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Littoral Environment Observations and Beach Changes Along the Southeast Florida Coast

by

Allan E. DeWall

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20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

Daily and weekly surveys and observations of the beach and nearshore were made at Jupiter, Boca Raton, and Hollywood, Florida, for 4½ years between 1969 and 1973. During this relatively storm-free period, mean annual breaker height varied from a high of 0.9 meter at Jupiter, the northernmost site, to 0.5 meter at Hollywood, the southernmost site. This decrease in wave energy reaching the shoreline is attributed to the varying protection afforded by the Bahama Banks, 80 kilometers offshore of Hollywood. Wave and longshore

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SECURITY CLASSIFICATION OF THIS PAGE *(When Data Entered)* current directions were observed to change seasonally, with directions from the northeast dominating during October through March and from the southeast during April through September. Potential gross longshore transport rates, estimated from these data, ranged from 1,800,000 cubic meters per year at Jupiter to 1,200,000 cubic meters per year at Boca Raton, to 480,000 cubic meters per year at Hollywood. The magnitude of beach changes, as defined by shoreline position and sand volume on the beach, decreased from north to south and is relatively low compared with typical U. S. east coast beaches. Contributing factors include the sheltering effect of the Bahama Banks, the lack of significant storms, and the underlying coquina limestone which characteristically crops out just below the MSL shoreline, forming a protective reef that effectively retards erosion. Beach changes were seasonal in nature, but were reversed at Boca Raton, where beach width and sand volume were highest during the winter months. Seasonal beach changes were two to three times greater than year-to-year changes. The average unit volume change rate above MSL was -1.8 cubic meters per meter per year at Jupiter, +1.0 cubic meter per meter per year at Boca Raton, and +0.1 cubic meter per meter per year at Hollywood. Corresponding MSL shoreline migration rates were -0.1 meter per year at Jupiter, +0.46 meter per year at Boca Raton, and -0.9 meter per year at Hollywood. Nearshore volume changes between surveys at Boca Raton were not related to above MSL beach changes.

PREFACE

This report is published to provide coastal engineers with an analysis of a series of beach profile surveys and littoral environment observations collected during a 4½-year study at three sites on the southeast Florida coast. The work was carried out under the coastal processes program of the U.S. Army Coastal Engineering Research Center (CERC).

The report was prepared by Allan E. DeWall, Geologist, under the supervision of Dr. Cyril J. Galvin, Jr., Chief, Coastal Processes Branch, Research Divison.

Data collection was accomplished by students and staff of the Florida Ocean Sciences Institute, Incorporated (FOSI), Deerfield Beach, Florida, under CERC Contracts Nos. DACW72-69-C-0018 and DACW72-71-C-0016. Project supervisors at FOSI were W. Gonzalez, from 1969 to 1970, and J. Richter. Principal observers were J. Brown, D. DeCoster, and J. Heon. Computer programing was done at CERC by A. Szuwalski, R. Bruno, J. Balsillie, J. Buchanan, B. Sims, W. Seelig, D. Mowrey, M. Leffler, and R. Hylton. Data reduction was accomplished at CERC with the assistance of D. Fresch, R. Guite, Wai Yin Der, and P. Campos. Mr. Richter completed a preliminary analysis of the data, in the form of contract reports, and is responsible for many of the ideas in this report. The author acknowledges and appreciates many helpful review comments from Dean Morrough P. O'Brien, and Drs. Robert G. Dean, Robert L. Wiegel, and Jack W. Pierce.

Comments on this publication are invited.

Approved for publication in accordance with Public Law 166, 79th Congress, approved 31 July 1945, as supplemented by Public Law 172, 88th Congress, approved 7 November 1963.

JOHN H. COUSINS
Colonel, Corps of Engineers
Commander and Director

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CONVERSION FACTORS, U.S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT

U.S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	by	To obtain
inches	25.4	millimeters
	2.54	centimeters
square inches	6.452	square centimeters
cubic inches	16.39	cubic centimeters
feet	30.48	centimeters
	0.3048	meters
square feet	0.0929	square meters
cubic feet	0.0283	cubic meters
yards	0.9144	meters
square yards	0.836	square meters
cubic yards	0.7646	cubic meters
miles	1.6093	kilometers
square miles	259.0	hectares
knots	1.8532	kilometers per hour
acres	0.4047	hectares
foot-pounds	1.3558	newton meters
millibars	1.0197×10^{-3}	kilograms per square centimeter
ounces	28.35	grams
pounds	453.6	grams
	0.4536	kilograms
ton, long	1.0160	metric tons
ton, short	0.9072	metric tons
degrees (angle)	0.1745	radians
Fahrenheit degrees	5/9	Celsius degrees or Kelvins[1]

[1]To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use formula: $C = (5/9)(F - 32)$.

To obtain Kelvin (K) readings, use formula: $K = (5/9)(F - 32) + 273.15$.

LITTORAL ENVIRONMENT OBSERVATIONS AND BEACH CHANGES ALONG THE SOUTHEAST FLORIDA COAST

by
Allan E. DeWall

I. INTRODUCTION

This report presents an analysis of data on beach changes and littoral processes at three locations along the southeastern Florida coast, collected by the Florida Ocean Sciences Institute, Inc. (FOSI), Deerfield Beach, Florida, from January 1969 to June 1973. The objectives of the study were to accumulate systematic information regarding winds, waves, and currents in the nearshore environment and to relate these factors to observed changes in beach profiles along Florida's southeastern coast. A total of 4,898 beach profile surveys and 1,560 littoral environment observations (LEO) was collected at the beaches of Jupiter, Boca Raton, and Hollywood, Florida (Fig. 1).

The study was carried out as part of the U.S. Army Coastal Engineering Research Center (CERC) Beach Evaluation Program (BEP), which has the objective of observing the response of beaches to waves and tides of specific intensity and duration as a first step in developing a system for warning low-lying coastal communities when dangerous beach erosion conditions exist (Galvin, 1969). The littoral environment parameters analyzed include wind, wave, and longshore current observations. The beach profile variables analyzed include: (a) sand level changes on surveyed beach profiles; (b) the horizontal translation of the mean sea level (MSL) shoreline; (c) volumetric changes above the MSL shoreline; and (d) volumetric changes below MSL, to a distance offshore of 500 feet (150 meters), at Boca Raton. Correlations are drawn between the environmental parameters and the observed beach changes.

1. Previous Work.

Much of the literature on the geomorphology and sediments of southeastern Florida has been reviewed by Duane and Meisburger (1969), Meisburger and Duane (1971), and Field and Duane (1974). Meisburger and Duane (1969) noted a distinct change in the nearshore shelf morphology and in the surface sediments in the vicinity of Boca Raton. They concluded that little, if any, sediment is transported into this area from the north and that little interchange of material occurs between the beach and shelf.

Watts (1953) studied the effectiveness of the sand bypassing plant at South Lake Worth Inlet and derived a relation between the net longshore transport rate and the height and direction of observed shallow-water waves. (South Lake Worth Inlet is approximately midway between Jupiter and Boca Raton. See Fig. 1.) Based on the volume of material impounded by the north jetty at the inlet over a 14-year period, Watts estimated a net southerly longshore transport rate of 200,000 cubic yards (153,000 cubic meters) per year (to a 27-foot (8.2 meters) depth).

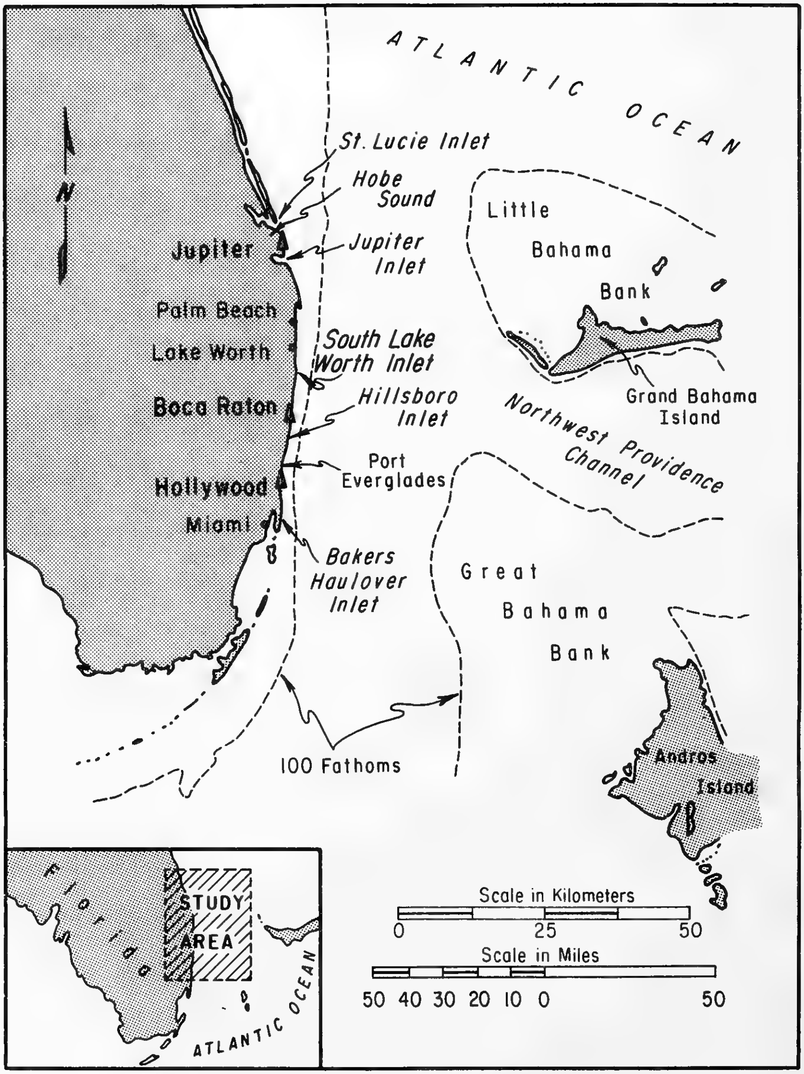


Figure 1. Map of study area.

In a study of St. Lucie Inlet, which forms the north boundary of Jupiter Island, Walton (1974) estimated that the annual net southerly longshore transport rate passing the north jetty was 100,000 cubic yards (76,500 cubic meters). However, the total volume crossing the inlet and continuing downcoast was estimated at only 30,000 cubic yards (22,950 cubic meters) per year, with the remainder either permanently trapped by the inlet or transported offshore.

A cooperative study by the University of Florida (1969) focused on a series of tests using a drag scraper for beach nourishment from offshore borrow sources at Jupiter Island.

The area has been the subject of a number of investigations including those by Purpura (1962), Bruun and Monohar (1963), and Bruun, Battjes, and Purpura (1966). Most of these studies dealt primarily with coastal engineering problems such as shape and placement of groins, seawalls, and inlet jetties, rather than general long-term changes in the coastal configuration.

A preliminary analysis of the data collected during this study has been presented by Richter (1971, 1972, 1974).

2. Study Area.

Under Shepard's (1963) coastal classification, the southeastern Florida coastline, with its lagoons and offshore islands, is a barrier coast. Tanner (1960) described it as a "perched" barrier coast; i.e., the sand is merely a thin veneer spread over Pleistocene coquina, sandstone, and limestone bedrock. Exposures of this bedrock, usually assigned to the Anastasia Formation, are visible at a number of places along the coast (Cooke, 1945; Puri and Vernon, 1964). Outcrops, such as those at Boca Raton, exhibit typical wave-cut cliff and platform features. Tanner further classified the area as an eroding, nonequilibrium coast but felt that the coquina at or near sea level effectively retarded the erosional process. Offshore profiles for Jupiter, Boca Raton, and Hollywood, from the beach to the shelf edge, were plotted from National Oceanic and Atmospheric Administration, National Ocean Survey (formerly U.S. Coast and Geodetic Survey), unpublished boat sheets (Fig. 2). Typical beach profile shapes are shown in Figure 3.

a. Jupiter. The Jupiter site is located in the northeast corner of Palm Beach County, approximately 80 miles (128 kilometers) north of Miami (Figs. 1 and 4). Of the three sites, it is least affected by the wave shadow of the Bahamas and the most exposed to the north Atlantic--through a 70° sector from approximately N. 05° W., where the nearest coastline is Cape Canaveral, to N. 65° E., where the Little Bahama Banks afford protection from waves approaching from the east. The effective fetch from the east, through a 45° sector, is limited to about 50 miles (80 kilometers). Exposure to the southeast through a 50° sector, is open to an approximate 100-mile (160 kilometers) fetch. Jupiter has a relatively straight coastline bearing about N. 17° W.

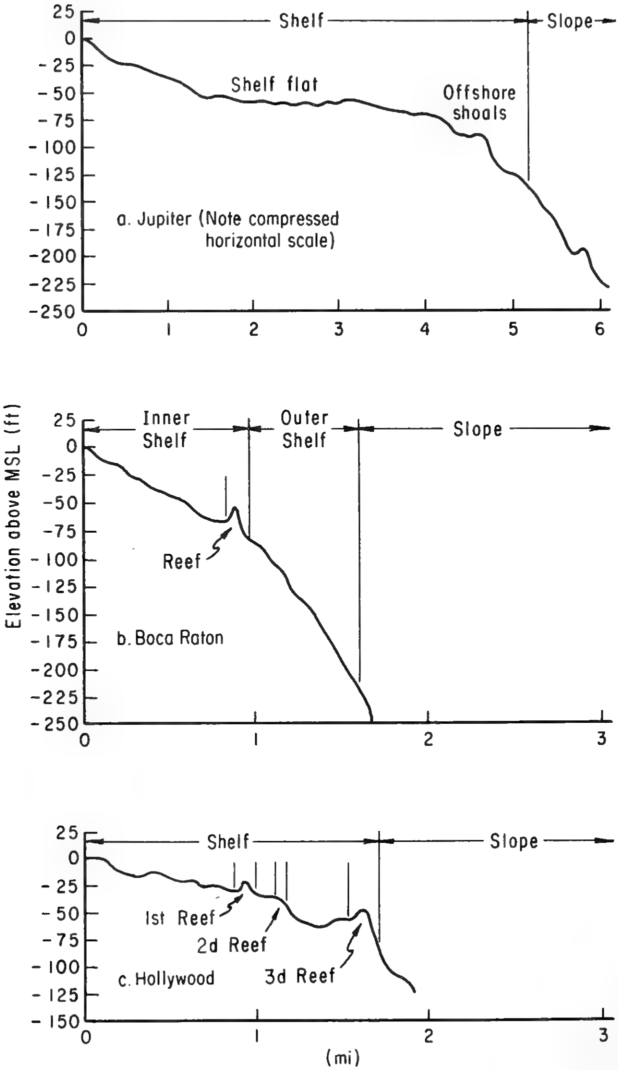


Figure 2. Offshore profiles at the three study sites.

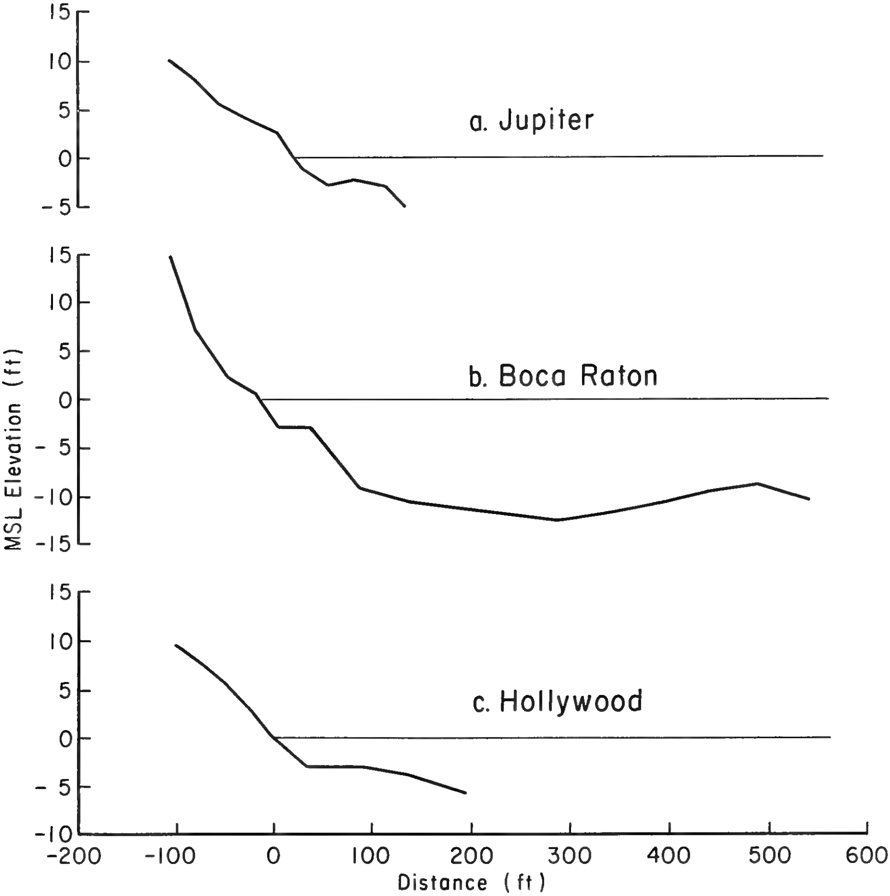


Figure 3. Typical beach profile shapes.

Figure 4. View north at Jupiter site, 6 May 1970; 2 hours before high tide (H = 5 ft, T = 7.0 s, α_b = 15°).

The site is 13.7 miles (21.9 kilometers) south of St. Lucie Inlet, and 1.3 miles (2.1 kilometers) north of Jupiter Inlet. A small protuberance of the coastline occurs about 800 feet (245 meters) north of the site. It is about 800 feet in length and extends about 200 feet (60 meters) seaward from the general trend of the shore. This protuberance appears unchanged in both position and magnitude on the U.S. Geological Survey 1967 photo revision of the 1948 7.5-minute series topographic map of the Jupiter quadrangle. The feature is probably the result of the resistant coquina limestone which crops out just below MSL. More pronounced exposures of coquina (Anastasia Formation) occur above MSL, about 1 mile (1.6 kilometers) north (Puri and Vernon, 1964). The large amount of shell fragments on the beaches in this area has been attributed to the gradual erosion of local coquina outcrop (U.S. Army Engineer District, Jacksonville, 1965; Meisburger and Duane, 1971; Field and Duane, 1974).

The beach at the Jupiter site is steep and narrow, with a typical width from the MSL shoreline to the toe of the frontal dune of 100 feet (30 meters) and a 1 on 10 slope (Fig. 3). A steep dune face with a maximum elevation of about 20 feet (6 meters) backs the beach. An abandoned asphalt roadbed occupies the crest of the dune and is being undermined by slumping of the eroding dune face. There has been minimal real estate development in the immediate vicinity; the nearest community, Jupiter Inlet Colony, occupies the southern one-half mile of Jupiter Island. Numerous seawalls, sloping revetments, and groins have been constructed by local interests in the town of Jupiter Island to the north. The town began an artificial beach nourishment program in 1956; about 700,000 cubic yards (640,000 cubic meters) of material from Hobe Sound and the Intracoastal Waterway was pumped onto the beach between 1957 and 1963 (U.S. Army Engineer District, Jacksonville, 1968). In September 1963, borrow material from a zone 600 to 800 feet (180 to 245 meters) offshore was placed on the beach with drag-scraper equipment (Gee, 1965). Although exact fill volume data are not available, a total of 500,000 cubic yards (382,500 cubic meters) was to have been placed over a 3-year period (U.S. Army Engineer District, Jacksonville, 1968). Between June and October 1973 a total of 2.5 million cubic yards (2.3 million cubic meters) of sand was pumped from offshore and placed along 16,800 feet (5,121 meters) of beach (Strock and Noble, 1975).

About 36,000 cubic yards (27,540 cubic meters) of material has been dredged annually from the St. Lucie Inlet since 1964 (Walton, 1974). Most of this material has either been dumped offshore or along the dredged channel, not placed directly on the adjacent beaches. How much of the spoil material remains in the littoral zone and is subsequently transported alongshore is unknown.

b. Boca Raton. The Boca Raton site is located in the southeast corner of Palm Beach County, approximately 40 miles (64 kilometers) north of Miami (Fig. 1). The shoreline trends N. 05° E. and has an intermediate exposure to open ocean waves, through a 30° sector from N. 10° E. to N. 40° E. A narrow "window" of exposure opens from N. 76° E. to N. 79° E. through the Northwest Providence Channel, separating Grand Bahama Island and Andros Island, about 60 miles (95 kilometers) from the mainland. Open exposure to the southeast is limited to a 24° sector from S. 19° E. to S. 04° W.

The site is 2.5 miles (4.0 kilometers) north of Boca Raton Inlet and 12 miles (19.2 kilometers) south of South Lake Worth Inlet. Coquina limestone crops out at about mean low water (MLW) and is generally expressed as a relatively smooth planar ledge dipping seaward (east) at 4° to 8° (Fig. 5). At times, this ledge is completely covered with sand. More often, it is exposed with the seaward edge forming a dropoff of from 4 to 5 feet (1.2 to 1.5 meters) about 50 feet (15 meters) from the MSL shoreline. The coquina ledge has dense seasonal growths of encrusting algae, sponges, and worm reef (*Sabellariidae*) (Kirtley, 1966). The coquina becomes the dominant shoreline feature about 2 miles (3.2 kilometers) south of the site, forming two minor promontories with maximum elevations of approximately 20 feet above MSL and an alongshore dimension of about 400 yards (360 meters) (Fig. 6).

The beach at the Boca Raton site is also steep and narrow with a typical width of about 100 feet and a 1 on 9 slope. Seaward of the coquina ledge the slope is about 1 on 100. The frontal dune is heavily vegetated and has a maximum elevation of about 25 feet (8 meters).

The beach-front property at Boca Raton has been subject to intensive development during the study period, with the construction of high-rise condominiums essentially on the dune line (Eyre, 1971). A section of a

Figure 5. View north at Boca Raton site, 4 May 1970; low tide (H = 1.0 ft; T = 4.6 s; α_b = -20°). Note coquina exposure in swash zone.

Figure 6. Coquina exposure about 2 miles south of the Boca Raton site, 15 May 1974; low tide (H = 2.9 ft; T = 5.2 s; α_b = 0°).

dune was leveled immediately to the north of the study site for construction of a new condominium in May 1969 (Fig. 7). A trench approximately 15 feet (4.6 meters) deep and 300 feet (90 meters) long was excavated for the construction of a protective seawall, with the spoil placed on the beach in front of the excavation.

Figure 7. Dune leveling at Boca Raton site, 7 May 1969; midtide, falling ($H = 3.4$ ft, $T = 3.6$ s, $\alpha_b = 2°$).

There are no groins in the immediate vicinity of the site although there are numerous groins, seawalls, and bulkheads farther north. Both South Lake Worth Inlet and Boca Raton Inlet are stabilized by parallel jetties. Sand was dredged and bypassed at South Lake Worth Inlet at an average of 77,500 cubic yards (59,300 cubic meters) per year between 1969 and 1973 (Ward, 1972). Boca Raton Inlet, an improved natural inlet, was dredged to an 8- to 12-foot (2.4 to 3.7 meters) channel depth in April 1969 by a private developer and has been continuously maintained since that time.

U.S. Army, Corps of Engineers (1971) determined that between 1929 and 1955 there was a net loss of about 1 million cubic yards (765,000 cubic meters) above the 18-foot (5.5 meters) depth contour along the 16 miles (26 kilometers) of shoreline south of South Lake Worth Inlet or approximately 0.5 cubic yard per foot (1.25 cubic meters per meter) of shoreline per year.

c. Hollywood. The Hollywood site is located in southeast Broward County, approximately 15 miles (24 kilometers) north of Miami (Fig. 1). It is the least exposed of the three sites. With the Great Bahama Bank lying 50 miles to the east, Hollywood is protected through a 125° sector from N. 33° E. to S. 22° E. Open exposure to the northeast is limited to the 24° sector from N. 09° E. to N. 33° E., and to the southeast from the 18° sector at S. 04° E. to S. 22° E. The shoreline trends N. 05° E.

The site is 9.7 miles (15.5 kilometers) north of Bakers Haulover Inlet and 3.5 miles (5.6 kilometers) south of Port Everglades. Port Everglades is a commercial harbor with an entrance channel 40 feet (12 meters) deep and 500 feet wide from its seaward end, 5,600 feet (1,700 meters) offshore, to the entrance jetties where it narrows to a width of 300 feet and depth of 37 feet (11 meters). The entrance is stabilized by two rubble-mound stone jetties and two converging submerged breakwaters (U.S. Army Engineer District, Jacksonville, 1971).

Coquina limestone, which is well exposed at the other two sites, is not exposed on the beach at the Hollywood site. However, it is found 4 to 6 feet (1.2 to 1.8 meters) below the sand surface. Patch reefs occur on a rock ledge about 250 feet (75 meters) seaward of the MSL shoreline at about -10 feet (-3 meters) MSL. Raymond (1972) described a large outcrop of coquina at Port Everglades where a 15-foot vertical section had been exposed by the cut for the entrance channel.

Beach width is about 100 feet with a 1 on 10 slope. The maximum elevation at this site is about 10 feet with essentially no existing frontal dune. A coastal highway (Florida A1A) is commonly flooded with water and sand during storms (U.S. Army Engineer District, Jacksonville, 1965).

A 900-foot-long (275 meters) fishing pier is located 1.1 miles (1.8 kilometers) north of the site. Approximately 2,100 feet (640 meters) north of the site several houses built out onto the beach are protected by seawalls and groins. About 1.5 miles (2.4 kilometers) south, a field of evenly spaced timber groins has been installed in an attempt to stabilize the beach in front of the city of Hollywood. Mechanized beach sweepers are frequently driven across the site, but do not appear to significantly change the topography (Fig. 8).

Surveys by U.S. Army Engineer District, Jacksonville (1971) have shown that in the 2-mile reach immediately south of Port Everglades Harbor during the period 1928 to 1961, the shoreline receded about 5 feet per year --the result of the complete littoral barrier provided by the entrance channel. About 46,000 cubic yards (35,000 cubic meters) of material is dredged annually from the turning basin and entrance channel at the port. Some of this material is placed on the beach, south of the inlet (U.S. Congress, 1965; U.S. Army Engineer District, Jacksonville, 1971).

3. Climate.

The climate of the study area is subtropical with a mean annual temperature of 75° Fahrenheit (23.9° Celsius). The average annual precipitation is 60 inches (152 centimeters). Winds are predominantly from the

Figure 8. View north at Hollywood site, 5 May 1970; midtide, rising (H = 0.5 ft; α_b = 15°). Note beach sweeper tracks.

southeast, but higher speeds are associated with winds from the northeast. Wind data from West Palm Beach are shown in Figure 9 (U.S. Congress, 1948b).

The area within a 50-mile radius of Fort Lauderdale experiences a hurricane on the average of once in 6 years, with the probability of a hurricane or tropical disturbance occurring once in a little over 3 years (U.S. Army Engineer District, Jacksonville, 1971). The area within a 50-mile radius of Jupiter experiences a hurricane on the average of once every 9 years, and once every 2.6 years within a 150-mile (240 kilometers) radius (U.S. Army Engineer District, Jacksonville, 1968). Ho, Schwerdt, and Goodyear (1975) reported that from 1871 to 1973, an average of two hurricane or tropical storm tracks crossed each 10 nautical miles (18.5 kilometers) of coastline in the region between Jupiter and Hollywood; about 60 percent of these storms were hurricanes (Fig. 10). In addition, an average of 1.44 offshore storm tracks per year was reported passing within 100 miles of the coastline in the vicinity of West Palm Beach during the same time period.

4. Oceanographic Data.

Tides are semidiurnal, with mean and spring ranges of 2.5 and 3.3 feet (0.76 and 1.01 meters), respectively (National Oceanic and Atmospheric Administration, 1973). The axis of the north-flowing Florida Current passes quite close to the shoreline in the study area, with an

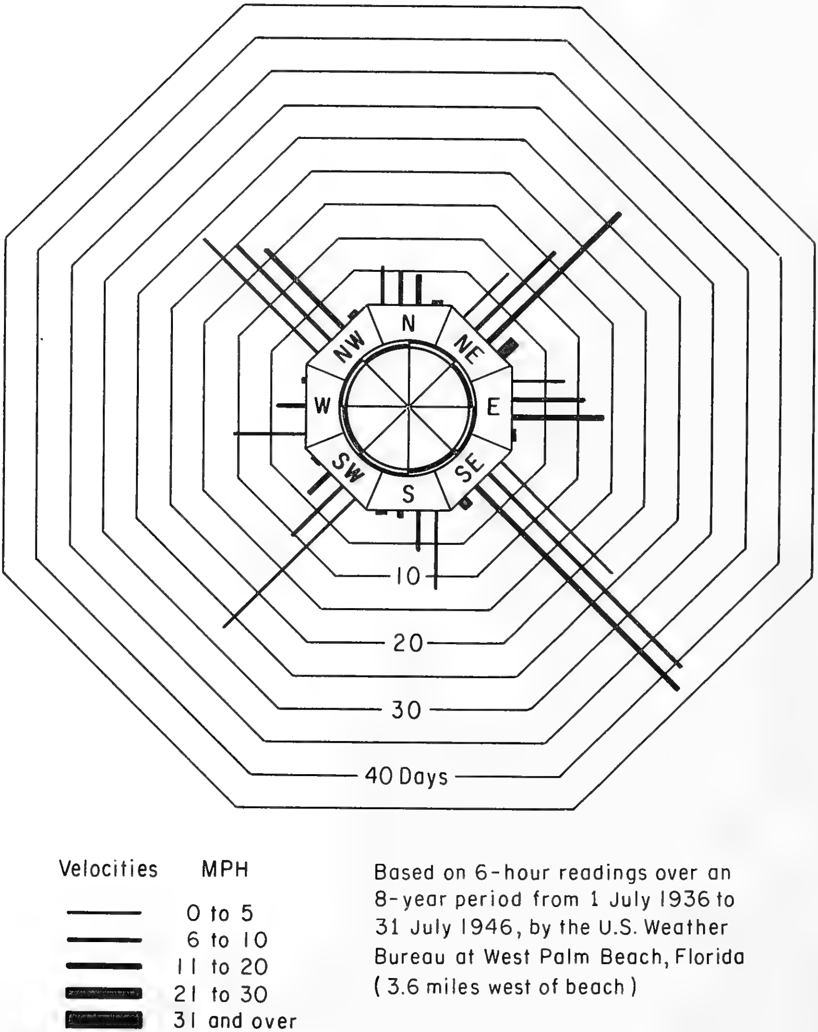


Figure 9. Average direction, duration, and velocity of winds for 1 year at West Palm Beach (from U.S. Congress, 1948).

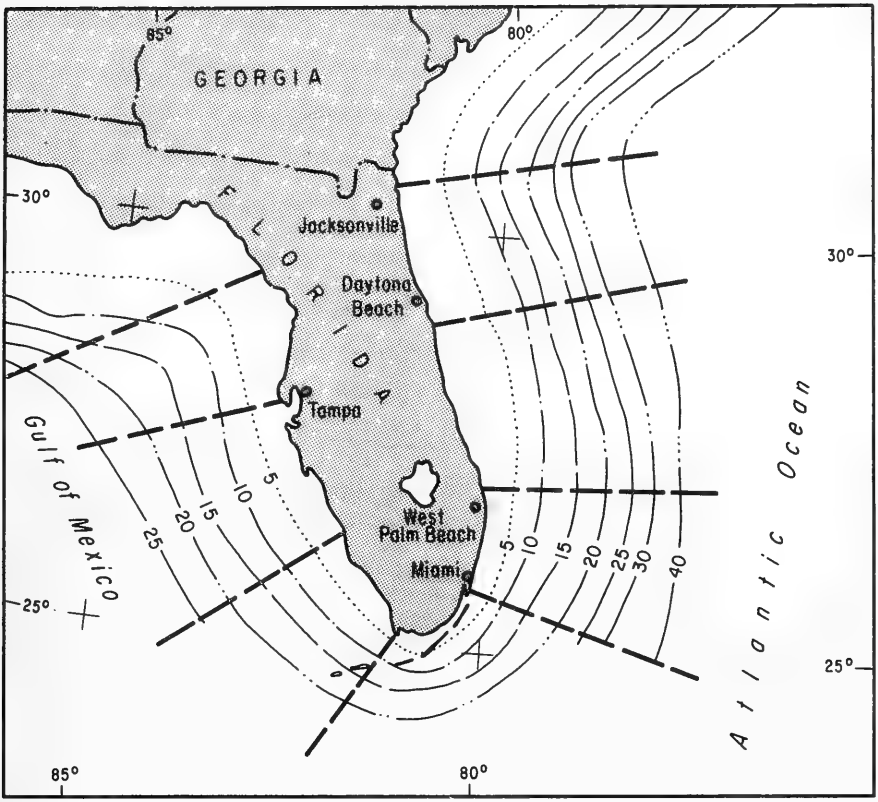


Figure 10. Accumulative count of hurricane and tropical storm tracks passing the coast (1871 to 1973). Based on counts along heavy dashlines shown projected normal to coast (from Ho, Schwedt, and Goodyear, 1975).

average speed of 3 knots. Lee (1969) documented the western edge of the Florida Current approximately 6,000 feet (2,000 meters) offshore at Boca Raton, along the edge of the Continental Shelf, with north-flowing surface currents between 0.6 and 1.5 knots. He measured comparable south-flowing currents in the same area which were attributed to large eddies produced by the Florida Current. Raymond (1972) suggested that the western edge of the current can move as far landward as the 60-foot (18.3 meters) depth contour.

In an analysis of long-period sea level data, Hicks (1972) determined a trend in relative sea level rise of approximately 0.007 foot (0.2 centimeter) per year at Miami Beach. Assuming an average beach slope of 1 on 10, this means that the shoreline position will retreat more than 1 foot (0.3 meter) in 16 years, due to this factor alone.

Visual observations of wind waves collected by shipboard observers for the U.S. Naval Weather Service Command were summarized by Walton (1973), and are shown in Figures 11 and 12. These data show that the largest percentage of waves are from the east and are less than 4 feet in height.

5. Beach Material.

The beach material at all three sites is medium to coarse, shelly sand. Rusnak, Stockman, and Hoffman (1966) reported a variable but systematic increase in shell content from Jacksonville south to Miami, with a high of 89 percent near Boca Raton Inlet. They attributed 40 to 50 percent of the shell material to erosion of the Anastasia Formation and the remainder to newly formed shells. In a study of beaches in the vicinity of Cape Canaveral, Field and Duane (1974) found that grain size increased with increasing shell content and attributed high shell content to local injection by erosion of coquinoid limestone.

Duane and Meisburger (1969) observed a transition zone in shelf topography and sediments in the vicinity of Boca Raton. To the north, the gently dipping shelf was found to be composed of an homogeneous fine- to medium-grained, gray, quartzose sand. To the south, the shelf was described as a series of two or three steplike linear flats separated by low reeflike ridges, with sediments composed of white to gray, calcareous skeletal sand and gravel. The inner flat is relatively fine sand and rock separating the shelf and nearshore zones of coarser and compositionally dissimilar materials. Duane and Meisburger (1969) concluded that, south of Boca Raton, sand movement between the beach and shelf either in a landward or seaward direction was improbable. Similarly, based on a study of the shelf sediments, they concluded that little if any sediment is transported into the shelf area from the north of Boca Raton to the south. They attributed *in situ* production of sediment by reef organisms as the primary source of shelf sediments south of Boca Raton.

Raymond (1972) described the shallow offshore terraces, reefs, and sand deposits of Broward County, including the Hollywood site, and

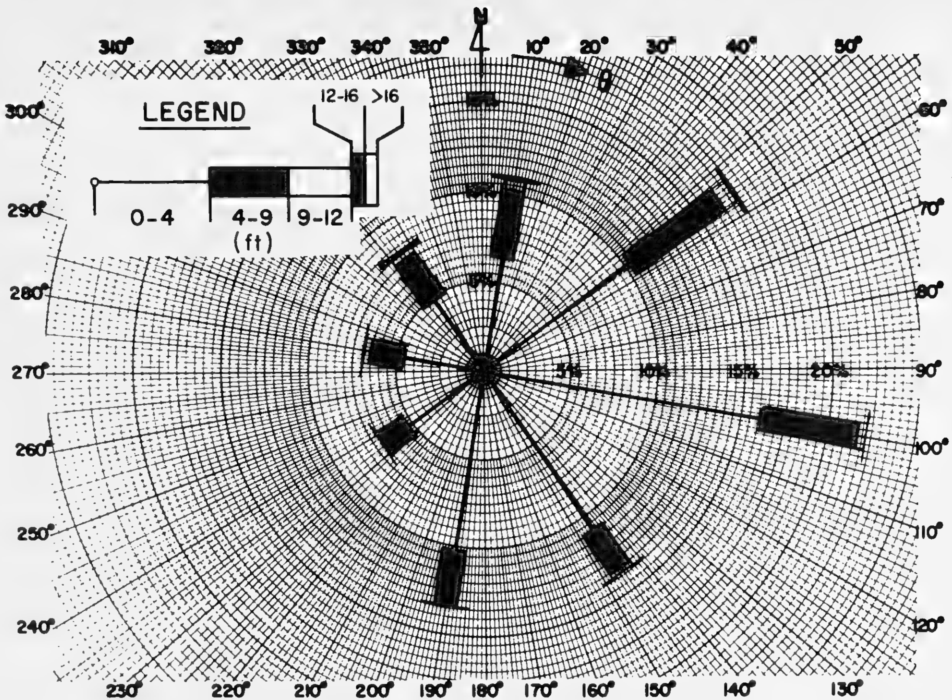


Figure 11. Wave height rose for offshore wave climate. Summary of Synoptic Meteorological Observations (SSMO) Data Square No. 12, annual (from Walton, 1973).

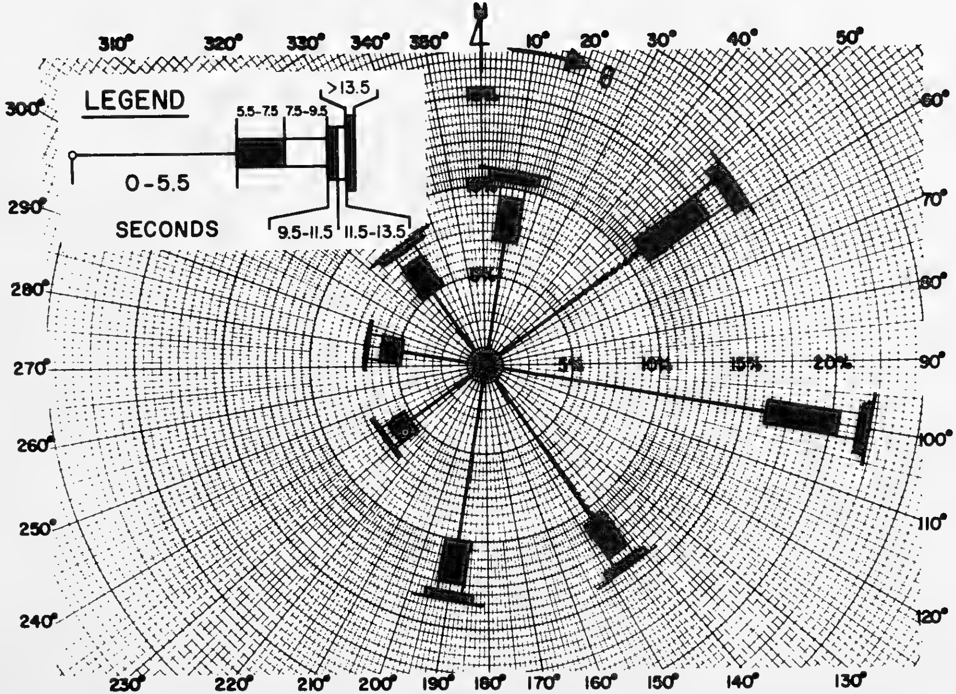


Figure 12. Wave period rose for offshore wave climate, SSMO Data Square No. 12, annual (from Walton, 1973).

concluded that beach sand transported offshore becomes trapped in deep interreef troughs and cannot be returned to the beaches naturally. Raymond noted anomalously high percentages of fine quartz sand in the vicinity of Port Everglades and Hillsboro Inlets.

Sand samples, collected by the U.S. Army Engineer District, Jacksonville (1968) in the vicinity of the Jupiter site and analyzed using sieving techniques, had median diameters ranging from 0.42 millimeter (1.25 phi) on the dune to 2.20 millimeters (-1.14 phi) at -6 feet MLW, and rapidly decreasing farther offshore. Samples taken from offshore by the University of Florida (1969) indicated that the borrow material was very poorly sorted and had a larger median grain diameter than the natural material on the beach (0.56 versus 0.29 millimeter, 0.83 versus 1.74 phi).

A set of surface samples collected during this study at Boca Raton and analyzed on the CERC Rapid Sediment Analyzer (RSA) (Duane and Meisburger, 1969, p. 2) had median diameters ranging from 0.30 millimeter (1.71 phi) at the toe of the dune to 1.15 millimeters (-0.20 phi) on the berm, and 0.33 millimeter (1.60 phi) at -13 feet (-4.0 meters) MSL. Samples from the beach face were generally coarser, with median diameters of 0.8 to 1.0 millimeter (0.32 to 0.0 phi). Shell content, as determined by acid solubility, was 40 to 65 percent. Surface samples collected from Hollywood and analyzed on the RSA had median diameters ranging from 0.27 to 0.92 millimeter (1.89 to 0.12 phi). Dune samples had the least variability in median diameters (0.42 to 0.51 millimeter, 1.25 to 0.97 phi); foreshore samples had the greatest variability (0.27 to 0.92 millimeter). In general, samples from all three sites were well sorted to moderately well sorted (Folk, 1965). A tabulation of sand size for samples collected during this study is in Appendix A.

II. PROCEDURE

1. Littoral Parameters.

Littoral environment observations, based on a procedure by Berg (1968) and Balsillie and Bruno (1973), were made once a week at Jupiter and Hollywood and up to five times a week at Boca Raton. The surf observations included visual estimates of breaker height and period, the direction from which the breakers were coming, and the type of breaker (i.e., spilling, plunging, surging, or spill-plunge). Wind observations included the measurement of windspeed with a hand-held Florite anemometer (Fig. 13), and the determination of the direction from which the wind was

Figure 13. Hand-held anemometer.

blowing. The longshore current observations included the measurement of current speed between the breaker zone and the shoreline, using fluorescein or rhodamine-B dye; the distance from shore to the point of measurement; and the determination of the direction of the flowing current. Water temperature and rip current spacing were also recorded.

Breaker direction was determined by one of three different visual estimation techniques during the study--the compass sector, coastal sector, and protractor methods. Between January and September 1969 the direction of breaker approach was classified by one of five possible compass sectors, assuming a north-south shoreline orientation at each site (Fig. 14,a). Between September 1969 and August 1972 the coastal sector method was adopted in an attempt to differentiate the majority of breaker direction observations which had been previously classified as approaching from the east sector (Fig. 14,b). In September 1972, the protractor method was adopted which allowed the recording of breaker direction to the nearest degree (Fig. 14,c).

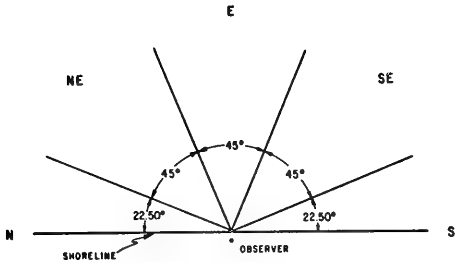
Breaker height was visually estimated to the nearest foot between January 1969 and August 1972. After August 1972, a change in format allowed breaker height to be recorded to the nearest 0.1 foot (0.03 meter).

Observations of beach surface features included the measurement of the berm-crest elevation above or below a fixed reference point, the distance between the berm crest and a known reference point, the slope of the foreshore, and the spacing of beach cusps, if present. The foreshore slope was measured by using either an Abney level (Fig. 15) or a marine sextant as an inclinometer.

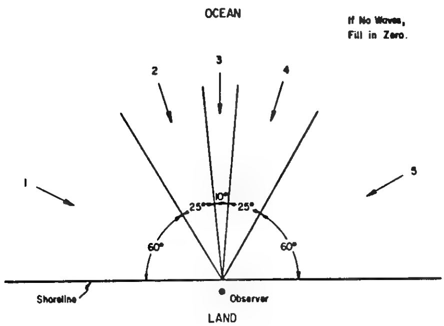
All of the data were recorded in a standard surveyor's field notebook and later transferred to a standardized data reporting form. The same principal observer collected all of the data at each of the three sites between January 1969 and July 1972. A new principal observer took over the data collection in August 1972 and continued through June 1973.

As part of another CERC study, a wave gage was maintained at the end of the Lake Worth Municipal Fishing Pier, 16.5 miles (26.5 kilometers) to the north of the Boca Raton site. The gage was operational during the following intervals of the present study: January to October 1969, March to May 1971, and January to February 1973. Storms, especially electrical storms, were the general cause of gage failure. A step-resistance gage was used through 1971, when it was replaced with a Baylor gage.

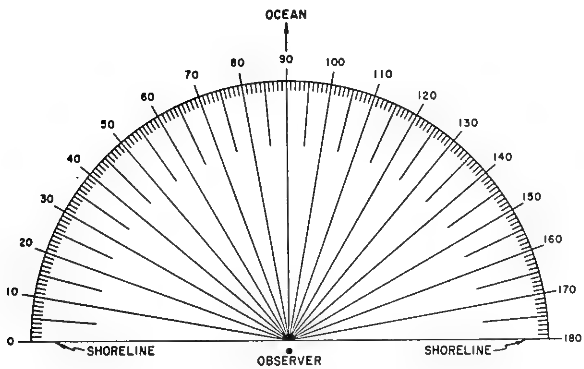
A cooperative surf observation program (COSOP) between CERC and the U.S. Coast Guard Light Station at Hillsboro Inlet, located approximately 8 miles (12.8 kilometers) south of the Boca Raton site, has been in existence since 1955. Data collected during the first 10 years (17,940 observations) were summarized in Galvin and Seelig (1969).



a. COMPASS SECTOR METHOD (Jan. 1969 to Sept. 1969)



b. COASTAL SECTOR METHOD (Sept. 1969 to Aug. 1972)



c. PROTRACTOR METHOD (Aug. 1972 to June 1973)

Figure 14. Breaker notation methods.

Figure 15. Abney level.

2. Beach Profile Surveys.

Rows of pipes were established perpendicular to the coastline at each site to determine elevation changes along the beach profile lines. The pipe method of measuring beach profile changes has been used in a number of studies (e.g., Inman and Rusnak, 1956; Harrison and Wagner, 1964; Williamson, 1972) and is discussed by Urban and Galvin (1969). Two-inch-diameter (5.1 centimeters) galvanized pipes were driven into the sand and beach rock with a pneumatic jackhammer (Fig. 16; Gonzalez, 1970). Many of the subaqueous (below MLW) pipes did not require the jackhammer technique, as sufficient sand cover existed for standard jetting installation.

Two rows of pipes were driven at both Jupiter and Hollywood, and four rows were driven at Boca Raton; each row was numbered from north to south. Spacing between rows was approximately 250 feet at Jupiter and Hollywood, and 250, 150, and 100 feet, from north to south at Boca Raton. The distance between adjacent pipes on the same profile line was approximately 28 feet (8.5 meters), with the exception of subaqueous pipes at Boca Raton and Hollywood, where the spacing was approximately 50 feet. The subaqueous pipes at Boca Raton were connected by a handline to facilitate the survey of that part of the profile by scuba-equipped divers (Fig. 17). Figure 18 is a plan view of the completed profile installation at Boca Raton.

Beach surface elevations relative to MSL were determined by measuring the distance between the sand surface and a permanent reference mark on each pipe. Elevations of the pipe reference marks were determined by standard transit and stadia rod or hand level surveying techniques using established bench marks in the vicinity (see Fig. 19).

With the exception of the subaqueous profile surveys at Boca Raton, all data were recorded directly in a standard field notebook. Subaqueous

Figure 16. Pneumatic jackhammer setup for driving profile pipes into sand and beach rock.

Figure 17. Diver making subaqueous sand level measurement at the Boca Raton site.

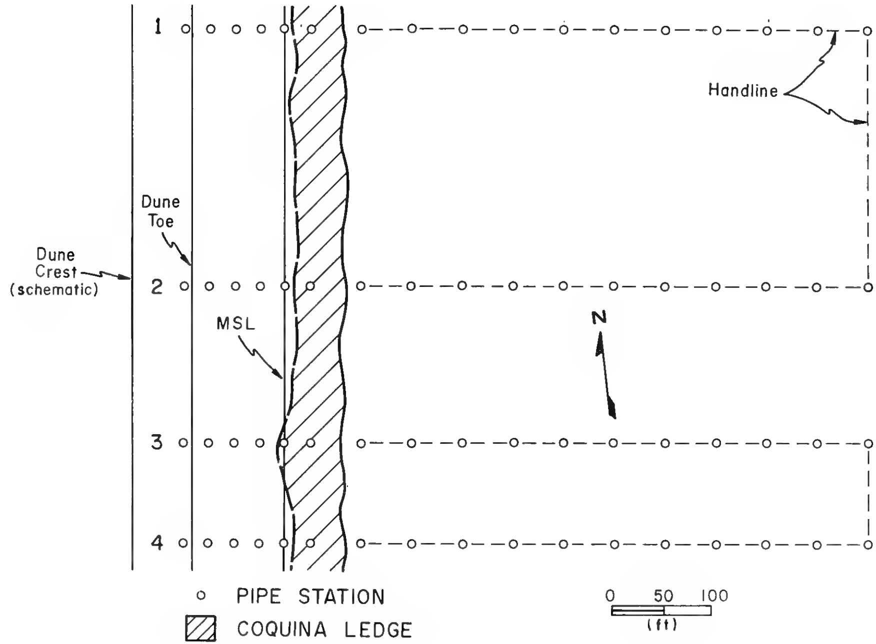


Figure 18. Plan view of Boca Raton pipe profile installation.

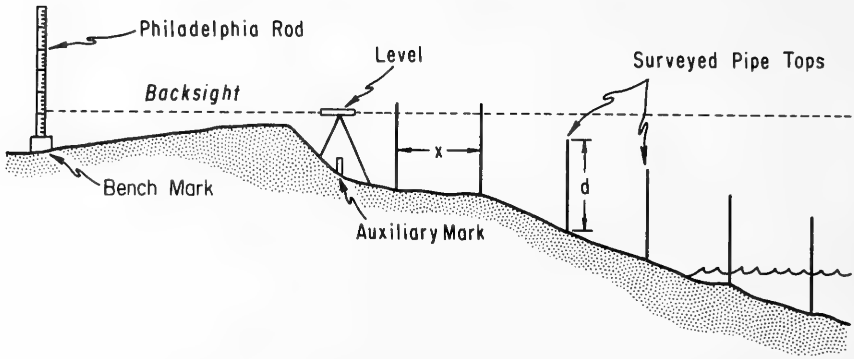


Figure 19. Pipe profile control survey.

profile data were recorded on a plastic writing board, and transferred to the notebook immediately following the dive. The pipe profile data were then transferred to a standardized data sheet for use in an IBM optical mark page reader.

3. Survey Precision.

Each profile line was referenced to an existing known bench mark in the area. Pipe stations were located to the nearest foot along the profile line, and the elevations of reference marks on the pipes were located to the nearest one-tenth of a foot. Reference marks were initially notches in the pipe. Later, the pipe tops were used for reference elevations. An instrument survey of all pipe stations was completed three times during the study. Individual pipe stations were resurveyed using hand level techniques whenever they were repaired or replaced.

The profile surveys consisted of sand level measurements from the pipe reference marks. These measurements were recorded to the nearest inch, but before January 1972 were rounded to the nearest 0.5 foot (15.2 centimeters) for computer processing. After January 1972 the sand level measurements were rounded to the nearest 2 inches. The rounding was felt necessary in order to keep the data reporting form, which was designed for use by untrained observers, as simple as possible. The pipe profile method is discussed in Section IV.

Profile documentation data, including bench-mark locations, profile azimuths, and pipe-stationing and reference elevations are presented in Appendix B.

4. Data Reduction.

Before being converted to standard punchcard format, the data sheets were visually checked for proper coding of date and location and for obvious errors. LEO data were tabulated by month and visually edited for unreasonable data (see App. C). Errors were checked against original field notes and either corrected or deleted.

Since breaker direction was recorded in three formats during this study, an arbitrary standardization procedure was used. Breaker direction data were standardized to the protractor notation as follows: compass sector notations of northeast, east, and southeast were assigned to coastal sectors 1, 3, and 5, respectively (Fig. 14). Occasional observations of east-northeast and east-southeast were coded as sectors 2 and 3. There were no observations from sectors north or south. Coastal sector notations were then converted to angles as follows: data falling in sectors 2, 3, or 4 were treated as having angles equal to the respective bisector angle; i.e., 73°, 90°, and 107°. Data in sectors 1 and 5 were assigned values of 45° and 135°, respectively. Protractor direction notations (Fig. 14,c) were used for all computations using breaker angles. For display purposes, breaker directions were regrouped into coastal sectors.

The raw pipe profile data, which consist of distances from pipe tops or reference marks to the sand level, were combined with the surveyed distance-elevation pair for each pipe to obtain ground elevations. The reduced data were then run through two separate editing programs. Obvious errors were checked against field notes and with the observer. These errors generally appeared as spikes in an otherwise smooth profile shape, and were errors of 1 foot or more in elevation. They were commonly the result of transcribing errors, but also occurred as the result of damaged pipes. (In the case of the subaqueous profiles, the observer occasionally misidentified or unknowingly skipped a pipe station along a profile. However, this was a rare occurrence that was usually immediately apparent and corrected in the field at the completion of a survey.) The corrected data were then rerun through the editing routines for further checks. It was usually necessary to repeat the editing process several times.

The largest amount of time in processing the data was spent in such quality control. After the data had been screened for obvious errors, they were transferred to magnetic tape for further analysis. The profile data were analyzed for changes in the MSL shoreline position and changes in the cross-sectional area between successive profile surveys.

The MSL intercept was interpolated for each profile survey. If more than one intercept occurred, the landwardmost position was used. If the profile survey did not reach the MSL elevation, but did reach the +2-foot (+0.61 meter) elevation, the profile was extrapolated to get the MSL intercept. Any profile survey not reaching a minimum elevation of +2 feet was discarded.

A total of 117 profile surveys (or 2.4 percent of the total) did not cross the +2-foot intercept. Most of these were collected during 10 separate two-tidal cycle series of 3-hour surveys, which are discussed separately.

5. MSL Position and Unit Volume.

The distance-elevation coordinates of the MSL contour intercept with the initial survey on each profile line were defined as the origin (0, 0) of a new coordinate system, to which all subsequent surveys were referenced (Fig. 20). Negative distances indicate stations landward of the MSL intercept with the initial profile; positive distances indicate seaward stations.

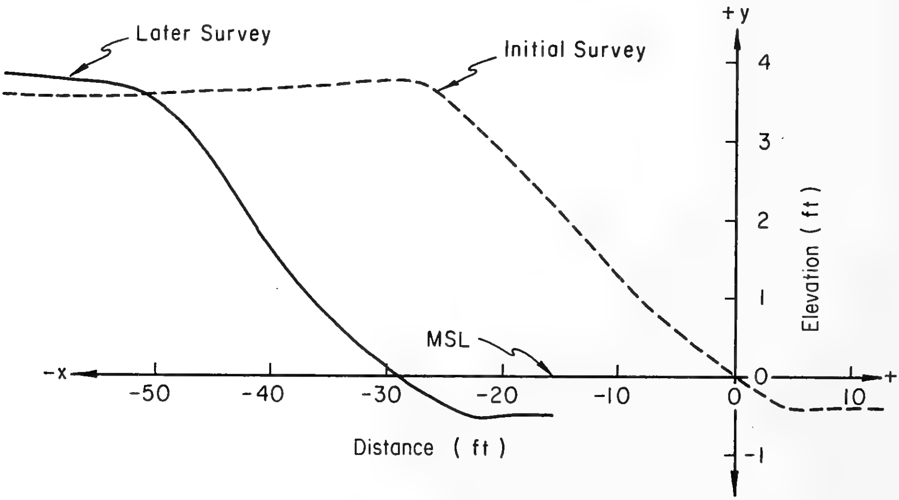


Figure 20. Profile coordinate system.

Unit volume was obtained from the area under the profile. Beach and nearshore cross-sectional areas were computed (in square feet) under each surveyed profile. These areas are bounded by four lines: the vertical line projected from the landwardmost station, the MSL elevation, the -12-foot elevation, and by the surveyed profile (Fig. 21). The total area is defined as that area bounded by the vertical line through the landwardmost station, the -12-foot elevation, and the surveyed profile. The beach area is that part of the total area above the MSL elevation. The nearshore area is the difference between the total area and the beach area. The beach area was computed by summing 1-foot horizontal slices (Fig. 21,a) and the total area was computed by summing vertical slices (Fig. 21,b). Area change between successive surveys was then computed by subtracting the area under the second survey from the area under the first (Fig. 22). These cross-sectional areas were then converted to the volumetric notation, termed "unit volume," of cubic yards per linear foot of beach.

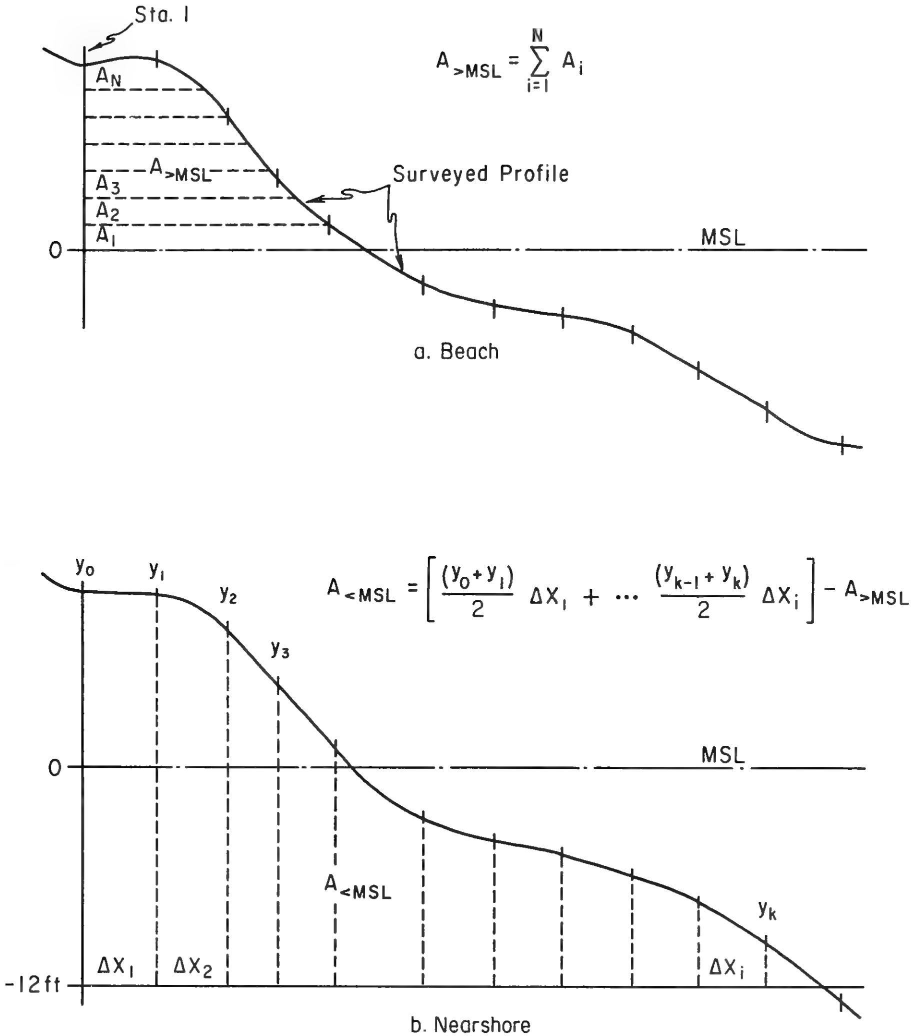


Figure 21. Beach and nearshore profile areas.

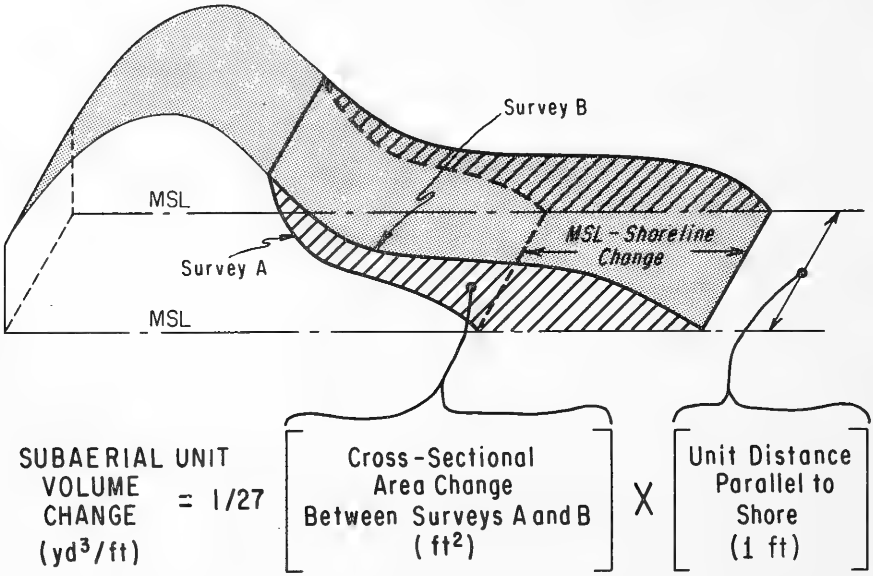


Figure 22. Definition of MSL shoreline change and subaerial unit volume change.

III. RESULTS: LITTORAL ENVIRONMENT OBSERVATIONS

1. Statistical Significance.

Littoral environment observations and sand height were measured once a week at Jupiter (Thursday) and Hollywood (Tuesday), and five times a week (Monday to Friday) at Boca Raton. In analyzing these data, several points must be considered relative to the frequency of data collection at each site and the statistical significance of the length of the study. First, there is the problem of comparing or relating data which have been taken once a week (Hollywood and Jupiter) to data taken five times a week (Boca Raton). Certain apparent differences in the three sites may be attributable to insufficient data from either Hollywood or Jupiter. To test the statistical significance of once-a-week versus five-times-a-week sampling, a comparison was made between the set of daily breaker height and period data collected at Boca Raton and a once-a-week sample from that same data set. To simulate the sampling plan at Jupiter and Hollywood, a subsample which included every Wednesday observation was selected from the Boca Raton data. If no Wednesday observation was made, the closest observation day was selected. This test resulted in a subsample of 229 observations out of a total sample of 1,077 observations. The average annual breaker height from both the total sample and the subsample was 2.0 feet, with a standard deviation of 1.4. Average breaker period from both the total sample and the subsample was 4.8 seconds (σ = 1.4 and 1.3). These values indicate that there is no significant difference between the two data sets, and suggest that comparisons of data collected from the three sites are valid.

A second consideration is the fact that the study was made during an interval of 4.5 years in an area where a hurricane is expected only once in 6 years and a tropical disturbance only once in 3 years. Although such storms have not been considered as destructive to the southeast Florida beaches as winter northeasters (U.S. Army Engineer District, Jacksonville, 1968), their effect on beaches has not been quantified, and is probably significant. No hurricanes passed within 300 miles (483 kilometers) of the three sites during the study. Three tropical disturbances passed within a 50-mile radius.

2. Winds and Storms.

Monthly wind roses summarizing data from this study are plotted for each site in Figures 23, 24, and 25. Winds are predominantly onshore with speeds ranging from 8 to 15 miles per hour. Winds from the southeast occur the greatest percentage of time and prevail during March through August. Higher velocities are associated with northeasterlies which occur mainly during September through February. The strongest offshore winds occur during the winter months (November through March) and are predominantly from the northwest. There is little difference between the annual averages for the three sites, except that Jupiter has a greater occurrence of northerly flow.

In general, the LEO wind data confirm the West Palm Beach wind data summarized in Figure 9. The annual wind rose from Boca Raton (Fig. 23) indicates onshore winds 66 percent of the time (see App. D for monthly averages per year); the West Palm Beach data indicate onshore winds 57 percent of the time. Both sets of data confirm the predominant southeast wind direction. The Boca Raton data indicate approximately 9 percent of the onshore winds are less than 4 miles (1.6 kilometers) per hour; the West Palm Beach data indicate that approximately 22 percent of the onshore winds at that island site are 5 miles (8 kilometers) per hour or less.

Although no hurricanes occurred within the study period, at least one hurricane (Agnes) did affect the local weather system as it moved northward over the Gulf of Mexico. Southerly winds of 15 to 17 miles (24 to 27 kilometers) per hour were recorded at Boca Raton and Hollywood as Hurricane Agnes passed some 350 miles (560 kilometers) to the west on 20 June 1972.

Gale-force winds were observed only once--during the 22 to 25 December 1971 northeaster at Jupiter, when a windspeed of 40 miles per hour was recorded. A windspeed of 30 miles (48 kilometers) per hour was measured during the same storm at Boca Raton. At least four tropical storms or tropical depressions passed within 100 miles of the study area.

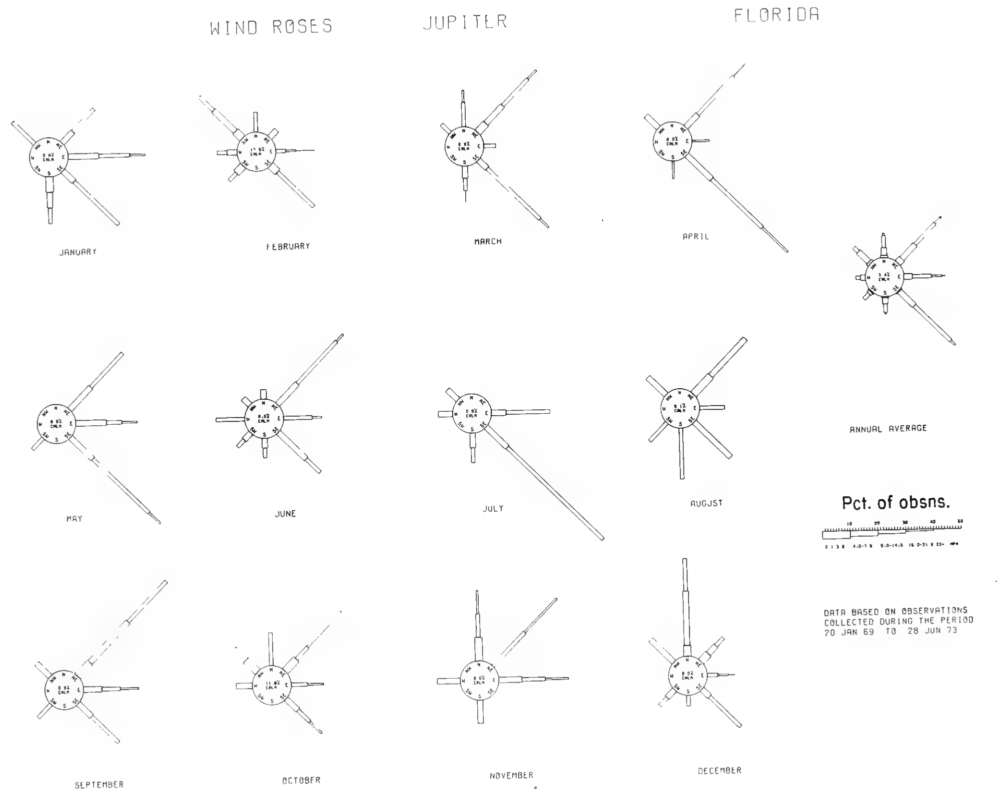


Figure 23. Mean wind roses from Jupiter.

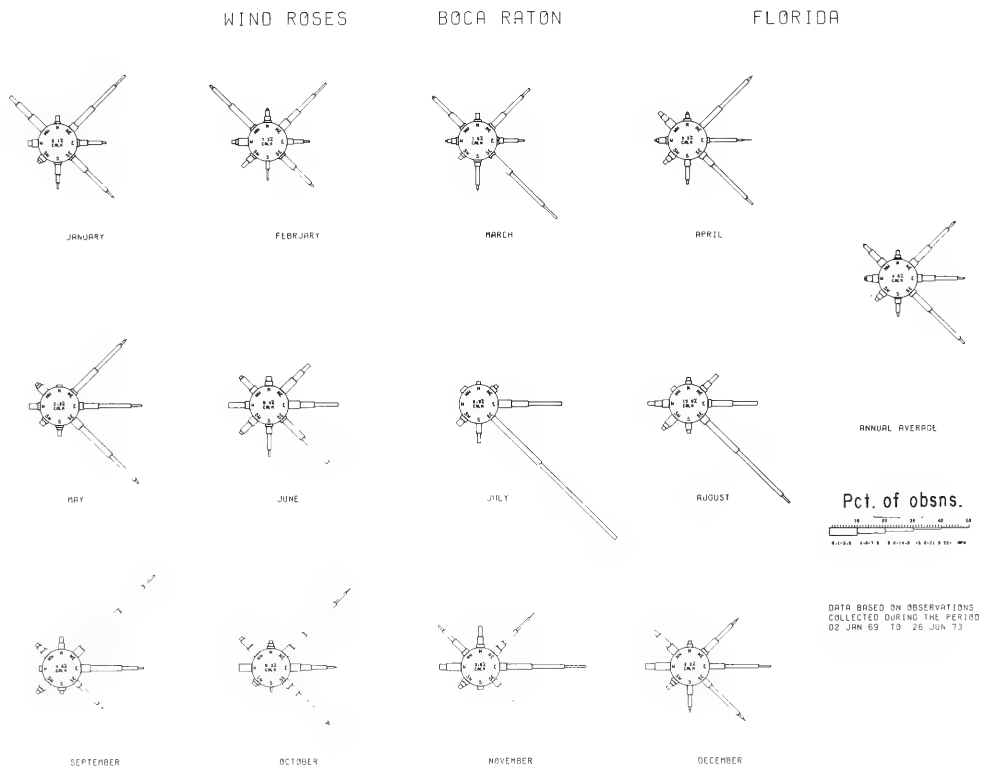


Figure 24. Mean wind roses from Boca Raton.

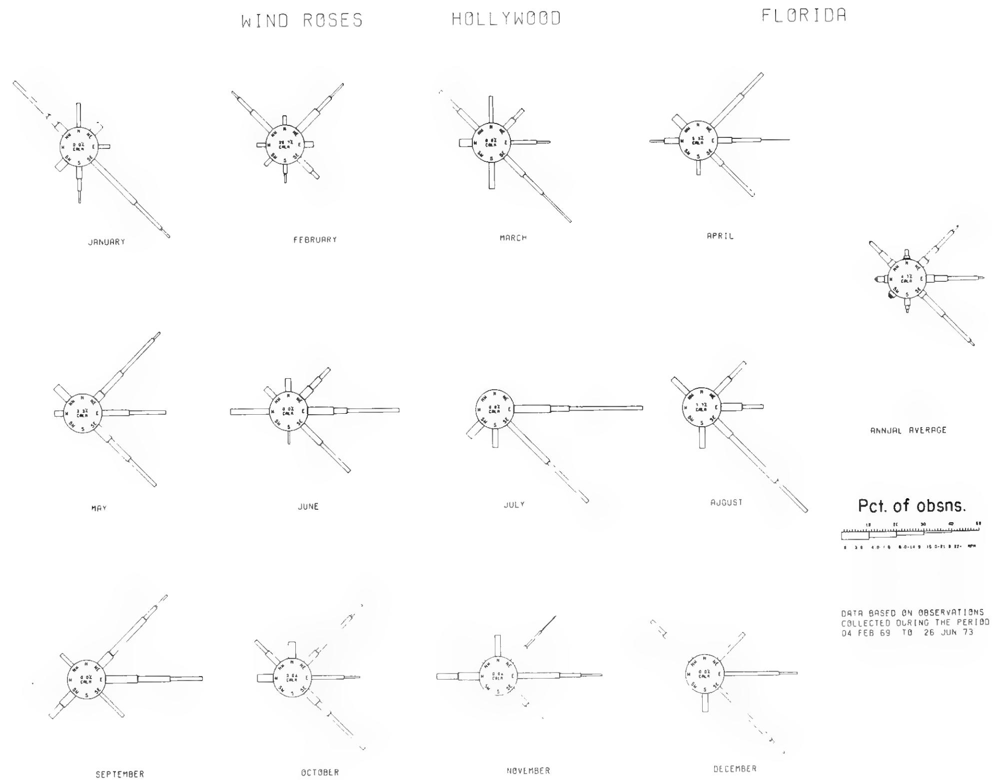


Figure 25. Mean wind roses from Hollywood.

Tropical Storm Gerda crossed the coastline near Palm Beach on 6 September 1969, before returning to sea to reach full hurricane force as it traveled north. Tropical Storm Felice passed within 90 miles (144 kilometers) to the southwest of the study area on 13 September 1970. Hurricane Beth began as a tropical storm just off the southeast coast of Florida on 10 August 1971. Hurricane Dawn was also spawned off the southeast Florida coast, and briefly moved through the study area in its tropical depression stage on 5 September 1972. None of these storms had a significant effect on the study area, other than locally heavy rain and winds of 9 to 14 miles (14 to 22 kilometers) per hour.

At least 21 other significant storms affected the area during the study. These storms lasted from 2 to 3 days with winds out of the eastern quadrant at 18 to 24 miles (29 to 38 kilometers) per hour. The three most significant storms were on 24 and 25 October 1969, 23, 24, and 25 December 1971, and 9 to 12 February 1973.

3. Wave Observations.

Breaker height roses summarizing height and direction data from each of the three sites are plotted in Figures 26, 27, and 28. Monthly breaker height roses from Boca Raton are plotted for each year in Appendix E.

Wave direction was recorded at the seawardmost line of breakers, where most of the wave refraction had already occurred. From all of the observations made during this study, the greatest percentage of breakers approached the shoreline from the sector between 85° to 95° (Fig. 14); 33 percent were from this sector at Boca Raton and Hollywood, and 34 percent were from this sector at Jupiter.

Since only a very small angle from a shore-normal breaker approach is required to initiate longshore current flow, it is convenient to refine direction notation further than this 10° sector in order to predict the direction of the longshore sediment transport. Table 1 lists the breaker direction distributions within the 11° sector, 85° to 95°, for those observations made according to the protractor method. These data indicate that more than 50 percent of the observations that would normally be grouped in sector 3 represent directions of approach other than shore-normal.

Table 1. Breaker direction distributions from protractor method.[1]

Locality	Total obsns.	Total obsns.	Relative frequency				
		85° to 95°	<85°	85° to 89°	90°	91° to 95°	>95°
Jupiter	58	33	0.12	0.14	0.26	0.17	0.31
Boca Raton	234	97	0.12	0.12	0.21	0.08	0.45
Hollywood	62	31	0.12	0.18	0.20	0.11	0.34

[1]Data collected from August 1972 to June 1973.

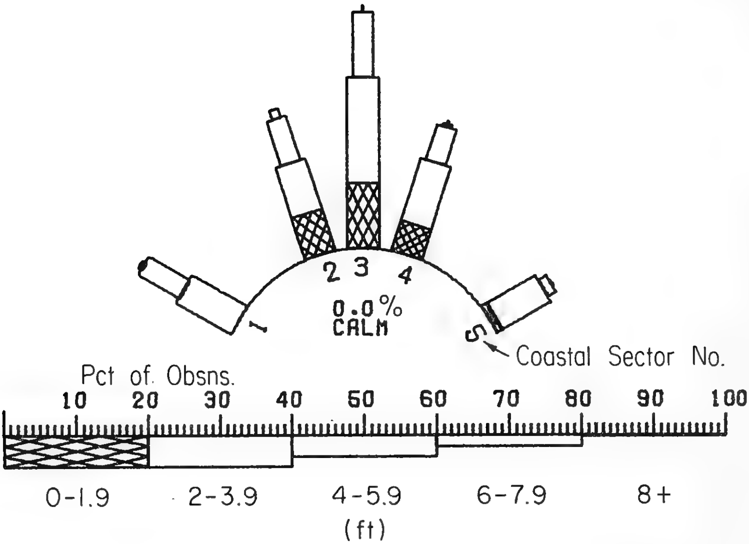


Figure 26. Breaker height rose for Jupiter, 20 January 1969 to 28 June 1973.

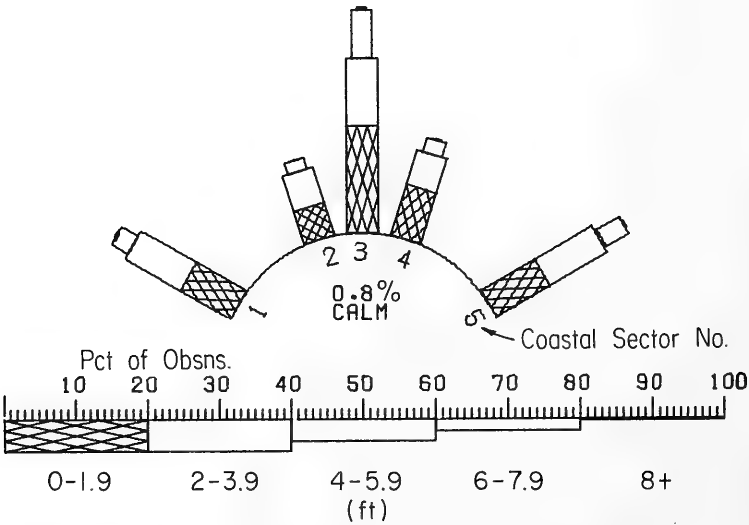


Figure 27. Breaker height rose for Boca Raton, 2 January 1969 to 29 June 1973.

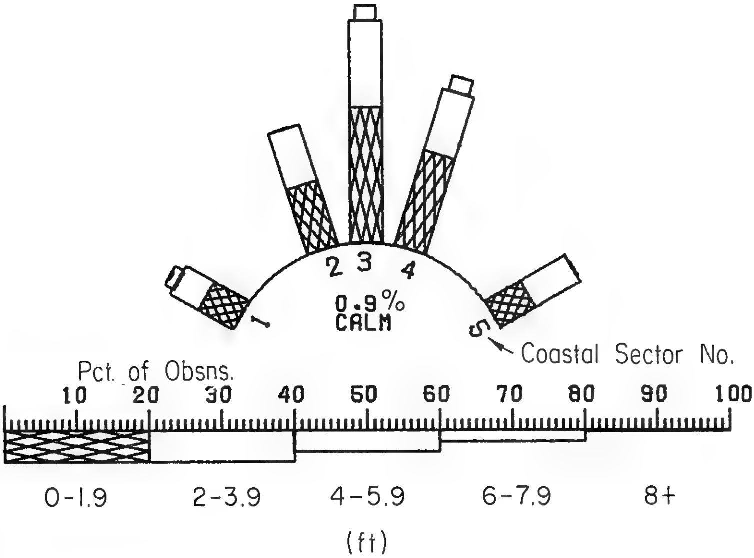


Figure 28. Breaker height rose for Hollywood, 4 February 1969 to 26 June 1973.

The frequency of breaker observations approaching "normal" to the shoreline, as defined by each of the three direction notations used is listed in Table 2. During use of the compass sector method at Boca Raton, the breakers were recorded as approaching from the "east" sector 46 percent of the time. When breaker direction was recorded to the nearest degree, only 21 percent of the observations were reported as shore-normal at Boca Raton. Large differences were noted between the frequency of "shore-normal" observations using the 10° coastal sector 3 notation and the frequency of observations within the 85° to 95° protractor method sector. This suggests that when an observer detected a small angle from a direct onshore breaker approach, either sector 2 or 4 was recorded when using the coastal sector method.

Table 2. "Normal" breaker approach frequency for visual methods.

Method	Dates in use	"Normal" sector				
		Name	Size	Reported frequency		
				Jupiter	Boca Raton	Hollywood
Compass sector	Jan. 1969 to Sept. 1969	East	45°	-------[1]	0.46	-------[1]
Coastal sector	Sept. 1969 to Aug. 1972	3	10°	0.24	0.27	0.14
Protractor	Aug. 1972 to June 1973	85° to 95°	11°	0.57	0.42	0.49
Protractor	Aug. 1972 to June 1973	90°	1°	0.26	0.21	0.20

[1]No data.

Observations which were made using the compass sector method, and subsequently converted to the coastal sector notation, show a strong bias toward sectors 1 and 5, a result of the relatively crude precision of notation (see App. C, January through September 1969). Observations subsequent to September 1969 suggest an observer bias influenced by the abandoned compass sector method until September 1970, after which direction observations appear unbiased.

In comparing the three methods of determining breaker direction, it is apparent that the compass sector method is the least useful for engineering purposes. The coastal sector method tends to over-represent breakers approaching from sectors 2 and 4, while the protractor method may over-represent breakers approaching 90° (see coastal sector and 90° protractor entries in Table 2). The average annual directions for all data were as follows: Jupiter, 87.1°; Boca Raton, 90.7°; and Hollywood, 90.4°.

At Jupiter, the higher breakers generally came from the northeast and prevailed during August through April. However, the highest breakers (8 feet) were observed during storms coming directly onshore (two observations) or from the southeast (one observation). Breakers from the southeast were predominant during May through July.

At Boca Raton, the higher breakers generally came from the southeast and prevailed during April through September. The highest breakers came from the northeast, however, in the wake of the 9 to 12 February 1973 northeaster, when 10-foot breakers were reported approaching at an angle of 10° to the north of a normal approach. Breakers from the northeast were predominant during October through March.

At Hollywood, the higher breakers were generally from the southeast and prevailed during January, March, May through July, and September. The highest breakers (5 feet) were observed coming directly onshore (two observations). Breakers from the northeast predominated during February, April, August, and October through December.

Figure 29 is a plot of the monthly averages of breaker height and period from the three sites. Both parameters decreased from north to south, which may have been the result of attenuation of waves by the Bahama Banks. Average breaker heights at Jupiter, Boca Raton, and Hollywood, from north to south were 2.8, 2.0, and 1.6 feet (0.8, 0.61, and

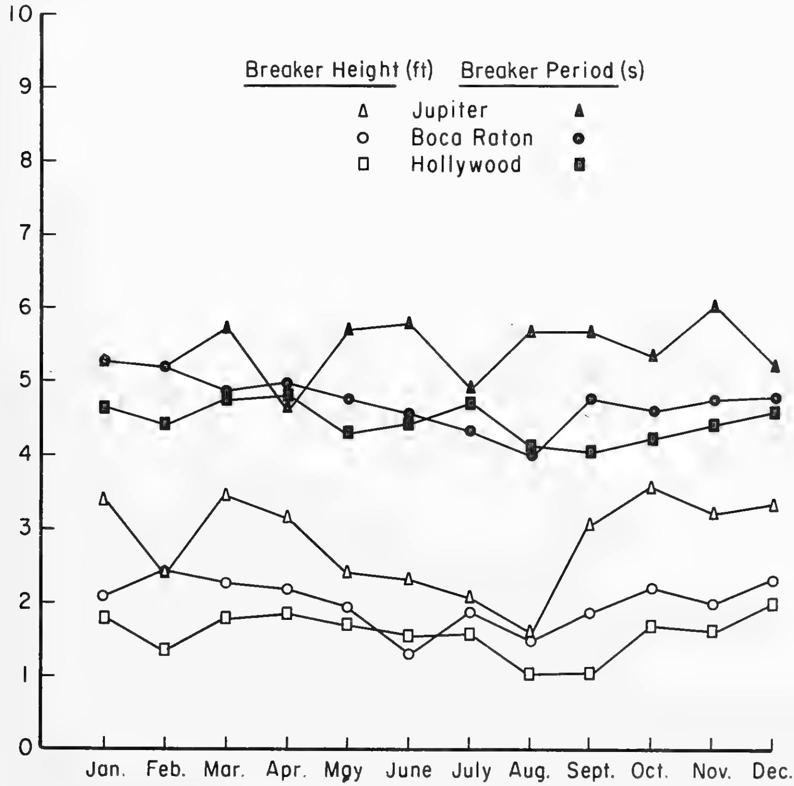


Figure 29. Monthly mean breaker height and period (visual observations).

0.49 meter), respectively. Average breaker periods at Jupiter were about 1.1 times greater than at Boca Raton and 1.2 times greater than at Hollywood. The lowest average breaker height occurred in August at Jupiter and Hollywood, but in June at Boca Raton. The highest average breaker height occurred in October at Jupiter, February at Boca Raton, and December at Hollywood.

Figure 30 is a comparison of the monthly breaker averages from Boca Raton with similar visual observation data collected at the Hillsboro Inlet Light Station and with wave gage data collected at Lake Worth. The wave gage data were collected during the study period; the Hillsboro Inlet data were collected between January 1955 and December 1965. A good correlation can be seen between the two sets of visual observations of height and period, and the wave gage height data. Lower heights and periods

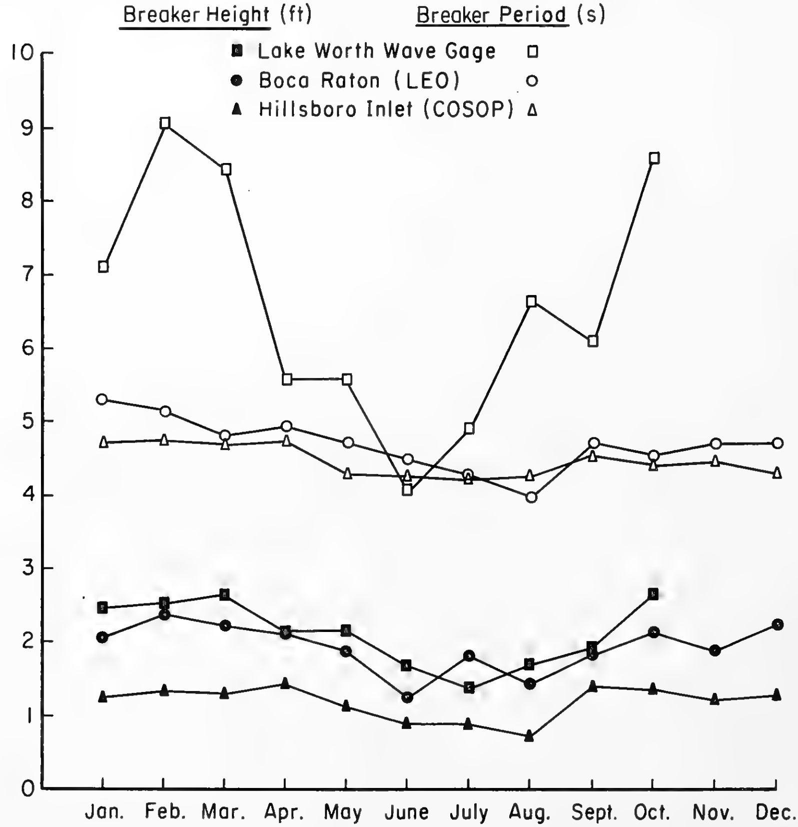


Figure 30. Comparison of visually observed and measured height and period data (monthly means).

occurred during June through August, with higher heights and periods occurring in September through April. A north-to-south decrease in height and period was also apparent for the three localities. The large discrepancy between period observations, as measured by the gage and by visual observers, might be due to a filtering effect caused by the shoaling and breaking of incoming waves. Gage observations were made 800 feet from the shoreline in an 18-foot water depth; visual observations were made in the breaker zone. The longer period winter waves may reform several shorter period secondary waves between the position of the gage and the breaker zone. Shorter period summer waves appear to remain more stable up to the breaker zone. Other explanations for the differences between visual and gage period observations may be the sheltering of the Boca Raton and Hollywood sites by the Bahama Banks, and the wider shelf at and north of the Lake Worth gage, which takes its damping toll preferentially on the long waves (R.G. Dean, CERB, personal communication, 1976).

Using data from the Boca Raton site for the interval October 1969 to March 1972, DeWall and Richter (1972) related the observed parameters of wind velocity and direction to those of breaker height and direction using the coastal sector method. This was done by deriving the ratio of a measure of the southerly component of the longshore energy flux to a measure of the total longshore energy flux (Fig. 31). Winds directly east or west and waves approaching normal to the shoreline were not computed. The monthly averages of these directional ratios correlate well, with a peak occurrence of northerly winds and waves in November and southerly winds and waves in August. The data imply an abrupt change in direction between the mean conditions in August (flow predominantly from south to north) and September (flow usually from north to south).

4. Longshore Current Observations.

Longshore currents, the littoral currents in the breaker zone moving essentially parallel to the shore, are principally generated by waves breaking at an angle to the shoreline. As indicated in the Shore Protection Manual (SPM) (U.S. Army, Corps of Engineers, Coastal Engineering Research Center, 1975), these currents are largely responsible for longshore sediment transport.

Longshore current data are compiled in Figure 32. The monthly mean current velocities (positive values equal flow from north to south) are superimposed as circles on each histogram; monthly mean current speeds (absolute values) as triangles (see App. B for definitions of these terms, and a tabulation of the monthly and annual averages).

The maximum observed longshore current velocity at each of the sites was +4.28, +4.53, and -3.48 feet (+1.3, +1.38, and -1.06 meters) per second at Jupiter, Boca Raton, and Hollywood, respectively. The average current speed decreased north to south from highs of 0.93 foot (0.28 meter) per second at Jupiter, and 0.92 foot (0.28 meter) per second at Boca Raton, to a low of 0.81 foot (0.25 meter) per second at Hollywood.

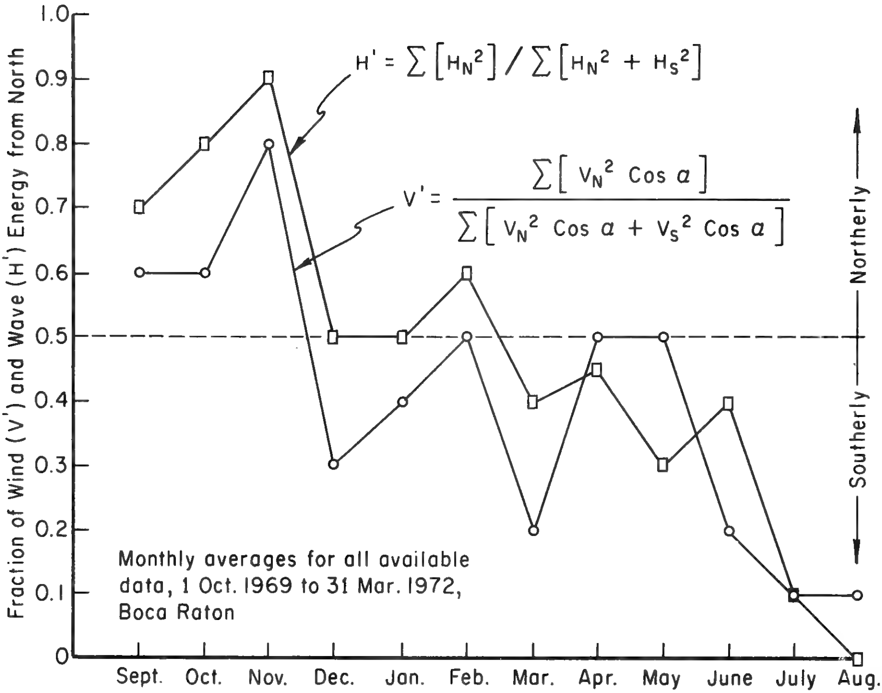


Figure 31. Correlation between measures of wind and wave energy (from DeWall and Richter, 1972).

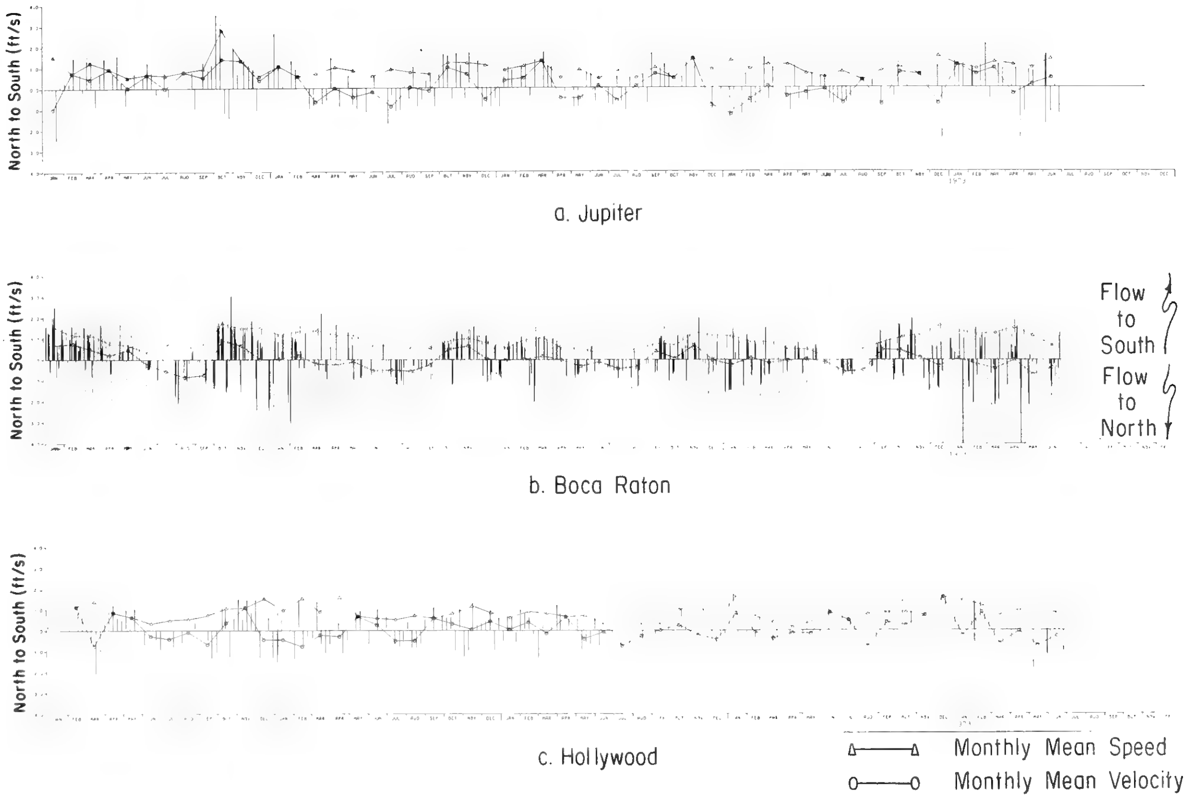


Figure 32. Longshore current observations at Hollywood, Boca Raton, and Jupiter.

Reversals in current direction occurred during almost any given month at each locality (Fig. 32). However, a definite seasonal pattern of reversals is evident at Boca Raton where the data were collected most frequently. The seasonal change in direction at Boca Raton indicated for monthly averages of wind and waves (Fig. 31) is confirmed by the longshore current data in Figure 32. At Boca Raton, currents flowing to the north dominate during April through August. Currents to the south dominate during September through February. Seasonal reversals are not as clear at Jupiter and Hollywood, which is probably a result of the less frequent observations. However, there is a definite tendency toward southerly currents during the winter months.

The annual vector sum of all longshore current velocity measurements is small and directed to the south. At Jupiter, it is 0.22 foot (0.07 meter) per second to the south, and at Boca Raton and Hollywood it is effectively zero (0.02 and 0.01 foot (0.006 and 0.003 meter) per second, respectively). The direction and the relative ordering of the vector sums agree with the direction and relative ordering of longshore transport rates at the three sites (Table 3) (U.S. Army, Corps of Engineers, 1971).

Table 3. Longshore transport estimates. Units are in cubic yards per year.

Locality	U.S. Army, Corps of Engineers (1971)[1]	Walton (1973)[2,3]	This study[2] Galvin (1972)	Das (1972)	SPM (1975)
Jupiter		(St. Lucie)			
Gross	-------------	700,000	1,545,680	1,459,188	2,342,248
Net	230,000	94,100	---------------	536,592	674,027
Direction	S.	S.	---------------	S.	S.
Boca Raton	(Hillsboro)	(Hillsboro)			
Gross	-------------	711,000	768,320	986,765	1,565,017
Net	120,000	315,000	---------------	−10,246	−14,031
Direction	S.	S.	---------------	N.	N.
Hollywood	(Port Everglades)	(Port Everglades)			
Gross	-------------	727,000	492,980	416,463	628,658
Net	50,000	259,000	---------------	−9,780	−177,990
Direction	S.	S.		N.	N.

[1] Based on impoundment and dredging records.

[2] Estimates of potential transport which are probably not reached because of underlying coquina.

[3] Computation based on U.S. Army, Corps of Engineers, Coastal Engineering Research Center (1966).

Currents to the south were observed 53 percent of the time at Jupiter, 42 percent at Boca Raton, and 47 percent at Hollywood. Currents to the north occurred 34 percent at Jupiter, 40 percent at Boca Raton, and 39 percent at Hollywood, with "calm" conditions accounting for the remaining observations.

Monthly mean net current velocities correlated reasonably well with monthly mean breaker directions (Fig. 33). During those months when breakers were approaching from the south of shore-normal, longshore currents generally flowed to the north. During the months when breakers were approaching from the north of shore-normal, longshore currents generally flowed to the south. As the breaker approach angle increased, so did the average current speed.

5. Longshore Transport.

Longshore transport rates have been estimated for the southeast coast of Florida and are listed in Table 3. U.S. Army, Corps of Engineers (1971) summarized estimates of the net transport rate based on impoundment rates and dredging records. Walton's (1973) estimates of net and gross longshore transport rates in the study area were based on shipboard observations. However, Walton questioned the validity of his estimates south of Jupiter Inlet due to possible effects of the Florida Current and the Bahama Banks. All estimates have confirmed a net north-to-south transport direction. Specific field indications of transport direction toward the south include the deposition north and erosion south of: (a) South Lake Worth jetties, (b) Boca Raton jetties, (c) Hillsboro Inlet jetties, (d) Port Everglades jetties, (e) Bakers Haulover jetties, (f) groin at Hollywood-Hallendale City line, and (g) seawall and groins at Parker Dorado condominium at Hallendale-Golden Beach City line (R.G. Dean, personal communication, 1976). The estimated magnitude of the net longshore transport rates as summarized by the U.S. Army, Corps of Engineers (1971) is observed to decrease southward between Jupiter and Hollywood.

Using the breaker height and direction data collected during this study, independent longshore transport rates were calculated and are listed in the last three columns in Table 3. The gross transport rate values from Galvin (1972) were computed by doubling the square of the mean yearly breaker height. Values from Das (1972) were computed based on individual observations of breaker height and direction. The SPM values were computed using the joint frequency distribution of the height and direction, following the example of the "wave energy flux method" on page 4-102 of the Shore Protection Manual (U.S. Army, Corps of Engineers, Coastal Engineering Research Center, 1975).

It should be noted that the calculated results in Table 3 are only potential values, based on available wave energy. Other factors, such as limits on the sand supply and protection afforded by the coquina ledge, would be expected to reduce the actual longshore transport rate.

Estimates of gross transport rates using data from this study confirm a trend of decreasing magnitude from north to south. However, the computation of net transport rates (Das, 1972; SPM) results in an apparently anomalous reversal of direction at Boca Raton and Hollywood. The Hollywood reversal is most likely the result of wave refraction at the deep entrance channel at Port Everglades, but may also be the result of the relatively calm weather which prevailed during the study period.

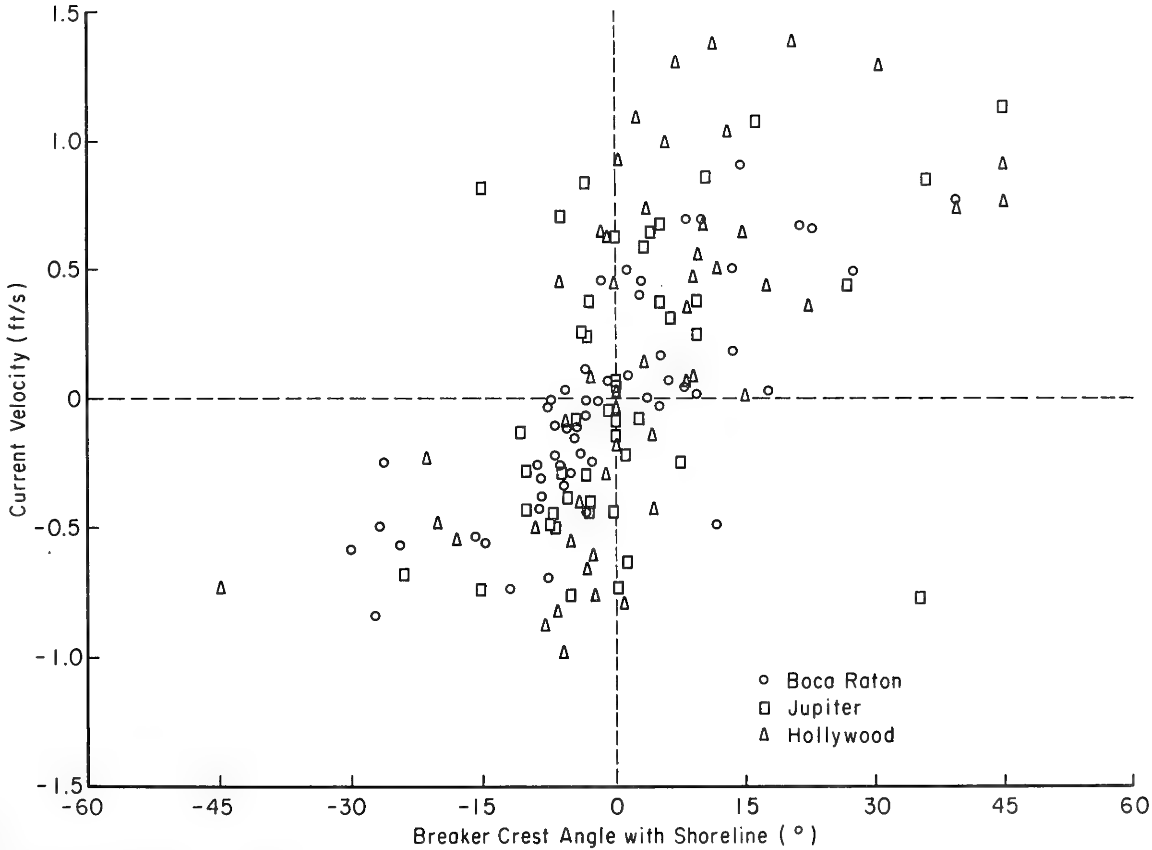


Figure 33. Mean longshore current velocity as a function of monthly mean breaker angle.

Using a set of LEO data from the vicinity of Channel Islands Harbor, Balsillie (1976) showed that monthly averages of longshore current observations are a qualitative predictor of longshore transport. Figures 34, 35, and 36 are plots of monthly mean longshore current velocity versus the longshore energy flux in the surf zone (U.S. Army, Corps of Engineers, Coastal Engineering Research Center, 1975, eq. 4-29). The observed agreement confirmed that the longshore current velocity data from southeast Florida would also be a reasonable predictor of longshore transport.

6. Tides.

A summary of the highest observed water levels recorded (by month) at Miami Beach by NOAA (National Ocean Survey) during the study period, is shown in Figure 37. These data show an annual cycle with the maximum highest tides occurring in October each year; the lowest tides generally occurred between April and June. Harris (1963) concluded that this annual cyclicity is predominately meteorological in origin.

7. Other Observations.

Beach cusps were recorded for 5.3 percent of the observations at Jupiter, 8.3 percent at Boca Raton, and 0.4 percent at Hollywood (one observation); cusps were present more frequently during January through April. Rip currents were observed during 12.7 percent of the observations at Jupiter, 7.8 percent at Boca Raton, and 6.0 percent at Hollywood.

IV. RESULTS: BEACH SURVEYS

Beach changes are primarily reflected as changes in beach width, slope, elevation, and volume. This discussion is divided into the changes analyzed over short terms (between surveys) and the changes analyzed over the longer seasonal and yearly terms. The term "average" used in describing beach changes at a locality means the average of data from all profile lines at that locality; i.e., two at Jupiter, four at Boca Raton, or two at Hollywood.

Survey frequency was generally daily at Boca Raton (except weekends) and weekly at Jupiter and Hollywood. In addition, several sets of 3 hourly surveys were collected through two complete tidal cycles at each site.

1. Pipe Profile Method.

Comparison of the pipe profile method for beach surveys with standard tape and level surveying techniques shows advantages as well as disadvantages.

Advantages include the ease of measuring the exact set of points over successive surveys of the profile lines, more rapid surveys, a minimum of crew and equipment, and accurate data through the surf zone and nearshore. After the installation of the pipe profile lines was completed, one person

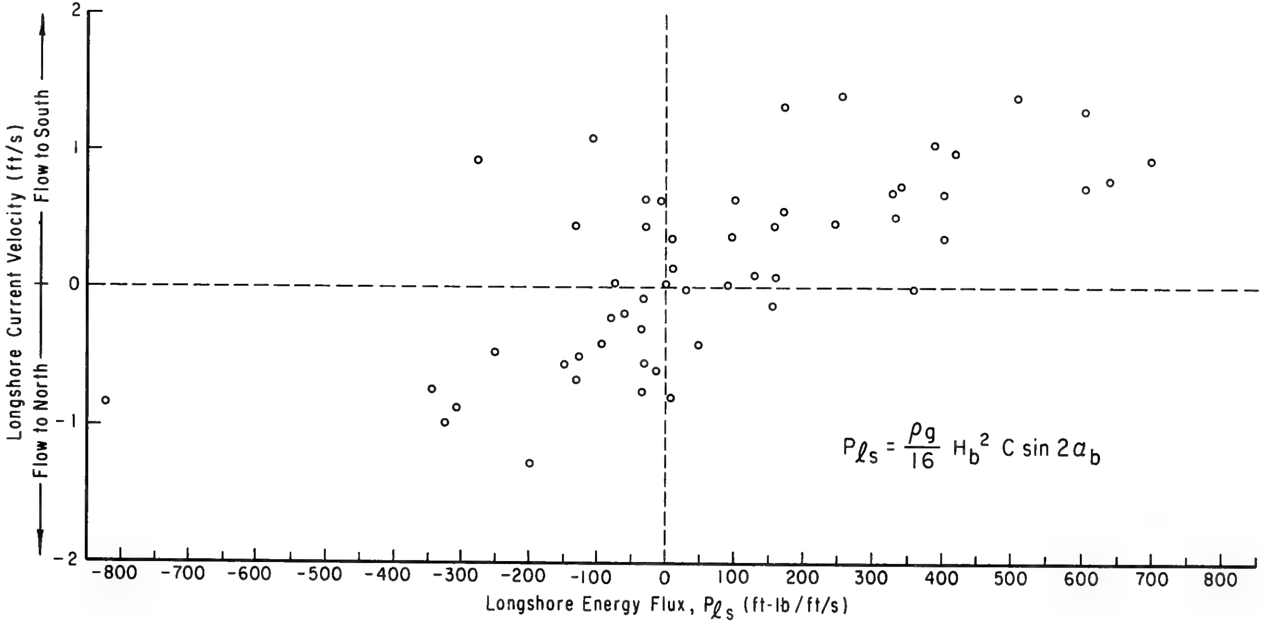


Figure 34. Longshore current velocity as a function of longshore energy flux, Jupiter.

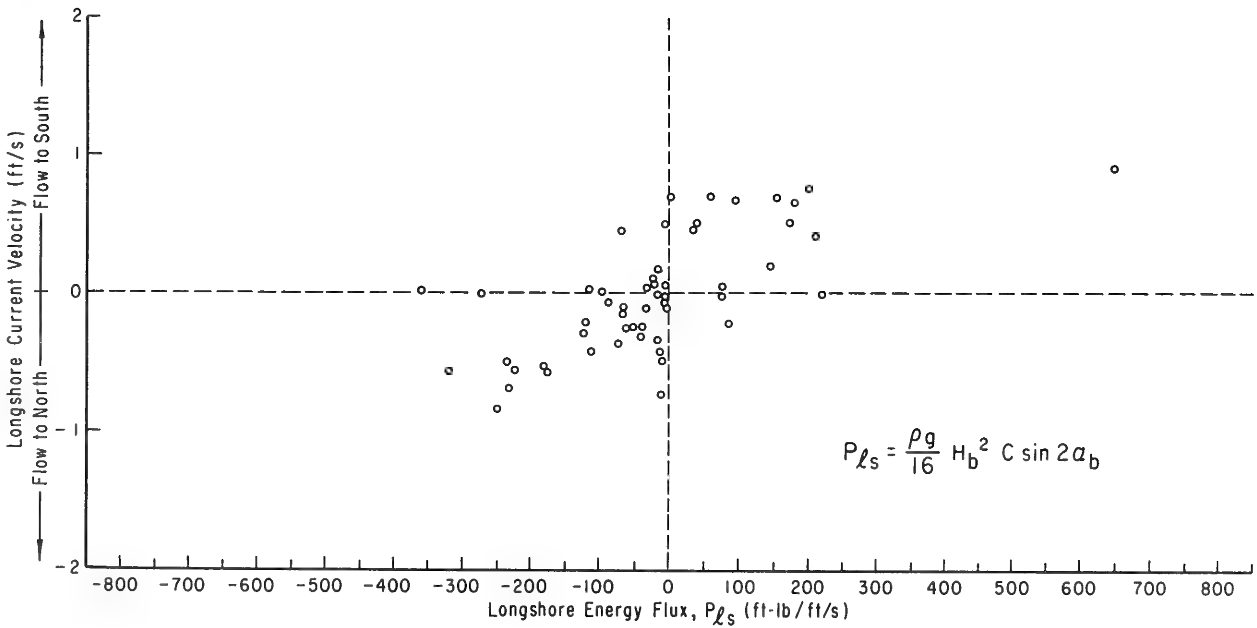


Figure 35. Longshore current velocity as a function of longshore energy flux, Boca Raton.

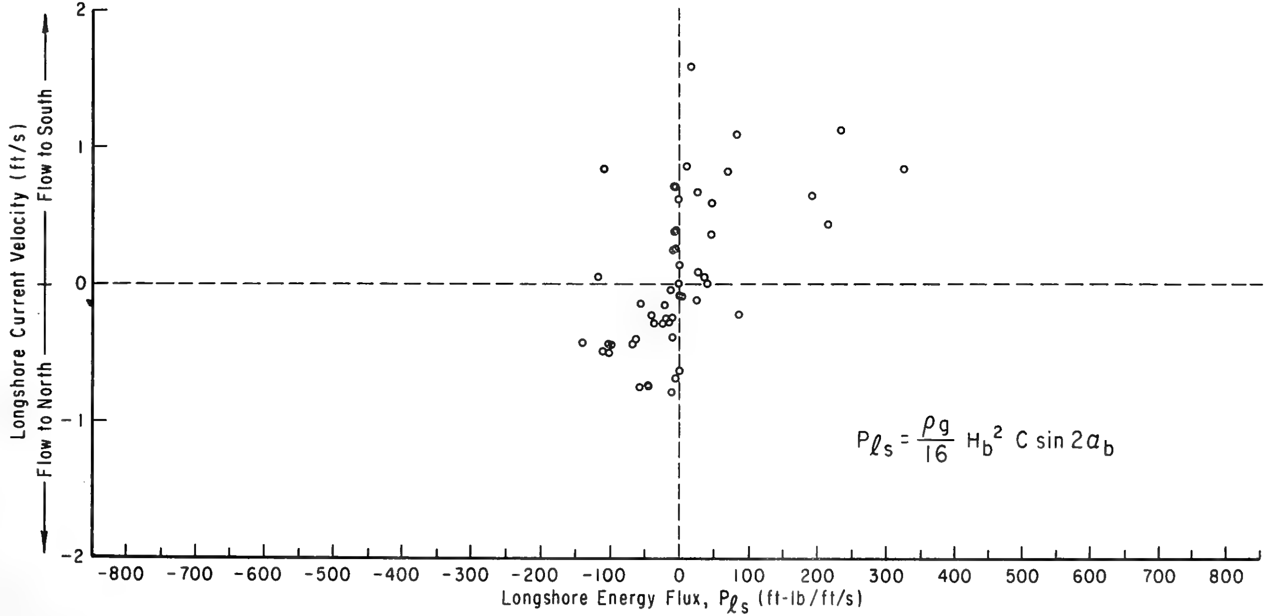


Figure 36. Longshore current velocity as a function of longshore energy flux, Hollywood.

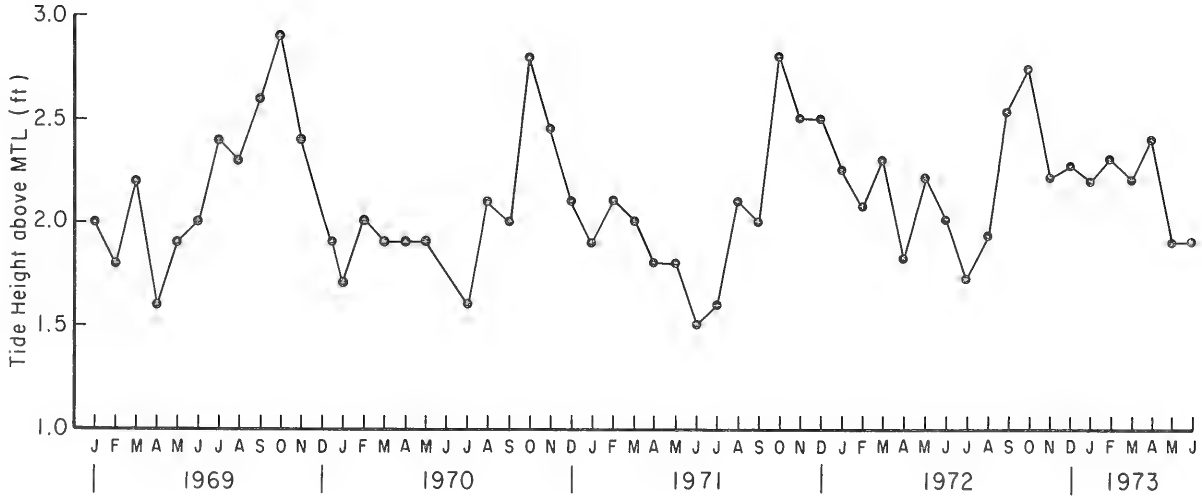


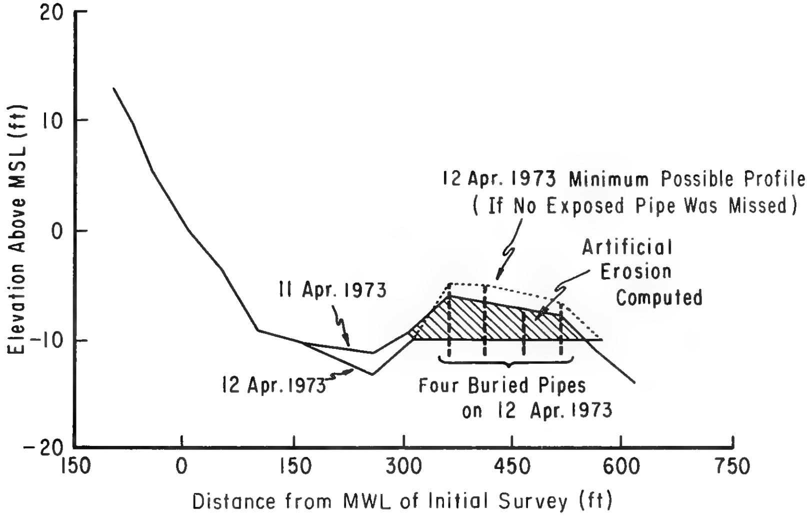
Figure 37. Highest observed water levels (by month) at Miami Beach.

could complete the survey of a beach profile line in less than 5 minutes. The survey of all four nearshore profile lines at Boca Raton was generally accomplished by a team of two divers in 30 to 45 minutes. The sand level measuring techniques are such that a minimum of training is required to complete a survey. The method has been used quite successfully, on a limited scale, at several other localities using unpaid observers with no previous surveying experience (Urban and Galvin, 1969).

Disadvantages of the pipe profile method include a smoothing effect on the surveyed profile shape, the problem of lost or damaged pipes, the possibility of misidentified pipes, and the difficulty of removing the pipes when the study is completed. Standard tape and level techniques, if properly done, will pick up major changes in slope as they occur between the standard-interval stations (Fig. 19). Normally, breaks in slope between pipe stations were not recorded in this study, except for the positions of the berm crest and any major scarps. The overall effect is one of smoothing the profile shape, which may or may not have a significant effect on the variable being analyzed. A continual problem with the pipe surveying method is the damage or loss of pipes, either through natural causes or vandalism. Damaged or lost pipes were replaced as required and new pipes were referenced horizontally and vertically with respect to adjacent pipes. Those pipes below MSL were occasionally buried by migrating bars. Burial lasted from 1 day to several months. If extended burial was apparent, a new pipe was installed and releveled from the bench mark. The effect of buried pipes was an artificial truncation of bed forms on the plotted profile, which might alternately reappear as pipes were excavated or replaced (Fig. 38). Similarly, buried pipes resulted in large artificial gains and losses being computed for the volume changes. This problem was particularly evident for the nearshore surveys at Boca Raton completed during the last 4 or 5 months of the study.

A problem not fully recognized at the outset of the study related to the safety aspects of the pipe profiling method. Initially, precautions were taken to ensure that the pipes were clearly marked with warning signs, fluorescent paint, and flagging. Later, broken pipe stubs, which were often rapidly covered with sand after storms, posed a hazard not only to unwary bathers, but also to the observers. When the stubs could be located, they were cut off smoothly and rethreaded so a new pipe section could be coupled to the top. This was not always easily accomplished, as in the breaker zone where visibility was restricted, the stubs quickly covered, and working conditions the most difficult.

At the end of the data collection phase of the study another unanticipated problem was encountered in removing the pipes. Previous studies, where jetted-in pipes were removed seasonally, encountered little problem in clearing profiles (Urban and Galvin, 1969). However, in this study many of the pipes had been in place for nearly 5 years and had been driven into beach rock. Complete clearing required the use of jetting gear, heavy equipment (a borrowed bulldozer), and, in some cases, explosives. Examination of the pipes after removal showed that many pipes had been severely deformed below the sand surface either during installation or during



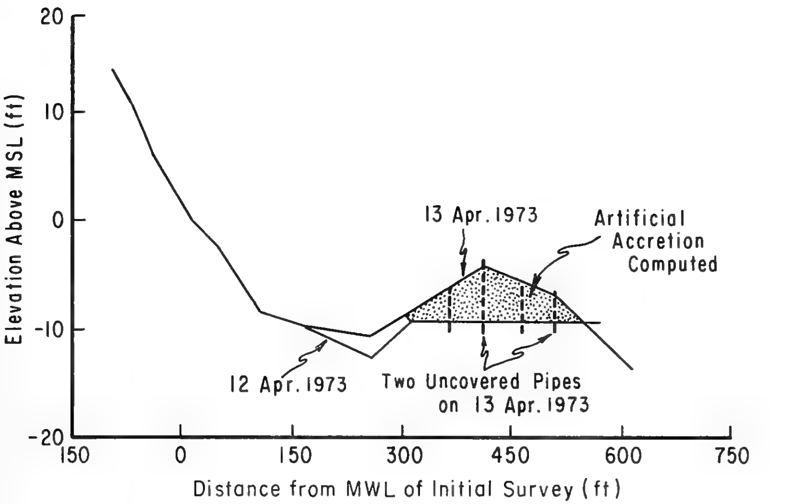


Figure 38. Profile changes between two surveys at Boca Raton, showing effects of buried pipes.

subsequent high-energy storm conditions, and that cementation of the pipes by either limonite or calcite had occurred. No geochemical analysis of the cementing material was made.

2. Jupiter.

The beach width on the two Jupiter profiles from the toe of the frontal dune to the MSL shoreline ranged from a minimum of 50 feet (February 1972) to a maximum of 180 feet (55 meters) (February 1969). The average berm elevation was 6.9 feet (2.1 meters). The average monthly foreshore slope ranged from 8° to 12°, with an overall average foreshore slope of 10° (1 on 5.7). The maximum elevation change at any station was 8.5 feet (2.6 meters) of accretion at pipe 3 (south row) between June 1972 and February 1973 during which period a gain of 27.5 cubic yards (69.0 cubic meters) of sand per lineal foot of beach was measured.

a. Short-Term Changes. A total of 223 sets of profile surveys was made at Jupiter, averaging once each 7.4 days over the study period. Changes between surveys in the MSL shoreline position and in the beach volume above the MSL elevation are presented in Appendixes F and G. The changes are referenced to the shoreline position and volume of the subaerial beach at the first survey in January 1969. Positive slopes on the plotted curves indicate either progradation or accretion; negative slopes indicate erosion.

The average change in the MSL shoreline position between weekly surveys was approximately 9 feet (2.7 meters) in either a landward or seaward direction. The average volumetric gain between weekly surveys when accretion occurred was 1.1 cubic yards per foot (2.8 cubic meters per meter) of beach; the average loss was 1.3 cubic yards per foot (3.3 cubic meters per meter).

Significant short-term changes were generally associated with observed periods of high wave activity, but were not necessarily associated with local storms. Shoreline and volumetric changes associated with three specific storms are listed in Table 4. The largest loss (an MSL shoreline retreat of 63 feet (19.2 meters) and volume loss of 12.6 cubic yards per foot (31.6 cubic meters per meter)) were observed at profile line II (south row), between surveys on 23 and 30 March 1972. These losses were confirmed by the observations recorded in the fieldbook on 30 March that the erosion was "most unusual this week . . . entire beach in front of pipe profile is now mostly rock." However, unusual wind velocities, wave heights, or longshore currents were not observed at the site during either of the two surveys. There was also no indication from the LEO or COSOP data of higher than normal wave activity at Boca Raton or Hillsboro during the same 7-day interval. The Lake Worth wave gage was not operational during this time period.

The largest accretion measured between surveys occurred 8 to 15 June 1972, a gain in the MSL shoreline of 81 feet (24.7 meters) and a

Table 4. Storm-induced beach changes.

Storm date	Locality	Profile line	Survey date	Change: MSL shoreline (ft)	Change: Subaerial volume (yd³/ft)
October 1969					
24 and 25 (Laurie)	Jupiter	I	20 and 27	–8	–4.95
		II		–14	–4.96
	Boca Raton	I	23 and 27	0	0.00
		II		–6	–0.71
		III		–3	–1.65
		IV		–2	–5.42
	Hollywood	I	21 and 28	–3	–1.19
		II		+5	+0.34
December 1971					
22 to 25	Jupiter	I	9 and 30	+1	+0.52
		II		–3	–3.14
	Boca Raton	I	22 and 27	+32	–0.82
		II		–22	–8.01
		III		–23	–4.46
		IV		+5	–0.06
	Hollywood	I	21 and 28	–5	–0.51
		II		0	–0.52
February 1973					
9 to 12	Jupiter	I	9 and 15	+11	–0.24
		II		–2	–0.44
	Boca Raton	I	9 and 12	+8	+0.07
		II		–7	+0.03
		III		–2	+1.23
		IV		–2	+2.29
	Hollywood	I	6 and 13	0	–0.17
		II		0	–0.17

volumetric gain of 15.3 cubic yards per foot (38.4 cubic meters per meter). Unusual conditions are not reflected in the LEO data for these two surveys, although the weather system could have been under the influence of Tropical Storm Agnes which was developing off the Yucatan coast on 14 and 15 June.

b. Long-Term Changes. Figures 39 and 40 are plots of the average monthly MSL shoreline position and volume for the two Jupiter profile lines, referenced to the shoreline position and beach volume at the first survey (see also Apps. F and G). The plotted regression line is a least squares fit for the beach changes from January 1969 through December 1972.

The zero MSL position in Figure 39 is the value of the MSL position at the first survey in January 1969; the starting point for the profile line I curve for the MSL position is a negative value, reflecting an average MSL position in January 1969 that was slightly landward of the MSL position on the first surveyed profile during January 1969. The straight line (-0.4 foot (-0.12 meter) per year) is a least squares fit to the average of the monthly values of MSL at the two profiles, using the months from January 1969 through December 1972. The partial year of data collected after December 1972 was not included in the least squares analyses because it was not a complete annual cycle.

The unit volume data are shown in similar fashion in Figure 40. The zero volume in the volume of the first survey, and the straight line (-0.71 cubic yard per foot (-1.8 cubic meters per meter) per year) is a least squares fit to the 4 years of average monthly averages (January 1969 through December 1972). The MSL position and unit volume were previously defined in Figures 20, 21, and 22. The same format used in Figures 39 and 40 is also used for comparable data at Boca Raton and Hollywood.

The monthly MSL and volume changes both indicate cyclic changes at Jupiter, with a slight net loss in both the shoreline position and beach volume above MSL. There is good correlation between the changes observed on the two profile lines, which is expected with a spacing of only 250 feet. However, the magnitude of changes on profile line II is greater than on profile line I, suggesting some variation in the attitude of the underlying coquina limestone. There is also a good agreement between the two parameters analyzed; i.e., a gain or loss in sand volume is associated with a concurrent gain or loss in the position of the MSL shoreline.

The cyclic changes are seasonal and may be a result of the onshore-offshore sediment transport which has been documented elsewhere by other investigators (e.g., King, 1959; Shepard, 1963; Bascom, 1964). During the summer months the longer, lower waves transport sand onto the beach, causing a seaward translation of the shoreline and an increase in the total sand volume on the beach. Another possible explanation for the cyclic changes might be the influence of the coquina exposures to the north, damming up littoral drift being transported to the north during the summer months.

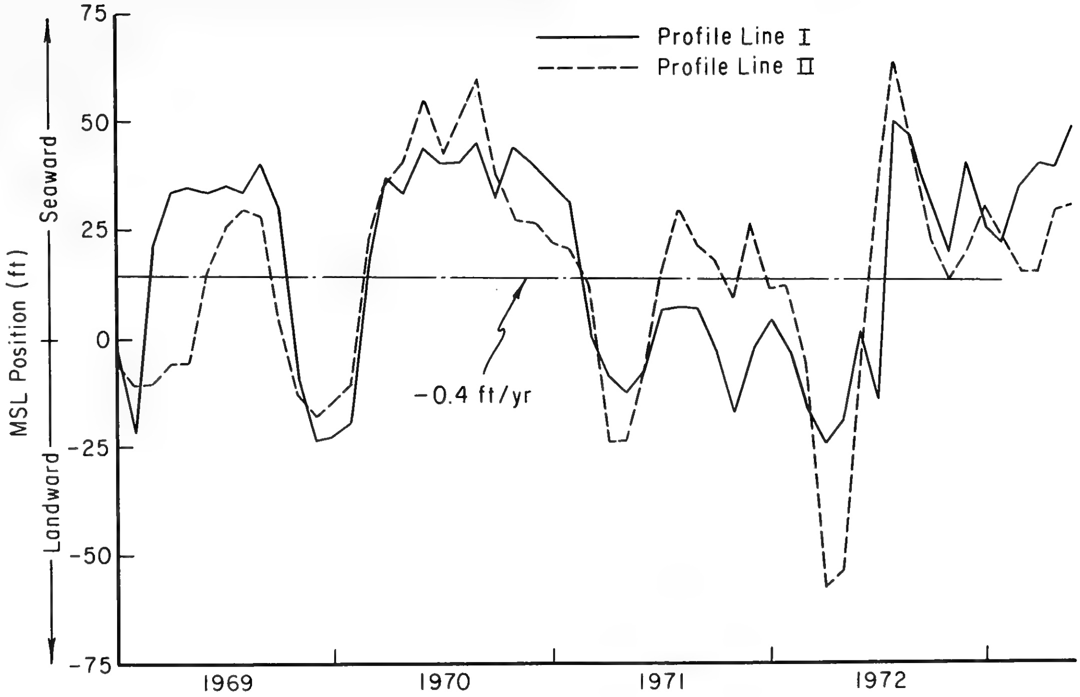


Figure 39. Annual and long-term changes in MSL position at Jupiter.

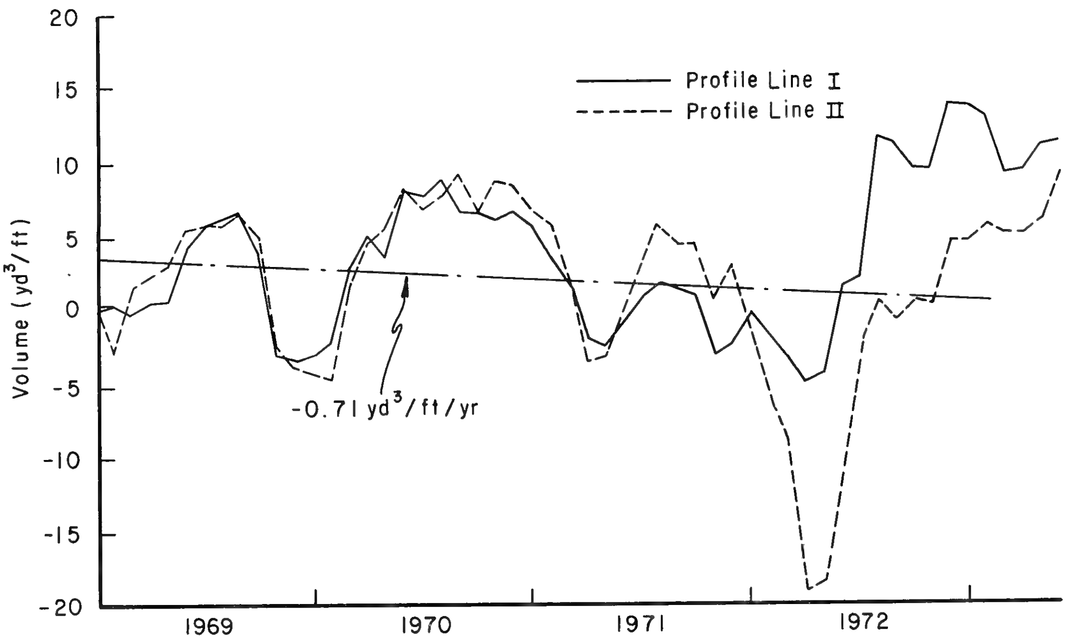


Figure 40. Annual and long-term changes in sand volume on subaerial beach at Jupiter.

Figures 41 and 42 have been rearranged to emphasize the seasonal change in shoreline and unit volume. Zero is not the value of the MSL position or unit volume on the first survey; instead, zero is the average value of all the monthly averages shown in Figures 39 and 40. The individual data points in Figures 41 and 42 are the average value for that month, for all the years when data were collected in that month. For example, the first point in Figure 41 indicates that the average MSL position in January for the five recorded January's was approximately 7.5 feet (2.2 meters) landward of the average MSL position. The same format used in Figures 41 and 42 is also used for comparable data from Boca Raton and Hollywood.

Figures 41 and 42 show a minimum of sand on the beach in April and a maximum on the beach in August. The net rate of change, averaged from

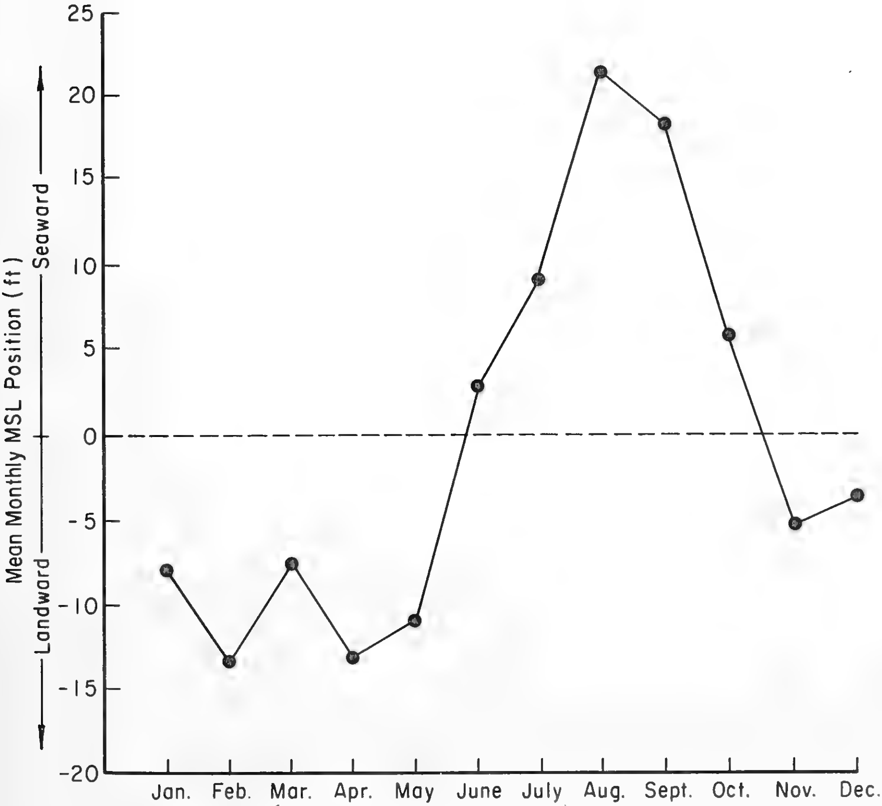


Figure 41. Seasonal change in MSL position at Jupiter.

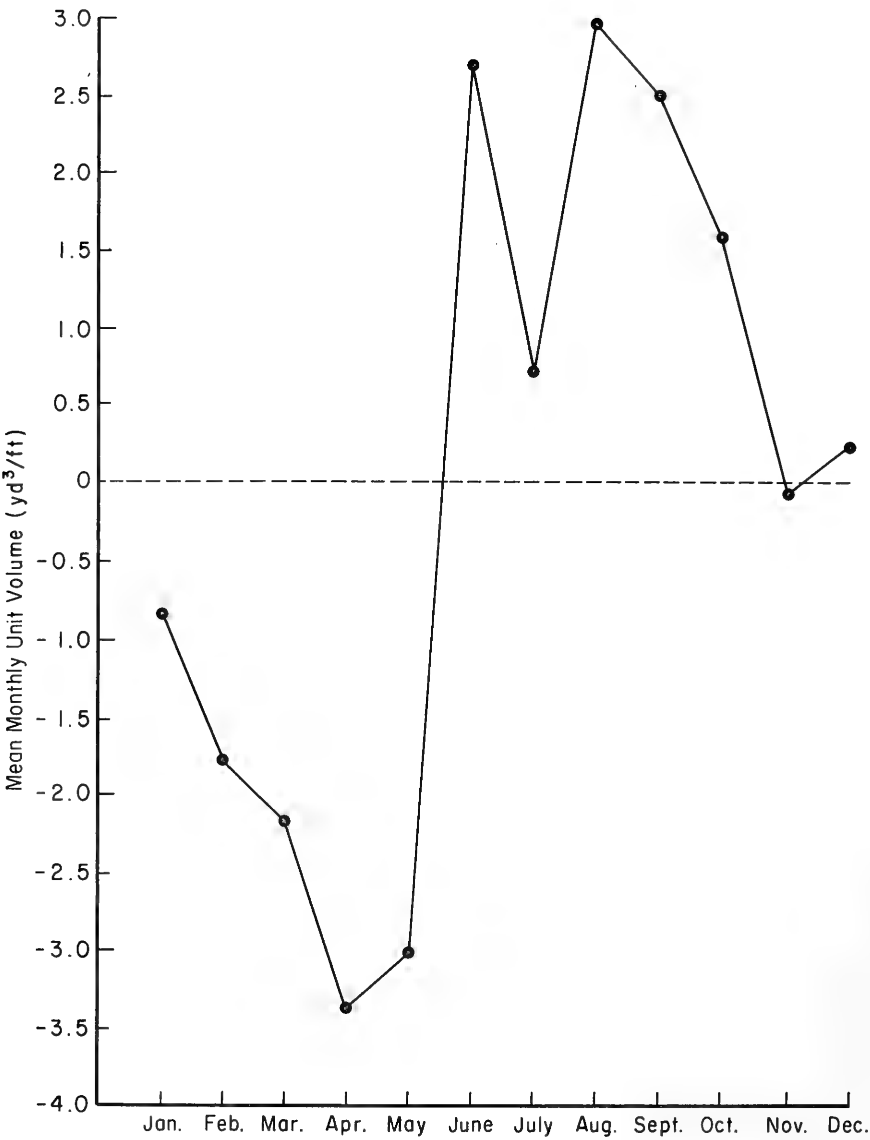


Figure 42. Seasonal change in subaerial beach to volume at Jupiter.

the two profile lines between January 1969 and January 1973, was a shoreline retreat of 0.4 foot per year which represented a volume loss rate of 0.71 cubic yard per lineal foot of beach per year.

3. Boca Raton.

Beach width on the four Boca Raton profile lines ranged from a minimum of 80 feet (24.4 meters) (March 1971) to a maximum of 131 feet (39.9 meters) (April 1973). The average berm elevation was 7.6 feet (2.3 meters). The average monthly foreshore slope ranged from 9° to 14°, with an overall average foreshore slope of 12° (1 on 4.7). The maximum elevation change at any station was a loss of 7 feet (2.1 meters) at pipe 4 (profile line II) between January 1970 and March 1971. This was representative of a total loss of 9.20 cubic yards per foot (23.1 cubic meters per meter) along the entire subaerial profile.

a Short-Term Changes. Plots of the cumulative MSL shoreline and volume changes are presented in Appendixes F and G. The changes are referenced to the shoreline position and beach volume at the first survey. Profile lines I and II were established and first surveyed in January 1969; profile lines III and IV were not established and surveyed until October 1969. A total of 1,002 sets of profile surveys was made on the four Boca Raton profiles at an average of once each 1.5 days over the study period.

The average MSL shoreline change between surveys was 2.5 feet landward or seaward. The average volumetric gain or loss when a change occurred between surveys of the subaerial beach was 0.7 cubic yard per foot (1.8 cubic meters per meter). Intervals which resulted in no measurable net volume changes between surveys occurred about 35 percent of the time.

Similar to the beach changes at Jupiter, the more significant short-term changes were generally associated with periods of high wave activity. Changes associated with three specific storms are listed in Table 4. The largest 24-hour loss was observed at profile line IV on 29 and 30 October 1969, when east and northeast winds at 25 miles (40 kilometers) per hour and 6-foot breakers from the northeast were observed. This storm, which closely followed the 24 and 25 October northeaster, caused a shoreline retreat of 14 feet (4.3 meters) and volume loss equivalent to 3.3 cubic yards per foot (8.3 cubic meters per meter) at profile line IV in the 24-hour interval.

The largest 24-hour accretion (2.6 cubic yards per foot, 6.5 cubic meters per meter) occurred on profile line II, between surveys on 26 and 27 October 1970. The shoreline progradation at profile line II was 5 feet during this same interval. Light westerly winds with breaker heights of less than 0.5 foot (0.2 meter) (7.2-second period) on the 26th, increasing to 2 feet (5.6-second period) on the 27th, were recorded.

b. Long-Term Changes. All four profile lines depict cyclic changes, with a slight net gain in shoreline position and beach volume (Figs. 43 and 44). Similar trends of gains and losses were observed on each of the four profile lines. Changes on profile lines III and IV most closely paralled each other; changes on profile lines I and II, the most widely spaced lines, were the most dissimilar of changes on adjacent profile lines. Profile line I underwent a significant departure from the trend of the three profile lines to the south by gaining sand at a rapid rate during the last quarter of 1969 and again in 1970. The 1969 gain appeared to be coincident with the excavation work at the condominium site immediately to the north (Fig. 6). Evidence of a southerly-migrating sand hump following the dune-leveling operation, such as reported at beach-fill sites elsewhere (Everts, DeWall, and Czerniak, 1974), is not apparent from the subsequent changes on profile lines II, III, and IV. Similar erosional and accretional trends are reflected by the computed volume changes and shoreline position changes at each of the four profiles.

The changes at Boca Raton appear to be seasonal, but do not show the same pattern as changes observed at Jupiter. The beach tends to be wider, with a maximum sand volume above MSL during the winter months, while the maximum loss rates occur during the summer months. Monthly averages of the shoreline position and sand volume on the four profiles for an average year are plotted in Figures 45 and 46. Maximum beach width and volume occur in February and again in June. Minimum beach width occurs in August; the minimum beach volume in October.

D.W. Kirtley, Fort Pierce, Florida (personal communication, 1973), suggested that the encrusting worm reefs, which commonly occur on the beach-rock ledge at Boca Raton, may be responsible for the anomalous accretion at the site. The worm reefs thrive in the surf zone, and have been observed to build their reefs upward by accumulating sand at rates of up to 2 centimeters per day in the laboratory. Although the worm-built structures probably cannot withstand the forces of storm waves and the worms themselves cannot withstand extended burial, they must have an effect on the littoral processes and sand storage rates at Boca Raton.

c. Nearshore Profile Changes. In October 1969 the Boca Raton profile lines were extended seaward from the beach-rock ledge to a distance of 540 feet (165 meters) from the MSL shoreline and an average maximum depth of 14 feet. A total of 262 nearshore profile surveys was made along each of the four profiles at an average of once each 4.5 days. No nearshore surveys were made from July through December 1972. Nearshore surveys were dependent on conditions favorable for safe scuba diving. Unfavorable diving conditions were generally caused by high breakers (4 feet or more) with resulting high current velocities. Other contributing problems included poor visibility, debris, insufficient air to complete a survey, equipment malfunction, and hazardous marine life.

Seaward of the beach-rock ridge, the nearshore zone consisted of one or more longshore bars. These bars were continually shifting in an

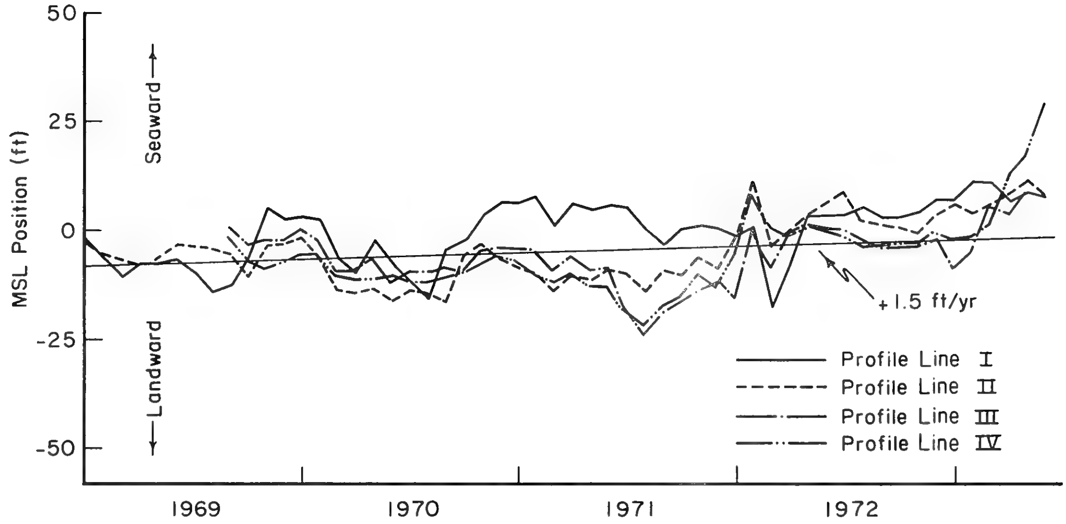


Figure 43. Annual and long-term changes in MSL position at Boca Raton.

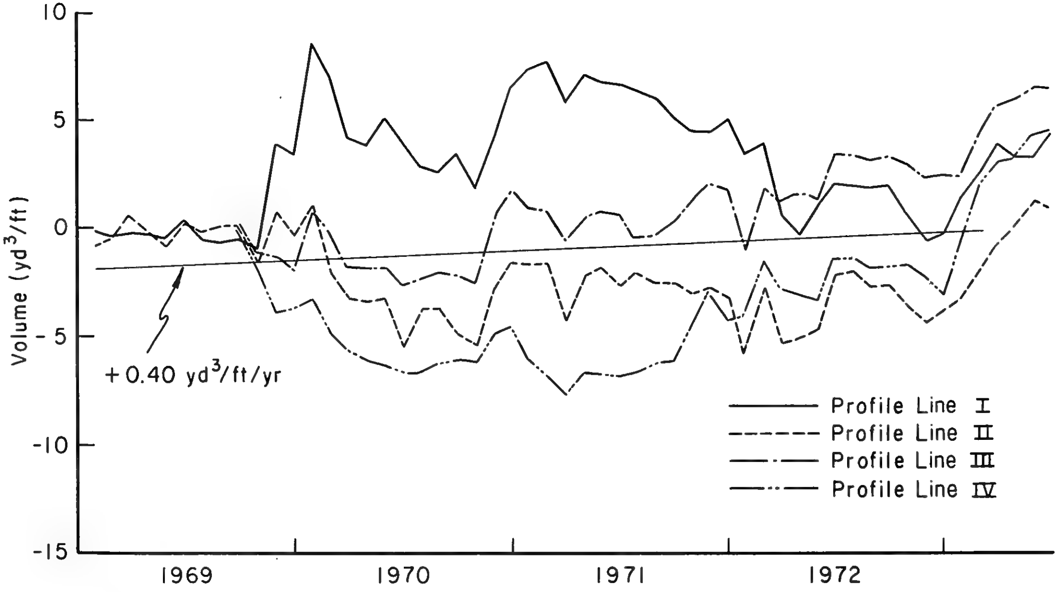


Figure 44. Annual and long-term changes in sand volume on subaerial beach at Boca Raton.

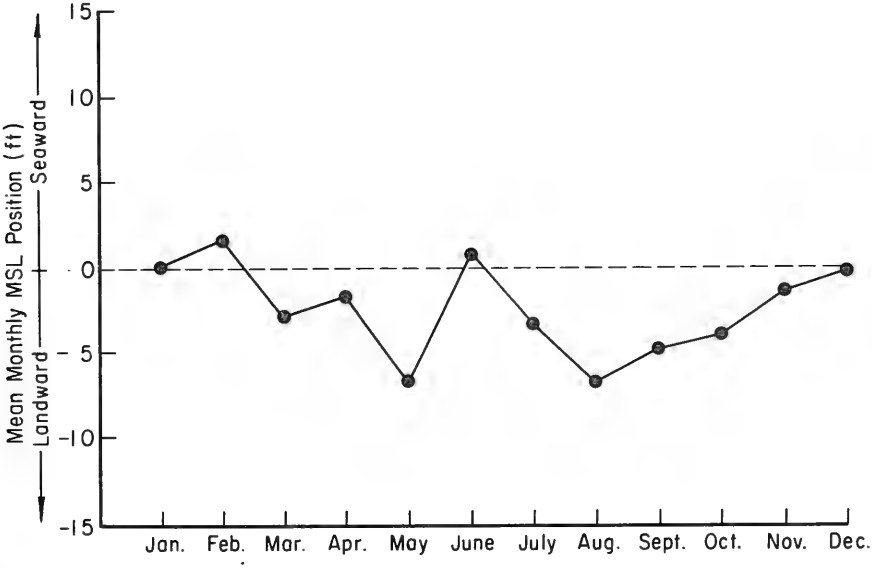


Figure 45. Seasonal change in MSL position at Boca Raton.

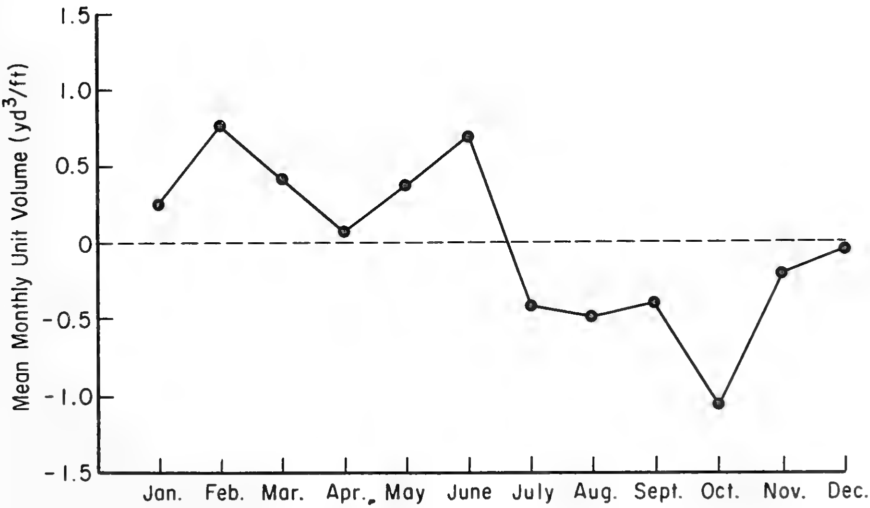


Figure 46. Seasonal change in subaerial beach volume at Boca Raton.

onshore-offshore direction as well as in an alongshore direction. Figures 47 to 54 are selected bathymetric plots for the nearshore profiles (modified from Richter, 1974).

For all surveys the station displaying the greatest nearshore sand level fluctuation was at pipe 7 on profile line III, located immediately seaward of the beach-rock ledge. The sand elevation varied from a high of -5.2 feet (-1.6 meters) MSL in April 1970, to a low of -11.6 feet (-3.5 meters) MSL in May 1972. Minimum sand level fluctuation occurred on the seaward end of profile line I, where elevation varied between -15.0 and -15.8 feet (-4.6 and -4.8 meters) MSL. Plots of the cumulative nearshore volume change between surveys are presented in Appendix H.

The average volumetric gain between nearshore surveys when accretion occurred was 5 cubic yards per foot (12.6 cubic meters per meter); the average loss was 4.9 cubic yards per foot (12.3 cubic meters per meter). Since the nearshore section of the profiles is about five times longer than the beach section, these volumetric changes indicate that the magnitude of change (per foot of profile length) is of the same order onshore as it is in the nearshore zone. However, this conclusion is complicated by the unknown changes during times of buried or missing pipes. Intervals during which there were no measurable net volume changes between nearshore surveys occurred about 11 percent of the time.

The greatest nearshore loss (-24.3 cubic yards per foot, -61.0 cubic meters per meter) between surveys occurred on profile line I between 8 and 10 March 1971. During the same interval the beach lost 0.9 cubic yard per foot (2.3 cubic meters per meter) and the shoreline eroded 3.3 feet. The greatest nearshore gain (+29.9 cubic yards per foot, +75.0 cubic meters per meter) occurred on profile line III between 30 March and 1 April 1970. The beach showed no measurable change in volume or shoreline position during the same interval. Although larger nearshore volume changes are suggested by the data, they could not be quantified due to the problem of lost or buried pipes.

d. Onshore-Offshore Changes. An objective of this study was to quantify the volume of material transported between the beach and nearshore region. This onshore-offshore transport has been recognized by many investigators (e.g., Johnson, 1919; King, 1959; and Shepard, 1963), and is especially evident in some localities as a seasonal fluctuation between a "summer" beach and "winter" beach. During storm conditions the higher, steeper waves remove sand from the beach, depositing it as a bar in the surf zone. As the storm conditions subside the bars begin to migrate onshore, welding to the foreshore (Davis and Fox, 1972). Other investigators have reported a more complex onshore-offshore bar migration (e.g., Goldsmith, 1969; Richter, 1974).

Figures 55 to 58 are plots of the beach volume changes versus the nearshore volume changes between surveys on each of the four profile lines at Boca Raton. The expected trend of onshore-offshore sand transport is plotted as a diagonal. However, this trend is not observed since

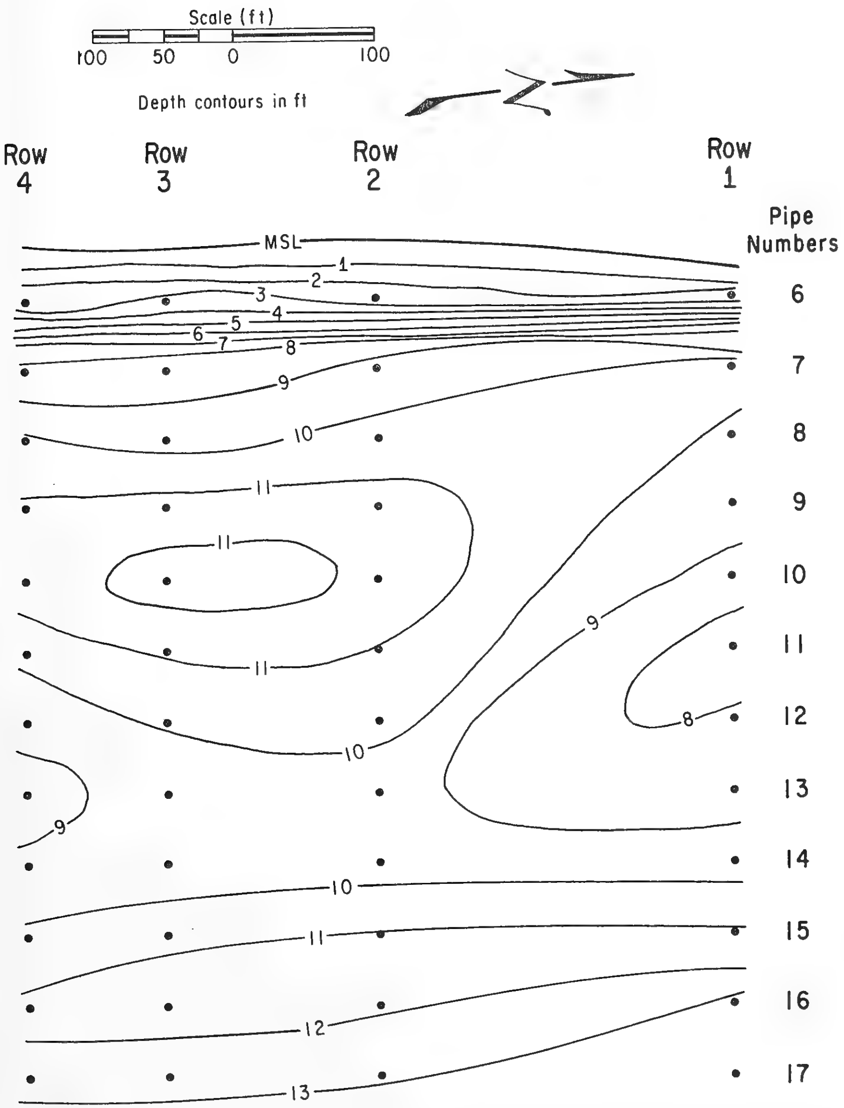


Figure 47. Nearshore bathymetry at Boca Raton, 1 October 1969 (depths in feet).

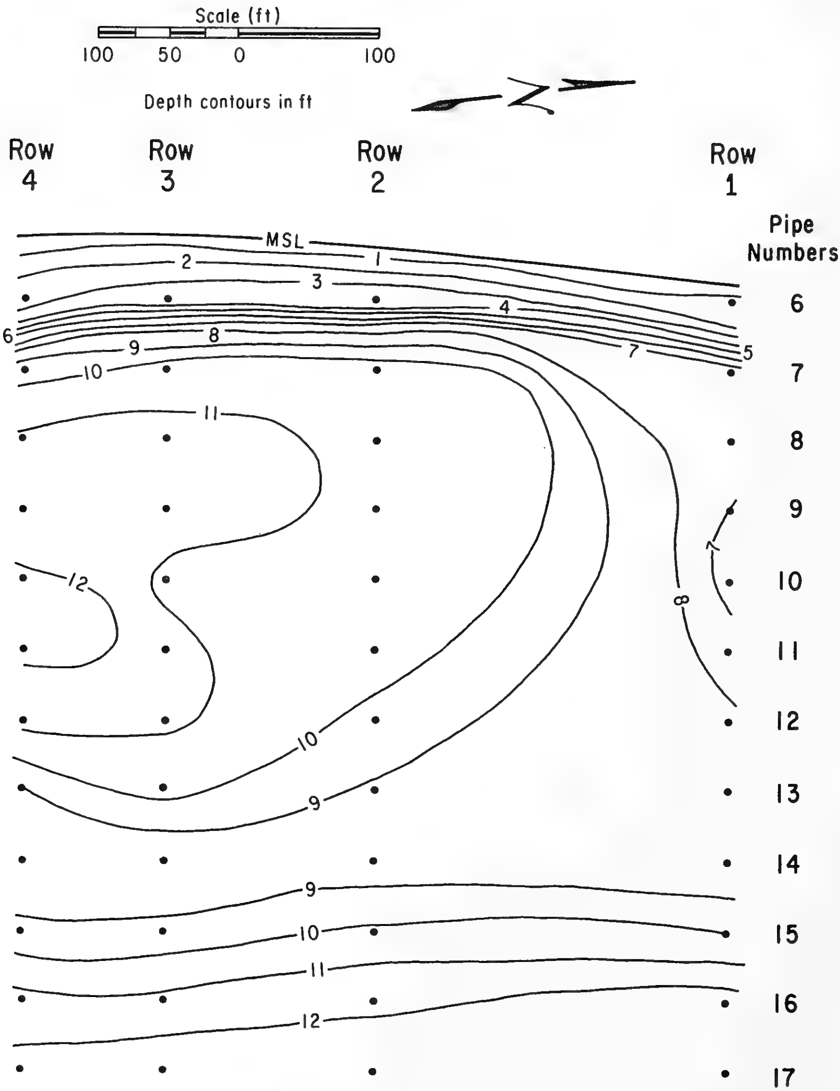


Figure 48. Nearshore bathymetry at Boca Raton, 27 February 1970 (depths in feet).

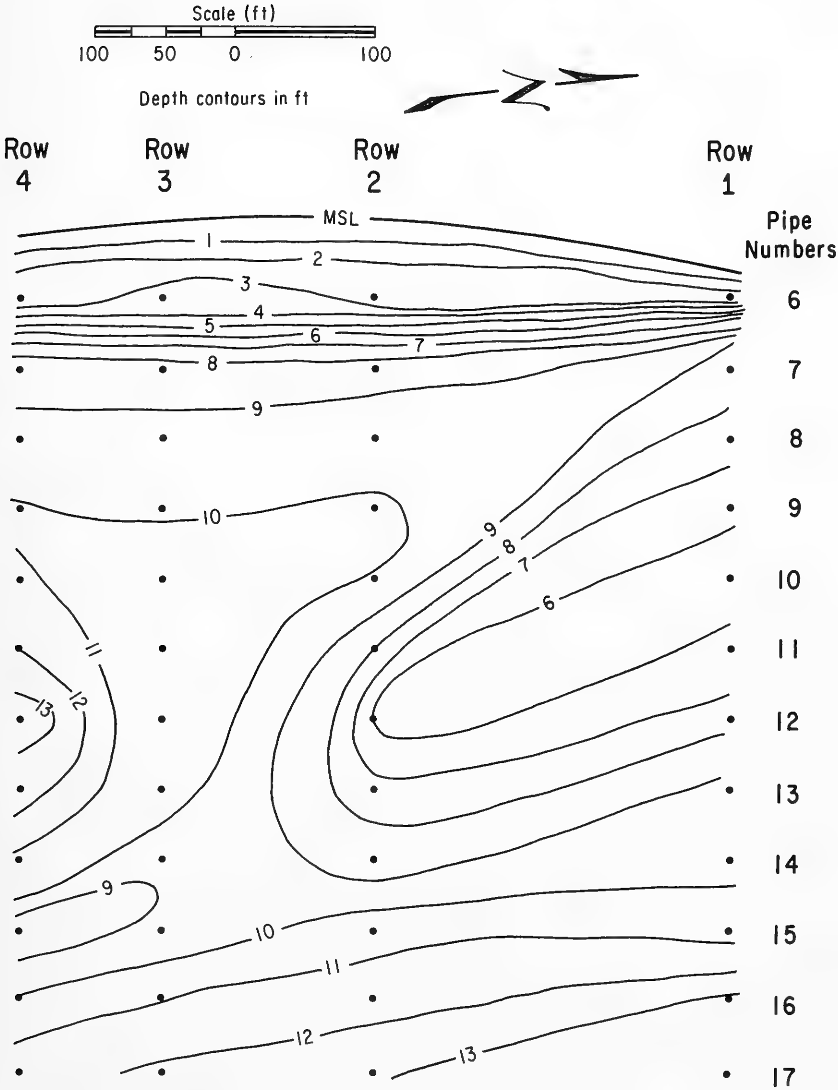


Figure 49. Nearshore bathymetry at Boca Raton, 30 September 1970 (depths in feet).

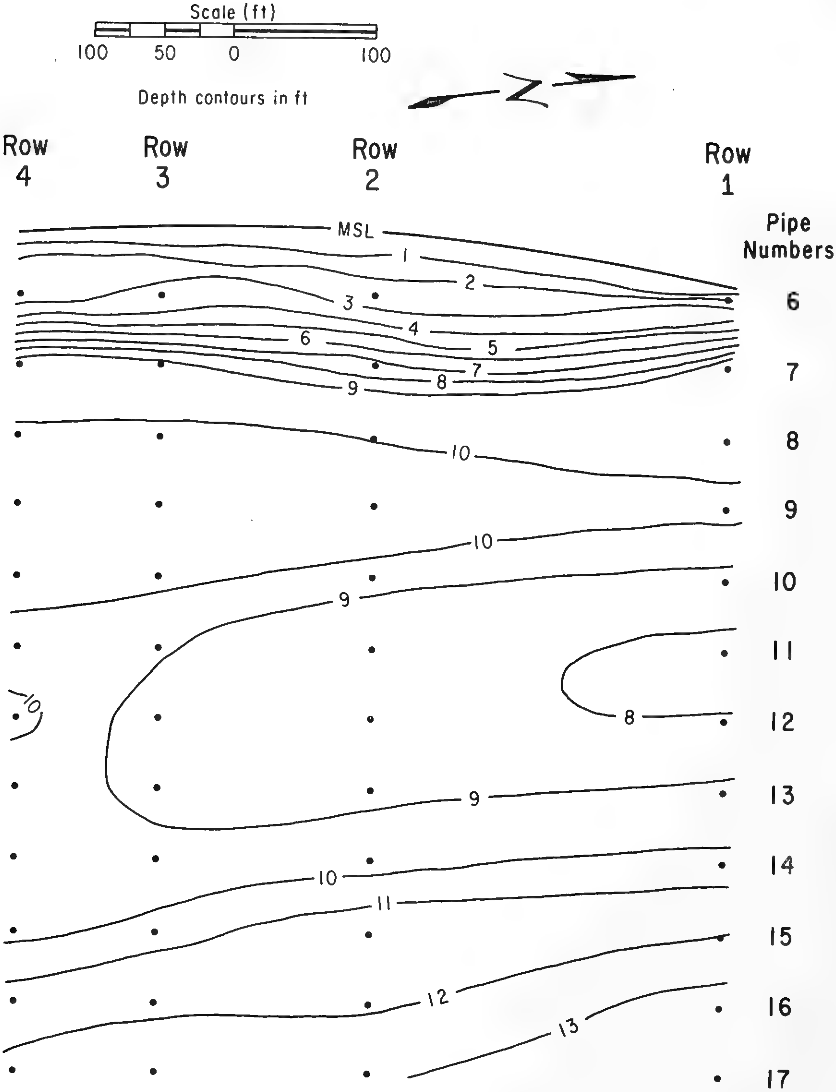


Figure 50. Nearshore bathymetry at Boca Raton, 30 April 1971 (depths in feet).

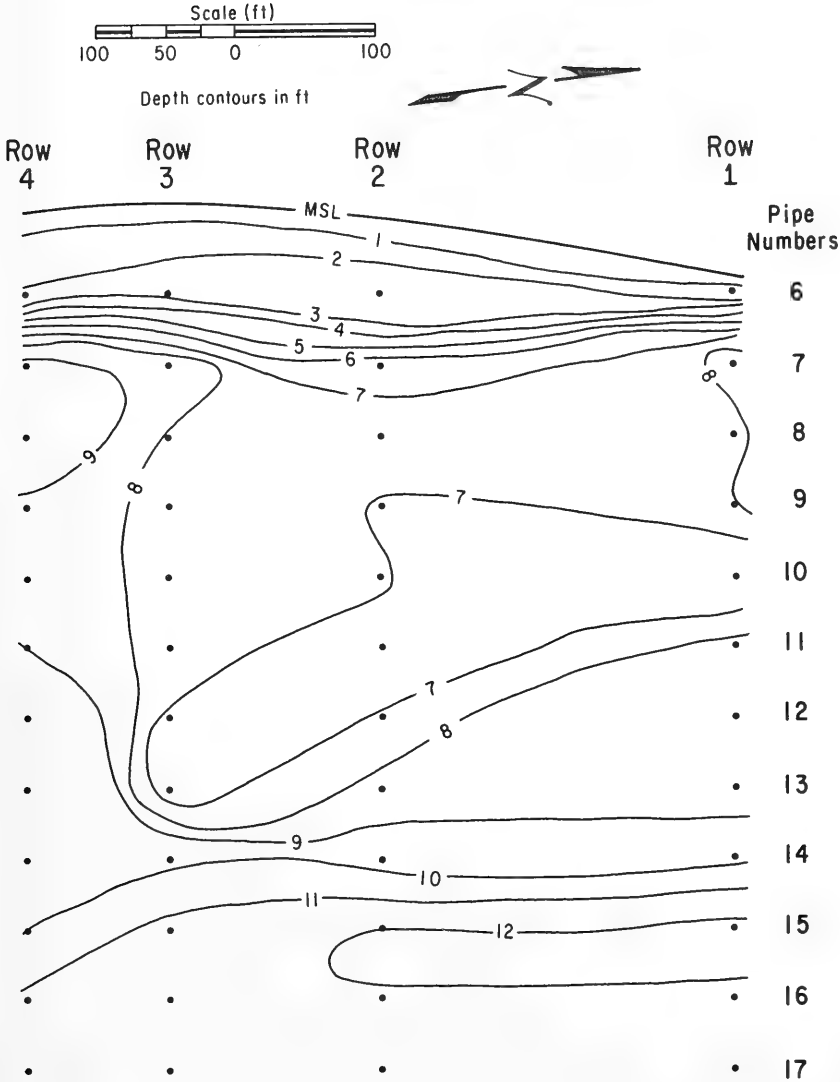


Figure 51. Nearshore bathymetry at Boca Raton, 27 August 1971 (depths in feet).

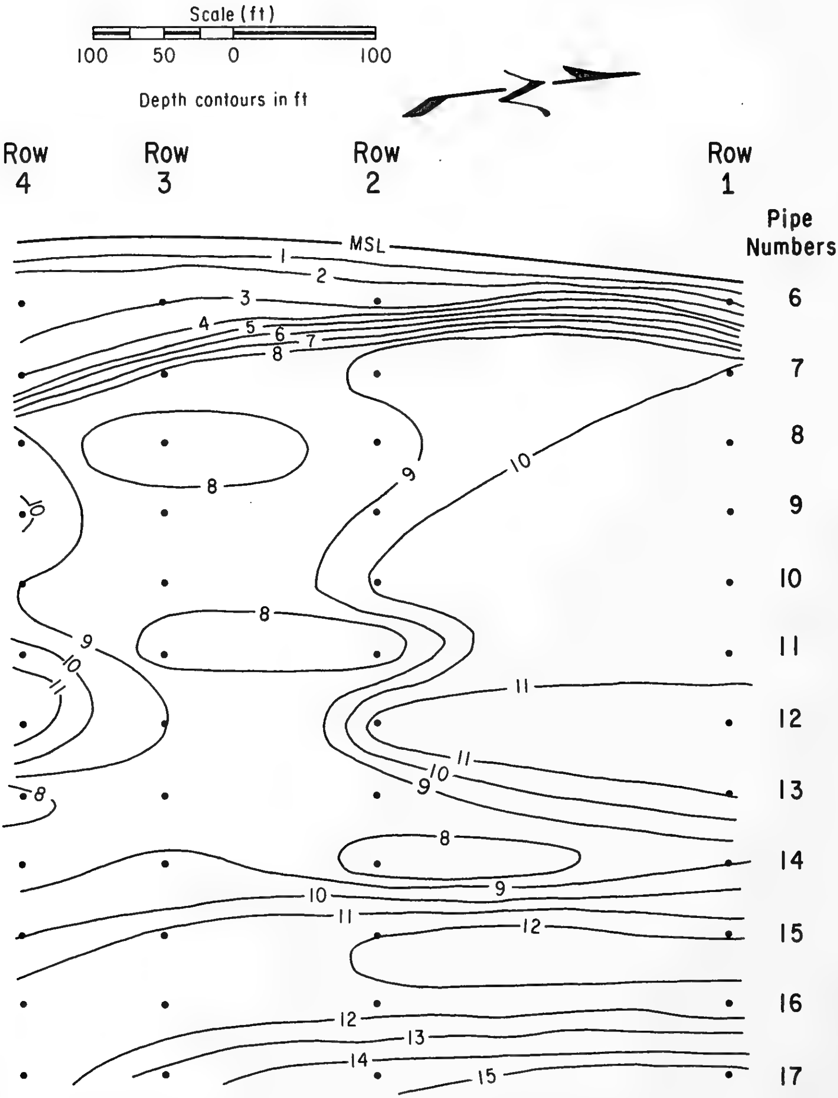


Figure 52. Nearshore bathymetry at Boca Raton, 28 February 1972 (depths in feet).

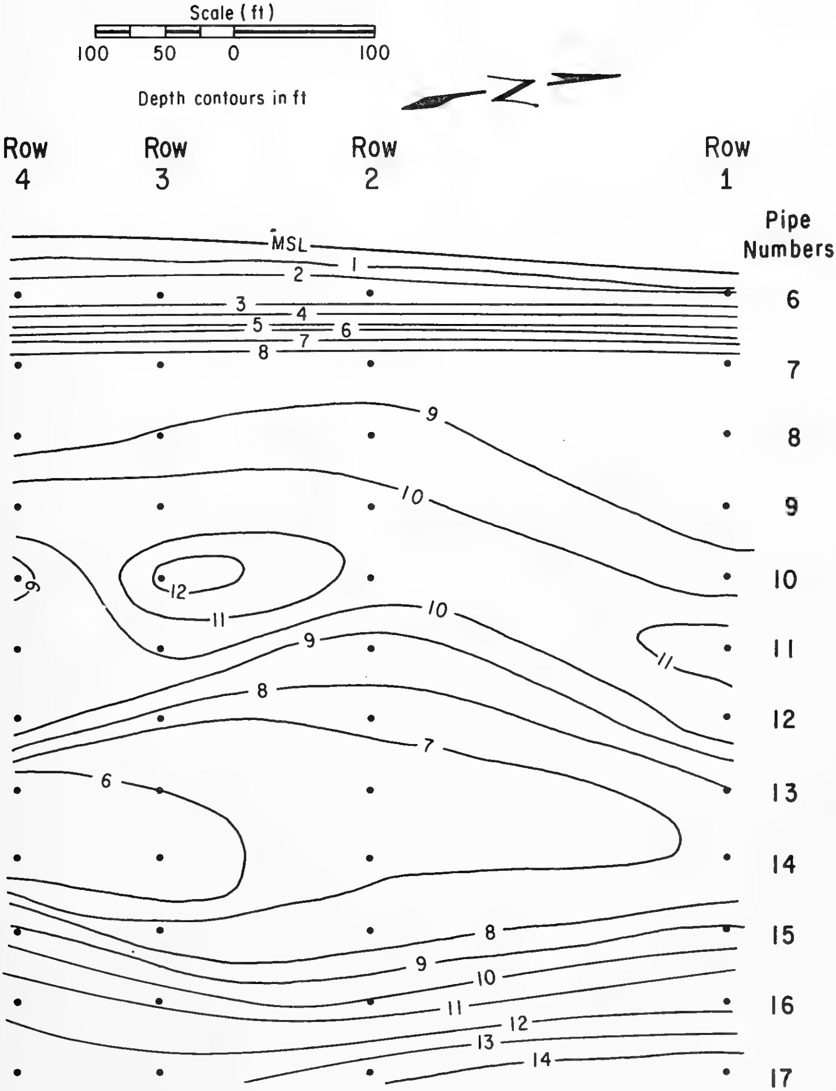


Figure 53. Nearshore bathymetry at Boca Raton, 28 February 1973 (depths in feet).

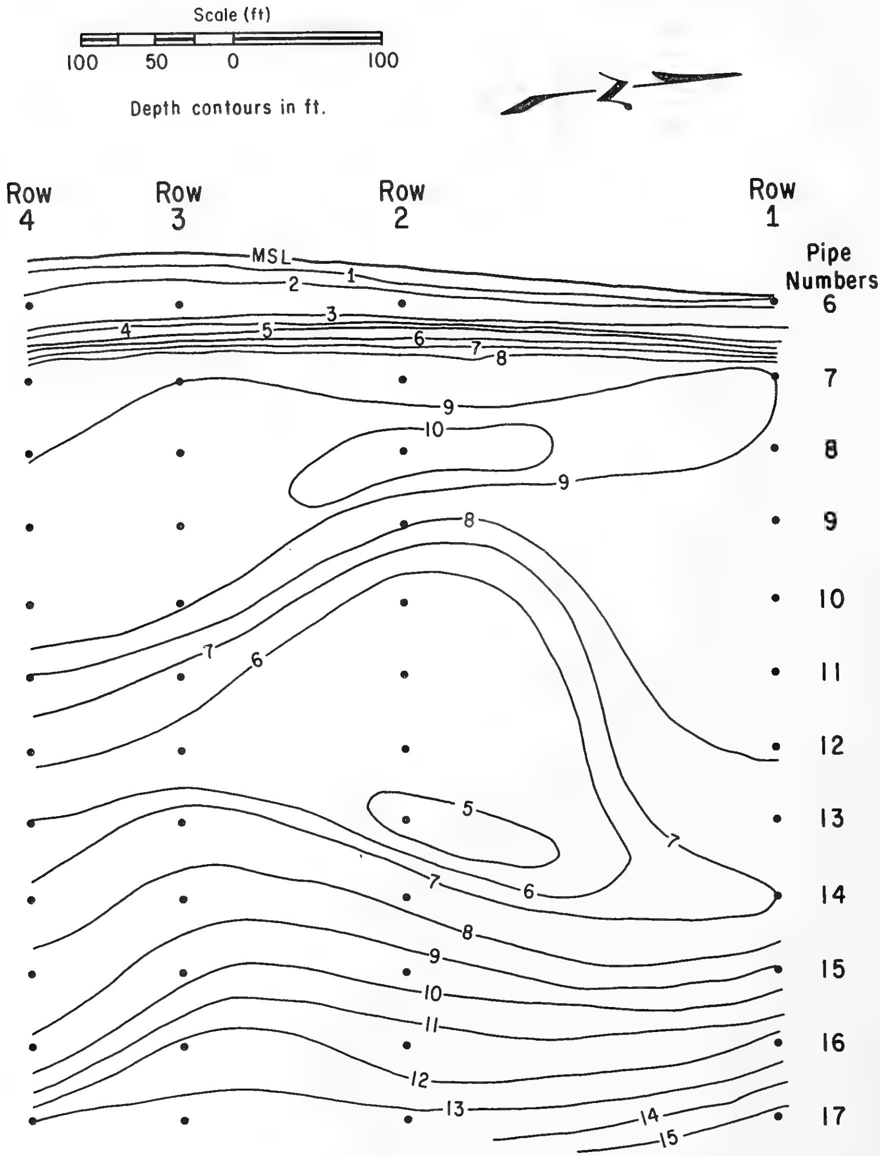


Figure 54. Nearshore bathymetry at Boca Raton, 27 June 1973 (depths in feet).

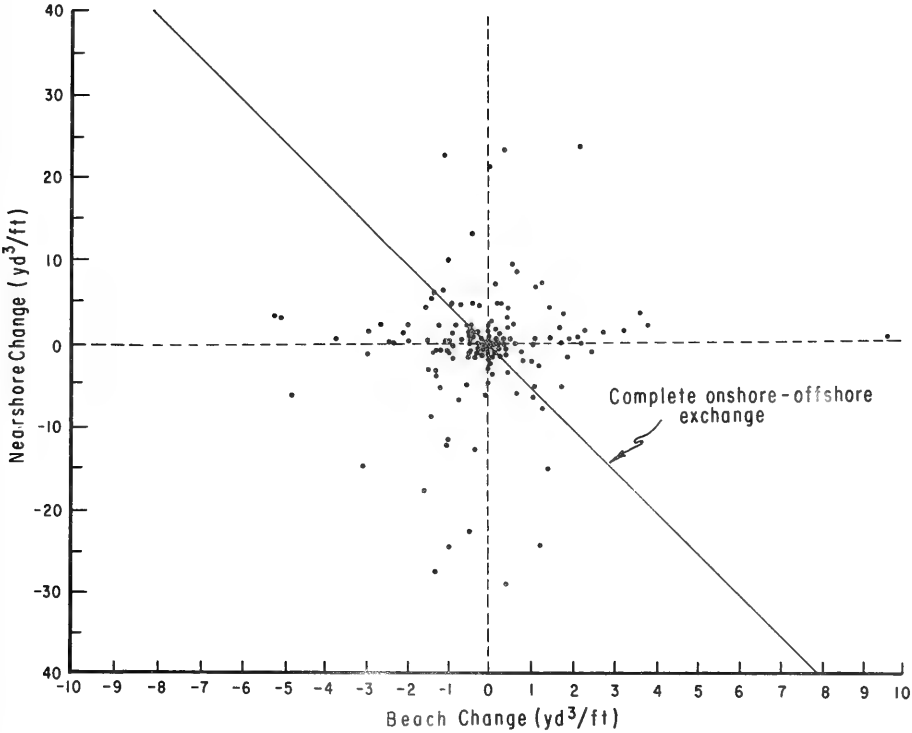


Figure 55. Beach versus nearshore volume changes at profile line I, Boca Raton.

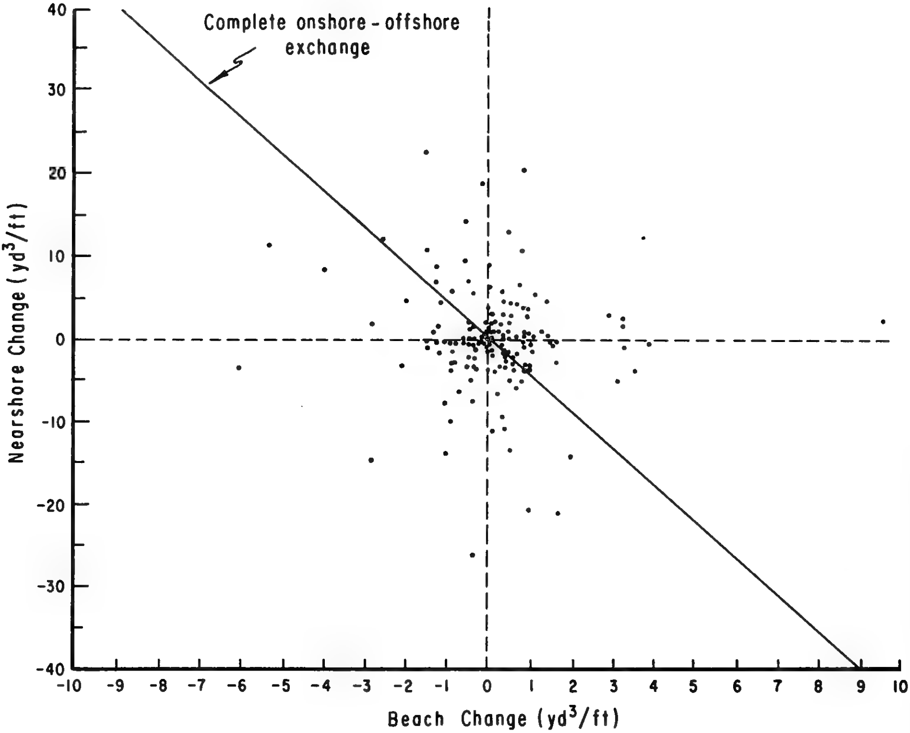


Figure 56. Beach versus nearshore volume changes at profile line II, Boca Raton.

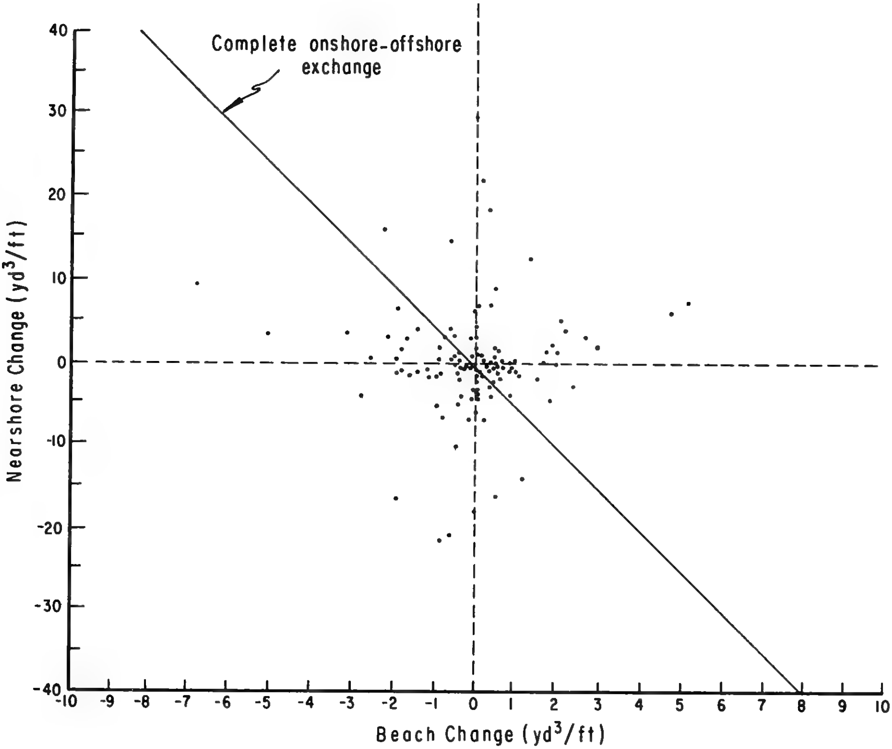


Figure 57. Beach versus nearshore volume changes at profile line III, Boca Raton.

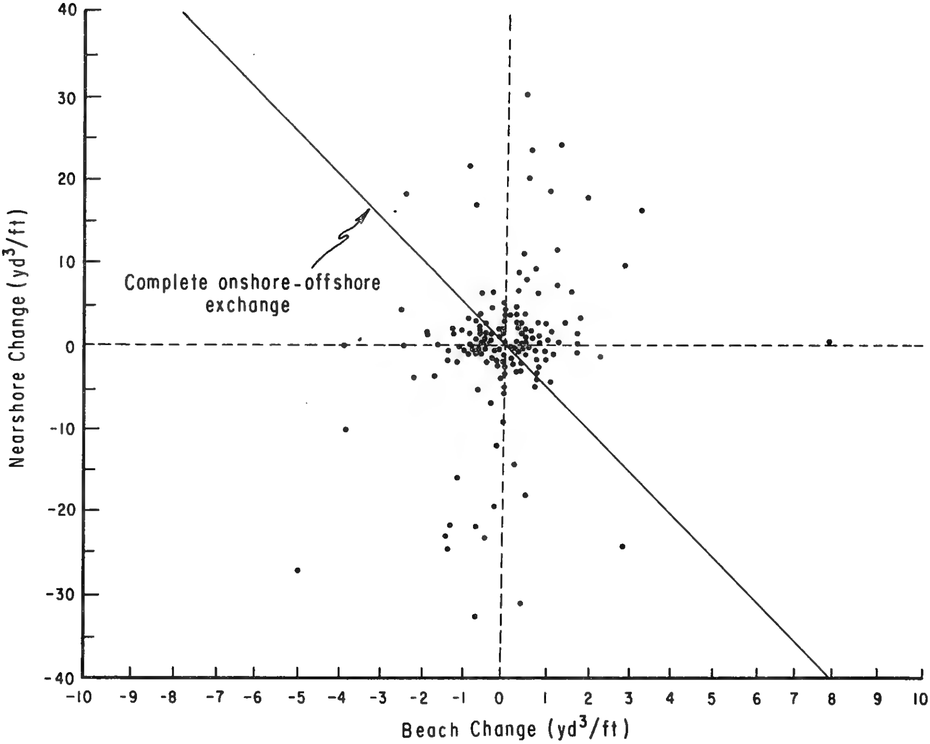


Figure 58. Beach versus nearshore volume changes at profile line IV, Boca Raton.

there is no obvious correlation between the volume changes on the two parts of the surveyed profiles. This may be an indication that most sand is moving in an alongshore direction, rather than in an onshore-offshore direction. The apparent lack of correlation also suggests that nearshore changes are not related to beach changes, but rather are related to the migration of nearshore bars in and out of the area being surveyed.

Other investigators working in the area (Duane and Meisburger, 1969; Raymond, 1972; Richter, 1974) have suggested that although sand can move offshore from the beaches, it is unlikely to move back onshore, due to the steplike configuration of the shore-parallel reefs. This might be reflected by a gain in the subaqueous profiles at the expense of the subaerial profiles. However, no such evidence is apparent from Figures 51 to 54.

4. Hollywood.

The beach width on the two Hollywood profiles ranged from a minimum of 66 feet (20 meters) to a maximum of 130 feet (40 meters), both occurring in February 1973. The average berm elevation was 5.4 feet (1.6 meters). The average monthly foreshore slope ranged from 9° to 12°, with an average slope of 11° (1 on 5.1). The maximum elevation change at any station was 6.8 feet (2.1 meters) of erosion between December 1970 and December 1972 at pipe 4 (north row). This change was concurrent with a subaerial beach volume loss of 9.34 cubic yards per foot (23.3 cubic meters per meter) during the 2-year period.

a. Short-Term Changes. A total of 223 sets of profile surveys was made at Hollywood at an average of once each 7.4 days over the study period. Plots of the cumulative change between surveys in the MSL-shoreline position and in the volume change above the MSL contour are presented in Appendixes F and G.

The average change in the MSL shoreline position between weekly surveys was approximately 5 feet in either a landward or seaward direction. The average volumetric gain between weekly surveys when accretion occurred was 0.9 cubic yard per foot (2.3 cubic meters per meter) of beach; the average loss was 0.7 cubic yard per foot.

Storm changes for three specific storms are listed in Table 4. The largest volume loss between weekly surveys (-4.9 cubic yards per foot) occurred on profile line I (north) between surveys on 2 and 9 December 1969. This corresponded to a shoreline retreat on profile line I of 8 feet. Profile line II (south) accreted 2.9 cubic yards per foot (7.3 cubic meters per meter), with a 28-foot seaward translation of the shoreline over the same 7-day interval. The Lake Worth wave gage was not operational during this interval. LEO data collected during the two surveys do not indicate unusual wind, wave, or current conditions. Breaker heights of 2 feet or less were observed at Boca Raton during the period of 2 to 9 December 1969. Winds were northeast at 18 miles per hour on 5 December and southeast at 22 miles (35 kilometers) per hour on 9 December. Otherwise winds were west and northwest at 19 miles (30 kilometers) per hour or less. Daily Weather Maps (National Oceanic and Atmospheric Administration, 1969) indicated a front passing through the study area late on 7 December or early 8 December.

The largest accretion between weekly surveys occurred on profile line I between the 27 February and 6 March 1973 surveys. A volume gain of 7.8 cubic yards per foot (19.6 cubic meters per meter) and a shoreline advance of 57 feet (17.4 meters) were computed. This accretion occurred shortly after the 9 to 12 February 1973 storm.

b. Long-Term Changes. A seasonal trend was not as apparent at Hollywood as at Jupiter and Boca Raton (Figs. 59 and 60). The average rate of change of the MSL shoreline for the two profiles was 2.9 feet (0.9 meter) per year in a landward direction. However, the net volume rate of change for the two profiles indicated a slight gain of 0.04 cubic yard per foot (0.10 cubic meter per meter) per year.

The two profiles, which were spaced only 250 feet apart often underwent changes that were opposite in sign; i.e., when profile line I was undergoing a gain in shoreline position and sand volume, profile line II was often eroding. When profile line II was accreting, profile line I was often eroding. This suggests that sand waves were moving along the shore, although more than two profile lines are needed to confirm wavelengths and direction of movement. A volumetric gain or loss on either profile was generally associated with a gain or loss in the MSL shoreline position on the profile. The average monthly gain or loss on the Hollywood profiles was a volume change of 0.88 cubic yard per foot (2.2 cubic meters per meter) per month and a shoreline change of 5.2 feet per month.

Monthly averages of the MSL shoreline position and sand volume for an average year are plotted in Figures 61 and 62. These averages indicate that November is the month of minimum sand in storage on the beach and minimum beach width. Maximum beach volume occurs in May and September; maximum beach width in March.

5. Three-Hourly Observations.

Ten sets of continuous LEO observations and beach profile surveys were made at 3-hour intervals through two complete tidal cycles during the following periods: 4 and 5 December 1969, 8 and 9 February 1973, and 6 and 7 June 1973 at Jupiter; 16 and 17 October 1969, 1 and 2 February 1973, 23 and 24 May 1973, and 18 and 19 June 1973 at Boca Raton; and 6 and 7 January 1970, 3 and 4 February 1973, and 30 and 31 May 1973 at Hollywood. Data from three sets of these observations are summarized in Figures 63, 64, and 65. Each set represents the series showing the largest change in the beach profiles at the locality.

In general, weather was relatively calm throughout most of the continuous observation sets, and changes in the subaerial beach profiles were small. Subaqueous surveys were not included in the 3-hourly surveys.

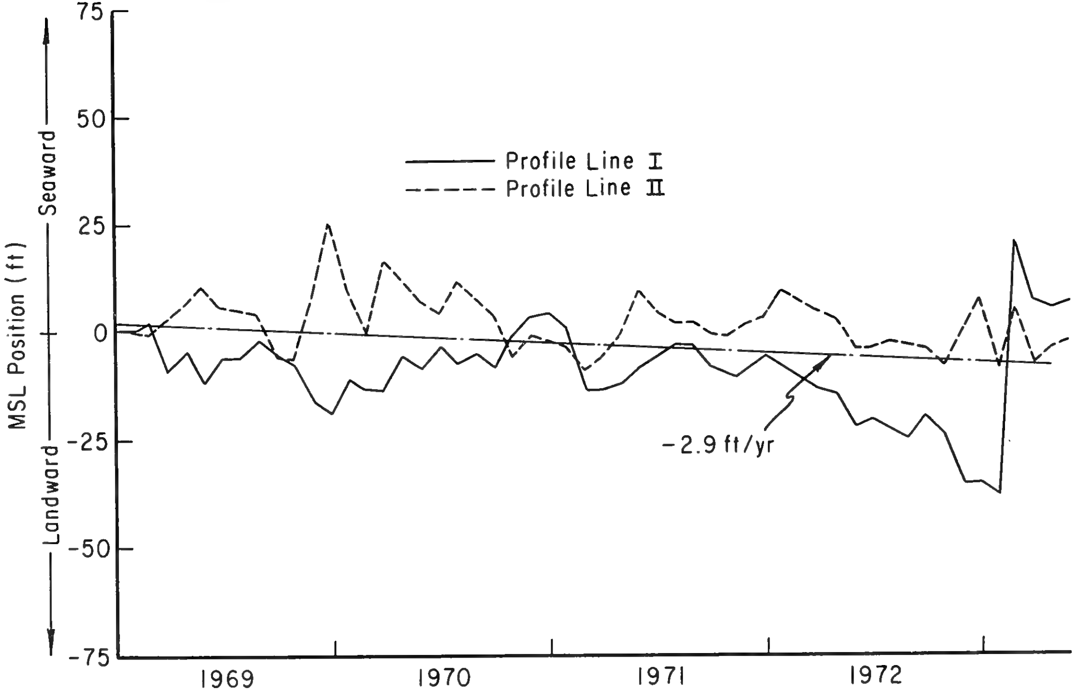


Figure 59. Annual and long-term changes in MSL position at Hollywood.

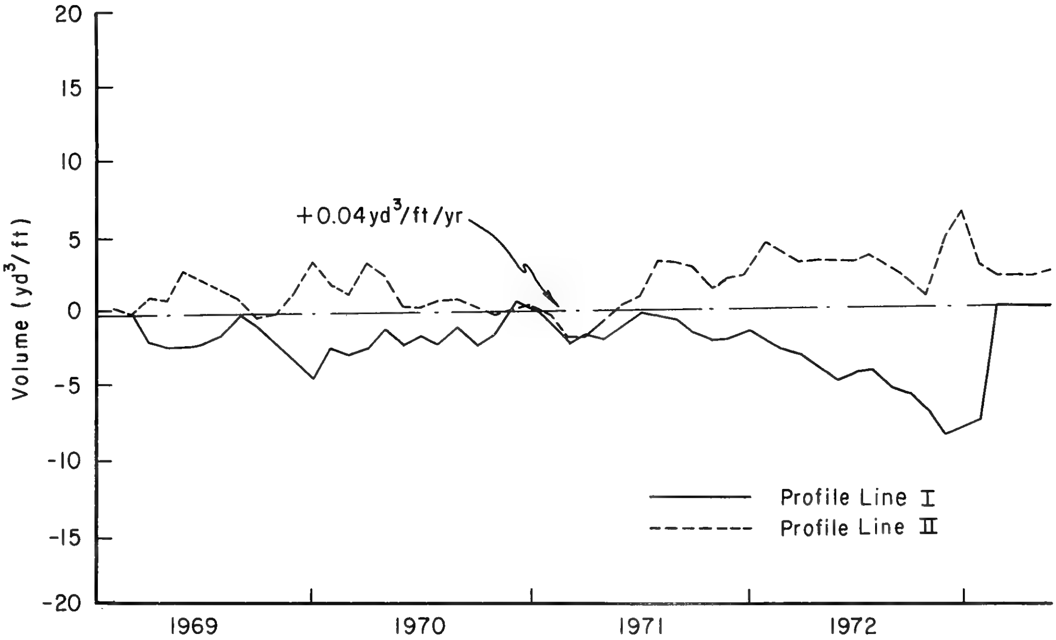


Figure 60. Annual and long-term changes in sand volume on subaerial beach at Hollywood.

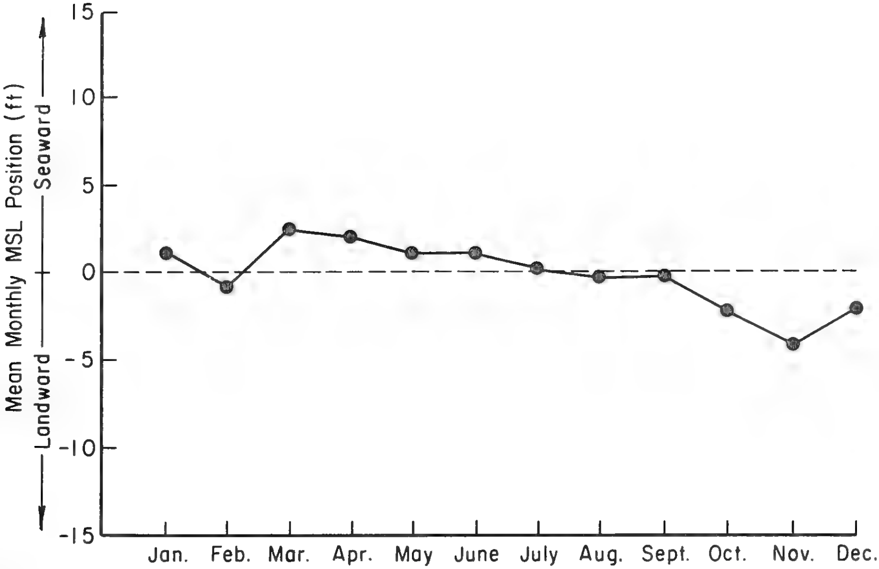


Figure 61. Seasonal change in MSL position at Hollywood.

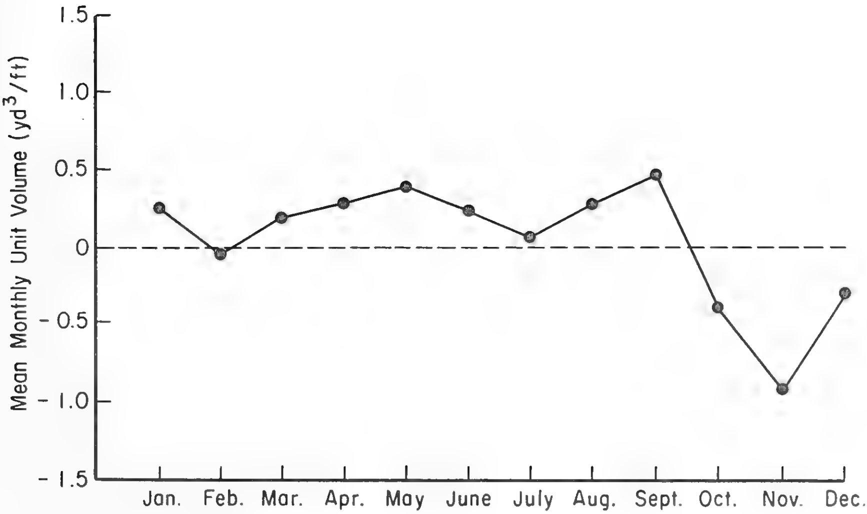


Figure 62. Seasonal change in subaerial beach volume at Hollywood.

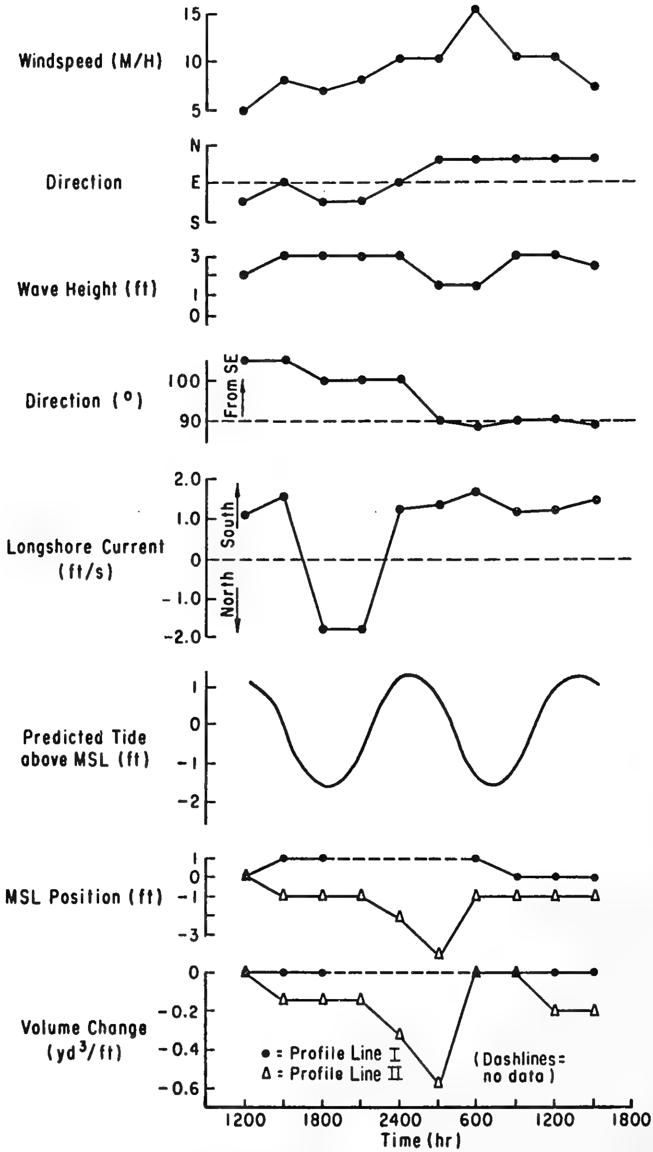


Figure 63. Three-hourly observations, 6 and 7 June 1973, Jupiter.

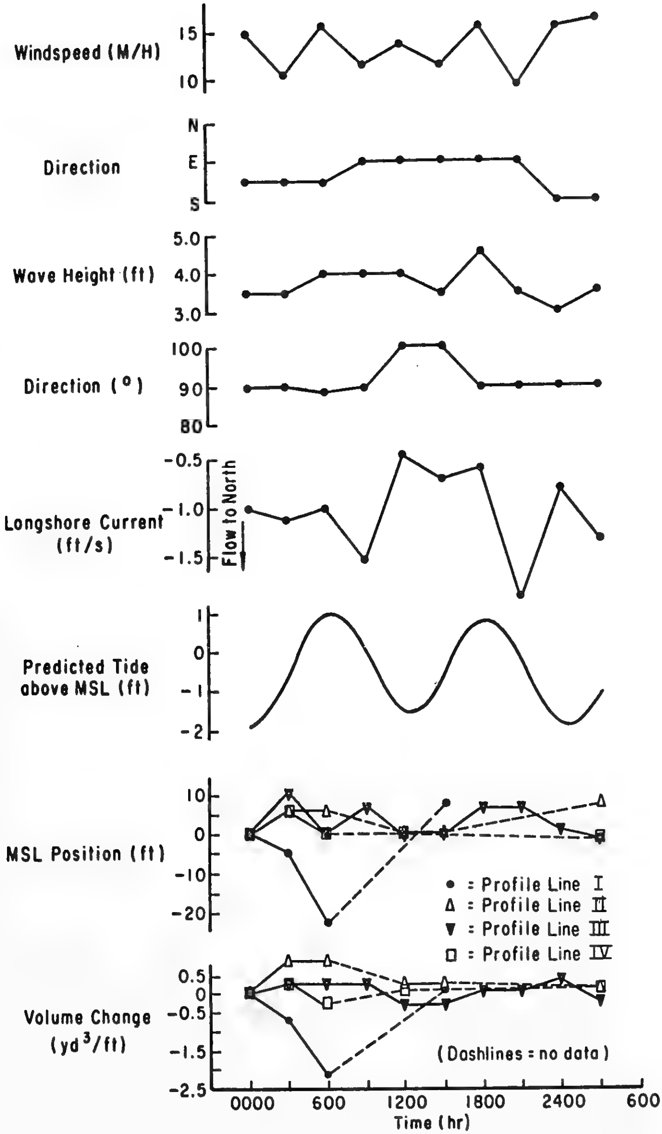


Figure 64. Three-hourly observations, 1 and 2 February 1973, Boca Raton.

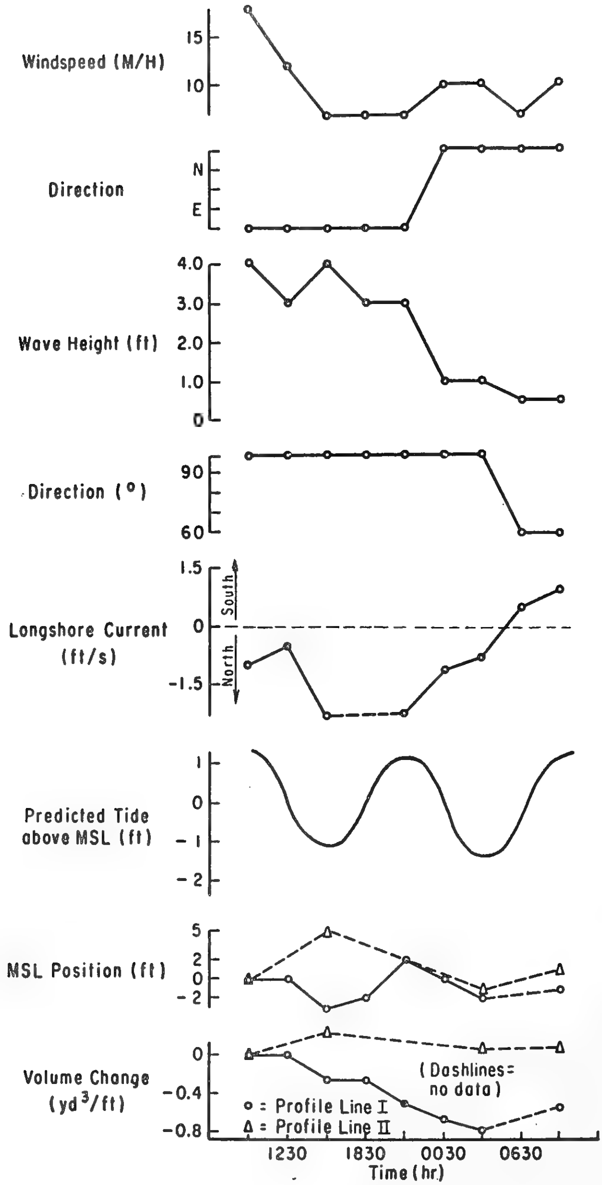


Figure 65. Three-hourly observations, 6 and 7 January 1970, Hollywood.

Breaker height during the 6 and 7 June 1973 series at Jupiter averaged 2.7 feet (0.8 meter) (Fig. 63). The longshore current averaged 1.2 feet (0.37 meter) per second from the north, except for a period of flow toward the north between 1500 and 2400 hours, when two observations of -1.9 feet (-0.58 meter) per second were made. Almost no change was observed on profile line I; profile line II showed a slight loss (0.6 cubic yard per foot, 1.5 cubic meters per meter) coincident with the second current reversal (returning to flow from the north) and high tide. This was followed by a recovery on the falling tide.

The 1 and 2 February 1973 series at Boca Raton shows the strongest wave and current conditions and the largest beach changes of any of the series of 3-hour observations (Fig. 64). Breakers averaging 3.7 feet (1.1 meters) high generated current velocities averaging 1 foot per second to the north. A shoreline migration of +30 feet (+9.1 meters), representing a volume gain of 2 cubic yards per foot (5.02 cubic meters per meter), occurred during a 9-hour interval on profile line I. This coincided with a sharp drop in the longshore current velocity from -1.5 feet (-0.5 meter) per second to less than -0.5 foot (-0.2 meter per second) ebbtide. Shoreline and volume changes on profile lines II, III, and IV were significantly smaller.

The 6 and 7 January 1970 series at Hollywood began in a moderate breeze from the southeast, with 4-foot breakers and a falling tide. By the end of the series conditions were nearly calm. At the beginning of the series, profile line I was eroding, while profile line II was accreting. The maximum shoreline migration was about 5 feet on both profiles. Volume changes were 0.8 cubic yard per foot (2.0 cubic meters per meter) on profile line I and 0.2 cubic yard per foot (0.5 cubic meter per meter) on profile line II (Fig. 65).

A significant correlation was observed between recorded sand level changes and changes in observers during those series when more than one observer was used. This observer correlation was most apparent when sand level was recorded to the nearest 0.5 foot. Apparent sand level changes appeared to be merely cases of rounding errors and differences in measurement techniques.

V. SUMMARY

1. Observations.

During the 4.5-year period from January 1969 through June 1973, series of littoral environment observations and beach profile surveys were made at three locations along the southeast coast of Florida. Frequency of observations ranged from once weekly to once daily to once every 3 hours.

Prevailing winds were onshore at speeds ranging from 8 to 15 miles per hour. No hurricanes or major storms occurred during the study period. Gale-force winds were observed only once, at Jupiter, during the study. A good correlation was found between wind velocity and direction and breaker height and direction.

For the three sites, there was a systematic measured decrease in the severity of the wave climate, from north to south, as well as a decrease in the magnitude of beach changes from north to south (Figs. 66, 67, and 68). Breaker heights averaged 2.8 feet at an average approach direction from 2.9° to the north of shore-normal at Jupiter, 2.0 feet from a near-normal shoreline approach at Boca Raton, 1.6 feet feet at an average approach direction from 0.6° to the south of shore-normal at Hollywood. Direction data may be observer-biased toward larger angles from shore-normal (see Fig. 14). It is concluded that this systematic change is a result of the sheltering effect of the Bahamas.

Net longshore current speed increased with an increasing breaker angle from the shore-normal approach. Average longshore current speed (nondirectional) decreased from a maximum of 0.93 foot per second at Jupiter, to 0.92 foot per second at Boca Raton, and 0.81 foot per second at Hollywood.

The greatest fluctuation in width of the three beaches (50 to 180 feet) was observed at Jupiter. Boca Raton displayed the least fluctuation, 80 to 131 feet, as a result of the natural stabilizing effect from the coquina ledge occurring in the intertidal zone. Beach width at Hollywood ranged from 66 to 130 feet.

2. Seasonal Changes.

The lowest waves at all three sites occur during the summer months and arrive from the southeast; the higher waves occur during the winter months and arrive from the northeast. Net longshore current speed and direction are directly related to breaker direction. Breakers approaching from the northeast generate currents flowing toward the south; breakers approaching from the southeast generate currents flowing toward the north.

Beach changes are seasonal at the three localities, but are reversed at Boca Raton. At Jupiter and Hollywood, beaches are narrowest in the winter with the least amount of sand in storage. At Boca Raton, which is 40 miles south of Jupiter and 25 miles north of Hollywood, the beach is widest in the winter with the greatest amount of sand in storage; the maximum beach loss rates occur during the summer months. Seasonal beach changes are two to three times the magnitude of year-to-year changes. The magnitude of beach changes through a tidal cycle was of the same order as the observed seasonal changes.

3. Transport.

Prediction of longshore transport rates at each site, using breaker height and direction data, confirms a previously published southward-decreasing trend. The prediction of net longshore transport rates suggests a nodal zone of convergence between Boca Raton and Jupiter, although this feature has not been demonstrated in other studies.

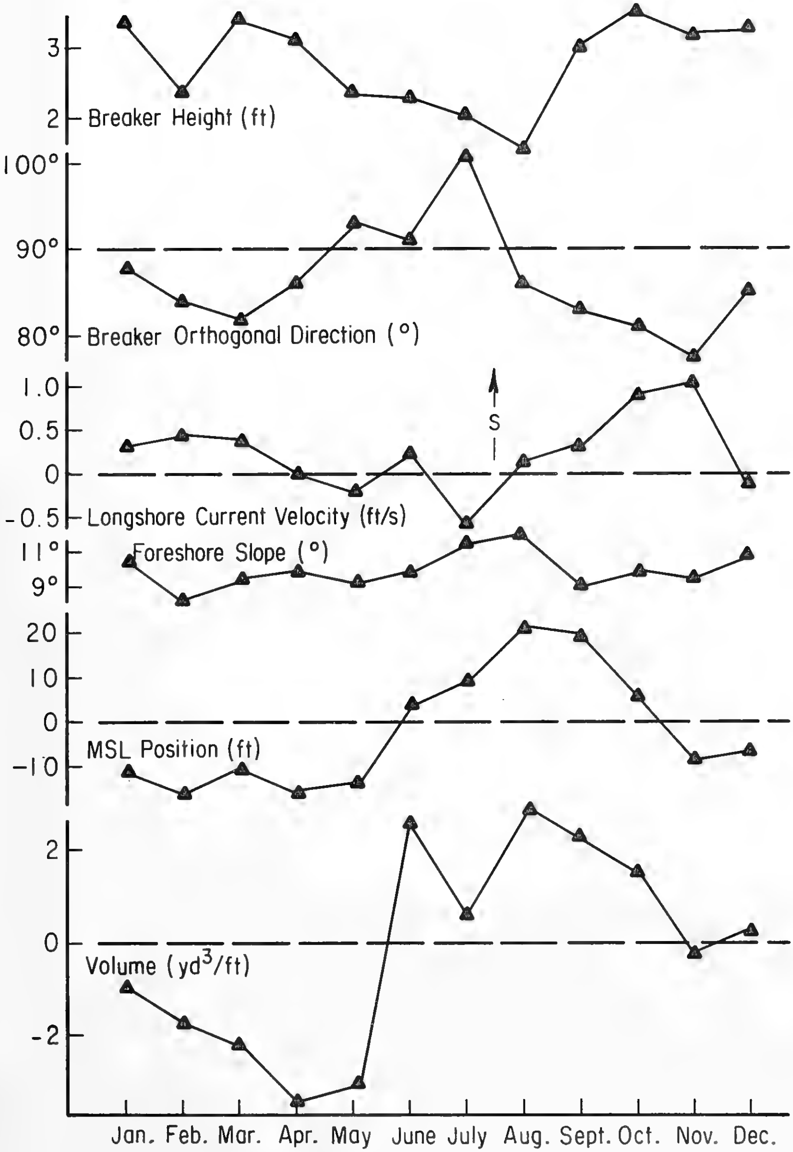


Figure 66. Monthly averages of observations, Jupiter.

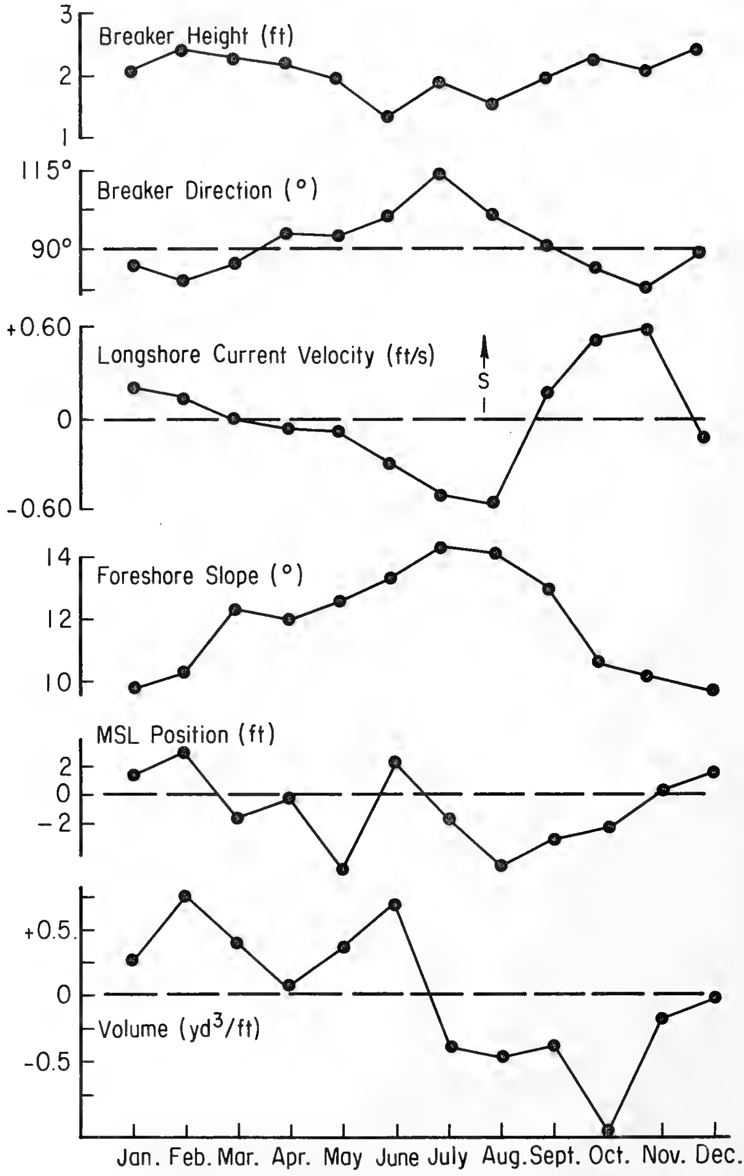


Figure 67. Monthly averages of observations, Boca Raton.

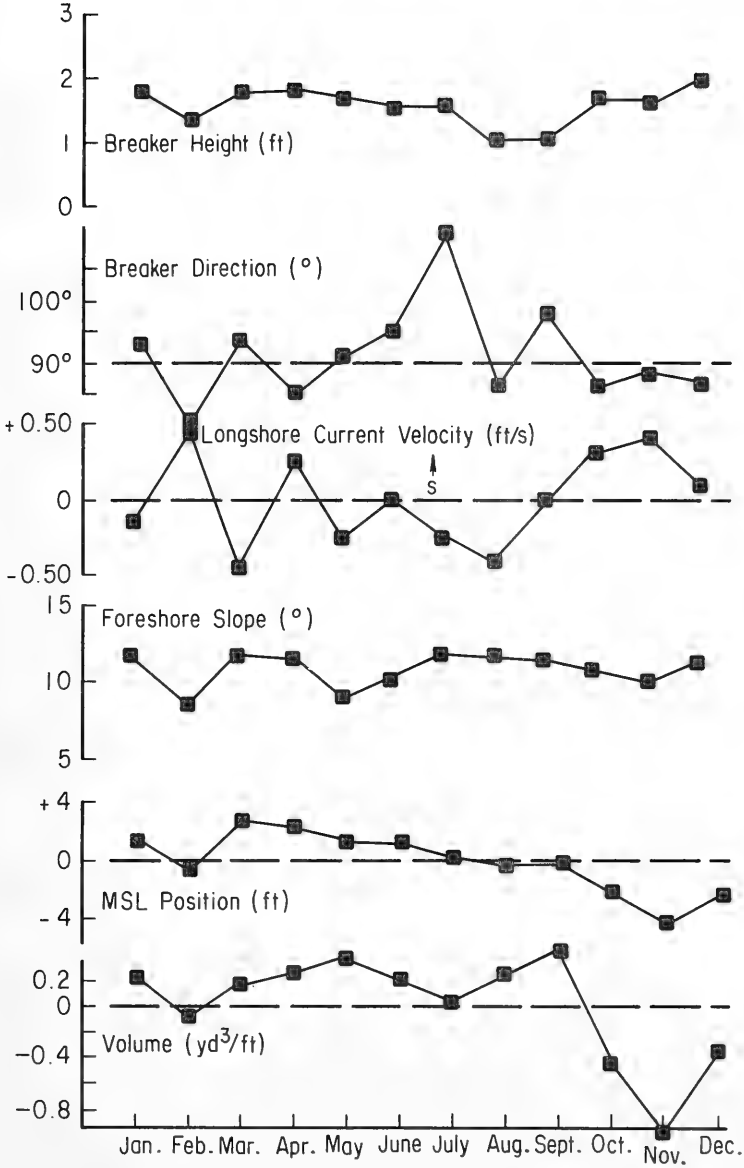


Figure 68. Monthly averages of observations, Hollywood.

The annual rates of MSL shoreline migration and volume changes for the three localities are summarized in Table 5. All profile lines at Jupiter and Hollywood showed a net erosion, as indicated by the MSL shoreline position. However, one profile line at each of the two sites indicated a net annual gain in beach volume. The net volume change at Jupiter was a loss of 0.71 cubic yard per foot per year; the net change at Hollywood was essentially zero. The profile lines at Boca Raton, however, indicated accretion, both by shoreline progradation and by beach volume. The volume changes computed over this 4.5-year study are similar to those computed by the U.S. Army, Corps of Engineers (1971) for a 26-year period ending in 1955.

Table 5. Rates of change on three southeast Florida beaches.

Locality	Profile line	Change	
		MSL shoreline (ft/yr)	Beach volume (yd^3/ft/yr)
Jupiter	I	−0.30	+0.53
	II	−0.42	−1.97
Boca Raton	I	+2.08	+0.34
	II	+2.33	−0.96
	III	−0.37	+1.44
	IV	+1.84	+0.76
Hollywood	I	−3.48	−0.70
	II	−2.24	+0.79

The magnitude of nearshore profile changes at Boca Raton was comparable to the magnitude of the beach profile changes. However, the changes on the two sections of the profiles were not directly related. Shore-parallel reefs and the beach-rock ledge at and below the MLW line impede the transfer of sand from the nearshore zone to the beach, but allow sand to flow from the beach to the offshore zone. Neither the beach nor the nearshore profiles provide conclusive evidence of migrating sand waves. The presence of sand waves is suggested by changes on the two Hollywood profile lines.

4. Wave Statistics.

Observations of breaker height and period made on a once-a-week basis over the 4.5-year period resulted in the same average as observations collected five times a week.

Of the three methods used to record breaker direction, the method allowing notation to the nearest degree was the most useful for predicting longshore transport rates, although it probably overestimates the frequency of waves approaching from 90° to the shoreline.

5. Coastal Engineering Design Implications.

When weekly height and period observations were statistically compared with daily height and period observations, no significant difference was found. This suggests that for long-term averages, weekly littoral environment observations collected over several years will provide representative data of average conditions. However, weekly observations will not provide information on the more important extreme events.

Experience indicates that weekly beach profile surveys adequately document seasonal and year-to-year beach changes.

The pipe profile surveying method is very useful for obtaining accurate data through the breaker zone and in the nearshore region. However, certain safety and logistics problems must be carefully considered before using this technique.

Long-term beach changes computed for the three southeast Florida beaches are relatively small when compared to changes reported for beaches on more exposed coasts (U.S. Army, Corps of Engineers, Coastal Engineering Research Center, 1975). However, storm changes were found to be of a magnitude similar to those reported for more exposed coasts, especially at Jupiter.

The underlying coquina limestone and the sheltering effect of the Bahamas both have a stabilizing influence on the southeast Florida beaches. The effect of storm waves from the open Atlantic Ocean is greatly reduced, due to the protection afforded by the Bahama Banks. Once the veneer of sand has been removed by storm waves or other forces, the underlying coquina greatly reduces further erosion.

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APPENDIX A

RAPID SEDIMENT ANALYZER RESULTS

Table A-1. RSA results from Jupiter.

LOCATION	PROFILE	CONSECUTIVE NUMBER	DATE	DEPTH ZONE(1)	MEDIAN (PHI)	MEDIAN (MM)	MEAN (PHI)	MEAN (MM)	ST DEV (PHI)	ST DEV (MM)	PIPE NO.
Jupiter	01	595	07NOV71	1	1.15	.451	1.19	.438	.55	.683	
	01	596	07NOV71	3	1.30	.406	1.36	.390	.55	.683	
	01	597	30DEC71	1	1.64	.321	1.66	.316	.53	.693	01
	01	598	30DEC71	3	1.29	.409	1.39	.382	.43	.742	05
	01	498	07SEP72	0	1.38	.384	1.40	.379	.53	.693	01
	01	499	07SEP72	1	1.25	.420	1.35	.392	.43	.742	02
	01	500	07SEP72	1	1.14	.454	1.24	.423	.53	.693	03
	01	501	07SEP72	1	.60	.660	.71	.611	.47	.722	04
	01	502	07SEP72	1	1.31	.403	1.37	.387	.48	.717	05
	01	503	07SEP72	1	1.19	.438	1.23	.426	.55	.683	06
	01	505	07SEP72	4	1.38	.384	1.39	.382	.54	.688	08
	01	506	07SEP72	5	1.79	.289	1.82	.283	.66	.653	09
	01	507	07SEP72	5	1.77	.293	1.82	.283	.63	.646	10
	01	508	05OCT72	0	1.41	.376	1.45	.366	.47	.722	01
	01	509	05OCT72	1	1.20	.435	1.30	.406	.48	.717	02
	01	510	05OCT72	1	1.25	.420	1.34	.395	.51	.702	03
	01	511	05OCT72	1	.95	.518	.96	.514	.44	.737	04
	01	512	05OCT72	1	1.22	.429	1.31	.403	.71	.611	05
	01	513	05OCT72	3	.50	.707	.44	.737	.28	.824	06
	01	514	05OCT72	5	1.29	.409	1.31	.403	.55	.683	07
	01	515	05OCT72	5	1.45	.366	1.57	.337	.64	.642	08
	01	516	07DEC72	0	1.38	.384	1.46	.363	.44	.737	01
	01	517	07DEC72	1	1.04	.486	1.10	.467	.63	.646	02
	01	518	07DEC72	1	1.06	.480	1.19	.438	.52	.697	03
	01	519	07DEC72	1	1.27	.415	1.33	.398	.52	.697	04
	01	520	07DEC72	1	1.35	.392	1.38	.384	.50	.707	05
	01	521	07DEC72	5	1.59	.332	1.70	.308	.59	.664	06
	01	522	07DEC72	5	1.39	.382	1.57	.337	.63	.646	07
	01	523	07DEC72	5	1.34	.395	1.57	.337	1.01	.497	08
	01	524	07DEC72	5	2.54	.172	2.45	.183	.62	.651	09
	01	525	07DEC72	5	1.32	.401	1.42	.374	.63	.646	10
	01	579	25JAN73	0	1.36	.390	1.47	.361	.62	.651	01
	01	580	25JAN73	1	1.21	.432	1.25	.420	.52	.697	02
	01	581	25JAN73	1	1.11	.463	1.18	.441	.52	.697	03
	01	582	25JAN73	1	.92	.529	1.05	.483	.59	.664	04
	01	583	25JAN73	3	1.09	.470	1.19	.438	.46	.727	05
	01	584	25JAN73	4	1.01	.497	1.03	.490	.68	.624	06
	01	585	22MAR73	0	1.38	.384	1.49	.356	.51	.702	01
	01	586	22MAR73	1	1.17	.444	1.25	.420	.54	.688	02
	01	587	22MAR73	1	1.30	.406	1.38	.384	.48	.717	03
	01	588	22MAR73	1	1.03	.490	1.17	.444	.58	.669	04
	01	589	22MAR73	3	1.18	.441	1.26	.418	.51	.702	05
	02	419	15APR69	5	1.39	.382	1.46	.363	.36	.779	07
	01	590	22MAR73	5	.68	.624	.71	.611	.56	.678	06
	01	591	22MAR73	5	1.10	.467	1.18	.441	.56	.678	07
	01	592	22MAR73	5	1.25	.420	1.31	.403	.52	.697	08
	01	593	22MAR73	5	1.26	.418	1.32	.401	.55	.683	09
	01	594	22MAR73	5	1.52	.349	1.58	.334	.53	.693	10

(1)DEPTH ZONE 0=DUNE, 1=BERM, 2=MHW TO BASE OF BERM, 3=MIDTIDE TO MHW, 4=MLW TO MIDTIDE, 5=MLW TO -2 METERS 6=-2 TO -4 METERS, 7=-4 TO -8 METERS, * SWASH ZONE

Table A-2. RSA results from Boca Raton.

LOCATION	PROFILE	CONSECUTIVE NUMBER	DATE	DEPTH ZONE(1)	MEDIAN (PHI)	MEDIAN (MM)	MEAN (PHI)	MEAN (MM)	ST DEV (PHI)	ST DEV (MM)	PIPE NO.
Boca Raton	02	276	26SEP69	*	-.04	1.028	.16	.895	.61	.655	04
	02	250	5NOV69	*	.44	.737	.40	.758	.33	.796	**
	01	248	1OCT69	0	.95	.518	.98	.507	.43	.742	01
	02	260	0MAY69	1	.26	.835	.24	.847	.50	.707	04
	02	246	28MAY69	0	.76	.590	.84	.559	.42	.747	01
	02	251	4JUN69	0	.95	.518	1.01	.497	.47	.722	01
	02	257	18JUN69	1	-.20	1.149	-.19	1.141	.43	.742	04
	02	256	17JUN69	1	.99	.503	.98	.507	.54	.688	04
	02	255	18JUN69	0	.84	.559	.93	.525	.42	.747	01
	02	261	9JUL69	3	.19	.877	.20	.871	.27	.829	05
	02	252	8AUG69	0	.79	.578	.89	.540	.45	.732	01
	02	259	8AUG69	3	.17	.889	.17	.889	.42	.747	05
	02	278	18AUG69	0	.90	.536	1.00	.500	.46	.727	01
	02	253	27AUG69	0	.86	.551	.94	.521	.41	.753	01
	02	275	17SEP69	0	.84	.559	.92	.529	.42	.747	01
	02	254	1OCT69	0	.77	.586	.85	.555	.44	.737	01
	02	249	1OCT69	1	.73	.603	.81	.570	.34	.790	04
	02	274	8OCT69	0	.98	.507	1.01	.497	.41	.753	01
	02	262	15OCT69	0	1.71	.306	1.72	.304	.37	.774	01
	02	258	18OCT69	1	.59	.664	.62	.651	.23	.853	04
	02	272	26OCT69	0	.53	.693	.59	.664	.45	.732	01
	02	279	29OCT69	0	.62	.651	.68	.624	.33	.796	01
	02	277	21NOV69	0	2.05	.241	2.06	.240	.21	.865	01
	02	420	14APR69	5	.53	.693	.59	.664	.38	.768	07
	02	234	4FEB70	*	.87	.547	.97	.511	.37	.774	**
	02	235	4FEB70	*	.47	.722	.50	.707	.26	.835	**
	02	268	30JUL69	0	.73	.603	.81	.570	.38	.768	01
	02	267	5NOV69	1	.79	.578	.88	.543	.38	.768	**
	02	236	11DEC69	*	.02	.986	.07	.953	.25	.841	**
	02	237	11DEC69	1	.66	.633	.75	.595	.39	.763	**
	02	232	24DEC69	1	.81	.570	.90	.536	.39	.763	**
	02	233	22SEP69	*	.24	.847	.25	.841	.27	.829	**
	02	241	4JUN69	1	.80	.574	.72	.607	.67	.629	04
	02	269	10JUN69	0	.75	.595	.82	.566	.38	.768	01
	02	263	11JUN69	3	.20	.871	.25	.841	.23	.853	05
	02	264	26JUN69	0	.82	.566	.90	.536	.40	.758	01
	02	247	2JUL69	0	.68	.624	.68	.624	.52	.697	01
	02	266	9JUL69	0	.76	.590	.83	.563	.47	.722	01
	02	243	20JUL69	1	.32	.801	.34	.790	.34	.790	04
	02	242	23JUL69	0	.65	.637	.78	.582	.42	.747	01
	02	239	23JUL69	3	.04	.973	.07	.953	.27	.829	05
	02	238	18AUG69	1	.48	.717	.61	.655	.45	.732	04
	02	271	17SEP69	1	.50	.707	.53	.693	.20	.871	04
	02	240	15OCT69	1	.48	.717	.50	.707	.21	.865	04
	02	270	22OCT69	3	.48	.717	.45	.732	.27	.829	05
	02	265	22OCT69	0	.74	.599	.81	.570	.37	.774	01
	02	244	29OCT69	1	.66	.633	.73	.603	.28	.824	03

(1)DEPTH ZONE 0=DUNE, 1=BERM, 2=MHW TO BASE OF BERM, 3=MIDTIDE TO MHW, 4=MLW TO MIDTIDE, 5=MLW TO -2 METERS 6=-2 TO -4 METERS, 7=-4 TO -8 METERS, * SWASH ZONE

Table A-2. RSA results from Boca Raton.--Continued

LOCATION	PROFILE	CONSECUTIVE NUMBER	DATE	DEPTH ZONE(1)	MEDIAN (PHI)	MEDIAN (MM)	MEAN (PHI)	MEAN (MM)	ST DEV (PHI)	ST DEV (MM)	PIPE NO.
Boca Raton		245	4SEP69	*	.34	.790	.36	.779	.34	.790	
	01	599	25OCT71	1	1.10	.467	1.17	.444	.51	.702	**
	01	600	25OCT71	3	.76	.590	.87	.547	.38	.768	**
	01	601	30NOV71	1	1.17	.444	1.23	.426	.49	.712	**
	01	602	30NOV71	3	.48	.717	.60	.660	.43	.742	**
	01	603	21DEC71	1	.66	.633	.76	.590	.45	.732	02
	01	604	21DEC71	3	.77	.586	.86	.551	.45	.732	05
	01	440	09JAN72	0	1.09	.470	1.20	.435	.49	.712	01
	01	441	09JAN72	1	.98	.507	1.10	.467	.57	.674	02
	01	442	09JAN72	1	1.26	.418	1.31	.403	.52	.697	03
	01	443	09JAN72	1	.45	.732	.63	.646	.59	.664	04
	01	444	09JAN72	3	-.05	1.035	.14	.908	.62	.651	05
	01	445	09JAN72	3	.59	.664	.78	.582	.69	.620	06
	01	446	09JAN72	6	1.03	.490	1.11	.463	.58	.669	07
	01	447	09JAN72	6	1.23	.426	1.36	.390	.49	.712	08
	01	448	09JAN72	6	1.05	.483	1.18	.441	.66	.633	09
	01	449	09JAN72	6	1.26	.418	1.34	.395	.49	.712	10
	01	450	09JAN72	6	.82	.566	.98	.507	.58	.669	11
	01	451	09JAN72	6	1.27	.415	1.34	.395	.48	.717	12
	01	452	02OCT72	0	.95	.518	1.07	.476	.59	.664	01
	01	453	02OCT72	1	.93	.525	1.06	.480	.53	.693	02
	01	454	02OCT72	1	1.24	.423	1.29	.409	.53	.693	03
	01	455	02OCT72	1	.87	.547	1.03	.490	.60	.660	04
	01	456	02OCT72	3	.36	.779	.59	.664	.68	.624	05
	01	457	02OCT72	3	1.53	.346	1.49	.356	.67	.629	06
	01	458	06DEC72	0	.97	.511	1.00	.500	.47	.722	01
	01	459	06DEC72	1	.40	.758	.59	.664	.53	.693	02
	01	460	06DEC72	1	1.40	.379	1.42	.374	.50	.707	03
	01	461	06DEC72	1	.73	.603	.82	.566	.44	.737	04
	01	462	06DEC72	3	.73	.603	.90	.536	.64	.642	05
	01	463	06DEC72	3	1.32	.401	1.43	.371	.61	.655	06
	01	464	06DEC72	6	1.04	.486	1.13	.457	.55	.683	07
	01	465	06DEC72	6	1.41	.376	1.42	.374	.48	.717	08
	01	466	06DEC72	6	1.22	.429	1.33	.398	.50	.707	09
	01	467	06DEC72	6	1.45	.366	1.50	.354	.48	.717	10
	01	468	06DEC72	6	.91	.532	1.06	.480	.59	.664	11
	01	469	06DEC72	6	1.59	.332	1.64	.321	.50	.707	12
	01	470	06DEC72	6	1.62	.325	1.63	.323	.56	.678	13
	01	471	06DEC72	6	1.46	.363	1.55	.342	.56	.678	14
	01	472	06DEC72	6	1.46	.363	1.54	.344	.59	.664	15
	01	473	06DEC72	7	1.50	.354	1.57	.337	.54	.688	16
	01	474	06DEC72	7	1.56	.339	1.60	.330	.56	.678	17
	01	537	23JAN73	0	1.00	.500	1.10	.467	.60	.660	01
	01	538	23JAN73	1	1.05	.483	1.12	.460	.58	.669	02
	01	539	23JAN73	1	.68	.624	.77	.586	.47	.722	03
	01	540	23JAN73	1	.79	.578	1.04	.486	.65	.637	04
	01	541	23JAN73	3	.47	.722	.69	.620	.69	.620	05

(1)DEPTH ZONE 0=DUNE, 1=BERM, 2=MHW TO BASE OF BERM, 3=MIDTIDE TO MHW, 4=MLW TO MIDTIDE, 5=MLW TO -2 METERS
6=-2 TO -4 METERS, 7=-4 TO -8 METERS, * SWASH ZONE

Table A-2. RSA results from Boca Raton.--Continued

LOCATION	PROFILE	CONSECUTIVE NUMBER	DATE	DEPTH ZONE(1)	MEDIAN (PHI)	MEDIAN (MM)	MEAN (PHI)	MEAN (MM)	ST DEV (PHI)	ST DEV (MM)	PIPE NO.
Boca Raton	01	542	23JAN73	3	.30	.812	.56	.678	.79	.578	06
	01	543	23JAN73	6	.72	.607	.92	.529	.66	.633	07
	01	544	23JAN73	6	.98	.507	1.09	.470	.60	.660	09
	01	545	23JAN73	6	.99	.503	1.16	.448	.52	.697	10
	01	546	23JAN73	6	.89	.540	.94	.521	.38	.768	11
	01	547	23JAN73	6	1.71	.306	1.75	.297	.46	.727	12
	01	548	23JAN73	6	1.61	.328	1.62	.325	.47	.722	13
	01	549	23JAN73	6	1.68	.312	1.72	.304	.51	.702	14
	01	550	23JAN73	6	1.62	.325	1.65	.319	.55	.683	15
	01	551	23JAN73	7	1.43	.371	1.50	.354	.59	.664	16
	01	552	23JAN73	7	1.57	.337	1.60	.330	.60	.660	17
	01	533	13MAR73	1	1.34	.395	1.34	.395	.53	.693	03
	01	534	13MAR73	1	.45	.732	.60	.660	.41	.753	04
	01	526	14MAR73	0	1.07	.476	1.12	.460	.57	.674	01
	01	527	14MAR73	1	.91	.532	1.02	.493	.59	.664	02
	01	528	14MAR73	1	1.22	.429	1.29	.409	.63	.646	03
	01	529	14MAR73	1	.50	.707	.63	.646	.45	.732	04
	01	530	14MAR73	3	.49	.712	.63	.646	.45	.732	05
	01	532	14MAR73	6	.66	.633	.84	.559	.65	.637	07
	01	553	19MAR73	0	1.02	.493	1.12	.460	.60	.660	01
	01	554	19MAR73	1	.91	.532	1.06	.480	.60	.660	02
	01	555	19MAR73	1	.50	.707	.62	.651	.46	.727	03
	01	556	19MAR73	1	.39	.763	.52	.697	.52	.697	04
	01	557	19MAR73	3	1.22	.429	1.24	.423	.55	.683	05
	01	558	19MAR73	3	.14	.908	.28	.824	.57	.674	06
	01	559	19MAR73	6	.52	.697	.64	.642	.58	.669	07
	01	560	19MAR73	6	.67	.629	.77	.586	.47	.722	08
	01	561	19MAR73	6	1.01	.497	1.16	.448	.64	.642	09
	01	562	19MAR73	6	.89	.540	.95	.518	.45	.732	10
	01	563	19MAR73	6	1.67	.314	1.62	.325	.66	.633	11
	01	564	19MAR73	6	1.37	.387	1.44	.369	.40	.758	12
	01	565	19MAR73	6	1.46	.363	1.54	.344	.56	.678	13
	01	566	19MAR73	6	1.61	.328	1.66	.316	.52	.697	14
	01	567	19MAR73	6	1.10	.467	1.22	.429	.52	.697	15
	01	568	19MAR73	7	1.74	.299	1.83	.281	.53	.693	16
	01	569	19MAR73	7	1.46	.363	1.54	.344	.58	.669	17

(1)DEPTH ZONE 0=DUNE, 1=BERM, 2=MHW TO BASE OF BERM, 3=MIDTIDE TO MHW, 4=MLW TO MIDTIDE, 5=MLW TO -2 METERS
6=-2 TO -4 METERS, 7=-4 TO -8 METERS, 8=-8 TO -16 METERS, 9=BELOW -16 METERS * SWASH ZONE

Table A-3. RSA results from Hollywood.

LOCATION	PROFILE	CONSECUTIVE NUMBER	DATE	DEPTH ZONE(1)	MEDIAN (PHI)	MEDIAN (MM)	MEAN (PHI)	MEAN (MM)	ST DEV (PHI)	ST DEV (MM)	PIPE NO.
Hollywood	01	370	3FEB69	1	1.38	.384	1.41	.376	.30	.812	
	01	369	27MAY69	*	.51	.702	.56	.678	.29	.818	
	01	418	27MAY69	0	1.05	.483	1.10	.467	.39	.763	01
	01	386	5JUN69	0	1.03	.490	1.05	.483	.53	.693	01
	01	390	9OCT69	0	1.32	.401	1.35	.392	.36	.779	01
	01	389	10JUN69	1	.81	.570	.87	.547	.27	.829	04
	01	407	10JUN69	0	1.02	.493	1.09	.470	.37	.774	01
	01	397	17JUN69	0	1.14	.454	1.18	.441	.40	.758	01
	01	385	24JUN69	0	1.24	.423	1.26	.418	.43	.742	01
	01	392	24JUN69	0	.11	.927	.13	.914	.29	.818	04
	01	398	15JUL69	1	.08	.946	.22	.859	.79	.578	01
	01	395	22JUL69	1	1.87	.274	1.88	.272	.11	.927	04
	01	391	22JUL69	0	1.33	.398	1.34	.395	.42	.747	01
	01	409	29AUG69	0	1.29	.409	1.33	.398	.36	.779	01
	01	399	3SEP69	0	1.23	.426	1.30	.406	.34	.790	01
	01	388	11SEP69	0	1.17	.444	1.22	.429	.35	.785	01
	01	404	16SEP69	0	1.19	.438	1.22	.429	.36	.779	01
	01	406	16SEP69	1	.50	.707	.55	.683	.34	.790	04
	01	414	22SEP69	*	.77	.586	.79	.578	.42	.747	
	01	415	22SEP69	*	.86	.551	.93	.525	.47	.722	
	01	379	22SEP69	0	1.25	.420	1.29	.409	.40	.758	01
	01	401	30SEP69	0	1.21	.432	1.23	.426	.36	.779	01
	01	403	30SEP69	1	.91	.532	1.03	.490	.53	.693	04
	01	400	14OCT69	0	1.34	.395	1.34	.395	.40	.758	01
	01	384	14OCT69	1	1.29	.409	1.28	.412	.40	.758	03
	01	402	21OCT69	0	1.33	.398	1.37	.387	.33	.796	01
	01	393	21OCT69	0	1.39	.382	1.31	.403	.88	.543	01
	01	394	28OCT69	0	1.08	.473	1.15	.451	.35	.785	01
	01	387	28OCT69	1	1.05	.483	1.16	.448	.41	.753	03
	01	376	2DEC69	1	.99	.503	1.05	.483	.36	.779	**
	01	408	4NOV69	*	.69	.620	.73	.603	.29	.818	
	01	405	4NOV69	*	1.00	.500	1.08	.473	.34	.790	
	01	371	11NOV69	0	.99	.503	1.05	.483	.34	.790	01
	01	372	11NOV69	1	.26	.835	.35	.785	.34	.790	04
	01	373	18NOV69	1	.55	.683	.62	.651	.24	.847	04
	01	374	18NOV69	0	1.01	.497	1.09	.470	.39	.763	01
	01	375	2DEC69	*	1.09	.470	1.16	.448	.32	.801	
	01	380	9DEC69	*	.29	.818	.38	.768	.32	.801	03
	01	381	9DEC69	0	1.00	.500	1.07	.476	.36	.779	01
	01	412	18DEC69	0	1.04	.486	1.09	.470	.34	.790	01
	01	413	18DEC69	*	.31	.807	.35	.785	.26	.835	
	01	410	23DEC69	*	.89	.540	.92	.529	.46	.727	
	01	411	23DEC69	1	1.00	.500	1.09	.470	.36	.779	
	01	382	30DEC69	*	.21	.865	.18	.883	.24	.847	
	01	383	30DEC69	1	.99	.503	1.08	.473	.41	.753	
	01	377	6JAN70	1	1.04	.486	1.08	.473	.39	.763	
	01	378	6JAN70	*	1.00	.500	1.08	.473	.51	.702	
	01	416	27JAN70	1	1.00	.500	1.09	.470	.34	.790	
	01	417	27JAN70	*	1.37	.387	1.25	.420	.42	.747	
	**	605	12OCT71	1	1.27	.415	1.33	.398	.44	.737	**
	**	606	12OCT71	3	.84	.559	.99	.503	.69	.620	**
	**	607	16NOV71	1	1.31	.403	1.39	.382	.43	.742	**
	**	608	21DEC71	1	1.15	.451	1.21	.432	.53	.693	01
	**	609	21DEC71	3	.62	.651	.71	.611	.42	.747	03
	01	610	07FEB72	0	1.29	.409	1.36	.390	.50	.707	01
	01	611	07FEB72	1	.97	.511	1.13	.457	.54	.688	02
	01	612	07FEB72	1	.85	.555	1.01	.497	.56	.678	03
	01	475	06SEP72	0	1.25	.420	1.33	.398	.52	.697	01
	01	476	06SEP72	1	1.01	.497	1.09	.470	.63	.646	02
	01	477	06SEP72	1	.79	.578	1.03	.490	.72	.607	03
	01	478	06SEP72	4	.34	.790	.48	.717	.53	.693	04
	01	479	06SEP72	5	.44	.737	.64	.642	.75	.595	05
	01	480	06SEP72	5	.45	.732	.55	.683	.54	.688	06
	01	481	06SEP72	5	1.40	.379	1.45	.366	.51	.702	07
	01	482	10OCT72	6	1.69	.310	1.72	.304	.71	.611	08
	01	483	10OCT72	0	1.16	.448	1.23	.426	.54	.688	01
	01	484	10OCT72	1	1.21	.432	1.25	.420	.59	.664	02
	01	485	10OCT72	1	.74	.599	.86	.551	.52	.697	03
	01	486	10OCT72	3	.53	.693	.74	.599	.76	.590	04
	01	487	10OCT72	5	.31	.807	.62	.651	.75	.595	05
	01	488	10OCT72	6	.43	.742	.67	.629	.72	.607	06
	01	489	10OCT72	6	.91	.532	.95	.518	.43	.742	07
	01	490	10OCT72	6	1.24	.423	1.32	.401	.63	.646	08
	01	491	12DEC72	0	1.26	.418	1.33	.398	.49	.712	01
	01	492	12DEC72	1	1.13	.457	1.22	.429	.55	.683	02
	01	493	12DEC72	1	.73	.603	.81	.570	.38	.768	03
	01	494	12DEC72	5	.28	.824	.36	.779	.54	.688	04
	01	496	12DEC72	5	.23	.853	.51	.702	.75	.595	06
	01	497	12DEC72	5	.35	.785	.55	.683	.69	.620	07
	01	570	20MAR73	0	1.37	.387	1.39	.382	.46	.727	01
	01	571	20MAR73	1	1.26	.418	1.31	.403	.49	.712	02
	01	572	20MAR73	1	1.32	.401	1.34	.395	.50	.707	03
	01	573	20MAR73	1	.89	.540	1.02	.493	.59	.664	04
	01	574	20MAR73	3	.96	.514	1.03	.490	.65	.637	05
	01	575	20MAR73	4	1.56	.339	1.65	.319	.48	.717	06
	01	576	20MAR73	5	1.60	.330	1.67	.314	.46	.727	07
	01	577	20MAR73	5	1.71	.306	1.77	.293	.62	.651	08
	01	578	20MAR73	6	1.78	.291	1.81	.285	.63	.646	09

(1)DEPTH ZONE 0=DUNE, 1=BERM, 2=MHW TO BASE OF BERM, 3=MIDTIDE TO MHW, 4=MLW TO MIDTIDE, 5=MLW TO -2 METERS
(6=-2 TO -4 METERS, 7=-4 TO -8 METERS, 8=-8 TO -16 METERS, 9=BELOW -16 METERS * SWASH ZONE

APPENDIX B

PROFILE DOCUMENTATION

1. Jupiter.

Reference elevations at the Jupiter site are based on the elevation of bench mark No. 8 (+7.88 feet (+2.4 meters) above MSL), which is a sixty-penny nail near the base of a power pole 55 feet east of the centerline on Florida State Road 707 (State Highway A1A) and 64.9 feet (19.9 meters) south of the Palm Beach-Martin County line. Figure B-1 shows the relationship between bench mark No. 8 and the Jupiter profile lines. Pipe stationing and reference elevations are listed in Tables B-1 and B-2.

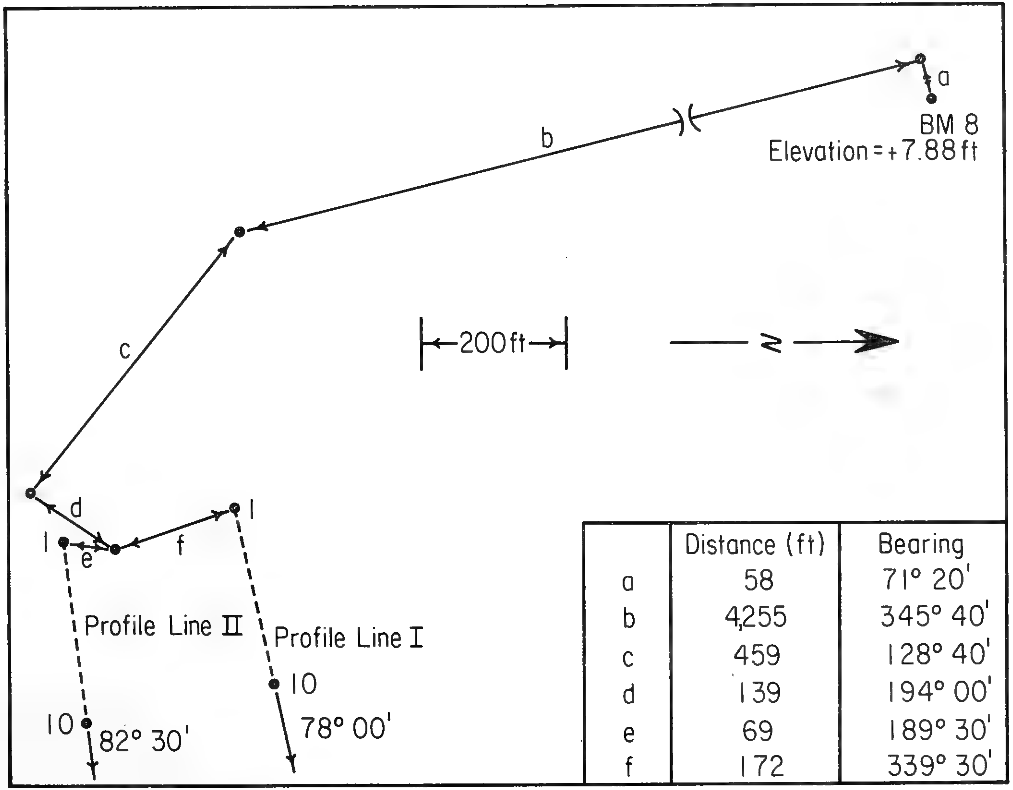
2. Boca Raton.

Reference elevations at the Boca Raton site are based on the elevation of bench mark No. 311 (+6.58 feet above MSL) which is approximately 50 feet west of Highway A1A and located next to the manhole slab on the sidewalk on the north side of the Palmetto Park Road, approximately 6,500 feet (199 meters) south of the site. A new temporary bench mark "A" was established at the site--a 1-inch galvanized pipe which was placed in the dune at an elevation of +28.16 feet (+8.5 meters) above MSL. Figure B-2 shows the relationship between the temporary bench mark "A" and the Boca Raton profile lines. The radar tower identified in the figure is shown as "Radio Tower" on the U.S. Geological Survey 1969 Boca Raton quadrangle map at latitude 26°22'11" N. and longitude 80°4'27" W., and refers to a Georgia Institute of Technology radar tower on the site. Pipe stationing and reference elevations are listed in Tables B-1 and B-3.

3. Hollywood.

Reference elevations at the Hollywood site are based on the elevation of bench mark No. 11 (4.18 feet above MSL), which is a disk located on the centerline of State Highway A1A approximately 800 feet north of Charleston Avenue. Figure B-3 shows the relationship between bench mark No. 11 and the Hollywood profile lines. Pipe stationing and reference elevations are listed in Tables B-1 and B-4.

All bench mark descriptions and elevation data were provided by the Florida Ocean Sciences Institute, Inc., Deerfield Beach, Florida.



	Distance (ft)	Bearing
a	58	71° 20'
b	4,255	345° 40'
c	459	128° 40'
d	139	194° 00'
e	69	189° 30'
f	172	339° 30'

Figure B-1. Jupiter profile line locations.

Table B-1. Pipe stationing at the three sites.

Pipes	Profile lines (distance in feet).[1]			
	I	II	III	IV
Jupiter (two profile lines)[2]				
1 and 2	28.8	28.0		
2 and 3	28.2	28.3		
3 and 4	27.9	28.7		
4 and 5	28.2	28.8		
5 and 6	27.7	27.8		
6 and 7	27.3	27.6		
7 and 8	26.8	27.0		
8 and 9	27.2	27.2		
9 and 10	26.8	27.9		
Boca Raton (four profile lines)[3]				
1 and 2	26.6	27.6	28.0	28.0
2 and 3	26.5	27.8	29.0	30.7
3 and 4	26.5	28.0	27.5	29.2
4 and 5	26.2	27.4	27.2	24.8
5 and 6	31.5	31.6	31.5	31.5
6 and 7	48.3	54.3	50.0	50.0
7 to 17[4]				
Hollywood (two profile lines)[5]				
1 and 2	28.4	27.4		
2 and 3	28.1	27.9		
3 and 4	27.8	27.7		
4 and 5	27.9	26.8		
5 and 6	27.0	27.8		
6 and 7	52.7	56.6		
7 and 8	52.8	52.1		
8 and 9	52.2	56.2		

[1]Between adjacent pipes in each profile line.

[2]Distance between profile lines I and II is 234 feet at pipe 1 and 254 feet at pipe 10.

[3]Distance between profile lines I and II is 255 ± 6 feet, profile lines II and III, 167 ± 18 feet, and profile lines III and IV, 119 ± 12 feet.

[4]Distance between pipes for pipes 7 to 17 in all profile lines is approximately 50 feet.

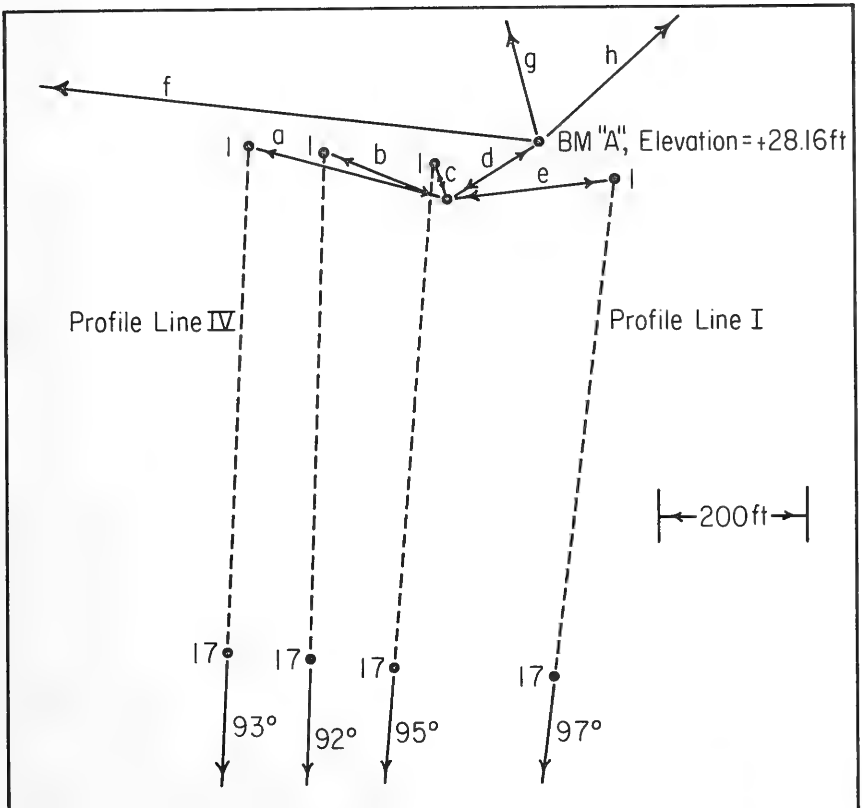
[5]Distance between profile lines I and II is 254 feet at pipe 1 and 280 feet at pipe 9.

Table B-2. Elevations of pipe reference marks relative to MSL, Jupiter.

Pipe	Elevation (ft)					
	Jan. 1969 to 1 July 1971		1 July 1971 to 25 Jan. 1973		25 Jan. 1973 through June 1973[1]	
	Profile line		Profile line		Profile line	
	I	II	I	II	I	II
1	16.2	15.7	15.3	13.9	15.9	14.7
2	15.2	14.7	13.8	13.0	14.4	14.0
3	11.7	12.7	9.2	11.0	9.5	11.5
4	8.0	10.0	6.4	7.0	7.1	9.2
5	6.3	5.7	4.8	4.6	5.0	5.7
6	4.0	2.5	3.3	1.0	–1.5	3.6
7	3.6	3.1	2.4	2.0	4.3	1.2
8	3.2	2.0	3.2	0.8	–2.2	0.7
9	3.0	3.4	2.6	2.4	–1.8	-------[2]
10	2.1	2.5	1.2	1.6	-------[2]	-------[2]

[1]During this period pipe tops were used as reference marks.

[2]Missing pipes.



	Distance (ft)	Bearing
a	284	196° 10'
b	183	202° 00'
c	57	249° 40'
d	146	329° 50'
e	229	353° 00'

f	Line of sight - NW corner of Cupola, Arvida Bldg. 187°
g	Line of sight - SE corner of radar tower 253° 30'
h	Line of sight - NE corner of radar tower 315° 10'

Figure B-2. Boca Raton profile line locations.

Table B-3. Elevations of pipe reference marks relative to MSL, Boca Raton.

Pipe	Elevation (ft)											
	Jan. 1969 to 1 July 1971		Oct. 1969 to 1 July 1971		1 July 1971 to 22 Jan. 1973				22 Jan. 1973 through June 1973[1]			
	Profile line		Profile line		Profile line				Profile line			
	I	II	III	IV	I	II	III	IV	I	II	III	IV
1	16.7	18.4	19.2	20.2	16.8	18.5	19.3	20.2	18.7	18.7	20.8	22.7
2	14.0	13.6	13.7	14.3	14.1	13.8	14.3	14.5	14.9	14.1	15.9	16.4
3	11.7	11.2	10.2	9.3	11.5	11.3	10.5	10.2	11.7	11.4	12.1	12.9
4	7.2	7.2	7.9	7.7	7.3	7.2	7.3	6.9	8.6	7.7	8.2	2.3[2]
5	5.8	3.1	4.8	3.6	5.7	4.0	4.2	3.7	8.7	5.3	0.5	5.4[3]
6	2.9	2.2	1.7	2.1	3.1	2.5	2.0	2.4	3.1	2.7	2.7	–1.8
7	–4.2	–4.1	–3.2	–3.2	–2.2	–4.4	–4.3	–2.7	–2.5	–4.3	–3.3	–8.0
8	–3.7	–4.7	–4.2	–4.7	–1.4	–1.7	–1.7	–3.9	–7.8	–9.8	–6.3	–8.3
9	–4.7	–6.2	–4.7	–5.7	–2.0	–0.9	–0.8	–3.3	-------[4]	-------[4]	–8.9	–8.5
10	–2.7	-------[4]	–4.7	–5.7	–4.2	–1.1	–1.1	–2.4	–7.5	–5.5	–6.8	–7.9
11	–1.7	-------[4]	–5.7	–4.2	–2.2	–0.6	–2.3	–3.5	–7.9	–5.3	–4.5	–9.2
12	-------[4]	–3.7	–4.7	–3.2	–2.8	–5.3	–3.7	–4.5	–8.1	–5.1	–4.3	–8.3
13	–3.7	–2.7	–3.2	–1.7	–3.9	–2.4	–1.9	–2.3	-------[4]	–4.8	–4.8	–4.3
14	–4.2	–3.7	–3.7	–2.7	–3.4	–3.4	–4.5	–2.6	–4.3	-------[4]	–5.3	–5.3
15	–6.2	–5.7	–4.7	–4.2	–6.1	–6.1	–5.1	–4.5	-------[4]	–5.8	–5.8	-------[4]
16	–7.7	–6.2	–5.7	–5.7	–5.7	–5.6	–4.6	–5.8	–10.7	–7.9	–9.2	–8.4
17	–8.2	–7.7	–6.7	–7.2	–9.3	–8.8	–7.8	–5.3	–11.3	–11.2	–10.4	–9.6

[1]During this period pipe tops were used as reference marks.
[2]Changed to 7.5 feet after 13 March 1973.
[3]Changed to 3.1 feet after 26 March 1973.
[4]Missing pipes.

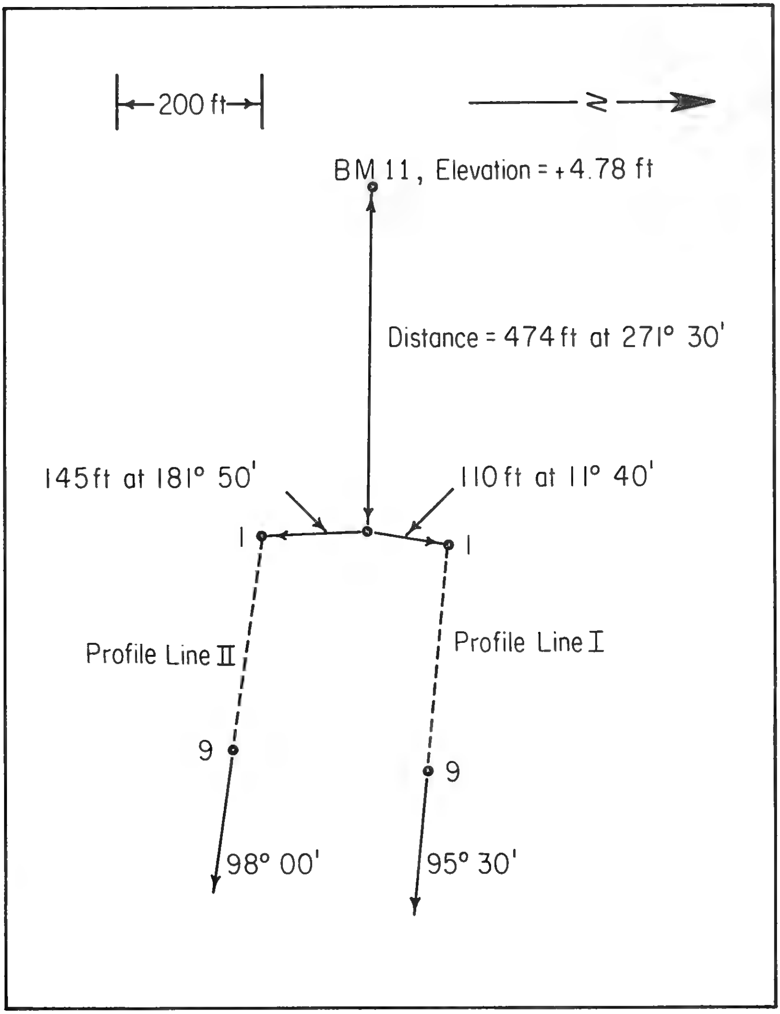


Figure B-3. Hollywood profile line locations.

Table B-4. Elevations of pipe reference marks relative to MSL, Hollywood.

Pipe	Elevation (ft)					
	Feb. 1969 to 1 Aug. 1971		1 Aug. 1971 to 23 Jan. 1973		23 Jan. 1973 through June 1973[1]	
	Profile line		Profile line		Profile line	
	I	II	I	II	I	II
1	14.9	15.1	15.1	16.1	15.3	16.2
2	12.1	12.2	12.4	13.2	13.6	13.8
3	11.0	8.6	11.2	10.5	12.0	11.2
4	8.0	5.8	7.2	6.8	3.9	2.4
5	4.3	1.1	4.8	2.8	8.2	–1.1
6	1.5	–0.1	1.3	0.0	4.9	4.6
7	2.2	–2.1	2.2	1.0	-------[2]	3.6
8	–1.9	–0.8	1.6	–2.5	4.2	-------[2]
9	–1.4	–2.1	0.3	–3.1	-------[2]	-------[2]

[1]During this period pipe tops were used as reference marks.
[2]Missing pipes.

APPENDIX C

LEO SUMMARY REPORT

Annual summaries of the monthly averages of breaker height, period, and type; net and gross longshore current velocities; foreshore slope; and percent occurrence and spacing of rips and cusps at the three localities are given in Tables C-1 to C-15.

All breaker direction observations were standardized to the protractor method. Perpendicular to the shoreline is defined as the 0° approach angle; i.e., breakers are approaching normal to the shoreline. Breakers approaching from the right of 0°, as the observer faces the shoreline, are noted as negative; those approaching from the left as positive. Breaker direction is given as percentage occurrence in range of degrees.

Longshore current speeds are given in terms of gross and net mean rates. The gross mean, C_g, which represents the total of the speeds measured, defined as:

$$C_g = \frac{\Sigma(C_S + C_N)}{n},$$

where C_S and C_N represent currents flowing to the south and the north, respectively. Both C_S and C_N are added as absolute values. The net mean longshore current, C_m, a cumulative number with assigned mathematical direction, is defined as:

$$C_m = \frac{\Sigma(C_N - C_S)}{n}.$$

Thus, net speeds are listed as either negative or positive means, where negative mean values indicate a net current speed to the north, positive mean values to the south. Rip current and beach cusp spacings are in feet.

Table C-1. Annual summary for Jupiter, 20 January to 30 December 1969.

12041 JUPITER FLORIDA SUMMARY FOR PERIOD STARTING 1-20-69 AND ENDING 12-30-69

	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	* ANNUAL
SURF OBS.													
HEIGHT (FT)													
MEAN	4.20	2.87	4.04	3.85	3.57	2.95	1.68	3.50	3.02	5.33	3.75	2.92	3.29
STD DEV	.00	2.12	.38	1.26	.90	1.39	.76	.00	1.43	.58	.96	.95	1.07
NO. OBS.	2.	4.	5.	4.	4.	4.	5.	1.	5.	3.	4.	13.	54.
PERIOD (SEC)													
MEAN	5.15	6.60	5.62	4.37	7.12	5.15	4.50	8.00	5.24	6.87	7.40	5.13	5.67
STD DEV	.49	1.50	.80	.89	4.20	.64	1.06	.00	1.99	3.94	1.73	.61	1.62
NO. OBS.	2.	4.	5.	4.	4.	4.	5.	1.	5.	4.	4.	13.	55.
DIRECTION													
PROTRACTOR METHOD													
% OCC > 45	.00	50.00	40.00	75.00	50.00	25.00	20.00	100.00	60.00	.00	.00	.00	26.79
30<X<= 45	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	61.54	14.29
20<X<= 30	.00	.00	.00	.00	.00	.00	.00	.00	.00	50.00	.00	15.38	7.14
10<X<= 20	.00	50.00	.00	.00	.00	.00	.00	.00	.00	.00	25.00	.00	5.36
5<X<= 10	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
0<X<= 5	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	50.00	15.38	7.14
X=0	33.33	.00	20.00	25.00	25.00	75.00	60.00	.00	.00	.00	25.00	.00	19.64
-5<=X< 0	.00	.00	.00	.00	.00	.00	.00	.00	.00	25.00	.00	.00	1.79
-10<=X< -5	.00	.00	.00	.00	.00	.00	.00	.00	.00	25.00	.00	.00	1.79
-20<=X<-10	33.33	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1.79
-30<=X<-20	33.33	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1.79
-45<=X<-30	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
% OCC <=-45	.00	.00	40.00	.00	25.00	.00	20.00	.00	40.00	.00	.00	7.69	12.50
% CALM	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
NO. OBS.	3.	4.	5.	4.	4.	4.	5.	1.	5.	4.	4.	13.	56.
MEAN	-5.67	39.50	.00	45.00	15.00	15.00	.00	60.00	12.00	11.25	7.00	22.46	16.54
BREAKER TYPE													
%OCC SPILL	50.00	25.00	60.00	25.00	100.00	100.00	60.00	100.00	80.00	75.00	50.00	92.31	70.91
SP/PL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PLUNGE	50.00	25.00	40.00	50.00	.00	.00	.00	.00	20.00	25.00	50.00	7.69	20.00
SURGE	.00	50.00	.00	25.00	.00	.00	40.00	.00	.00	.00	.00	.00	9.09
CALM	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
NO. OBS.	2.	4.	5.	4.	4.	4.	5.	1.	5.	4.	4.	13.	55.
CURRENT OBS.													
(FT/SEC)													
NET MEAN	-.99	.73	.44	.92	.02	.64	-.03	.77	.51	1.38	1.31	.36	.51
NO. OBS.	2.	4.	5.	4.	4.	4.	5.	1.	5.	4.	4.	13.	55.
GROSS MEAN	1.46	.73	1.22	.92	.46	.64	.60	.77	.92	2.73	1.31	.53	.94
NO. OBS.	2.	4.	5.	4.	4.	4.	5.	1.	5.	4.	4.	13.	55.
FORESHORE SLOPE													
MEAN (DEG)	.00	.00	9.00	6.33	7.50	13.33	13.80	11.00	7.20	12.33	9.50	11.85	10.48
NO. OBS.	0.	0.	3.	3.	4.	3.	5.	1.	5.	3.	4.	13.	44.
RIPS % OCC	.00	.00	.00	.00	.00	.00	.00	100.00	60.00	50.00	100.00	15.38	21.57
MEAN SPAC.	.00	.00	.00	.00	.00	.00	.00	75.00	84.00	175.00	74.00	42.50	89.45
NO. OBS.	1.	4.	4.	3.	4.	4.	5.	1.	5.	4.	3.	13.	51.
CUSPS % OCC.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
MEAN SPAC.	.00	.00	.00	.00	.00	.00	.00	.02	.00	.00	.00	.00	.00
NO. OBS.	1.	4.	4.	3.	4.	4.	5.	1.	5.	4.	3.	13.	51.

* ANNUAL MEANS WEIGHTED BY TOTAL NO. OF MONTHLY OBS.

Table C-2. Annual summary for Jupiter, 8 January to 31 December 1970.

12041 JUPITER FLORIDA SUMMARY FOR PERIOD STARTING 1- 8-70 AND ENDING 12-31-70

	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	* ANNUAL
SURF OBS.													
HEIGHT (FT)													
MEAN	3.75	3.00	2.75	3.67	2.67	2.00	3.00	2.25	3.00	3.60	2.33	3.40	3.00
STD DEV	.50	.82	1.26	2.08	1.53	1.00	1.00	1.50	1.15	1.95	1.15	1.14	1.26
NO. OBS.	4.	4.	4.	3.	3.	3.	5.	4.	4.	5.	3.	5.	47.
PERIOD (SEC)													
MEAN	5.12	6.10	4.85	5.10	5.33	4.43	4.88	5.07	4.57	5.22	5.50	5.60	5.16
STD DEV	1.30	.94	.78	1.85	1.19	1.19	.76	1.41	1.02	1.81	1.30	.47	1.17
NO. OBS.	4.	4.	4.	3.	3.	3.	5.	4.	4.	5.	3.	5.	47.
DIRECTION													
PROTRACTOR METHOD													
% OCC > 45	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
30<X<= 45	25.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	50.00	20.00	6.78
20<X<= 30	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10<X<= 20	.00	25.00	.00	20.00	33.33	25.00	.00	33.33	25.00	50.00	.00	.00	16.95
5<X<= 10	50.00	75.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	8.47
0<X<= 5	.00	.00	20.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1.69
X=0	.00	.00	.00	.00	.00	25.00	11.11	.00	75.00	16.67	.00	20.00	11.86
-5<=X< 0	.00	.00	40.00	.00	66.67	.00	.00	.00	.00	.00	.00	.00	6.78
-10<=X< -5	25.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	1.69
-20<=X<-10	.00	.00	20.00	40.00	.00	25.00	44.44	33.33	.00	16.67	25.00	.00	20.34
-30<=X<-20	.00	.00	20.00	40.00	.00	25.00	44.44	33.33	.00	16.67	25.00	.00	20.34
-45<=X<-30	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	60.00	5.08
% OCC <-45	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
% CALM	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
NO. OBS.	4.	4.	5.	5.	3.	4.	9.	6.	4.	6.	4.	5.	59.
MEAN	13.75	9.25	-3.20	-3.00	4.33	.00	-7.56	.00	4.25	5.67	18.25	-18.00	.68
BREAKER TYPE													
%OCC SPILL	75.00	100.00	100.00	66.67	100.00	66.67	100.00	50.00	50.00	20.00	33.33	60.00	68.09
SP/PL	.00	.00	.00	.00	.00	.00	.00	.00	25.00	60.00	33.33	40.00	14.89
PLUNGE	25.00	.00	.00	33.33	.00	.00	.00	.00	.00	.00	.00	.00	4.26
SURGE	.00	.00	.00	.00	.00	33.33	.00	50.00	25.00	20.00	33.33	.00	12.77
CALM	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
NO. OBS.	4.	4.	4.	3.	3.	3.	5.	4.	4.	5.	3.	5.	47.
CURRENT OBS.													
(FT/SEC)													
NET MEAN	1.04	.55	-.67	-.01	-.43	-.19	-.88	.03	-.14	.98	.67	-.55	.02
NO. OBS.	4.	4.	4.	3.	3.	3.	5.	4.	4.	5.	3.	5.	47.
GROSS MEAN	1.04	.55	.67	.98	.83	.58	.88	.76	.65	1.21	1.21	1.06	.88
NO. OBS.	4.	4.	4.	3.	3.	3.	5.	4.	4.	5.	3.	5.	47.
FORESHORE SLOPE													
MEAN (DEG)	13.33	11.25	11.25	9.67	8.67	10.00	9.60	12.75	10.25	9.40	.00	.00	10.58
NO. OBS.	3.	4.	4.	3.	3.	3.	5.	4.	4.	5.	0.	0.	38.
RIPS % OCC	25.00	66.67	66.67	33.33	.00	.00	.00	.00	.00	.00	.00	.00	13.33
MEAN SPAC.	100.00	150.00	87.50	100.00	.00	.00	.00	.00	.00	.00	.00	.00	112.50
NO. OBS.	4.	3.	3.	3.	3.	3.	5.	4.	4.	5.	3.	5.	45.
CUSPS % OCC.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
MEAN SPAC.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
NO. OBS.	4.	3.	3.	3.	3.	3.	5.	4.	4.	5.	3.	5.	45.

* ANNUAL MEANS WEIGHTED BY TOTAL NO. OF MONTHLY OBS.

Table C-3. Annual summary for Jupiter, 7 January to 30 December 1971.

12041 JUPITER FLORIDA SUMMARY FOR PERIOD STARTING 1- 7-71 AND ENDING 12-30-71

	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	* ANNUAL
SURF OBS.													
HEIGHT (FT)													
MEAN	2.25	3.50	2.80	1.65	2.50	1.57	.92	.82	3.26	1.75	3.33	4.40	2.44
STD DEV	.50	1.29	1.64	1.91	.58	1.18	.70	.35	2.40	1.50	1.15	2.07	1.27
NO. OBS.	4.	4.	5.	2.	4.	4.	5.	4.	5.	4.	3.	5.	49.
PERIOD (SEC)													
MEAN	5.35	5.72	6.34	6.50	6.85	8.22	4.86	5.00	7.12	6.05	5.17	6.16	6.12
STD DEV	.55	.35	.77	.57	.58	1.14	1.77	2.21	2.22	1.74	1.53	3.17	1.38
NO. OBS.	4.	4.	5.	2.	4.	4.	5.	4.	5.	4.	3.	5.	49.
DIRECTION													
PROTRACTOR METHOD													
% OCC > 45	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
30<X<= 45	25.00	20.00	60.00	.00	.00	20.00	.00	.00	.00	.00	33.33	.00	11.67
20<X<= 30	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10<X<= 20	50.00	20.00	20.00	.00	20.00	20.00	14.29	16.67	60.00	100.00	33.33	.00	26.67
5<X<= 10	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
0<X<= 5	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
X=0	.00	20.00	20.00	.00	20.00	20.00	28.57	16.67	40.00	.00	33.33	25.00	20.00
-5<=X< 0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
-10<=X< -5	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
-20<=X<-10	.00	20.00	.00	33.33	20.00	20.00	28.57	33.33	.00	.00	.00	37.50	18.33
-30<=X<-20	.00	20.00	.00	33.33	20.00	20.00	28.57	33.33	.00	.00	.00	37.50	18.33
-45<=X<-30	25.00	.00	.00	33.33	20.00	.00	.00	.00	.00	.00	.00	.00	5.00
% OCC <-45	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
% CALM	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
NO. OBS.	4.	5.	5.	3.	5.	5.	7.	6.	5.	4.	3.	8.	60.
MEAN	8.50	9.00	30.40	-20.67	-9.00	9.00	-2.43	-2.83	10.20	17.00	20.67	-6.37	4.42
BREAKER TYPE													
%OCC SPILL	50.00	50.00	60.00	50.00	100.00	50.00	40.00	25.00	20.00	.00	33.33	60.00	44.90
SP/PL	.00	50.00	20.00	.00	.00	.00	.00	.00	60.00	25.00	66.67	40.00	22.45
PLUNGE	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
SURGE	50.00	.00	20.00	50.00	.00	50.00	60.00	75.00	20.00	75.00	.00	.00	32.65
CALM	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
NO. OBS.	4.	4.	5.	2.	4.	4.	5.	4.	5.	4.	3.	5.	49.
CURRENT OBS.													
(FT/SEC)													
NET MEAN	.36	.47	1.29	-.49	-.50	.08	-.61	.08	.67	.44	1.39	-.84	.23
NO. OBS.	4.	3.	5.	2.	4.	4.	5.	4.	5.	3.	2.	2.	43.
GROSS MEAN	.85	1.02	1.29	.49	.85	.45	.83	.47	.98	.44	1.39	.84	.83
NO. OBS.	4.	3.	5.	2.	4.	4.	5.	4.	5.	3.	2.	2.	43.
FORESHORE SLOPE													
MEAN (DEG)	.00	11.75	11.00	.00	.00	12.00	11.20	11.25	9.25	12.00	12.00	.00	11.12
NO. OBS.	0.	4.	4.	0.	0.	2.	5.	4.	4.	2.	1.	0.	26.
RIPS % OCC	.00	25.00	.00	.00	.00	.00	.00	.00	20.00	25.00	.00	.00	6.12
MEAN SPAC.	.00	75.00	.00	.00	.00	.00	.00	.00	30.00	50.00	.00	.00	51.67
NO. OBS.	4.	4.	5.	2.	4.	4.	5.	4.	5.	4.	3.	5.	49.
CUSPS % OCC.	.00	25.00	.00	.00	.00	.00	.00	.00	20.00	25.00	.00	.00	6.12
MEAN SPAC.	.00	75.00	.00	.00	.00	.00	.00	.00	30.00	50.00	.00	.00	51.67
NO. OBS.	4.	4.	5.	2.	4.	4.	5.	4.	5.	4.	3.	5.	49.

* ANNUAL MEANS WEIGHTED BY TOTAL NO. OF MONTHLY OBS.

Table C-4. Annual summary for Jupiter, 6 January to 21 December 1972.

12041 JUPITER FLORIDA SUMMARY FOR PERIOD STARTING 1- 6-72 AND ENDING 12-21-72

	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	* ANNUAL
SURF OBS.													
HEIGHT (FT)													
MEAN	2.57	2.12	3.40	3.67	1.50	1.80	2.50	.70	2.00	3.75	3.00	2.67	2.54
STD DEV	1.59	1.03	.42	.58	.58	.84	.58	.42	.00	2.60	1.41	1.53	1.05
NO. OBS.	4.	4.	5.	3.	4.	5.	4.	2.	1.	4.	2.	3.	41.
PERIOD (SEC)													
MEAN	6.65	6.17	6.28	5.10	4.95	4.72	5.50	6.80	4.60	4.95	5.15	2.93	5.39
STD DEV	1.00	.73	1.13	.10	.75	.85	.57	1.13	.00	3.26	.35	.29	.92
NO. OBS.	4.	4.	5.	3.	4.	4.	4.	2.	1.	4.	2.	3.	40.
DIRECTION													
PROTRACTOR METHOD													
% OCC > 45	.00	.00	14.29	.00	.00	.00	.00	.00	.00	.00	.00	.00	2.04
30<X<= 45	.00	.00	.00	25.00	.00	.00	.00	.00	.00	.00	.00	.00	2.04
20<X<= 30	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10<X<= 20	20.00	14.29	28.57	.00	.00	20.00	.00	50.00	.00	.00	.00	.00	12.24
5<X<= 10	.00	.00	.00	.00	.00	.00	.00	.00	.00	50.00	.00	.00	4.08
0<X<= 5	.00	.00	.00	.00	.00	.00	.00	.00	100.00	25.00	.00	.00	4.08
X=0	20.00	.00	.00	.00	20.00	60.00	.00	50.00	.00	.00	50.00	66.67	18.37
-5<=X< 0	.00	.00	.00	.00	.00	.00	.00	.00	.00	25.00	50.00	.00	4.08
-10<=X< -5	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	33.33	2.04
-20<=X<-10	20.00	42.86	28.57	25.00	20.00	.00	.00	.00	.00	.00	.00	.00	16.33
-30<=X<-20	20.00	42.86	28.57	25.00	20.00	.00	.00	.00	.00	.00	.00	.00	16.33
-45<=X<-30	20.00	.00	.00	25.00	40.00	20.00	100.00	.00	.00	.00	.00	.00	18.37
% OCC <-45	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
% CALM	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
NO. OBS.	5.	7.	7.	4.	5.	5.	4.	2.	1.	4.	2.	3.	49.
MEAN	-9.00	-4.86	8.57	-4.25	-21.40	-5.60	-45.00	8.50	1.00	3.50	-1.00	-2.00	-6.67
BREAKER TYPE													
%OCC SPILL	25.00	100.00	60.00	100.00	75.00	60.00	100.00	50.00	.00	25.00	.00	66.67	60.98
SP/PL	50.00	.00	40.00	.00	.00	.00	.00	.00	.00	50.00	100.00	.00	19.51
PLUNGE	.00	.00	.00	.00	.00	.00	.00	.00	100.00	25.00	.00	33.33	7.32
SURGE	25.00	.00	.00	.00	25.00	40.00	.00	50.00	.00	.00	.00	.00	12.20
CALM	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
NO. OBS.	4.	4.	5.	3.	4.	5.	4.	2.	1.	4.	2.	3.	41.
CURRENT OBS.													
(FT/SEC)													
NET MEAN	-1.28	-.56	.07	-.41	-.23	-.08	-.74	.35	-.80	.73	.62	-.76	-.25
NO. OBS.	2.	4.	5.	3.	3.	5.	4.	1.	1.	4.	1.	3.	36.
GROSS MEAN	1.28	.90	1.08	1.08	.68	.52	.74	.35	.80	.98	.62	1.46	.90
NO. OBS.	2.	4.	5.	3.	3.	5.	4.	1.	1.	4.	1.	3.	36.
FORESHORE SLOPE													
MEAN (DEG)	.00	.00	18.00	16.67	15.00	12.20	11.00	.00	11.00	7.50	8.50	6.67	11.52
NO. OBS.	0.	0.	1.	3.	4.	5.	4.	0.	1.	4.	2.	3.	27.
RIPS % OCC	25.00	.00	20.00	.00	.00	.00	.00	.00	.00	66.67	50.00	.00	12.50
MEAN SPAC.	50.00	.00	45.00	.00	.00	.00	.00	.00	.00	685.00	1320.00	.00	557.00
NO. OBS.	4.	4.	5.	3.	4.	5.	4.	2.	1.	3.	2.	3.	40.
CUSPS % OCC.	25.00	75.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	9.76
MEAN SPAC.	50.00	48.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	48.50
NO. OBS.	4.	4.	5.	3.	4.	5.	4.	2.	1.	4.	2.	3.	41.

* ANNUAL MEANS WEIGHTED BY TOTAL NO. OF MONTHLY OBS.

Table C-5. Six-month summary for Jupiter, 4 January to 28 June 1973.

12041 JUPITER FLORIDA SUMMARY FOR PERIOD STARTING 1- 4-73 AND ENDING 6-28-73

	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	* ANNUAL
SURF OBS.													
HEIGHT (FT)													
MEAN	4.50	1.67	4.12	2.25	1.33	2.54	.00	.00	.00	.00	.00	.00	2.51
STD DEV	2.38	1.11	3.20	1.89	.29	.83	.00	.00	.00	.00	.00	.00	1.62
NO. OBS.	4.	12.	4.	4.	3.	13.	0.	0.	0.	0.	0.	0.	40.
PERIOD (SEC)													
MEAN	4.10	3.90	5.22	3.30	3.67	4.33	.00	.00	.00	.00	.00	.00	4.11
STD DEV	1.22	1.29	2.01	.38	.35	1.38	.00	.00	.00	.00	.00	.00	1.11
NO. OBS.	4.	12.	4.	4.	3.	13.	0.	0.	0.	0.	0.	0.	40.
DIRECTION													
PROTRACTOR METHOD													
% OCC > 45	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
30<X<= 45	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
20<X<= 30	.00	.00	.00	25.00	.00	.00	.00	.00	.00	.00	.00	.00	2.17
10<X<= 20	.00	.00	20.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	2.17
5<X<= 10	25.00	.00	.00	.00	33.33	.00	.00	.00	.00	.00	.00	.00	4.35
0<X<= 5	25.00	16.67	.00	25.00	.00	11.11	.00	.00	.00	.00	.00	.00	13.04
X=0	25.00	25.00	20.00	25.00	66.67	16.67	.00	.00	.00	.00	.00	.00	23.91
-5<=X< 0	25.00	50.00	20.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	17.39
-10<=X< -5	.00	8.33	.00	.00	.00	16.67	.00	.00	.00	.00	.00	.00	8.70
-20<=X<-10	.00	.00	20.00	.00	.00	27.78	.00	.00	.00	.00	.00	.00	13.04
-30<=X<-20	.00	.00	20.00	.00	.00	27.78	.00	.00	.00	.00	.00	.00	13.04
-45<=X<-30	.00	.00	.00	25.00	.00	.00	.00	.00	.00	.00	.00	.00	2.17
% OCC <-45	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
% CALM	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
NO. OBS.	4.	12.	5.	4.	3.	18.	0.	0.	0.	0.	0.	0.	46.
MEAN	2.00	-1.50	.20	-1.25	3.33	-6.17	.00	.00	.00	.00	.00	.00	-2.50
BREAKER TYPE													
%OCC SPILL	50.00	83.33	50.00	75.00	66.67	61.54	.00	.00	.00	.00	.00	.00	67.50
SP/PL	.00	8.33	25.00	25.00	33.33	30.77	.00	.00	.00	.00	.00	.00	20.00
PLUNGE	50.00	8.33	25.00	.00	.00	7.69	.00	.00	.00	.00	.00	.00	12.50
SURGE	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
CALM	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
NO. OBS.	4.	12.	4.	4.	3.	13.	0.	0.	0.	0.	0.	0.	40.
CURRENT OBS.													
(FT/SEC)													
NET MEAN	1.09	.64	.92	-.30	.14	.45	.00	.00	.00	.00	.00	.00	.52
NO. OBS.	4.	12.	4.	4.	3.	13.	0.	0.	0.	0.	0.	0.	40.
GROSS MEAN	1.09	.87	1.22	1.03	.94	1.37	.00	.00	.00	.00	.00	.00	1.11
NO. OBS.	4.	12.	4.	4.	3.	13.	0.	0.	0.	0.	0.	0.	40.
FORESHORE SLOPE													
MEAN (DEG)	8.25	6.00	4.75	7.75	4.33	7.17	.00	.00	.00	.00	.00	.00	6.51
NO. OBS.	4.	12.	4.	4.	3.	12.	0.	0.	0.	0.	0.	0.	39.
RIPS % OCC	.00	.00	25.00	50.00	.00	.00	.00	.00	.00	.00	.00	.00	7.50
MEAN SPAC.	.00	.00	50.00	75.00	.00	.00	.00	.00	.00	.00	.00	.00	66.67
NO. OBS.	4.	12.	4.	4.	3.	13.	0.	0.	0.	0.	0.	0.	40.
CUSPS % OCC.	25.00	.00	25.00	75.00	.00	.00	.00	.00	.00	.00	.00	.00	12.50
MEAN SPAC.	42.00	.00	102.00	60.33	.00	.00	.00	.00	.00	.00	.00	.00	65.00
NO. OBS.	4.	12.	4.	4.	3.	13.	0.	0.	0.	0.	0.	0.	40.

* ANNUAL MEANS WEIGHTED BY TOTAL NO. OF MONTHLY OBS.

Table C-6. Annual summary for Boca Raton, 2 January to 31 December 1969.

12042 BOCA RATON FLORIDA SUMMARY FOR PERIOD STARTING 1- 2-69 AND ENDING 12-31-69

	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	* ANNUAL
SURF OBS.													
HEIGHT (FT)													
MEAN	2.25	1.73	2.38	2.86	2.72	1.41	1.62	2.12	2.00	3.11	1.98	1.63	2.29
STD DEV	1.60	1.18	1.20	1.35	1.32	1.29	1.83	1.41	1.89	1.83	1.24	1.32	1.45
NO. OBS.	37.	22.	26.	27.	21.	18.	12.	13.	8.	28.	17.	20.	249.
PERIOD (SEC)													
MEAN	5.64	5.23	5.06	4.30	4.61	3.82	3.84	4.02	5.80	4.90	4.68	4.73	4.80
STD DEV	1.29	1.36	1.16	.78	.57	.96	.65	1.47	2.10	1.29	.86	.98	1.12
NO. OBS.	38.	22.	26.	27.	21.	18.	12.	13.	10.	28.	16.	20.	251.
DIRECTION													
PROTRACTOR METHOD													
% OCC > 45	9.30	73.91	65.38	19.23	14.29	.00	.00	23.08	10.00	.00	.00	.00	19.46
30<X<= 45	.00	4.35	.00	.00	.00	.00	.00	.00	.00	64.29	58.82	60.00	15.95
20<X<= 30	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10<X<= 20	53.49	.00	.00	3.85	.00	.00	.00	.00	.00	.00	.00	.00	9.34
5<X<= 10	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
0<X<= 5	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
X=0	4.65	4.35	15.38	50.00	76.19	55.56	41.67	7.69	60.00	3.57	29.41	.00	24.90
-5<=X< 0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
-10<=X< -5	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
-20<=X<-10	11.63	4.35	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	2.33
-30<=X<-20	11.63	4.35	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	2.33
-45<=X<-30	.00	.00	.00	.00	.00	.00	.00	.00	.00	32.14	11.76	40.00	7.39
% OCC <-45	9.30	8.70	19.23	26.92	9.52	44.44	50.00	69.23	30.00	.00	.00	.00	17.90
% CALM	.00	.00	.00	.00	.00	.00	8.33	.00	.00	.00	.00	.00	.39
NO. OBS.	43.	23.	26.	26.	21.	18.	12.	13.	10.	28.	17.	20.	257.
MEAN	7.65	39.91	27.69	-3.85	2.86	-26.67	-24.55	-27.77	-12.00	14.46	21.18	9.00	6.41
BREAKER TYPE													
%OCC SPILL	36.36	13.64	34.62	51.85	47.62	44.44	33.33	53.85	30.00	39.29	52.94	40.00	40.00
SP/PL	.00	4.55	.00	.00	.00	.00	.00	.00	.00	3.57	.00	.00	.89
PLUNGE	27.27	.00	.00	3.70	4.76	.00	8.33	15.38	30.00	25.00	5.88	10.00	9.33
SURGE	36.36	81.82	65.38	44.44	47.62	55.56	50.00	30.77	40.00	32.14	41.18	50.00	49.33
CALM	.00	.00	.00	.00	.00	.00	8.33	.00	.00	.00	.00	.00	.44
NO. OBS.	11.	22.	26.	27.	21.	18.	12.	13.	10.	28.	17.	20.	225.
CURRENT OBS.													
(FT/SEC)													
NET MEAN	.69	.76	.49	-.07	.45	-.25	-.57	-.85	-.74	.91	.67	.01	.29
NO. OBS.	38.	22.	26.	26.	21.	18.	12.	13.	9.	28.	17.	19.	249.
GROSS MEAN	1.28	1.07	1.14	.76	.63	.31	.63	1.14	.74	1.70	1.41	1.48	1.08
NO. OBS.	38.	22.	26.	26.	21.	18.	12.	13.	9.	28.	17.	19.	249.
FORESHORE SLOPE													
MEAN (DEG)	.00	.00	14.09	13.62	11.57	15.65	13.80	14.92	13.00	11.62	10.18	11.33	12.76
NO. OBS.	0.	0.	11.	26.	21.	17.	10.	12.	9.	26.	17.	18.	167.
RIPS % OCC	.00	.00	3.85	.00	.00	.00	.00	15.38	30.00	32.14	35.29	25.00	11.56
MEAN SPAC.	.00	.00	1.00	.00	.00	.00	.00	260.00	100.00	89.78	80.00	74.00	95.35
NO. OBS.	12.	21.	26.	27.	21.	18.	12.	13.	10.	28.	17.	20.	225.
CUSPS % OCC.	8.33	.00	.00	.00	.00	.00	.00	.00	.00	32.14	35.29	25.00	9.33
MEAN SPAC.	20.00	.00	.00	.00	.00	.00	.00	.00	.00	89.78	80.00	74.00	79.90
NO. OBS.	12.	21.	26.	27.	21.	18.	12.	13.	10.	28.	17.	20.	225.

* ANNUAL MEANS WEIGHTED BY TOTAL NO. OF MONTHLY OBS.

Table C-7. Annual summary for Boca Raton, 5 January to 31 December 1970.

12042 BOCA RATON FLORIDA SUMMARY FOR PERIOD STARTING 1- 5-70 AND ENDING 12-31-70

	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	* ANNUAL
SURF OBS.													
HEIGHT (FT)													
MEAN	2.50	2.27	2.62	2.21	2.95	1.83	2.13	1.56	2.45	2.60	1.85	2.29	2.29
STD DEV	1.50	1.70	1.32	1.52	1.32	1.19	1.16	1.17	1.36	1.41	1.07	1.38	1.34
NO. OBS.	18.	20.	21.	20.	20.	14.	20.	20.	17.	22.	18.	21.	231.
PERIOD (SEC)													
MEAN	4.78	5.23	4.59	4.89	4.16	4.25	4.02	3.55	4.31	4.87	5.38	5.55	4.65
STD DEV	.88	1.15	.98	1.57	.69	.63	.88	.42	.97	1.38	1.09	.90	.96
NO. OBS.	18.	20.	21.	20.	20.	14.	20.	18.	16.	21.	17.	21.	226.
DIRECTION													
PROTRACTOR METHOD													
% OCC > 45	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
30<X<= 45	55.56	60.00	19.05	35.00	15.00	14.29	10.00	.00	.00	.00	50.00	38.10	24.17
20<X<= 30	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10<X<= 20	.00	.00	.00	.00	.00	.00	.00	.00	18.18	62.50	5.00	19.05	10.00
5<X<= 10	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
0<X<= 5	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
X=0	27.78	10.00	52.38	10.00	60.00	35.71	20.00	40.00	31.82	16.67	10.00	14.29	27.08
-5<=X< 0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
-10<=X< -5	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
-20<=X<-10	.00	.00	.00	.00	.00	.00	.00	.00	22.73	8.33	10.00	.00	3.75
-30<=X<-20	.00	.00	.00	.00	.00	.00	.00	.00	22.73	8.33	10.00	.00	3.75
-45<=X<-30	16.67	30.00	28.57	55.00	25.00	50.00	70.00	50.00	4.55	.00	10.00	28.57	29.58
% OCC <-45	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
% CALM	.00	.00	.00	.00	.00	.00	.00	10.00	.00	4.17	5.00	.00	1.67
NO. OBS.	18.	20.	21.	20.	20.	14.	20.	20.	22.	24.	20.	21.	240.
MEAN	17.50	13.50	-4.29	-9.00	-4.50	-16.07	-27.00	-15.00	-2.82	13.52	22.79	7.52	.13
BREAKER TYPE													
%OCC SPILL	44.44	45.00	66.67	70.00	95.00	64.29	80.00	50.00	52.94	40.91	61.11	33.33	58.44
SP/PL	.00	.00	.00	.00	.00	.00	.00	.00	11.76	31.82	5.56	14.29	5.63
PLUNGE	16.67	10.00	4.76	15.00	.00	.00	.00	.00	.00	.00	.00	.00	3.90
SURGE	38.89	45.00	28.57	15.00	5.00	35.71	20.00	40.00	35.29	22.73	27.78	52.38	30.30
CALM	.00	.00	.00	.00	.00	.00	.00	10.00	.00	4.55	5.56	.00	1.73
NO. OBS.	18.	20.	21.	20.	20.	14.	20.	20.	17.	22.	18.	21.	231.
CURRENT OBS.													
(FT/SEC)													
NET MEAN	.03	.18	-.21	-.26	-.11	-.50	-.50	-.57	-.25	.50	.65	.03	-.07
NO. OBS.	18.	20.	17.	15.	18.	13.	20.	20.	14.	21.	18.	20.	214.
GROSS MEAN	1.13	1.29	1.38	1.13	1.10	.62	.65	.57	.54	.91	1.00	.81	.93
NO. OBS.	18.	20.	17.	15.	18.	13.	20.	20.	14.	22.	18.	20.	215.
FORESHORE SLOPE													
MEAN (DEG)	12.67	13.50	12.50	11.75	9.90	11.00	13.80	14.50	12.47	12.00	12.58	11.00	12.35
NO. OBS.	18.	20.	20.	20.	20.	13.	20.	20.	17.	22.	12.	16.	218.
RIPS % OCC	33.33	40.00	38.10	35.00	40.00	7.14	.00	5.00	11.76	.00	.00	.00	17.75
MEAN SPAC.	57.50	56.25	70.00	61.43	65.63	75.00	.00	56.00	40.00	.00	.00	.00	61.49
NO. OBS.	18.	20.	21.	20.	20.	14.	20.	20.	17.	22.	18.	21.	231.
CUSPS % OCC.	33.33	40.00	38.10	35.00	40.00	7.14	.00	5.00	11.76	.00	.00	.00	17.75
MEAN SPAC.	57.50	56.25	70.00	61.43	65.63	75.00	.00	56.00	40.00	.00	.00	.00	61.49
NO. OBS.	18.	20.	21.	20.	20.	14.	20.	20.	17.	22.	18.	21.	231.

* ANNUAL MEANS WEIGHTED BY TOTAL NO. OF MONTHLY OBS.

Table C-8. Annual summary for Boca Raton, 4 January to 30 December 1971.

12042 BOCA RATON FLORIDA SUMMARY FOR PERIOD STARTING 1-4-71 AND ENDING 12-30-71

	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	* ANNUAL
SURF OBS.													
HEIGHT (FT)													
MEAN	1.61	2.61	1.92	1.13	1.09	.54	1.41	1.28	1.69	1.04	2.35	2.54	1.59
STD DEV	1.33	1.36	1.20	1.10	.68	.44	.75	.99	1.39	.57	1.10	1.61	1.04
NO. OBS.	20.	20.	22.	20.	20.	22.	18.	22.	21.	21.	18.	21.	245.
PERIOD (SEC)													
MEAN	5.96	5.83	5.35	6.89	6.77	5.70	4.14	4.34	5.40	4.76	5.01	5.00	5.44
STD DEV	.57	.80	1.08	.78	.55	1.56	.92	.80	2.09	1.79	1.33	2.06	1.20
NO. OBS.	20.	20.	22.	20.	20.	21.	17.	22.	21.	21.	18.	21.	243.
DIRECTION													
PROTRACTOR METHOD													
% OCC > 45	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
30<X<= 45	35.00	26.09	32.00	4.00	4.35	3.57	.00	7.41	19.23	4.00	28.57	3.33	13.27
20<X<= 30	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10<X<= 20	15.00	13.04	8.00	20.00	8.70	14.29	.00	3.70	15.38	32.00	9.52	6.67	12.24
5<X<= 10	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
0<X<= 5	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
X=0	20.00	17.39	16.00	24.00	39.13	17.86	57.14	37.04	15.38	20.00	28.57	30.00	26.53
-5<=X< 0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
-10<=X< -5	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
-20<=X<-10	.00	13.04	12.00	20.00	13.04	25.00	14.29	18.52	19.23	16.00	14.29	30.00	17.01
-30<=X<-20	.00	13.04	12.00	20.00	13.04	25.00	14.29	18.52	19.23	16.00	14.29	30.00	17.01
-45<=X<-30	30.00	17.39	20.00	12.00	21.74	14.29	14.29	14.81	11.54	12.00	4.76	.00	13.95
% OCC <-45	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
% CALM	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
NO. OBS.	20.	23.	25.	25.	23.	28.	21.	27.	26.	25.	21.	30.	294.
MEAN	4.80	3.91	4.72	-3.60	-8.57	-6.64	-8.86	-5.85	2.81	-.88	9.90	-2.47	-1.12
BREAKER TYPE													
%OCC SPILL	25.00	45.00	45.45	47.37	35.00	22.73	44.44	40.91	52.38	19.05	72.22	85.71	44.26
SP/PL	10.00	20.00	13.64	5.26	.00	.00	.00	.00	4.76	.00	16.67	9.52	6.56
PLUNGE	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
SURGE	65.00	35.00	40.91	47.37	65.00	77.27	55.56	59.09	42.86	80.95	11.11	4.76	49.18
CALM	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
NO. OBS.	20.	20.	22.	19.	20.	22.	18.	22.	21.	21.	18.	21.	244.
CURRENT OBS.													
(FT/SEC)													
NET MEAN	-.03	-.00	.16	-.01	-.32	-.11	-.44	-.39	.40	.06	.69	-.02	.00
NO. OBS.	20.	18.	22.	20.	19.	21.	17.	20.	21.	21.	17.	18.	234.
GROSS MEAN	.57	.93	1.00	.47	.47	.29	.44	.49	.77	.71	1.32	1.15	.71
NO. OBS.	20.	18.	22.	20.	19.	21.	17.	20.	21.	21.	17.	18.	234.
FORESHORE SLOPE													
MEAN (DEG)	12.50	13.73	14.95	13.78	13.44	14.68	14.50	14.41	15.12	13.80	11.62	13.00	14.09
NO. OBS.	12.	11.	20.	9.	18.	22.	14.	22.	17.	5.	8.	1.	159.
RIPS % OCC	5.00	10.00	4.55	.00	.00	.00	.00	.00	.00	.00	.00	4.76	2.04
MEAN SPAC.	50.00	50.00	100.00	.00	.00	.00	.00	.00	.00	.00	.00	50.00	60.00
NO. OBS.	20.	20.	22.	20.	20.	22.	18.	22.	21.	21.	18.	21.	245.
CUSPS % OCC	5.00	10.00	4.55	.00	.00	.00	.00	.00	.00	.00	.00	4.76	2.04
MEAN SPAC.	50.00	50.00	100.00	.00	.00	.00	.00	.00	.00	.00	.00	50.00	60.00
NO. OBS.	20.	20.	22.	20.	20.	22.	18.	22.	21.	21.	18.	21.	243.

* ANNUAL MEANS WEIGHTED BY TOTAL NO. OF MONTHLY OBS.

Table C-9. Annual summary for Boca Raton, 3 January to 21 December 1972.

12042 BOCA RATON FLORIDA SUMMARY FOR PERIOD STARTING 1- 3-72 AND ENDING 12-21-72

	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	* ANNUAL
SURF OBS.													
HEIGHT (FT)													
MEAN	1.73	1.55	2.10	1.50	1.19	1.66	1.95	.74	1.47	1.54	1.50	2.57	1.63
STD DEV	.98	.97	1.32	1.31	.93	1.38	.60	.68	1.05	1.63	.95	1.36	1.10
NO. OBS.	19.	18.	23.	19.	23.	19.	20.	13.	24.	20.	12.	14.	224.
PERIOD (SEC)													
MEAN	5.94	5.39	5.64	5.60	4.93	5.15	5.02	4.00	4.06	3.56	3.74	3.75	4.82
STD DEV	2.70	1.17	.73	1.01	.92	.81	.80	.93	.89	.96	1.26	.78	1.08
NO. OBS.	19.	18.	23.	18.	23.	19.	20.	10.	22.	20.	12.	14.	218.
DIRECTION													
PROTRACTOR METHOD													
% OCC > 45	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
30<X<= 45	8.33	35.00	23.08	18.18	3.70	11.11	.00	.00	3.70	.00	.00	.00	8.88
20<X<= 30	.00	.00	.00	.00	.00	.00	.00	.00	3.70	.00	.00	.00	.39
10<X<= 20	4.17	5.00	3.85	4.55	29.63	11.11	.00	.00	.00	.00	.00	.00	5.41
5<X<= 10	.00	.00	.00	.00	.00	.00	.00	.00	3.70	4.00	6.67	7.14	1.54
0<X<= 5	.00	.00	.00	.00	.00	.00	.00	.00	29.63	32.00	26.67	14.29	8.49
X=0	29.17	10.00	19.23	18.18	14.81	50.00	.00	18.75	22.22	12.00	6.67	28.57	18.53
-5<=X< 0	.00	.00	.00	.00	.00	.00	.00	18.75	3.70	8.00	13.33	21.43	4.25
-10<=X< -5	.00	.00	.00	.00	.00	.00	.00	.00	11.11	4.00	6.67	14.29	2.70
-20<=X<-10	20.83	10.00	11.54	13.64	14.81	.00	20.00	18.75	11.11	20.00	20.00	.00	13.90
-30<=X<-20	20.83	10.00	11.54	13.64	14.81	.00	20.00	18.75	11.11	20.00	20.00	14.29	14.67
-45<=X<-30	16.67	30.00	30.77	31.82	22.22	27.78	60.00	.00	.00	.00	.00	.00	19.69
% OCC <-45	.00	.00	.00	.00	.00	.00	.00	6.25	.00	.00	.00	.00	.39
% CALM	.00	.00	.00	.00	.00	.00	.00	18.75	.00	.00	.00	.00	1.16
NO. OBS.	24.	20.	26.	22.	27.	18.	25.	16.	27.	25.	15.	14.	259.
MEAN	-6.58	1.40	-4.77	-7.68	-5.81	-5.61	-30.40	11.23	1.26	-2.12	-3.27	-5.29	-5.61
BREAKER TYPE													
%OCC SPILL	68.42	77.78	56.52	26.32	30.43	26.32	95.00	15.38	29.17	25.00	50.00	21.43	44.20
SP/PL	5.26	.00	21.74	10.53	4.35	10.53	.00	15.38	20.83	25.00	16.67	64.29	15.18
PLUNGE	.00	.00	.00	.00	.00	.00	.00	.00	12.50	25.00	33.33	14.29	6.25
SURGE	26.32	22.22	21.74	63.16	65.22	63.16	5.00	46.15	33.33	25.00	.00	.00	32.59
CALM	.00	.00	.00	.00	.00	.00	.00	23.08	4.17	.00	.00	.00	1.79
NO. OBS.	19.	18.	23.	19.	23.	19.	20.	13.	24.	20.	12.	14.	224.
CURRENT OBS.													
(FT/SEC)													
NET MEAN	-.26	.09	-.15	-.03	.03	-.12	-.59	-.49	.49	.45	.11	-.29	-.02
NO. OBS.	19.	18.	21.	17.	23.	11.	18.	7.	24.	20.	12.	14.	204.
GROSS MEAN	1.11	.81	.85	.52	.53	.12	.59	.49	.82	1.02	1.16	1.60	.82
NO. OBS.	19.	18.	21.	17.	23.	11.	18.	7.	24.	20.	12.	14.	204.
FORESHORE SLOPE													
MEAN (DEG)	.00	9.78	13.74	15.94	17.43	17.33	15.08	9.83	11.52	6.50	6.17	5.14	12.28
NO. OBS.	0.	9.	19.	18.	23.	18.	12.	6.	23.	20.	12.	14.	174.
RIPS % OCC	.00	.00	13.04	.00	.00	.00	5.00	.00	.00	.00	.00	.00	1.79
MEAN SPAC.	.00	.00	33.33	.00	.00	.00	39.00	.00	.00	.00	.00	.00	34.75
NO. OBS.	19.	18.	23.	19.	23.	19.	20.	13.	24.	20.	12.	14.	224.
CUSPS % OCC.	.00	.00	13.04	.00	.00	.00	5.00	7.69	25.00	15.00	.00	.00	6.25
MEAN SPAC.	.00	.00	33.33	.00	.00	.00	39.00	57.00	37.00	80.67	.00	.00	47.14
NO. OBS.	19.	18.	23.	19.	23.	19.	20.	13.	24.	20.	12.	14.	224.

* ANNUAL MEANS WEIGHTED BY TOTAL NO. OF MONTHLY OBS.

Table C-10. Six-month summary for Boca Raton, 2 January to 29 June 1973.

12042 BOCA RATON FLORIDA SUMMARY FOR PERIOD STARTING 1- 2-73 AND ENDING 6-29-73

	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	* ANNUAL
SURF OBS.													
HEIGHT (FT)													
MEAN	1.95	3.06	2.33	2.63	1.53	1.12	.00	.00	.00	.00	.00	.00	2.13
STD DEV	1.19	2.08	1.23	1.91	1.72	1.23	.00	.00	.00	.00	.00	.00	1.56
NO. OBS.	20.	27.	21.	19.	16.	25.	0.	0.	0.	0.	0.	0.	128.
PERIOD (SEC)													
MEAN	3.79	4.24	3.39	3.16	3.07	3.40	.00	.00	.00	.00	.00	.00	3.57
STD DEV	.94	1.09	.94	1.12	.98	1.48	.00	.00	.00	.00	.00	.00	1.09
NO. OBS.	20.	27.	21.	19.	16.	20.	0.	0.	0.	0.	0.	0.	123.
DIRECTION													
PROTRACTOR METHOD													
% OCC > 45	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
30<X<= 45	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
20<X<= 30	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10<X<= 20	4.55	18.52	11.54	.00	.00	.00	.00	.00	.00	.00	.00	.00	6.38
5<X<= 10	27.27	7.41	7.69	14.29	5.88	.00	.00	.00	.00	.00	.00	.00	9.93
0<X<= 5	9.09	3.70	3.85	9.52	.00	.00	.00	.00	.00	.00	.00	.00	4.26
X=0	22.73	33.33	3.85	9.52	35.29	39.29	.00	.00	.00	.00	.00	.00	24.11
-5<=X< 0	9.09	3.70	11.54	4.76	5.88	3.57	.00	.00	.00	.00	.00	.00	6.38
-10<=X< -5	4.55	14.81	19.23	28.57	5.88	17.86	.00	.00	.00	.00	.00	.00	15.60
-20<=X<-10	9.09	3.70	19.23	9.52	17.65	10.71	.00	.00	.00	.00	.00	.00	11.35
-30<=X<-20	9.09	11.11	23.08	19.05	17.65	21.43	.00	.00	.00	.00	.00	.00	17.02
-45<=X<-30	.00	.00	.00	4.76	11.76	7.14	.00	.00	.00	.00	.00	.00	3.55
% OCC <-45	.00	3.70	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.71
% CALM	4.55	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.71
NO. OBS.	22.	27.	26.	21.	17.	28.	0.	0.	0.	0.	0.	0.	141.
MEAN	5.95	-7.30	-3.69	-7.52	-7.65	-8.79	.00	.00	.00	.00	.00	.00	-5.01
BREAKER TYPE													
%OCC SPILL	25.00	48.15	42.86	36.84	37.50	24.00	.00	.00	.00	.00	.00	.00	35.94
SP/PL	40.00	22.22	47.62	36.84	12.50	28.00	.00	.00	.00	.00	.00	.00	31.25
PLUNGE	30.00	.00	.00	5.26	.00	.00	.00	.00	.00	.00	.00	.00	5.47
SURGE	5.00	29.63	9.52	21.05	50.00	48.00	.00	.00	.00	.00	.00	.00	27.34
CALM	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
NO. OBS.	20.	27.	21.	19.	16.	25.	0.	0.	0.	0.	0.	0.	128.
CURRENT OBS.													
(FT/SEC)													
NET MEAN	.06	-.22	-.43	-.01	-.70	-.38	.00	.00	.00	.00	.00	.00	-.27
NO. OBS.	20.	27.	21.	19.	15.	24.	0.	0.	0.	0.	0.	0.	126.
GROSS MEAN	1.35	1.21	1.26	1.49	1.11	.65	.00	.00	.00	.00	.00	.00	1.17
NO. OBS.	20.	27.	21.	19.	15.	24.	0.	0.	0.	0.	0.	0.	126.
FORESHORE SLOPE													
MEAN (DEG)	5.00	5.48	6.11	5.32	7.00	6.24	.00	.00	.00	.00	.00	.00	5.77
NO. OBS.	18.	21.	18.	19.	12.	17.	0.	0.	0.	0.	0.	0.	105.
RIPS % OCC	.00	.00	.00	.00	100.00	16.67	.00	.00	.00	.00	.00	.00	4.46
MEAN SPAC.	.00	.00	.00	.00	50.00	154.75	.00	.00	.00	.00	.00	.00	133.80
NO. OBS.	20.	27.	21.	19.	1.	24.	0.	0.	0.	0.	0.	0.	112.
CUSPS % OCC.	10.00	.00	.00	15.79	.00	.00	.00	.00	.00	.00	.00	.00	4.46
MEAN SPAC.	64.50	.00	.00	22.67	.00	.00	.00	.00	.00	.00	.00	.00	39.40
NO. OBS.	20.	27.	21.	19.	0.	25.	0.	0.	0.	0.	0.	0.	112.

* ANNUAL MEANS WEIGHTED BY TOTAL NO. OF MONTHLY OBS.

Table C-11. Annual summary for Hollywood, 4 February to 30 December 1969.

12043 HOLLYWOOD FLORIDA SUMMARY FOR PERIOD STARTING 2- 4-69 AND ENDING 12-30-69

	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	* ANNUAL
SURF OBS.													
HEIGHT (FT)													
MEAN	.00	2.23	2.44	2.48	3.22	1.10	1.65	1.05	.60	2.37	1.88	1.75	1.92
STD DEV	.00	.74	.34	1.82	1.36	.69	1.48	.07	.22	.75	1.31	.96	.89
NO. OBS.	0.	3.	5.	5.	4.	4.	4.	2.	5.	4.	4.	4.	44.
PERIOD (SEC)													
MEAN	.00	7.73	4.76	3.92	4.22	3.57	3.82	6.00	3.54	4.82	5.00	4.62	4.56
STD DEV	.00	1.80	1.86	.80	.59	.67	1.19	2.83	.67	.92	.57	1.18	1.19
NO. OBS.	0.	3.	5.	5.	4.	4.	4.	2.	5.	4.	4.	4.	44.
DIRECTION													
PROTRACTOR METHOD													
% OCC > 45	.00	100.00	40.00	60.00	.00	.00	.00	50.00	.00	.00	.00	.00	19.57
30<X<= 45	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	25.00	.00	2.17
20<X<= 30	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10<X<= 20	.00	.00	.00	.00	.00	25.00	.00	.00	.00	25.00	25.00	.00	6.52
5<X<= 10	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	25.00	16.67	4.35
0<X<= 5	.00	.00	.00	.00	.00	.00	.00	.00	.00	50.00	25.00	.00	6.52
X=0	.00	.00	.00	40.00	100.00	50.00	25.00	.00	60.00	.00	.00	.00	26.09
-5<=X< 0	.00	.00	.00	.00	.00	.00	.00	.00	.00	25.00	.00	16.67	4.35
-10<=X< -5	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
-20<=X<-10	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	33.33	4.35
-30<=X<-20	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	33.33	4.35
-45<=X<-30	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
% OCC <-45	.00	.00	60.00	.00	.00	25.00	50.00	50.00	40.00	.00	.00	.00	19.57
% CALM	.00	.00	.00	.00	.00	.00	25.00	.00	.00	.00	.00	.00	2.17
NO. OBS.	0.	3.	5.	5.	4.	4.	4.	2.	5.	4.	4.	6.	46.
MEAN	.00	60.00	-12.00	36.00	.00	-10.00	-10.00	.00	-24.00	5.00	16.50	-3.17	3.93
BREAKER TYPE													
%OCC SPILL	.00	66.67	20.00	80.00	25.00	25.00	50.00	.00	20.00	100.00	50.00	50.00	45.45
SP/PL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
PLUNGE	.00	.00	.00	.00	25.00	.00	.00	.00	.00	.00	.00	.00	2.27
SURGE	.00	33.33	80.00	20.00	50.00	75.00	50.00	100.00	80.00	.00	50.00	50.00	52.27
CALM	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
NO. OBS.	0.	3.	5.	5.	4.	4.	4.	2.	5.	4.	4.	4.	44.
CURRENT OBS.													
(FT/SEC)													
NET MEAN	.00	1.12	-.76	.84	.62	-.29	-.43	-.10	-.69	.36	1.08	-.45	.08
NO. OBS.	0.	3.	5.	5.	4.	4.	4.	2.	5.	4.	4.	4.	44.
GROSS MEAN	.00	1.12	1.35	.84	.62	.29	.43	.48	.69	1.01	1.08	1.48	.87
NO. OBS.	0.	3.	5.	5.	4.	4.	4.	2.	5.	4.	4.	4.	44.
FORESHORE SLOPE													
MEAN (DEG)	.00	.00	13.25	16.60	15.25	14.75	12.75	9.50	12.40	11.75	11.00	13.50	13.32
NO. OBS.	0.	0.	4.	5.	4.	4.	4.	2.	5.	4.	4.	4.	40.
RIPS % OCC	.00	.00	.00	.00	.00	.00	.00	.00	.00	50.00	50.00	25.00	11.63
MEAN SPAC.	.00	.00	.00	.00	.00	.00	.00	.00	.00	110.00	87.50	50.00	89.00
NO. OBS.	0.	3.	4.	5.	4.	4.	4.	2.	5.	4.	4.	4.	43.
CUSPS % OCC.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
MEAN SPAC.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
NO. OBS.	0.	3.	4.	5.	4.	4.	4.	2.	5.	4.	4.	4.	43.

* ANNUAL MEANS WEIGHTED BY TOTAL NO. OF MONTHLY OBS.

Table C-12. Annual summary for Hollywood, 6 January to 29 December 1970.

12043 HOLLYWOOD FLORIDA SUMMARY FOR PERIOD STARTING 1- 6-70 AND ENDING 12-29-70

	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	* ANNUAL
SURF OBS.													
HEIGHT (FT)													
MEAN	1.88	2.00	2.40	2.00	2.37	2.25	1.75	1.50	1.75	2.25	1.75	2.00	1.98
STD DEV	1.40	1.41	1.14	.00	1.25	1.89	.96	.58	.96	1.26	.50	1.22	1.14
NO. OBS.	12.	4.	5.	3.	4.	4.	4.	4.	4.	4.	4.	5.	57.
PERIOD (SEC)													
MEAN	4.42	4.35	5.82	5.00	4.17	4.42	5.02	4.52	3.80	5.47	4.90	5.38	4.76
STD DEV	.40	.93	3.59	2.29	.64	.94	.97	.70	.32	2.45	.67	.64	1.21
NO. OBS.	12.	4.	5.	3.	3.	4.	4.	4.	4.	4.	4.	5.	56.
DIRECTION													
PROTRACTOR METHOD													
% OCC > 45	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
30<X<= 45	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	50.00	80.00	8.57
20<X<= 30	16.67	.00	.00	.00	.00	.08	.00	.00	.00	.00	.00	.00	2.86
10<X<= 20	.00	.00	20.00	20.00	25.00	.00	.00	.00	40.00	60.00	.00	.00	11.43
5<X<= 10	8.33	16.67	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	2.86
0<X<= 5	16.67	.00	20.00	.00	75.00	.00	.00	.00	.00	.00	.00	.00	8.57
X=0	.00	.00	.00	.00	.00	60.00	14.29	14.29	20.00	.00	.00	.00	8.57
-5<=X< 0	.00	.00	40.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	2.86
-10<=X< -5	58.33	16.67	20.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	12.86
-20<=X<-10	.00	33.33	.00	40.00	.00	20.00	42.86	42.86	20.00	20.00	.00	.00	18.57
-30<=X<-20	.00	33.33	.00	40.00	.00	20.00	42.86	42.86	20.00	20.00	.00	.00	18.57
-45<=X<-30	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	50.00	20.00	4.29
% OCC <-45	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
% CALM	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
NO. OBS.	12.	6.	5.	5.	4.	5.	7.	7.	5.	5.	4.	5.	70.
MEAN	.25	-5.67	1.20	-3.60	5.25	-3.40	-7.29	-7.29	3.40	6.80	.00	27.00	.64
BREAKER TYPE													
%OCC SPILL	58.33	75.00	100.00	100.00	75.00	33.33	50.00	75.00	25.00	75.00	100.00	40.00	66.07
SP/PL	.00	.00	.00	.00	.00	.00	.00	.00	.00	25.00	.00	20.00	3.57
PLUNGE	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
SURGE	41.67	25.00	.00	.00	25.00	66.67	50.00	25.00	75.00	.00	.00	40.00	30.36
CALM	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
NO. OBS.	12.	4.	5.	3.	4.	3.	4.	4.	4.	4.	4.	5.	56.
CURRENT OBS.													
(FT/SEC)													
NET MEAN	-.45	-.77	-.23	-.30	.67	.25	-.51	-.50	.58	.31	.05	.43	-.98
NO. OBS.	11.	4.	5.	3.	4.	4.	4.	4.	4.	4.	4.	5.	56.
GROSS MEAN	.97	1.51	.89	.78	.67	.58	.51	.70	.58	.81	1.15	.82	.85
NO. OBS.	11.	4.	5.	3.	4.	4.	4.	4.	4.	4.	4.	5.	56.
FORESHORE SLOPE													
MEAN (DEG)	13.27	13.75	11.60	10.33	11.75	9.50	11.00	11.50	14.75	13.75	.00	.00	12.32
NO. OBS.	11.	4.	5.	3.	4.	4.	4.	4.	4.	4.	0.	0.	47.
RIPS % OCC	41.67	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	8.93
MEAN SPAC.	118.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	118.00
NO. OBS.	12.	4.	5.	3.	4.	4.	4.	3.	4.	4.	4.	5.	56.
CUSPS % OCC.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	00	.00
MEAN SPAC.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
NO. OBS.	12.	4.	5.	3.	4.	4.	4.	3.	4.	4.	4.	5.	56.

* ANNUAL MEANS WEIGHTED BY TOTAL NO. OF MONTHLY OBS.

Table C-13. Annual summary for Hollywood, 5 January to 28 December 1971.

12043 HOLLYWOOD FLORIDA SUMMARY FOR PERIOD STARTING 1- 5-71 AND ENDING 12-28-71

	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	* ANNUAL
SURF OBS.													
HEIGHT (FT)													
MEAN	1.50	2.25	1.57	1.82	1.75	.58	1.33	.78	.92	.65	1.43	1.75	1.32
STD DEV	1.00	.96	1.18	1.39	.50	.38	.58	.75	.70	.40	1.40	.96	.85
NO. OBS.	4.	4.	4.	4.	4.	5.	3.	5.	5.	4.	3.	4.	49.
PERIOD (SEC)													
MEAN	5.37	5.70	5.30	6.32	6.75	5.50	3.73	3.86	4.54	3.70	4.00	3.85	4.90
STD DEV	.51	.37	1.41	.55	.17	1.86	.25	.55	.68	.54	1.50	1.57	.83
NO. OBS.	4.	4.	4.	4.	4.	4.	3.	5.	5.	4.	3.	4.	48.
DIRECTION													
PROTRACTOR METHOD													
% OCC > 45	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
30<X<= 45	50.00	25.00	20.00	25.00	20.00	.00	.00	16.67	.00	33.33	.00	.00	14.06
20<X<= 30	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10<X<= 20	.00	50.00	20.00	25.00	.00	12.50	.00	16.67	16.67	.00	20.00	.00	12.50
5<X<= 10	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
0<X<= 5	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
X=0	.00	.00	.00	25.00	20.00	12.50	25.00	33.33	33.33	.00	.00	14.29	14.06
-5<=X< 0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
-10<=X< -5	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
-20<=X<-10	.00	.00	20.00	.00	20.00	37.50	25.00	16.67	16.67	33.33	40.00	42.86	23.44
-30<=X<-20	.00	.00	20.00	.00	20.00	37.50	25.00	16.67	16.67	33.33	40.00	42.86	23.44
-45<=X<-30	50.00	25.00	20.00	25.00	20.00	.00	25.00	.00	16.67	.00	.00	.00	12.50
% OCC <-45	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
% CALM	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
NO. OBS.	4.	4.	5.	4.	5.	8.	4.	6.	6.	6.	5.	7.	64.
MEAN	.00	8.50	.00	4.25	-3.40	-4.25	-15.50	7.50	-7.50	9.33	-3.40	-7.29	-1.16
BREAKER TYPE													
%OCC SPILL	25.00	50.00	50.00	50.00	50.00	20.00	33.33	40.00	20.00	25.00	33.33	100.00	40.82
SP/PL	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	33.33	.00	2.04
PLUNGE	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
SURGE	75.00	50.00	50.00	50.00	50.00	80.00	66.67	60.00	80.00	75.00	33.33	.00	57.14
CALM	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
NO. OBS.	4.	4.	4.	4.	4.	5.	3.	5.	5.	4.	3.	4.	49.
CURRENT OBS.													
(FT/SEC)													
NET MEAN	.04	.38	-.15	.64	-.41	-.09	-.75	-.27	.00	.24	-.23	-.45	-.06
NO. OBS.	4.	4.	4.	4.	4.	5.	2.	4.	4.	3.	3.	4.	45.
GROSS MEAN	.60	.84	.80	.64	.69	.32	.75	.27	.28	.98	1.16	.45	.62
NO. OBS.	4.	4.	4.	4.	4.	5.	2.	4.	4.	3.	3.	4.	45.
FORESHORE SLOPE													
MEAN (DEG)	.00	12.75	14.00	.00	.00	.00	.00	14.00	15.00	13.00	14.00	.00	13.64
NO. OBS.	0.	4.	4.	0.	0.	0.	0.	3.	1.	1.	1.	0.	14.
RIPS % OCC	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
MEAN SPAC.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
NO. OBS.	4.	4.	4.	4.	4.	5.	3.	5.	5.	4.	3.	4.	49.
CUSPS % OCC.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
MEAN SPAC.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
NO. OBS.	4.	4.	4.	4.	4.	5.	3.	5.	5.	4.	3.	4.	49.

* ANNUAL MEANS WEIGHTED BY TOTAL NO. OF MONTHLY OBS.

Table C-14. Annual summary for Hollywood, 4 January to 19 December 1972.

12043 HOLLYWOOD FLORIDA SUMMARY FOR PERIOD STARTING 1- 4-72 AND ENDING 12-19-72

	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	* ANNUAL
SURF OBS.													
HEIGHT (FT)													
MEAN	2.00	.80	1.00	.72	1.06	2.32	1.50	.50	1.00	1.34	1.00	2.75	1.30
STD DEV	1.00	.84	.82	.85	.61	1.58	.58	.71	.00	1.15	.00	.35	.85
NO. OBS.	3.	5.	4.	4.	5.	4.	4.	2.	3.	5.	2.	2.	43.
PERIOD (SEC)													
MEAN	4.50	4.94	5.60	4.90	4.42	4.92	5.95	3.80	4.27	3.06	2.75	3.75	4.54
STD DEV	.87	.57	.92	.72	1.07	.54	.24	.00	.50	.30	.64	.49	.62
NO. OBS.	3.	5.	4.	4.	5.	4.	4.	1.	3.	5.	2.	2.	42.
DIRECTION													
PROTRACTOR METHOD													
% OCC > 45	.00	.00	.00	.00	.00	20.00	.00	.00	.00	.00	.00	.00	1.85
30<X<= 45	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
20<X<= 30	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
10<X<= 20	25.00	42.86	.00	25.00	50.00	.00	.00	.00	.00	.00	.00	.00	14.81
5<X<= 10	.00	.00	.00	.00	.00	.00	.00	.00	.00	14.29	.00	.00	1.85
0<X<= 5	.00	.00	.00	.00	.00	.00	.00	.00	25.00	14.29	.00	50.00	5.56
X=0	.00	.00	33.33	50.00	.00	20.00	.00	.00	25.00	14.29	.00	50.00	14.81
-5<=X< 0	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	50.00	.00	1.85
-10<=X< -5	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	50.00	.00	1.85
-20<=X<-10	25.00	28.57	33.33	.00	16.67	20.00	.00	33.33	25.00	28.57	.00	.00	20.37
-30<=X<-20	25.00	28.57	33.33	.00	16.67	20.00	.00	33.33	25.00	28.57	.00	.00	20.37
-45<=X<-30	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
% OCC <-45	25.00	.00	.00	25.00	16.67	20.00	100.00	.00	.00	.00	.00	.00	14.81
% CALM	.00	.00	.00	.00	.00	.00	.00	33.33	.00	.00	.00	.00	1.85
NO. OBS.	4.	7.	6.	4.	6.	5.	4.	3.	4.	7.	2.	2.	54.
MEAN	-15.00	2.43	-5.67	-10.75	-4.33	-3.40	-60.00	35.00	-2.75	-3.00	-6.00	1.50	-7.06
BREAKER TYPE													
%OCC SPILL	66.67	60.00	75.00	25.00	20.00	50.00	75.00	.00	100.00	60.00	100.00	50.00	55.81
SP/PL	.00	.00	.00	.00	.00	25.00	.00	50.00	.00	.00	.00	50.00	6.98
PLUNGE	33.33	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	2.33
SURGE	.00	40.00	25.00	75.00	80.00	25.00	25.00	.00	.00	40.00	.00	.00	32.56
CALM	.00	.00	.00	.00	.00	.00	.00	50.00	.00	.00	.00	.00	2.33
NO. OBS.	3.	5.	4.	4.	5.	4.	4.	2.	3.	5.	2.	2.	43.
CURRENT OBS.													
(FT/SEC)													
NET MEAN	.81	-.08	-.39	-.13	-.16	.83	.48	-.78	.37	.23	.70	1.57	.21
NO. OBS.	3.	5.	3.	4.	5.	2.	4.	2.	3.	5.	2.	2.	40.
GROSS MEAN	1.64	.62	.39	.13	.39	.82	.48	.78	.83	.82	.70	1.57	.70
NO. OBS.	3.	5.	3.	4.	5.	3.	4.	2.	3.	5.	2.	2.	41.
FORESHORE SLOPE													
MEAN (DEG)	.00	.00	.00	.00	.00	.00	.00	10.00	4.33	6.50	7.00	7.00	6.42
NO. OBS.	0.	0.	0.	0.	0.	0.	0.	1.	3.	4.	2.	2.	12.
RIPS % OCC	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
MEAN SPAC.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
NO. OBS.	3.	5.	4.	4.	5.	4.	4.	2.	3.	5.	2.	2.	43.
CUSPS % OCC.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
MEAN SPAC.	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
NO. OBS.	3.	5.	4.	4.	5.	4.	4.	2.	3.	5.	2.	2.	43.

* ANNUAL MEANS WEIGHTED BY TOTAL NO. OF MONTHLY OBS.

Table C-15. Six-month summary for Hollywood, 3 January to 26 June 1973.

12043 HOLLYWOOD FLORIDA SUMMARY FOR PERIOD STARTING 1- 3-73 AND ENDING 6-26-73

	JAN	FEB	MARCH	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	* ANNUAL
SURF OBS.													
HEIGHT (FT)													
MEAN	1.62	.89	.83	2.00	1.15	1.37	.00	.00	.00	.00	.00	.00	1.21
STD DEV	.75	.90	.58	1.00	.77	.75	.00	.00	.00	.00	.00	.00	.79
NO. OBS.	4.	14.	3.	5.	13.	4.	0.	0.	0.	0.	0.	0.	43.
PERIOD (SEC)													
MEAN	4.62	4.67	2.67	4.28	3.82	3.65	.00	.00	.00	.00	.00	.00	4.14
STD DEV	2.34	1.91	1.15	1.27	.88	.97	.00	.00	.00	.00	.00	.00	1.42
NO. OBS.	4.	14.	3.	5.	12.	4.	0.	0.	0.	0.	0.	0.	42.
DIRECTION													
PROTRACTOR METHOD													
% OCC > 45	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
30<X<= 45	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
20<X<= 30	.00	.00	.00	16.67	.00	.00	.00	.00	.00	.00	.00	.00	2.13
10<X<= 20	.00	7.14	25.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	4.26
5<X<= 10	.00	28.57	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	8.51
0<X<= 5	20.00	35.71	.00	16.67	15.38	.00	.00	.00	.00	.00	.00	.00	19.15
X=0	20.00	14.29	25.00	16.67	30.77	20.00	.00	.00	.00	.00	.00	.00	21.28
-5<=X< 0	20.00	.00	.00	.00	23.08	40.00	.00	.00	.00	.00	.00	.00	12.77
-10<=X< -5	.00	7.14	.00	.00	7.69	.00	.00	.00	.00	.00	.00	.00	4.26
-20<=X<-10	20.00	.00	25.00	16.67	.00	20.00	.00	.00	.00	.00	.00	.00	8.51
-30<=X<-20	20.00	.00	25.00	33.33	.00	20.00	.00	.00	.00	.00	.00	.00	10.64
-45<=X<-30	.00	.00	.00	.00	15.38	.00	.00	.00	.00	.00	.00	.00	4.26
% OCC <-45	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
% CALM	.00	7.14	.00	.00	7.69	.00	.00	.00	.00	.00	.00	.00	4.26
NO. OBS.	5.	14.	4.	6.	13.	5.	0.	0.	0.	0.	0.	0.	47.
MEAN	-3.40	11.54	1.25	-.50	.25	-6.00	.00	.00	.00	.00	.00	.00	2.40
BREAKER TYPE													
%OCC SPILL	100.00	35.71	.00	80.00	61.54	75.00	.00	.00	.00	.00	.00	.00	55.81
SP/PL	.00	.00	.00	.00	23.08	25.00	.00	.00	.00	.00	.00	.00	9.30
PLUNGE	.00	.00	33.33	.00	.00	.00	.00	.00	.00	.00	.00	.00	2.33
SURGE	.00	57.14	66.67	20.00	15.38	.00	.00	.00	.00	.00	.00	.00	30.23
CALM	.00	7.14	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	2.33
NO. OBS.	4.	14.	3.	5.	13.	4.	0.	0.	0.	0.	0.	0.	43.
CURRENT OBS.													
(FT/SEC)													
NET MEAN	-.26	.85	-.64	-.05	-.74	-.29	.00	.00	.00	.00	.00	.00	-.05
NO. OBS.	4.	14.	3.	4.	13.	4.	0.	0.	0.	0.	0.	0.	42.
GROSS MEAN	1.40	1.15	.74	.93	.90	.80	.00	.00	.00	.00	.00	.00	1.01
NO. OBS.	4.	14.	3.	4.	13.	4.	0.	0.	0.	0.	0.	0.	42.
FORESHORE SLOPE													
MEAN (DEG)	7.25	6.00	4.50	6.50	6.15	6.50	.00	.00	.00	.00	.00	.00	6.20
NO. OBS.	4.	14.	2.	4.	13.	4.	0.	0.	0.	0.	0.	0.	41.
RIPS % OCC	.00	.00	.00	.00	30.77	.00	.00	.00	.00	.00	.00	.00	9.30
MEAN SPAC.	.00	.00	.00	.00	22.50	.00	.00	.00	.00	.00	.00	.00	22.50
NO. OBS.	4.	14.	3.	5.	13.	4.	0.	0.	0.	0.	0.	0.	43.
CUSPS % OCC.	.00	.00	33.33	.00	.00	.00	.00	.00	.00	.00	.00	.00	2.33
MEAN SPAC.	.00	.00	125.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	125.00
NO. OBS.	4.	14.	3.	5.	13.	4.	0.	0.	0.	0.	0.	0.	43.

* ANNUAL MEANS WEIGHTED BY TOTAL NO. OF MONTHLY OBS.

APPENDIX D

BOCA RATON ANNUAL WIND ROSES

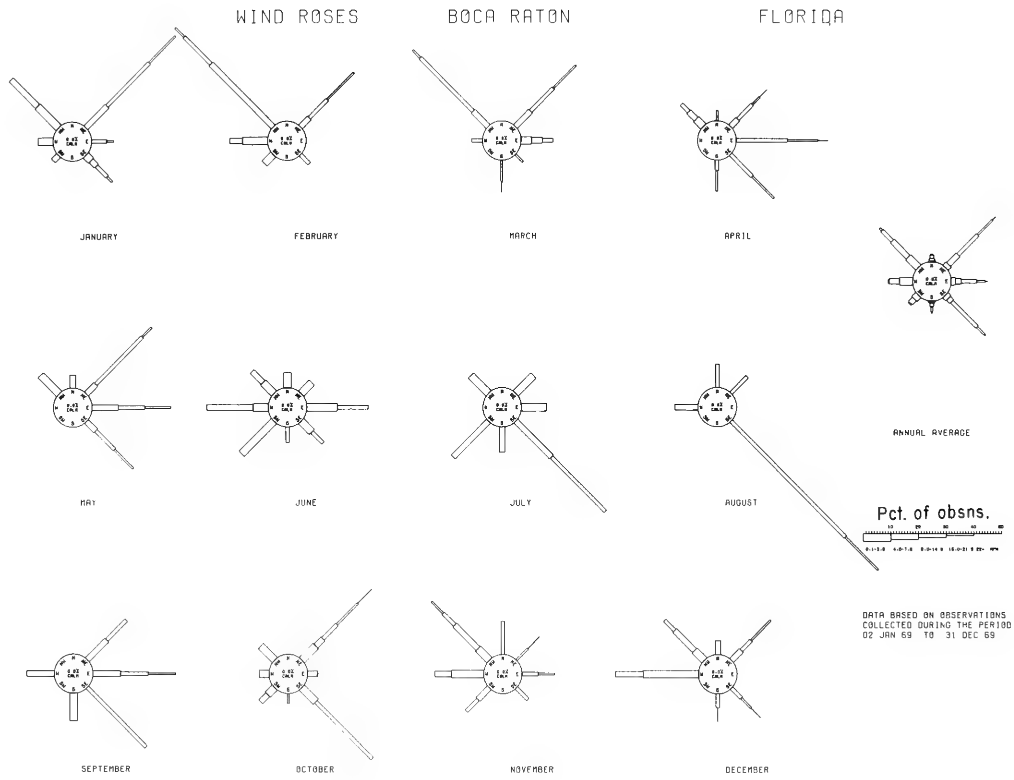


Figure D-1. Wind roses, Boca Raton, 1969.

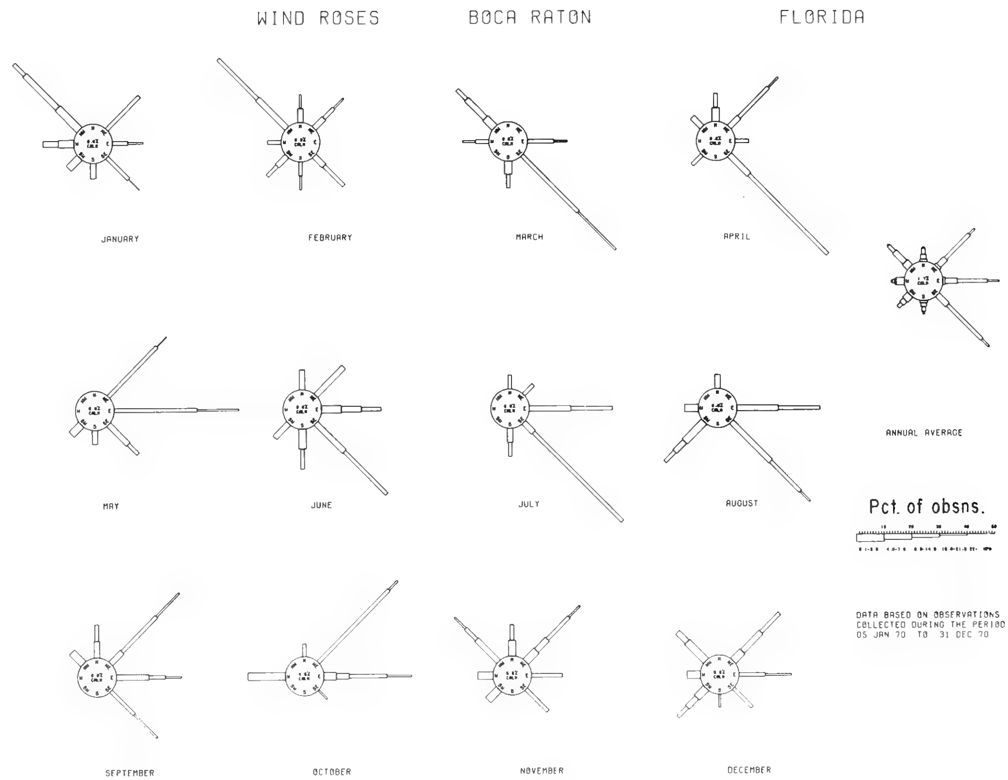


Figure D-2. Wind roses, Boca Raton, 1970.

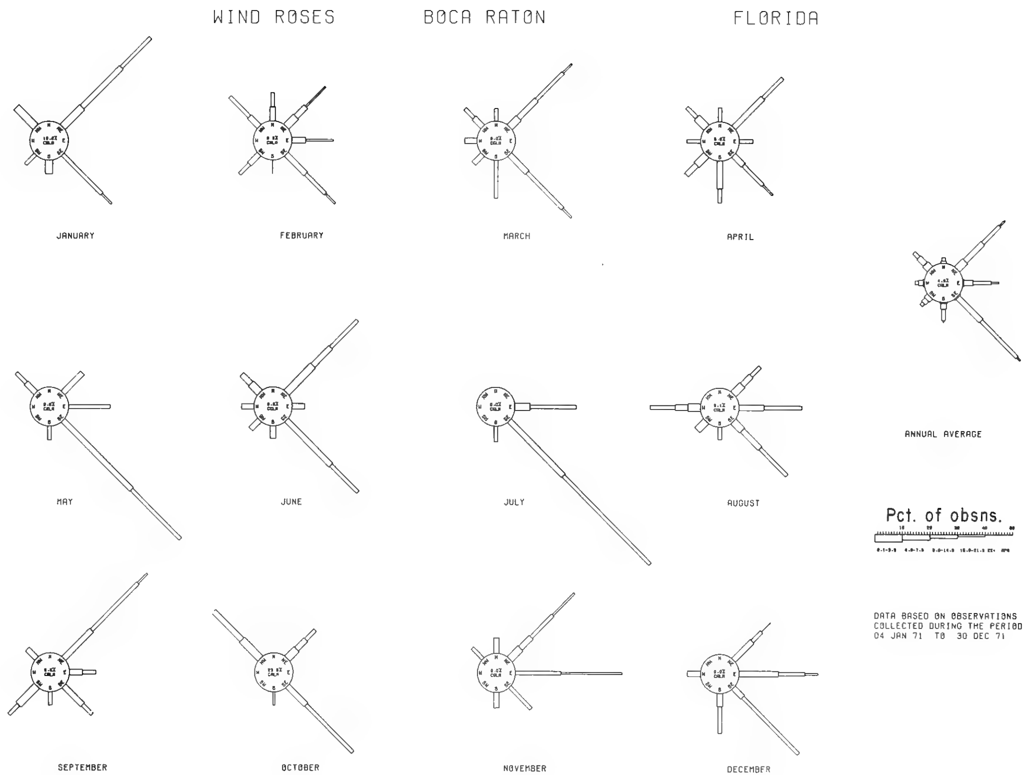


Figure D-3. Wind roses, Boca Raton, 1971.

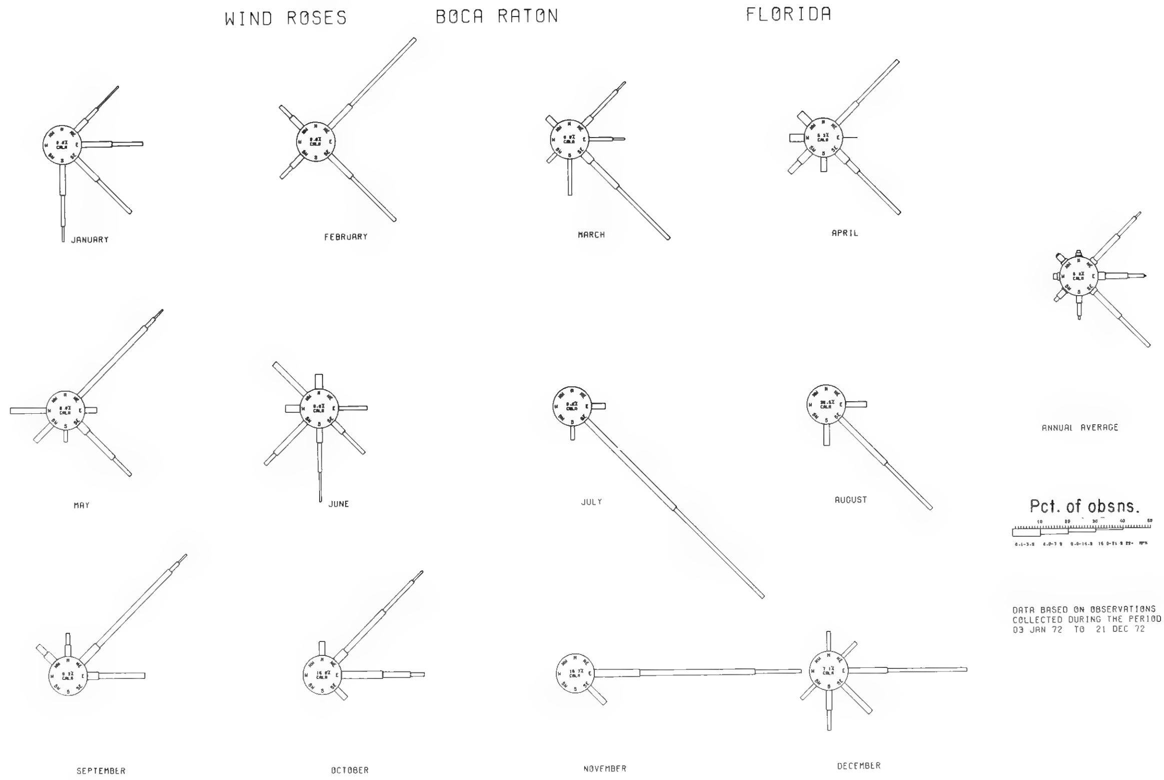


Figure D-4. Wind roses, Boca Raton, 1972.

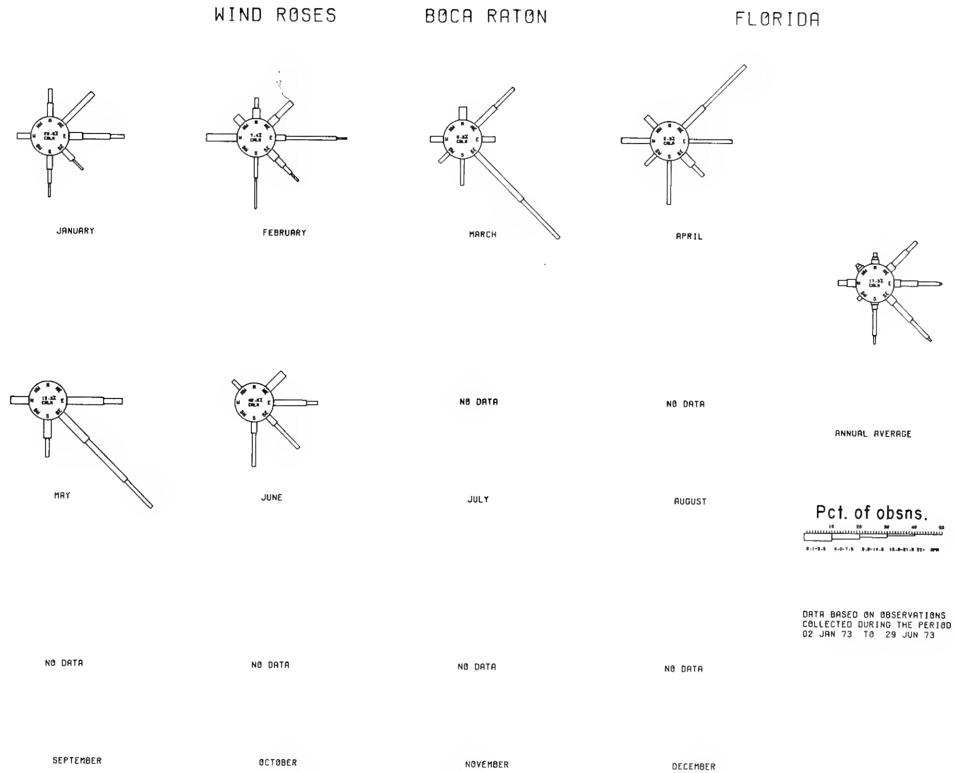


Figure D-5. Wind roses, Boca Raton, 1973.

APPENDIX E

BOCA RATON ANNUAL WAVE HEIGHT ROSES, 1969 TO 1973

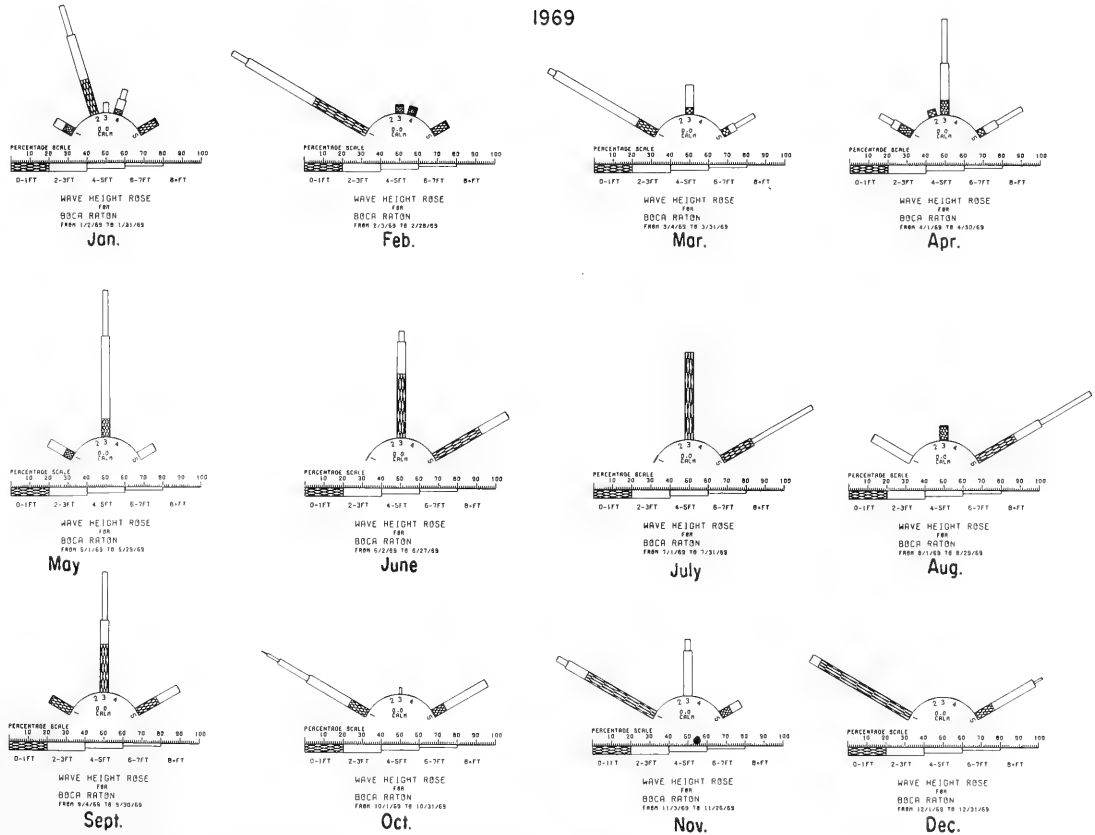


Figure E-1. Breaker height roses, Boca Raton, 1969.

1970

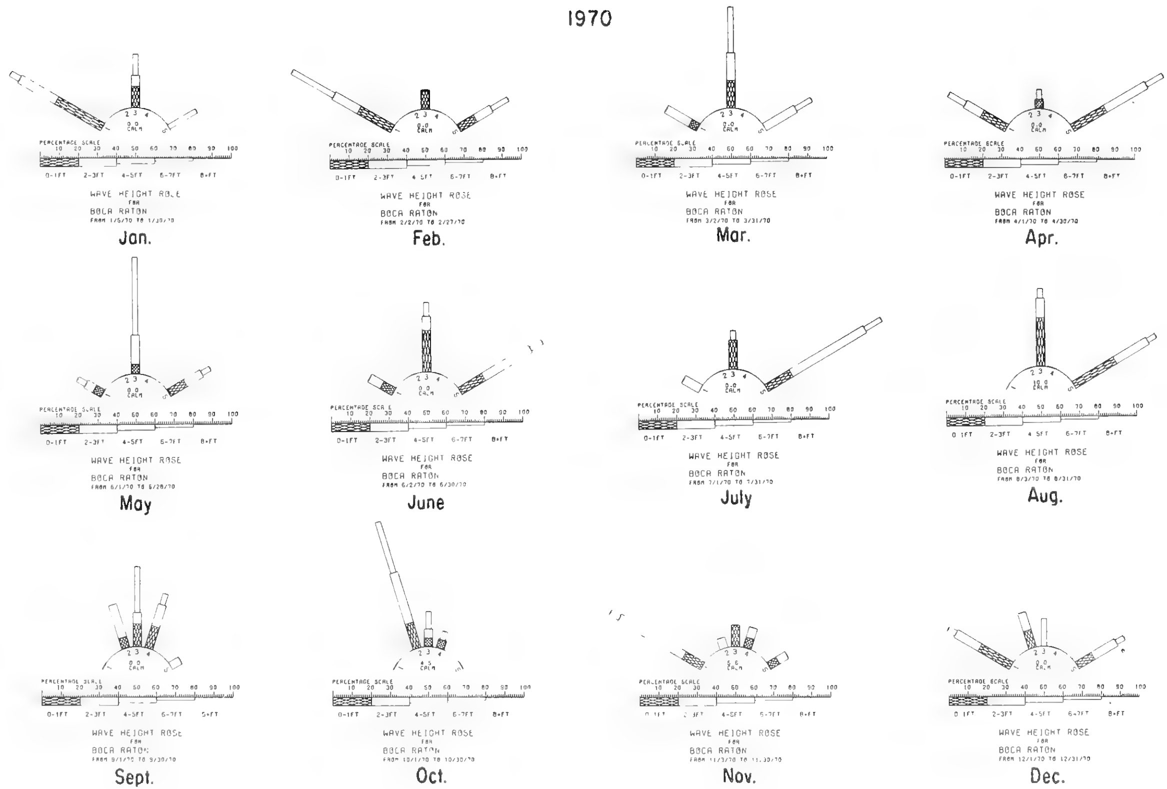


Figure E-2. Breaker height roses, Boca Raton, 1970.

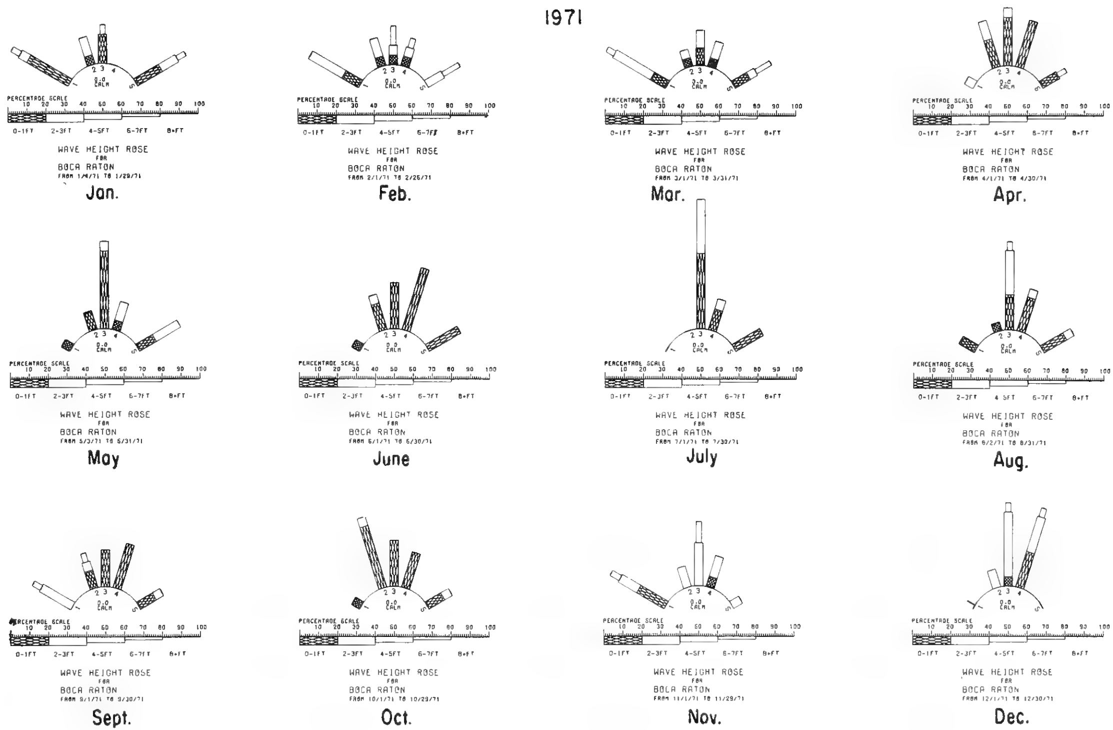


Figure E-3. Breaker height roses, Boca Raton, 1971.

1972

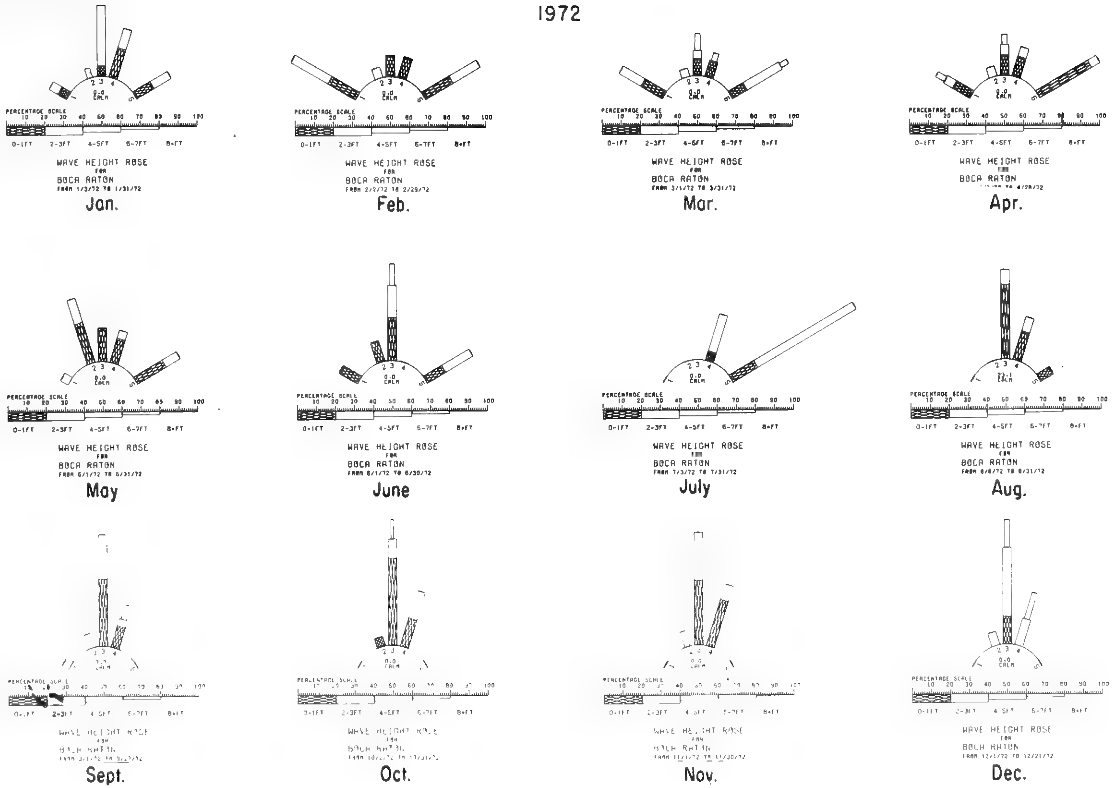


Figure E-4. Breaker height roses, Boca Raton, 1972.

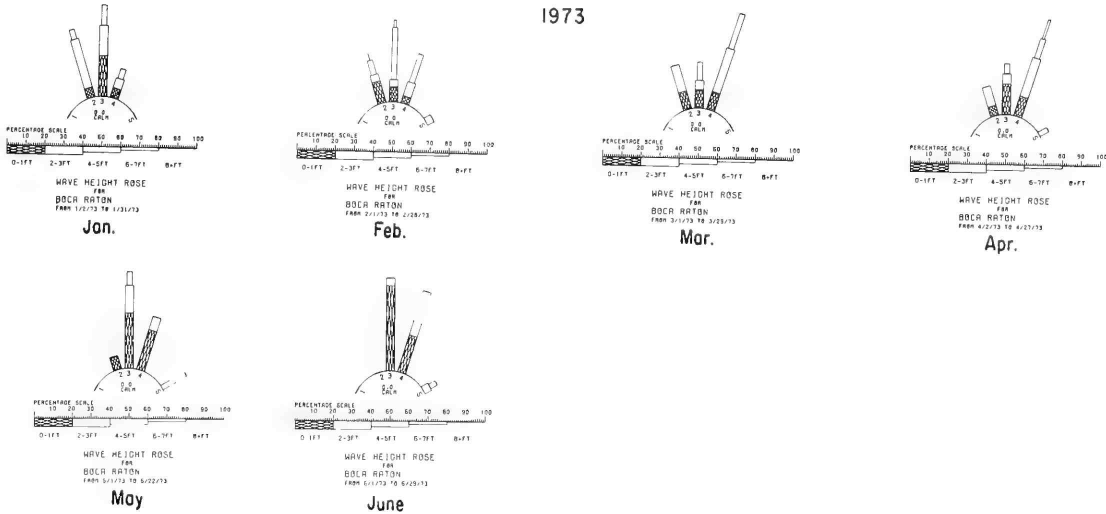


Figure E-5. Breaker height roses, Boca Raton, 1973.

APPENDIX F

MSL SHORELINE CHANGES BY PROFILE LINE

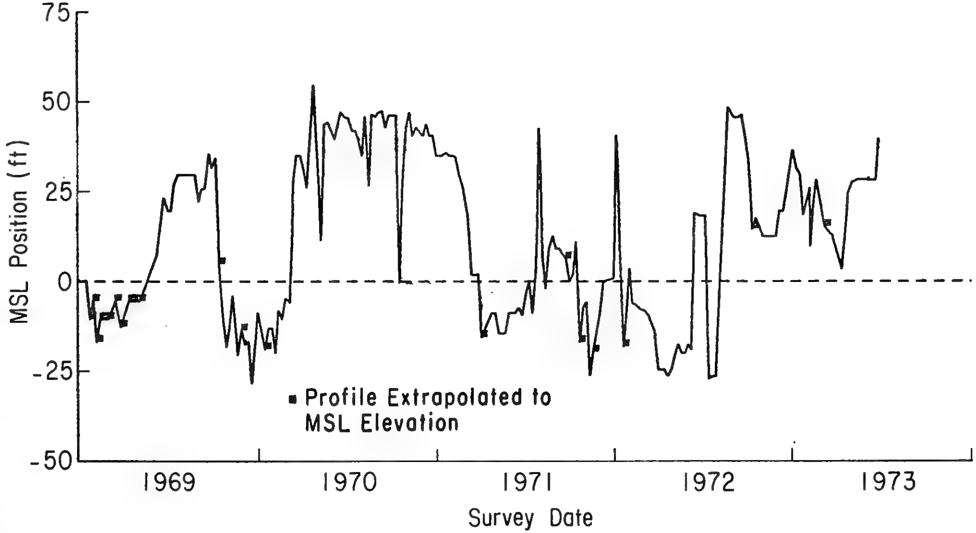


Figure F-1. Changes in MSL position on profile line I at Jupiter.

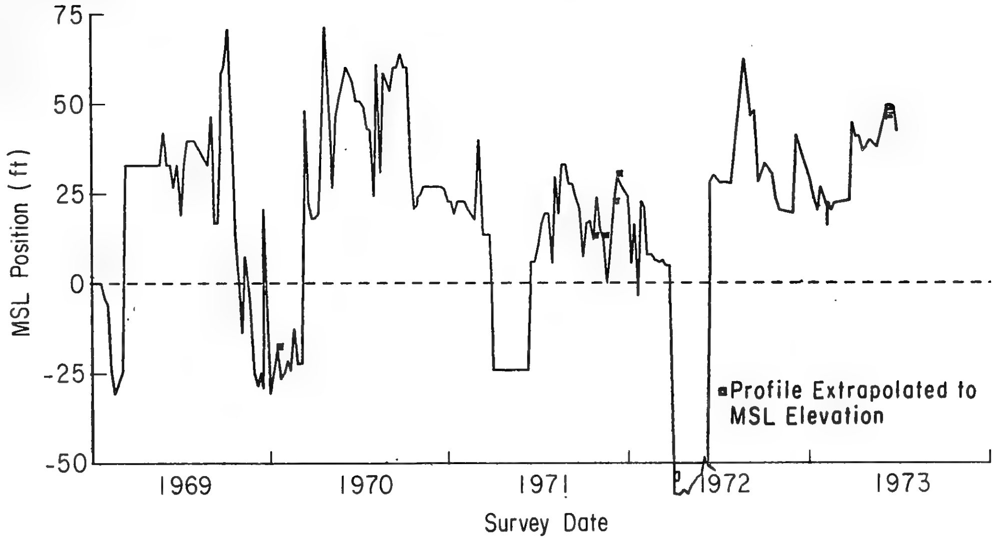


Figure F-2. Changes in MSL position on profile line II at Jupiter.

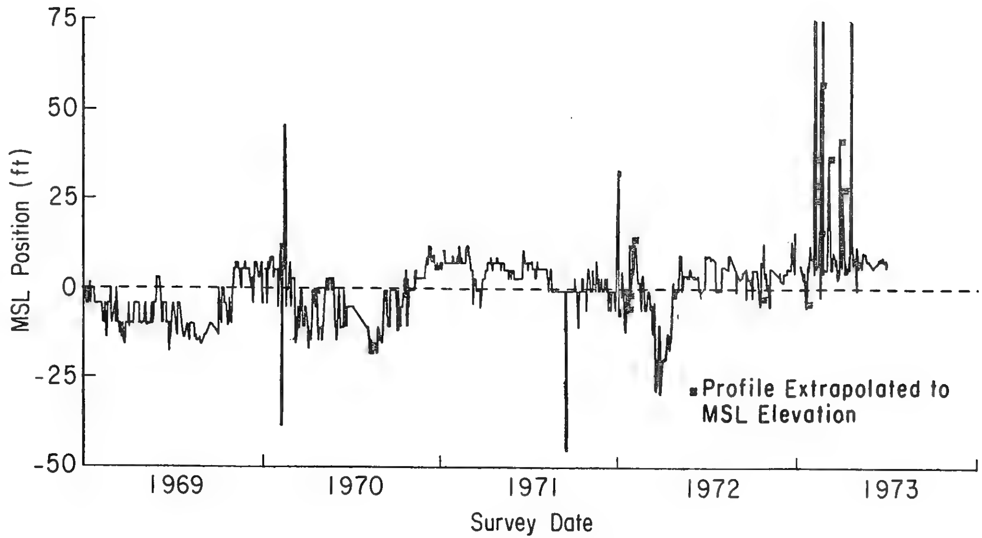


Figure F-3. Changes in MSL position on profile line I at Boca Raton.

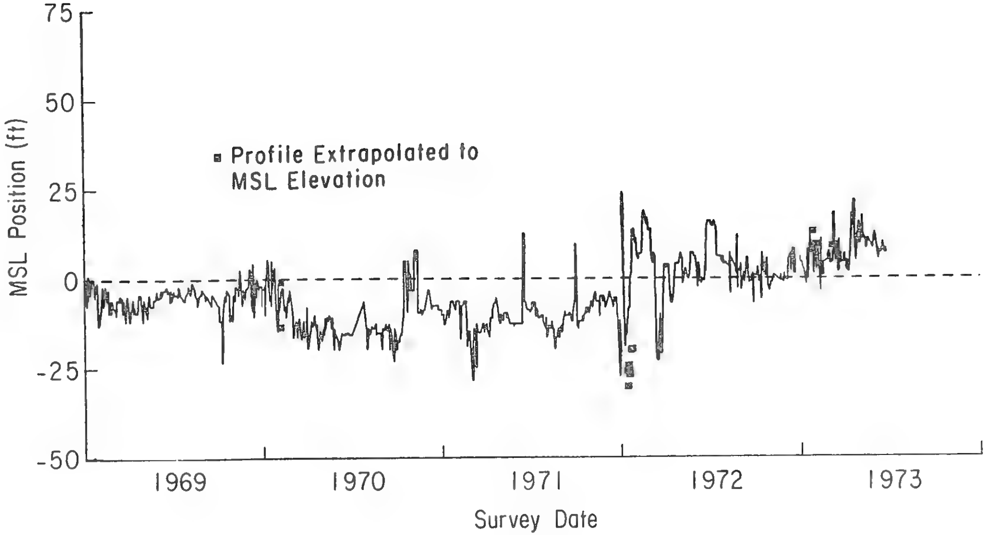


Figure F-4. Changes in MSL position on profile line II at Boca Raton.

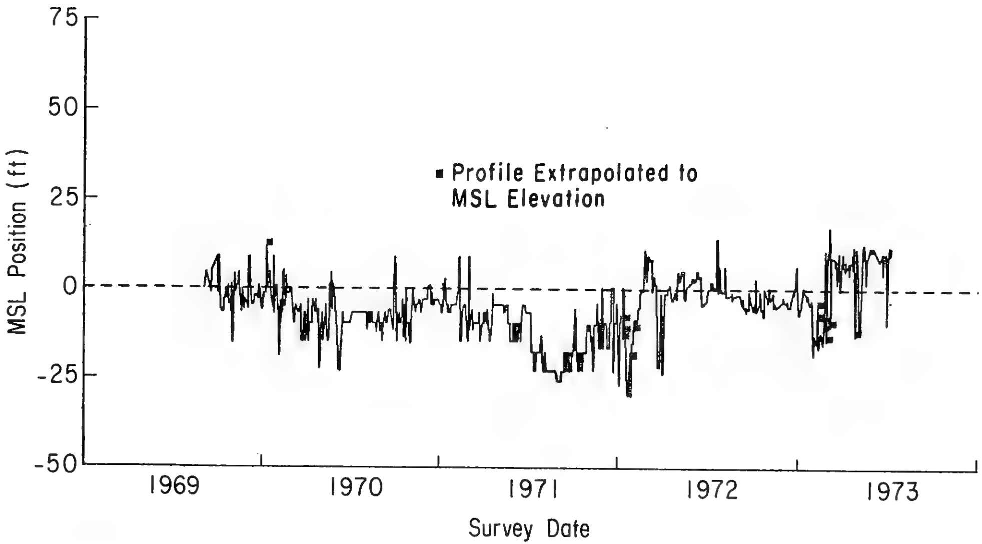


Figure F-5. Changes in MSL position on profile line III at Boca Raton.

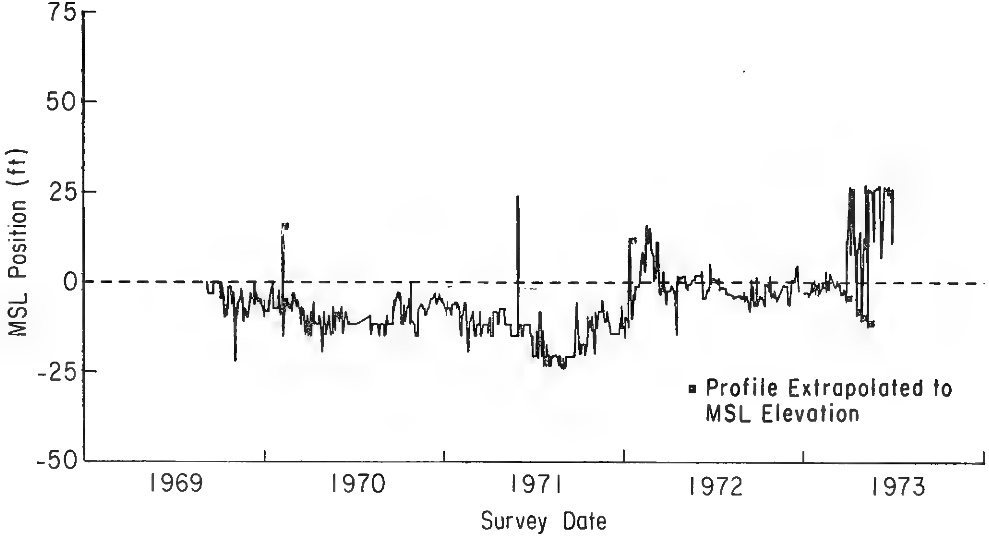


Figure F-6. Changes in MSL position on profile line IV at Boca Raton.

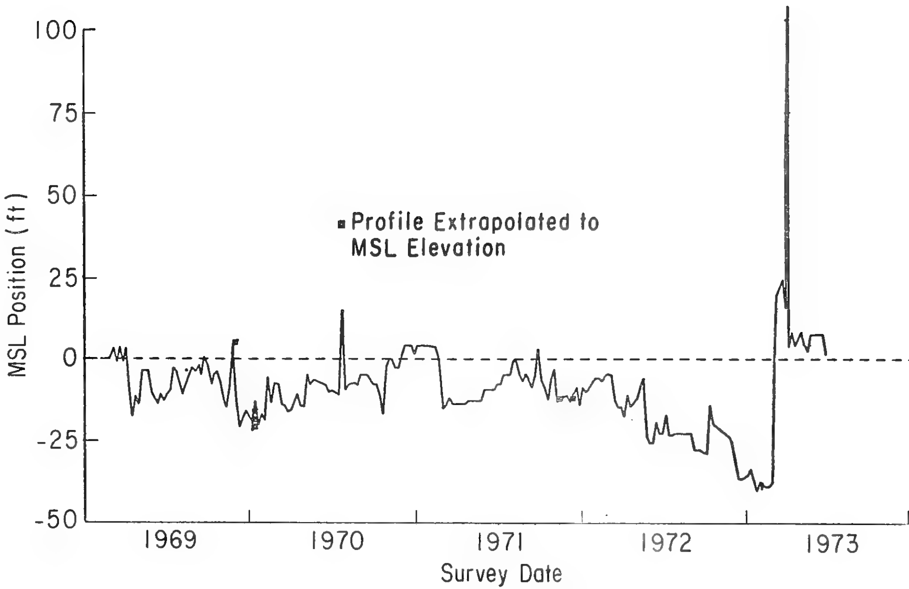


Figure F-7. Changes in MSL position on profile line I at Hollywood.

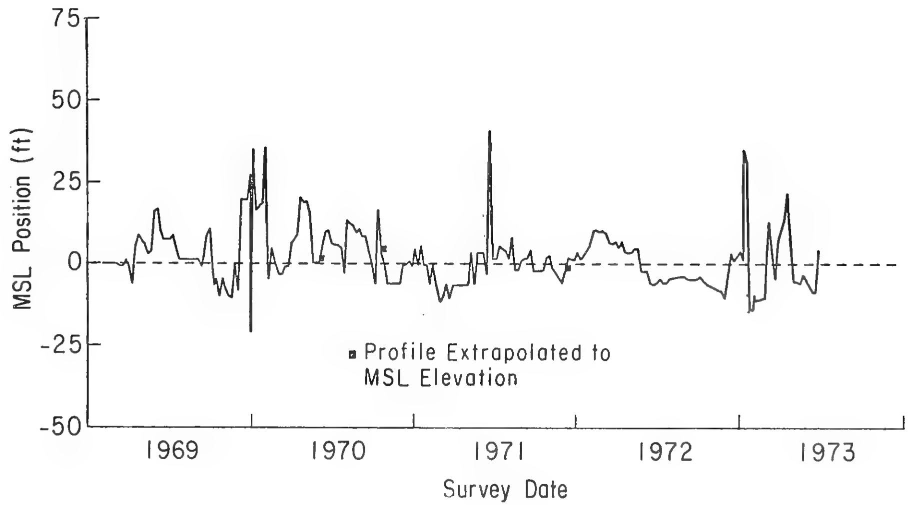


Figure F-8. Changes in MSL position on profile line II at Hollywood.

APPENDIX G

SUBAERIAL PROFILE VOLUME CHANGES BY PROFILE LINE

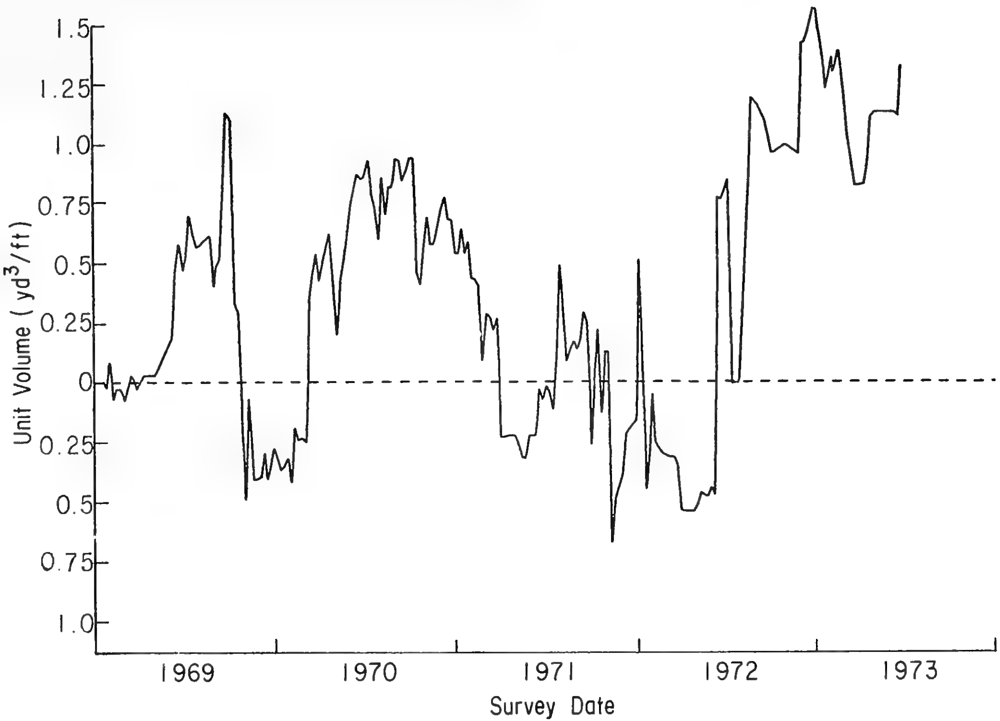


Figure G-1. Changes in sand volume on subaerial beach on profile line I at Jupiter.

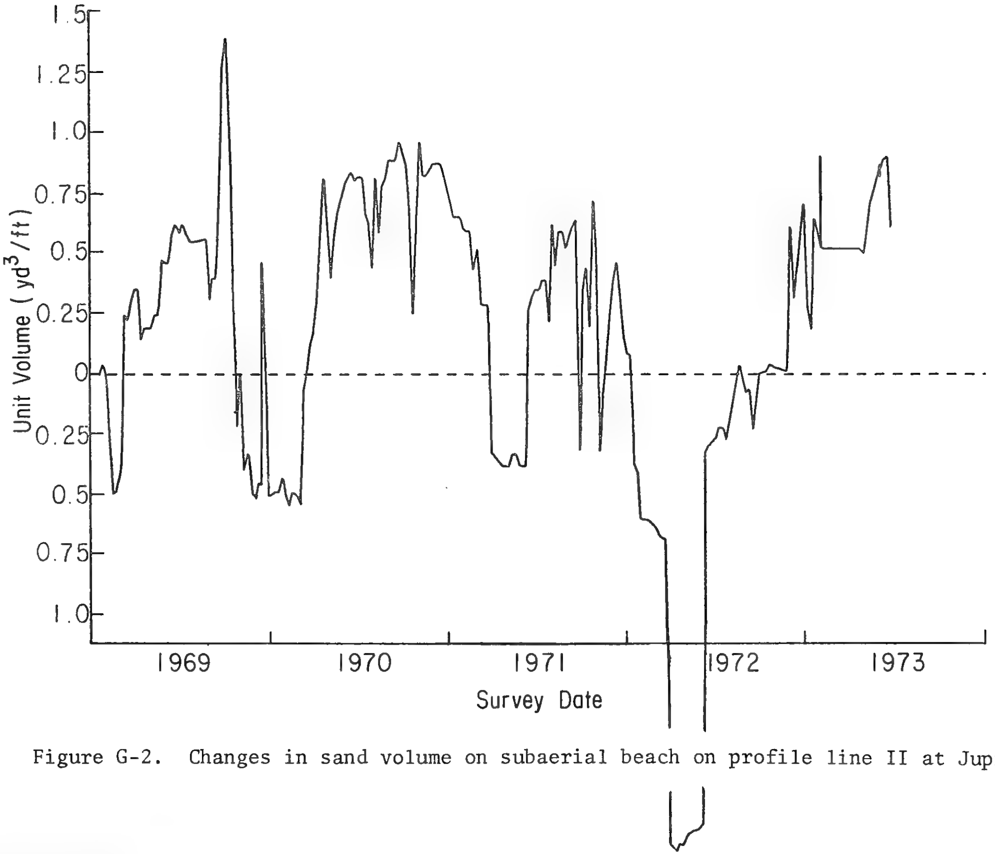


Figure G-2. Changes in sand volume on subaerial beach on profile line II at Jupiter.

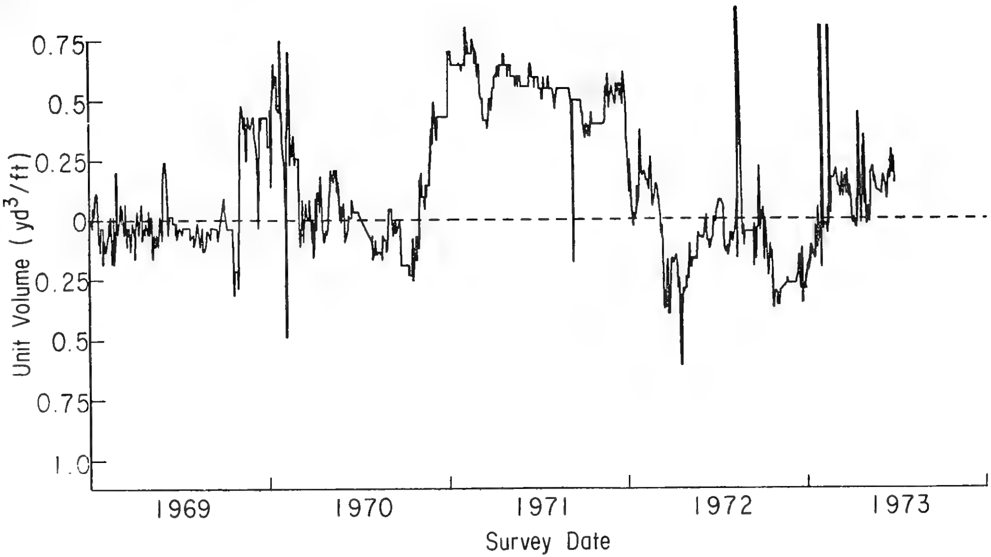


Figure G-3. Change in sand volume on subaerial beach on profile line I at Boca Raton.

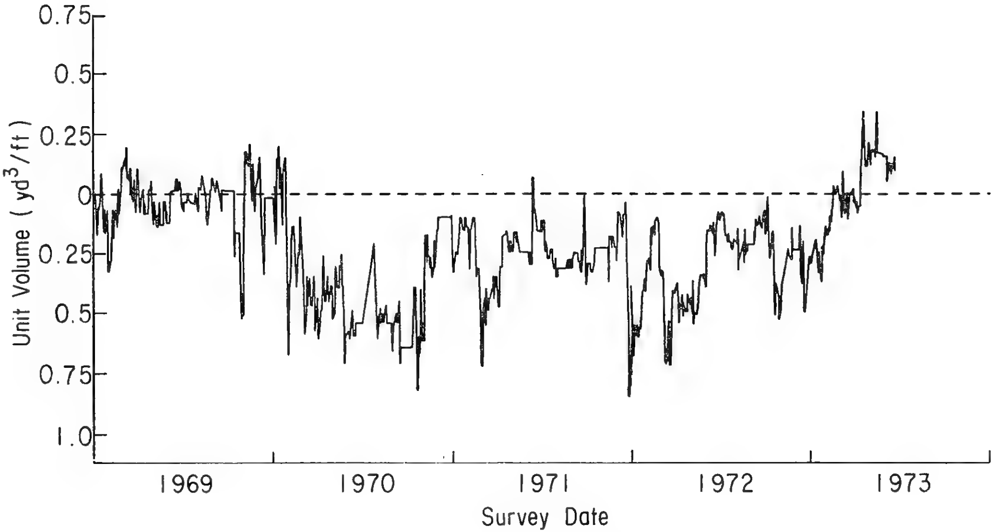


Figure G-4. Changes in sand volume on subaerial beach on profile line II at Boca Raton.

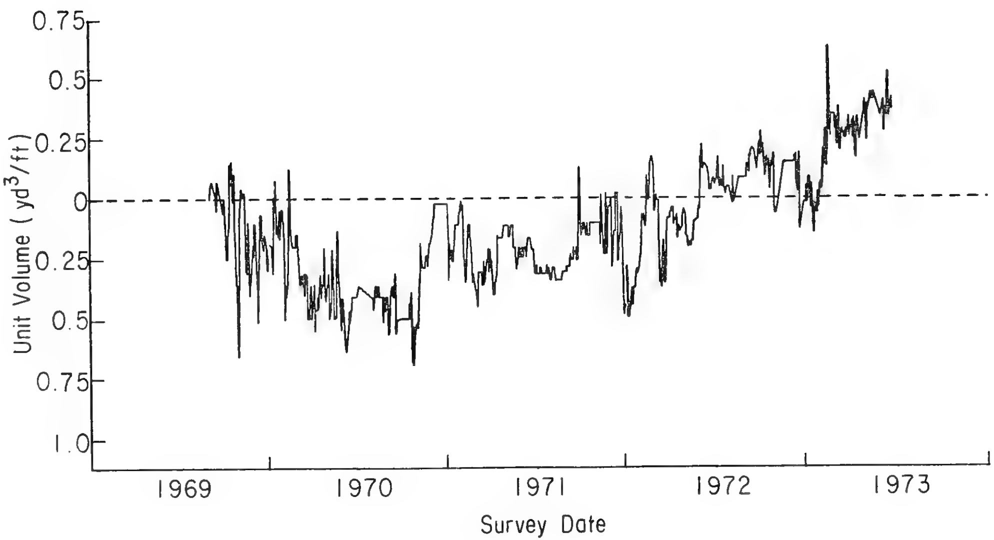


Figure G-5. Changes in sand volume on subaerial beach on profile line III at Boca Raton.

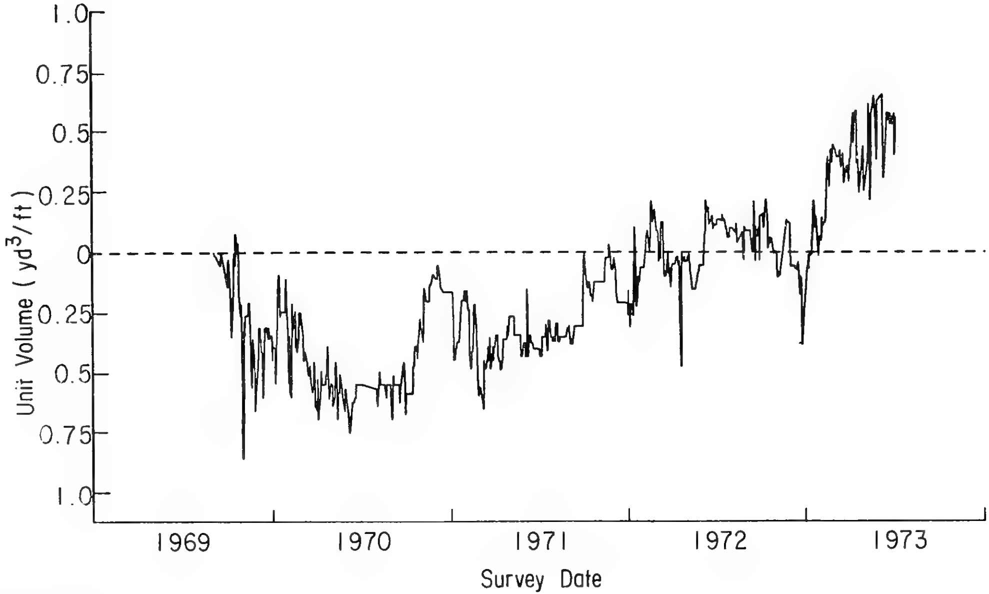


Figure G-6. Changes in sand volume on subaerial beach on profile line IV at Boca Raton.

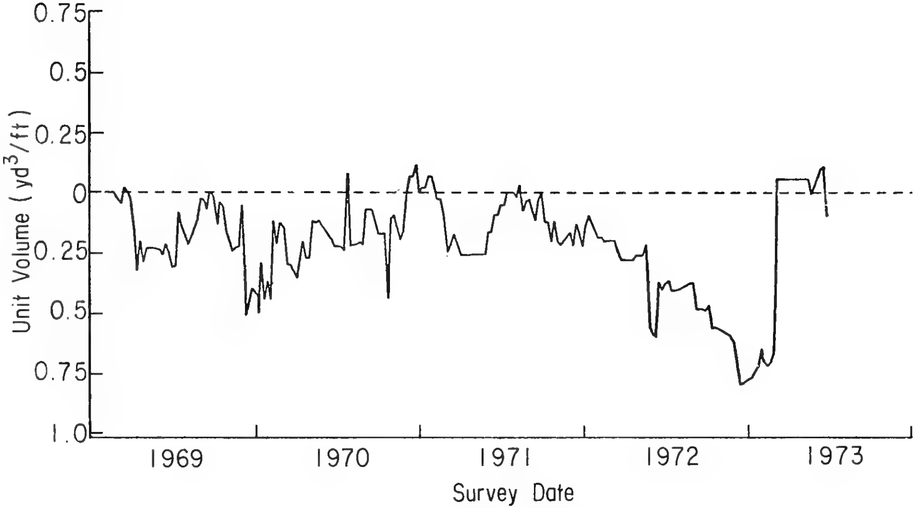


Figure G-7. Changes in sand volume on subaerial beach on profile line I at Hollywood.

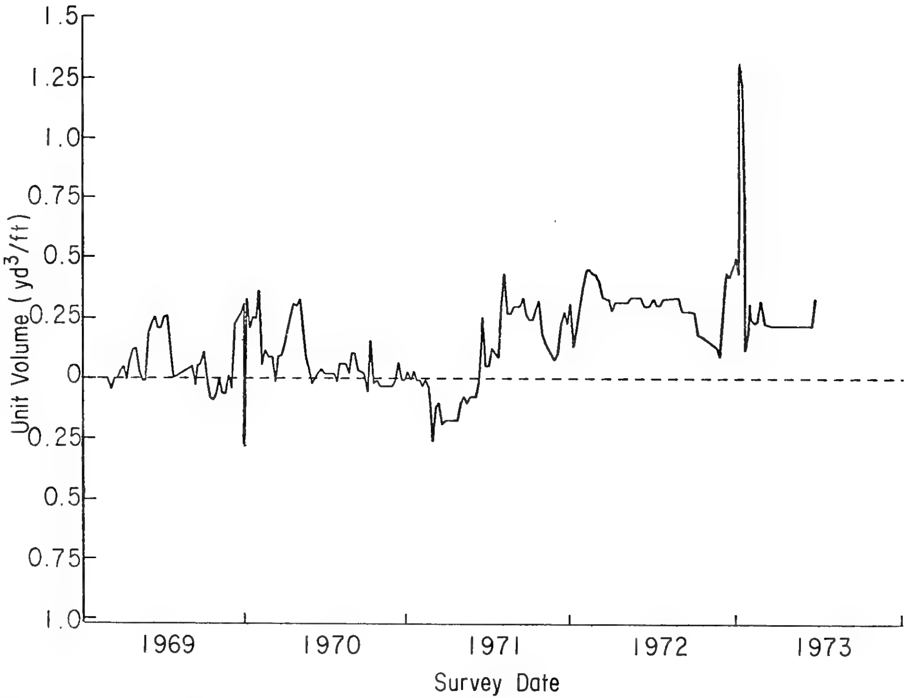


Figure G-8. Changes in sand volume on subaerial beach on profile line II at Hollywood.

APPENDIX H

SUBAQUEOUS PROFILE VOLUME CHANGES AT BOCA RATON BY PROFILE LINE

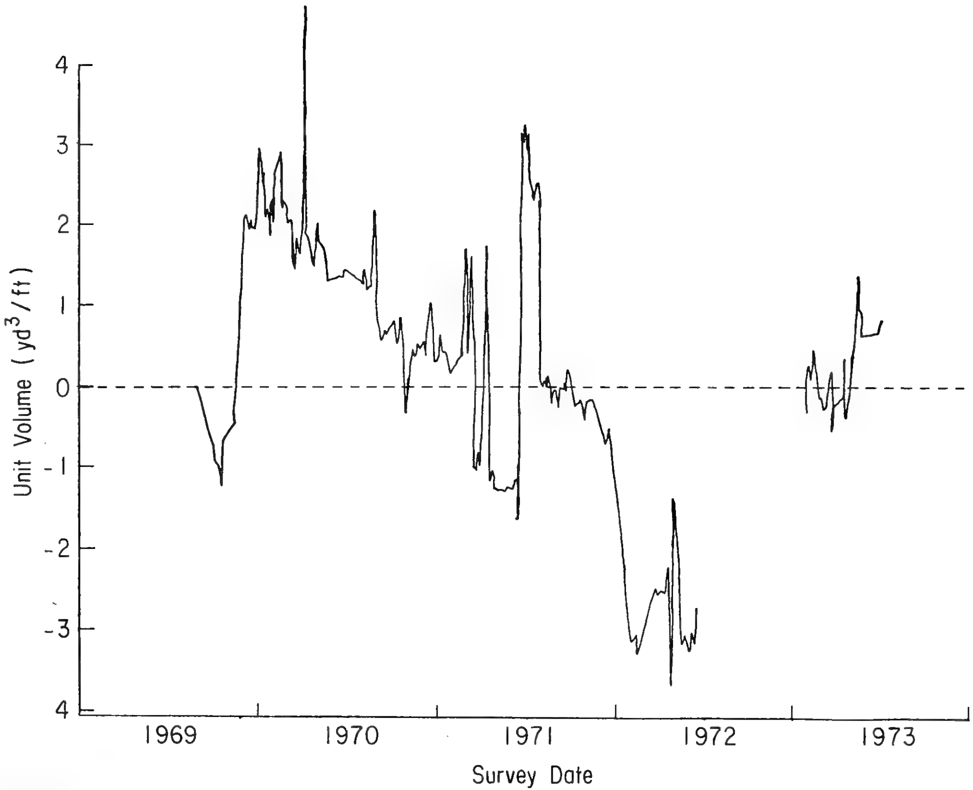


Figure H-1. Changes in sand volume between MSL and -12 feet on profile line I at Boca Raton.

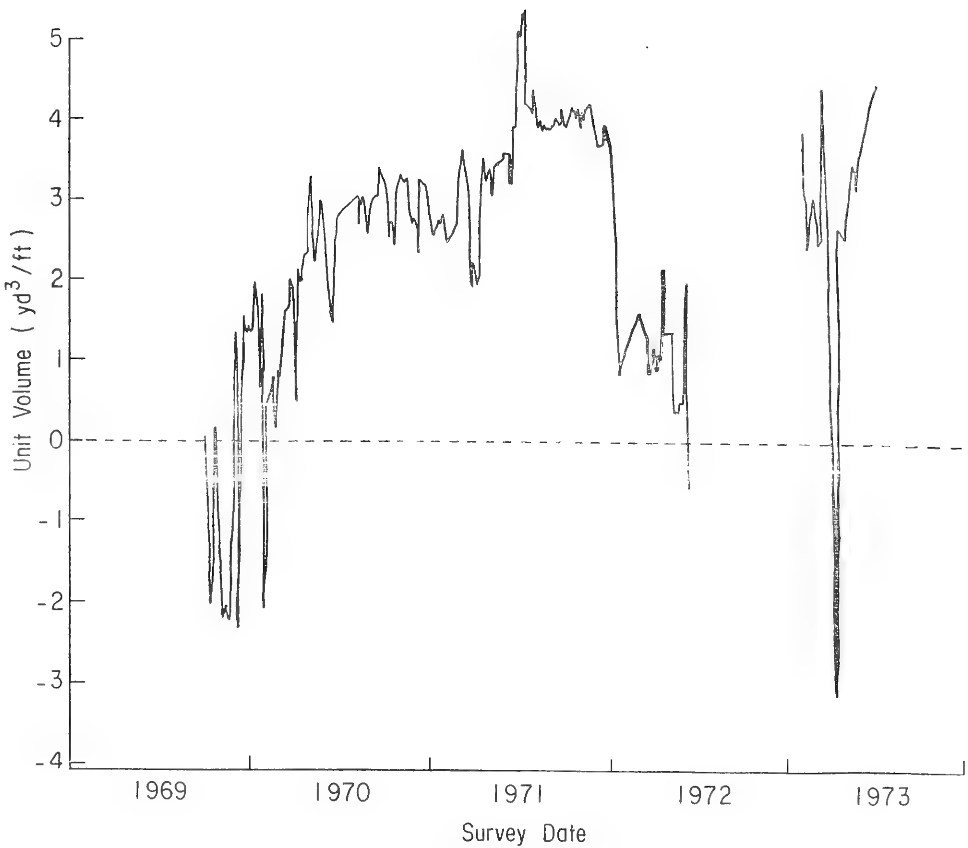


Figure H-2. Changes in sand volume between MSL and -12 feet on profile line II at Boca Raton.

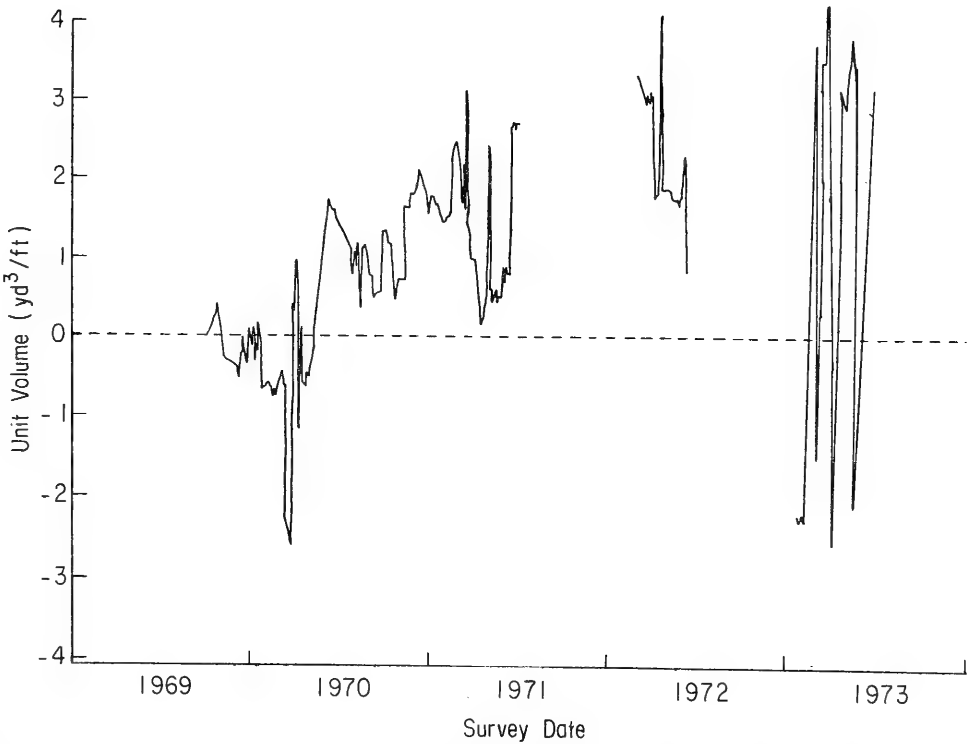


Figure H-3. Changes in sand volume between MSL and -12 feet on profile line III at Boca Raton.

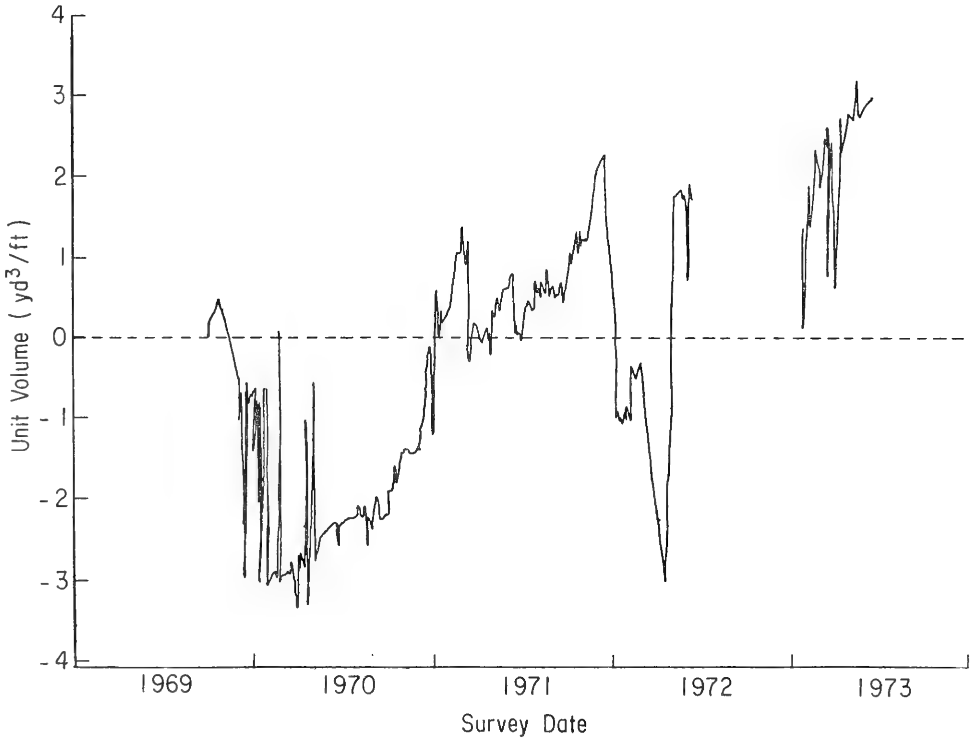


Figure H-4. Changes in sand volume between MSL and -12 feet on profile line IV at Boca Raton.

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TC203 .U581tp no. 77-10 627

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