yards per mile of nourished beach. For the 9.4 miles of critically-eroded beach within St. Lucie County, the total required additional volume increases by 0.4 to 1.6 million cubic yards. For all central Florida Atlantic shoreline counties (Brevard, Indian River, St. Lucie, and Martin Counties) the additional volume requirement increases from 3.5 to 14 million cubic yards). Current projections (Taylor Engineering 2009) show a 50-year sand consumption (without accounting for sea level rise) of 24.44 million cubic yards, and a surplus of available sand in upland mines and areas offshore of the applicant. However, 50-year beach nourishment requirements for the region (Brevard County through Miami-Dade County) barely meet the estimated sand stores for the region (Taylor Engineering 2009). Sea level rise could easily result in a shortage of fill material within the 50-year cumulative impact timeframe. Consumption of the available sand could result in negative effects to species using the offshore sand habitat resources.

Elko (2009) considered potential sea level rise effects on local beach communities, particularly in Florida. The article reached the conclusion that "at least in the near-term future (50-100 years) most beach nourishment projects will adapt to accelerating sea-level rise with moderate increases in volume and will continue to be cost-effective." However, Elko also recognized that "how developed beaches will adjust to rising sea levels and the long-term effects of continued shore protection should be investigated."

Sea level rise within the range described in Table 6 would not greatly change the appearance of the beach or the performance of T-head groins, should they become part of the preferred plan. A greater increase in sea level might require an increase in the height of the groins in order to provide the same seaward location of the mean high water line as envisioned in the current plans.

5. RESOURCES RESPONSES TO CHANGE AND CAPACITY TO WITHSTAND STRESSES

Beach construction in the proposed area will introduce additional sediment, directly or indirectly, to the beach system — dune, upland beach, intertidal beach, and subtidal areas including parts of the nearshore hardbottom. The degree to which this sediment will impart change or stress to the system is in large part associated with the amount and quality (grain size, compatibility) of the sediment, and the lines, grades and slopes to which construction places the sediment. The sand may directly and indirectly impact resources with variable capacities to withstand and/or respond to the stresses.

At the borrow site, the proposed action will remove sediment from the ocean floor, altering the bathymetry and wave climate of the area, removing sessile organisms living in the sand, entraining planktonic species near the dredge head and potentially entraining pelagic species that do not move quickly enough to avoid the dredge. The degree to which these changes will impart change or stress to offshore physical and biological system depends on the amount of sand removed, the pattern of dredging, and the degree to which human operators take precautions to avoid potential impacts. Collisions of larger species (turtles, fishes, marine mammals) with the dredge vessel may also occur. Such accidents are often lethal to the individual animal or animals involved.

Beach and Dune Upland Resources

Upland resources include the dune and beach above mean high tide. The proposed alternatives evaluated in detail will bury the existing beach, associated burrowing (e.g. ghost crabs) and interstitial species, and possibly some foredune vegetation. Salvaging and replanting or replacement plantings of dune vegetation will rapidly replace the impacted dune resources and little cumulative impact would likely occur to those resources. Depending on the depth of the sand, beach species may be able to dig out through the additional sand. Many individuals however will remain buried and die.

Placement of T-head groins, one alternative evaluated in detail, would permanently replace part of the beach with rock. Sand infauna would be replaced with species capable of living within and on the rock. This permanent change would not vary over time. The groins may reduce the desirability of the beach for recreational purposes, increase swimming risks due to the presence of rock in the surf zone. It may also increase fishing opportunities by providing additional habitat for fish species sought by anglers. For marine turtles, groins would reduce the amount of nesting beach. The groin vertical structure in the nearshore may bring additional predators to the area through which hatchling turtles must swim.

Repeated nourishments using sand with qualities slightly different than those of the native (pre-nourishment) beach may result in a cumulative change in overall beach sand quality. This may in turn impact the rate of beach erosion (potentially leading to a requirement for more frequent renourishment than currently projected), may impact sea turtle nesting success, and may bury nearshore hardbottom resources.

Benthic Resources

The Hutchinson Island beach area typifies sandy Atlantic shoreline beaches subject to coastal processes. The biological diversity of the sandy beach intertidal area is low, but the populations of individual species, particularly invertebrates, are often immense. Species found in the project area, such as polychaete worms, coquina clams, and mole crabs, are highly specialized and adapted to the harsh, dynamic environment. Since the benthic communities characteristic of sandy beaches include large populations of small, short-lived organisms with great reproductive potential, these communities usually recover quickly from most environmental disturbances such as beach restoration projects (ATM 1991, Taylor Engineering 2009). However, Lindquist and Manning (2001) have suggested that repeated renourishment without adequate recovery time between events could reduce the proportion of large adult coquina clams and mole crabs in the benthic community. These species often comprise a large, stable biomass component of the benthic community that also grows and reproduces much more slowly that the rest of the community. Loss of this component of the benthos could have long-term negative consequences.

Dredging offshore borrow areas will result in the loss of benthic organisms, including the arrowhead sand dollar (*Encope emarginata),* a common species found throughout the sandy substrate and one of the largest members of the offshore benthic invertebrate community. Direct impacts to these organisms will include direct removal and burial. However, these highly fecund invertebrates will likely repopulate after dredging activities. Many studies have concluded that borrow sites fully recover within 1 year post-dredging, developing taxonomic diversity and density similar to the pre-dredge conditions (e.g. ATM 1991, Welker 1974; McCauly et al. 1977; Oliver et al. 1977; Goldberg 1988; Deis et al. 1992, Posey and Alphin 2002). Burlas et al. (2001) monitored borrow sites with bathymetric high points off northern New Jersey and found that essentially all infaunal assemblage patterns recovered within 1 year after dredging disturbance except average sand dollar weight and biomass composition, which required 2.5 years. Based on previous studies, Byrnes et al. (2004) concluded that levels of infaunal abundance and diversity may recover within 1 to 3 years, but recovery of species composition and community biomass may take longer.

Nearshore Hardbottom Resources

Natural sand migration in the nearshore along Hutchinson Island periodically covers and uncovers hardbottom habitat. Field surveys (CSA 2008, 2010) have identified three characteristic hardbottom communities: a relatively persistent hardbottom community consisting of low relief (up to 3 feet) relief substrate dominated by macroalgae and including a significant worm rock component (HB: Coastal Technology Draft Mitigation Plan September 2010, CSA 2009). A second community characterized by a sporadic cover of low-growing turf algae lives on an ephemerally exposed, patchy, low relief substrate of consolidated coquina rock ledges (PEHB: Coastal Technology Draft Mitigation Plan September 2010, CSA 2009). A third, relatively persistent hardbottom community (HB3) locates on the seaward edge of hardbottom substrate in the southern end of the project area from approximately 100 to 300 meters from the shoreline. HB3 supports many faunal species not observed in the more nearshore hard bottom areas including spiny lobster (*Panulirus argus*), octocorals (*Leptogorgia* sp.), holothuroids, and a variety of encrusting sponges. Fishes observed in this community included porkfish (*Anisotremus virginicus*), sheepshead (*Archosargus probatocephalus*), striped burrfish (*Chilomycterus schoepfii*), highhat (*Pareques acuminatus*), juvenile angelfish (*Pomacanthus* sp.), and many other species of newly settled juvenile fishes (CSA 2010a). The alternatives considered in detail and similar future activities would not likely impact this third community, due to its distant location with respect to the beach project area, equilibrium toe of fill and turbidity mixing area.

The hardbottom habitat begins (albeit irregularly) as close to shore as the intertidal zone but more typically about 30 meters (100 feet) seaward of the shore. These habitat types occur in an environment with a high rate of sedimentation, elevated turbidity, and sand scouring, as sandy sediments move with wave energy and longshore and cross-shore currents. Because of the necessary resiliency of the living community associated with the hardbottom substrate in this area (being periodically exposed, buried by sand, and re-exposed), hardbottom habitat organisms likely would survive the temporary, elevated turbidities a beach nourishment project may produce. Federal and state regulatory agencies typically consider sand burial of hardbottom to construct additional beach width as a permanent impact requiring mitigation (even though the beach will erode and re-expose those substrates over time). The biota on the limestone substrate are typically rapid recolonizers and either very resilient to the environmental stresses encountered in the nearshore or very resistant to them (ATM 1991, Lindeman et al. 2009). Monitoring of previous projects in St. Lucie County and in Martin County has revealed no impacts other than those predicted and mitigated as permit conditions. Past monitoring reports of Broward County nourishment projects did not document any statistically significant long-term effects of turbidity and on adjacent reef systems directly attributable to the nourishment actions (Dodge et al. 1991, 1995).

Hardbottom communities also include some fishes (CSA 2010b). Turbidity can affect feeding, movements and respiration in fishes. High concentrations of suspended or fine sediments can clog or abrade gills. The ability of fish species specific to the existing hardbottom to survive within this dynamic and turbulent environment indicates their tolerance to high levels of sedimentation, turbidity, and possibly occasional burial. These species can also move away from particularly turbid waters and return when the turbidity returns to normal levels.

The placement of T-head groins (if selected as part of the final plan) could result in an altered nearshore fish community as the groins would provide additional habitat to fish species that prefer strong vertical components of the nearshore hardbottom.

Sea Turtles

The alternatives considered in detail will directly affect 3.9 miles of the approximately 1,400 miles of available sea turtle nesting habitat in the southeastern U.S. The physical properties of the beach, if altered by a beach fill project or similar future projects, may recover over time as sand carried in shoreline currents replaces the nourishment sand. Nesting sea turtles may nest less on beaches with altered physical characteristics. If nesting occurs in a lower quality habitat, hatch rate or hatchling survival may suffer, or other impacts may result. The USFWS Biological Opinion developed for the Martin County Shore Protection Project (abutting the south end of the proposed project extent), concluded that the proposed Martin County action had the potential to adversely affect nesting females, nests, and hatchlings within the St. Lucie County project area (USFWS 2005). Potential effects of beach nourishment action include:

- Destruction of nests deposited within project fill boundaries
- Harassment in the form of disturbing or interfering with female turtles attempting to nest within the construction area or on adjacent beaches as a result of construction activities
- Disorientation of hatchling turtles on beaches adjacent to the construction area as they emerge from the nest and crawl to the water as a result of project lighting
- Behavior modification of nesting females due to escarpment formation within the project area during a nesting season, resulting in false crawls or situations where they choose marginal or unsuitable nesting areas to deposit eggs.

Additional impacts could occur if T-head groins are incorporated into the final plans. Turtles may have difficulty approaching and exiting the beach with the obstruction of the groins. Hatchling turtles may suffer disorientation or injury if they encounter the rock on the beach or in the water.

The quality of the placed sand could affect the ability of the female turtles to nest, the suitability of the nest incubation environment, the ability of hatchlings to emerge from the nest, and the sex ratios of the hatchling population. While nesting marine turtles are adapted to a dynamic, energetic, sandy environment, non-nesting emergences may result on beaches that are overly compacted due to construction operations or unsuitable sand size. Sand beaches with poor gas exchange, or which are subject to physical erosion or frequent inundation may adversely impact hatching success.

The principal effect of beach nourishment on sea turtle reproduction is a reduction in nesting success, and this reduction is most often limited to the first year following project construction (Martin and Ernest 2004, USFWS 2005). Nesting success decreases during the year following nourishment because nourishment temporarily alters beach profiles, creates escarpments that reduce beach accessibility to turtles, and results in more compacted sand while the beach equilibrates. USFWS (2005) reported that the impacts of a nourishment project on sea turtle nesting habitat are typically short-term because natural processes will rework a nourished beach, over time reducing beach compaction and the frequency of escarpment formation.

Hopper dredging operations may injure or kill turtles swimming in the open ocean or resting on the ocean floor. Marine turtles are relatively slow-moving and may not be able to avoid the vessel, the suction of the dredge, or the pace at which the dredge moves.

Fish and Wildlife

Potential direct impacts of beach nourishment and sand dredging to fisheries are virtually unknown, but may include effects from loss of essential habitat and alteration in trophic energy transfer from the benthos to fish populations (Coastal Tech 2007). Lindeman and Snyder (1999) reported that burial of hardbottom habitat reduced fish species by 90% and more at two sites they studied.

Fish that prey on exclusively non-motile organisms and fish that are less motile themselves likely would suffer the greatest effects from dredging (Greene 2002). The degree to which fish that prey on benthic invertebrates are affected depends on the recovery rate of the benthic communities. With the loss of autotrophic and heterotrophic invertebrates, small fish (juveniles and small species) will lose a valuable food source. If full recovery of benthic communities is measured in terms of years (not months), as some researchers have asserted, it is reasonable to consider that full recovery of benthic predator species may require a similar or greater amount of time (Peterson and Manning 2001).

Fish, including predatory species, may benefit from the presence of T-head groins, which create vertical structure in the nearshore not otherwise present, but at the expense of their prey species, including hatchling turtles. In addition, birds may use the groin as a perch to locate hatchlings on which they prey.

Few studies have directly assessed the effects of dredging on the living community inhabiting the coastal shelf shoals off the east coast of Florida. Capron Shoal, just north of St. Lucie Shoal, has been largely depleted of usable beach fill and future dredging activities along the Florida east coast will likely propose the use of other area shoals, including the St. Lucie Shoal. Potential responses of biological communities to dredging include reduced use or abandonment of the affected area due to the deflation (complete shoal removal) or severe reduction of habitat (e.g. shoal elevation gradients). Pits or trenches produced by dredging may develop biological communities that differ from the pre-dredging shoal communities. The post-dredging communities may or may not provide resources for predator species similar to the pre-dredging communities.

The offshore fish community could be affected by repeated dredging. However, environmental impact assessments for offshore coastal shelf mining have predicted that effects from dredging will be minimal or non-existent based on the assumption that resident fish are wide-foraging or migratory and spend only a portion of their life cycle at the borrow site (Hammer et al. 2005; Louis Berger Group 1999). Hobbs (2002) suggested that dredging will have minimal effects on transitory fish, given that the dredging impacted habitat represents only a small percentage of these fishes overall geographic range. However, if many projects dredge the shoals in a geographic region, such as the central Florida Coastal Shelf, the dredging could impact a significant amount of shoal habitat and the associated fish community.

Contrasting opinion suggests that fish (and other secondary production) may depend on the areal extent of required habitat(s) and that every unit of loss of habitat function results in a decrease in production (e.g. Peterson et al. 2001).

Gilmore (2009) provided a comprehensive literature review and gathered new, primarily unpublished data on shoal fisheries identifying an extremely diverse fish community in the general region. Finding that the shoals served as important habitat as predatory refugia for schooling planktivores, feeding habitat for a wide variety of species, and spawning site for some, he concluded that the sand shoals represent unique habitat within an “integrated continental shelf ecosystem”. Gilmore (2009) and Visslides and Able (2008) concluded that depletion of shoals in the northeast U.S. coastal shelf would deplete planktivorous fishes and their predators (e.g. mackerel). Diaz et al. (2004) predicted that shoal removal would permanently displace pelagic species. These conclusions suggest cumulative impacts of multiple offshore shoal removals could reduce the overall size and recovery capacity of an important marine fish community and offshore ecosystem.

Gilmore (2008, 2009) concluded that:

> *The continental shelf off South Hutchinson Island is unique in that its climatic, oceanographic, topographical setting within tropical and warm temperate aquatic environments has produced an exceptionally complex and uniquely rich fish fauna and quality habitat setting in a relatively small area. Pelagic waters, shoals, and reefs are within a few kilometers of one another. Major pelagic fishery spawning sites for billfish and other migratory fishery species are less than 8 nautical miles from St. Lucie shoal. This means that shoal removal may have equally complex impacts on regional pelagic fisheries through trophic links.*

Shoal Structure, Wave Climate, and Potential Shoreline Erosion

St. Lucie Shoal affects the wave climate and erosion potential of the adjacent shoreline, including the proposed project area. Alternation of the St. Lucie Shoal could increase shoreline erosion and require additional and/or more frequent renourishment. Kelley et al (2004) and Hammer et al. (2005) evaluated potential effects of dredging the St. Lucie Shoal on the adjacent shoreline. Hammer et al. (2005) recommended revising a St. Lucie Shoal dredging design that those authors evaluated for dredging impacts: ”Therefore, Area C sites should be redesigned so impacts are within acceptable limits, most likely by reducing the maximum depth of excavation at the sites”... The authors modeled dredging scenarios that included removal of 19.1 million cy of sand, almost 25 times the amount of sand proposed for removal by the applicant. The modeled dredging reduced shoal elevation by 5.4 m and 7.6 m (17.7 to 24.9 ft), deflating the shoal to the surrounding bottom elevation of -12 m (-39.4 ft). The model predicted potentially unacceptable increases in wave height and sediment transport along the shoreline with these shoal removal designs. The applicant's proposed project will dredge only a small fraction of the total shoal area, will not reduce the maximum elevation of the shoal in the project area, and should not have the same impact on wave climate as the Hammer et al. 2005 dredging scenarios.

Similarly, Kelley et al. (2004) modeled the removal of an estimated 31.4 million cubic yards with an excavation depth of 4.6 meters (15 ft) - all of St. Lucie Shoal in federal waters). After determining that this dredging would cause unacceptable effects on the wave climate and resulting sediment transport, they determined that the shoal — if reduced in elevation by less than 2.3 meters (7.5 ft) — would yield 15.7 million cubic yards of sand without causing significant impacts on longshore sediment transport. The applicant's proposed project maintains the shoal height and extracts less than 5% of the volume Kelley et al. identified as safe to remove.

Dibajnia and Nairn (2010) summarized field investigations and modeling studies intended to recommend offshore dredging guidelines to protect and maintain the integrity of ridges and shoals found on the OCS. They found that for shoals less than 30 meters deep a shoal reforms itself after dredging with the remaining (smaller) volume. They concluded, "there was no indication that there exists a critical threshold for dredging that once crossed, ridge and shoal features may deflate, losing their morphologic integrity".

Coastal Tech (2011 and 2011 Addenda) compared the current wave climate to that potentially created by the proposed project dredging and by the dredging associated with the 50 year conceptual offshore borrow area. In an analysis similar to that developed by Kelley et al. they evaluated the change in wave climate at the borrow area, how that changed climate translated to the surf zone (where littoral longshore current occur) and whether that change would result in significant increases in erosion potential. The analysis indicated no significant effects on potential erosion rates would occur as a result of shoal dredging for the proposed project.

If future beach nourishment projects consider use of the St. Lucie Shoals as a borrow area, wave climate analyses should provide the necessary information to evaluate project-related potential changes to shoreline erosion, and provide a tool to test alternative borrow area designs to identify those that avoid shoreline impacts.

6. STRESSES AFFECTING THESE RESOURCES, ECOSYSTEMS, AND HUMAN COMMUNITIES AND THEIR RELATION TO REGULATORY THRESHOLDS

The goal of characterizing stresses is to determine whether the resources, ecosystems, and human communities of concern are approaching conditions where additional stresses will have an important cumulative effect or effects, particularly in regulatory terms. The effects of a particular disturbance often depend critically on impacts from previous perturbations. Consequently, even the same type of recurrent stressor can have different effects at different times, depending on history (CEQ 1997).

Upland Resources and Ecosystems

Increases in population growth rates and corresponding urbanization of the region have increased the potential for coastal water quality degradation. Intense recreational use of the beaches and coastal resources is also a stress factor that can result in degradation of habitat quality. The natural physical stresses of the nearshore habitat limit the biodiversity and survivability of epibenthic species. Nutrient enrichment, sedimentation, turbidity, temperature fluctuations, freshwater inflows, and other regional and global climatic changes are additional potential stressors that could affect hardbottom resources in the area. St. Lucie County development ordinances prohibit development that "results in the alteration, degradation or destruction of environmentally sensitive resources or habitats" except if the project eliminates a hazard, and the project cannot be otherwise accomplished, the project provides public benefit, or the project is water dependent and the developer demonstrates that the impacts are minimized and unavoidable (St. Lucie Municipal Code Chapter VI 6.02.01 Coastal Area Protection). Martin County has extensive land use development codes (Ordinance Number 849, amending the text of Chapter 8, Coastal Management Element of the Martin County Comprehensive Growth Management Plan) that severely limits and specifically defines allowable coastal development. State water quality regulations (Chapter 62.302 and CH 62.303 F.A.C) identify water quality standards and require maintenance of appropriate water quality.

Artificial lighting, coupled with loss of dune/coastal hammock vegetation and increased elevation of the beach berm, may cast light upon marine turtle nesting beaches. This lighting can lead to disorientation of marine turtles and disruption of critical life functions. For adults these include disturbance of nest site selection, nesting behavior (abbreviating or abandoning nesting), and sea finding. For hatchlings, artificial lighting may result in disorientation and difficulty finding the sea (Witherington and Martin 1996). St. Lucie County and Martin County have turtle lighting ordinances to minimize impacts to marine turtle nesting and both conduct or require surveys to verify existing or proposed lighting conditions.

Beach fill projects may bury vegetation on the existing foredune. The plant community that lives in this habitat, particularly sea oats (*Uniola paniculata)* captures and holds wind-blown sand. Sea oats often provide the dominant plant cover in beach and dune communities. A pioneer species, its' clumping habit collects, traps and holds sand blown by the wind. The presence of this plant results in dune formation and erosion control. Sea oats also provides excellent year round habitat for a variety of animal species. The seeds serve as a late fall and winter food source for small birds, mammals and insects. Chapter 161.242 of the Florida Statutes prohibits the cutting, harvesting, removal, or eradication of sea oats on any public land or from private land without the consent of the owner. The purpose of the statute is to protect the beaches and shores of the state from erosion by preserving natural vegetative cover to bind the sand. State and federal environmental permits for beach nourishment typically require at least replacement of buried foredune vegetation, and often require salvage and replanting of existing vegetation and new plantings of the foredune with sea oats.

Benthic and Hardbottom Communities

The natural physical stresses of the nearshore habitat limit the biodiversity and survivability of epibenthic species. Nutrient enrichment, sedimentation, turbidity, temperature fluctuations, freshwater inflows, and other regional and global climatic changes are additional potential stressors that could affect hardbottom resources in the area. Whether the beach nourishment project negatively impacts these hardbottom areas depends on such variables as the areas' distance from shore, relief, and composition (e.g., worm rock, or limestone).

Sediments can suffocate and bury soft bottom and hardbottom benthic biota, although some mobile soft bottom organisms are able to migrate vertically to the new surface (Maurer et al. 1986, Nelson 1988). Unlike most soft bottom biota, many hardbottom organisms are sessile and unable to burrow up through sediment overburden (Nelson 1989, Weaseling et al. 1999). Heavy sedimentation can result in acute stress and death, and chronic high turbidity can cause stress responses and reductions in health and growth of algae, corals, and other filter-feeding organisms (Dodge et al. 1974, Dodge and Vaisnys 1977, Bak 1978). Corals and algae with shapes that allow sediments to accumulate are particularly sensitive to depositional effects from mining (Courtenay et al. 1972, Owen 1977, Bak 1978, Goldberg 1985 and 1989, Hubbard 1986, Chansang 1988, Rogers 1990, Riegl 1995). Sediment deposition harms the photosynthetic activity of zooxanthellae and thus the viability of corals (Yentsch et al. 2002, Philipp and Fabricius 2003). Sediment can also inhibit settlement of numerous invertebrate species that need hard surfaces on which to attach and develop (Thorson 1966, Rogers 1990). Herrnkind et al. (1988) suggested that large-scale siltation resulting from dredging, mineral mining, and other human activities must be viewed as potentially deleterious to spiny lobster recruitment.

Whether the beach nourishment project negatively impacts hardbottom areas depends on such variables as the areas' distance from shore, relief, and composition (hard or soft coral, worm rock, or limestone). Turbidity from dredging can elicit a variety of benthic responses, primarily because attributes of the physical environment are affected (Wilber et al. 2005). Large quantities of bottom material placed in suspension decrease light penetration and change the proportion of wavelengths of light reaching the bottom, leading to decreases in photosynthesis and primary productivity of benthic organisms such as algae, seagrasses, and zooxanthellae (symbiotic algae) associated with corals (Phinney 1959, Courtenay et al. 1972, Owen 1977, Onuf 1994). Light (among other factors) affects dispersal and settlement of marine invertebrate larvae (e.g. see Burgess 2009 for a short review of potential factors). Suspended materials can prevent growth of benthic organisms such as corals and plants that provide habitat complexity and biological structures used by many other species for shelter and egg attachment

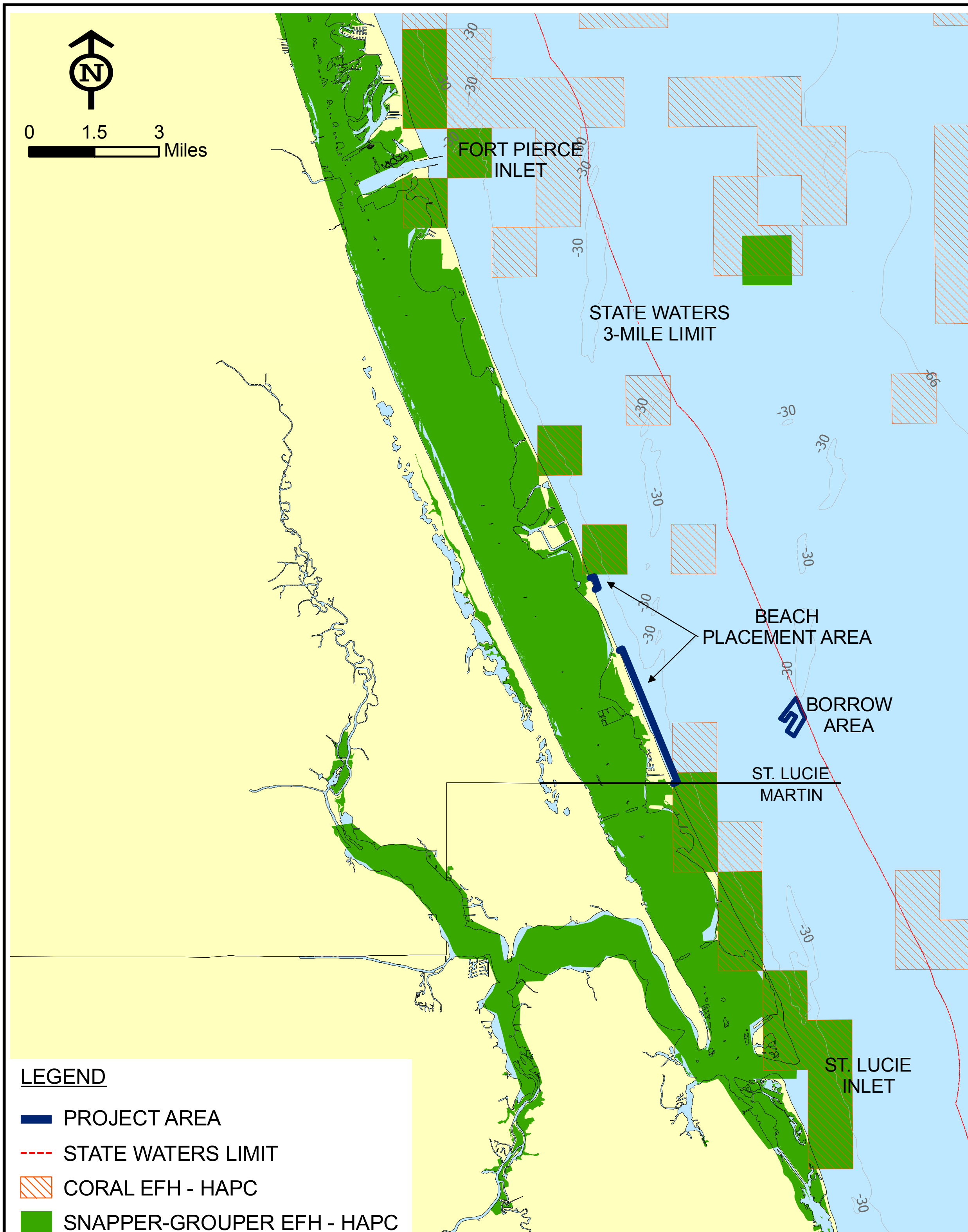
(Phinney 1959, Owen 1977, Connell 1997, Nelson 1989a). Although coral reefs are adapted to transient increases in turbidity, a continuous reduction in light penetration from dredging may significantly reduce respiration and productivity, cause bleaching and death, and lead to severe alterations of community structure and function, particularly in deep reef zones where light is already limiting (Rogers 1979).

The project area lies partially within and near NMFS EFH Habitat Area of Particular Concern (HAPC) for corals and snapper-grouper (Figure 3). Substantial deposition of sediments may impact coral growth, although many corals can withstand some sedimentation through active removal (Levin 1970, Courtenay et al. 1972, Rice and Hunter 1992, Stafford-Smith and Ormond 1992, Stafford-Smith 1993, Torres and Morelock 2002). Corals lose the ability to clean sediments when exposed to extended periods of high turbidity (Clarke et al. 1993). Sediment removal by organisms requires time and energy that otherwise could be used for growth, food capture, and reproduction (Dodge and Vaisnys 1977, Riegl and Branch 1995, Dustan 1999). Some coral species that are efficient sediment rejectors may experience reduced growth rates as they expend energy to manage the excess sediment. Colonies of other species may lose their symbiotic zooxanthellae and die because of sediment cover they are unable to remove (Bak 1978). Heavy sedimentation can result in decreased calcification and net productivity of corals, fewer coral species, greater abundance of branching forms, less live coral, lower coral growth rates, reduced coral recruitment, and slower rates of reef accretion (Rogers 1990). Increased sediment loads can contribute to coral reef degradation and shifts from coral to algal dominance (de Sylva 1994, Umar et al. 1998, McCook et al. 2001).

Critical levels of sedimentation (in terms of thickness and temporal length of sand burial) and sedimentary abrasion affecting the survival or growth of macroalgae, worm rock, infauna and other biota associated with the nearshore hardbottom are likely cross-dependent on numerous other factors and vary with the biota, and are otherwise not definitive. Direct measurements of sedimentation and sediment movement fine enough to quantify effects of such processes on hardbottom communities are unavailable. These processes are extremely difficult and time consuming to measure with any accuracy. In addition, no numeric standards (e.g. critical levels of sedimentation) apply to sedimentation in these very shallow water, dynamic habitats. Either fill sand has, or has not buried hardbottom. Because sedimentation is so difficult to measure, regulatory agencies use turbidity as a surrogate measure for sedimentation (and inappropriate sediment quality) when monitoring to protect against sedimentation impacts of dredge and fill projects. While turbidity and sedimentation may have a tenuous relationship, turbidity appears to provide the best available technology to achieve the protective goals of state and federal agencies.

Relevant State of Florida turbidity thresholds require that activities create less than 29 Nephelometric Turbidity Units (NTU) of turbidity above project area background levels. Based on the quality of the borrow area sand proposed for use in this project a project using that material will not likely result in turbidity that reaches the state level of concern at the edge of the approved mixing zone for the project.

To maintain nourished beaches for turtle nesting, standards developed by the USFWS require that measured beach compaction measure less than 500 pounds per square inch at 6 inches, 12 inches, and 18 inches below beach grade, in order that the beach provide suitable marine turtle nesting habitat. If compaction exceeds that value, agencies require tilling to achieve a suitable density. All beach restoration projects in St. Lucie County require monitoring for beach compaction and tilling when required or as an alternative to compaction testing.



TAYLOR ENGINEERING INC. 10151 DEERWOOD PARK BLVD BLDG 300 SUITE 300 JACKSONVILLE, FL 32256	Figure 3 Coral and Snapper Grouper EFH-HAPC St. Lucie County Beach and Dune Restoration Project St. Lucie County, Florida	PROJECT C2010-018 DRAWN BY AC DATE NOVEMBER 2010

Offshore dredging activities may impact swimming sea turtles, whales, and smalltooth sawfish. The 1997 Southeast Atlantic Regional Biological Opinion (NMFS 1997), which applies to this project, concluded that hopper dredge activities were likely to “take” marine turtles but would not likely endanger the continued existence of those species. An incidental take statement allowed for taking of a limited number of individuals of several marine turtle species and a hopper dredge protocol required the use of turtle excluder devices, use of sea turtle observers, cessation of operations if three turtles were killed during a dredging operation, and other contingencies to avoid and minimize impacts to sea turtles. The protocol also requires whale observers and a minimum allowable distance between a whale and an operating dredge.

7. BASELINE CONDITION FOR THE RESOURCES, ECOSYSTEMS, AND HUMAN COMMUNITIES

<u>Upland and Shoreline Ecosystems</u>

The private upland property along the project shoreline (and along most of the Hutchinson Island shoreline) is more or less fully developed. The large majority of the upland properties adjacent to the project beach include multi-story condominium developments. Those lands not already developed are almost all in public ownership. With-project development on public lands may occur as improvements or expansions to existing park facilities. When viewed in the cumulative context of past, present and future related activities, project at the proposed site is not anticipated to significantly alter (increase) the density and nature of upland development.

Coastline development on Hutchinson Island includes a significant amount of conservation land between almost fully developed upland areas. Current land use data indicate that little private land remains available for development, including only a few beachfront properties (see above for description of land uses on Hutchinson Island).

<u>Beach and Upland</u>

Inlet development and related channel protection activities are among the leading causes of beach erosion in Florida (FDEP 2010). Structure placement and inlet development have contributed to the interruption of natural littoral processes within the study area, resulting in erosional “hot spots” on the downdrift sides of entrances. Dean et al (1998) showed a shoreline region between FDEP Monuments R-077 to R-115, receded at an annual rate of 0.114 meter ± 0.323 meter (between 1971 and 1989). Coastal Technology (2009a) calculated a similar but slightly higher annual change rate of -0.120 meter ± 0.183 meter (between 1987 and 1997) under similar climatic conditions (between 1971 and 1997 no hurricanes impacted the study area).

The FDEP has identified most of the shoreline in the project area as critically eroded (FDEP 2010). FDEP recognizes 9.4 miles of St. Lucie County beaches and 18 miles of Martin County beaches as critically eroded. The critically eroded shorelines occur primarily on Hutchinson Island. Of approximately 22 miles of shoreline between Ft. Pierce and St. Lucie inlets, FDEP identifies 13.9 miles as critically eroded (FDEP 2010).

Loggerhead, green, and leatherback sea turtles use beaches of southeast Florida, including St. Lucie County, as a primary nesting habitat. Hutchinson Island supports one of the highest loggerhead sea turtle nesting aggregations in the western Atlantic (Harris et al. 1984, Hopkins and Richardson 1984, Williams-Walls et al. 1983). St. Lucie County and Florida Power and Light, Inc. (FPL) support collection and reporting of daily marine turtle nesting data for most of the St. Lucie County coastline including the project area. Martin County provides the same service within its jurisdiction. The project beach provides significant turtle nesting habitat. Analysis of turtle nesting patterns on the four-mile Martin County Shoreline Protection Project (which abuts the south end of the proposed project area) (Ernest and Martin 2004) indicated that the beach nourishment activities there included no long-term impacts to turtle nesting. They found reduced turtle nesting the first year following nourishment, with a rebound the following year.

The beach also provides habitat for a wide variety of shorebirds. The shorebirds use the beach and intertidal areas primarily for loafing and feeding. No nesting has been reported in the general project area (personal communication, Jonathan Gorham, Inwater Research Group, Inc., May 2010).

Nearshore Hardbottom

The nearshore hardbottom exist in a shallow, turbulent, highly dynamic, energetic, and sedimentary environment. The physical stresses of the nearshore habitat limit the biodiversity and survivability of epibenthic species. Much of the nearshore hardbottom habitat experiences frequent burial and exposure by sand, turbidity, and partial or total removal by abrasion from sand transported in longshore currents. However, few studies exist that describe typical exposure periods or other key physical dynamics of this habitat. Olson Associates, Inc. (2003) reported that field measurements recorded changes of over 35% in hardbottom exposure along the entire Brevard County Mid-Reach Beach Nourishment Project shoreline with temporary burial varying between 1 and 100 centimeters in vertical thickness). The St. Lucie County nearshore area experiences similar (though not yet quantified) sand movements (personal communication, Keith Spring, CSA, August 2010). Coastal Tech (Draft Mitigation Plan, Revised September 15, 2010) estimated that approximately 1/3 of the hardbottom remained exposed at any point in time. They did not estimate the typical exposure period.

Several sessile species, predominantly algae, are well adapted to the prevailing environmental conditions of the nearshore hardbottom habitat. These species often cover high portions of the exposed rock. Macroalgae are an important functional group within the near shore hardbottom communities off the east coast of central and southern Florida. CSA (2009) documented reports of nearly 300 different species of macroalgae within these near shore hardbottom communities. Macroalgae serve as a dominant primary producer within near shore hardbottom and provide foraging habitat for sea turtles, mollusks and fish (CSA 2009). Surveying hardbottom habitat one mile north of the project area, Dial Cordy and Associates (2010 unpublished data), identified seven dominant macroalgae genera, *P. lapidosa*, and turf algae dominating the habitat. One octocoral genus (*Leptogorgia* sp*)* occurred within Dial Cordy's transects. Sand or bare rock accounted for about 10% of the transect cover, and turf algae with bryozoans comprised about 2% cover.

Worm rock, created by the sabellarid polychaete *Phragmatopoma lapidosa*, also provides a substantial portion of the hardbottom community. The polychaete forms large gregarious colonies commonly referred to as worm rock or reefs (Kirtley and Tanner 1968, McCarthy 2001). *P. lapidosa* is a keystone species for the near shore hardbottom communities along the east coast of Central Florida. Numerous tiny sabellariid worms construct the low mounding wormrock. Each worm settles onto a hard, durable surface and constructs a protective tube out of the surrounding sand. Each worm attaches its tube to a neighbor's tube, forming large colonies, which grow into mounding reefs. These structures add considerable relief and structural complexity to existing natural hardbottom substrate. The growth of worm rock depends on a combination of available hard substrate, wave energy, sediment availability, and larval supply (McCarthy et al., 2003). Wave impacts from storms can dislodge and destroy much or almost all of the worm rock colonies in an area, but colonies typically reform within a few summers (personal communication, Dan McCarthy, August 2008). Wormrock reefs may host a wide diversity of other polychaete worm, crustacean, mollusk, sponge, bryozoan, and anthozoan species (Gore et al., 1978; Nelson 1989a).

During summer 2008, CSA initiated baseline monitoring efforts for the project nearshore area (CSA 2008). Fish censuses were completed along two quantitative 15m by 2m strip transects perpendicular to the three transects surveyed and one qualitative timed swim along the nearshore hardbottom features. The fish censuses resulted in observations of sergeant major (*Abudefduf saxatilis*), black margate (*Anisotremus surinamensis*), porkfish (*A. virginicus*), sheepshead (*Archosargus probatocephalus*), bar jack (*Caranx ruber*), spottail pinfish (*Diplodus holbrookii*), mojarra (*Eucinostomus* sp.), tomtate (*Haemulon aurolineatum*), hairy blenny (*Labrisomus nuchipinnis*), and highhat (*Pareques acuminatus*). Additional transects surveyed during summer 2009 (CSA 2010) provided observations of 71 species that were primarily reef-associated species, 24 of which are federally-managed species. The most commonly observed fishes were in the grunt family (Haemulidae). CSA (2009) noted that the area hardbottom serves as nursery habitat for these and other species. Hardbottom also functions include spawning, feeding, and sheltering (e.g., ledges, crevices, holes). Cross-shelf distribution generally did not differ in composition, but different assemblages occurred at transects on hardbottom farther from shore (i.e., in deeper water). CSA (2010a) provided a full report on field survey of 19 shore-perpendicular transects and nearshore hardbottom edge mapping.

Offshore Borrow Area

The offshore borrow area comprises the end of the St. Lucie Shoal nearest the coastline. The full shoal extends north -northeast from the proposed project borrow area to a point approximately six miles offshore of the Florida shoreline. Only the proposed borrow area lies within state waters. The large majority of the shoal lies in federal waters.

Hammer et al. (2005) provided an extensive reconnaissance study on the federal portion of the coastal shelf three to eight miles offshore of Brevard, Indian River, St. Lucie, and Martin Counties. They characterized the benthic infauna community as follows:

> *Infaunal organisms inhabiting inner shelf waters offshore central east Florida predominantly consist of members of the major invertebrate groups that commonly inhabit sand bottom marine ecosystems, including crustaceans, echinoderms, mollusks, and polychaetous annelids. Infaunal assemblages that inhabit shelf waters of the study area include taxa common to much of the South Atlantic Bight (SAB) (Tenore, 1985; Weston, 1988; Barry A. Vittor & Associates, Inc., 1991, 2000), eastern Gulf of Mexico (Dames & Moore, 1979), and tropical areas of southern Florida and the Caribbean (Foster, 1971; Camp et al., 1998). Generally, inner shelf infaunal assemblages are numerically dominated by polychaetes in terms of overall abundance and taxa (Day et al., 1971; Tenore, 1985; Weston, 1988; Barry A. Vittor & Associates, Inc., 1990, 1991, 2000). Other conspicuous members of the coastal infaunal community include amphipod crustaceans and bivalve mollusks. Infauna that inhabit sand bottoms in the study area are similar to marine assemblages in other regions in that they comprise assemblages that exhibit spatial and seasonal variability in their distributions.*

CPE (2006) identified five potential borrow sites along the St. Lucie Shoal that may contain a 6 to 7 meter layer of suitable sand with grain size distributions similar to beach sand. Sampling revealed that sediments exhibited little variability between sampling stations. Therefore, biological assemblages within each sand resource area likewise may exhibit relative homogeneity.

The ecosystems of the offshore shoals in the coastal shelf between Cape Canaveral and Jupiter inlet have received little basic research attention. Gilmore (2009) has provided the most comprehensive and current assessment of the available information. That report includes unpublished studies, reports, theses and previously unanalyzed fish capture/observation data from the continental shelf between Cape Canaveral and Jupiter Inlet as the basis for his conclusion that the offshore sand shoals serve as aggregation and spawning sites for schooling planktivorous fishes that support regional pelagic fisheries, such as mackerel fisheries. The unpublished local work “revealed a direct link between shoals, planktivorous fishes, and planktivorous fish predators that support the region's largest commercial fishery." Pelagic fishes such as bluefish, cobia, jack crevalle, and king and Spanish mackerels are important economically and ecologically in eastern Florida shelf waters. Gilmore (2009) stated:

> *Shoals from Cape Canaveral south to Gilbert Shoal north of St. Lucie Inlet (includes Thomas, Indian River, Capron, St. Lucie, and Pierce Shoals) act as predictable habitat for specific fish species. These species are mostly schooling planktivorous fishes (clupeids: thread herring, Spanish sardine, scaled sardine, menhaden; engraulids: Cuban anchovy; and carangids: Atlantic bumper, mackerel scad) that feed the major offshore mackerel, jack, billfish and tuna fisheries. However, periodic use by inshore open bottom fishes such as the kingfish (= whitings Menticirrhus spp.), pompano, sand/silver seatrout and red drum occurs with repetitive seasonal observations*.

Managed Fisheries

Species or species groups managed by the South Atlantic Fisheries Management Council (SAFMC) and occurring in the project area include penaeid and rock shrimps, golden crab, spiny lobster, corals, coral reefs, and hard/live bottom areas, red drum, coastal pelagic fishes, reef fishes (snapper-grouper management unit), highly migratory species, and *Sargassum*. Although some of these species or groups do not normally inhabit the sand resource areas, most of them will traverse the water column as planktonic early life stages.

Threatened and Endangered Species

Endangered or threatened marine species that may occur in the project area include the smalltooth sawfish, five species of sea turtles, the Florida manatee, the North Atlantic right whale, and the humpback whale.

The smalltooth sawfish, an endangered demersal fish species, typically inhabits shallow, nearshore waters but also occurs in offshore coastal waters (NMFS 2009). Historically, its population has declined and its range has contracted, mainly due to fisheries bycatch, habitat loss and degradation, entanglement in marine debris, pollution, and anthropogenic disturbance (NMFS 2009). These widespread ongoing impacts will likely continue. Turbidity and noise during construction activities may disturb the smalltooth sawfish and a hopper dredge draghead could entrain individuals. However, individuals may likely avoid construction areas and return after the disturbance has passed. All dredging and beach fill projects in the region comply with "Sea Turtle and Smalltooth Sawfish Construction Conditions" (NMFS 2006), which should significantly reduce risks to this species from dredging.

Five endangered or threatened sea turtle species occur in the area (loggerhead, green, hawksbill, Kemp's ridley, and leatherback). Loggerhead, green, and leatherback turtles nest on project area beaches. High levels of turtle nesting occur in south St. Lucie

County within the project area. Loggerhead, green, and leatherback turtles account for all nests in the southern portion of the project area (EAI 2007, 2008, 2009).

Between 2000 and 2009, loggerhead turtle nests accounted for 91.2 % of the total sea turtle nests in the project area, followed by green sea turtle nests (7%), and leatherbacks sea turtle nests (1.8 %). In 2009, turtles created 2,942 nests between FDEP Monuments R-84 in St. Lucie County and R-7 in Martin County, a 7-mile beach stretch including the project area. During the five previous nesting seasons for which data are available (2004, 2005, 2006, 2007, and 2008), project area nests totaled 2,620; 2,857; 2,288; 2,810; and 2,634, respectively (personal communications, Jonathan Gorham, Inwater Research Group, Inc., May 17, 2010; Beth Brost, FWC, July 1, 2010).

The project area lies within two Statewide Nesting Beach Survey (SNBS) zones: North Hutchison Island (24.5 kilometers) in St Lucie County and South Hutchison Island (12 kilometers) in Martin County. According to the Fish and Wildlife Research Institute (FWRI 2008, 2010) between 1993 and 2009, 76,040 loggerhead turtles (an average of 4,473 per nesting season), 2,902 green sea turtles (an average of 171 per nesting season), and 1,296 leatherback turtles (an average of 76 per nesting season) nested on the beaches of the northern Hutchinson Island in St Lucie County. Between 1993 and 2009, 28,538 loggerhead turtles (an average of 1,679 per nesting season), 935 green sea turtles (an average of 55 per nesting season), and 1244 leatherback turtles (an average of 73 per nesting season) nested on the beaches of south Hutchinson Island, Martin County (FWRI 2008, 2010).

Juvenile green turtles use nearshore hardbottom ledges for feeding (macroalgae), resting, and shelter from predators. All species use the U.S. Atlantic coastal shelf, including the proposed borrow area, as part of their habitat. Species recovery plans indicate that past and current threats to sea turtle populations include artificial lighting, beach armoring, anthropogenic disturbance, trawling, dredging, vessel strikes, fishing gear entanglement, and ingestion of marine debris (NMFS and USFWS, 1991a, 1991b, 1992a, 1992b, 1993, 2008). These impacts are widespread, diffuse, and ongoing in the region and beyond.

Three endangered marine mammal species may occur in the area: the Florida manatee, North Atlantic right whale and humpback whale. Of these, only the manatee is common regionally. Manatees are usually found in quiescent inshore waters and are an unlikely presence in the nearshore or offshore borrow areas. The two endangered whales are rare and may occur seasonally (December – March) (NMFS and USFWS 1991c, 2005).

Historically, the most significant threat presently faced by Florida manatees is death or serious injury from boat strikes (USFWS 2001). Other known causes of manatee deaths include entrapment or crushing in water control structures and navigational locks, poaching and vandalism, entanglement in shrimp nets, monofilament line (and other fishing gear), entrapment in culverts and pipes, and ingestion of debris. Natural causes of death include disease, parasitism, reproductive complications, and other non-human-related injuries, as well as occasional exposure to cold and red tide. Vessel strikes will continue to provide a very significant threat to the Florida manatee population regardless of whether this project is conducted.

Northern right whales occur as seasonal (winter and early spring) residents in the offshore regional waters. Humpback whales could occur as occasional transients (strays), primarily during winter. Generally, the probability of encountering these species in the study area would be lowest during summer and highest between December and March when North Atlantic right whales typically reside in waters of the study area (Kraus et al. 1993, Slay et al. 1998). For humpback whales and right whales, ship collisions and fishing gear entanglements are the most common anthropogenic causes of mortality (NMFS 1991c, 2005). Other potential threats are habitat degradation, noise, contaminants, underwater explosive activities, climate and ecosystem change, and commercial exploitation. These impacts are widespread, diffuse, and ongoing.

Any vessel striking a manatee or North Atlantic right whale represents a significant cumulative impact because the existing populations are so small. To reduce the risk of vessel strikes to marine mammals, federal permits require that all Atlantic Ocean dredging and beach fill projects comply with the "Vessel Strike Avoidance Measures and Reporting for Mariners" issued by NOAA Fisheries, Southeast Region. The measures include the use of trained and NMFS-approved protected species observers during all dredging operations. Training for vessel operators and crews include maintaining a constant lookout for marine mammals during transits and maneuvers. With these mitigation measures in place, a much reduced potential for marine mammal "takes" due to vessel strikes should occur.

8. IMPORTANT CAUSE-AND-EFFECT RELATIONSHIPS BETWEEN HUMAN ACTIVITIES AND RESOURCES, ECOSYSTEMS, AND HUMAN COMMUNITIES

Causal relationships are very difficult to determine when multiple actions and resources are involved (CEQ 1997). Beach nourishment may generate multiple indirect impacts. These indirect effects include consequence of increased beachfront development and recreational uses, changes in the physical characteristics of the beach, the formation of escarpments, and future sand migration (USFWS 2005). Biological impacts of beach nourishment activities include diminished reproductive success, reduction in biomass of prey food items, and long-term changes to substrate composition at sand dredging and beach placement sites (Jutte and Van Dolah 1999, Peterson and Manning 2001).

Human activities that potentially may, and principally do result in substantial effects to the nearshore hardbottom communities in the project impact area include shore protection, pollution, mechanical destruction, and overfishing. Of these, shore protection (beach nourishment) and mechanical destruction activities are most relevant.

If constructed at approximately the same time as a St. Lucie County project, a Martin County project that begins at the southern terminus of the proposed project area could reduce the erosion rate of a beach nourishment project within the proposed area. In addition, sand transported downdrift from the St. Lucie County project would help maintain the Martin County project.

Dredging, filling, anchoring, and other anthropogenic activities leading to changes in a reef environment or reef destruction may increase the incidence of ciguatera, known to occur irrespective of season along the Florida east coast, including locations near the study area (de Sylva 1994). Dredging causes suspension of sediments and creates a plume that drifts with water currents. The extent of suspension/dispersion depends on a multitude of factors, including the type of dredging equipment, techniques for operating the equipment, amount of dredging, thickness of the dredged layer, sediment composition, and sediment transport processes. Although turbidity plumes associated with dredging often are short-lived and affect relatively small areas (Cronin et al. 1970, Nichols et al. 1990), resuspension and dispersion of dredged sediments by subsequent currents and waves can propagate dredge-related turbidity for extended periods after dredging ends (Onuf 1994). Biological responses to turbidity depend on all of these physical factors coupled with the types of organisms affected, geographic locations, and the time of year.

Pollution would adversely affect the hardbottom biota. Sources of pollution may include heated water discharges from the FPL power plant located about 1 mile north of the project northern boundary and stormwater outfalls upon the beach, particularly from multifamily condominium developments with large parking lots.

The County and/or private landowners could propose shore protection by structural means (e.g. revetments, , groins, breakwaters,) should no beach project occur in the foreseeable future. Seawalls are prohibited by St. Lucie County ordinance. Revetments could increase shoreline erosion, increasing downdrift sand transport and burial of downdrift hardbottom, and reduce turtle nesting habitat. Groins and breakwaters could (a) cover hardbottom habitat beneath their footprint (b) capture sand that results in direct hardbottom burial and reduction in supply of sand to downdrift beaches (c) impact survival of hatchling sea turtles.

Shore protection by beach nourishment could directly impact nearshore hardbottom habitat during sand placement; create turbidity during sand placement, indirectly impact hardbottom through increasing sedimentation / burial of hardbottom by longshore and cross shore fill sand transport,

Significant mechanical destruction of the hardbottom (by dredging or displacement, etc.) could, but would not likely occur during construction. Best management practices include placement of the dredge pipelines necessary to transfer sand from the hopper dredge to the beach to avoid all hardbottom impacts unless no other location for pipe placement is available. Preconstruction site surveys for pipe placement would identify sand “avenues” that avoid hardbottom impacts.

Mechanical disturbance of the seabed provides the primary impact-producing factor at offshore sand borrow sites (Hammer et al. 2005). This physical disruption includes removal, suspension/dispersion, and deposition of dredged material, which may make the benthic environment less suitable for some species and better for others. Physical removal of sediments from a borrow site removes benthic habitat, along with infauna and epibiota that are incapable of avoiding the dredge, resulting in drastic reductions in individuals, species, and community biomass. Extraction of habitat and biological resources may in turn disrupt the functioning of associated communities within the ecosystem. Benthic resources are an important link in the food web for commercially and recreationally important fishes. Invertebrates contribute to the pelagic environment through benthic-pelagic coupling mechanisms. These mechanisms include larval transport and diurnal strategies, and behavioral patterns of other members of the assemblage (Hammer and Zimmerman 1979, Hammer 1981).

In some cases dredging borrow sites may create new and different habitats from surrounding substrates, which could result in beneficial impacts in terms of increased habitat complexity and biodiversity of an area. Removal of sand resources can also expose underlying sediments and change the sediment structure and composition of a borrow site, consequently altering its suitability for burrowing, feeding, or larval settlement of some benthic organisms. NRC (1995) reported that many studies show decreases in mean grain size and in some cases increases in silt and clay in borrow sites following dredging. Changes in sediment composition could potentially prevent recovery to an assemblage similar to that which occurred in the borrow site before dredging and could, by implication, affect the nature and abundance of food organisms for commercial and recreational fishery stocks (Coastline Surveys Limited 1998, Newell et al. 1998). Selective bottom feeders could be affected due to removal of specific prey species from borrow sites.

Removing sediments from borrow sites will temporarily and may permanently alter seabed topography, creating pits that may refill rapidly or cause detrimental impacts for extended periods. A deep borrow pit with reduced current velocity (compared to the surrounding bottom) can create conditions favorable for settlement of fine particulate matter. This altered benthic environment may develop a biological assemblage much different in composition from the original. Turbidity during dredging and increased water depths after dredging may reduce the photic zone for benthic and planktonic primary producers. Deep holes may decrease dissolved oxygen to hypoxic or anoxic levels and increase hydrogen sulfide levels (Murawski 1969, Saloman 1974, NRC 1995).

Anecdotal information suggests that recreational beach (surf) fishing, although popular in the project area, does not yield unusually frequent or abundant quantities of fish. Likelihood of significant impacts on this activity will likely remain low.

Mechanical and beach lighting activities along the beach can adversely impact marine turtle nesting by (1) physical impact, (2) burial, inundation and/or exposure of nests, (3) establishment of beach sediment that is not compatible with nesting, and (4) disorientation.

Direct burial of nearshore hardbottom will result in mortality of macroalgae and faunal epibenthic species, as well direct burial of newly settled life stages of fishes. Suspension of sediment may cause mortality of eggs and larvae of marine and estuarine fish, and a reduction in feeding in juvenile and adult fish. Potential burial of as much as 6.97 acres of nearshore hardbottom habitat may reduce settlement and shelter of juvenile fish and other planktonic taxa that would otherwise settle and grow on the buried hardbottom. Reduced feeding success may influence survival, year-class strength, and recruitment of juvenile fish that inhabit nearshore hardbottom. Foraging sea turtles and fish will move away to hardbottom habitat outside the impact area.

For these reasons, the proposed beach nourishment action includes compensatory mitigation to replace ecological functions lost with the temporary or permanent, partial or total burial of a potential maximum of 6.97 acres of nearshore hardbottom.

Depending on project location, other beach nourishment projects may impact and benefit resources in the proposed project area. The longshore current (and associated sand transport) along Hutchinson Island flows predominantly south (although it may also flow north). As sand placed on beaches north of the proposed project erodes and moves south, that sand may temporarily bury nearshore hardbottom. Conversely, that same sand may help maintain intertidal and upper beach habitat that supports shorebirds and nesting sea turtles. By the same token, the proposed project may have similar effects on beach and nearshore hardbottom habitats south of the project area.

9. MAGNITUDE AND SIGNIFICANCE OF CUMULATIVE EFFECTS

The potential for resources, ecosystems, and/or human communities to sustain their structure and function depends on resistance to stress and resilience (CEQ 1997). The magnitude and significance of cumulative effects are functions of the context of the effects and severity of the effects (CEQ 1997). The CEQ (40 CFR § 1508.27) states, "the significance of an action must be analyzed in several contexts such as society as a whole (human, national), the affected region, affected interests, and the locality".

Any of the alternatives considered in detail may include cumulative effects, particularly to Hutchinson Island property owners, to St. Lucie County, and to beachgoers to Hutchinson Island. Such a project may also impact anyone using or planning to use the resources offered by the beaches, nearshore hardbottom, and offshore habitats associated with the project. The project may include cumulative impacts to species listed as threatened and endangered under the Endangered Species Act of 1973, particularly smalltooth sawfish, sea turtles, manatees, and right and humpback whales. In addition, the project and future projects may impact coastal shelf fishes and ecosystems.

Should the County not nourish the beach and allow ongoing erosion, cumulative impacts to local residents, visitors to the beaches, and local governments would likely exceed those created by any of the alternatives considered in detail. Loss of the beaches, adjacent infrastructure, and the economy associated with those resources could prove a significant blow to the local economy and result in less than desirable solutions (e.g. seawalls, revetments) that would not replace the beach and would provide less effective protection than a nourished beach. The no action scenario would leave hardbottom and offshore resources unaffected.

Based upon 2008 and 2010 hardbottom maps (CSA 2008, Taylor Engineering, Inc. 2011), and fieldwork (CSA 2010a, b) the project impact area consists of a matrix of two different hardbottom communities. Community One (HB1) characteristics include low- to medium-relief limerock ledges relatively close to the shoreline. Wormrock communities are a primary characteristic of this community along with a large percentage cover of robust, canopy-forming red algae. Community Two (HB2) included low to medium relief nearshore hard bottom ledges generally lower in relief than HB1. This community included a lower percent cover of floral and faunal species. HB2, dominated by the low growing and often sporadic turf, lacked the substantial ecological contribution provided by wormrock and robust macroalgae observed in HB1. This community generally occurred seaward of HB1. A third, relatively persistent hardbottom community with medium (1-2m) relief (HB3) occurs along the seaward edge of the nearshore hardbottom area farther seaward than HB1 or HB2 (CSA 2010a). The applicant's preferred plan would likely impact 0.57 acres of HB2. . Other alternatives have greater or lesser impacts depending primarily on the amount of sand placed on the beach and in what locations. HB3, the relatively persistent hardbottom community, would not likely experience direct impacts or cumulative impacts due to the distance of that habitat from the shoreline. Between nourishment projects, direct impacts (hardbottom burial) may decrease substantially due to longshore and cross-shore sand transport processes that transport the sand away from the project area. For mitigation planning purposes, the applicant has assumed permanent impacts to likely impacted and potentially- impacted hardbottom.

Cumulatively, the project may also impact downdrift hardbottom, particularly in the nearshore of Hutchinson Island in Martin County. Two nearby USACE Shore Protection Projects provide one basis to assess possible cumulative impacts in the project area. The Ft. Pierce Shore Protection Project area lies about 8 miles north of the proposed project area and about 13 miles north of the Martin County Shore Protection Project. The Ft. Pierce beach and dune renourishment projects have occurred periodically since 1971 with relatively large nourishments occurring every few years since 1995 (Table 3). These sands pass southward along the shoreline with predominantly southward longshore currents. Aerial mapping of hardbottom extents in 1997, 2001, 2004, and 2008 aerials for the Ft. Pierce project extent and annual physical monitoring of Martin County Shore Protection Project hardbottom resources since 1996 (Maguire 2009) have identified little overall change in hardbottom exposure.

Medium) relief (6.5 ft) mitigation reefs in deeper waters have proven successful in developing complex, diverse benthic and pelagic communities (e.g. Bohnsack et al 1994; Harris and Dillon 2008 describing St. Lucie County mitigation reefs). The applicant proposes placement of low relief mitigation reefs in nearshore waters (5 meters / 16.4 feet depth), a relatively new approach to hardbottom mitigation on the east coast of Florida. Little information exists to predict potential performance. Thus, impacts to hardbottom carry even greater significance because of the uncertainty associated with the performance of low relief mitigation structures in shallow nearshore environments.

Mitigation reefs proposed for this project may not replace all (100%) of ecological functions for the same suite of species or life stages that exist on natural reefs in shallower water. Differences between the impacted area and the proposed mitigation site in substrate characteristics, water depth, wave energy, light penetration, turbidity, and other factors may result in development of a different biological community. In addition, colonization of newly available substrate by marine planktonic species involves a certain amount of chance that any individual propagule or specific set of species will find and settle on any particular substrate or location. However, over time the mitigation structures will likely provide sufficient permanent low-relief reef community to offset cumulative impacts from the project selected from among the alternatives and expected future projects in the same location. Detailed, quantitative monitoring and comparison of monitoring results to specific success criteria will provide regulatory agencies the ability to determine the success of the project. The applicant has also proposed a contingency mitigation plan should the mitigation hardbottom perform below specific expectations detailed in their mitigation plan.

Hammer et al. (2005) concluded that proposed sand mining will likely have a negligible impact on large-scale circulation along the shelf. The proposed sand mining locations are small relative to the entire shelf area, and project-related dredging is designed to minimize changes to the shoal features. The estimated volume required for the alternative with the greatest sand requirements would not include enough material to alter major bathymetric features in the region. Therefore, the forces and/or geometric features that principally affect circulation patterns will remain relatively unchanged. Natural changes may continue to occur and potentially reduce the changes created by dredging. Krecic et al (2007) found that major storms in 2004 rearranged bathymetric profiles in depths of 30 – 60 feet seven miles offshore of St. Johns County, Florida.

The importance of offshore sand shoal habitats to fishes, sea turtles and other organisms is largely unknown. Repetitive dredging of offshore shoal habitats for multiple nourishment projects could potentially impact fish and wildlife species that use those resources. Coastal managers and commercial and recreational fishermen are concerned that losing this habitat would lead to a decline in local fisheries and possibly a loss of local productivity (Gilmore 2009). Additional potential negative effects of dredging on sea turtles include disrupted feeding ability and loss of prey, interference with underwater resting areas, noise disruption, and possible collision or entrainment with dredging equipment (MMS 1999).

That the applicant, Martin Counties, and others may consider dredging sand for proposed beach nourishment projects from some of the same general areas increases the potential for cumulative impacts - due to repeated dredging in a borrow area within short periods. This may not give the benthic community time to recover or reduce local levels of recolonizing propagules of benthic invertebrates. Dredging involves the complete removal of sediment, which leads to direct mortality to the benthic infauna that live in the substrate. If wave patterns and sediment transport mechanisms are altered near the borrow site following dredging, physical changes to the seafloor geomorphology can take place (e.g., substrate type and composition, surface texture, water circulation, and nutrient distribution) (Greene 2002). Such changes may reduce the ability of benthic flora and fauna to adapt to the existing conditions. Additionally, subsequent dredging in areas close to each other may result in impacts to potential adult organism recruitment to the dredged areas, further lengthening the time for recovery in an area (MMS 1999). However, if most nourishment projects in the region rely on offshore sources, the shoals may disappear, as the sand stored in the shoals are barely equivalent to current 50-year need projections (Taylor Engineering 2009a). Local dredging projects have largely deflated Gilbert Shoal. Gilmore (2009) hypothesized that deflation of a large fraction of or all the shoals could have an enormous impact of the coastal shelf ecosystem. Kelley et al (2004) and Hammer et al. (2005) assessed the effects of deflation level dredging on wave climate, and recommended that more modest dredging would allow the wave climate to remain relatively unaltered. Dibajnia and Nairn (2010) concluded that short of complete shoal removal, they could not identify a threshold of shoal “collapse”. Their research suggested that at least for the area they studied, for shoals less than 30 m (98 ft) deep the shoal would reform to or close to its former elevation (albeit with less sand) following dredging.

Many factors unrelated to dredging sand from borrow areas may affect benthic resources. The factors may include natural events such as natural population cycles or favorable or negative weather conditions (e.g. La Niña, El Niño, and major storms or hurricanes). These global events potentially can have far greater impacts on these resources at the population level than relatively local, small-scale activities such as removing sand from a given borrow area. When examining the cumulative effects other factors may far outweigh the potential incremental effects of borrow dredging of sand on benthic or fish populations.

The lack of knowledge concerning ecosystems associated with coastal shelf sand shoals, particularly with respect to the fish community and their uses of these shoals, presents a more significant cumulative impact issue, particularly when considering potential cumulative impacts of repeated dredging events. This lack of understanding raises the significance of those potential impacts because without additional knowledge, prediction of how much dredging, or in what areas, may or may not impact the ecosystem, and to what degree those impacts may accumulate over time is impossible. As noted in Gilmore (2008, 2009):

> *Shoal removal may or may not impact the local faunal diversity and fishery production if only specific portions of the shoals that are not known spawning or feeding sites are removed. It is likely that there is local geographic variation in fish distribution in association with shoals. Until this is known, the impact of entire or proportional shoal removal on particular*

fish and fisheries is unknown….Shoal removal should be weighed against potential impacts on valuable pelagic fisheries and highly migratory species. Partial shoal removal may be an option if sufficient new information defines the relative value of portions of a particular shoal to regional fish and fisheries.

As recommended by Diaz et al. (2003, 2004), the applicant proposes maintaining a significant portion of the shoal borrow area, including the highest elevation, as a refuge; the proposed dredging design avoids impacts to that area (Figure 4). Based on current expert opinion in the matter this project minimizes impacts as the dredging footprint avoids shoal removal (elimination of the entire shoal within the general borrow area) and maintains a significant and complete shoal cross section. However, this assumes that the refuge will not incur indirect impact from dredging. All future projects must also avoid disturbing the proposed refuge area and should always include refuge areas as a part of shoal dredging design. The conceptual 50-year dredging plan proposed by the applicant (Coastal Tech 2009) continues the refuge concept in other potential borrow locations along the St. Lucie Shoal (Figure 4). All other dredging projects will have to avoid dredging these refuge areas to hope to avoid potential cumulative impacts. This assumes that current hypotheses are correct (that refuges can avoid or minimize cumulative impacts), which only specific research may prove or disprove. Thus, the potential cumulative impacts to offshore shoal ecosystem functions appear the most significant of the set of cumulative impacts this project may produce.

In a letter to Colonel Joe R. Miller, USACE Jacksonville District Engineer, 70 concerned scientists wrote that:

The paradigm for managing beach systems of the southeastern United States using frequent and massive dredge and fill projects ("renourishments") may have significant cumulative effects upon coastal habitat quality and fisheries production" (Environmental Defense 2000). The biological impacts of large and frequent dredge-and-fill operations across the east Florida shelf are of particular concern due to the region's very high biodiversity of invertebrates, algal species, and fishes. Nearshore reefs serve as important recruitment and nursery areas for these flora and fauna and provide important feeding and shelter areas for endangered green sea turtles. There is concern that at the current rates hundreds of acres of shallow reefs along the east coast of Florida will be buried in the next 50 years. There are no studies of the long-term effects of dredge-and-fill projects on these resources. Additionally, potential long-term physical and biological impacts could occur if dredging significantly changes the physiography of offshore shoals.

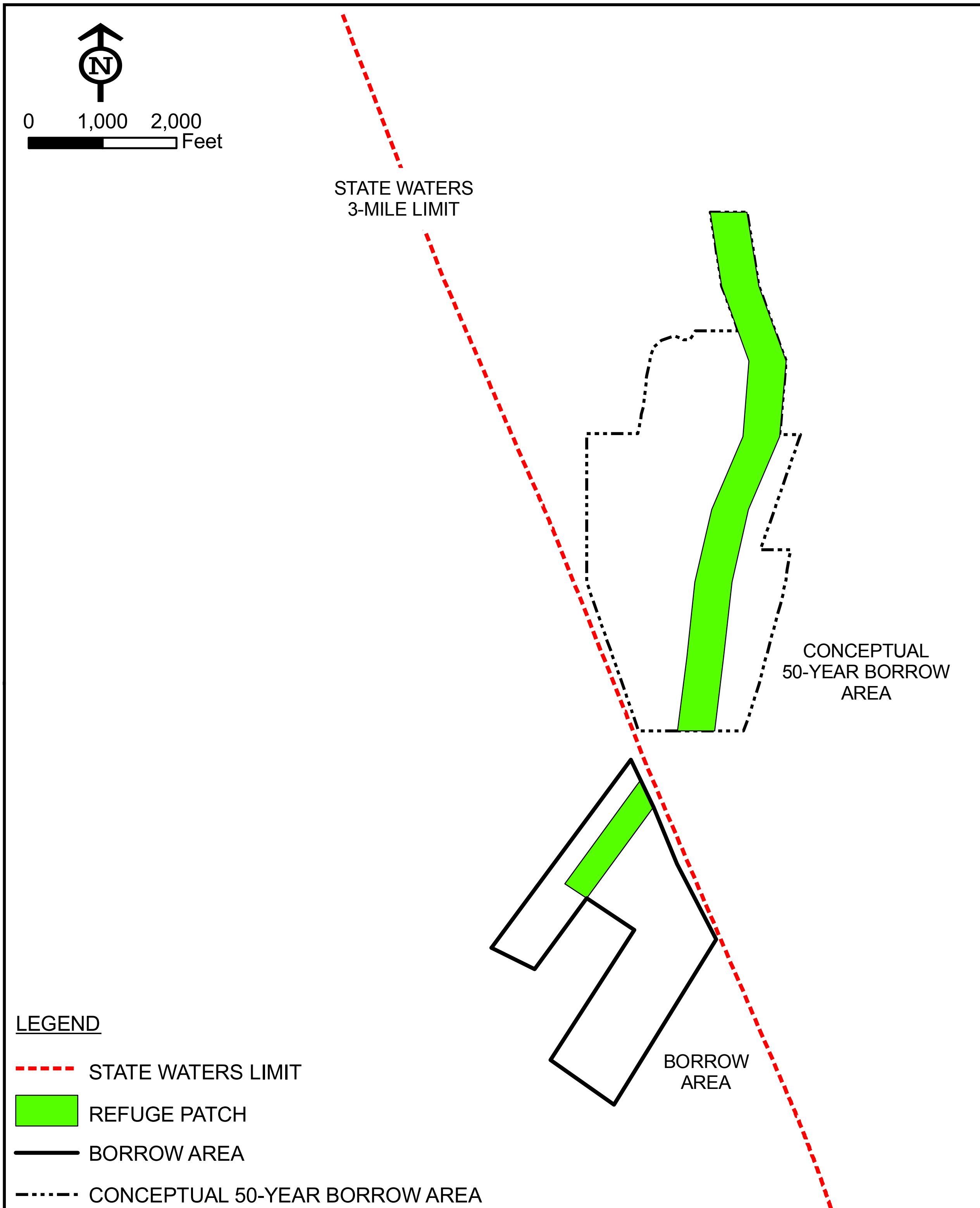
10. ADDITIONAL ALTERNATIVES TO AVOID, MINIMIZE, OR MITIGATE SIGNIFICANT CUMULATIVE EFFECTS

The USACE Regulatory Division has reduced the potential for significant cumulative effects to environmentally sensitive nearshore resources and offshore borrow area resources for the proposed project in consultation with Florida Department of Environmental Protection, Florida Fish and Wildlife Conservation Commission, National Marine Fisheries Service, U.S. Fish & Wildlife Service, Environmental Protection Agency, the Corps of Engineers Planning Divisions, and the Bureau of Ocean Energy Management.

As described in the main text, the Environmental Impact Statement (EIS), for the proposed project considers seven beach-fill project alternatives (one with structures) in addition to other alternatives comprising coastal structures, armoring, reefs, nearshore sand mounds, coastal regulation, retreat, and land acquisition. The ultimate selection of a preferred alternative will balance avoidance and minimization of project-related impacts with maximization of project benefits. Mitigation will account for unavoidable impacts of the selected alternative. Modification of the proposed project mitigation reef may occur as the USACE identifies a final recommended plan and the applicant selects specific a mitigation site or sites and develops detailed (final) engineering plans. Monitoring and adaptive management (including a contingency mitigation plan) will increase the probable long-term success of the reef in replicating displaced ecological function of the impacted nearshore hardbottom.

<u>Project Area Beach</u>

Assessments of impacts to turtles during past restoration projects have largely compared pre- and post-project construction nesting data. Post-project monitoring reports indicate that a reduction in sea turtle nest success was most pronounced the first year following construction. After this period, sea turtle reproductive success rebounded to pre-construction levels (Ernest and Martin 2004). Martin County beaches lie within the peak nesting range for the loggerhead sea turtle, green sea turtle, and leatherback sea turtle. Each of the alternatives considered in detail has the potential to adversely affect nesting females, nests, and hatchlings within the proposed project area. Protective measures and the use of compatible sand sources help ensure the continued existence of suitable nesting habitat for sea turtles without jeopardizing the existence of the species. To avoid and minimize the risk of impacts nesting sea turtles and hatchlings, beach construction activities should begin as soon as possible after the sea turtle nesting season ends (November 1) and end before the beginning of the main nesting season (April 15). USFWS agreed to this period for allowing construction of the beach fill project in other St. Lucie and Martin County projects. Use of minimal lighting on dredge barges (if dredging at night) may help reduce migration interference and collisions with hatchlings when they exit the beach and during their swim offshore (Greene 2002). However, if the project begins in November, all turtles will likely have hatched. However, the same general rule applies to swimming turtles (adults and juveniles) which may be in the project area (either nearshore or offshore). Predation can also be reduced if lighting is minimized, since predatory fish are often attracted to light (such as on well-lit barges). Tilling the sand to reduce compaction also reduces impacts to sea turtle nesting.



TAYLOR ENGINEERING INC. 10151 DEERWOOD PARK BLVD BLDG 300 SUITE 300 JACKSONVILLE, FL 32256	Figure 4 Offshore Borrow Area and Conceptual 50-year Borrow Area St. Lucie County Beach and Dune Restoration Project St. Lucie County, Florida	PROJECT C2010-018 DRAWN BY AC DATE NOVEMBER 2010

11. CUMULATIVE EFFECTS MONITORING AND ADAPTIVE MANAGEMENT

Assuming permit requirements for a finally selected project design remain similar to those of other nearby projects, the applicant will conduct physical and biological monitoring before and after project construction, providing data to evaluate the physical and biological conditions before and after construction, and for some years following construction. The physical monitoring program will measure project performance against the predicted performance, considering changes in elevation and sand distribution in the beach nourishment template, and beyond in the nearshore hardbottom. St. Lucie County maintains a permanent turtle nest monitoring program. Other project-specific biological monitoring activities proposed by the applicant include the nearshore hardbottom, the mitigation reef, and offshore borrow area benthic habitat. The monitoring plan also describes adaptive management actions that the applicant will take in response to results of the monitoring plan. Based on the results of numerous similar projects along the Florida Atlantic coastline, the proposed nourishment activity and its predicted nearshore effects are likely relatively small and reversible. The affected resources of the nearshore hardbottom affected by the proposed sand placement exist in a dynamic environment are adapted to naturally high sedimentation, sand abrasion, turbidity, cyclical sand burial and subsequent exposure. The physical and temporal scales of the sand placement and resultant impacts to the beach and nearshore hardbottom are relatively small. The scale of the project can be readily adapted to respond to the monitored effects of the project's action, relative to the predicted effects described herein.

The project shall likewise implement monitoring during construction attendant to threatened and endangered species protection, turbidity, cultural resources, beach compaction, beach lighting and marine turtle nesting and success, sediment-quality assurance, and dredge location and control. These monitoring activities are described in Coastal Tech (2009: Physical Monitoring Plan, Biological Monitoring Plan). Specific impact and mitigation values listed in those plans have not received final approval from USACE regulatory staff at the time of this cumulative effects assessment). Note that each plan includes prescribed measures for monitoring and real-time response (adaptive management) to the monitoring observations. Various coastal projects have successfully used very similar monitoring protocols and measures for projects constructed within the affected region and elsewhere throughout the State of Florida.

In general, the literature describes an absence of data regarding ecological functions within potential shoal borrow areas (Greene 2002; Drucker et al. 2004; Michel 2004; Nordstrom 2005; Peterson and Bishop 2005; Thayer and Kentula 2005; Speybroeck et al 2006; Gilmore 2008, 2009). The cumulative project effects on the offshore borrow area are known with less certainty due to a lack of data concerning the coastal shelf ecosystem and the role of the shoals in ecosystem function. Those potential cumulative effects are therefore more significant as the proposed actions and others like it will create unknown impacts that may or not prove amenable to mitigation. Further, existing data suggests that without other sand supplies the projected projects will deflate the entire shoals system. Beach nourishment project regulatory requirements and the cost of environmental monitoring in the beach and offshore environments are important factors in the lack of data and understanding about the true implications and impacts to the ecological communities. In most cases, projects rely on minimally-developed baseline studies followed by short post-construction monitoring periods. Most projects in the past have developed physical data to identify deposits of sufficient quality and at best have recognized existing literature concerning rapid redevelopment of benthic communities. Past projects have not typically included borrow area monitoring of any kind.

Information needs to reduce the potential for cumulative impacts of shoal dredging include research on fisheries uses of the shoals in undisturbed areas and already dredged locations (such as Capron Shoals) over a range of depths may allow identification of general uses of these habitats, key habitat components, and sensitive species. Nordstrom (2005) suggested that data on changes in sediment characteristics, redevelopment of faunal communities and differences in pre- and post-dredge communities, spatial and temporal habitat uses and faunal cycles, ecological relationships among flora and fauna, and behavior of the affected species with respect to site fidelity are among the key factors necessary to understand the shoal environment. Nordstrom (2005) also suggested that without these long-term data, negative ecological impacts cannot be considered minimal. The process of attaching monitoring requirements to individual permits may not provide adequate evaluation of cumulative impact (Nordstrom 2005, Peterson and Bishop 2005). Grober (1992) suggested that to determine the full effects of beach nourishment, simultaneous short- and long-term monitoring of three areas: borrow area, nearshore habitat and the beach. Monitoring is especially necessary in areas not previously sampled or in new project areas.

Project sponsors should develop monitoring programs that are appropriate to the scale of the nourishment programs and use the data appropriately to make project related decisions (NRC 1995). The scale (and related costs) at which beach nourishment now occurs suggests that regional cooperation in monitoring (e.g. through a multi-county, state, and federal funding agreement) might provide a feasible means for all the project owners and sponsors to obtain and use the information necessary to make appropriate decisions. Such an approach would decrease overall costs for each entity. Of greater importance, such an approach would provide a platform to develop a data-driven regional plan for beach nourishment and development of sand resources that better supports environmental impact avoidance and minimization.

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