3. AFFECTED ENVIRONMENT

The Affected Environment section succinctly describes the existing environmental resources of the areas that would be affected if any of the alternatives were implemented. This section describes only those environmental resources that are relevant to the decision to be made. It does not describe the entire existing environment, but only those environmental resources that would affect or that would be affected by the alternatives if they were implemented. This section, in conjunction with the description of the "no-action" alternative forms the baseline conditions for determining the environmental impacts of the proposed action and reasonable alternatives.

3.1. GENERAL ENVIRONMENTAL SETTING.

The shoreline along Broward County has been highly developed by residential and commercial interests. The two inlets, Hillsboro Inlet and Port Everglades Inlet, experience intense recreational and commercial navigation usage, and virtually all of the upland areas surrounding Hillsboro Inlet have undergone extensive urban development. Due to extensive development of Port Everglades and adjacent urban areas, most of the native uplands and dune habitat that once surrounded Port Everglades Inlet are no longer dominant in the area (Coastal Technology Corporation, 1994).

3.1.1. STORM EVENTS.

The coastline of Broward County is low-lying and vulnerable to storm surge and other storm event damages. Tropical cyclones (tropical storms and hurricanes), typically occurring between the months of June and November, generally originate in the tropical and subtropical latitudes in the Atlantic Ocean north of the equator. During the winter months (December through March), frontal weather patterns driven by cold arctic air masses reach South Florida with greater frequency. These fronts typically generate southwest winds changing to the northwest before frontal passage, then shifting to the northeast behind the front. If the northeaster occurs when the moon is in perigee, the winds are accompanied by abnormally high tides.

The surges and waves caused by cyclonic disturbances and northeaster storms present a major threat to the stability of the shoreline in Broward County. Since 1960, major storms that have affected Broward County include Hurricane Donna (1960), Hurricane Cleo (1964), Hurricane Isbell (1964), Hurricane Betsy (1965), Hurricane David (1979), Hurricane Andrew (1992), Tropical Storm Josephine (1996), Tropical Storm Mitch (1998), Hurricane Irene (1999), and Hurricane Michelle (2001). Notable northeaster storms that have influenced the Broward County shoreline occurred in March 1962, November 1984, and October 1991.

3.1.2. WINDS.

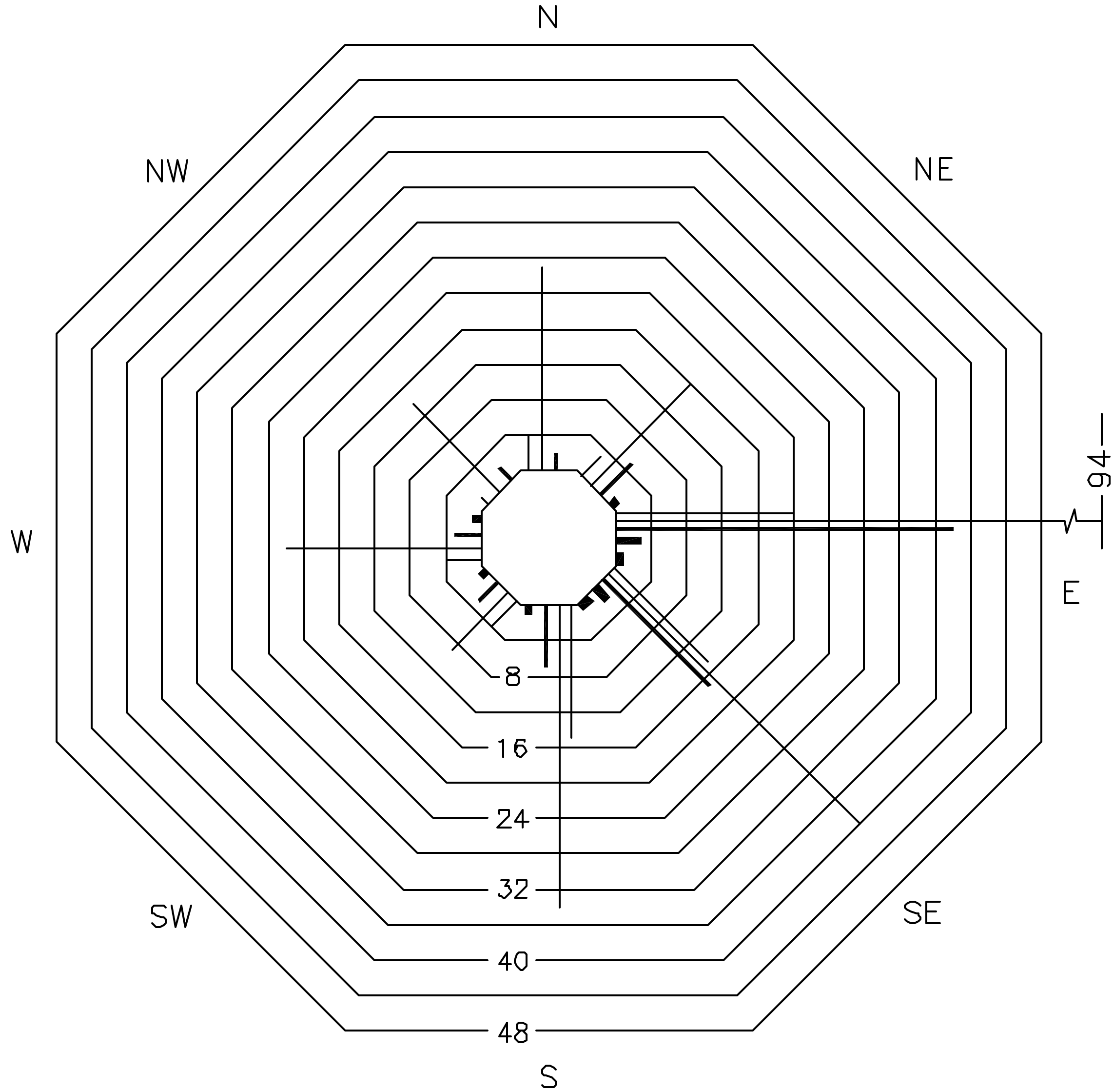
The National Oceanic and Atmospheric Administration provides a Local Climatological Monthly Summary for the U.S. Weather Bureau Office located at Miami International Airport. The Local Climatological Data Summary includes comparative temperature, precipitation, and wind data. Annual precipitation averages approximately 55 inches per year in Miami. The mean daily maximum temperature in Miami is approximately 82 degrees Fahrenheit (F) and the daily minimum temperature is approximately 69 degrees Fahrenheit (F) (USACE, 1996).

Broward County lies in the subtropical climatic band, and due to its latitude, is seasonally dominated by trade winds. These prevailing winds generally blow from the southeast to east at speeds between 5 and 15 mph. This trend is reflected in the wind diagram (Figure 2) of climatological data collected at Miami International Airport from March 1998 through March 2000.

Large scale weather patterns are responsible for a majority of the winds affecting Broward County. During the months of October through May, weather fronts of varying intensity traverse South Florida. The passage of a cold front brings strong pre-frontal south to southwest winds, and post-frontal north to northeast winds that can last as long as a week or longer. These frontal winds can reach peak speeds near hurricane strength but are generally limited to under 30 mph. During the summer months, characteristic weather system patterns travel east to west in the lower latitudes. The fastest wind speed of 86 mph observed for one minute and the peak gust of 115 mph for Miami, Florida, both occurred during Hurricane Andrew in August 1992 (USACE, 1996).

3.1.3. WAVES.

The wave size and strength of local seas is primarily affected by wind speed, duration, and length of open water over which the wind blows (fetch). Unlike local seas, which are influenced by local winds, swells are waves that have been generated from distant storms or open ocean prevailing winds. Swells generally have longer periods and wavelengths than wind waves. The configuration of the Bahama Banks limits the easterly and southeasterly fetch up to 50-80 miles in Broward County, decreasing the chance of receiving major swells. Although these east and southeast wind-generated local waves are most frequent, these waves cannot build up to the size of



AVERAGE DIRECTION, DURATION AND VELOCITY OF WINDS
FOR ONE YEAR AT TAMPA BAY, FLORIDA

VELOCITIES	MPH
(thinnest line)	0 TO 5
(thin line)	6 TO 10
(medium line)	11 TO 15
(thick line)	16 TO 20
(thickest line)	21 TO 30

SOURCE: LOCAL CLIMATOLOGICAL DATA; PUBLISHED BY THE NATIONAL CLIMATIC DATA CENTER, NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION, U.S. DEPARTMENT OF COMMERCE

FIGURE 2

WIND DIAGRAM
MARCH 1998 – MARCH 1999
MIAMI, FLORIDA

COASTAL PLANNING & ENGINEERING, INC.

northeast waves, hence the predominance of the largest waves from the northeast. In addition, weather patterns hundreds of miles away in the North Atlantic can send waves that pass between the Northern Bahamas and the eastern coast of Florida, thereby contributing to the north and northeast wave set.

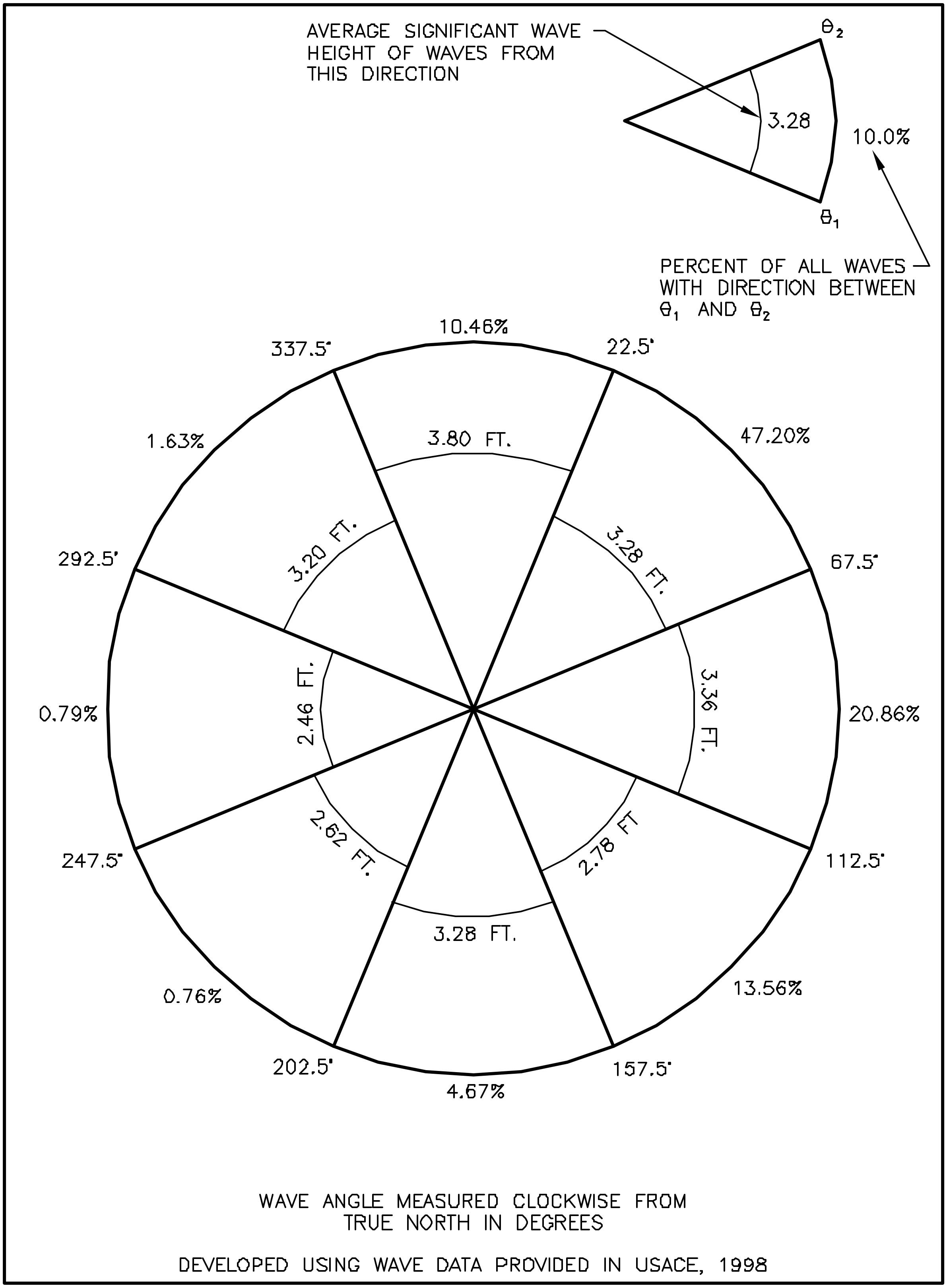
The best available data set for waves in Florida is the Coastal Engineering Research Center Wave Information Study (WIS). These data are a time series produced from a computer hindcast model. A wave rose diagram summarizing the wave height and direction for the years 1976-1995 at Station 10, located approximately 5.64 miles northeast of the northern boundary of Segment II and 12.8 miles northeast of the northern boundary of Segment III, is presented in Figure 3. A wave rose diagram for Station 9, located 17 miles southeast of the northern boundary of Segment II and approximately 9.25 miles southeast of the northern limit of Segment III, is presented in Figure 4.

All waves impacting the shoreline have an effect on sediment transport. Sand is moved along the beach either to the north or south by waves striking the coast at oblique angles. Waves approaching from the north and northeast cause a southerly sand movement, and waves from the south and southeast cause a northerly movement. Northeast storms are a major factor in sand transport in the Broward County area, and the largest waves reaching the Broward coastline arrive from the north (mean significant wave height of 3.80 feet and 3.69 feet for Stations 10 and 9, respectively. The largest percentage of waves (approximately 45%) that reach the Broward County shoreline approach from the northeast (See Figures 3 and 4).

Shore-perpendicular waves produce little longshore sand movement, but typically move sand in an onshore-offshore direction. Due to seasonal changes in wind, and therefore, wave direction, the east coast of Florida experiences a seasonal reversal in the direction of littoral drift (south in winter and north in summer). The most regular eastern waves are generated by the daily onshore-offshore breeze. These waves constitute approximately 21% of the total nearshore waves observed (Figures 3 and 4). The frequency of waves from the southeast (14%) is caused by the summer prevailing tradewinds. These winds are the primary driving force behind the northward littoral drift observed during the summer months.

3.1.4. CURRENTS.

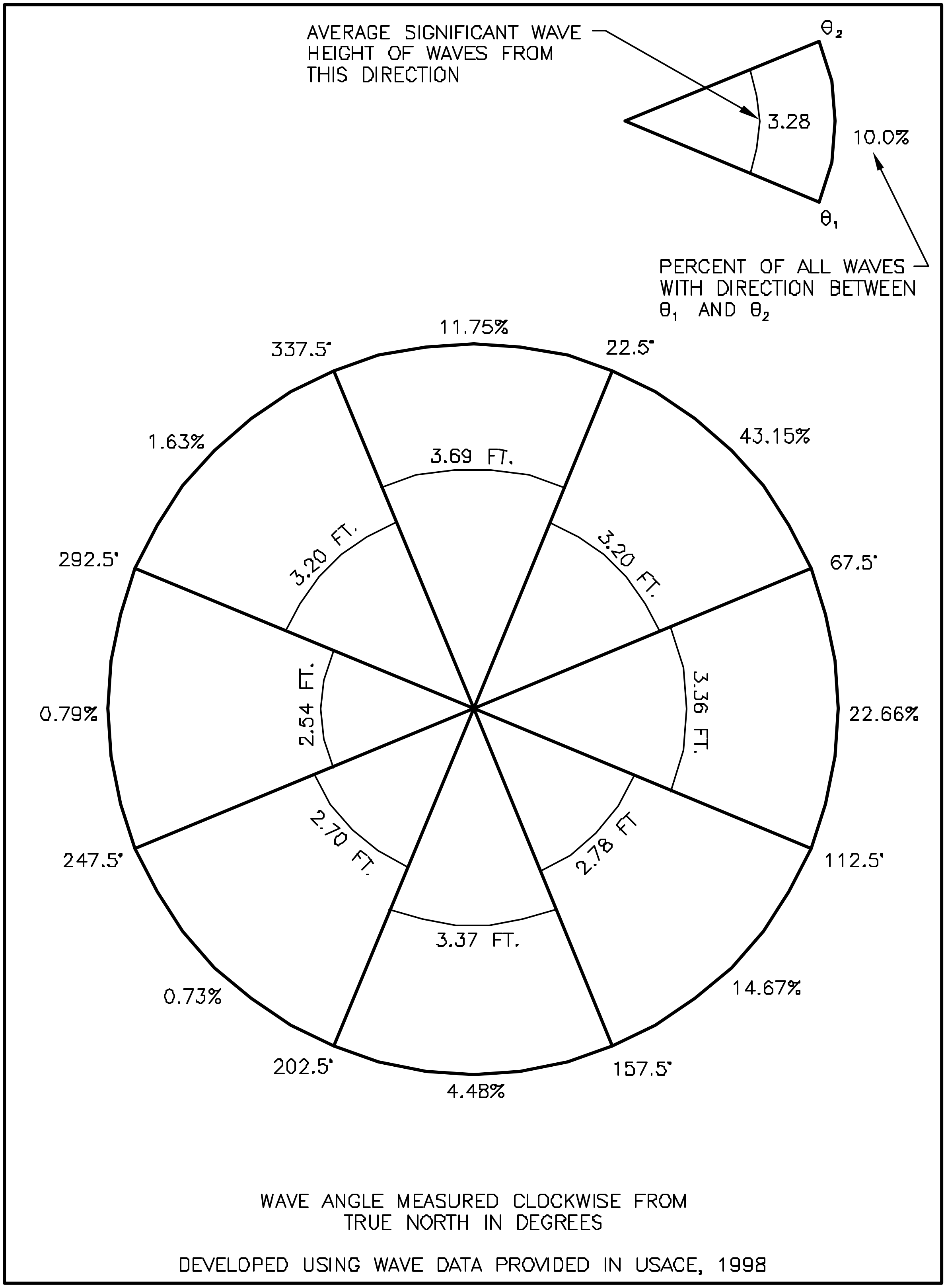
The dominant currents in the study area are the Florida Current (the portion of the Gulf Stream flowing through the Florida Straits), the wave induced longshore current, and astronomical tidal currents both along the beach and



FIUGRE 3

WAVE DATA
WIS STATION 10
BROWARD COUNTY, FLORIDA

COASTAL PLANNING & ENGINEERING, INC.



FIUGRE 4

WAVE DATA
WIS STATION 9
BROWARD COUNTY, FLORIDA

COASTAL PLANNING & ENGINEERING, INC.

through Hillsboro Inlet and Port Everglades Inlet. The Florida current of the Florida Gulf Stream, which flows about one mile offshore, is the most significant of the currents. The Florida Current generally flows northward between 17 and 37 miles per day with occasional intermittent local reversals.

As discussed above, the east coast of Florida typically experiences a seasonal reversal in the direction of longshore current, south in the winter and north in the summer. Typical longshore current flow is about 1.0 foot per second (USACE, 1996).

Tidal flood currents (landward) and ebb currents (seaward) also influence the morphology of the coast. The Hillsboro Inlet provides tidal flushing to the Intracoastal Waterway and the adjoining coastal canals in northern Broward County. The inlet also serves as one of the two outlets for freshwater releases from the Hillsboro Canal. Freshwater runoff into the Intracoastal Waterway contributes to the ebb dominant nature of the inlet. Velocity measurements on flood and ebb tide were taken in Hillsboro Inlet in the 1960's during studies by the University of Florida. The strongest velocities were found at the mouth of the inlet and at the bridge where the flow is constricted. Maximum ebb flow ranged from 2.5 to 6.7 feet per second, while maximum flood flow velocity ranged from 2 to 6 feet per second (CPE, 1992).

Flow velocities in the vicinity of the spoil shoal north of Port Everglades Inlet have established a stable narrow flow "channel" between the shoal and shoreline. The maximum ebb flow velocity measured in December 1992 was found to be 1.3 feet per second within the Port Everglades Inlet channel, and 1.0 foot per second in the narrow flow "channel" between the spoil shoal and adjacent shoreline. The maximum flood flow velocity at the Inlet channel and the narrow flow "channel" was 1.0 and 0.8 feet per second respectively (Coastal Technology Corporation, 1994).

3.1.5. TIDES.

The tides in the project area are semidiurnal with a mean range of approximately 2.6 feet and a spring range of approximately 3.0 feet. Highest tides occur in association with storms as a combination of wind setup, barometric pressure setup, and normal peak tides (full moon and new moon conditions). Elevations of mean high water and mean low water tidal datum in Broward County were reported to be +1.64 feet (NGVD) and –0.89 feet (NGVD) (USACE, 1994).

3.1.6. STORM SURGE.

Storm surge is the rise of the ocean surface above its normal high-tide level. The increased water level elevation is the result of the interaction of waves, wind shear stress, and atmospheric pressure. With a higher surge, larger waves are able to reach the shoreline to accelerate erosion. The increase in water level also allows for larger breakers to attack the shoreline at high elevations above mean sea level. The maximum calculated storm surge height for the 100-year still water elevation at the Atlantic Ocean shoreline in Broward County was reported as 12 feet in the 1982 FEMA Flood Insurance Study (USACE, 1996).

3.1.7. SEA LEVEL RISE.

Eustatic sea level change is defined as a global change of oceanic water level. Total relative sea level change is the difference between eustatic sea level and any change in local land elevation (USACE, 1996). Global sea level changes, both rise and fall, have occurred throughout geologic history. There has been a steady decline in the predicted rise in sea level from two meters in the original 1983 EPA study to 0.5 meters in the most recent NRC estimate (USACE, 1996). The 1990 NRC estimate predicted a 0.5 meter rise in sea level by the year 2100 with an error of plus or minus one meter. The lower limit of this NRC prediction is a sea level fall of 0.5 meters (Houston, 1993).

3.1.8. GEOLOGY AND GEOMORPHOLOGY OF STUDY AREA.

The Florida Plateau, occupied by present-day peninsular Florida, originated some 200 million years ago during the Mesozoic Era. Since then, between 4,000 to 20,000 feet of carbonate and marine sediments have accumulated, as the plateau fluctuated between dry land and coverage by shallow seas. Florida experienced four periods of inundation and emergence during the Pleistocene Epoch, resulting in the deposition of four surficial Pleistocene formations (Miami (youngest), Key Largo, Anastasia, and Fort Thompson (oldest)). A thin layer of quartzose sand, the Pamlico Sand, was deposited over the Miami and Anastasia formations during the last glacial retreat (USACE, 1996).

The present day barrier islands of southeast Florida were formed during the Holocene (Recent) Epoch. In Broward County, the barrier island is founded on Miami Limestone and Anastasia formation. The sand that comprises the modern barrier island is a combination of quartz sand that has migrated southward along the coast from rivers and the coast north of Broward County, the Pamlico Sand that blankets southeast Florida, and the skeletal carbonate sand from mollusc and calcareous reef flora and fauna.

The continental shelf along the southeast coast of Florida varies in width from a few miles to slightly greater than one mile (Raymond, 1972). The shelf is narrowest between Palm Beach and Miami and consists of three step-like terraces (Raymond, 1972). These terraces coincide with the first, second and third reef flats outlined by Duane and Meisberger (1969). Relict barrier reefs form intermittent ridges at the seaward edges of each terrace (Raymond, 1972). The reefs trend parallel to the approximately north-south oriented shoreline.

South of approximately 26°20'N, the shelf surface rises from the outermost reef system to the shore in a series of step-like linear flats separated by rocky irregular slopes and ridges marking the former position of paleoshoreline (Finkl, 1994). North of 26°20'N, the step-like character of the topography gives way to a more or less constant sediment slope extending from shore to near the outer reef line. Intrareefal flats are covered with calcareous sands, limestone gravels, and intercolated clays and silt. The inner shore zone is characterized by sandy beaches, large tracts of unconsolidated sediments and hardgrounds including Sabellariid worm reefs (Finkl, 1994).

3.1.8.1. Sand Source Location

The USACE *Coast of Florida Erosion and Storm Effects Study: Region III, Preliminary Feasibility Report* (1996) estimated the total project requirement for the 50-year life of the Broward County Shore Protection Program to be 39,243,000 cubic yards. At the time of the *USACE Coast of Florida Study*, the total volume of sand sources available in shore-parallel deposits offshore of Broward County was estimated to be 28,658,000 cubic yards, or 73% of the total sand requirement, a sufficient supply for 36 years of project life. However, the *USACE Coast of Florida Study* results only stated the total volume of sand in these deposits. The study did not consider possible reduction of useable sand resources due to environmental buffers around natural reefs and artificial reef structures, buffers around potential and known cultural and historical resources, and logistical considerations associated with dredging. Table 4 lists the estimated sand resources in the *USACE Coast of Florida Study.*

TABLE 4

SAND RESOURCES LISTED IN USACE COFS

Segment	Estimated total amount of material (cubic yards)
Northern end of Broward County to Hillsboro Inlet (DNR-1 to DNR-24)	11.7 million
Pompano Beach (DNR-24 to DNR-46)	4.6 million
Lauderdale-By-The-Sea (DNR-46 to DNR-52)	0.8 million
Fort Lauderdale to Port Everglades (DNR-52 to DNR-85)	13 million
Dania Beach, Hollywood, and Hallandale (DNR-100 to DNR-128)	1.2 million (Note: Most of the sand is spread out over five areas and may not be feasible for dredging).

Source: USACE, 1996

In 1996, a geotechnical study was conducted for the Broward County Department of Planning and Environmental Protection (formerly Department of Natural Resource Protection) (CPE, 1997). The study was conducted in four phases. In the first phase, a thorough literature search was conducted that reviewed available sources of geotechnical or physical information for Broward County. The second phase involved jet probes to ground-truth seismic information and vibracoring of potential sand borrow areas. Phase three involved the analysis of the acquired data, and phase four was the delineation of the borrow areas available for beach nourishment. The results of the 1997 study defined the best quality sediment source available for future nourishment projects.

The offshore geotechnical surveys consisted of seismic, side scan, bathymetric surveys, probes, and vibracoring. The limits of the study area were between the Broward-Palm Beach County line to Lauderdale-By-The-Sea and between the -10 foot (NGVD) contour and about 1.5 miles offshore. The 1.5 mile distance corresponds to the -180 foot (NGVD) contour north of Hillsboro Inlet, and the –79 to –140 foot (NGVD) contour offshore of Lauderdale-By-The-Sea. The seven borrow areas identified in 1997 were located from 0.25 to 1.0 mile offshore in water depths of 25.5 feet to 74 feet (NGVD). Four (4) borrow areas were identified in the 2nd intrareefal flat and three (3) were located in the 3rd intrareefal flat. The combined borrow areas provided approximately 4.42 million cubic yards of sand as potential beach fill material (CPE, 1997). The light gray to dark gray, medium grained sand sediments are a mixture of calcium (coquina shell fragments, reef fragments, skeletal fragments of marine organisms) and silica sands in the form of quartz. Mean grain size ranged from 0.25 to 0.41 mm, sorting averages ranged from 0.80 to 1.38, and the overall silt content varied from 1.7% to 6.8%. Table 5 presents a summary of the sediment characteristics determined for the seven borrow areas in the 1997 study.

TABLE 5

1997 BORROW AREA SEDIMENT CHARACTERISTICS

Borrow Area	Average Depth of Cut (ft.) (1)	Volume of Sand (cy) (1)	Mean Grain Size (mm)	Mean Grain Size (phi)	Mean Sorting (phi)	Mean Silt/Clay (%)	Mean Calcium Carbonate (%)
I	6.0	988,426	0.36	1.49	0.92	1.7	57.2
II	6.1	1,422,197	0.30	1.73	0.79	1.7	60.2
III	7.2	716,683	0.41	1.28	1.38	4.6	90.4
IV	6.0	295,342	0.32	1.65	0.97	2.4	65.7
V	7.6	344,057	0.25	1.98	1.14	6.8	83.5
VI	7.6	300,280	0.41	1.28	0.90	2.6	72.3
VII	7.0	361,480	0.42	1.24	1.30	3.3	79.7
TOTAL (cy)		4,425,465					

Note: (1) Based on 1997 borrow area limits and preliminary design dredge cuts. Borrow area limits and dredge cuts have been revised for the preferred design alternative (see Table 6).

3.1.8.2. 2001 Borrow Area Revisions

In June and July 1999, Broward County visually inspected the hardbottom locations to ground-truth the 1997 side scan sonar survey. Additional environmental investigations were conducted in 2001 by CPE/Olsen Associates (J-V) and Nova Southeastern University of the seven, proposed borrow areas and the adjacent reef edges. Two of the previously defined borrow areas, BA-V and BA-VII, were eliminated due to environmental and geotechnical concerns. Borrow Area V had an average calcium carbonate component of 84% and a fine-sand, silt clay component of approximately 20%. Borrow Area VII had an average calcium carbonate component of 79.7% and a fine-sand, silt/clay component of 7.2%. The boundaries of the remaining five borrow areas were redefined to avoid small patch reef formations and rubble areas with reef benthic communities, as well as scattered seagrass beds within the proposed borrow areas and adjacent buffer zones. The revised buffer zones range from approximately 200 to more than 400 feet from the hardbottom communities and are dependent upon the habitat quality of the adjacent reef edge. Borrow Areas I, II and III are located north of Hillsboro Inlet and Borrow Areas IV and VI lie to the south of Hillsboro Inlet. Figure 5 is a location map of the five proposed borrow areas. Figures 6.0 through 6.5 show the revised borrow areas with buffer distances to reef edges.

Environmentally refining the remaining borrow areas reduced the total volume such that the required 50% additional fill material was not available. To increase the volume, additional cores were performed to investigate deeper sediment within the borrow areas. A larger vibracore rig was contracted in 2001 than was utilized during the 1996 geotechnical investigations. The heavier Alpine rig was able to achieve deeper penetration into and through the scattered rubble layers located within the unconsolidated sediments. Based on the sediment findings of the 2001 vibracores, the cut depths were increased within the limits of the original Borrow Areas I, II, III, IV, and VI.

Table 6 shows the total area and estimated quantity of sand in each borrow site based on the increased buffer zone and revised borrow area limits. The selected borrow areas range in size from 140.1 acres (Borrow Area II) to 8.6 acres (Borrow Area VI). The amount of sand available from these borrow sites ranges from 2,482,000 cubic yards (Borrow Area II) to 84,000 cubic yards (Borrow Area IV). The total volume identified within the five borrow areas is approximately 4.9 million cubic yards of sand. The total fill requirement for the life of the authorized project is approximately 5.4 million cubic yards. The mean grain size ranges from 0.43 mm in Borrow Area III to 0.31 mm in Borrow Areas II and IV. The composite silt content ranges from 4.38 percent in Borrow Area III to 1.86 percent in Borrow Area II (Table 6).

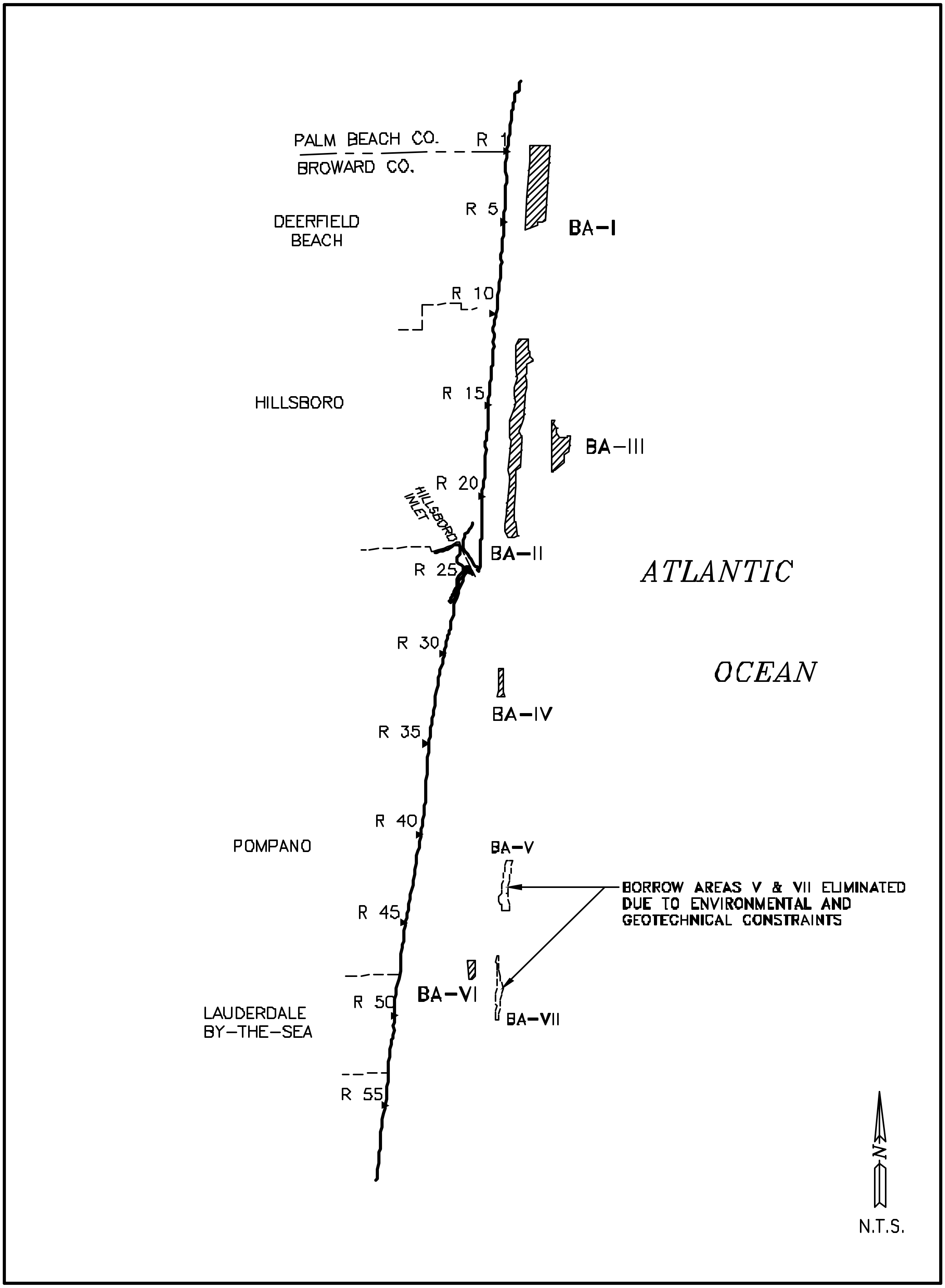


FIGURE 5

BROWARD COUNTY
BORROW AREAS

TABLE 6

REVISED AVAILABLE BORROW AREA VOLUMES AND SEDIMENT DATA INCORPORATING THE 2001 CORES WITH THE 1996 DATA

B.A. No.	Average Depth of Cut[1] (ft)	Volume of Sand[1] (cy)	Borrow Area Surface Area (Acres)	Rubble & Coral Fragments Greater than ¾ Inch (%)	Mean Silt/Clay (%)	Mean Grain Size (mm)	Clean Sand Volume[2] (cy)
I	10.0	1,724,000	108.0	9.5	2.0	0.39	1,529,000
II	14.5	2,482,000	140.1	6.0	1.9	0.31	2,288,000
III	9.0	560,000	38.1	7.5	4.4	0.43	495,000
IV	5.0	84,600	10.5	4.5	2.6	0.31	78,000
V	Borrow area eliminated due to environmental concerns						
VI	7.5	106,000	8.6	4.5	2.1	0.42	99,000
VII	Borrow area eliminated due to environmental concerns						
TOTAL		4,956,000					

Note: (1) Based on revisions of the 1997 borrow areas in size and dredge cuts for the preferred design alternative.
(2) Clean Sand Volumes reflect remaining sand after silt and rock have been removed.

The 1996/97 geotechnical investigations identified the presence of layers of coral rubble and fragments in the sand recommended for use in each borrow area. The recommended dredge cut depths vary based upon the variability of the depth of the rock rubble layers. The dredge cuts contain varying levels of discontinuous rock rubble which reduce the volume of available sand. Table 6 shows the volume of available sand by reducing the dredge volumes by the estimated rock percentage and the percentage of silt/clay.

3.1.8.3. Sand Quality.

The first quantitative study of native carbonate content of Florida's east coast beaches was published by Martens (1935). This data represents littoral conditions that existed prior to beach restoration and maintenance nourishment along Florida's southeast coast beaches (Balsillie, unpublished). Data reported for Hollywood's beaches indicated a native carbonate content of 53.4% (Martens, 1935). A study by Raymond (1972) entitled "A geological investigation of the offshore sands and reefs of Broward County" revealed that the offshore sand grades from silica-rich (>50% quartz) in the northern part of the Broward County to silica-poor (<10% quartz) at the southern end. Raymond found that the average quartz content of Broward County beach sand was 51%, with a decrease in quartz content southward, from greater than 55% in the north to less than 30% at Hallandale (Raymond, 1972).

In May 1999, a sediment sampling program was carried out along the Segment II and Segment III shorelines of Broward County. Samples were obtained from the dune and mid-berm at every third FDEP monument in southern Pompano Beach and northern Ft. Lauderdale (from R-33 to R-75) and in John U. Lloyd State Park, Dania Beach, Hollywood, and Hallandale (from R-87 to R-126). Also, sediment samples were taken along the profile from the dune to the –16 ft (NGVD) contour at every sixth FDEP monument in the southern Pompano Beach and northern Ft. Lauderdale (from R-36 to R-74) and in John U. Lloyd State Park, Dania Beach, Hollywood, and Hallandale (from R-87 to R-126).

The sediment sampling scheme used to collect the samples across the beach profile was based upon the guidelines outlined by CERC (1991). The samples were generally collected at the toe of the dune, mid berm, MHW (1.9 ft. [NGVD]), MTL (0 ft. [NGVD]), MLW (-1 ft. [NGVD]), -4ft (NGVD), -8ft (NGVD), -12ft (NGVD), and -16ft (NGVD). Grain size distributions of the existing beach sediments were determined using standard sieving techniques. The mean grain size, sorting, and silt content along each profile line are shown in Table E-4 for Segment II and Table E-5 for Segment III in Appendix E of the February 2002 GRR.

The mean grain sizes of the beaches in southern Pompano Beach and Lauderdale-By-The-Sea are 0.27 mm and 0.29 mm, respectively. The sorting values for these areas are 0.69 phi and 0.70 phi, respectively. The silt contents are 1.54% and 0.82%, respectively. The mean grain size, sorting, and silt content values for Ft. Lauderdale are 0.33 mm, 0.83 phi, and 1.65%, respectively. The mean grain sizes of the beaches along the John U. Lloyd State Park and Hollywood/Hallandale (Segment III) are 0.33 mm and 0.37 mm, respectively. The sorting value for these areas is 0.72 phi. The silt contents are 1.15% and 1.07%, respectively.

Sediment Composition. Eight sediment samples were obtained from the 72 vibracores and analyzed for the calcium carbonate content of the sediment. One representative vibracore from each borrow area was selected with the exception of Borrow Area II, where two representative vibracores were selected. The 1997 geotechnical study concluded that the medium to coarse grained sand was found to be more calcareous in composition than siliceous. The silica content of the sediment generally decreases to the south (50.3% to 25.6%) as calcium carbonate content increases (48.1% to 72.0%) (CPE, 1997). One representative vibracore from the 2001 cores within each borrow area was also sampled and tested to determine the calcium carbonate content of the proposed fill material. The 2001 vibracore composition was found to be similar to the previous analysis showing an increase in calcareous content and a decrease in silica from north to south. Borrow Area III, the most offshore borrow area within the third intrareefal flat, exhibited the highest calcareous composition of the 2001 vibracores (93.5% carbonate content). The carbonate content is primarily a mixture of shell and shell hash. Similar trends were observed for the existing beaches. Samples collected from the Segment II and III berms were found to contain 55% and 84% calcium carbonate, respectively. Since beaches in both segments have been nourished, calcium carbonate contents are directly related to the calcium carbonate contents of the previous borrow areas. Results of the sediment composition analysis are presented in Table 7.

TABLE 7

BROWARD COUNTY BORROW AREAS SEDIMENT COMPOSITION

BORROW AREA	SAMPLE NUMBER	QUARTZ CONTENT (%)	CALCIUM CARBONATE CONTENT (%)
BA-I	BV96-44#1 BC96-44#2 BCVC-01-02#3	51.9 45.5 30.9	48.1 54.5 69.1
BA-II	BC96-29#1 BC96-29#2 BC96-39#2 BCVC-01-10#2	40.1 42.8 45.6 30.7	59.9 57.2 54.4 69.3
BA-III	BC96-50#1 BC96-50#2 BCVC-01-14#2	6.5 14.4 7.8	93.5 85.6 92.2
BA-IV	BC96-54#2 BC96-54#3 BCVC-01-17#1	28.6 43.9 30.4	71.4 56.1 69.6
BA-V	BC96-71#2 BCVC-01-20#2	26.4 6.5	73.6 93.5
BA-VI	BC96-24#1 BC96-24#2 BCVC-01-21#1	27.6 28.0 27.6	72.4 72.0 72.4
BA-VII	BC96-25#1 BC96-25#3 BCVC-01-23A#2	25.6 27.5 7.7	74.4 72.5 92.3

3.2. VEGETATION.

3.2.1. DUNE COMMUNITIES.

Most of the native dune habitat in Broward County has been lost, either to urban development, beach erosion, or a combination of the two. Upland areas along Fort Lauderdale beach have been impacted by urban development and are generally devoid of dune and hardwood hammock habitat. South of Port Everglades Inlet at John U. Lloyd State Park, exotic invasive species such as Australian pine (*Casuarina equisetifolia*) and Brazilian pepper (*Schinus terebinthifolius*) dominate the uplands areas. Many of these upland areas were created by filling with dredge spoil. However, there are areas within the park where native species of the coastal dune and hammock region still remain (Coastal Technology Corporation, 1994). The dune revegetation program 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, (*Terminalia catappa*) bitter panicum (*Panicum amarum*) and others (Hamilton, 1994).

3.2.2. SEAGRASSES.

Seagrasses are typically found in clear, shallow water. One species of seagrass found in Florida waters, *Halophila decipiens* (commonly known as paddle grass) possesses specific morphological and structural features that allow it to occupy low light environments (Josselyn et al., 1986). In relatively clear water, *H. decipiens* can grow in deeper, offshore waters ranging to 100 feet. During the summer months, which correspond to the peak growing season for seagrasses throughout most of Florida, scientists estimate that more than one million acres of *H. decipiens* may grow offshore (FWCC, 2001).

A reconnaissance, towed-diver, video survey of the original seven, proposed borrow areas was performed from April to July of 2001 to provide complete visual coverage of the substrate within the interior of the borrow areas. An integrated digital video system was used to incorporate DGPS data directly onto the video record. When features other than sand bottom or sand with turf algae were observed, DGPS positioning was recorded. Biologists performed ground-truthing SCUBA dives of the DGPS targets to document the presence/absence of significant biological resources, and to identify and characterize any bottom substrate types that were not sand bottom. Scattered patches of *H. decipiens*, consisting of less than 50 shoots, were observed in several of the borrow areas during these ground-truthing dives. Two of the proposed borrow areas, VI and VII, contained contiguous areas of *H. decipiens*, estimated in July 2001 to cover approximately 3,000 square feet. The seagrass was covered by epiphytic growth of filamentous red algae and cyanobacteria. Video and still photography documentation of the *H. decipiens* beds in Borrow Areas VI and VII is included in the Broward County GIS. The southern half of Borrow Area VI, and all of Borrow Area VII, were removed from the proposed project design. The remaining five borrow areas do not contain significant areas of seagrass coverage.

There are no known seagrass beds located within or adjacent to the proposed beach fill areas. The nearshore benthic communities were characterized at 55 locations within and adjacent to the equilibrium toe of fill. During these investigations, a single observation of approximately 10 *Thalassia testudinum* shoots was observed at Station R-73 in Fort Lauderdale, 1,000 feet south of the design taper limit (see Figures 8 through 8.13 for station locations).

Seagrass beds consisting of *Halophila decipiens* were observed in the Port Everglades Inlet channel and Intracoastal Waterway adjacent to Port Everglades during reconnaissance dives performed in 1998 by Broward County Department of Planning and Environmental Protection (DPEP) staff (Ken Banks, DPEP, personal communication, 1999). Three inlet, cross-transectional transects were surveyed during the reconnaissance dives. Abundant coverage by *H. decipiens* was observed along the easternmost transect, approximately 500 feet east of the entrance to Port Everglades Inlet Channel, in a sandy bottom. The second cross-sectional transect, located at the entrance to the inlet channel, was colonized by *H. decipiens;* however the seagrass was not as abundant and occurred as patches separated by sand areas. The seagrass patches became more rare as the divers moved west into the channel along the third cross-sectional transect (DPEP, 1999).

3.3. THREATENED AND ENDANGERED SPECIES.

3.3.1. SEA TURTLES.

Broward County is within the normal nesting areas of three species of sea turtles: loggerhead sea turtle (*Caretta caretta*), green sea turtle (*Chelonia mydas*), and leatherback sea turtle (*Dermochelys coriacea*). Additionally, two of the seven hawksbill nests laid in the State of Florida between the years 1979 and 1998 were in Broward County: one nest in 1994, and one in 1997 (Florida Marine Research Institute, 1999). The loggerhead (*C. caretta*) is listed as a threatened species, while all other sea turtles are listed as endangered under the U.S. Endangered Species Act of 1973. The nesting season for all species of sea turtles, as defined by the Florida Fish and Wildlife Conservation Commission, is between March 1 and October 31 in Broward County.

3.3.1.1. Nesting Habitat.

Overall, 2,942 nests were recorded in 2000 over the 24-mile beach from the Palm Beach County/Broward Line south to the Broward County/Dade County Line. Total nests recorded for the previous five nesting seasons (1999, 1998, 1997, 1996, 1995) were 2,620; 2,857; 2,288; 2,810; and

TABLE 8
RARE, THREATENED AND ENDANGERED SPECIES IN THE COASTAL STUDY AREAS OF BROWARD COUNTY

Common Name	Scientific Name	FWC	FWS
BIRDS			
Cape Sable seaside sparrow	*Ammodramus maritimus miribalis*	E	E (CH)
Florida scrub-jay	*Aphelocoma coerulescens*	T	T
Limpkin	*Aramus guarauna*	SSC	NL
Piping plover	*Charadrius melodus*	T	T
Little blue heron	*Egretta caerulea*	SSC	NL
Snowy egret	*Egretta thula*	SSC	NL
Peregrine falcon	*Falco peregrinus*	E	E(S/A)
Southeastern American kestrel	*Falco sparverius paulus*	T	NL
Florida sandhill crane	*Grus canadensis pratensis*	T	NL
Bald eagle	*Haliaeetus leucocephalus*	T	T
Wood stork	*Mycteria americana*	E	E
Osprey	*Pandion haliaetus*	SSC	NL
Red cockaded woodpecker	*Picoides (Dendrocopos borealis*	T	E
Audubon's crested caracara	*Polyborus plancus audubonii*	T	T
Everglade snail kite	*Rostrhamus sociabilis plumbeus*	E	E
Burrowing owl	*Speotyto cunicularia*	SSC	NL
Least tern	*Sterna antillarum*	T	NL
Roseate tern	*Sterna dougallii dougallii*	T	T
REPTILES			
American alligator	*Alligator mississippiensis*	SSC	T(S/A)
Atlantic loggerhead turtle	*Caretta caretta*	T	T
Atlantic green turtle	*Chelonia mydas mydas*	E	E
American crocodile	*Crocodylus acutus*	E	E
Leatherback turtle	*Dermochelys coriacea*	E	E
Eastern indigo snake	*Drymarchon corais couperi*	T	T
Red rat snake; corn snake	*Elaphe guttata guttata*	SSC	NL
Atlantic hawksbill turtle	*Eretmochelys imbriccata imbratica*	E	E
Gopher tortoise	*Gopherus polyphemus*	SSC	NL
Florida scrub lizard	*Sceloporus woodi*		NL
Miami black-headed snake; rimrock crowned snake	*Tantilla oolitica*	T	NL
AMPHIBIANS			
Gopher frog	*Rana capito*	SSC	NL
FISHES			
Common snook	*Centropomus undecimalis*	SSC	NL
INVERTEBRATES			
Pillar coral	*Dendrogyra cylindrus*	E	E
MAMMALS			
Right whale	*Balaena glacialis*	E	E
Sei whale	*Balaenoptera borealis*	E	E
Finback whale	*Balaenoptera physalus*	E	E
Mountain lion	*Felis concolor*	NL	T (S/A)
Florida panther	*Felis concolor coryi*	E	E
Short-finned pilot whale	*Globicephala macrorynchus*	NL	NL
Long-finned pilot whale	*Globicephala melas*	NL	NL
Pygmy sperm whale	*Kogia breviceps*	NL	NL
Humpback whale	*Megaptera novaeangliae*	E	E
Everglades mink	*Mustela vison evergladensis*	T	NL
round-tailed muskrat	*Neofiber alleni*	NL	NL
Southeastern beach mouse	*Peromyscus polionotus niveiventris*	T	T
Sperm whale	*Physeter catadon*	E	E
Florida mouse	*Podomys floridanus*	SSC	NL
West Indian (Florida) manatee	*Trichechus manatus*	E	E
Florida black bear	*Ursus americanus floridanus*	T	NL

TABLE 8
RARE, THREATENED AND ENDANGERED SPECIES IN THE COASTAL STUDY AREAS OF BROWARD COUNTY

Common Name	Scientific Name	FWC	FWS
PLANTS			
Johnson's seagrass	*Halophila johnsonii*	NL	T (NMFS) *
Sand-dune surge	*Chamaesyce cumulicola*	NL	C
Garber's spurge	*Chamaesyce garberi*	E	T
Large-flowered rosemary	*Conradiana grandiflora*	E	C
Cupgrass	*Eriochloa michauxli var. simpsonii*	NL	C
Hairy beach sunflower	*Helianthus debilis sp. vestitus*	NL	C
Florida lantana	*Lantana depressa*	NL	C
Devil's shoestring	*Tephrosia angustissima*	E	C
Burrowing four-o'clock	*Okenia hypogaea*	E	NL
Beach-star	*Remirea maritima*	E	NL
Bay cedar	*Suriana maritima*	E	NL
Coconut palm	*Cocos nucifera*	T	NL
Beach-creeper	*Ernodea littoralis*	T	NL
Sea-lavander	*Mallotonia gnaphalodes*	T	NL
Inkberry	*Scaevola plumieri*	T	NL
Black Mangrove	*Avicennia germinans*	SSC	NL
Red Mangrove	*Rhizopora mangle*	SSC	NL
Beach clustervine	*Jacquemontia reclinata*	E	E

Notes: E = Endangered; T = Threatened; C = Candidate; SSC = Special Concern; NL = Not Listed; CH = Critical Habitat has been designated for this species in this county; S/A = Threatened due to Similar Appearance

* Johnson's seagrass, *Halophila johnsonii,* has been listed by the National Marine Fisheries Service as a threatened species under the Endangered Species Act as of October 14, 1998.

Sources: University of Florida Institute of Food and Agricultural Sciences, Florida Cooperative Extension Service Wildlife Website, Updated Nov. 1998; Florida Game and Freshwater Fish Commision, 1997. U.S. Fish & Wildlife Service - South Florida Ecological Services Office, Updated Feb. 1999

2,634, respectively. The 2000 total nest count was the highest since the inception of the County monitoring program in 1978. The distribution of nests among species in 2000 was 2,674 loggerhead nests, 255 green sea turtle nests, and 13 leatherback nests. The distribution of nests among species during the 1998 season was 2,643 loggerhead nests, 200 green sea turtle nests, and 14 leatherback nests (Burney & Margolis, 1999). The distribution of nests among species during the 1997 season was 2,216 loggerhead nests, 29 green sea turtle nests, 42 leatherback nests, and one nest was confirmed as hawksbill (Burney & Margolis, 1998).

The Florida statewide nesting database provides the nesting results of Florida's surveyed beaches for the years 1979 through 1996, including an addendum for the years 1993 through 1998. A total of 413,051 loggerhead nests (an average of 68,842 per nesting season); 14,167 green sea turtle nests (an average of 2,361 per nesting season); 1,584 leatherback nests (an average of 264 per nesting season; and 7 hawksbill nests were documented on Florida beaches between 1993 and 1998. Two of the seven hawksbill nests were laid in Broward County, one in 1994, and one in 1997 (Florida Marine Research Institute, 1999).

Due to the heavily developed nature of the Broward County coastline, the relative location of Highway A-1-A to the beach, and extensive beach front lighting, all of which have the potential to negatively impact nesting sea turtles and their hatchlings, Broward County has relocated all discovered nests at Pompano Beach, Deerfield Beach, Hollywood-Hallandale, and Fort Lauderdale since the inception of its sea turtle conservation program in 1978 (Burney and Margolis, 1998). Figure 7 shows the historical patterns of the yearly hatching success of all species combined from 1981 through 2000. In 1998, hatching success was at its lowest level since the nest relocation program was initiated. However, loggerhead hatching success was slightly higher in relocated nests than *in situ* nests, lending credence to the hypothesis that environmental factors, such as the unusually high early summer temperatures in 1998, negatively affected early loggerhead nests (Sterghos, 1998).

3.3.1.2. Offshore Habitat.

Sea turtles are present in the open ocean offshore of Broward County due to the warm water temperatures and hardbottom habitat used for both foraging and shelter. The predominant species is the loggerhead turtle, *Caretta caretta*. *Chelonia mydas* (green turtle), *Dermochelys coriacea* (leatherback turtle), *Eretmochelys imbricata* (hawksbill turtle) and *Lepidochelys kempii* (Kemp's ridley) are also known to exist offshore of South Florida.

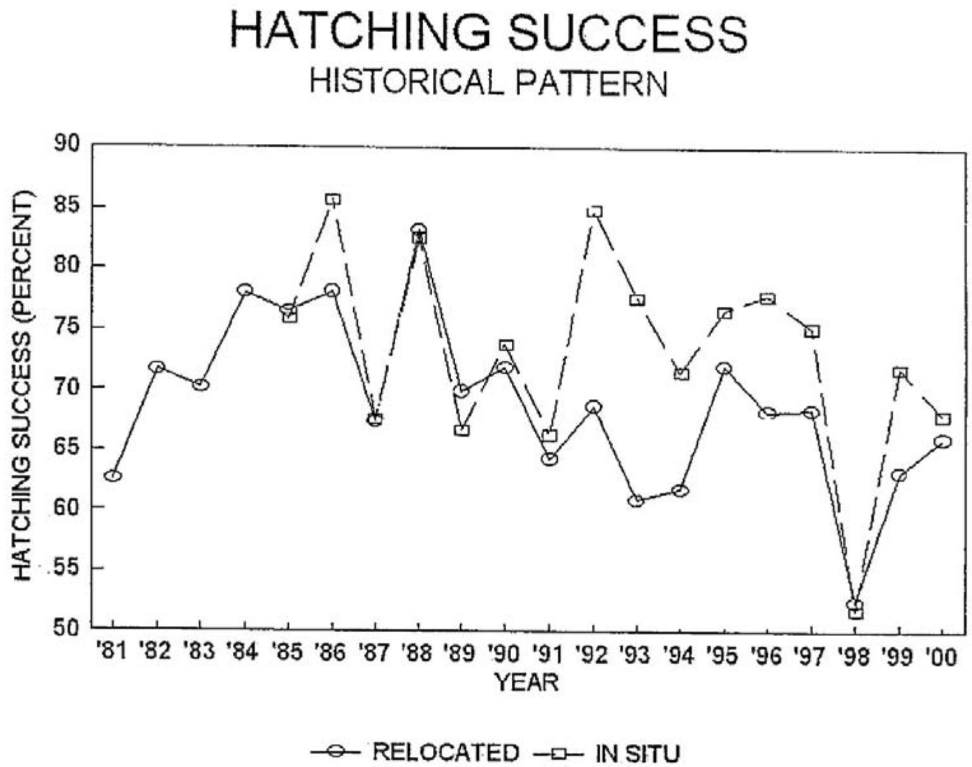


FIGURE 7: The historical patterns of yearly hatching success for all evaluated *in situ* sea turtle nests since 1981.

Source: Burney, C., and W. Margolis. 2000. Sea Turtle Conservation Report. (Technical Report 01-02). Nova Southeastern University.

3.3.1.3. Nearshore Habitat.

A capture and release study by Wershoven and Wershoven (1989; 1990) indicated that hardbottom areas offshore of Broward County serve as important developmental habitat for juvenile green sea turtles. One hundred and five juvenile green turtles were captured and tagged during nocturnal diving surveys between March 1, 1986 and December 31, 1988. Four juvenile hawksbill sea turtles were also captured. The highest number of captures were recorded during the months of June and October; the fewest captures were in September and December (Wershoven and Wershoven, 1990). Analysis of stomach contents from stranded green sea turtles of the same size revealed a preference for turf algae of the Family Gelidiaceae (particularly *Pterocladia, Gelidium,* and *Gelidiella* species) (Wershoven and Wershoven, 1990). Other algal species documented as food sources were *Gracilaria* sp., *Bryothamnion* sp., and *Hypnea* sp. A study in south-east Queensland found that juvenile green turtles fed primarily on *Gracilaria* sp., followed by *Hypnea* sp., and three seagrass species. Interestingly, the most dominant seagrass (*Zostera capricorni*) found in the study area was ingested in relatively low volumes. The most frequently ingested food items (*Gracilaria* sp.) were present in very small quantities within the study area. This suggests that juvenile green sea turtles may be actively exercising a degree of choice in their diet. This choice may be the result of nitrogen and fiber content within the selected food sources. Food sources with low fiber content, such as *Gracilaria* sp., may be easier for turtles to digest since they are incapable of chewing their food (Brand-Gardner et al., 1999).

Juvenile green sea turtle abundance and distribution along the Broward County shoreline was assessed for the proposed project via a series of three shore-parallel, boat-towed diver transects conducted between July and September 2001. The study area extended from R-31 in north Pompano Beach to Dade County's FDEP Control monument R-5 for a total study distance of 18.18 miles. The shore-parallel transects were located along: 1) the nearshore hardbottom edge; 2) the estimated location of the equilibrium toe of fill; and 3) 300 feet east of the estimated equilibrium toe of fill. Additionally, prior to filming the hardbottom edge, the hardbottom interface was determined by a diver propelled by scooter with a GPS antenna attached directly to the diver. This methodology provided extremely accurate positioning for the hardbottom edge. The diver on scooter also noted any observations of sea turtles during the survey with minimal disturbance to the turtles. Therefore, a total of four, shore-parallel transects were conducted along the 18.18 miles of Broward County shoreline; and the two different methodologies of observation (boat towed diver versus diver on scooter) allow for a comparison of results based upon survey methodology.

The boat-towed diver sea turtle surveys were performed by a second diver/biologist attached to a tow line above the diver filming the video transect of the benthic communities. The biologist was positioned higher than the video diver to obtain a wider field vision of the transect, and was solely dedicated to identifying the presence of sea turtles along the transect, describing sea turtle activity and general habitat type, and estimating relative size by visual observation. When a sea turtle was observed by the biologist, s/he signaled the line tender on the boat with a hand signal, and a DGPS event was recorded along the trackline. Sea turtles that were observed by the boat operator on the surface of the water along the transect line were also documented during the survey. All sighting data has been incorporated into the GIS database.

Table 9 provides the listing of sea turtle observations during the four, shore-parallel surveys, including the location (easting, northing), time of day, date of sighting, water depth, description of observations, survey identifier, and sea state conditions during the survey. The locations of all sea turtle sightings are shown in the Broward County GIS.

A total of thirty-three (33) sea turtles were sighted during the four, shore-parallel surveys. The only species observed during the surveys was the green sea turtle (*Chelonia mydas*), and all visual size estimations of carapace length were described as juveniles. The approximate size estimation for the majority of the sightings was one foot (30.5 cm), and the largest observation was estimated at two feet (~62 cm). Twenty- seven (27) of the 33 sightings were in Segment II; and two of the six sightings in Segment III were observed on the surface by the boat operator. There were two instances in Segment II where a pair of juveniles were seen in the same location: one pair was observed swimming over sand/rubble/macroalgae bottom offshore of R-38 in Pompano Beach; and one pair was resting on sand bottom offshore of R-60 in Fort Lauderdale.

Twenty-four (24) of the sea turtles were observed swimming (or surfacing) and nine were resting on the bottom. No sea turtles were observed feeding; however, their activity may have been disrupted by the noise of the boat. Eleven (11) sea turtles were observed during the scooter survey of the nearshore edge in July while only five were seen during the boat-towed diver survey of the hardbottom edge in August 2001. Differences in sea turtle densities along the same transect may be the result of the

TABLE 9
2001 BROWARD COUNTY SEA TURTLE SURVEY RESULTS

Easting	Northing	Time	Date of Sighting	Water Depth (NGVD)	Description	Survey Identifier	Sea state during survey
953667.33	674231.73	9:39:54 AM	8/31/2001	-11.52	Juvenile green sea turtle- swimming near Pier	ETOF+300 towed diver	Choppy seas 1-2 feet, southeast wind 5 to 10 mph
952932.08	669307.85	10:14:32 AM	8/31/2001	-14.36	Juvenile green sea turtle- swimming	ETOF+300 towed diver	Choppy seas 1-2 feet, southeast wind 5 to 10 mph
952802.42	668366.00	10:21:23 AM	8/31/2001	-13.12	Juvenile green sea turtle- swimming	ETOF+300 towed diver	Choppy seas 1-2 feet, southeast wind 5 to 10 mph
951329.15	656127.78	11:49:01 AM	8/31/2001	-17.08	Juvenile green sea turtle- swimming	ETOF+300 towed diver	Choppy seas 1-2 feet, southeast wind 5 to 10 mph
951231.89	654796.66	11:58:14 AM	8/31/2001	-17.42	Juvenile green sea turtle- swimming	ETOF+300 towed diver	Choppy seas 1-2 feet, southeast wind 5 to 10 mph
956265.66	692318.23	10:32:24 AM	8/30/2001	-18.86	Juvenile green sea turtle- swimming over sand bottom with rubble/macroalgae	ETOF+300 towed diver	Seas 1 foot, light east wind
955604.46	689670.88	10:53:41 AM	8/30/2001	-17.39	2 Juvenile green sea turtles- swimming over sand bottom with rubble/macroalgae	ETOF+300 towed diver	Seas 1 foot, light east wind
954542.07	681222.06	1:02:24 PM	8/30/2001	-15.38	Juvenile green sea turtle- swimming over sand bottom	ETOF+300 towed diver	Seas 1 foot, light east wind
953878.46	676275.02	1:38:04 PM	8/30/2001	-13.78	Juvenile green sea turtle- swimming near Pier	ETOF+300 towed diver	Seas 1 foot, light east wind
953944.38	675386.54	1:45:06 PM	8/30/2001	-15.09	Juvenile green sea turtle-swimming near Pier	ETOF+300 towed diver	Seas 1 foot, light east wind
949401.07	639594.93	10:30:01 AM	8/29/2001	-10.83	Juvenile green sea turtle- swimming	ETOF+300 towed diver	Choppy seas 1 to 2 feet, variable east wind
953066.00	672818.00	10:41:39 AM	7/5/2001	-14.25	Juvenile green sea turtle- resting	Nearshore scooter survey	Calm, flat seas, no wind, water visibility in excess of 50 feet
953028.00	671104.00	11:03:35 AM	7/5/2001	-16.08	Juvenile green sea turtle- resting	Nearshore scooter survey	Calm, flat seas, no wind, water visibility in excess of 50 feet
952696.00	668886.00	11:19:09 AM	7/5/2001	-15.26	Juvenile green sea turtle- swimming	Nearshore scooter survey	Calm, flat seas, no wind, water visibility in excess of 50 feet
952661.00	668853.00	11:19:45 AM	7/5/2001	-15.09	Juvenile green sea turtle- swimming	Nearshore scooter survey	Calm, flat seas, no wind, water visibility in excess of 50 feet
952340.00	665448.00	11:41:15 AM	7/5/2001	-16.91	Juvenile green sea turtle- swimming	Nearshore scooter survey	Calm, flat seas, no wind, water visibility in excess of 50 feet
951794.00	661819.00	12:10:52 PM	7/5/2001	-15.74	Juvenile green sea turtle- swimming	Nearshore scooter survey	Calm, flat seas, no wind, water visibility in excess of 50 feet
951100.00	656605.00	2:03:16 PM	7/5/2001	-15.68	Juvenile green sea turtle- resting	Nearshore scooter survey	Calm, flat seas, no wind, water visibility in excess of 50 feet
951284.00	658388.00	2:12:52 PM	7/5/2001	-15.76	Juvenile green sea turtle- swimming	Nearshore scooter survey	Calm, flat seas, no wind, water visibility in excess of 50 feet
948488.00	629446.00	2:28:04 PM	7/5/2001	-11.16	Juvenile green sea turtle- resting	Nearshore scooter survey	Calm, flat seas, no wind, water visibility in excess of 50 feet
955742.00	693079.00	3:12:52 PM	7/9/2001	-13.79	Juvenile green sea turtle- swimming	Nearshore scooter survey	Calm, flat seas, no wind, water visibility in excess of 50 feet
947520.00	609133.00	11:13:32 AM	7/11/2001	-16.1	Juvenile green sea turtle- resting on bottom	Nearshore scooter survey	Calm seas, excellent underwater visibility in excess of 50 feet
951768.00	661251.00	11:49:20 AM	7/20/2001	-16.24	Juvenile green sea turtle- resting on bottom	Hardbottom edge towed diver	Calm seas- excellent water visibility in excess of 50 feet
950565.00	649816.00	1:20:26 PM	8/13/2001	-12.77	Juvenile green sea turtle- swimming over sand bottom with red macroalgae	Hardbottom edge towed diver	Choppy seas 1-2 feet, poor underwater visibility ~ 20 feet
954799.00	685847.00	3:05:56 PM	8/13/2001	-13.78	Juvenile green sea turtle- resting on hardbottom dominated by red macroalgae	Hardbottom edge towed diver	Choppy seas 1-2 feet, poor underwater visibility ~ 20 feet
946567.62	597005.06	10:39:26 AM	8/15/2001	-13.81	Juvenile green sea turtle- observed on surface of water by boat operator/hardbottom with sand and red macroalgae	Hardbottom edge towed diver	Calm seas, poor underwater visibility ~ 15 feet
946880.20	600310.21	11:04:55 AM	8/15/2001	-19.75	Juvenile green sea turtle- observed on surface of water by boat operator /bottom was sand with red macroalgae	Hardbottom edge towed diver	Calm seas, poor underwater visibility~ 15 feet
951503.12	660785.56	10:11:54 AM	9/26/2001	-14.22	Juvenile green sea turtle- swimming	ETOF towed diver	Seas 1 foot
950875.06	655029.98	10:38:06 AM	9/26/2001	-13.94	Juvenile green sea turtle- swimming	ETOF towed diver	Calm seas- excellent water visibility in excess of 50 feet
950524.57	648621.38	11:09:58 AM	9/26/2001	-13.87	Juvenile green sea turtle -swimming	ETOF towed diver	Calm seas- excellent water visibility in excess of 50 feet
952240.50	666015.00	3:09:56 PM	9/24/2001	-13.1	2 Juvenile green sea turtles- resting on sand bottom	ETOF towed diver	Seas 1 foot

different methodologies used for observation. The scooter survey may be less intrusive and less likely to disrupt behavior and/or elicit a flight response, thereby decreasing the likelihood of escaping detection, than the boat-towed diver survey.

The results of the surveys also suggest that sea state conditions may influence sea turtle density in the nearshore zone. Most of the sea turtle sightings occurred during calm, flat seas, or seas less than one foot. Five of the seven sightings that were made in choppy conditions (seas 1 to 2 feet) occurred along the ETOF+300 transect, located 300 feet east (offshore) of the equilibrium toe of fill. It is possible that the hardbottom located slightly further offshore provides more refuge from wave activity (i.e. areas of higher rugosity and vertical relief), and that the juveniles move offshore during periods of intense wave activity. It was noted that no sea turtles were observed on days when seas were greater than two feet. Sea state conditions in excess of three feet prevented survey work along the nearshore edge or equilibrium toe of fill transect.

Twelve (12) sea turtles were observed during the ETOF+300 towed diver survey in late August 2001. Four (4) of the twelve were observed within 1,000 feet of the Pompano Pier (1 sea turtle) and Anglin's Pier (3 sea turtles). More than half (nineteen of thirty-three) of the observations during the four surveys occurred along the stretch of shoreline between R-50 and R-72, and seven of those nineteen were observed outside of the projected equilibrium toe of fill. Only five sea turtles were observed over the equilibrium toe of fill (ETOF) transect in late September, and none were observed in Segment III.

The macroalgal community within and adjacent to the proposed beach fill areas in Broward County was investigated in August 2001. The methodology used during the survey was a modification of the AGRRA Rapid Assessment Protocol (Atlantic and Gulf Rapid Reef Assessment). A total of 116, 30-meter transects were investigated, forty-two experimental and 16 control transects per project segment, based upon the beach fill design as proposed in the January 2001 General Reevaluation Report. The exact locations of the transects are shown in the GIS. The transects were established at the nearshore hardbottom edge and ran 30 meters due east (offshore).

The algal community was evaluated every three meters along each transect using a 25 x 25 cm quadrat. This resulted in ten sampling units per transect for a grand total of 1,160 sites. Following the AGRRA protocol, the two dominant macroalgal species were identified and their relative percent cover was estimated; total percent cover of macroalgae, turf algae, and coralline algae was estimated; and turf/coralline algae were identified to the species level whenever possible. In addition to this data, the researchers recorded the relative percent cover of blue-green algae (cyanobacteria) due to its extensive distribution along the nearshore hardbottom edge, particularly in Segment III just south of Port Everglades.

The most abundant genera in Segment II were *Dictyota* and *Dasya*. *Dictyota* sp. was one of the dominant two macroalgal species in 328 of the 580 quadrats evaluated, while *Dasya* sp. was one of the two dominant species in 160 quadrats. The dominant turf algal species was *Gelidium* sp. and was identified in 63 quadrats in Segment II. *Gelidium* sp. appeared to be most common along the hardbottom edge in Pompano Beach between R-38 and R-44. Other documented food sources for juvenile green sea turtles (Wershoven and Wershoven 1989) that were either a dominant species or a component of a dominant, red macroalgal mix consisting of several species were *Gracilaria* sp. (25 sites in Segment II and 81 sites in Segment III), *Hypnea musciformis (*17 sites in Segment II and 25 in Segment III), and *Bryothamnion* sp. (41 sites in Segment II and 24 sites in Segment III).

The blue-green algae, *Lyngbya* sp., was very common along stretches of the Segment III shoreline, occurring in 277 of the 580 sites, and covering up to 90% of the benthic community. In Segment II, *Lyngbya* sp. occurred in only 104 quadrats, and when observed, usually composed less than 10% of the bottom cover. One of the dominant genera in Segment III was *Caulerpa*; and a *Caulerpa* species (*prolifera*, *racemosa*, *mexicana*, and *sertularioides*) was one of the two dominant species at 172 sites. *Dasya* sp. was also abundant in Segment III, and one of the two dominant species in 152 quadrats; while *Dictyota* sp., was one of the two dominant genera at 119 sites. *Halimeda discoidea* was one of the two dominant species at 89 sites in Segment III. Table 10 provides a listing of the average percent cover per transect line for the two dominant macroalgal species, and overall average percent cover of macroalgae, turf algae, coralline algae, and blue-green algae.

3.3.2. MANATEES.

The estuarine waters around the inlets and bays within south Florida provide year-round habitat for the West Indian manatee, *Trichechus manatus*. A larger winter transient population exists due to their winter southward migration patterns. Manatees reside and feed mainly in the estuarine areas and around inlets, and are only occasionally observed in the open ocean. No significant foraging habitat is known to exist in the areas around the project

TABLE 10
2001 BROWARD COUNTY MACROALGAL SURVEY RESULTS

LINE #	% Overall Macroalgae	Dom Macroalgae sp 1	% SP 1	Dom Macroalgae sp 2	% SP 2	% TURF	Turf identified	% CORALLINE	Coralline species	CYANOBACTERIA
R34C	0.5	Dictyota sp.	0.5			2.1	Wrangelia argus	0.0		
R36-500C	25.5	Dictyota sp.	16.5	Gracilaria sp.	3.0	7.0		10.0	Lithophyllum sp.	1.5
R38-750	28.0	Dictyota sp.	22.0	Laurencia sp.	5.5	10.0	Gelidium sp.	5.5	Lithophyllum sp.	0.5
R38-500	10.5	Dictyota sp.	9.0	Gracilaria sp.	1.0	3.0		1.1		
R38-250	22.0	Dictyota sp.	17.0	Laurencia spp.	4.0	7.5		5.5	Jania adherens	0.3
R38	23.6	Dictyota sp.	17.5	Laurencia sp.	5.0	3.0	Gelidium sp.	2.5	Lithophyllum sp.	0.5
R39-750	16.2	Dictyota sp.	12.7	Laurencia spp.	2.5	26.5	Gelidium sp.	5.0	Lithophyllum sp.	1.5
R39-500	14.5	Dictyota sp.	10.5	Heterosiphonia gibbesii	2.5	40.5	Gelidium sp.	5.8	Lithophyllum sp.	6.1
R39-250	22.5	Dictyota sp.	11.0	Laurencia spp.	10.0	28.5	Gelidium sp.	1.0		1.5
R39-100	19.4	Dictyota sp.	14.5	Laurencia sp.	4.7	39.7	Gelidium sp.	1.0	Lithophyllum sp.	2.7
R39+200	12.1	Dasya sp.	6.0	Laurencia spp. / Dictyota sp.	2 each	52.0	Gelidium sp.	4.0	Lithophyllum sp.	1.1
R40	32.5	Dictyota sp.	15.5	Dasya sp.	15.0	43.5	Gelidium sp.	11.5	Lithophyllum sp.	1.7
R40+250	24.5	Dictyota sp.	20.4	Dasya sp.	3.5	20.0	Gelidium sp.	3.3	Jania adherens	0.5
R42-700	5.5	Dictyota sp.	3.5	Dasya sp.	2.0	31.5	Gelidium sp.	2.8	Jania adherens	
R42-500	4.5	Dictyota sp.	3.0	Dasya sp.	1.0	30.0	Gelidium sp.	0.0		3.4
R42-250	8.4	Dictyota sp.	5.3	Dasya sp.	3.0	42.5	Gelidium sp.	2.5	Lithophyllum sp.	3.5
R42	6.8	Dictyota sp.	6.2	Dasya sp.	0.5	61.4	Gelidium sp.	3.0	Lithophyllum sp.	4.6
R44C	34.5	Dictyota sp.	25.0	Dasya sp.	9.5	18.0	Gelidium sp.	5.0	Lithophyllum sp.	2.0
R46C	11.1	Dasya sp.	7.0	Dictyota sp.	3.5	23.0	Gelidium sp.	1.5	Lithophyllum sp.	
R47-100C	12.0	Dictyota sp.	10.0	Laurencia sp. / Dasya sp.	1 each	31.5	Gelidium sp.	2.0	Lithophyllum sp.	5.5
R48C	3.0	Dictyota sp.	1.5	Hypnea musciformis	1.0	10.0		10.0		
R49-100C	14.1	Dasya sp.	6.5	Dictyota sp.	5.5	20.5	Gelidium sp.	0.0		2.0
R53-600	15.0	Dictyota sp.	6.4	Halimeda discoidea	2.6	5.0	Gelidium sp.	8.0	Jania adherens	0.6
R53-450	10.6	Dictyota sp.	3.0	Dasya sp.	3.5	20.0		1.0	Lithophyllum sp.	0.1
R53+100	57.5	Dictyota sp.	42.5	Dasya sp.	7.0	5.0		8.0	Jania adherens	4.0
R54-750	28.5	Dictyota sp.	13.5	Laurencia sp.	5.5	21.7	Gelidium sp.	9.0	Jania adherens	5.5
R54-500	34.5	Gracilaria sp.	8.5	Dictyota sp.	15.0	19.0	Wrangelia argus	7.5	Jania adherens	5.5
R54-250	36.5	Dictyota sp.	18.5	Dasya sp.	10.5	20.0		7.0	Jania adherens	0.5
R54	21.0	Dasya sp.	9.0	Bryothamnion triquetrum / Dictyota sp.	5 each	11.7	Gelidium sp.	6.0	Lithophyllum sp.	1.5
R55-400	38.5	Dictyota sp.	21.0	Bryothamnion triquetrum / Dasya sp.	5 each	12.9	Enteromorpha flexuosa	6.0	Jania adherens	2.0
R55-250	41.3	Bryothamnion triquetrum	8.5	Ceramium sp.	7.5	15.0	Enteromorpha flexuosa	14.5	Jania adherens	2.0
R56C	34.0	Dictyota sp.	25.5	Dasya sp.	3.5	16.8	Gelidium sp.	7.5	Lithophyllum sp.	7.5
R59C	31.0	Dictyota sp.	24.0	Dasya sp.	4.0	16.4	Gelidium sp.	7.0	Lithophyllum sp.	0.5
R65C	19.5	Bryothamnion triquetrum	9.5	S. hypnoides	3.5	14.5		2.8	Jania adherens	3.0
R66-500	0.0	None				0.0		0.0		0.0
R66-250	19.0	Dasya sp.	8.6	Bryothamnion triquetrum / Hypnea musciformis	5.6 each	0.0		0.0		
R66-100	16.2	Dasya sp.	5.9	Bryothamnion triquetrum	3.7	0.0		15.0	Lithophyllum sp.	
R66	22.5	Dasya sp.	7.3	Bryothamnion triquetrum	5.5	0.0		0.5	Jania adherens	
R67+250	26.0	Dictyota sp.	89.9	Dasya sp.	38.3	0.5	Gelidium sp.	2.0	Lithophyllum sp.	
R71	28.6	Dictyota sp.	10.8	Bryothamnion triquetrum	5.8	1.5		11.8	Jania adherens	
R72-750	21.0	Dasya sp.	10.5	Bryothamnion triquetrum	3.0	6.0		4.0	Jania adherens	
R72-500	28.5	Heterosiphonia gibbesii	6.5	Halimeda discoidea / Dictyota sp.	5 each	1.0		11.0	Jania adherens	0.5
R72-250	15.1	Dictyota sp.	7.0	Dasya sp. / Spyridia hypnoides	2 each	9.5		1.5	Amphiroa sp., Lithophyllum sp.	
R72	22.2	Dictyota sp.	9.5	Dasya sp.	3.0	4.5		8.5	Jania adherens	
R73-750	20.1	Dictyota sp.	10.5	Halimeda discoidea	2.8	3.5		4.0	Lithophyllum sp.	
R73-500	18.1	Dictyota sp.	8.5	Halimeda discoidea	3.1	19.0	Grazed Dictyota sp.	2.0	Amphiroa sp.	
R73-250	23.8	Dictyota sp.	8.7	Dasya sp.	4.5	12.6		1.5	Lithophyllum sp.	
R73	29.1	Dictyota sp.	13.5	Spyridia hypnoides	8.0	8.5		2.0	Amphiroa sp.	
R74-750	9.1	Dictyota sp.	4.6	Halimeda discoidea	2.0	12.6		0.6		
R74-500	20.3	Dictyota sp.	15.5	Halimeda discoidea	1.7	0.0	Grazed Dictyota sp.	5.5	Jania adherens	
R74-250	16.9	Dictyota sp.	4.4	Caulerpa prolifera	4.3	6.0		1.5	Jania adherens	0.0
R74	38.9	Dictyota sp.	20.5	Dasya sp.	12.8	1.5	Grazed Dictyota sp.	1.0	Lithophyllum sp.	
R76-150C	25.5	Bryothamnion triquetrum	7.0	Dictyota sp.	5.0	0.0		3.5	Jania adherens	
R77-300C	3.5	Caulerpa racemosa	2.0	Halimeda discoidea	1.0	22.0		0.5	Lithophyllum sp.	3.0
R79-100C	16.7	Dictyota sp.	11.0	H. discoidea	4.5	8.5	Wrangelia argus	12.0		
R80C	34.5	Dasya sp.	19.5	Dictyota sp.	10.0	10.5		3.6	Jania adherens, Lithophyllum sp.	
R81C	25.8	Dictyota sp.	13.0	C. prolifera	5.0	16.5		4.0	Jania adherens, Lithophyllum sp.	
R82C	12.5	Hypnea musciformis	6.0	Halimeda discoidea	4.0	1.2		1.0		2.0

TABLE 10
2001 BROWARD COUNTY MACROALGAL SURVEY RESULTS

LINE #	% Overall Macroalgae	Dom Macroalgae sp 1	% SP 1	Dom Macroalgae sp 2	% SP 2	% TURF	Turf identified	% CORALLINE	Coralline species	CYANOBACTERIA
R87	51.0	Dasya sp.	15.0	Caulerpa prolifera	13.0	0.0		9.5	Jania adherens	19.5
R87+250	45.2	Caulerpa prolifera	26.0	Dasya sp.	8.0	0.0		4.5	Jania adherens	14.5
R87+500	41.0	Caulerpa prolifera	13.5	Dasya sp.	6.0	0.0		5.5	Jania adherens, Lithophyllum sp.	21.0
R87+750	76.5	Caulerpa prolifera	56.5	Dictyota sp.	9.0	0.0		4.5	Jania adherens	19.5
R88	62.0	Caulerpa prolifera	44.0	Padina sanctae-crucis	5.5	0.0		1.1	Jania adherens	9.0
R88+250	58.5	Caulerpa prolifera	30.0	Codium isthmocladum	6.0	0.0		2.0	Jania adherens	7.5
R88+500	27.1	Caulerpa mexicana	7.0	Dasya sp.	4.5	3.0		0.5	Lithophyllum sp.	6.5
R88+750	32.5	Caulerpa prolifera	12.5	Dasya sp.	5.3	0.0		1.0	Jania adherens, Lithophyllum sp.	8.5
R89	42.8	Caulerpa prolifera	26.8	Dasya sp.	3.0	10.0		0.5	Lithophyllum sp.	1.2
R89+250	46.2	Caulerpa prolifera	16.0	Bryothamnion triquetrum	11.8	10.5		4.0	Jania adherens, Lithophyllum sp.	3.0
R89+500	46.2	Caulerpa prolifera	23.5	Dasya sp.	6.0	10.5		2.5	Jania adherens	15.5
R89+750	57.8	Caulerpa prolifera	20.0	Dasya sp.	15.5	1.0		2.5	Jania adherens	14.0
R90	43.7	Caulerpa prolifera	16.5	Dasya sp.	11.0	4.0		1.0	Jania adherens	49.0
R90+250	53.5	Caulerpa prolifera	29.5	Dasya sp.	6.0	21.5		2.0	Jania adherens	12.0
R90+500	29.6	Bryothamnion triquetrum	14.0	Caulerpa mexicana	12.5	6.0	Gelidium sp.	0.0		27.5
R91	6.3	Bryothamnion triquetrum	2.0	Caulerpa prolifera / Halimeda discoidea	1.9 each	0.2	Wrangelia argus	0.0		4.1
R91+300	6.6	Halimeda discoidea	4.4	Dictyota sp.	1.5	0.0		0.0		5.4
R91+650	12.6	Caulerpa prolifera	6.5	Bryothamnion triquetrum	2.0	3.0		0.0		7.5
R92+250	18.8	Halimeda discoidea	8.9	Caulerpa prolifera / Dictyota sp.	2.5 each	0.0		4.5	Lithophyllum sp.	5.0
R93	5.4	Halimeda discoidea	2.9	Dasya sp.	1.6	1.0		0.6		0.2
R93+400	37.0	Dictyota sp.	17.0	Caulerpa prolifera	8.0	0.0		6.5		14.5
R94+250	39.2	Dictyota sp.	18.8	Caulerpa prolifera	6.5	1.0		12.5	Jania adherens	43.0
R94+750	46.5	Caulerpa mexicana	15.0	Dictyota sp.	14.0	0.2	Wrangelia argus	0.0		0.5
R96C	9.5	Dasya sp.	8.8	Halimeda discoidea	0.6	0.0		0.0		14.1
R97C	25.0	Hypnea musciformis	15.0	Galaxaura sp.	3.6	1.0		0.5		3.0
R98C	29.0	Halimeda discoidea	8.0	Dasya sp.	6.5	4.0	Gelidium sp.	0.0		11.0
R99+250	0.0	None	0.0			0.0		0.0		40.0
R99+500	12.2	Dasya sp.	11.5	Halimeda discoidea	0.6	0.0		0.0		49.0
R100	31.5	Gracilaria	9.0	Hypnea musciformis	5.0	3.5		1.0	Lithophyllum sp.	3.0
R100+700	6.8	Dictyota sp.	2.5	Dasya sp.	1.7	9.0	Wrangelia argus	4.5	Lithophyllum sp.	12.0
R101	7.0	Gracilaria	5.0	Galaxaura sp.	1.5	0.8		0.0		0.8
R101+500C	1.6	Gracilaria	0.7	Dasya sp.	0.5	0.1		0.0		5.1
R111-650	9.3	Dasya sp.	4.2	Halimeda discoidea	3.5	4.0		0.0		0.0
R111C	63.5	Dictyota sp.	16.8	Caulerpa prolifera	14.5	2.5	Wrangelia argus	18.5	Jania adherens	59.5
R112+550	6.5	Halimeda discoidea	3.0	Dictyota sp.	2.9	0.0		0.0		0.8
R113	46.5	Halimeda discoidea	14.5	Caulerpa prolifera	12.0	2.5	Wrangelia argus	14.0	Jania adherens	45.0
R116-500	51.0	Gracilaria	26.8	Dictyota sp.	16.3	0.0		11.0	Jania adherens	31.0
R116-200	26.0	Gracilaria	11.5	Hypnea musciformis	7.0	0.0		0.5		28.5
R117C	27.5	Gracilaria	17.8	Dictyota sp.	3.3	0.0		5.5	Jania adherens	0.0
R118C	9.5	Gracilaria	4.5	Heterosiphonia gibbesii / Hypnea musciformis	2 each	0.0		0.0		2.5
R119C	13.9	Dasya sp.	5.5	Caulerpa racemosa	5.0	1.5	Wrangelia argus	4.7	Lithophyllum sp.	6.5
R121+125C	29.8	Dictyota sp.	13.0	Dasya sp.	6.5	5.0	Wrangelia argus	6.0	Lithophyllum sp.	11.0
R122+500	13.6	Dasya sp.	4.3	Caulerpa racemosa	3.5	16.0	Wrangelia argus	0.0		18.5
R124C	8.5	Gracilaria	5.0	Dasya sp.	3.0	0.5		0.0		10.0
R125+125C	16.5	Gracilaria	8.0	Halimeda discoidea / Caulerpa racemosa	3 each	0.0		0.0		0.0
R126C	12.6	Gracilaria	7.0	Hypnea musciformis	2.0	0.3	Gelidium sp.	0.5	Lithophyllum sp.	5.3
R127+75	6.3	Gracilaria	4.0	Dasya sp.	2.5	1.1		0.5	Lithophyllum sp.	4.0
R2C DADE	38.5	Gracilaria	17.0	Dasya sp.	8.0	0.5		0.5	Lithophyllum sp.	16.0
R3C DADE	3.6	Dasya sp.	3.5	Neomeris annulata	0.1	18.5		19.5		1.0
R4C DADE	4.8	Dasya sp.	1.9	Gracilaria	1.8	0.0		0.0		2.2
R5C DADE	2.9	Dasya sp.	2.9			0.0		0.0		4.4
R103	4.4	Halimeda discoidea	2.9	Caulerpa sertularioides	1.0	0.0		0.0		0.0
R103+250	0.1	Neomeris sp.	0.1			0.5		0.0		0.0
R103 + 500	8.5	Caulerpa racemosa	5.0	Caulerpa sertularioides	2.2	1.5		0.0		0.0
R103+750	3.5	Caulerpa prolifera	2.5	Halimeda incrassata	1.0	0.5		0.0		0.0
R103-300	1.0	Padina sanctae-crucis	0.8	Acetabularia sp.	0.1	0.0		0.0		0.0
R103+900	8.5	Caulerpa prolifera	6.5	Caulerpa sertularioides	2.0	0.0		0.0		0.0
R104+100	22.5	Caulerpa sertularioides	10.3	Padina sanctae-crucis	7.7	1.5		0.0		0.0

sites in Broward County (letter from FDEP dated November 14, 1994), nor have West Indian manatees been known to congregate in the nearshore environments within Broward County (USACE, 1996).

3.3.3. PROTECTED MARINE MAMMALS.

Rare, threatened, or endangered marine mammal species that are infrequent visitors to the coastal waters off Broward County during their migration patterns are listed in Table 10.1. Although generally reported as rare, little is known about the population size of pygmy sperm whales (*Kogia breviceps*) along the Atlantic coast, particularly because of their offshore distribution and uncertainty in species identification. The species is not listed as endangered or threatened under the ESA due to insufficient information with which to assess population trends (NMFS, 1999). Pygmy sperm whales commonly beach themselves on southeast Florida beaches, and approximately 20 to 30 strandings are recorded each year within the State of Florida (Odell, 1991). Short-finned and long-finned pilot whales (*Globicephala* spp.) also strand along the beaches of southeast Florida. Similar to the status of the pygmy sperm whale, pilot whales are not listed under the ESA or by the State of Florida due to insufficient data to determine population trends (NMFS, 1999). All marine mammals that may be found near the project area are protected under the Marine Mammal Protection Act of 1972 and/or the Endangered Species Act of 1973.

3.4. HARDGROUNDS.

3.4.1. NEARSHORE HARDBOTTOM COMMUNITIES.

The nearshore hardbottom in Broward County is of Miami Oolite formation and composed of minute calcareous spherules or ooids. Ooids are formed by the precipitation of calcium carbonate around microscopic particles in the water column. These precipitated particles settle to the bottom and become bound together by secondary calcite to form hard substrate (Hoffmeister et al., 1967). The Miami Oolite formation is contiguous beneath the beach zone through Broward County, but exposed nearshore hardbottom occurs intermittently where the higher profile areas are exposed by wave action (Duane and Meisburger, 1969).

Nearshore hardbottom habitat, typically occurring in 0 to 10 feet of water, is located in a physically stressed environment characterized by variable wave action, sediment transport, turbulence, and water clarity (USACE, 1996). Species present on nearshore hardbottom habitat must be extremely tolerant of this fluctuating physical environment. Therefore, nearshore hardbottom, particularly the westernmost 100 feet along the hardbottom edge, mainly provides habitat for low profile, encrusting and boring organisms capable of securely attaching themselves to the hard substrate.

Table 10.1
Marine Mammals Under the Law that May Occur in Area of Broward County

Species	Endangered	Depleted	Strategic Status
Northern Right Whale (*Eubalaena glacialis*) - Western Stock	X		X
Humpback Whale (*Megaptera novaeangliae*) - Gulf of Maine Stock	X		X
Blue Whale (*Balaenoptera musculus*) - Western North Atlantic Stock	X		X
Sperm Whale (*Physeter macrocephalus*) - North Atlantic Stock	X		X
Fin Whale (*Balaenoptera physalus*) - Western North Atlantic Stock	X		X
Sei Whale (*Balaenoptera borealis*) - Nova Scotia Stock	X		X
Minke Whale (*Balaenoptera acutorostrata*) - Canadian East Coast Stock			
Bryde's Whale (*Balaenoptera edeni*) - No Stock Identified			
Pygmy Sperm Whale (*Kogia breviceps*) - Western North Atlantic Stock			X
Drawf Sperm Whale (*Kogia simus*) - Western North Atlantic Stock			
Cuvier's Beaked Whale (*Ziphius cavirostris*) - Western North Atlantic Stock			X
Gervais' Beaked Whale (*Mesoplodon europaeus*) - Western North Atlantic Stock			X
True's Beaked Whale (*Mesoplodon mirus*) - Western North Atlantic Stock			X
Blainville's Beaked Whale (*Mesoplodon densirostris*) - Western North Atlantic Stock			X
Killer Whale (*Orcinus orca*) - Western North Atlantic Stock			
Short-Finned Pilot Whale (*Globicephala macrorhynchus*) - Western North Atlantic Stock			X
False Killer Whale (*Pseudorca crassidens*) - No Stock Identified			
Risso's Dolphin (*Grampus griseus*) - Western North Atlantic Stock			
Bottlenose Dolphin (*Tursiops truncatus*) - Western N. Atlantic Coastal Stock		X	X
Bottlenose Dolphin (*Tursiops truncatus*) - Western N. Atlantic Offshore Stock			
Pygmy Killer Whale (*Feresa attenuata*) - No Stock Identified			
Melonheaded Whale (*Peponocephala electra*) - No Stock Identified			
Rough-Toothed Dolphin (*Steno bredanensis*) - No Stock Identified			
Striped Dolphin (*Stenella coeruleoalba*) - Western North Atlantic Stock			
Pantropical Spotted Dolphin (*Stenella attenuata*) - Western N. Atlantic Stock			
Atlantic Spotted Dolphin (*Stenella frontalis*) - Western North Atlantic Stock			
Spinner Dolphin (*Stenella longirostris*) - Western North Atlantic Stock			

Endangered: Under the ESA - stocks of species that are in jeopardy of extinction

Depleted: Under the MMPA - when a species falls below its optimum sustainable population

Strategic Status: Under the NMFS Stock Assessments of 2002 - A species is listed as "strategic" if estimated fishery-related mortality and serious injury exceeds PBR (Potential Biological Removal) or if it is listed as threatened or endangered under the ESA

References:

Correspondance with Terri Jordan - Biologist Corps of Engineers

NOAA-NMFS Status of Marine Mammals Under the Law

www.nmfs.noaa.gov/prt_res/PR2/Conservation_and Recovery_Program/listedmms.html

NOAA-NMFS U.S. Atlantic and Gulf of Mexico Marine Mammal Stock Assessments --2002

NOAA Technical Memorandum NMFS-NE-169

Literature review of past studies on nearshore hardbottom communities suggests that wave action and sand scouring are the factors that control algal community distribution along the nearshore hardbottom of southeast Florida (Taylor, 1979). Several studies have indicated that the nearshore hardbottom areas along Florida's southeast coast are ephemeral in nature, being alternately covered and uncovered by shifting beach sand (Ginsburg, 1953; Gore et al., 1978; Goldberg, 1982; Arthur V. Strock and Associates, Inc., 1983; Continental Shelf Associates, Inc., 1984, 1985, and 1987). Gilmore et al. (1981) and Continental Shelf Associates (1985, 1987) suggested that some larger outcrops may provide more permanent habitat. Larger outcrops usually display increased habitat heterogeneity, which results in increased biomass and increased species abundance and richness (Peters and Nelson, 1987; Luckhurst and Luckhurst, 1978). Studies have also demonstrated the seasonal fluctuation in composition and coverage of the nearshore macroalgal community off southeast Florida (Continental Shelf Associates, Inc., 1985).

A detailed mapping and nearshore hardbottom characterization was performed during the summer of 2001 for the proposed Broward County Shore Protection Project. The nearshore hardbottom investigations were designed to 1) characterize the nearshore hardbottom communities within and adjacent to the proposed equilibrium toe of fill (ETOF); and 2) determine if differences in epibenthic community structure exist between sites proposed to be impacted (i.e. inshore of the equilibrium toe of fill), and sites located slightly offshore (within 100 feet east) of the proposed equilibrium toe of fill. The study also allowed for a comparison of epibenthic communities adjacent to previously nourished beaches to those adjacent to never-nourished beaches. The study area extended from DEP control monument R-31 in north Pompano Beach to Dade County DEP control monument R-5.

Prior to commencement of field operations, stony coral species-area curves for the nearshore reef areas in Broward County were used to estimate the number of one-meter square quadrats to be sampled at each site. In the field, the one-square meter quadrat was repeatedly turned until stony coral species richness reached a plateau. Site selection was biased as the biologists searched the immediate area for the presence of stony corals, and began their transect in the area suggestive of the highest stony coral density. The area sampled ranged from 7 square meters to 24 square meters depending upon stony coral diversity at the site. A total of fifty-five (55) sites were investigated along the 18.18-mile study area coastline (Figures 8.0 through 8.13, and the Broward County GIS database). Forty (40) of the characterization sites corresponded to the locations of the fish counts performed by Nova Southeastern University as part of nearshore fish assemblage study. DGPS positioning of the characterization sites was recorded in the field by the survey vessel using a Trimble AgGPS with ProBeacon interfaced to the Coastal and Oceanographic Hydrographic Data Collection and Processing (HYPACK) System. Assessment of the inshore sites was performed from the western edge of exposed hardbottom (or hardbottom with epibenthic organisms under a sand veneer) and ran east. The sites located just offshore of the equilibrium toe of fill were assessed from east to west (i.e. toward the hardbottom edge). The locations of the characterization sites were determined based upon the original project design as proposed in the January 2001 GRR.

A complete epibenthic organism inventory, including estimations of percent cover, was performed for stony corals, soft corals, zoanthids/hydroids, and sponges. Percent cover was also assessed for macroalgae, turf algae, blue-green algae, and substrate type. All species were identified to the lowest taxon reasonably achievable. Data collected during the nearshore characterization investigations was incorporated into the Broward County GIS. *In-situ* habitat characterization data was supplemented with a series of three, shore-parallel and 126 shore-perpendicular, boat-towed diver, GPS-integrated, digital video transects. The shore-parallel transects were located along: 1) the nearshore hardbottom edge; 2) the estimated location of the equilibrium toe of fill; and 3) 300 feet east of the equilibrium toe of fill. Additionally, prior to filming the hardbottom edge, the hardbottom interface was determined by a diver propelled by scooter with a GPS antenna attached directly to the diver. This methodology allowed for extremely accurate positioning for the hardbottom edge (as of July 2001). Representative digital video transects are included in the GIS.

Overall species richness within the Broward County nearshore study area was 85 with 61 faunal species and 24 algal species (including macroalgae, turf, and blue-green algae) observed at the 55 characterization sites. Overall faunal species density for the study area was 4.6 organisms/square meter, and average algal coverage was 20.4%. There were a total of 44 faunal species observed at the stations located inshore of the estimated equilibrium toe of fill (inshore ETOF) compared to 58 faunal species at the stations located slightly offshore of the equilibrium toe of fill (offshore ETOF). Stations designated as inshore ETOF are based upon the estimated equilibrium toe of fill as proposed in the January 2001 GRR, and therefore, although included in the project analysis, may not fall directly within the revised beach fill limits as proposed in the February 2002 GRR. Average species density at the inshore ETOF sites was 2.7 organisms/square meter, and the average for the offshore ETOF sites was 5.7 organisms/square meter. There was little difference observed in algal species richness between the inshore and offshore ETOF stations (23 versus 22 respectively). Average algal coverage was 24.1% for the inshore ETOF stations and 18.0% for the offshore stations.

Table 11 presents the dominant faunal and floral species and densities per municipality for both the inshore and offshore ETOF locations. Dominant organisms for the inshore ETOF locations include feather hydroids, the soft corals *Pseudopterogorgia americana* and *Pterogorgia anceps*, and the stony coral *Siderastrea radians*. In addition to these species, the sponges *Haliclona rubens* and *Plakortis angulospiculatus*, and the soft coral *Eunicea* sp., were dominant at offshore ETOF locations (Table 11). Dominant macroalgal species were *Dasya* sp., *Dictyota* sp., *Laurencia* sp., and the green macroalgae, *Caulerpa prolifera*, and *Halimeda discoidea*. Table 12 provides a summary of species richness and dominance of the stations inshore of the equilibrium toe of fill within the proposed beach fill impact areas (See Broward GIS [http://www.browardmarinegis.com/] for raw data listings).

The ten overall dominant faunal species within the entire nearshore study area are presented in Table 13. The soft coral, *Eunicea* sp., was the overall dominant organism at the offshore ETOF sites with 0.70 individuals/square meter. A soft coral, *Pterogorgia anceps*, was also the dominant organism at the inshore ETOF sites with 0.64 individuals/square meter. The stony coral, *Siderastrea radians*, was slightly less frequent at the offshore sites with 0.69 individuals/square meter, and was also the second most frequent organism at the inshore ETOF sites with 0.47 individuals/square meter. Table 13 also demonstrates that the inshore ETOF sites were more depauperate with lower frequencies of dominant organisms (only four species greater than 0.20 individuals/square meter at the inshore ETOF sites versus nine at the offshore sites). In addition, there were eleven faunal species present at the offshore ETOF sites that were not present on the inshore sites: two sponge species (*Agelas clathrodes* and *Callyspongia* sp.); the hydrocoral, *Millepora alcicornis*; three soft coral species (*Muricea* sp., *Pseudoplexaura* sp., and *Erythropodium caribaeorum*; and five stony coral species (*Diploria labyrinthiformis*, *Diploria strigosa*, *Madracis decactis*, *Manicina areolata*, and *Stephanocoenia michilini*).

Mean percent cover by algal species (macroalgae, turf, and blue-green algae) was highest immediately south of Port Everglades at John U. Lloyd State Park. Overall mean algal percent cover per square meter was 39.4% for the

TABLE 11

2001 BROWARD COUNTY NEARSHORE HARDBOTTOM INVESTIGATIONS

DOMINANT SPECIES PER AREA

Project Area Geographic Reference	Dominant organism	# inds./sq. meter	Dominant macroalgae	% cover/sq. meter
Segment II				
Pompano Beach inshore ETOF	Feather hydroids	1.43	*Dasya* sp.	2.60
Pompano Beach offshore ETOF	*Haliclona rubens*	0.78	*Laurencia* sp.	0.21
Lauderdale By The Sea inshore ETOF	*Pterogorgia anceps*	0.42	*Dictyota* sp.	6.08
Lauderdale By The Sea offshore ETOF	*Haliclona rubens*	0.80	*Dictyota* sp.	10.74
Fort Lauderdale inshore ETOF	*Pterogorgia anceps*	2.29	*Dictyota* sp.	8.98
Fort Lauderdale offshore ETOF	*Pterogorgia anceps*	1.00	*Dictyota* sp.	8.42
Segment III				
John U. Lloyd inshore ETOF	*Siderastrea radians*	0.51	*Caulerpa prolifera*	22.77
John U. Lloyd offshore ETOF	*Siderastrea radians*	1.92	*Caulerpa prolifera*	9.18
Dania inshore ETOF	*Siderastrea radians*	1.00	*Dictyota* sp.	4.98
Dania offshore ETOF	*Plakortis angulospiculatus*	1.12	*Dictyota* sp.	4.88
Hollywood/Hallandale inshore ETOF	*Pseudopterogorgia americana*	0.33	*Caulerpa prolifera*	5.00
Hollywood/Hallandale offshore ETOF	*Eunicea sp.*	2.18	*Halimeda discoidea*	7.39

TABLE 12
2001 BROWARD COUNTY NEARSHORE HARDBOTTOM INVESTIGATIONS
EPIBENTHIC HABITAT DATA SUMMARY OF NEARSHORE HARDBOTTOM IMPACT AREAS

	Impact Area 1	Impact Area 2	Impact Area 3	Impact Area 4	Impact Area 5	Impact Area 6	Impact Area 7	Impact Area 8	Impact Area 9
Species richness (N)	23	19	12	18	9	21	14	26	15
Relative species richness	0.27	0.22	0.14	0.21	0.10	0.24	0.16	0.30	0.17
Dominant benthic group	Macroalgae	Feather hydroids	Macroalgae	Macroalgae	Macroalgae	Macroalgae	Macroalgae	Cyanobacteria	Macroalgae
Stony coral species richness	5	2	2	4	0.0	3	1	6	0
Relative stony coral species richness	0.26	0.11	0.11	0.21	0.0	0.16	0.05	0.32	0
Numerical dominant stony coral	*Siderastrea radians*	*Siderastrea radians*	*Siderastrea radians*	*Siderastrea radians*	N/A	*Siderastrea radians*	*Siderastrea radians*	*Siderastrea radians*	N/A
Numerical dominant stony coral density	$0.30/m^2$	$0.59/m^2$	$0.71/m^2$	$1.33/m^2$	N/A	$1.11/m^2$	$0.50/m^2$	$0.30/m^2$	N/A
Dominant faunal species	*Pterogorgia anceps*	feather hydroids	*Siderastrea radians*	*Aplysina* sp.	*Diplastrella* sp./*Niphates digitalis*	*Pterogorgia anceps*	*Siderastrea radians*	Sun zoanthid	*Aplysina fistularis*
Dominant faunal species density	$0.80/m^2$	$8.33/m^2$	$0.71/m^2$	$0.40/m^2$	$0.10/m^2$	$11.1/m^2$	$0.50/m^2$	$0.71/m^2$	$0.71/m^2$
Dominant floral species	*Dasya* sp.	*Dictyota* sp.	*Dasya* sp.	*Dictyota* sp.	*Gracilaria* sp.	*Dasya* sp.	*Caulerpa prolifera*	*Halimeda discoidea*	*Caulerpa prolifera*
Dominant floral species density (%)	5.3%	5.1%	1.3%	6.0%	3.4%	10.1%	22.7%	6.9%	10.0%
Faunal Diversity (Shannon-Wiener)	2.5-2.6	1.4	0.7 - 1.7	2.1-2.3	0.7	1.1	0.0-0.7	2.6	1.3
GIS Habitat Classification Scheme									
Color	Green(4)	Brown	Green (3)	Green(4)	Green(1)	Green(4)	Green(2)	Orange	Green(2)
Dominant benthic group	Macroalgae	Feather hydroids	Macroalgae	Macroalgae	Macroalgae	Macroalgae	Macroalgae	Cyanobacteria	Macroalgae
Relative species richness	0.27	0.22	0.14	0.21	0.10	0.24	0.16	0.30	0.17
Relative stony coral species richness	0.26	0.11	0.11	0.21	0.0	0.16	0.05	0.32	0.0
Faunal Diversity (Shannon-Wiener)	H	D	L	M	D	D	D	H	D

Faunal Diversity Key: H= High, M= Moderate, L= Low, D= Depauperate

Note: This table presents data on only those impact areas upon which detailed quantitative and qualitative investigations were conducted.

TABLE 13
2001 BROWARD COUNTY NEARSHORE HARDBOTTOM INVESTIGATIONS
OVERALL DOMINANT SPECIES IN STUDY AREA

Dominant Organism	Taxonomic Group	Inshore ETOF	Offshore ETOF
		(# of individuals/square meter)	
Eunicea sp.	Alcyonarian (soft coral)		0.70
Pterogorgia anceps	Alcyonarian (soft coral)	0.64	0.39
Siderastrea radians	Scleractinian (stony coral)	0.47	0.69
Feather hydroids	Hydrozoan	0.41	0.25
Plakortis angulospiculatus	Porifera (sponges)	0.20	
c.f. *Dysidea etheria*	Porifera (sponges)		0.37
Palythoa caribaerorum	Zoanthid		0.25
Anthosigmella varians	Porifera (sponges)		0.25
Briareum asbestinum	Alcyonarian (soft coral)		0.25
Haliclona rubens	Porifera (sponges)		0.24

offshore ETOF in John U. Lloyd State Park, and 48.4% for the inshore ETOF sites. *Caulerpa prolifera* was the dominant algal species at both the inshore and offshore sites (Table 11). Other common macroalgal species at the John U. Lloyd stations were *Dictyota* sp., *Jania adherens*, *Caulerpa racemosa*, *Caulerpa sertularioides*, and *Halimeda dicoidea*. The highest coverage of macroalgae corresponded to the lowest faunal species richness inshore (3) and offshore (13) at John U. Lloyd State Park. Algal coverage was lowest at Pompano Beach for both the inshore (4.2%) and offshore ETOF (0.62%) sites, while faunal species richness inshore was highest at Pompano Beach (33 of 44 species observed). Algal species richness was also lowest at the inshore ETOF stations in Pompano Beach (4 algal species).

Algal species richness was highest in Fort Lauderdale with 18 species observed at the inshore ETOF sites and 17 species observed at the offshore ETOF sites. The brown macroalga, *Dictyota* sp., was the dominant species at the inshore sites in Fort Lauderdale. Several red macroalgal species were also very common on the westernmost 100 feet of the hardbottom in Fort Lauderdale. These include *Bryothamnion triquetrum*, *Ceramium* sp., *Gracilaria* sp., *Laurencia* sp., and *Heterosiphonia gibbesii*. Common macroalgae at the offshore ETOF sites in Fort Lauderdale include *Gracilaria* sp., *Laurencia* sp., and *Dasya* sp., and the green macroalga, *Halimeda discoidea*. Faunal species richness was also highest at the offshore sites in Fort Lauderdale with 46 of the 58 species recorded.

Coverage of cyanobacteria (blue-green algae) was prevalent south of Port Everglades. The ten locations with blue-green algal coverage greater than 20% were located in Segment III, south of Port Everglades. The highest coverages of blue-green algae were observed at station R-120 (74.0%) in Hollywood/Hallandale, Site 15-94.5 (49.5%), 16-99.5 (43.6%), and 17-100.5 (27.4%) in Dania Beach, R-116 (27.8%) in Hollywood/Hallandale, and 11-88 (27.7%), R-89 (27.2%), R-90 (21.5%), and R-88 (21.0%) in John U. Lloyd State Park (See Figures 8 through 8.13 for station locations). The unusually high coverage by blue-green algae at Station R-120 corresponded to an area with a high density (~5% bottom coverage) of large, epiphytized, stony coral skeletons belonging to the genera *Diploria*, *Dichocoenia*, and *Solenastrea*. The coral skeletons were distinguishable after removal of the dense, blue-green, epiphytic slime coating, allowing for determination of coral genera.

Many previous studies have demonstrated Caribbean and Atlantic coast reefs to be dominated by macroalgae (Hughes, 1994; Costa et al., 2001; Mumby and Harborne 1999). Given the lack of quantitative dominance by stony corals, Mumby and Hardborne (1999) added the caveat that algal-dominated and bare substratum dominated reefs must have less than one percent coral cover. Just over one-third (19 of 55) of the sites examined during the 2001 Broward County nearshore hardbottom investigations exhibited stony coral coverage greater than

1%, and only two of these sites were located inshore of the proposed equilibrium toe of fill (Table 14). The numerically dominant stony coral species within the entire nearshore study area was *Siderastrea radians* (0.60 individuals/square meter). Other less common stony corals were small finger coral (*Porites porites* – 0.07 individuals/square meter), relatively large individuals of smooth star coral (*Solenastrea bournoni* – 0.06 individuals/square meter) and brain coral (*Diploria clivosa* – 0.04 individuals/square meter). Station R-119 in Hollywood exhibited an exceptionally high stony coral coverage of 28.25%. An unusually high density of *Diploria* spp. was observed within the station with a variable sediment layer of ½” to 1” covering the epibenthic community. Several stony coral stresses were also observed, including bioerosion from the boring sponge, *Cliona* sp., sedimentation, and competition with *Palythoa caribaeorum*. Several dead colonies of the stony coral *Diploria* spp. were observed west of this station, apparently from sedimentation stress and burial, suggesting that this station is located on a migrating hardbottom edge.

The highest density of juvenile corals, defined in this study as stony corals less than 2 cm in diameter, was recorded at stations R-88 (4.1 colonies/sq. meter), R-98 (3.5 colonies/sq. meter), R-87 (2.3 colonies/square meter), R-101 (2.1 colonies/square meter), and R-125 (1.3 colonies/square meter). The smallest stony coral recruits detectable to the naked eye were approximately 5 mm in size. The small star coral species, *Siderastrea radians*, was the most frequently observed juvenile coral species, accounting for more than 90% of all juvenile corals observed at the nearshore sites. *S. radians* was the only stony coral species recorded at Station R-88, where the highest density of stony coral juveniles was observed. Table 15 presents a summary of stony coral species richness.

In the absence of sharp boundaries in environmental conditions, benthic assemblages can be considered as opportune groupings of species/substrate which merge gradually into other groupings (Gray, 1997). Review of the data collected as part of the 2001 Broward County nearshore habitat investigations lends credence to this generalization. The *in-situ* data from the 55 nearshore characterization sites was subjected to Principal Components Analysis (PCA) to examine differences in epibenthic community structure between the inshore and offshore ETOF sites. The analysis revealed that the two principal components at both the inshore and offshore locations were macroalgae and cyanobacteria (commonly referred to as blue-green algae).

TABLE 14
NEARSHORE MONITORING STATIONS WITH STONY CORAL COVERAGE GREATER THAN ONE PERCENT COVER

Station reference		Stony coral coverage (percent cover)
Inshore ETOF		
Site 1.5 (38-250) Pompano Beach		4.64%
Site 17 (100.5) Dania		4.37%
Offshore ETOF		
R119 Hollywood/Hallandale		28.25%
R123 Hollywood/Hallandale		13.00%
R-83 Fort Lauderdale*		8.31%
R-41 Pompano Beach		7.40%
R-46 Lauderdale By The Sea*		6.72%
R-116 Hollywood/Hallandale		6.14%
R-79 Fort Lauderdale*		5.93%
R-100 Dania		4.30%
R-76 Fort Lauderdale*		3.70%
R-97 Dania*		3.07%
R-66 Fort Lauderdale		2.86%
R-74 Fort Lauderdale*		2.75%
R-108 Hollywood/Hallandale		2.53%
R-125 Hollywood/Hallandale		1.89%
R-40 Pompano Beach		1.62%
R-96 Dania*		1.50%
R-87 John U. Lloyd		1.20%

*Note: These stations are not located within the project beach fill areas as proposed in the revised February 2003 General Reevaluation Report.

TABLE 15
2001 BROWARD COUNTY NEARSHORE HARDBOTTOM INVESTIGATIONS
STONY CORAL SPECIES RICHNESS

Monitoring station	Most speciose (# of stony coral species present)	Least speciose (# of stony coral species present)
Segment II		
Inshore ETOF		
Site 6-66 Fort Lauderdale		0
Offshore ETOF		
R-52 Lauderdale By The Sea*	6	
R-72 Fort Lauderdale		0
R-83 Fort Lauderdale*	6	
Segment III		
Inshore ETOF		
Site 11-88 John U. Lloyd		0
R-89 John U. Lloyd		1
R-91 John U. Lloyd		1
Site 15-94.5 Dania Beach*		0
Site 16-99.5 Dania Beach		1
Site 17-100.5 Dania Beach	6	
R102 Hollywood/Hallandale Beach		0
Site 20-122.5 Hollywood/Hallandale Beach		0
Offshore ETOF		
R-88 John U. Lloyd		1
R-93 John U. Lloyd*		1
R-96 Dania Beach*	8	
R-100 Dania Beach	8	
R-113 Hollywood/Halladale Beach		1
R-123 Hollywood/Hallandale Beach	6	
R-125 Hollywood/Hallandale Beach	6	

*Note: These stations are not located within the project beach fill areas as proposed in the revised February 2003 General Reevaluation Report.

However, the strength of these two principal components was much greater at the inshore ETOF locations (88% of cumulative community composition) than the offshore sites (54% of cumulative community composition) (Figure 9). Coverage by soft corals and sponges was substantially lower at the inshore ETOF sites than the offshore ETOF locations; and although stony corals did not occur often enough to be considered a principal component, their abundance differed between the inshore (1.5% of the overall community structure) and offshore sites (7.1% of the overall community structure). The data suggests that the survivability of soft corals, sponges, and stony corals increases from the fluctuating (i.e. ephemeral) hardbottom edge in an easterly direction over the persistent nearshore hardbottom community. With this increase in survivability and habitat stability, an increase in biodiversity is observed.

These summary statistics of stony coral coverage do not preclude the occurrence of individual, large stony coral colonies along the hardbottom edge. For example, the macroalgal transect along line R-40+250 in Pompano Beach revealed the presence of a very large boulder coral colony approximately 80 feet east of the hardbottom edge (see GIS for photo and exact location), and a large *M. cavernosa* was observed along the sand-covered, hardbottom edge at approximately R-68.5 during the scooter survey (see hardbottom edge notations in the GIS for exact location).

In addition to faunal/floral densities and species richness, ecological diversity of the nearshore sites was examined using a variety of indices: Shannon-Wiener Index of Diversity; Pielou Index of Equitability; Margalef's Index; and Simpson's Dominance Index (Table 16). The Shannon-Wiener (S-W) index equates diversity to the amount of uncertainty that exists regarding the identity of an individual collected at random from a community. The more species and the more evenly the distribution of individuals among species, the greater the uncertainty and the greater the diversity (i.e. the higher the Shannon-Wiener Index of Diversity, the higher the species diversity and the higher the equitability). Equitability (assessed using Pielou's Index) is considered a component of diversity in that it provides an idea about the evenness of species distribution at a site. A positive correlation usually exists between diversity and equitability (i.e. high equitability indicates high diversity). Margalef's Index assumes a relationship between the number of individuals and the number of species in a sample. This index logarithmically scales the value of the number of species, and provides a comparison between stations with different ratios of number of species and individuals. Simpson's Dominance Index assesses the degree of dominance by one or a few species and provides the probability that two individuals drawn at random from the same sample are the same species (i.e. the higher the

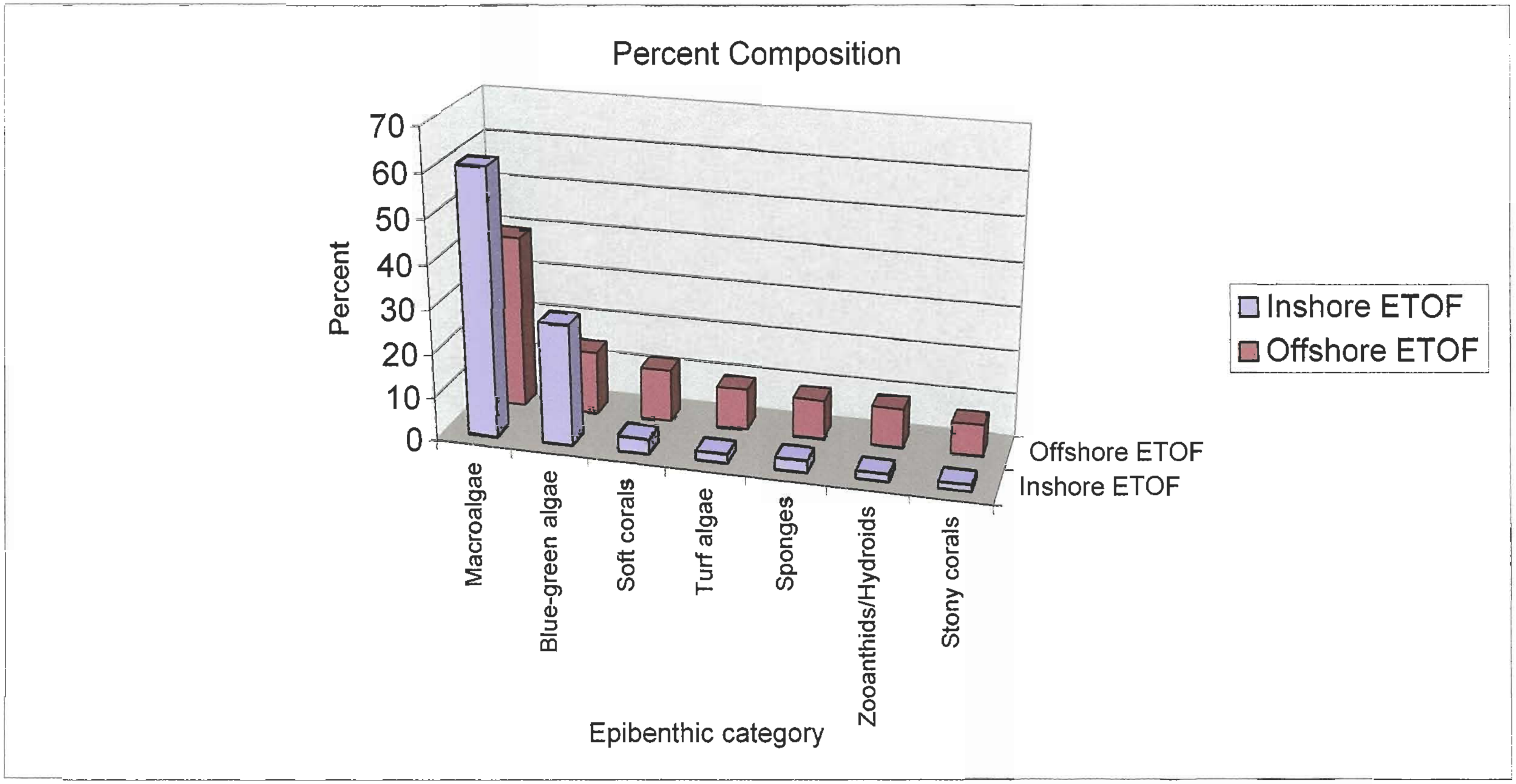


FIGURE 9

2001 BROWARD COUNTY NEARSHORE EPIBENTHIC COMMUNITY CHARACTERISTICS

TABLE 16
2001 BROWARD COUNTY NEARSHORE HARDBOTTOM INVESTIGATIONS
SUMMARY OF DIVERSITY INDICES

	Pompano Beach												J.U. Lloyd						
Station	1-38	1-5	2-40	3+250(41+250)	3-41.5	R42	R34	R37	R38	R39	R40	R41	11-88	R89	R91	R87	R88	R90	R93
Number of Species	20	18	16	6	2	10	15	14	20	26	24	22	0	3	2	8	5	2	5
Number of Individuals/sq m	4.1	2.3	12.1	1.4	0.1	2.3	3.9	3.6	4.2	8.7	7.0	5.8	0.0	0.9	0.9	5.5	4.7	0.7	1.0
Shannon Weiner	2.6	2.5	1.4	1.3	0.7	1.7	2.5	2.2	2.7	2.7	2.8	2.8	0.0	0.7	0.3	1.6	0.5	0.4	1.2
Margalef	13.5	20.5	6.0	15.7	-0.5	11.0	10.3	10.1	13.2	11.6	11.8	11.9	0.0	-19.0	-10.5	4.1	2.6	-2.8	0.0
Pielou's Evenness	0.9	0.9	0.5	0.7	1.0	0.7	0.9	0.8	0.9	0.8	0.9	0.9	0.0	0.6	0.5	0.8	0.3	0.6	0.8
Simpsons Index	-0.8	-1.4	5.5	-1.8	0.1	-0.6	-0.8	-0.5	-0.8	-0.1	-0.5	-0.6	0.0	3.9	2.5	0.5	3.5	1.1	0.0

	Lauderdale by the Sea			Ft. Lauderdale															
Station	4-52	R46	R52	5-54	6-66	7-71	8-72	9-74	R54	R58	R60	R66	R71	R72	R73	R74	R76	R79	R83
Number of Species	12	21	16	9	2	11	8	9	22	18	17	12	8	12	11	19	16	16	24
Number of Individuals/sq m	1.5	3.8	4.0	1.0	0.3	15.5	1.3	3.6	4.2	8.2	8.4	2.2	6.4	9.4	7.8	5.8	6.5	2.3	8.4
Shannon Weiner	2.3	3.0	2.2	2.1	0.7	1.1	1.8	1.7	2.8	2.3	2.1	1.7	0.7	1.7	1.6	2.5	2.2	2.5	2.7
Margalef	27.1	15.1	10.8	3.6E+16	-0.8	3.7	24.3	6.3	14.6	8.1	7.5	14.1	3.8	4.9	4.9	10.2	8.0	17.9	10.8
Pielou's Evenness	0.9	1.0	0.8	1.0	1.0	0.4	0.8	0.8	0.9	0.8	0.7	0.7	0.3	0.7	0.7	0.8	0.8	0.9	0.8
Simpsons Index	-2.4	-0.9	-0.5	0.0	0.3	8.0	-2.8	0.1	-0.9	0.2	0.6	-0.4	4.4	1.9	1.2	-0.4	0.0	-1.3	-0.2

	Dania							
Station	15-94.5	R98	16-99.5	17-100.5	R96	R97	R100	R101
Number of Species	0	7	1	18	24	13	25	11
Number of Individuals/sq m	0.0	5.0	0.3	2.6	5.3	3.8	7.9	5.3
Shannon Weiner	0.0	1.0	0.0	2.6	2.8	2.1	2.6	1.6
Margalef	0.0	3.7	0.0	17.6	13.9	9.0	11.6	6.0
Pielou's Evenness	0.0	0.5	0.0	0.9	0.9	0.8	0.8	0.7
Simpsons Index	0.0	0.0	2.6	-1.8	-0.2	2.8	-0.1	0.6

	Hollywood/Hallandale								
Station	R102	20-122.5	R108	R113	R116	R119	R120	R123	R125
Number of Species	0	5	18	5	10	25	13	22	21
Number of Individuals/sq m	0.0	1.4	13.4	2.9	3.4	6.6	5.2	14.0	5.2
Shannon Weiner	0.0	1.3	1.9	1.4	2.1	3.1	2.3	2.4	2.5
Margalef	0.0	11.5	6.5	3.8	7.3	12.8	7.3	8.0	12.1
Pielou's Evenness	0.0	0.8	0.6	0.9	0.9	1.0	0.9	0.8	0.8
Simpsons Index	0.0	-1.9	3.6	-0.2	-0.7	-0.5	0.0	1.1	-0.4

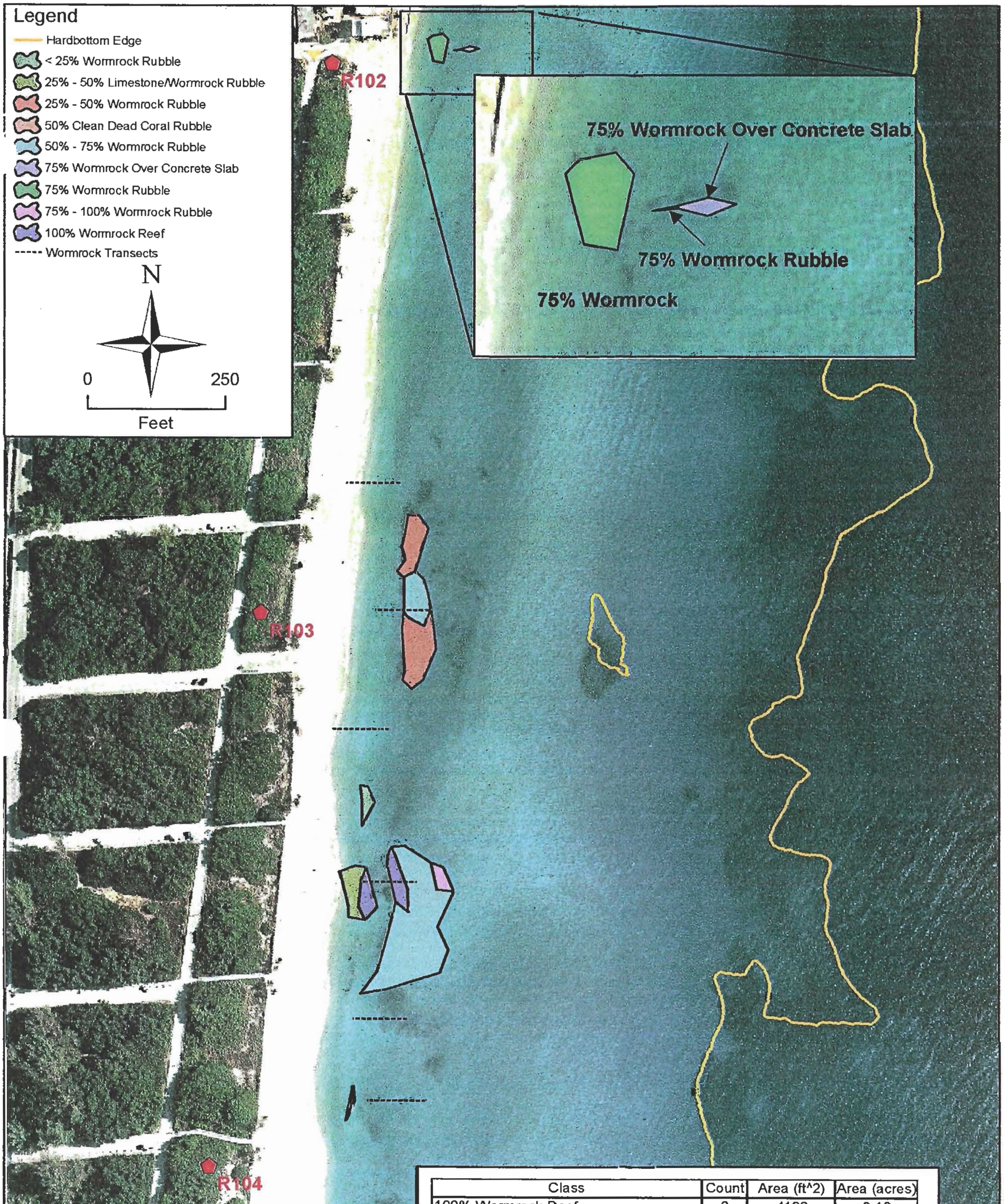
Note: Shaded cells indicate inshore stations.

Simpson Dominance Index is, the higher the degree of dominance by one or a few species, the lower the species diversity and equitability).

Sixteen of the 55 nearshore characterization sites recorded Shannon-Wiener Diversity indices greater than 2.4, indicating relatively high faunal species diversity. The highest S-W indices were observed at offshore ETOF locations: Station R-119 in Hollywood (3.1); R-46 in Lauderdale-By-The-Sea (3.0); R-40 and R-41 in Pompano Beach, R-54 in Fort Lauderdale, and R-96 in Dania Beach (all 2.8); and R-38 and R-39 in Pompano Beach and R-83 in Fort Lauderdale (all 2.7). Only two inshore ETOF sites recorded S-W indices greater than 2.5: Site 1-38 in Pompano Beach and Site 17-100.5 in Dania Beach, where the S-W index was 2.6. There were 18 sites with S-W indices less than 1.5, and 13 of the 18 were located inshore of the proposed equilibrium toe of fill (Table 16).

Wormrock, formed by the colonial polychaete, *Phragmatopoma lapidosa*, is fairly common in the nearshore waters off Broward County. These polychaetes live in tubes that they build around themselves by cementing sand grains together and are capable of forming large, biologically significant structures known as “worm rock reefs”. Wormrock colonies are found on hard substrate in the intertidal zone, along rock jetties, and around inlet mouths due to their need for constant high-energy wave action to supply food, remove wastes, and maintain the suspension of sand grains needed to build their tube homes (USACE, 1996). Wormrock colonies provide a hard and stable substrate, shelter, and food, enabling many species to inhabit the surf zone that otherwise might not (Gore et al., 1978). Rudolph (1977) observed 88 species of other polychaetes living in association with worm rock reefs, and Gore et al. (1978) and van Montfrans (1981) described a rich decapod crustacean community associated with worm rock habitat (USACE, 1996).

An area of wormrock reef exists between DEP control monuments R-102 and R-104 in Hollywood. A detailed survey was performed on October 25, 2001 that revealed 0.10 acres of solid wormrock reef, and 0.95 acres of unattached wormrock rubble that varies in density from 5 to 100 percent coverage (Figure 10). The rubble areas are most dense on the seaward side of the reef due to the constant wave erosion. Areas of scattered wormrock were also observed along the hardbottom edge in Pompano Beach (R-38, R-39+750, R-39-500, R-39-100, R-40+250) and Lauderdale-By-The-Sea (R-48C, R-47-100, R-49-100, R-53+100, and R-54-250). These locations refer to the macroalgal transect data in the GIS database.



Notes:
Dates of aerial photograph: 6/16 - 6/18 of 2000
Date survey performed: 10/25/01
Survey performed by: Earl Soeder, P.S.M., Cheryl Miller, M.S. Marine Biologist, and Rob Weber, Survey Technician CST I.

Class	Count	Area (ft^2)	Area (acres)
100% Wormrock Reef	2	4132	0.10
25% - 50% Limestone/Wormrock Rubble	1	2760	0.06
25% - 50% Wormrock Rubble	2	9644	0.22
50% - 75% Wormrock Rubble	2	25179	0.58
75% - 100% Wormrock Rubble	1	1168	0.03
75% Wormrock Over Concrete Slab	1	170	0.00
75% Wormrock Rubble	2	1386	0.03
< 25% Wormrock Rubble	2	1293	0.03
		45733	1.05

Figure 10

Title: Broward County Segment III Wormrock Mapping

DATE: 11/1/01

BY: MFK

Comm. No. 5350.53

Sheet: 1 of 1

3.4.2. OFFSHORE HARDBOTTOM COMMUNITIES.

The reef distribution pattern described for southeast Florida reefs north of Key Biscayne consists of three separate parallel reef tracts: the first reef occurs in approximately 10 to 20 feet of water and ranges from 100 to 2,000 feet from shore; the second reef is located 3,000 to 6,500 feet offshore in water depths of 10 to 55 feet; and the third reef is in water depths of 45 to 90 feet and approximately 8,000 feet or more offshore (GDM, 1987 J.U. Lloyd Beach Renourishment Project). Active barrier reef development occurred as far north as the Fort Lauderdale area as late as 8,000 years ago (Lighty et al., 1978). It is possible that the reefs and hardground areas seen from Delray Beach (Palm Beach County) southward are the result of active coral reef growth in the relatively recent past, whereas the hardbottom features seen north of Palm Beach inlet may be representative of the outcropping of older, weathered portions on the Anastasia Formation (Lighty, 1978). A relict *Acropora palmata* reef extends along the shelf break from Palm Beach south to Miami. This relict barrier reef forms a low ridge with a crest at depths of 15 to 30 meters (Lighty, 1978). The death of this shallow water *A. palmata* reef coincided with the flooding of the Florida continental shelf during the rising seas of the Holocene transgression approximately 7,000 years ago (Lighty, 1978). The flooding, in combination with a major influx of turbid water and significant reduction of water temperature due to the atmospheric cooling of the shallow shelf water, most probably caused the death of the relict reef off Florida (Lighty, 1978).

Algal coverage fluctuates seasonally in the offshore hardbottom areas. The most common algal species observed within the southeast Florida offshore hardbottom areas include *Caulerpa prolifera*, *Codium isthmocladum*, *Gracilaria* sp., *Dictyota* sp., *Udotea* sp., *Halimeda* sp., and various crustose coralline algae species of the family Corallinaceae (USACE, 1996). Algal coverage is most dense from late July through late October or early November, with a bloom in the macroalgal population observed in conjunction with seasonal upwelling in late July or early August (Smith, 1981, 1983; Florida Atlantic University and Continental Shelf Associates, Inc., 1984).

The composition of hardbottom biological assemblages along Florida's southeast 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, 1993), and Blair and Flynn (1989) (USACE, 1996). The reefs observed north of Government Cut have been described as "gorgonid reefs" (Goldberg, 1970; Raymond and Antonius, 1977) due to their extensive, healthy assemblage of octocorals (gorgonians). The U.S. Environmental Protection Agency (1992) lists 46 species of shallow water gorgonians found in the waters of southeast Florida. Surveys by Continental Shelf Associates, Inc. (1984, 1985) identified 33 sponge, 21 octocoral, and 5 stony coral species on offshore reefs off Ocean Ridge (Palm Beach County); and 40 sponge, 18 octocoral and 14 stony coral species on the offshore reefs off Boca Raton, Florida.

Broward County has established 23 permanent reef community monitoring sites on the first, second, and third reef tracts along the 24 miles of coastline to assess potential effects from the proposed Broward County Shore Protection Project. Eighteen of the twenty-three sites have been monitored since 1997. Five additional sites were established in December 2000. In response to numerous concerns by resource protection agencies and non-governmental organizations for secondary impacts of turbidity and sedimentation to areas of high stony coral coverage located on the first reef tract offshore of Fort Lauderdale (approximately FDEP monuments R-65 to R-67), Broward County proposed two additional reef community and sedimentation monitoring sites to the program (FTL5 and FTL6). Figures 1 through 7 of the offshore reef monitoring plan present the locations of the permanent reef community monitoring sites (See Appendix E - Biological Monitoring Program). The location and depth of each of the 25 sites are listed in Table 17 and the sites are included in the Broward County GIS database.

Surveys performed in 1997 and 1998 at the original eighteen reef monitoring locations documented 26 species of stony (scleractinian) corals, including the hydroid, *Millepora alcicornis*. The most commonly observed stony corals were *Siderastrea radians*, *Siderastrea siderea*, *Porites astreoides*, and *Montastrea cavernosa*. Overall average percent stony coral coverage was similar in 1997 and 1998: 1.43% and 1.46% respectively (DPEP, 1999). A total of 1,600 stony coral colonies and 29 species were observed during the January/February 2001 monitoring. Stony coral percent species composition at the 23 sites was *Siderastrea siderea* (20%), *Montastrea cavernosa* (16%), *Stephanocoenia michilini* (12%), *Porites astreoides* (11%), *Millepora alcicornis* (hydrocoral 11%), and *Siderastrea radians* (5%) (Gilliam et al., 2001). Mean stony coral density for the 23 sites was 2.30 ±0.95 colonies/m^2 (± 1 S.D.). Mean stony coral coverage was 2.25 ±3.41%. These values were comparable to the 1997, 1998, and 1999 values for the original eighteen stations. A slight increase in percent cover was observed, but no trends in density or evenness were suggested. Mean gorgonian density was 9.27±11.75 colonies/m^2 and mean sponge density was 19.81 ±10.44 colonies/m^2 (Gilliam et al. 2001a).

TABLE 17. BIOLOGICAL MONITORING SITES (NAD 83)						
	SITE	**DEPTH**	**LATITUDE**	**LONGITUDE**	**NORTHING**	**EASTING**
1	JUL2	50	26 00.2593 N	80 05.3010 W	608306	955595
2	JUL1	35	26 00.3014 N	80 05.8134 W	608541	952788
3	HH2	15	26 00.6946 N	80 06.7572 W	610888	947605
4	JUL8	50	26 04.9957 N	80 05.0990 W	637007	956500
5	JUL7	25	26 04.9635 N	80 05.7321 W	636788	953038
6	JUL6	12	26 04.9120 N	80 06.2226 W	636457	950356
7	FTL6 (propose d)	18	26 08.9850 N	80 05.8070 W	661149	952461
8	FTL5 (propose	18	26 08.8710 N	80 05.7580 W	660460	952733
9	FTL4	18	26 08.2080 N	80 05.8440 W	656439	952289
10	FTL3	55	26 09.5183 N	80 04.6406 W	664424	958813
11	FTL2	40	26 09.5971 N	80 04.9522 W	664889	957106
12	FTL1	18	26 09.5343 N	80 05.7475 W	664478	952761
13	POMP6	52	26 14.5660 N	80 04.3980 W	695013	959921
14	POMP5	31	26 14.5660 N	80 04.7310 W	695000	958102
15	POMP4	19	26 12.7320 N	80 05.2010 W	683871	955613
16	POMP3	50	26 11.2141 N	80 04.3650 W	674708	960247
17	POMP2	40	26 11.3289 N	80 04.8039 W	675386	957843
18	POMP1	14	26 11.4356 N	80 05.2256 W	676016	955533
19	HB3	47	26 16.4255 N	80 03.8189 W	706301	963004
20	HB2	35	26 16.5350 N	80 04.2620 W	706947	960579
21	HB1	18	26 16.8357 N	80 04.5390 W	708758	959053
22	DB3	57	26 18.6828 N	80 03.5764 W	719986	964229
23	DB2	42	26 18.6280 N	80 04.0262 W	719637	961775
24	DB1	15	26 18.5869 N	80 04.3928 W	719373	959775
25	BOCA	30	26 20.8030 N	80 03.8830 W	732819	962462

Source: Gilliam et al. (2001). Marine Biological Monitoring in Broward County, Florida: Year 2 Annual Report, Technical Report DPEP 02-01.

TABLE 18

BROWARD COUNTY REEF COMMUNITY SUMMARY STATISTICS FOR THE 23 PERMANENT TRANSECT SITES IN 2001

	Depth	Stony Coral Density (colonies/m^2)		Stony Coral % cover		H'C		H'N		J'C		J'N		# Coral Species	Sponge Density (per m^2)		Octo-coral Density (per m^2)	
		By site	By reef	By Site	By reef	By site	By reef	By site	By reef	By site	By Reef	By site	By reef		By site	By reef	By site	By reef
FIRST REEF																		
JUL6	12	1.73		4.35		1.16		1.12		0.53		0.51		7	6.43		1.53	
DB1	18	10.13		0.80		0.93		0.56		0.58		0.35		4	4.27		3.27	
HH2	19	1.13	2.90	1.36	3.76	0.19	0.91	0.87	1.24	0.17	0.46	0.79	0.64	7	4.93		6.17	6.41
FTL1	19	1.37	±	0.85	±	1.43	±	1.64	±	0.62	±	0.71	±	9	10.83	9.80 ±	8.80	±
FTL4*	20	2.17	3.02	19.95	6.67	0.37	0.51	1.54	0.39	0.16	0.24	0.64	0.15	9	26.17	7.89	4.73	5.48
POMP4*	20	1.37		0.17		1.68		1.47		0.86		0.75		6	5.80		2.47	
POMP1	18	1.13		2.10		0.86		1.63		0.39		0.74		9	3.47		5.57	
HB1	21	3.57		0.50		0.66		1.15		0.37		0.64		5	16.53		18.73	
SECOND REEF																		
BOCA1*	30	3.43		1.14		1.70		1.56		0.87		0.80		7	15.53		6.60	
JUL7	32	2.03		0.99		1.84		1.86		0.74		0.75		12	12.73		2.83	
HB2	35	1.67	2.26	3.71	1.41	1.39	1.73	1.97	1.93	0.56	0.74	0.79	0.83	9	25.43	17.25	2.30	6.70
DB2	37	3.37	±	1.16	±	1.92	±	1.96	±	0.80	±	0.82	±	15	26.73	±	0.47	±
JUL1	40	2.23	0.75	0.81	0.97	1.92	0.20	2.01	0.16	0.73	0.09	0.76	0.07	12	14.19	5.64	2.90	7.40
FTL2	48	1.53		0.79		1.66		1.94		0.76		0.88		12	13.40		9.73	
POMP5*	48	1.60		0.97		1.51		2.08		0.69		0.95		11	12.97		23.57	
POMP2	52	2.20		1.74		1.87		2.06		0.78		0.86		11	17.00		5.20	
THIRD REEF																		
HB3	49	4.13		2.04		2.04		2.10		0.82		0.84		15	33		4.23	
POMP3	51	3.77	2.72	2.77	1.94	1.93	1.74	1.95	2.01	0.75	0.73	0.76	0.84	11	25	15.36	2.63	11.02
JUL8	50	1.97	±	1.48	±	1.89	±	2.05	±	0.82	±	0.89	±	11	13	±	3.33	±
POMP6*	51	2.13	0.99	2.56	0.66	1.20	0.28	2.23	0.16	0.47	0.13	0.87	0.07	13	39	5.14	13.97	10.96
JUL2	52	1.87		1.46		1.74		2.12		0.79		0.96		11	15		2.70	
DB3	55	3.37		2.28		1.55		1.78		0.67		0.77		8	22		30.97	
FTL3	60	1.83		0.96		1.84		1.86		0.80		0.81		8	13		19.33	
MEAN (± 1 SD)		2.62 ± 1.85		2.39 ± 3.96		1.45 ± 0.53		1.72 ± 0.44		0.64 ± 0.21		0.77 ± 0.14		9.65	14.08± 6.93		7.91± 8.01	

Source: Gilliam et al. (2001b). Marine Biological Monitoring in Broward County, Florida: Year 2 Annual Report. Technical Report DPEP 02-01.

Overall coral density increased from 2000 to 2001 but the increase was not statistically significant. A total of 1,800 colonies and 31 species were observed at the 23 sites during the September/October 2001 monitoring event. Overall mean stony coral density in 2001 was 2.62 ± 1.85 colonies/m^2. Overall mean coral cover was 2.39 ± 3.96%. Mean density was highest on the first reef tract, and one site in Fort Lauderdale (FTL 4) had the highest stony coral coverage of 19.95% in comparison to a mean cover of 1.45% for the remaining first reef sites. The first reef showed the greatest increase in coral density between 2000 and 2001. The large increase and high variability of coral density observed at the first reef sites can be attributed to an increase in small *Siderastrea* spp. recruits at site DB1 in 2001. Stony coral percent species composition was similar in 2000 and 2001 with the exception of *S. radians* which showed an increase from 5% to 21%. Overall soft coral density decreased to 7.91 ± 8.01 colonies/m^2 in 2001 which was not statistically different from 2000. Mean sponge density decreased significantly between 2000 and 2001 with an overall mean density of 14.09 ± 6.93 colonies/m^2 observed during the September/October 2001 monitoring (Gilliam et al. 2001b).

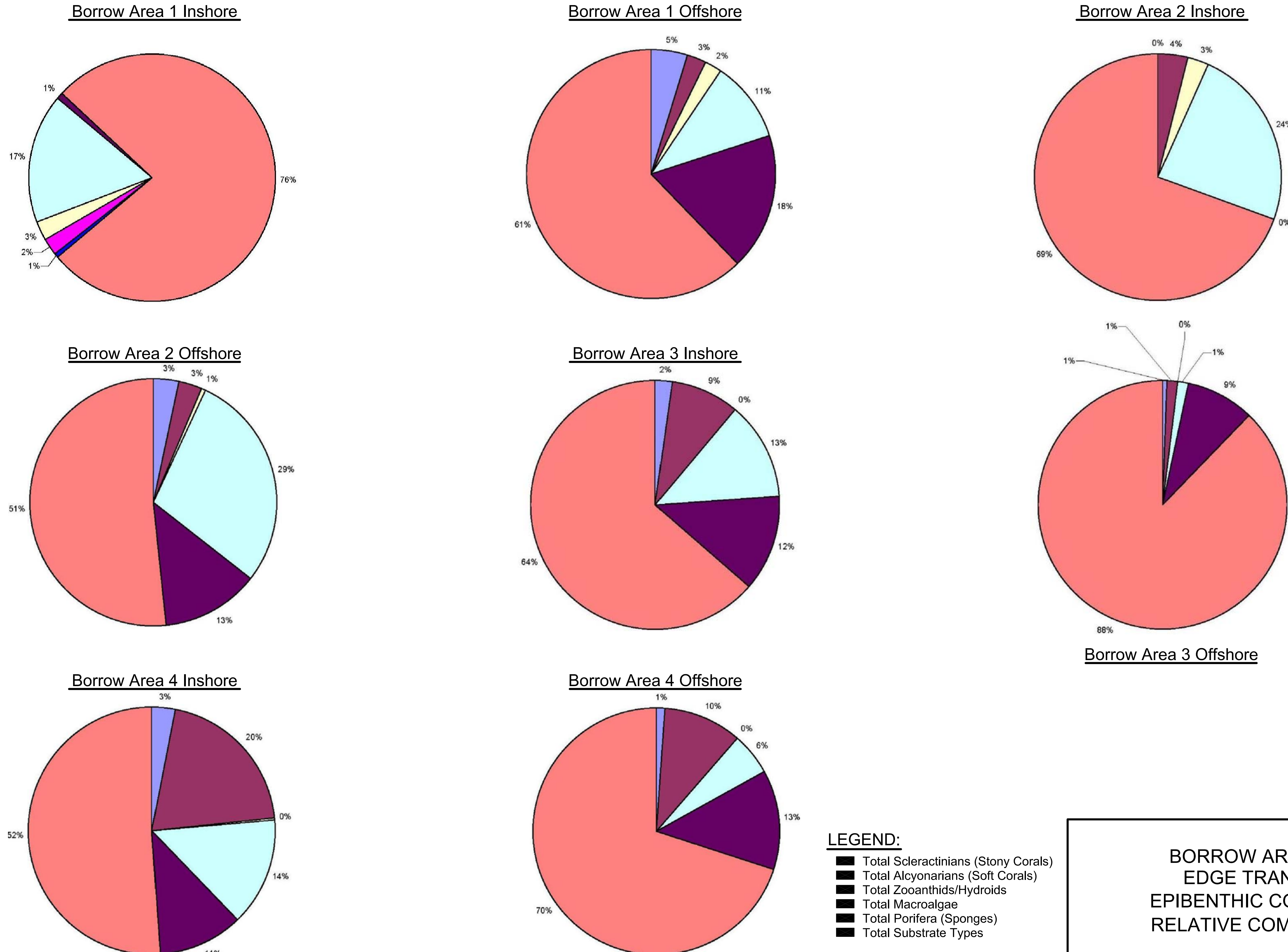
Blair and Flynn (1989) compared data obtained from Miami-Dade County Department of Environmental Resources Management's biological monitoring program with information available for Palm Beach County. Their compilation revealed a general decrease in stony coral species diversity moving northward from Miami-Dade County through Broward to Palm Beach County. Goldberg (1973) recorded 25 stony coral species for Palm Beach County; Britt Associates (1979) and Goldberg (1985) recorded 30 species for Broward County; and 33 species of stony corals were identified in northern Miami-Dade County by Dade-DERM. The overall hardbottom assemblages of stony corals, gorgonians, and sponges along southeast Florida offshore reefs basically remain consistent throughout the counties of Miami-Dade, Broward, and Palm Beach (Blair and Flynn, 1989).

The reef edges adjacent to the original seven proposed borrow areas for the Broward County Shore Protection Project were investigated by coral reef scientists with Nova Southeastern University Oceanographic Center during the summer/fall of 2001. A combination of Laser Airborne Depth Soundings (LADS) and multibeam bathymetry, acoustic remote sensing, diver-operated *in situ* WAAS-GPS, and ecological data analysis were used to determine the reef edges. The results were geo-referenced into the Broward County GIS database, including the biological assessment of the reef edges and video/still photography of representative portions of reef edges.

Reef edges were defined as the edges of hardground or rubble areas which were covered by a benthic assemblage similar to that of the surrounding reef areas. Although not geologically a coral reef as defined in the scientific literature, the rubble fields associated with the reef slopes are often well populated by benthic organisms and can therefore be considered functionally as "reef" (NSU, 2001). However, since this definition does not necessarily denote the edge of a solid structure, these reef edges are unstable and may migrate due to wave, current, and gravity-driven transport processes. Many areas, particularly the inshore edge of the third reef tract, were characterized by a wide rubble fringe between the actual edge of the proper reef crest and the clean sand body of the borrow area. In these instances, the term reef edge refers to the outer edge of the rubble area where the rubble became so sparse that very little to no benthic fauna and flora was observed. The 2001 reef edges adjacent to the five borrow areas (BA I, II, III, IV, and VI) are shown in Figures 6 through 6.5.

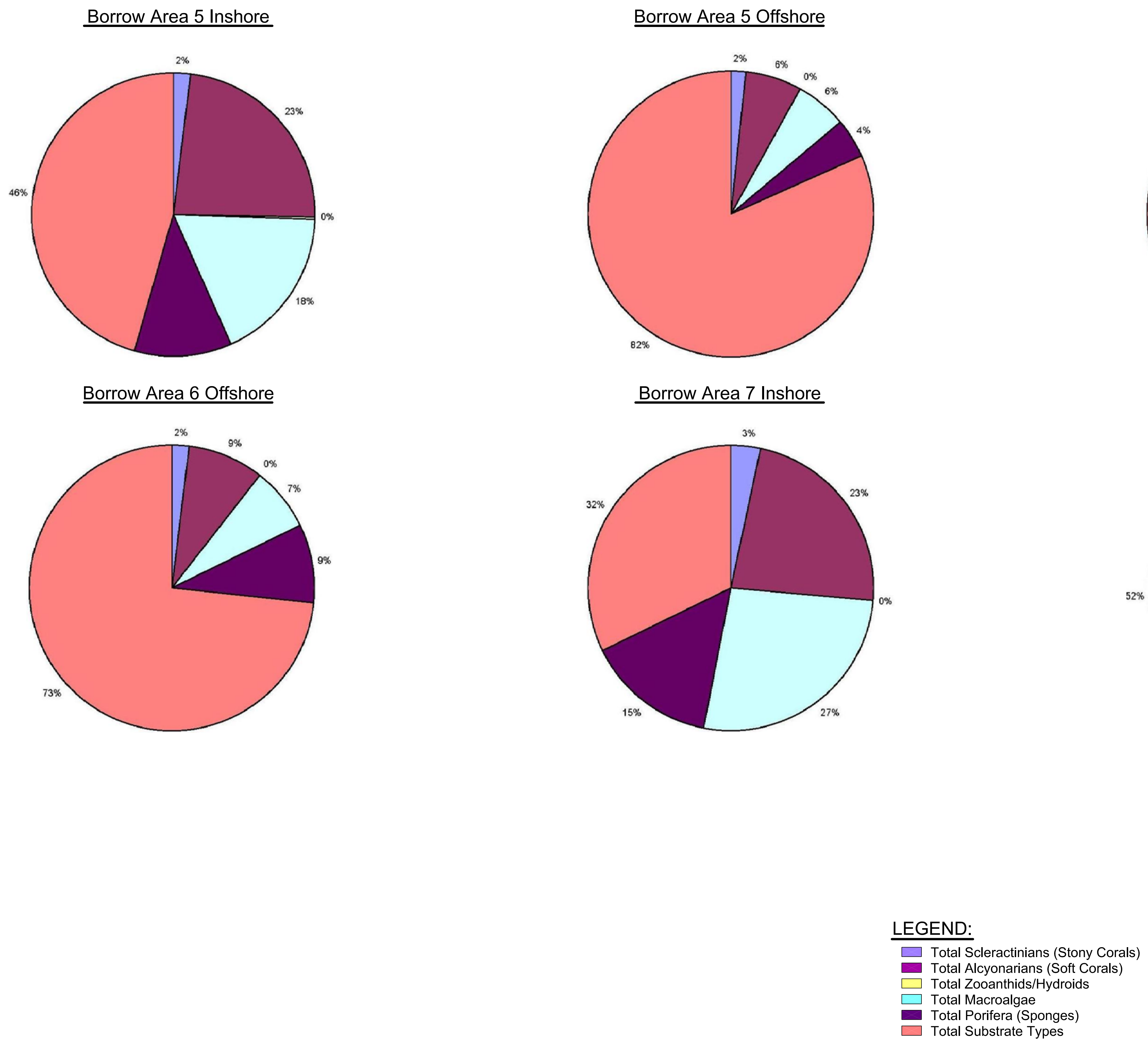
A detailed biological assessment of the reef edges was performed along the east and west sides of the borrow areas using the line-intercept method. On each reef edge adjacent to the borrow areas, a sample site was chosen by a double-randomized design within which 6 transects of 50 meters length were sampled. At each sample site, 105 linear meters of reef edge were evaluated to a distance of 10 meters from the edge of the sand into the reef to account for irregularities in the reef edges and the width of the ecotone along this fluctuating edge. A total of 81 transects were sampled during the study (NSU, 2001). Figure 11 (a and b) summarizes the relative epibenthic community structure along each of the fourteen reef edges.

A total of 26 stony coral species (including the hydrocoral, *Millepora alcicornis*) and 15 soft coral species were identified along the original seven borrow area reef edges (NSU, 2001). Three typical benthic assemblages were identified by ecological analysis and supported by acoustic remote sensing: 1) first reef and nearshore hardground: low cover (<30%), dominated by green macroalgae (*Halimeda discoidea*) and turf algae, fauna dominated by bushy hydrozoans and the soft coral, *Pseudopterogorgia Americana*; 2) second reef: high cover (up to 50%), dominated by green macroalgae (*Halimeda opuntia*) and fauna dominated by barrel sponges *Xestospongia muta*, and the soft corals *Eunicea* spp., and *Pseudopterogorgia* spp; and 3) third reef: medium cover (mostly 10-30%), dominated by turf algae, fauna dominated by sponges (*Aplysina* spp.) and *Eunicea* spp. The benthic assemblages along the reef edges were significantly different between the first reef (and nearshore hardbottom), second reef, and third reef tracts and were also significantly different among sample sites (NSU, 2001).



BORROW AREA REEF EDGE TRANSECTS EPIBENTHIC COMMUNITY RELATIVE COMPOSITION

FIGURE 11A



BORROW AREA REEF
EDGE TRANSECTS
EPIBENTHIC COMMUNITY
RELATIVE COMPOSITION

FIGURE 11B

Two of the previously defined borrow areas, BA-V and BA-VII, were eliminated from the proposed project due to geotechnical and environmental concerns. The boundaries of the remaining five borrow areas were redefined to avoid small patch reef formations and rubble areas with dense reef benthic assemblages. The following is a description of the hardbottom communities adjacent to the five proposed borrow areas.

1. Borrow Area I

The first reef tract almost disappears north of Hillsboro Inlet, where it is replaced by nearshore hardbottom. The reef edge inshore of Borrow Area I is the offshore edge of the nearshore hardbottom in this area. This hardbottom is a more or less, continuous low ridge with numerous sandy breaks (NSU, 2001). Ledges occur in areas where sand has eroded, while in other areas, sand floods the hardbottom and covers its biota. The hardbottom is mainly covered by turf algae with hard corals composing only one percent of spatial coverage (NSU, 2001). Reef transects along the inshore hardbottom edge revealed a very high percentage of unsettled substratum. The highest count in substratum types was of "hardground with algal turf." This was also the only sampled reef edge where hydroids are dominant. The macroalgal community is dominated by *Caulerpa* spp. along the inshore reef edge adjacent to Borrow Area I (NSU, 2001).

The reef edge offshore of Borrow Area I is broken up into a series of low platforms interconnected by rubble beds. Relatively narrow rubble halos exist around the well-defined hardbottom areas which are characterized by a rich benthos. The hardbottom and rubble areas are covered by a diverse community dominated by macroalgae and sponges (NSU, 2001). However, almost two thirds of the area is substratum – most of which is covered by an algal turf. The large amount of free substratum reflects the relatively small size of reef patches with much rubble in between, allowing for sparser benthic settlement. An outstanding feature of this area is the high cover (5%) by scleractinian corals, dominated by *Montastrea cavernosa*, *Stephanocoenia michilini*, and *Meandrina meandrites*, the highest observed near any of the borrow areas. Sponges were the dominant benthic group, particularly the barrel sponge, *Xestospongia muta* (NSU, 2001).

2. Borrow Area II

The reef edge inshore of Borrow Area II is best described as nearshore hardbottom, and is likely lithified shoreface (NSU, 2001). The rocks do not crop out along the entire inshore edge of the borrow area. Rather, wide areas of hardbottom are covered by a thin veneer of sand. The NSU acoustic remote sensing survey indicated that a continuous hardground underlies most sandy areas inshore of Borrow Area II. This is also supported by the LADS delineated imagery of the nearshore hardbottom edge which did not match the diver verification surveys in some areas.

The biotic communities that occupy the nearshore hardbottom inshore of Borrow Area II vary according to the amount of sand. The dominant benthic group was turf algae. However, dense beds of soft corals, dominated by *Pseudopterogorgia americana*, were encountered. Unoccupied substratum (sand and hardgrounds covered only by algal turfs) covered more than two thirds of the investigated area during the reef edge transects. Sponges and scleractinians (hard corals) were not of importance in the inshore assemblage (NSU, 2001). A small section of reef with higher diversity and stony coral coverage exists inshore of the southernmost 300 feet of the borrow area (Figure 6.2).

Offshore of the southern section of Borrow Area II, the second reef is well defined with vertical ledges ranging to 2 meters (NSU, 2001). Dominant stony coral species were *Montastrea cavernosa* and *Meandrina meandrites*. Dominant soft coral species include *Briareum asbestinum*, *Erythropodium caribaeorum*, and *Eunicea* sp. The west edge of the second reef loses its integrity along the northern half of Borrow Area II. The reef edge becomes increasingly poorly defined from approximately the middle of the borrow area to the north end. Along the northern extremity of the borrow area, a wide rubble field exists. Additionally, both in the southern and northern sectors, wide tongue-shaped, rubble areas extend inshore from the reef crest (i.e. dense, mature reef communities). These rubble areas are characterized by a relatively dense benthic assemblage (dominated by sponges and gorgonians) that is reminiscent of, but poorer, than those found on the reef proper (NSU, 2001).

3. Borrow Area III

Inshore of Borrow Area III, the east edge of the second reef is a well-defined, almost straight line, where the sand and reef slope intersect. The gently sloping reef edge is characterized by a dense benthic assemblage. Macroalgae are the dominant benthic group while sponges, dominated by *X. muta*, are the most important faunal component. Soft corals comprised 9% of the benthic cover. Although not a true coral species, *Millepora* *alcicornis*, a hydrocoral, was the most frequent stony coral species (NSU, 2001).

Immediately north of the borrow area, an intermediate hardground exists. It is a low, but well-defined ridge, that is covered by a dense benthic assemblage dominated by gorgonians and sponges. The offshore reef edge (inshore edge of the third reef) adjacent to Borrow Area III consists of two reefal bodies separated by a sand gap. The two reefal bodies are well defined, but extend inshore as dense rubble fields. The rubble field is colonized by sponges and gorgonians, and the assemblage is markedly poorer than on top of the third reef crest. Stony corals (only *Stephanocoenia michilini*) on the rubble bodies in these transition zones account for 1% of spatial coverage (NSU, 2001).

4. Borrow Area IV

The east edge of the first reef inshore of Borrow Area IV is well developed with a relatively straight reef edge. The first reef in this area forms a slightly sloping, hard substratum; and a rubble zone extends seaward from the reef edge in only a few places, and generally less than 5 meters from the reef. The benthic community on the first reef edge adjacent to Borrow Area IV is relatively rich and is dominated by macroalgae (*Halimeda opuntia*), sponges (*Iotrochota birotulata* and *Aplysina* sp.), and gorgonians (*Eunicea* sp., *Briareum asbestinum*, and *Erythropodium caribaeorum*) (NSU, 2001).

The west edge of the second reef offshore of Borrow Area IV demonstrated low, benthic coverage comprised of approximately 70% open substrate with high sand counts interspersed amongst rubble. The benthic assemblage is dominated by sponges, *Iotrochota birotulata*, *Aplysina* sp., *Amphimedon compressa*, and *Xestospongia muta*. Common gorgonians were *Pseudopterogorgia* spp., *Eunicea* spp., *Briareum asbestinum*, and *Erythropodium caribaeorum*. The stony corals, *Porites astreoides* and *Siderastrea siderea*, only accounted for 1% spatial coverage (NSU, 2001).

5. Borrow Area VI

The east edge of the first reef adjacent to Borrow Area VI is a shallow incline from the sandy area. In some places, particularly the southern sector, some sandy gaps dissect the reefs. More than two thirds of the substratum was bare, or covered only with a low algal turf. Macroalgae are the dominant benthic category, dominated by *Dictyota* sp, and sponges are the second most common benthic group. Offshore of Borrow Area IV, the west edge of the second reef is equally dominated by sponges (*X. muta*) and gorgonians (mostly *Pseudopterogorgia* spp., *Briareum asbestinum*, and *Eunicea* sp.). Stony corals (*Dichocoenia stokesii*, *Meandrina meandrites*, *Montastrea cavernosa*, and *Stephanocoenia michilini*, and the hydrocoral *Millepora alcicornis*) covered 2% of space (NSU, 2001).

3.5. FISH AND WILDLIFE RESOURCES.

3.5.1. BEACH AND DUNE HABITAT.

Very few birds utilize the beach and dunes in the project area due to intense coastal development. Several species of protected birds have been observed at John. U. Lloyd Beach State Recreation Area, including the Southeastern American Kestrel (*Falco sparverius paulus*), Eastern brown pelican (*Pelecanus occidentalis*), least tern (*Sterna antillarum*), little blue heron (*Egretta caerulea*), snowy egret (*Egretta thula*), tri-colored heron (*Egretta tricolor*), Roseate spoonbill (*Ajaia ajaja*), and osprey (*Pandion haliaetus carolinensis*) (Coastal Technology Corporation, 1994; Florida Game and Fresh Water Fish Commission, 1991).

Based upon database reports of the Florida Fish and Wildlife Conservation Commission, there are over 80 species of birds listed in the Federal Migratory Bird Treaty Act that have been recorded as inhabiting the southeast Florida coastline (Palm Beach, Broward, and Dade counties) between the surf zone and densely vegetated forest of the back dune for at least part of the year (USACE, 1996). However, very few species utilize the beach and dune areas in this area due to intense coastal development. Sanderlings (*Calidris alba*) and ruddy turnstones (*Arenaria interpres*) are generally the only wintering species that are commonly observed foraging and resting on the beaches along Broward County. Royal terns (*Sterna maxima*), ring-billed gulls (*Larus delawarensis*), laughing gulls (*Larus atricilla*) and herring gulls (*Larus argentatus*) also winter along the southeast Florida coastline and are generally observed foraging and resting near fishing piers and on beaches adjacent to piers (USACE, 1996).

The beaches of Broward County are typical of southeast Florida beaches that receive the full impact of wind and wave action. The diversity of species that can survive in this environment is low, but the population density of the few resident species that are specialized to survive in this high energy environment is usually very high. The upper portion of the beach, or subterrestrial fringe, is dominated by talitrid amphipods and ghost crab (*Ocypode quadrata*). In the midlittoral zone (beach face of the foreshore), polychaetes, isopods, and haustoriid amphipods are the dominant organisms. In the surf zone, coquina clams (*Donax* spp.) and mole crabs (*Emerita talpoida*) typically dominate the beach fauna (Spring, 1981; Nelson, 1985; and USFWS, 1997).

3.5.2. INLET COMMUNITIES.

The estuarine wetlands surrounding the Hillsboro Inlet contain two types of habitat: predominately unvegetated soft bottom (sand/silt) areas and isolated mangrove trees. Shoreline development and dredge and fill activities have resulted in the loss of most of the native vegetation. The area of vegetated estuarine wetlands surrounding Port Everglades Inlet is also limited due to the extensive development of the Port and adjacent urban areas, absence of stable substrate, and excessive water depth. Approximately 1,000 feet south of Port Everglades Inlet, along the Intracoastal Waterway at John U. Lloyd State Park, there is an estuarine, intertidal, forested wetlands consisting of red (*Rhizophora mangle*), black (*Avicennia germinans*), and white mangroves (*Laguncularia racemosa*) and buttonwood trees (*Conocarpus erectus*). In many areas, mangrove communities have been impacted or replaced by exotic species, including Australian pine (*Casuarina equisetifolia*), Brazilian pepper (*Schinus terebinthifolius*), corktree (*Thespesia populnea*), and melaleuca (*Melaleuca quinquenervia*).

Corals (*Siderastrea* spp., *Porites* sp., *Montastrea* sp., *Oculina* sp., and *Leptogorgia setacea*) and sponges (*Cliona* sp. and *Spheciospongia vesparium*) are sparsely distributed in some inlets in southeast Florida. Species commonly observed in association with jetty structures include fireworm (*Hermodice carunculata*), Cuban stone crab (*Menippe nodifrons*), flat crab (*Plagusia depressa*); sponges (*Haliclona* sp.), colonial anemone (*Zoanthus sociatus* and *Palythoa variabilis*), hydroids, and the octocoral, *Telesto riisei.* (CPE, 1992).

3.5.3. NEARSHORE SOFT BOTTOM COMMUNITIES.

Shallow subtidal soft bottom habitat (0 to 3 feet deep) are dominated by a relatively even mix of polychaetes (primarily spionids), gastropods (*Oliva* sp., *Terebra* sp.), portunid crabs (*Arenaeus* sp., *Callinectes* sp., and *Ovalipes* sp.) and burrowing shrimp (*Callianassa* sp.). In slightly deeper water (3 to 10 feet deep), the dominant fauna are polychaetes, haustoriid and other amphipod groups, and bivalves (*Donax*, sp. and *Tellina* sp.) (Marsh et al. 1980; Goldberg et al., 1985; Gorzelany and Nelson, 1987: Nelson, 1985; Dodge et al., 1991). Dexter (1972), Croker (1977), and Shelton and Robertson (1981) have indicated that there is no latitudinal pattern of diversity and species distribution among the tropical intertidal sand beach macrofauna (USACE, 1996).

3.5.4. OFFSHORE SOFTBOTTOM COMMUNITIES.

Offshore soft bottom communities display a greater species diversity than nearshore soft bottom communities, partly due to the decrease in wave-related stress. Polychaetes are generally the dominant organisms in offshore soft bottom communities although infaunal diversity varies within areas. Selected stations along borrow sites offshore Pompano/Lauderdale-by-the Sea were found to have predominantly polychaetes (45%), nematodes (29%) and tanaid crustaceans (13%) before beach construction in 1983 (Goldberg, 1984). Infaunal studies offshore Hollywood Beach (Dodge et al., 1991) found polychaetes (52%), nematodes (14%), and crustaceans (9%) to be the dominant taxa. In a 1990 pre-construction survey of offshore infauna in the Hollywood/Hallandale project area, nematodes (44%), polychaetes (24%), crustaceans (amphipods, isopods. cumaceans, tanaidaceans and mysids) (13%) and bivalves (7%) were the dominant fauna (Dodge et al., 1995). Barry A. Vittor & Associates, Inc. (1984) reported that 68.9% of the macrobenthic community off Port Everglades consisted of polychaetes, followed by mollusks (13.2%), arthropods (10.7%), echinoderms (1.2%) and miscellaneous other groups (6.0%).

Extensive seasonal macroalgal growth has been recorded in these soft bottom areas, with abundant green macro algae (*Caulerpa* spp., *Halimeda* spp., and *Codium* sp.) occurring during the summer months, and brown algae (*Dictyota* sp. and *Sargassum* sp.) dominant during the winter months (USACE, 1996).

Larger invertebrate macrofauna occasionally observed in offshore soft bottom areas between the second and third reef lines include the queen helmet (*Cassia madagascariensis*); king helmet (*Cassia tuberosa*); Florida fighting conch (*Strombus alatus*); milk conch (*Strombus costatus*); Florida spiny jewel box (*Arcinella comuta*); decussate bittersweet (*Glycymeris decussata*); calico clam (*Macrocallista maculata*); tellin (*Tellina* sp.); and cushion star (*Oreaster reticulatus*) (USACE, 1998). The Florida spiny lobster, a commercially valuable species, may move through this area during migration from offshore to nearshore reef areas (Courtenay et al., 1974).

3.5.5. FISHES.

3.5.5.1. Nearshore community.

The inshore surf zone fish community consists mainly of small species or juveniles (Modde, 1980). A relatively few species typically dominate the surf zone area (Modde and Ross, 1981: Peters and Nelson, 1987). Common surf zone fish include Atlantic threadfin herring (*Opisthonema oglinum*); blue runner *(Caranx crysos*); spotfin mojarra (*Eucinostomus argenteus*); southern stingray (*Dasyatis americana*); greater barracuda (*Sphyraena barracuda*); yellow jack (*Caranx bartholomaei)* and the ocean triggerfish (*Canthidermis sufflamen*); none of which are of local commercial value (USACE, 1998).

A mixture of coastal pelagic, surf zone, and reef fishes are attracted to the shelter and food source provided by the nearshore hardbottom along southeast Florida (USACE, 1996). Coastal pelagic species observed are primarily migratory species that include Spanish mackerel, *Scomberomorus maculatus*; bluefish, *Pomatomus saltatrix*; mullets, *Mugil* spp.; and jacks, *Caranx* spp. Only Spanish mackerel and mullet are of commercial value (USACE, 1996). Typical surf zone fishes observed in association with the rock outcrops of southeast Florida include Atlantic croaker, *Micropogonias undulatus*; pompano, *Trachinotus carolinus*; jacks, *Caranx* spp.; snook, *Centropomus undecimalis*; anchovies, *Anchoa* spp.; and herrings, *Clupea* spp. (USACE, 1996). Common snook (*C. undecimalis*) is listed as a species of special concern by the State of Florida. These species are not confined to the nearshore hardbottom areas and can be found along the sandy periphery of the rocks in the nearshore zone (Herrema, 1974; Futch and Dwinnel, 1977; Gilmore, 1977; Gilmore et al., 1981). In contrast to surf zone fishes, reef fishes are always associated with some form of natural or artificial bottom structure. The offshore reefs support the largest populations of reef fish. Reef species often observed along the nearshore rock outcrops include grunts, snappers, groupers, wrasses, damselfish, blennies, gobies, angelfishes, and parrot fishes. Only snapper and grouper are of commercial value (USACE, 1996).

From June to August 2001, 398 fish counts were performed within the westernmost 30 meters of nearshore hardbottom in Broward County. There was a transect-count and either a point-count or a rover-diver count completed every 152 m of shoreline. A total of 72,723 fish of 47 families were recorded (Spieler, 2001b). Taking differences in census results into account, the nearshore, hardbottom fish assemblages consist of at least 169 species of which more than 85% are juveniles. Most of these juveniles are grunts (family

Haemulidae) which make up more than 90% of the juveniles and 80+% of the total fish assemblage. The remaining families are represented in decidedly lower numbers. The wrasses (Labridae) at 5.0% comprised the next largest portion of the population followed by Pomacentridae at approximately 2.0%, Acanthuridae 1.0%, Scaridae 0.8%, and Gobiidae 0.5%. The rest of the 47 families contributed less than 0.5% each (Spieler, 2001b).

Courtney at al. (1980) recorded 67 species of 26 families on the nearshore hardbottom (first reef) off Hallandale. All but four of these species were recorded during the 2001 Broward County study (polka-dot batfish, *Ogcocephalus radiatus*; freckled cardinalfish, *Phaeoptyx conklini*; spotfin mojarra, *Eucinostomus argenteus*; and ocean triggerfish, *Canthidermis sufflamen*) and were recorded only as rare or occasional at Hallandale (Spieler, 2001b). Lindeman and Snyder (1999) reported 86 species with juveniles representing 80+%. Likewise, they also found haemulids made up the largest percentage of fishes with 6 of the 11 most abundant species. The remaining of the most abundant species, a porgy (*Diplodus argenteus*,) two damsels (*Stegastes variabilis, Abudefduf saxatilis*) a wrasse (*Halichoeres bivittatus*) and a blenny (*Labrisomus nuchipinnis*), differ in that the porgies and blennies were not major components in the Broward County nearshore hardbottom fish assemblages. In addition, two of the most abundant species in Jupiter, sailors choice and silver porgy, (13% and 11%, respectively, of the total fish counts) were not abundant in Broward. Both of these species are present in Broward, but seldom in great abundance (Spieler, 2001b).

From previous studies, it is clear that the inshore reef has significantly lower richness and abundance of fishes than either the middle or second reef in Broward County. (Spieler, 2000b; 2001a; Ettinger et al., 2001; Harttung et al., unpublished). Although juvenile grunts are not unique to the Broward County nearshore reef, they are more abundant there than on the other reef tracts. With rare exception, juvenile grunts are not found on the offshore reef tract or the eastern edge of the middle reef in Broward County. Twenty-three species were unique to the fish counts of the Broward County nearshore hardbottom, that is they have not been previously recorded on natural or artificial substrate in Broward County (Spieler, 1999; 2000b; 2001a; Ettinger et al., 2001). However, 18 of these were only noted at one site and therefore may be due simply to chance occurrence or differences in methodology; the rover-diver counts have not been done on either the middle or offshore reef tract. The remaining five species [molly miller (*Scartella cristata*), rosy razorfish (*Xyrichtys martinicensis*), tiger goby (*Gobiosoma macrodon*), banded blenny (*Paraclinus fasciatus*), and sea bream (*Archosargus rhomboidalis*)] are neither rare nor endangered in Florida and, with the exception of the banded blenny, have a published depth distribution exceeding that of the nearshore hardbottom. Thus, it appears that although the Broward County nearshore hardbottom is an important habitat for juvenile fishes, especially grunts, the species makeup of the fish assemblage is not unique to this reef tract.

3.5.5.2. Offshore Community.

Fish species associated with the sand flats and soft bottom area between the first and second reefs off Broward County includes 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 (USACE, 1996).

The most important commercial invertebrate species associated with the hardbottom areas is the Florida lobster (*Panulirus argus*). The reefs also support a thriving recreational diving industry. Herrema (1974) listed 206 species of primary reef fish occurring off Broward and Palm Beach Counties. Abundant fish include wrasses, damselfishes, sea basses, parrotfishes, grunts, and angelfishes (USACE, 1996). Relatively abundant food fish species include the sheepshead (*Archosargus probatocephalus*), porkfish (*Anisotremus virginicus*), black margate (*Anisotremus surinamensis*), mutton snapper (*Lutjanus analis*), gray snapper (*Lutjanus griseus*), spadefish (*Chaetodipterus faber*), summer flounder (*Paralichthys dentatus*), and gray triggerfish (*Balistes capriscus*). Juveniles of commercial importance include the gag grouper (*Mycteroperca microlepis*), red grouper (*Epinephelus morio*), and black grouper (*Epinephelus bonaci*). One of the largest and most abundant predators on the reefs is the sport and food fish, the common snook (*Centropomus undecimalis*).

The 2000 status report of U.S. Caribbean coral reef ecosystems stated that many coral reef fish populations along the Florida southeast coast appear to be in relatively good condition (Causey et al., 2000). The Florida current (Gulf stream) moderates winter temperatures; however, reef fish kills do occur during cold-water upwelling events (Causey et al., 2000).

3.6. ESSENTIAL FISH HABITAT.

The Magnuson-Stevens Fishery Conservation and Management Act requires identification of habitats needed to create sustainable fisheries and comprehensive fishery management plans with habitat inclusions. The Act also requires preparation of an Essential Fish Habitat (EFH) assessment and coordination with National Marine Fisheries Service (NMFS) when essential fish habitat impacts occur. Essential Fish Habitat consultation for the proposed Broward County Shore Protection Project was initiated by coordination of the Draft Environmental Impact Statement. Essential fish habitat (EFH) is defined by Congress in the Magnuson-Stevens Act as "those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity." The Broward County Shore Protection

Project includes fill activities which will temporarily and permanently impact EFH. The proposed project will affect approximately 13.6 acres of coastal habitat identified as EFH. Specific impacts to hardbottom habitat, a portion which consists of wormrock, and the water column are addressed in Section 4.0 Environmental Effects.

The Federally managed species identified by the South Atlantic Fisheries Management Council include shrimp, red drum, reef fish, stone crab, spiny lobster, migrating/pelagic fish, snapper, grouper, and golden crab (NMFS, 1999). The nearshore hardbottom habitat in the project area and offshore reefs adjacent to the borrow areas are designated as Essential Fish Habitat – Habitat Areas of Particular Concern (EFH-HAPC) for the snapper-grouper complex (SAFMC, 2000). Thirty-three species of the snapper/grouper management unit and one coastal migratory pelagic species were recorded on the Broward County nearshore hardbottom during the 2001 study (Table 19) (Spieler, 2001b).

Although spiny lobster are documented to occur within the nearshore and offshore hardbottom habitats in Broward County, no spiny lobsters were observed within the 55 nearshore stations during characterization dives in August 2001. Three, relatively young queen conch (*Strombus gigas*) individuals were observed along the nearshore hardbottom edge during the summer 2001 field investigations: 2 individuals within Site 15-94.5 in Dania Beach and 1 individual at Station R-88 in John U. Lloyd State Park.

3.7. COASTAL BARRIER RESOURCES.

The following history and the applicability of the Coastal Barrier Resources Act (CBRA) of 1982 and the Coastal Barrier Resources Improvement Act (CBRIA) of 1990 to the Broward County Shore Protection Project located in Broward County, Florida was provided by the U.S. Fish and Wildlife Service in a letter dated April 30, 2003. The proposed project will overlap the boundaries of two “otherwise protected areas” (OPAs) (Birch Park, FL-19P and Lloyd Beach, FL-20P) and one CBRA unit (North Beach, P-14A) (USFWS, 2003).

Historically, some Federal expenditures (e.g., Federal flood insurance and other Federal financial assistance) had the effect of encouraging development in fragile, high-risk coastal barrier systems (e.g., barrier islands, sand spits, and mangrove forests). The CBRA and CBRIA limit federally-subsidized development within a

TABLE 19
SOUTH ATLANTIC FISHERIES MANAGEMENT COUNCIL
LIST OF MANAGED SPECIES RECORDED ON
BROWARD COUNTY NEARSHORE HARDBOTTOM

South Atlantic Snapper-Grouper Complex

Gray Triggerfish
Queen Triggerfish
Yellow Jack
Blue Runner
Bar Jack
Spadefish
Black Margate
Porkfish
Margate
Tomtate
Smallmouth Grunt
French Grunt
Spanish Grunt
Cottonwick
Sailors Choice
White Grunt
Bluestripe Grunt
Mutton Snapper
Schoolmaster
Gray Snapper
Mahogany Snapper
Dog Snapper
Lane Snapper
Yellowtail Snapper
Rock Hind
Grasby
Red Hind
Red Grouper
Scamp
Sheepshead
Saucereye Porgy
Hogfish
Puddingwife

Coastal Migratory Pelagics

Cero

defined Coastal Barrier Resources Unit. Three important goals of these acts are to: (1) minimize loss of human life by discouraging development in high-risk areas; (2) reduce wasteful expenditure of Federal resources; and (3) protect the natural resources associated with coastal barriers. In addition, CBRIA also provided development goals for undeveloped coastal property held in public ownership, such as wildlife refuges, parks, or other lands set aside for conservation, which are identified as OPAs. The only restriction applied to an OPA prohibits the expenditure of Federal Flood Insurance to new construction of structures (buildings) in an OPA, as stated in Section 9, Prohibitions of Flood Insurance Coverage In Certain Coastal Barriers. There are no other restrictions placed on Federal expenditures in an OPA (USFWS, 2003).

Federal monies can be spent within the Coastal Barrier Resource System for certain activities, which are exempted under Section 6, Exceptions To Limitations On Expenditures. These activities include: (1) projects for the study, management, protection, and enhancement of fish and wildlife resources and habitats; (2) establishment of navigation aids; (3) projects funded under the Land and Water Conservation Fund Act of 1965; (4) scientific research; (5) assistance for emergency actions essential to saving lives and the protection of property and the public health and safety, if preferred pursuant to the Disaster Relief, Emergency Assistance Act, and National Flood Insurance Act and are necessary to alleviate the emergency; (6) maintenance, repair, reconstruction, or repair, but not expansion of publicly owned or publicly operated roads, structures, or facilities; (7) nonstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore a natural stabilization system; (8) any use or facility necessary for the exploration, extraction, or transportation of energy resources; (9) maintenance or construction of improvements of existing Federal navigation channels, including the disposal of dredge materials related to such projects; and (10) military activities essential to national security (USFWS, 2003).

Since the proposed Broward County Shore Protection Project does not include the construction of structures that would require Federal Flood Insurance, then Federal expenditures for the proposed project are not restricted in the FL-19P, Birch Park and FL-20P, Lloyd Beach OPAs. The Service has determined that the construction activities proposed within CBRA Unit, P-14A, North Beach are consistent with the intent of the Act and are exempt pursuant to section 6(a)(G) which authorizes "nonstructural projects for shoreline stabilization that is designed to mimic, enhance, or restore a natural stabilization system" (USFWS, 2003).

3.8. WATER QUALITY.

The waters off the coast of Broward County are listed as Class III waters by the State of Florida. Class III category waters are suitable for recreation and propagation by fish and wildlife. Turbidity is the major limiting factor in coastal water quality in South Florida. Turbidity, expressed in Nephelometric Turbidity Units (NTU), quantitatively measures the light-scattering properties of the water. However, the properties of the material suspended in the water column that create turbid conditions are not reflected when measuring turbidity. The two reported major sources of turbidity in coastal areas are very fine organic particulate matter, and sand-sized sediments that are re-suspended around the seabed by local waves and currents (Dompe and Haynes, 1993). In Class III waters, Florida state guidelines limit turbidity values to under 29 NTU above ambient levels outside the turbidity mixing zone during beach restoration activities.

Turbidity values are generally lowest in the summer months and highest in the winter months, corresponding with winter storm events and the rainy season (Dompe and Haynes, 1993, Coastal Planning & Engineering, 1989). Turbidity data specific to beach renourishment projects in Broward County was collected during the 1991 renourishment of the Hallandale and Hollywood beaches, and the 1989 renourishment of John U. Lloyd State Park. Tables 20 and 21 show the average turbidity values associated with construction activities of these two nourishment projects, respectively. No values exceeded the State standards of 29 NTU for either project (Broward County DPEP, 1999). Field measurements of turbidity and wave climate were collected at two shore normal sites off the coast of Hollywood, Florida from January 1990 to April 1992 in water depths of approximately 10 meters and 5 meters. Turbidity was found to vary significantly under natural conditions, with values during storms sometimes exceeding 29 NTU (Dompe and Haynes, 1993).

Higher turbidity levels are typically expected around inlet areas, and particularly in estuarine areas, due to high nutrient and entrained sediment levels. Although some colloidal materials remain suspended in the water column upon disturbance, high turbidity episodes usually return to background conditions within several days to several weeks, depending on the duration of the perturbation (storm event or other) and on the amount of suspended fines (USACE, 1996).

3.9. HAZARDOUS, TOXIC AND RADIOACTIVE WASTE.

The probability of contamination by hazardous wastes in the project area has been judged to be negligible (USACE, 1994). There are currently no hazardous, toxic,

TABLE 20
1991 HOLLYWOOD/HALLANDALE NOURISHMENT PROJECT
AVERAGE TURBIDITY VALUES (NTU)

Station location	Background			Compliance 1			Compliance 2			Compliance 3		
DREDGE SITE	S	M	B	S	M	B	S	M	B	S	M	B
4/30 - 5/10/91	0.83	0.78	0.82	5.12	5.48	7.27	2.52	2.25	2.81	3.48	2.53	2.87
5/11 -5/24/91	0.81	0.86	0.78	8.30	7.63	8.65	1.06	1.76	1.95	1.33	1.30	2.24
5/24 -6/30/91	0.93	0.93	0.81	9.76	5.96	4.74	3.88	3.19	1.56	2.25	5.25	3.73
6/4 - 6/16/91	0.91	0.95	0.89	8.20	6.39	4.20	5.70	4.50	6.01	5.42	4.66	5.75
6/17 - 6/26/91	0.84	0.62	0.72	12.93	6.43	3.82	1.93	1.62	1.52	1.97	3.44	2.76
6/26 - 7/7/91	0.61	0.40	0.53	6.55	6.99	6.38	1.95	2.36	2.64	2.63	2.32	3.54
OVERALL AVERAGE (4/30 - 7/7/91)	0.82	0.76	0.76	8.48	6.48	5.84	2.84	2.61	2.75	2.85	3.25	3.48
DISCHARGE SITE												
4/30 - 5/10/91	3.83	3.89	4.22	8.68	9.63	12.20	6.13	6.21	10.36	N/A	N/A	N/A
5/11 -5/24/91	2.61	2.77	3.50	5.56	4.30	6.66	5.23	5.72	7.49	N/A	N/A	N/A
5/24 -6/30/91	2.19	1.76	1.76	4.02	4.59	3.29	3.92	4.16	3.86	N/A	N/A	N/A
6/4 - 6/16/91	3.25	3.14	3.16	7.41	6.95	8.53	6.22	6.17	8.79	N/A	N/A	N/A
6/17 - 6/26/91	1.94	2.03	2.02	3.39	5.56	6.72	4.17	5.32	11.30	N/A	N/A	N/A
6/26 - 7/7/91	2.71	2.46	2.06	5.46	5.75	5.29	6.91	7.78	6.26	N/A	N/A	N/A
OVERALL AVERAGE (4/30 - 7/7/91)	2.75	2.67	2.79	5.75	6.13	7.11	5.43	5.89	8.01	N/A	N/A	N/A

Notes: S= Surface; M= Mid-depth, and B= Bottom
Background station was located 500 m up-current of the dredge away from any turbidity plume.
Compliance stations were located 150 m down-current of the dredge and within the densest portion of any visible turbid plume; 100 m west of that point; and 100 meter east of the point
N/A = Not applicable
Source: Broward County Department of Planning and Environmental Protection

TABLE 21
1989 JOHN U. LLOYD BEACH NOURISHMENT PROJECT
AVERAGE TURBIDITY VALUES (NTU)

Station location	DREDGE SITE	DISCHARGE SITE
5/19/89 - 5/29/89	3.8	6.6
6/14/89 - 6/20/89	4.7	2.7
7/7/89 - 7/14/89	7.1	5.3
OVERALL AVERAGE (5/19/89 - 7/14/89)	5.2	4.9

Source: Broward County Department of Planning and Environmental Protection

and radioactive waste producers adjacent to the project site that discharge effluents near the Broward County shoreline. The potential borrow sites are sufficiently removed from shipping lanes and are located in high energy areas experiencing littoral drift. Studies have also shown that contaminants usually do not adsorb to particles with grain size suitable for beach restoration (USACE, 1994). There is recent history of an oil spill at the beach site. In August 2000, oil washed onto Broward County beaches. Recreational beaches
from North Miami Beach to Pompano Beach were impacted and required cleaning.

3.10. AIR QUALITY.

Ambient air quality along coastal Broward County is generally good due to prevalent ocean breezes from the northeast through the southeast. In June 1998, the EPA revoked the 1-hour ozone standard in Broward County; however the 1 hour ozone non-attainment area remains in effect for Fort Lauderdale. Broward County is classified as an attainment area for all other Federal Air Quality Standards.

3.11. NOISE.

Ambient noise levels in Broward County are low to moderate and are typical of recreational environments. The major noise producers include the breaking surf, adjacent commercial and residential areas, and traffic (boat, vehicular, and airplane).

3.12. AESTHETIC RESOURCES.

The shoreline along Broward County has been highly developed by residential and commercial interests, and much of the shoreline is hardened. Derelict or non-functional outfall pipes and shoreline stabilization structures are intermittently spaced along the Broward County shoreline. Due to the extensive development of Port Everglades and adjacent urban areas, the dune habitat that once surrounded the Inlet no longer dominates the area, and virtually all the upland areas surrounding Hillsboro Inlet have undergone extensive urban development.

3.13. RECREATION RESOURCES.

No Florida State or national wildlife refuges or management areas, forest, wilderness areas, trails, estuarine or research reserves exist along coastal Broward County (State of Florida, Division of Recreation and Parks, 1994d). The only official national or state recreational resources documented in the coastal areas of Broward County are John U. Lloyd State Park and Hugh Taylor Birch State Park (USACE, 1996). Also, North Beach in Broward County was acquired by the State of Florida under the “Save Our Coast Program” and is now a protected, lightly developed, public recreational beach (USACE, 1996).

Common water related activities in southeast Florida include onshore fishing, offshore fishing, recreational diving, sailing, sailboarding, surfing, personnel water craft, and other activities. According to FMRI data, there are approximately 592 recorded fishing sites (estuarine, open ocean and fresh water) along the coastal areas of Palm Beach, Broward, and Miami-Dade Counties combined (USACE, 1996). However, only 106 of the 592 sites are listed as high probability of encountering anglers (State of Florida, FMRI, 1994b and 1994f). Of the 106 sites, 19 are open ocean sites, and four are fishing piers located in Broward County (Deerfield Beach Fishing Pier, Pompano Pier in Pompano Beach, Anglin Pier at Lauderdale-By-The-Sea, and Dania Beach Fishing Pier (USACE, 1996). As noted, many of the sites or recreational fishing origination points are located in the estuary areas along the intracoastal waterway and inlets (USACE, 1996).

Creel survey data describing kept quantities of landed fish suggest that approximately 55% of recreational fishing is done from shore, 41% is performed from private boats, and only 4% is from charter boats (State of Florida, FMRI, 1994e). The 1998 Marine Recreational Statistics Survey of the National Marine Fisheries Service indicates, by grand total catch (weight of fish in pounds), that approximately 56% of recreational fishing is performed from private/rental boats, 32% is done from shore, and 12% is from charter boats (NMFS, 1998). The 1998 grand total catch for all fishing modes in east coast Florida State waters was 11,439,467 pounds (NMFS, 1998). The 1998 NMFS survey data also suggests that the most important recreational species in east coast Florida State waters within three miles offshore are tuna and mackerels (1998 grand total catch for king mackerel, little tunny, Spanish mackerel, and other tunas was 2,420,622 lbs); drums (1998 grand total catch for kingfish, black drum, red drum, and spotted sea trout was 1,645,715 lbs); jacks (1998 grand total catch for blue runner, crevalle jack, Florida pompano, greater amberjack, and other jacks was 1,197,724 lbs); porgies (1998 grand total catch for sheepshead [672,070 lbs] and pinfishes was (1,052,247); mullets (1998 grand total catch of 948,384 lbs); snappers (1998 grand total catch for gray snapper, lane snapper, red snapper, yellowtail snapper, and other snappers was 402,088 lbs); and dolphin (1998 grand total catch of 341,664 lbs) (NMFS, 1998). The most common game fishes landed in Florida waters are dolphin, little tunny, yellowtail snapper, and king mackerel (NMFS, 1998).

In a socio-economic study completed from June 2000 to May 2001, the net economic value was determined for southeast Florida's natural and artificial reef resources to the local economies and reef users. Broward County, one of the four counties comprising southeast Florida, was included in this study. The reefs in Broward County hosted 9.44 million person-days (person-day= one person participating in an activity for a portion or all of a day) during this study. This is the largest number of the three other counties in southeast Florida: Miami-Dade 9.17 million person-days, Monroe 5.11 million person-days, and Palm Beach 4.24 million person-days. In addition to providing a place for tourists and residents to fish, snorkel, and SCUBA dive, the reefs in Broward County contribute 36,000 full-time and part-time jobs and generated $2.1 billion in sales during the 12-month study. Of the $2.1 billion, artificial reefs generated $961 million, and the natural reefs generated $1.1 billion (Hazen and Sawyer, 2001).

To obtain demographic characteristics of the reef users in southeast Florida, resident and visitor boater surveys were completed. The median age of respondents in Broward County who were resident reef users was 48, and the median age was 39 for visitor reef users. Ninety-two percent of the resident reef users were male and 8% were female. Seventy-seven percent of the visitor reef users were male and 23% were female. On average, residents have been boating in Broward County for 22 years, while visitors have only been boating for 7 years. The average length of boats used for salt-water activities was 25 feet for residents and 27 feet for visitors. The median household income for resident reef users was $72,310 and $87,500 for visitor reef users. Both resident and visitor reef users were willing to spend $126 million per year for reef maintenance via water quality monitoring, means to prevent damage to reefs from anchoring, and preventing reef overuse (Hazen and Sawyer, 2001).

The economic benefit of the proposed Broward County beach renourishment project is an estimated $60.7 million. Bell and Leeworthy (2003) present three benefit to cost (B/C) ratios based on three varying environmental cost scenarios. In the first scenario, the proposed mitigation (1:1) is completely effective in replacing losses to the natural reef sustained from project construction. Construction costs are estimated to be $7.4 million and the B/C ratio is 8.2:1 in this scenario. The second scenario presumes a 20-year period before the limestone boulders provide a successful mitigative reef. The initial costs remain the same in this scenario, but an additional cost of $76,201 is added for the loss of recreational value to the artificial reef constructed at a 1:1 mitigation ratio during the 20-year recovery. Total cost is then estimated to be $8.924 million and the B/C ratio is 8.12:1. In the third scenario the mitigation achieves no replacement value and a mitigation ratio of 10:1 is also used in this last, most conservative scenario. Considering the added mitigation cost ($2.634 million), the initial cost ($7.4 million) and the loss of recreation value ($0.182 million) to the mitigation reef, the total cost in scenario three is $10.452 million. The B/C ratio is 5.94:1 in this most unrealistic scenario (Bell and Leeworthy, 2003). The Bell and Leeworthy (2003) report can be found at http://marineeconomics.noaa.gov.

Bell and Leeworthy (2003) also propose that beach alteration poses potential harmful effects to the endangered green turtle (*Chelonia mydas*). Although the study does not state what the possible effects may be, they project that the annual existence value (number of Florida households multiplied by the cost each household is willing to pay to ensure the existence of a species) for the green turtle could range from $1.95 million in Broward County to $18.9 million per year for the entire State. The B/C ratio, which factors in annual green turtle existence value, is still economically justified. Bell and Leeworthy (2003) cite only loss of green turtle foraging habitat (nearshore hardbottom) as the only effect resulting from project construction. The study does not address the positive effect project construction will have on green turtle existence value by increasing the amount of nesting beach habitat available to the species.

3.14. NAVIGATION.

The majority of boating activity is concentrated in close proximity to the inlets which serve as the access points for recreational diving and fishing vessels. Both Hillsboro Inlet and Port Everglades Inlet experience intense recreation and commercial navigation usage. In Broward County, listed dive shops and dive boat operations are concentrated in Fort Lauderdale and Pompano Beach (Florida Scuba News, 1994). Consultation with dive-charter boat operators revealed that most dive trips involve approximately 30 minutes of travel from port, which corresponds to about four to six miles north or south of the inlets (USACE, 1996). The second and third reef zones and artificial reef areas are the most popular dive trip destinations in Broward County, with the Pompano Pier reef off the Pompano Pier mentioned as a significant resource by dive operators (USACE, 1996).

3.15. AFFECTED ENVIRONMENT.

The project area has a rich maritime history. Potential cultural resources located within the proposed shore protection project areas include archaeological resources located on the beach, underwater historic shipwrecks, and historic structures located near the shoreline. There are 46 reported shipwrecks along the coast of Broward County. Only one of these (the *S.S. Copenhagen*) has been located. The *Copenhagen* has been listed on the National Register of Historic Places and designated as a Florida State Underwater Archaeological Preserve.

A magnetometer survey of the proposed borrow areas for the Broward County Shore Protection Project was conducted in December 1996/January 1997 by Coastal Planning & Engineering (Baer, 1999). The survey located twenty-seven (27) magnetic anomalies, sixteen (16) of which were located in or immediately adjacent to the original seven, proposed borrow areas. SCUBA divers investigated nineteen (19) of the 27 magnetic anomalies, three of which were not visually identified. Consultation with the Florida State Historic Preservation Officer July 11, 2000 (DHR No. 2000-05106) identified the area of potential effects for the project as the borrow areas. This consultation recommended a systematic underwater survey along with ground-truthing of potentially significant underwater targets (Letter dated January 26, 2000 in Appendix C).

An underwater archaeological SCUBA investigation and ROV video surveys of the project area were conducted during the first half of January 2001 by Coastal Planning & Engineering (Baer, 1999). This survey located, physically examined, and documented each of the 27 magnetic anomalies within or near the project area. Follow-up diver visits to the anomalies identified two large anchors, a possible sunken dredge or deck machinery, and the bow portion of the *Copenhagen*. Only one of the anomalies, Anomaly A27, the bow section of the *S.S. Copenhagen*, located approximately 300 feet north of Borrow Area VI, represents a known submerged cultural resource.

On April 24, 2003 (copy included in Appendix C) James C. Duck, Chief of the USACE Planning Division requested that the State Historic Preservation Officer (SHPO) concur with the USACE finding that no significant historic properties will be affected by the project. Final SHPO approval is expected before the USACE issues their Record of Decision on the FEIS.