habitat heterogeneity, which in turn is reflected in increased biomass, greater species abundance, and increased biodiversity (Peters and Nelson, 1987; Luckhurst and Luckhurst, 1978; Vare, 1991). Evaluating the biological community associated with a nearshore rock outcrop requires consideration of habitat stability (permanence) and the structural complexity (rugosity and/or profile characteristics) of the specific outcrop.

The epibenthic community associated with low profile, smooth, intertidal and subtidal rock outcrops is best characterized as an algal mat community dominated by a number of filamentous algal species, including *Cladophora* sp., *Chaetomorpha linum*, and *Gelidiopsis panicularis*. Other algal species observed commonly only on subtidal rocks include *Jania rubens*, *Wrangelia argus*, and *Bryothamnion seaforthii*. The green algae *Ulva lactuca* and the barnacle *Tetraclita squamosa* are dominant species on exposed intertidal rocks (Continental Shelf Associates, Inc., 1984). Along rock outcrops offering greater profile, the algal community is dominated by *Caulerpa sertularioides, Dasycladus vermicularis, Padina* sp., *Dictyota* sp., *Halimeda* sp., and *Lyngbya* sp. (Vare, 1991). Other large macroalgal species characteristic of southeast Florida nearshore rock outcrops are *Bryothamnion seaforthii, Wrangelia argus, Codium* sp., *Gracilaria* sp., and *Caulerpa racemosa* (Continental Shelf Associates, Inc., 1985). The type of marine algae present at a given location is dependent upon the chemical nature of the substratum and the physical nature of the environment at that location. Taylor (1979) suggest that along the nearshore rock outcrops of southeast Florida, wave action and sand scouring are the factors controlling algal community distribution.

Comparisons of an April and December survey of the algal mat community at Boca Raton indicate there is a decline in the number of algal species present, a shift in the dominant species, and a slight decrease in the algal coverage. Algal species that appeared more prevalent during the winter survey were *C. racemosa, Padina profunda, C. mexicana, B. seaforthii,* and *Dictyota* sp. *Wrangelia argus,* which was very common on the Boca Raton rock platform in April, was quite rare during December (Continental Shelf Associates, Inc., 1985).

Vare (1991) listed a total of 42 encrusting and 33 non-encrusting macro invertebrate species found along the nearshore rock outcrops of Palm Beach County. Six phyla were observed to predominate at the stations he quantitatively analyzed. In order of descending percent composition these were: Cnidaria 45 percent (Hydrozoa 26 percent and Anthozoa 19 percent); Porifera 17 percent; Mollusca 11 percent; Arthropoda 11 percent; Echinodermata 9 percent; and Annelida 7 percent. Those species with the highest frequency of occurrence were the star coral *(Siderastrea radians)*, various species of wine glass hydroids *(Campanularia* spp.), several species of tube type sponges, the boring sponge *Cliona celata,* the worm rock building polychaete *Phragmatopoma lapidosa,* and the fire coral hydroid *Millipora alcicornis* (Vare, 1991). The encrusting macroinvertebrate community does not appear to vary significantly by season (Continental Shelf Associates, Inc., 1985). Mobile epibenthic species such as sea urchins, brachyuran and xanthid crabs, and the Florida lobster, *Panulirus argus* were more frequently observed in the spring and summer than in the winter. Most of these species were seen in holes and crevices along the vertical face of rock outcroppings (Continental Shelf Associates, Inc., 1985; Vare, 1991).

Worm rocks formed by colonies of *Phragmatopoma lapidosa* have been described from Cape Canaveral to as far south as the Cape Florida Lighthouse on Key Biscayne (Kirtley and Tanner, 1968). These polychaetes live in tubes, which they build about themselves by cementing sand grains together. They are quite common along Palm Beach and northern Broward counties, and in some areas they build large and biologically significant structures called "worm rock reefs." *Phragmatopoma lapidosa* requires constant high-energy wave action to supply food, remove waste products, and maintain the suspension of sand grains required for tube building. Generally, worm rock colonies are seen on hard substrate in the near intertidal, along rock jetties, and around the mouths of inlets. Worm rock supports a diverse assemblage of other invertebrate species and in some cases provides habitat for juvenile and cryptic fish species (Kirtley, 1974; Gore *et al.*, 1978; van Montfrans, 1981; Gilmore *et al.*, 1981). Rudolph (1977) observed 88 species of other polycheate annelids living in association with worm rock reefs. Gore *et al.* (1978) and van Montfrans (1981) described a rich decapod crustacean community associated with the worm rock habitat. By providing hard and stable substrate, shelter, and food, worm rock colonies allow many species to inhabit the surf zone that otherwise would be unable to survive there (Gore *et al.*, 1978).

Fish assemblages associated with beach rock outcrops along the southeastern Florida coastline essentially comprise a mixture of coastal pelagic, surf zone, and reef fishes attracted to the cover and food source provided by these nearshore hard substrates. The coastal pelagic species seen are primarily migratory species, including the Spanish mackerel, *Scomberomorus maculatus*; bluefish, *Pomatomus saltatrix*; mullets, *Mugil* sp.; and some jacks, *Caranx* sp, of which only Spanish mackerel and mullet are of any local commercial value. These species may be seen near rock outcrops during their migrations, but they are not specifically attracted to them. Surf zone fishes as a group are those species that typically occur on open sand or shell bottom throughout the western Atlantic and Gulf of Mexico. Typical surf zone fish species seen along the rock outcrops of southeast Florida include Atlantic croaker, *Micropogonias undulatus*; pompano, *Trachinotus carolinus*; jacks, *Caranx* sp.; snook, *Centropomus undecimalis*; anchovies, *Anchoa* sp.; and herrings, *Clupea* sp., none of which are commercially harvested locally. These species are not confined to nearshore rock outcrops and occur along the sandy periphery of such outcrops when they exist in the nearshore zone (Herrema, 1974; Futch and Dwinnel, 1977; Gilmore, 1977; Gilmore *et al.*, 1981). Reef fishes are always associated with some form of bottom structure, man-made or natural. Although reef fish reach their peak abundance along the offshore reefs, the presence of the Anastasia and Miami Oolite formations in the nearshore environment do attract some of those species. Species seen along the nearshore rock outcrops include grunts, snappers, groupers, and wrasses, as well as some of the damselfish, blennies, gobies, angelfishes, and parrot fishes, of which only snappers and groupers are of any local commercial value. Vare (1991) indicates that the most frequently observed, year-round resident fish species along the nearshore rock outcrops of Palm Beach County include the sergeant major, *Abudefduf saxatilis*; spottail pinfish, *Diplodus holbrooki*; cocoa damselfish, *Pomacentrus variabilis*; slippery dick, *Halichoeres bivittatus*; and doctorfish, *Acanthurus chirurgus*. All these species are considered primary reef fish (Stark, 1968) and can be assumed to be drawn to the nearshore rock outcrops because of the hard substrate habitat provided there.

Vare (1991) suggested that the nearshore rock outcrop communities of southeastern Florida may serve as a critical linkage between the estuaries and deeper offshore reefs for many important sport and commercial fish species with estuarine life stages. Structures associated with these nearshore hard bottom outcrops may provide juveniles of many offshore species with a temporary habitat in which to feed and hide from predation while they grow. In his study of the fish community associated with a nearshore artificial reef off Boca Raton, Cummings (1990) noted the shifting nature in particular life stages observed.

Some reef fish species become permanent residents of nearshore rock outcrops. The bluehead wrasse, *Thalassoma bifasciatum*, and bicolor damselfish, *Pomacentrus partitus*, which are quite common along nearshore rock outcrops (Vare, 1991), are examples of such permanent residents. Both these species are extremely territorial and once established live their entire lives in a given territory ranging from one to several square meters. For these and other primary reef fish species, the nearshore rock provides a habitat for breeding, nursery activities, feeding, and protection.

3.3.4 Offshore Communities Potentially Found In or Near the Proposed Borrow Sites

Generalized proposed borrow areas set forth in the *Feasibility: Coast of Florida Erosion and Storm Effects Study, Region III*, October 1996, (USACE, Jacksonville District) are based on preliminary sand thickness (isopach) and side-scan sonar hard bottom maps. The biological communities in and adjacent to these proposed borrow areas are relatively consistent throughout this three-county area, although their exact species composition may vary from site to site based on physical parameters such as distance from shore and hardground profile.

3.3.4.1 Soft Bottom. Offshore soft bottom communities are less subject to wave-related stress than are nearshore soft bottom communities. They exhibit a greater numerical dominance by polychaetes as well as an overall greater species richness than their nearshore counterparts. Seasonally, there is extensive macroalgal growth in these areas, with species of green algae (*Caulerpa* sp., *Halimeda* sp., and *Codium* sp.) being particularly abundant in the summer and the brown algal species (*Dictyota* sp. and *Sargassum* sp.) being more abundant in the winter (Courtenay *et al.*, 1974; Florida Atlantic University and Continental Shelf Associates, Inc., 1994). The sea grass *Halophila decipiens* has been observed in the nearshore soft bottom communities offshore of Region III, but is considered seasonal (April through November) in these offshore soft bottom areas (Jim Berry, 1984, Palm Beach County Health Department, personal communication).

Barry A. Vittor & Associates, Inc. (1984) reported polychaetes made up 68.9 percent of the macrobenthic community off Port Everglades, followed by mollusca (13.2 percent), arthropods (10.7 percent), echinoderms (1.2 percent), and miscellaneous other groups (6.0 percent). Goldberg (1985) reported polychaetes as the dominant taxon from his infaunal survey off northern Broward County. Dodge *et al.* (1991) found polychaetes to be the most abundant group in 18 meters (60 feet) of water off Hollywood, Florida. In March 1989, polychaetes made up 51.7 percent of the macrofaunal community at that location followed by nematodes (14.3 percent), smaller species of crustaceans (9.0 percent), oligochaetes (4.3 percent), nemerteans (3.6 percent), and bivalves (2.9 percent).

Larger members of the invertebrate macrofauna seen occasionally in these offshore soft bottom areas between the second and third reef lines include the queen helmet, *Cassia madagascariensis*; the king helmet, *Cassia tuberosa*; Florida fighting conch, *Strombus alatus*; milk conch, *Strombus costatus*; Florida spiny jewel box, *Arcinella cornuta*; decussate bittersweet, *Glycymeris decussata*; calico clam, *Macrocallista maculata*; tellin, *Tellina* sp.; and cushion star, *Oreaster reticulatus*. Commercially valuable species, such as the Florida lobster, *Panulirus argus* move through this area as they migrate from offshore to nearshore areas (Courtenay *et al.*, 1974).

Herrema (1974) reported over 300 fish species as occurring off southeast Florida. Approximately 20 percent of these species were designated as "secondary" reef fish. Secondary reef fish are fish species that, although occurring on or near reefs, are equally likely to occur over open sand bottoms. Many of these species, such as the sharks, jacks, mullet, bluefish, sailfish, and marlin (none of which have significant local commercial value), are pelagic or open water species and are transient through all areas of their range. Fish species specifically associated with the sand flats and soft bottom areas between the first and second reefs off Palm Beach, Broward, and Dade counties include lizardfish, *Synodus* sp.; sand tilefish, *Malacanthus plumieri*; yellow goatfish, *Mulloidichthys martinicus*; spotted goatfish, *Pseudupeneus maculatus*; jawfish, *Opistognathus* sp.; stargazer, *Platygillellus (Gillellus) rubrocinctus*; flounder, *Bothus* sp.; and various species of gobies and blennies, none of which have significant local commercial value.

3.3.4.2 <u>Hardgrounds</u>. The classic reef distribution pattern described for southeast Florida reefs north of Key Biscayne consists of an inner reef in approximately 15 to 25 foot (5 to 8 meters) of water, a middle patch reef zone in about 30 to 50 foot (9 to 15 meters) of water, and an outer reef in approximately 60 to 100 foot (18 to 30 meters) of water. This general description was first published by Duane and Meisburger (1969) and has been the basis for most descriptions of hardground areas north of Government Cut, Miami since that time (Goldberg, 1973; Courtenay *et al.*, 1974; Lighty *et al.*, 1978; Jaap, 1984). Development of these three reef terraces into their present form is thought to be related to fluctuations in sea level stands associated with the Holocene sea level transgression that began about 10,000 years ago.

Lighty *et al.* (1978) showed that active barrier reef development took place as far north as the Fort Lauderdale area as late as 8,000 years ago. It is possible that the reefs and hardground areas seen from Delray Beach southward are the result of active coral reef growth in the relatively recent past, whereas the hard bottom features seen north of Palm Beach Inlet may represent the outcropping of older, weathered portions on the Anastasia Formation. The reefs north of Palm Beach Inlet (Lake Worth Inlet) do not show the same orientation to shore as those to the south and the classical "three reef" hardgrounds description begins to differ north of that inlet (Continental Shelf Associates, Inc., 1993a).

Algal coverage on the offshore hardground areas fluctuates seasonally. The most common algal species observed within southeast Florida offshore hardground areas are *Caulerpa prolifera*, *Codium isthmocladum*, *Gracillaria* sp., *Udotea* sp., *Halimeda* sp., and various members of the crustose coralline algae of the family Corallinaceae. Algal growth is most luxuriant from late July through late October or early November, and there seems to be a particular burst or bloom in the macroalgal population in conjunction with the seasonal upwelling that occurs in late July or early August (Smith, 1981, 1983; Florida Atlantic University and Continental Shelf Associates, Inc., 1994).

The composition of hardground biological assemblages along Florida's east coast has been detailed by Goldberg (1970, 1973), Marszalek and Taylor (1977), Raymond and Antonius (1977), Marszalek (1978), Continental Shelf Associates, Inc. (1984; 1985; 1987; 1993b), Wheaton (1987), and Blair and Flynn (1989). Although there are a large variety of hard coral species growing on the reefs north of Government Cut, these corals are no longer actively producing the reef features seen there. The reef features seen north of Government Cut have been termed "gorgonid reefs" (Goldberg, 1970; Raymond and Antonius, 1977) because they support such an extensive and healthy assemblage of octocorals. Goldberg (1973) identified 39 species of octocorals from Palm Beach County waters. The U.S. Environmental Protection Agency (1992) lists 46 species of shallow water gorgonids as occurring along southeast Florida. Surveys by Continental Shelf Associates, Inc. (1984; 1985) identified 33 sponge, 21 octocoral, and 5 hard coral species on offshore reefs off Ocean Ridge and 40 sponge, 18 octocoral, and 14 hard coral species on the offshore reefs off Boca Raton. Wheaton (1987) identified 17 octocoral species on the deep reefs off the City of Palm Beach. Blair and Flynn (1989) described the reefs and hard bottom communities off Dade County and compared them to the offshore reef communities from Broward and Palm Beach counties. They documented a decrease in the hard coral species density moving northward from Dade County to Palm Beach County. Despite this gradual decrease in the density of hard coral species present, the overall hardground assemblage of hard corals, soft corals, and sponges seen along southeast Florida's offshore reefs remains remarkably consistent throughout the counties of Dade, Broward, and Palm Beach.

Commercially, the most important invertebrate species directly associated with these hardground areas is the Florida lobster, *Panulirus argus*. The reefs are also economically important as the foundation for a thriving sports diving industry. Herrema (1974) listed 206 species of primary reef fish as occurring off Broward and Palm Beach counties. This assemblage is numerically dominated by wrasses, damselfishes, sea basses, parrotfishes, grunts, and angelfishes. The precise composition of the fish assemblage associated with any given location along these hardground areas is dependent upon the structural complexity of the reef at that location.

3.3.5 Inlet Communities

Estuarine areas within Region III are bordered by black mangroves, *Avicennia germinans*; red mangroves, *Rhizophora mangle*; white mangroves, *Laguncularia racemosa*; and buttonwood, *Conocarpus erectus*. In many areas, mangrove communities have been impacted or replaced by exotic species, including Australian pine, *Casuarina equistifolia*; Brazilian pepper, *Schinus terebinthifolius*; corktree, *Thespesia populnea*; and melaleuca, *Melaleuca quinquenervia*. Cordgrass, *Spartina alterniflora* is also found among these border mangroves and is the dominant species in many areas (County of Palm Beach, 1994b). Corals (*Siderastrea* sp., *Porites* sp., *Montastrea* sp., *Oculina* sp., *Leptogoria setacea*) and sponges (*Cliona* sp. and *Sphecíospongia vesparium*) have limited communities in the highly flushed areas of some inlets. Species found predominantly on jetty structures include the fireworm, *Hermodice carunculata*; Cuban stone crab, *Menippe nodifrons*; flat crab, *Plagusia depressa*; *Haliclona viridis* and *Haliclona* sp.; varieties of sponges; colonial anemone, *Zoanthus sociatus*; colonial anemone, *Palythoa variabilis*; solitary anemone, *Bunodosoma granuliferum*; hydroid, *Campanularia marginata*; stinging hydroid, *Macrorhynchia philipinus*; and the octocoral, *Telesto riisei* (CPE, 1992). Various species of fish and the West Indian manatee also are members of these communities.

Of particular note is the Lake Worth and South Lake Worth Inlet communities, where sand transfer plant operations are planned under the proposed combination of alternatives. Although having similar communities to those discussed above, natural shorelines in Lake worth are limited (Applied Technology and Management, 1995). Most of the shoreline is bulkhead (60 percent), with approximately 19 percent of the shoreline bordered by Mangroves, and 10 percent remaining naturally unvegetated. The remainder (11 percent) of the shoreline is bulkhead with riprap, riprap revetment, or exotic vegetation. *Halodule wrightii*, *Halophila* *decipiens*, and *Halophila johnsonii* comprise over 75 percent of the recorded sea grass beds in the Lake Worth Lagoon System although *Syringodium filiforme*, *Thalassia testudinum* are also present in much lower densities. According to sea grass bed location maps generated by the State of Florida, FMRI (1994h), no sea grass beds are recorded in the immediate vicinity of the inlets. However, dense beds of mixed *Halodule wrightii* and *Halophil sp.* and of Halophila wrightii have been recorded directly east of Peanut Island, west of Lake Worth Inlet. A small but dense patch of *Halodule wrightii* has also been recorded directly west of South Lake Worth Inlet, with extensive beds of mixed *Halodule wrightii* and *Halophil sp.* located southwest of the inlet and *Halodule wrightii* and mixed *Halodule wrightii* and attached macro algal species north of the inlet (Dames & Moore, 1990). Marine communities in the vicinity of the inlet are similar to those generalized in the above discussion, with coral species encrusting atop outcroppings of Anastasia limestone (Applied Technology and Management, 1995). Various fishes and other motile species including the green turtle, loggerhead turtle, and the West Indian manatee have been observed in Lake Worth Lagoon.

3.3.6 Dune Communities

Most of the natural dune communities exist in the northern sections of Region III in Palm Beach County, although some natural dune communities exist in John U. Lloyd Park and other areas of Broward County.[2] The Dade County dune system is also largely artificial.[3] Dominant plant species in the Palm Beach and Broward counties dune communities include sea grapes, *Coccoloba uvifera*; the beach morning glory, *Ipomoea pes-caprea*; beach bean, *Canavalia rosea*; sea oats, *Uniola paniculata*; dune panic grass, *Panicum amarulum*; bay bean, *Canavalia maritima*; and Australian pine, *Casaurina equisetifolia*. As with the Australian pine, the Brazilian pepper, *Schinus terebenthifolius* is an invasive plant, which is predominant in some areas south of Port Everglades in Broward County. Generally, Dade County dune communities are inhabited with these species; however, there are no appreciable amounts of either Brazilian pepper or Australian pine. The beach berry or inkberry, *Scaevola plumieri;* sea lavender, *Mallotonia gnaphalodes*; spider lily, *Hymenocalis latifolia*; beach star, *Remirea maritima*; and coconut palm, *Coco nucifera* are also present in some dune communities. Mammals typically present in dune communities include the raccoon, *Prycon lotor*; house mouse, *Mus musculus*; gray fox, *Urocyon cinereoargenteus*; and spotted skunk, *Spilogale putorius*. Birds utilizing the beach and dune habitats include the American oystercatcher, *Haematopus palliatus*; Eastern

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[2]Dune revegetation in Broward County has included sea oats, *Uniola paniculata*; sand bur, *Xanthium strumarium strumarium*; beach bean, *Canavalia maritima*; beach morning glory, *Ipomea stolonifera*; cucumberleaf sunflower, *Helianthus debilis cucumerifolius*; sea purslane, *Sesuvium portulacastrum*; lantana, *Lantana depressa*; buttonwood, *Conocarpus erectus*; beach elder, *Iva frutescens*; inkberry, *Scaevola frutescens*; seagrape, *Coccoloba uvifera*; tropical almond, [sic]; bitter panicum, *Panicum amarum*; crowfoot grass, *Dactyloctenium Willd*; St. Augustine grass, *Stenotaphrum secundatum*; Australian pine, *Casaurina equisetifolia*; coconut palm, *Cocus nucifera*; silverleaf croton, *Croton punctatus jacq.*; Spanish bayonet, *Yucca aloifolia*; cabbage palm, *Sabal palmetto*; mimusops, *Manilkara roxburghiana*; cocoplum, *Chrysobalanus icaco l.*; and others (Hamilton, 1994).

[3]Dade county species used in artificial dune stabilization include panic grass, *Panicum ararulum*; saltgrasss, *Distichlis spicata*; sea oats, *Uniola paniculata;* dropseed, *Sporobolus virginicus*; seashore paspalum, *Paspalum vaginatum*; beach bean, *Canavalia maritima*; beach creeper, *Ernodea littoralis*; beach elder, *Iva imbricata*; beach morning glory, *Ipomea stolonifera*; beach sunflower, *Helianthus debilis*; camphorweed, *Heterotheca subaxillaris*; railroad vine, *Ipomea pes-caprae*; sea purslane, *Sesuvium portulacastrum*; seaside evening primrose, *Oenothera humifusa*; spider lilly, *Hymenocallis* sp.; wild sage *Lantana involucrata*; bay cedar, *Suriana maritima*; cocoplum, *Chrysobalanus icaco*, inkberry, *Scaevola frutescens*; Jamaica caper, *Capparis cynophallophora*; limber caper *Capparis flexuosa*; mysine, *Mysine floridana*; necklace pod, *Sophora tomentosa*; saw palmetto, *Serenoa repens;* seagrape, *Coccoloba uvifera*; silver buttonwood, *Conocarpus erectus* v. *cericeus*; sweet acacia, *Acacia faresiana*; varnish leaf, *Dodonaea viscosa*; wax myrtle, *Myrica cerifera*; white indigo berry, *Randia aculeata* (Flynn and Halwani, 1990).

brown pelican, *Pelecanus occidentalis carolinensis*, great blue heron, *Ardea herodia*; great egret, *Casmeodius albus*; least tern, *Sterna albifrons*; osprey, *Pandion haliaetus*; laughing gull, *Larus atricilla*; and the common tern, *Sterna hirundo*. Sea turtles (*Caretta caretta, Chelonia mydas,* and *Dermochelys coriacea*) also use the lower regions of dune communities for nesting, with loggerheads nesting more frequently than other species.

3.3.7 Migratory Birds

Based on database reports of the Florida Game and Freshwater Fish Commission, there are over 80 species of birds listed in the Federal Migratory Bird Treaty Act that have been recorded as inhabiting Region III's coastline between the surf zone and densely vegetated forest of the back dune for at least part of the year. However, very few species utilize the beach and dune areas in Region III because of Region III's intense coastal development. Birder reports note that only sanderlings, *Calidris alba*; and ruddy turnstones, *Arenaria interpres* are generally the only wintering species that can be found foraging and resting on beaches along Region III's coastline (Rosenburg, 1994). Royal terns, *Sterna maxima*; ring-billed gulls, *Larus delawarensis*; laughing gulls, *Larus atricilla*; and herring gulls, *Larus argentatus*, also winter along Region III's coastline and are generally found foraging and resting near fishing piers and on beaches adjacent to piers. Occasional winterings of other species can be found near the dune and beach zones.

3.4 Socioeconomic Resources

3.4.1 Demographics

Region III is composed of a virtually contiguous stretch of development spanning from the West Palm Beach metropolitan area southward to Greater Miami and Key Biscayne. Details of the socioeconomic profile of this region are contained in the Economics Appendix of the *Feasibility Report, Coast of Florida Erosion and Storm Effects Study, Region III, October 1996,* USACE, Jacksonville District; however, highlights are discussed herein (USACE, 1991).

Population in Region III has grown from approximately 3.2 million persons in 1980 to 4.1 million persons in 1990, and population is expected to grow 7.7 percent between 1990 and 2000 and 27.1 percent between 2000 and 2035. Populations in 1990 of coastal cities in Palm Beach, Broward, and Dade counties were 85,929; 83,176; and 124,117; respectively. Coastal census tracts include only a small portion of county populations but a large segment of coastal city populations. Coastal census tract populations for 1990 in Palm Beach, Broward, and Dade counties are 49,230; 40,294; and 110,802; respectively.

Coastal census tract data reveal that proportionately more single-family, non-family, and single householders over the age of 65 live in these areas. Additionally, these data indicate that a smaller portion of the non-white population lives in the coastal census tracts than in the rest of Region III.

3.4.2 Employment/Income

Employment in this area is diverse but driven by tourism. Accordingly, the services sector is the most important employing sector in all three counties within Region III, followed by retail trade, financial, and government sectors. Information on coastal-dependent industries is described below. Employment is anticipated to grow through 2035; however, the rate of growth is expected to decline from current levels. Unemployment has generally not been a major concern in Region III. In fact, Region III's unemployment during 1989 and 1990 varied from a high of 7.35 to a low of 5.14 percent.

Dade, Broward, and Palm Beach counties ranked first, second, and third in the State for total personal income. Population density of this Region is the main factor responsible for these rankings. However, per capita income in Palm Beach is the highest in the State, and Broward and Dade counties, fifth and 13th, respectively.

3.4.3 Coastal-Dependent Industries

Coastal-dependent industries such as commercial fishing, recreational fishing charters and party boats, diving charters and rentals, and other businesses are numerous in the coastal areas of Region III. According to data provided on aggregated county business patterns for the counties in Region III, there are approximately 17 fishing, hunting, and trapping establishments; 13 refrigerated warehousing and storage; 77 marinas; 88 travel tour operators; 111 fish and seafood wholesalers; 207 meat and fish retail markets; 429 sporting goods and bicycle shops; 9 sporting and recreational camps; and 182 membership sports and recreation clubs.

National Marine Fisheries Landings Reports reveal that commercial catches have increased most significantly in Broward County between 1970 and 1980. Between 1980 and 1990 catches have remained fairly constant as a region (1.56 percent average annual increase), although within the region, Broward County catches increased 66 percent (5.2 percent average annual growth), whereas both Dade and Palm Beach counties' catches declined slightly. Since 1990, Broward County catches have declined slightly and both Dade and Palm Beach catches have increased. Moreover, the combined Region III has experienced an approximate 5.91 percent average annual growth in its fisheries' catches, having a total 1993 catch of 7,386,651 pounds worth $14,512,624 (U.S. Department of Commerce, NMFS, 1994). Based on 1993 landings reports, important commercial fish species (based on catch value over $100,000 by species in 1993) for the region are (in decreasing value) swordfish, spiny lobster, king mackerel and cero, yellowtail snapper, shrimp, sheepswool sponge, bluefish, bigeye tuna, gag grouper, jumbo stone crabs, pompano, snapper (mutton), bigeye shad, and dolphinfish. Most of these species are found in state waters within three miles of shore; however, some species (swordfish, dolphin fish, and bigeye tuna) are found further offshore (five to six miles). Several species (shrimp and sheepswool sponge) are typically harvested within a mile of shore. Marine life collection for aquariums is another water dependent industry in Region III. Collections in 1991 and in 1994 were both similar in targeted organisms and quantities harvested. Marine life landings in Palm Beach, Broward, and Dade counties in 1991 were valued at over $460,000 and were dominated by anemones, live rock and sand, snails, crabs, and angelfish. As noted, landings for 1994 were of similar value (approximately $440,000) and were dominated by the same targeted organisms (State of Florida, FMRI, 1994c). Although marine organisms are not necessarily landed in the same county in which they are caught, landing reports are the most comprehensive data available to display marine life collection trends in Palm Beach, Broward, and Dade Counties' waters.

3.4.4 Land Use

Land use in the vicinity of Region III's shoreline is fairly limited to affluent single family residential, seasonal and permanent multifamily residential, hotels, public recreation and open space, limited commercial retail sales, other water-dependent commercial enterprises, and public works.

3.4.5 Storm Damages

Between 1871 and 1950, 12 recorded hurricanes have struck Region III's coastline, and since 1950, approximately seven significant storm events have caused considerable damage to Region III's coastline and upland areas. Damages from hurricanes and northeasters occur from both high winds and storm surges and increased wave activity. Inundation caused most damages in past hurricanes; however, high winds also played a significant role and were the dominant destructive force in Hurricane Andrew in 1992. Total damages for hurricanes that have affected Region III's coastline have been estimated to be $28 million (1950$) for King in 1950; $600 million (1990$) for Cleo in 1964; $131.2 million (1994$) for Betsy in 1965; $5 million (1990$) for David in 1979; and $15-20 billion (1993$) for Andrew in 1992.[4] Two northeasters, the Halloween Northeaster of 1991 and the Thanksgiving Day Northeaster of 1984, also caused significant damage to Region III's coastline, causing $2 million (1991$) and $1 million (1984$) in damages, respectively (USACE, 1996)..

3.5 Cultural Resources

Many significant cultural resources are known to exist within Region III of COFS. Because the entire Region III study area has not been subjected to a systematic survey, additional potentially significant resources may be located there. The types of cultural resources located within COFS study areas include: archeological resources located on the beach; underwater historic shipwrecks; and historic structures located near the shoreline.

Although potentially significant cultural resources exist in Region III, such resources are not likely to be located in areas that have been disturbed by previous construction activities. Areas where significant cultural resources are not anticipated include previously used borrow areas, maintenance dredged material from existing Federal projects, and previously nourished beach segments.

3.6 Recreational Resources

3.6.1 Beach Activities

Beach activities available on Palm Beach, Broward, and Dade counties vary in type and extent. No Florida State or national wildlife refuges or management areas, forests, wilderness areas, trails, estuarine or research reserves exist along coastal Palm Beach, Broward, or Dade counties, Florida (State of Florida, Division of Recreation and Parks, 1994d). The Biscayne

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[4]Total damages include but not limited to Region III. Only damage estimates for Hurricane Betsy (1964) reflect damages to Region III only (Palm Beach, Broward, and Dade counties). Details of these storm events and damage estimates can be obtained from the *Feasibility Report, Coast of Florida Erosion and Storm Effects Study, Region III, April 1996,* USACE, Jacksonville District and *Florida Hurricanes and Tropical Storms, 1871-1993: An Historical Survey,* Doehring et. al. (1991).

National Park, Biscayne Bay-Cape Florida State Aquatic Preserve, the Biscayne Bay-Card Sound Florida State Aquatic Preserve, John D. MacArthur Beach State Park, Hugh Taylor Birch State Recreation Area, John U. Lloyd Beach State Recreation Area, Oleta River State Recreation Area, North Shore State Recreation Area, and Bill Baggs Cape Florida State Recreation Area are the only official national or state recreational resources documented in the coastal areas of Region III. In addition, the Barnacle, located west of Key Biscayne, is a Florida State Special Feature Site. In addition, three beaches, Juno Beach [Ocean Cay] in Palm Beach County, North Beach in Broward County, and the North Shore Open Space in Dade County, have been acquired by the State of Florida under the "Save Our Coast Program" and are now protected State undeveloped public recreational beaches.

Ample public access is available to local residents and tourists alike, with a total of 218 public access points or an average of approximately one access point every half mile of shoreline. Access is limited by parking availability, which varies greatly and includes both designated parking lots and street parking with hourly and daily parking fees. The 218 public access sites along the coast in Region III have approximately 31 miles of beach frontage with an average of approximately 100 parking facilities per public access point but a median of only eight parking places. This is explained by a few very large recreational areas with many parking places such as Haulover Park, Hollywood Beach, John U. Lloyd State Recreation Area, Delray Beach and others. All of these recreation areas have over 750 designated parking spaces. Some of the larger public areas in terms of square yards of beach include Crandon Park, Pompano Beach, Lummus Park, and the John U. Lloyd State Recreation Area. Although available facilities differ among sites, 44 sites have lifeguards, 91 sites have showers, 24 sites have potable water, and 35 sites have restrooms.

3.6.2 Water Related Activities

Water related activities in Region III vary from onshore fishing to offshore fishing and diving. Most boating activities (diving and recreational boat fishing) originate from inlets and are concentrated within limited distances from these points. According to the *Florida Scuba News* (1994b), listed dive shops are concentrated in Miami, Fort Lauderdale, Pompano Beach, Riviera Beach, West Palm Beach, and Boca Raton. Operating dive boats also reflect this concentration. Miami, Riviera Beach, and Fort Lauderdale have over nine listed dive boat operations *(Florida Scuba News,* 1994a). Accordingly, the Government Cut, Port Everglades, Lake Worth inlets, Boyton Inlet, and the Boca Raton Inlet are the most important origination points for dive operations. Discussions with a very limited number of dive-charter boat operators revealed that travel is kept to approximately 30 minutes from port, which corresponds typically to four to six miles north or south of the inlets. Furthermore, most trip destinations are to the second and third reef zones and artificial reef areas. Significant resources noted by operators include "the Breakers" reef off West Palm Beach, Pompano Pier reef off the Pompano Pier, and the Key Biscayne artificial reef zone.

According to data obtained from the FMRI, there are approximately 592 recorded fishing sites (estuarine, open ocean, and fresh water) along the coastal areas of Region III; however, only 106 of these sites are recorded as having a high probability of encountering anglers (State of Florida, FMRI, 1994b and 1994g). Of these 106 sites, 19 are open ocean sites with a high probability of encountering anglers, and only six are actually fishing piers on the ocean with the same high probability (North Deerfield Beach Fishing Pier, Fisherman's Warf Pier in Pompano

Beach, Anglin Pier at Lauderdale-by-the-Sea, Dania Fishing Pier, Newport Fishing Pier in Sunny Isles, and South Point Park Fishing Pier at Miami Beach). The most popular fishing areas are from eleven beaches, while two others provide only private boat access (Riverfront Marina in Fort Lauderdale, Elizabeth Virrick Boxing Gym and Boat Ramp in Miami, and Virginia Key Recreation Complex in Miami). As noted, however, many sites or recreational fishing origination points are located in the estuary areas along the intercoastal waterway and inlets.

Creel survey data on kept quantities of fish landed suggest that approximately 55 percent of recreational fishing is done from the shore, 41 percent from private boats, and only four percent from charter boats (State of Florida, FMRI, 1994f). These data also suggest that the ten most important recreational species in order of importance for Palm Beach County are dolphin, false pilchard, little tunny, blue runner, king mackerel, white grunt, yellowtail snapper, striped mojarra, herring, and gray (grey) snapper, with several of these species sought only for recreational fishing bait (false pilchard, blue runner, white grunt, and herring). The ten most important species in Broward County are false pilchard, dolphin, king mackerel, blue runner, bigeye scad, white grunt, little tunny, yellowtail snapper, spanish mackerel, and crevalle jack, again with several species used predominantly for bait (false pilchard, blue runner, bigeye scad, and white grunt). Like Broward and Dade counties, landings are dominated by false pilchards used mainly as bait fish. The nine most important species besides the false pilchard are dolphin, white grunt, pinfish, blue runner, little tunny, bluestriped grunt, yellowtail snapper, ballyhoo, and king mackerel, with the only gamefishes in the top ten landings list being dolphin, little tunny, yellowtail snapper, and king mackerel. Most listed species are found within state waters (three miles offshore), with several found very close to shore (false pilchard, grunts, runners, and bigeye scad). Several species are found further out (dolphin, little tunny [bonita]). Still others are found mainly in the intercostal waterway and shallow waters around shore (stripped mojarra, crevalle jack, and pinfish) (Schaffer, 1994).

4.0 ENVIRONMENTAL CONSEQUENCES

4.1 Physical Setting

4.1.1 Impacts

Projects proposed within Region III of COFS will not generally affect the physical setting of the region; however, minor aesthetic impacts would occur during the construction phase and post-construction for most of the action alternatives. The presence of construction equipment and personnel would detract from the natural aesthetics of the beach environment. However, permanent structures (sand transfer plants) would not likely create any significant aesthetic impacts based on the relative level of existing anthropogenic disturbance and activity in the location of the Lake Worth, and South Lake Worth inlets. Post-nourished beach sand color will generally be different from the native beach sand (depending on sand source), detracting from the natural aesthetic quality of project beaches. The no-action alternative, however, would allow beach erosion to continue, also diminishing beach aesthetic values.

Small to undetectable changes in the wave climate in the nearshore environment (approximately 5-foot depth) would likely result from borrow site excavation and nearshore berm construction. However, as predicted for a similar project by Coastal Technology Corporation [CTC] (1993), these impacts would likely be insignificant.[5] The no-action alternative should not allow conditions to develop that will significantly affect wave climate; however, further erosion will allow the surf zone to advance landward and thereby increase storm damage impacts and costs.

Direct emissions from COFS's action alternatives would be confined to exhaust emissions of labor transport equipment (land and water vehicles), and construction equipment (dredge barges), and likely well under the *de minimus* levels for ozone non-attainment areas as cited in 40 CFR 91.853; that is, projects implemented cannot produce total emissions greater or equal to 100 tons per year of Volitle Organic Compounds (VOCs). Furthermore, although beach restoration may induce tourism and development and indirectly increase emissions (indirect emissions), control and maintenance of these emissions by the USACE would be impractical and infeasible. Consequently, a conformity determination with the Florida State Implementation Plan is inappropriate for increases of indirect emissions from any COFS action alternative implementation. Coordination with local air quality managers in Palm Beach, Broward, and Dade counties will determine if further determination is necessary to evaluate conformity of COFS's action alternatives with the Florida State Implementation Plan. As with COFS's action alternatives, the no-action scenario will witness continued development, which may cause marginal adverse impacts to air quality. The extent of these impacts, however, is difficult to predict.

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[5]CTC (1994) completed several model runs on the Regional Coastal Processes Wave (RCPWAVE). The borrow area used in the model run was approximately 1.8 miles offshore, 4,800 feet long and averaged 800 feet long in depths of -50 to -60 feet. The borrow depth in the model run was from -62 to -70 feet (10 to 12 feet of dredging). Model runs calculated an average of only 0.1 foot increase in prevailing 3 foot waves in the nearshore (within -5 foot contour) environment. Model runs for the 100-year storm wave regime showed similar insignificant changes: 0.02 feet from the northeast, -0.01 feet from the east, and -0.22 feet from the southeast.

4.1.2 Mitigation

Because no significant adverse impacts are expected from the proposed projects on the physical setting of Region III, no mitigation is expected. However, best management practices would be implemented to ensure swift construction and the avoidance of a lengthy presence of construction equipment and personnel.

4.2 Geology/Hydrology

4.2.1 Impacts

Although COFS meets the criteria for a Section 404 (r) exemption under the Clean Water Act, all attempts will be made to obtain a State Water Quality Certificate.[6] Projects proposed in Region III would not likely cause significant adverse effects on the existing geologic and hydrologic environments. Impacts to these environments would largely be confined to temporary, insignificant turbidity impacts to water quality around the borrow and fill areas as a result of nourishment activities. The extent of these impacts, however, would be a function of the dredge and fill methods employed and the amount of fines in the sand source used. Haynes and Dompe (1995 in press) note that cutterhead/suction dredge operations generally have greater turbidity impacts than hopper dredge operations.[7] However, similar turbidity impacts have been documented for both cutterhead/suction and hopper dredge operations (CPE, 1991; County of Dade, 1990).[8] Monitoring reports (CPE, 1991; County of Dade, 1990) suggest that hopper style dredging may result in higher turbidity around the borrow sites than would occur under suction/hydraulic dredge operations, but turbidity around the fill site would likely be lower with a hopper dredge operation than that experienced with the cutterhead/suction dredge technique.[9] Post-construction monitoring reports for turbidity suggest that turbidity generally settles out

[6]Section 404 (r) of the Clean Water Act states that any discharge resulting from a Federally approved construction project authorized by Congress is not subject to 404 regulation or any State program approved under Section 404 of the Clean Water Act if information on the effects of the discharge are included in the environmental impact statement (EIS) of the project, and if the EIS has been submitted prior to actual discharge and prior to either authorization or appropriation of construction.

[7]Haynes and Dompe (1995 in press) note that cutterhead/suction dredge operations generally create higher turbidity levels because 1) the cutterhead disturbs some sediment that is not retrieved by the cutter pipe, 2) pipeline leakage enroute to the fill site, and 3) discharge of the slurry onto the beach. This method differs from the hopper dredge operation, which typically allows excess turbid water to spill over the gunwales of the dredge barge, leaving the remaining, generally dewatered, slurry for deposition.

[8]CPE (1991) documented only two exceedences over one month of the Florida 29 NTU-over-background standard for the 1988 North Boca Raton Beach nourishment, which employed a cutterhead/suction dredge. Both of these exceedences occurred within 5,000 feet down current from the discharge pipe and 1,000 feet seaward of the mean high water line. Turbidity within the fill zone monitoring network ranged between 0.20 and 36.50 NTU, with an average of 2.14 NTU (CPE, 1991). Turbidity levels around the borrow area site were low (between 0.20 and 3.90 NTU, with an average of 0.85 NTU), with no recorded exceedances within the 300-foot monitoring radius. Likewise, turbidity levels associated with a hopper dredge and fill operation at Bal Harbor were generally low (typically between 0.7 and 4.0 NTU although several samples greater than 10 NTU and one at 54.3 NTU were documented). One exceedence (54.3 NTU) around the borrow site was recorded for the two-month Bal Harbor Beach nourishment, which used a hopper style dredge (County of Dade, 1990). This exceedence occurred approximately 500 feet seaward and 330 feet south of the dredge. Both projects used borrow material with low pre-dredge percentages of fines (silt and clay): between 0.51 and 1.44 percent for North Boca Raton (CPE, 1991); and approximately 1 percent for Bal Harbor (County of Dade, 1990).

[9]The hopper dredge operation would allow a greater portion of the water collected with the borrow material to be released prior to fill than would a cutterhead/suction dredge operation.

within a short time period after the perturbation.[10] Permanent perturbations (sand-transfer plants) would likely elevate turbidity levels adjacent to discharge points; however, shoal dredge material cleansed daily by tidal flushing would render these impacts insignificant. These permanent structures would also permanently affect littoral drift in the region, cumulatively increasing the shoreline's dependence on maintenance. The use of Bahamian sand as a source material in the southern portion of Region III would alter the color, density, and texture of sand beaches in these areas and in downdrift areas. However, the introduction of Bahamian sand (virtually 100 percent calcium carbonate) should not pose any water quality or beach morphology concerns relative to other sand sources.[11,12,13] Bahamian sand mining in the Bahamas should likewise not create any turbidity or deposit morphology concerns.[14]

Because no hazardous, toxic, or radioactive waste sites or producers should be affected by any COFS action alternatives, no impacts associated with disturbance of these sites are anticipated from either the action or no-action alternatives.

Temporary, insignificant impacts to the nearshore freshwater lens may occur from dune construction activities with saltwater-saturated sand; however, saltwater intrusion into potable groundwater sources is not anticipated to become a problem for any proposed project. The no-action alternative should allow conditions to develop that may induce saltwater intrusion in areas; however, significant landward advances of the freshwater/saltwater interface from beach erosion are not likely.

With the use of dredging equipment and labor in the areas around the borrow and nourishment areas, there is also a potential for hydrocarbon spills or other effluent releases; however, the likelihood of significant accidents and releases of this sort is very remote. The no-action alternative should not allow conditions to develop that would increase accidents or releases of this sort.

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[10] Post-construction monitoring reports for offshore hardground and barrier reef sites around the North Boca Raton borrow site show that turbidity levels fell to background levels within one month of the action (CPE, 1991). Turbidity levels for borrow and fill zone water quality monitoring samples for this project illustrated similar trends. Based on the high variance in daily turbidity level data for the borrow sites, perturbation turbidity likely settled out within several days.

[11] Information on the use of Bahamian sand for beach nourishment was gained solely from CPE (1994), "Feasibility Study For the Use of Aragonite for Beach Nourishment in Broward County."

[12] CPE (1994) completed a literature review that concluded that although native Florida sand generally has lower specific gravity, smaller average grain size, and lower sphericity/larger gradation than Aragonite (Slatton, 1986 [as cited by CPE, 1994]), the use of aragonite may provide more benefits in terms of greater resistance to erosion (Monroe, 1969; USACE, 1985; Slatton, 1986; Miller-Way *et al.*, 1987[all cited by CPE, 1994]), having steeper and more stable foreshores (Cunningham, 1966; Olsen and Bodge, 1991) [both cited by CPE, 1994]) with generally lower turbidity than typical offshore Florida sand deposits or upland sources (CPE, 1985; USACE, 1987 [both cited by CPE, 1994]). Furthermore, the concerns of potential abrasion from harder quartz particles, the dissolution from acidic rain or freshwater, and the cementation of particles into beach rock have all been discredited (Dean, unpublished; CPE, 1985; USACE, 1985; and Olsen Associates, Inc., 1993 [all cited by CPE, 1994]).

[13] Nelson *et al.* (1987) [as cited by CPE (1994)].

[14] CPE (1994) cites Michael (1971), in which he concludes that the Sandy Cay deposit location is subject to intense tidal currents; therefore, neither existing fines and corresponding turbidity nor erosion would likely be exacerbated by dredging in the Sandy Cay shallow bank reserves. Michael (1971) cautions that current velocities should be monitored so that mitigative actions, if needed, could be implemented early in activities. Tabb *et al.*, (1973) as cited by CPE (1994) notes that levees used to confine outwash from the stockpiles on Ocean Cay, east of Sandy Cay, effectively reduce the amounts of fines returning to the ocean.

4.2.2 Mitigation

Best management practices would be used in the excavation of borrow material and for nourishment activities. Specifically, buffer zones and the precision positioning of dredge equipment would be utilized to ensure that turbidity associated effects and the potential for hydrocarbon spills would be minimized.

4.3 Biological Resources

4.3.1 Impacts

4.3.1.1 Endangered Species.

Sea Turtles: Of the endangered species located in the coastal area of Region III, sea turtles are the most likely to be impacted by COFS nourishment projects, and to a lesser extent, dune activities. According to biological opinions for similar projects (USACE, 1987), the major concerns are: (1) timing of nourishment activities, and (2) the burial, compaction, and destruction of sea turtle nests from sand and heavy equipment associated with nourishment activities. Incidental takings of turtles from nest destruction are possible from sand deposition and shore activities associated with nourishment activities; however, mitigation should minimize adverse impacts (takings).[15] Safety lighting of moored dredging equipment may also deter nesting in the vicinity of the project areas of COFS; however, timing of actions and lighting protocols should ameliorate potential impacts.[16] Encounters with sea turtles during dredge operations is also a possibility. Impacts to motile species from dredge operations should generally be minimal, although unacceptable levels of takes have been reported with the use of hopper dredges in navigation channels by the NMFS (Committee on Sea Turtle Conservation, 1990).[17] After nourishment, gains in beach width would also cause concurrent gains in sea turtle nesting habitat.[18] It is estimated that an additional 100, 91, and 24 acres of new beach would be created under the proposed combination of alternatives in Palm Beach, Broward, and Dade counties, respectively. Based on studies of the Fisher Island Beach nourishment (Lutz *et al.*, 1993), the use of Bahamian sand for nourishment activities

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[15] It should be noted that "takings" are noted by Section 9 of the Endangered Species Act as harassing, harming, pursuing, hunting, shooting, wounding, killing, trapping, capturing, collecting, or attempting to engage in any such conduct with respect to any listed species.

[16] Witherington (1989) studied the effects of mercury vapor lighting and low pressure sodium lighting on the nesting activities of *Caretta caretta* and *Chelonia mydas*. He found that mercury vapor (yellow) lighting and suggested that other broad-spectrum lighting have the potential to disturb nesting activities, while no significant disruptions were observed with the use of low pressure sodium lighting. In a latter study (1991), he found that hatchlings released at both a "naturally dark" and an "artificially lighted" beach swam approximately perpendicular to shore, and the hatchlings released from the lighted beach were not significantly affected by the high-pressure sodium lights located approximately 1 km from the release site. However, hatchlings released on the lighted beach had a greater dispersion angle.

[17] In a 25 August 1995 Regional Biological Opinion of the National Marine Fisheries Service, it was found that hopper dredging without the use of ridgid deflectors could result in unacceptable levels of sea turtle takes.

[18] The North Boca Raton two-year monitoring report documented increased sea turtle nesting densities and fewer nests requiring relocation due to possible inundation from coastal waters (CPE, 1991).

should not adversely affect sea turtle nesting or hatching success significantly.[19] However, there is concern that the temperatures and subsequent incubation times of sea turtle nests in Bahamian sand may be cooler, longer, and prone to produce more males. To date, studies comparing sex ratios of hatchlings incubated on Bahamian sand beaches to those of Florida sand beaches have not been documented (CPE, 1994).[20] Although Bahamian sand is currently under consideration as a sand source for southern Region III, consultation with the USFWS will be completed prior to the use of Bahamian sand in Corps nourishment projects. The no-action alternative would allow erosion on the coast of Region III to continue, decreasing available nesting habitat for sea turtles.

Manatees: Manatee encounters are likely with activities associated with COFS projects, with most likely encounters by support boats moving from marinas and dock areas through the channels and inlets towards dredge vessels (letter from DEP, 14 November 1994a). Based on manatee mortality data compiled by the Office of Protected Species Management of the Florida DEP for the period between 1976 and 1994, there have been 548 watercraft and 158 other human attributed manatee deaths recorded. These numbers reflect that of the total 2,184 recorded manatee mortalities during this period, 25 percent were attributed to watercraft, and seven percent were attributed to other human activity. Furthermore, 698, or 32 percent, of all recorded manatee deaths were of undetermined origin. According to records of the Jacksonville District, USACE, no manatee mortalities have ever occurred from dredge operations or nourishment operations of the Jacksonville District, USACE. However, impacts to foraging, congregation, or resting habitat are not anticipated from any activities of COFS, and accordingly, significant adverse impacts are not likely with mitigating precautions. The no-action alternative would not likely allow conditions to develop that would significantly affect foraging, resting, congregation, or migration habitat of manatees in Region III waters.

Other Endangered Species: Endangered species found in dune communities (all coastal species found in Table 3.1) may be potentially impacted from COFS actions if proper

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[19] The Sea Turtle Laboratory at the Rosenstiel School of Marine and Atmospheric Science recently conducted a three-year study of the loggerhead sea turtle (*Caretta caretta*) nesting along Fisher Island, Miami on a beach renourished with commercially mined Bahamian aragonite (Lutz, *et al.*, 1993). This study included comparisons of temperature, compactability, grain size, grain morphology, water potential, and gas permeability between Bahamian aragonite and Florida silicate beaches. The study found hatching success was high and mortality low in both types of sand. There were no significant differences in grain size, waste potential, or gas exchange between the two types of sands studied. There were no significant differences in hatchling size or mortality between the two types of beaches. No correlation was observed between compactability and nesting success in natural beach sands or the renourished aragonite beach. Nesting success ranged from 70 percent to 75 percent throughout this study. The major difference detected between nests laid on aragonite and silicious sand beaches resulted from the lighter color of the aragonite. The lighter color of the aragonite sands produced "in nest" temperatures that were 1.4 to 2.0°C cooler than those in nests laid on natural beaches. This cooler temperature resulted in an incubation period three to 10 days longer for the aragonite beach nests than for the silicious sand beach nests. These differences are well within the normal physiological ranges for the loggerhead turtle, but some concern was raised that in conditions of lower atmospheric temperature, or increased shading, these lower temperatures could cause excessively long incubation periods, and possibly produce an imbalance in the sex ratios of the hatchlings (Lutz, *et al.*, 1993).

[20] Incubation temperatures have been documented to influence sex determinations in sea turtles (Mrosovsky and Yntema, 1980; Yntema and Mrosovsky, 1980; Miller and Limpus, 1981; Morreale, *et al.*, 1982; Yntema and Mrosovsky, 1982; Mrosovsky, *et al.*, 1984; Limpus, *et al.*, 1985 [sic]; Standora and Spotila, 1985; Spotila *et al.*, 1987; Mrosovsky, 1988; Nelson, 1988; Girondot and Pieau, 1990 [all cited by CPE, 1994]). However, it has also been proposed that there are male- and female-producing regions within the nesting range of each species of sea turtles (Mrosovsky, 1988 [as cited by CPE, 1994]) or segregation of nesting populations (Owens, *et al.*, 1989; Bowen, *et al.*, 1993; and Sears, 1994 [all cited by CPE, 1994]). Moreover, it has also been proposed that sex determination in sea turtles results from an interaction between environmental and genetic mechanisms and not simply the incubation temperature (Zobroski *et al.*, 1979, 1982, 1988; Mrosovsky, *et al.*, 1984; Mrosovsky, 1988; Mrosovsky and Pieau, 1991 [all cited by CPE, 1994]).