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Geomorphology and Sediments of the Inner Continental Shelf Palm Beach to Cape Kennedy, Florida

by

Edward P. Meisburger

and

David B. Duane

TECHNICAL MEMORANDUM NO. 34
FEBRUARY 1971

U. S. ARMY, CORPS OF ENGINEERS

COASTAL ENGINEERING RESEARCH CENTER

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ABSTRACT

The Inner Continental Shelf off eastern Florida was surveyed by CERC to obtain information on bottom morphology and sediments, subbottom structure, and sand deposits suitable for restoration of nearby beaches. Primary survey data consists of seismic reflection profiles and sediment cores. This report covers that part of the survey area comprising the inner Shelf between Palm Beach and Cape Kennedy.

Sediment on beaches adjacent to the study area consists of quartzose sand and shell fragments. Median size of midtide samples generally lies in the range between 0.3 to 0.5 mm (1.74 to 1.0 phi) diameter.

The Shelf in the study area is a submerged sedimentary plain of low relief. Ridge-like shoals generally of medium-to-coarse (0.25 to 1.0 mm) calcareous sand resting on the seaward dipping subbottom strata contain material suitable for beach restoration. A minimum volume of 92.2×10^6 cubic yards of suitable sand is available within study limits.

FOREWORD

This report is the second of a series which will describe CERC's exploration of the Inner Continental Shelf. The program (ICONS) has the basic mission of finding offshore deposits of sand suitable for artificial beach restoration and nourishment.

Edward P. Meisburger, staff geologist, and David B. Duane, Chief of the Geology Branch, prepared the report under the general supervision of George M. Watts, Chief of the Engineering Development Division. The field work was done by Alpine Geophysical Associates under contract (DA-08-123-CIVENG-65-57, modified).

Cores taken during the exploration are stored at the Smithsonian Oceanographic Sorting Center (SOSC). Microfilms of the seismic profiles, the 1:80,000 navigational plots, and other associated data are at the National Oceanographic Data Center (NODC). Requests for information relative to these items should be directed to SOSC or NODC.

Dr. Joseph Rosewater and Mr. Walter J. Byas of the Mollusk Division, Smithsonian Institution, verified the identification of the important biogenic constituents of the sediments. Their assistance is deeply appreciated.

At the time of publication, Lieutenant Colonel Edward M. Willis was Director of CERC.

NOTE: Comments on this publications are invited. Discussion will be published in the next issue of the CERC Bulletin.

This report is published under authority of Public Law 166, 79th Congress, approved July 31, 1945, as supplemented by Public Law 172, 88th Congress, approved November 7, 1963.

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GEOMORPHOLOGY AND SEDIMENTS OF THE INNER CONTINENTAL SHELF PALM BEACH TO CAPE KENNEDY, FLORIDA

by

Edward P. Meisburger
and
David B. Duane

Section I. INTRODUCTION

1. Background

Ocean beaches and dunes constitute a vital buffer zone between the sea and coastal areas and provide at the same time much needed recreation areas for the public. The construction, improvement, and maintenance of beaches through the artificial placement (nourishment) of sand on the shore is one of several protection methods. This technique has gained prominence in coastal engineering largely as a result of the successful program initiated at Santa Barbara, California, in 1938 (Hall, 1952).

Where the specified plan of improvement involves shore restoration and periodic nourishment, large volumes of sand fill may be involved. In recent years it has become increasingly difficult to obtain suitable sand from lagoonal or inland sources in sufficient quantities and at an economical cost for beach fill purposes. This is due in part to increased land value, diminution and depletion of previously used nearby sources, and added cost of transporting sand from areas increasingly remote. Material composing the bottom and subbottom of estuaries, lagoons, and bays, in many instances is too fine-grained and not suitable for long-term protection. While the loss of some fines is inevitable as the new beach sediment seeks equilibrium with its environment, it is possible to estimate the stability of the beach fill and therefore keep the loss to a minimum through selection of the most suitable fill material (Krumbein and James, 1965).

The problem of locating a suitable and economical sand supply led the Corps of Engineers to a search for new unexploited deposits of sand. The search focused offshore with the intent to explore and inventory deposits suitable for future fill requirements, and subsequently to develop and refine techniques for transferring offshore sand to the beach. The exploration program is conducted through the U. S. Army Coastal Engineering Research Center (CERC). An initial phase in developing techniques for transferring offshore sand to the beach is described by Mauriello (1967).

Formerly called the sand inventory program, it was begun in 1964 with a survey off the New Jersey Coast. Subsequent surveys included the inshore waters off New England, New York, Florida, Maryland, and parts of Delaware and Virginia. Recognizing the broader application of the information collected in the conduct of the research program toward the CERC mission, especially in terms of Continental Shelf structure (Meisburger and Duane, 1969), Continental Shelf sedimentation (Field, Meisburger and Duane, 1971), and its potential application to historical geology and engineering studies of the shelf, the sand inventory program is now referred to as the Inner Continental Shelf Sediment and Structure Program (ICONS).

2. Field and Laboratory Procedures

The exploration phase of the ICONS program uses seismic reflection profiling supplemented by cores of the marine bottom. Additional supporting data for the studies are obtained from USC&GS hydrographic boat sheets and related published literature. Planning, and seismic-reflection profiling, coring, positioning, and analysis of sediment obtained in the cores are detailed in *Geomorphology and Sediment Characteristics of the Nearshore Continental Shelf, Miami to Palm Beach, Florida* (Duane and Meisburger, 1969). However, a brief description of techniques is germane to this paper and follows.

a. Planning - Survey tracklines were laid out by the CERC Geology Branch staff in either of two line patterns: grid and reconnaissance lines. A grid pattern (line spacing about 1 statute mile) was used to cover areas where a more detailed development of bottom and subbottom conditions was desired. Reconnaissance lines are one or several continuous zigzag lines followed to explore areas between grids, and to provide a means of correlating sonic reflection horizons between grids. Reconnaissance lines provide sufficient information to show the general morphologic and geologic aspect of the area covered, and to identify the best places for additional data collection.

Selection of core sites was based on a continuing review of the seismic profiles as they became available during the survey. This procedure allowed core-site selection based on the best information available; it also permitted the contractor to complete coring in one area before moving his base to the next area.

b. Seismic Reflection Profiling - Seismic reflection profiling is a technique in wide use for delineating subbottom structures and bedding planes in sea floor sediments and rocks. Continuous reflections are obtained by generating repetitive high-energy, sound pulses near the water surface and recording "echoes" reflected from the bottom-water interface, and subbottom interfaces between acoustically dissimilar materials. In general, the compositional and physical properties which commonly differentiate sediments and rocks also produce acoustic contrasts. Thus, an acoustic profile is roughly comparable to a geologic cross section.

Seismic-reflection surveys of marine areas are made by towing sound-generating sources and receiving instruments behind a survey vessel which follows predetermined survey tracklines. For continuous profiling, the sound source is fired at a rapid rate, and returning signals from bottom and subbottom interfaces are received by one or more hydrophones. Returning signals are amplified and fed to a recorder which graphically plots the two-way signal travel time. Assuming a constant velocity for sound in water and Shelf sediments, a vertical depth scale can be constructed to the chart paper. Horizontal location is obtained by frequent navigational fixes keyed to the chart record by an event marker, and by interpolation between fixes.

A more detailed discussion of seismic profiling techniques can be found in a number of technical publications (Miller et al., 1967; Ewing, 1963; Hersey, 1963; and Moore and Palmer, 1968).

c. Coring Techniques - A pneumatic vibrating hammer-driven coring assembly was used for obtaining cores from the survey area. The apparatus consists of a standard core barrel, liner, shoe and core catcher with the driver element fastened to the upper end of the barrel. These are enclosed in a self-supporting frame which allows the assembly to rest on the bottom during coring, thus permitting limited motion of the support vessel in response to waves. Power is supplied to the vibrator from a deck-mounted air compressor by means of a flexible hoseline. After the core is driven and returned, the liner containing the cored material is removed and capped.

d. Processing - Seismic records are analyzed to establish the principal bedding or structural features in upper subbottom strata. After preliminary analysis, record data is reduced to detailed cross-sectional profiles showing all reflective interfaces within the subbottom. Selected reflectors are then mapped to provide areal continuity or reflective horizons considered significant because of their extent and relationship to the general structure and geology of the study area. If possible, the upper mapped reflector is correlated with core data to provide a measure of continuity between cores.

Cores are visually inspected and logged aboard ship. After delivery to CERC, these cores are sampled by drilling through the liners and removing samples of representative material. After preliminary analysis, a number of representative cores are split in order to determine details of the bedding. Cores are set up for splitting on a wooden trough. A circular power saw mounted on a base which is designed to ride along the top of the trough is set so as to cut just through the liner. By making a cut in one direction and then reversing the saw base and making a second cut in the opposite direction, a 120-degree segment of the liner is cut. The sediment above the cut line is then removed with a spatula, and the core is logged, sampled and photographed.

Samples from cores are examined under a binocular microscope, and described in terms of gross lithology, mineralogy, and the type and abundance of skeletal fragments of organisms.

3. Scope

The area covered by this report extends along the east Florida coast and adjacent Continental Shelf, from Palm Beach (26°48'N) to the southern part of Canaveral Peninsula (28°27'N). The adjacent coastal segment, from Palm Beach to Miami, is covered in CERC's Technical Memorandum No. 29 (Duane and Meisburger, 1969). Figure 1 is a map of the location and major geographic features of the region. Field work in support of the study was accomplished between January and May 1965 by contract (Alpine Geophysical Associates, Inc.). Data collected and reported consists of continuous seismic reflection profiles covering 611 statute miles of survey line and 72 sediment cores ranging from 6 to 12 feet long (Figures 2 and 3).

Basic data processing covered analysis and reduction of geophysical records, visual description and size analysis of sediment samples from the cores, and construction of large-scale navigation overlays showing the position of geophysical lines and cores. Field data was supplemented by literature pertaining to the region and by U. S. Coast and Geodetic Survey hydrographic smooth-sheet coverage at 1:40,000 scale.

4. Geologic Setting

a. Hydrography - The shoreline of the study area extends 100 miles in a north-northwesterly direction from North Palm Beach (26°48'N) to near Canova Beach (28°08'N) thence northward and eastward 24 miles along the south flank of Canaveral Peninsula to Cape Kennedy (28°27'N). South from Palm Beach, the Florida shoreline has a north-south alignment.

The study comprises coastal portions of the counties of Brevard, Indian River, St. Lucie, Martin, and Palm Beach, and includes the adjacent submerged plain of the Continental Shelf (Figure 1). The abrupt change in shoreline orientation near Palm Beach and the Canaveral Peninsula salient combined with changes in width of the Continental Shelf form geographic boundaries to the study area.

Adjacent to the study area the Continental Shelf is complex. The major morphologic element of the Shelf is a submerged coastal plain with naturally divisible inner and outer zones and a well-developed shoreface zone. This shelf region varies from 2 to 38 miles in width and terminates at a break marking the top of the Florida-Hatteras Slope in water depths varying from 80 to 230 feet. The Florida-Hatteras Slope (name proposed by Uchupi, 1968) is defined as an incipient continental slope by Heezen, et al., (1959). It forms the western wall of the Straits of Florida in that part of the study area lying south of 28°00'N. North of 28°00'N the slope descends to the Blake Plateau at about 2,300 feet (Figure 1).

Within the study limits the immediate shore area consists of a low barrier island. North of St. Lucie Inlet, the barrier is backed by the broad lagoons of the Banana River and Indian River; south of the inlet, the barrier fronts a marshy swale traversed by the Atlantic Intracoastal

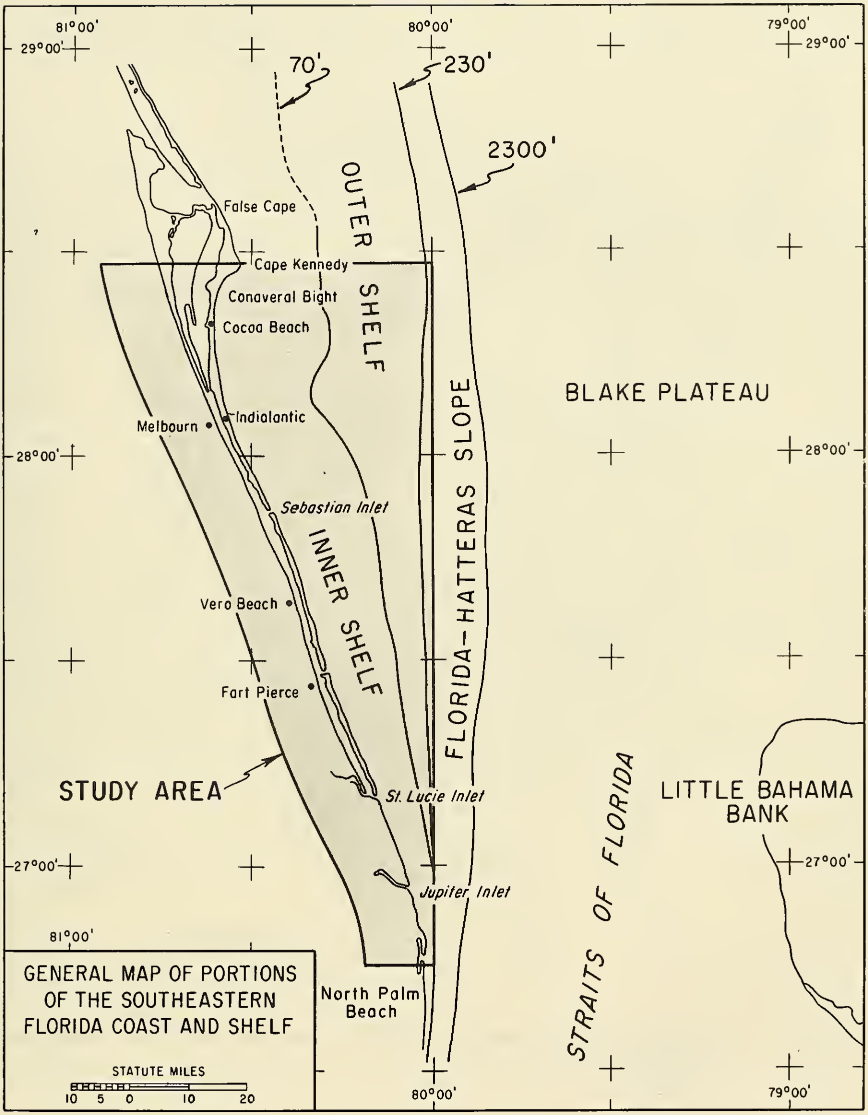


Figure 1. General Map of the Study Area

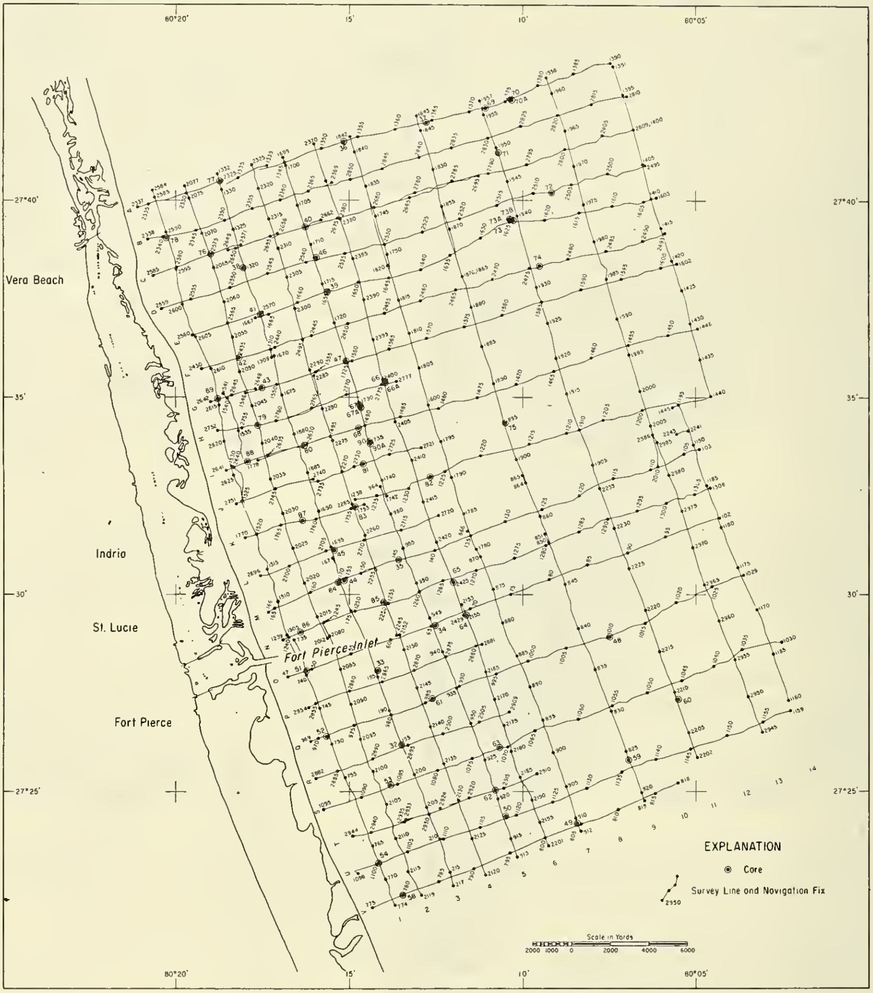


Figure 2. Navigation Plot Showing Survey Tracklines and Core Locations, Fort Pierce Grid Area.

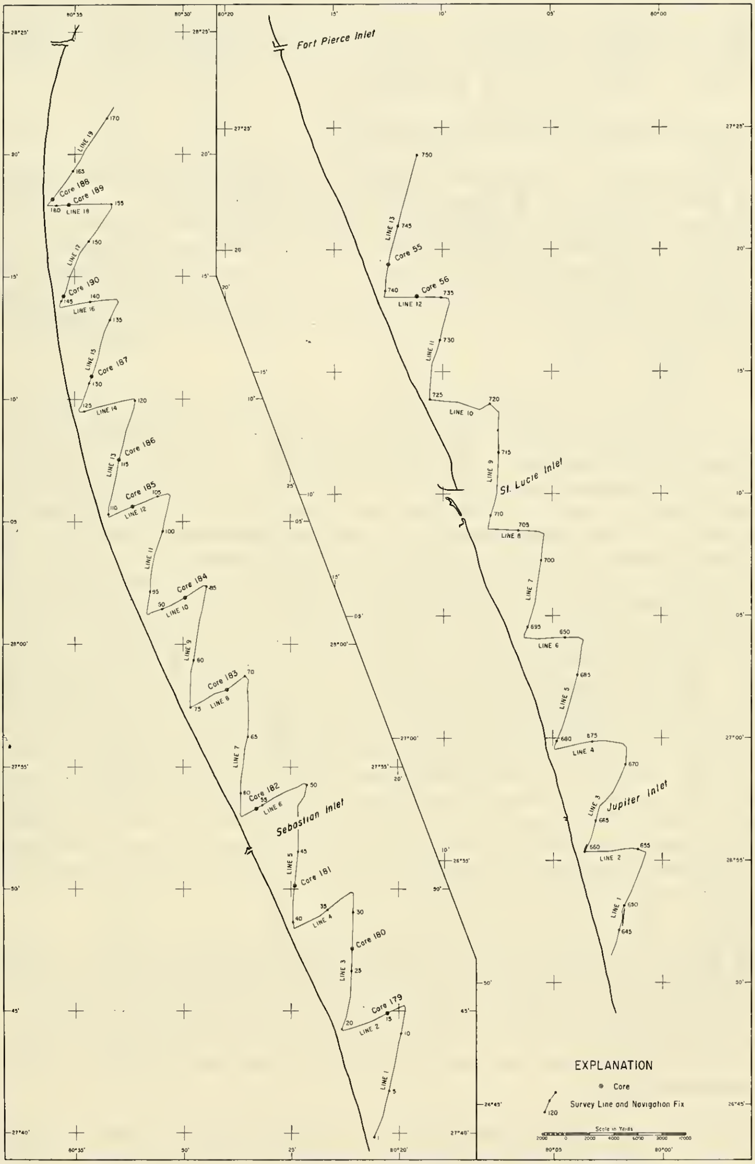


Figure 3. Navigation Plot Showing Survey Tracklines and Core Locations in Reconnaissance Areas North (left) and South (right) of Fort Pierce Grid.

Waterway. The mainland shore is bordered by a flat-topped coastal ridge which rarely exceeds 30 feet in elevation and 5 miles in width. Inland of the coastal ridge is an extensive, low plain, characterized by its numerous lakes, sinks, streams and swamps.

b. Stratigraphy and Geologic History

(1) General. An extremely thick section of sedimentary rocks underlies the study area; however, only the uppermost strata are germane to this report (Table I). Consequently the following discussion is limited to the upper Eocene Ocala Group (Puri, 1953) and younger rocks. (For a general discussion of older strata, see Cooke, 1945, and Puri and Vernon, 1964.) Knowledge of lithology, structure and formational boundaries of pre-Pleistocene rocks in the coastal area is scant. Existing knowledge is based largely on scattered well logs and projection from outcrops situated some distance inland.

(2) Eocene and Oligocene Strata. The Eocene Ocala Group as defined by Puri (1953) includes in ascending order the Ingles, Williston, and Crystal River Formations - all lithologically similar. Rocks of the Ocala Group are characteristically white- or cream-colored, granular limestones described in well logs as varying from soft to hard, and containing abundant fossils. At Cape Kennedy, the top of the Ocala Group lies at -180 feet MLW (Brown, et al., 1962). From Cape Kennedy, the top of the Ocala Group dips southward and eastward to -380 feet MLW near the Brevard-Indian River County line. Well logs from Indian River and Martin Counties indicate a sharp drop in the Ocala surface near the shoreline. On the basis of these well logs and other evidence, the sharp dip is attributed to a fault or series of faults trending more or less parallel to the present shoreline. The fault presumably is continuous through St. Lucie County. There is no clear evidence that the coastal fault extends north into Brevard County, although farther west a fault with similar strike is known (Brown, et al., 1962). A sharp increase in the dip of the Ocala occurring near the south line of Brevard County may indicate that the hinge line of this fault lies in this location. Further evidence of a sharp southward dip, in a presumed upper Eocene-Ocala surface commencing south of Cape Kennedy, occurs on seismic reflection records made in the Florida ICONS Program (Meisburger and Duane, 1969).

Oligocene rocks have not been reported from Brevard County. Rocks of Oligocene age lie unconformably on the eroded Ocala Group in the southern part of the study area (Indian River, St. Lucie and Martin Counties). Variously described as gray limestone with calcite crystals and soft granular limestone, the strata are thickest on the downthrown block east of the coastal fault zone and south of the Brevard County line (Bermes, 1958; Lichtler, 1960).

The Eocene and (where present) the Oligocene rocks of east Florida form the upper layers of the permeable Florida artesian aquifer. Impermeable units in the overlying Miocene section form the aquiclude. Some

TABLE I

STRATIGRAPHIC COLUMN; UPPER-EOCENE TO RECENT: CAPE KENNEDY-PALM BEACH, FLORIDA, COASTAL ZONE

Age	Group	Formation	Depth to Top of Formation (Below MSL)		Lithologic Character
			Brevard and Indian River Counties	St. Lucie, Martin and Palm Beach Counties	
Recent			0 to +30	0 to +30	Quartzose sand in beaches and dunes; silt and sand in lagoons.
Pleistocene		Pamlico	Around +30	Around +30	Quartzose sand
		Anatasia	0	0	Coquina, shell sand and gravel
		Caloosahatchee	May occur locally	230-330	Sand and shells
Miocene		Tamiami	60-230	230-400	Greenish sand, clay, silt, shells
		Hawthorn	100-400	400-890	Gray-green clay silt, sand, shells
Oligocene		Suwannee	Around 400	up to 1000	Gray limestone
Eocene	Ocala	Crystal River	180-600	600 to over 1100 feet	granular limestone
		Williston			Limestone
		Ingles			Limestone

permeable Miocene rocks at the base of the section may also be part of the aquifer locally, but stratigraphic details of the system are not well known (Bermes, 1958; Lichtler, 1960; Brown, et al., 1962).

(3) Miocene Strata. Overlying Oligocene rocks where present (elsewhere directly on the Eocene) is a thick Miocene section of variegated (dark green, brown, and white) phosphatic marine clays, silt, sand and shells. These sediments comprise the Hawthorn Formation and the Tamiami Formation as defined by Parker (1951). Along the coast, the top of Miocene strata lies at approximately -60 feet MLW in the northern part of the study area, and drops to around -200 feet MLW at the south end. A discontinuity exists between the top of the Miocene and a time transgressive formation below. The pre-Miocene surface in the coastal part of the study area dips southeast about 8 feet or more per mile, while the top of the Miocene dips eastward at a much lower rate.

(4) Post-Miocene Strata. Miocene sediments under the coastal area are unconformably overlain by Pleistocene sediments of the Anastasia formation, a highly variable series of coquina, sand, and biogenic limestone deposits possibly representing depositional episodes throughout Pleistocene time (Puri and Vernon, 1964). The Caloosahatchee marl considered by early workers as Pliocene, but more recently as Pleistocene in age (Puri and Vernon, 1964; Du Bar, 1958, 1962), may occur in places as the basal Pleistocene unit. Along the coastal ridge, Anastasia rocks are overlain by quartzose sand of the Pamlico Formation which locally attains a thickness of 40 feet, but is usually much thinner.

Holocene and modern deposits occur on the Continental Shelf, in beaches and dunes of the coastal zone and in lagoons behind the barrier islands. Miocene and Pleistocene rocks are likely contributors to sediments comprising the Holocene littoral system, either at natural or manmade exposures at the coastline or from presumed outcrops on the nearshore Continental Shelf. Pre-Miocene sediments in the study area are too deep to be exposed, and do not contribute directly to the present littoral supply.

(5) Geologic History. The Eocene and post-Eocene history of the study area is one of repeated invasions and retreats of the sea. Erosional unconformaties and hiatuses in the Eocene column point to tectonic instability throughout that period. A structural movement dated by Vernon (1951) as post-Oligocene and pre-Miocene resulted in the Ocala uplift - centered in western and central Florida - and associated structural flexures and faults affecting a larger part of the central Florida peninsula. A coastal fault or fault zone in pre-Miocene rocks stretching north-northwest through the study area is probably related to the Ocala movement. The downthrown blocks on these faults are to the east and plunge southward from a probable hinge line in the northern part of the study area. Seismic reflection records collected for this study show an abrupt steepening of dip of some deep reflections, an apparent effect of a near-coast fault between Canaveral Bight and Fort Pierce (Meisburger and Duane, 1969).

Oligocene and early Miocene rocks are reported from coastal Martin and Indian River Counties but apparently do not occur in Brevard County which may have been above sea level during this period (Brown, et al., 1962). However, offshore, under the shelf section within the study limits, Oligocene and early Miocene deposits may have been deposited on the downdip slope of the Eocene surface.

During middle-Miocene time, the entire study area was flooded by the sea, and sediments of the Hawthorn Formation were deposited. This episode was followed by a retreat of the seas - at least from the northern part of the study area - and subsequent erosion of the Hawthorn surface. In late Miocene and possibly Pliocene time the area was again submerged and deposition took place. Parker (1951) included all upper Miocene sediments in southern Florida in the Tamiami Formation; most pre-Pleistocene deposits overlying Hawthorn sediments are probably part of this formation.

During Pleistocene time, the study area was alternately flooded and exposed to subaerial erosion leaving a variable and sometimes complexly related series of sediments and erosional surfaces. The last major event was the advance of the Holocene Sea across the upper Continental Slope and Shelf, starting about 12,000 years ago and essentially concluded about 4,000 years ago (Curray, 1965; Milliman and Emery, 1968).

c. Coastal Morphology and Sediment Characteristics - From Palm Beach north to Cape Kennedy, the coast consists of a chain of sandy barrier islands separated infrequently by narrow inlets. A narrow sandy beach continuously borders the ocean sides of the islands, and a marshy lowland fringes the lagoon sides. These islands rarely exceed 1 mile in width or 20 feet in elevation.

North of St. Lucie Inlet, the shallow lagoon (Indian and Banana Rivers) which separates the barrier islands from the mainland is 1 to 3 miles wide. Waters of Hobe Sound, Lake Worth, and marshy tidal creeks separate the islands and mainland between St. Lucie Inlet and Palm Beach. Following the coastal classification system of Shepard (1963), a coast, with features as those described, is referred to as a marine depositional coast, and more specifically as a barrier coast.

Real-estate development of the shorefront has been intensive locally, however, much of the barrier island coast of the study area is still undeveloped. Sand on the beaches and on the adjacent nearshore bottom is composed of quartz and shell fragments. The quartz fragments are colorless and vary from subangular to rounded forms. Shell-derived fragments are most commonly well-worn smooth pieces of mollusk shell colored to shades of white, pink, gray, and orange-brown.

In the high-energy beach and shallow nearshore zone (to about 12 feet MLW), sediments are characteristically coarse, poorly sorted to moderately well-sorted, calcareous quartzose sand. In this zone, variations in size from place to place along the coast are pronounced and numerous. These variations result from availability of a wide range of particle sizes in the shell material and alongshore variations in factors controlling sediment distribution and shell supply. The coarsest material, for example, occurs near inlets or close to outcrops of the Anastasia Formation where large quantities of shell are available. As shell is moved away from these source areas, it may be reduced by mechanical and chemical degradation and is diluted by an increase in finer quartzose material.

In deeper nearshore water (from -21 to -30 feet MLW), material composing the bottom surface is finer, better sorted and far more uniform in size than the sediment in shallower water nearer shore. These deeper shoreface deposits probably result from the classic sedimentation model of seaward transport of finer particles winnowed from the sands in high-energy surf zone; deposition of the fines occurs in quieter water. The few samples available from the outer nearshore zone are richer in quartz.

Median diameter of foreshore beach samples from the study area are mostly between 0.3 and 0.5 millimeters (1.74 to 1.0 phi). This, then, is the approximate range of median sizes required in a normally sorted borrow material which would be most suitable for fill sand to nourish eroding beaches in the study area.

Section II. GEOMORPHOLOGY AND SHALLOW SUBBOTTOM STRUCTURE OF THE CONTINENTAL SHELF

1. Continental Shelf Geomorphology

a. General - The Shelf between Palm Beach and Cape Kennedy covers about 2,500 square miles. From about Gomez (27°05'N) northward, the shelf plain is divided into inner and outer zones by a subtle slope break generally falling between the 70- and 80-foot depth contour. The first major break in slope on the Continental Shelf occurs at the top of the Florida-Hatteras Slope (Uchupi, 1968). The break of the Florida-Hatteras Slope in the study area trends almost due north-south, while the alignment of the shoreline trends about 20 degrees west of north. This divergence between shoreline and slope break accounts for the great increase of shelf width northward from Palm Beach to Cocoa Beach.

In general, the shelf off the study area is typical of a submerged coastal plain with gentle seaward inclination and subdued topographic relief. Based on slope characteristics, differences in sediments, and minor relief features, the shelf can be divided into three linear zones; a profile is schematically illustrated in Figure 4. A narrow shoreface zone extends from the low water line to about -40 feet MLW. Next is an inner-shelf plain lying between -40 and -75 feet MLW which is succeeded seaward by a more steeply sloping irregular outer shelf that is transitional from the "flat" inner shelf to the top of the Florida-Hatteras Slope lying at -80 to -230 feet MLW. Linear features on the inner shelf often parallel the shoreline alignment while outer shelf features tend to follow the shelf break.

b. Shoreface - Between North Palm Beach (26°48'N) and Cape Kennedy (28°27'N), the shoreface zone is a relatively narrow terrace-like feature extending from mean low water to depths of -30 to -40 feet (Figure 4). Most of this 1,000- to 1,500-yard wide zone dips seaward on a slope of about 1 on 80. Many shoals lie in the segment between Hobe Sound and Vero Beach; some extend into the shoreface area and are possibly an integral part of the shoreface. (In the absence of more detailed data concerning this zone and for reasons of clarity, the shoreface as outlined on Figure 5 excludes these shoal projections.)

Coquina outcrops occur alongshore from place to place throughout the study area. Moe (1963) describes a "reef" in this area lying about -35 feet MLW but covered in many places by overlying sediment. Borings in the Intracoastal Waterway have also revealed consolidated coquina layers - in some places at depths of less than -20 feet MLW. This suggests that the core of the shoreface may be partly composed of consolidated or semi-consolidated coquina rock of the Anastasia Formation. The few ICONS cores obtained in the zone indicate that consolidated rock does not occur within 5 to 10 feet of the water-sediment interface (approximately -30 feet MLW).

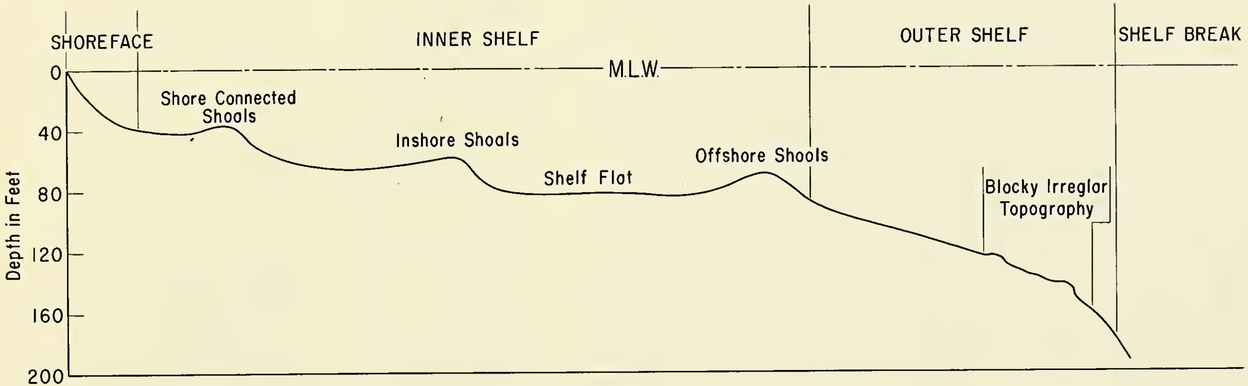


Figure 4. Schematic Profile of Shelf Morphology Typical of the Study Area and Descriptive Terminology.

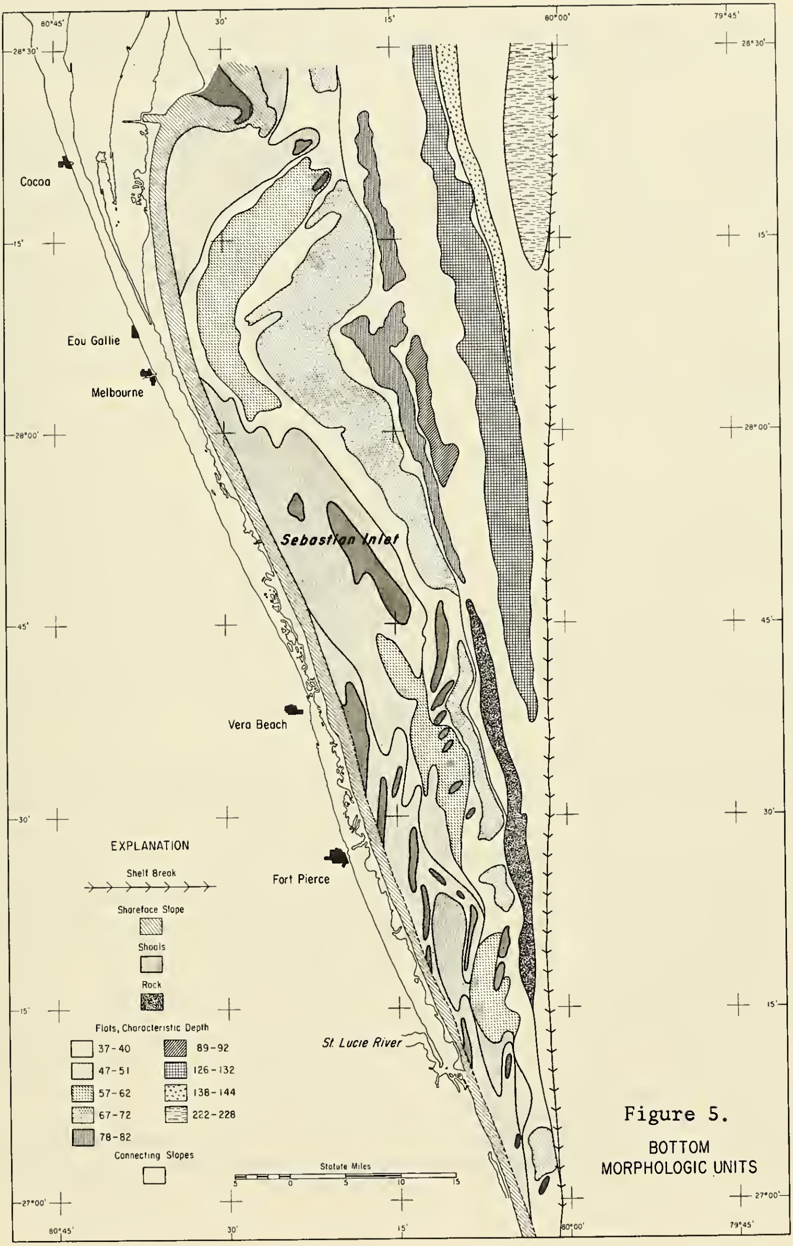


Figure 5.
BOTTOM MORPHOLOGIC UNITS

c. Inner-Shelf Plain - The inner-shelf plain is characterized by its extremely gentle seaward inclination, narrow depth range (nearly all the area is between -40 to -70 feet MLW) and its general alignment parallel to the northwesterly trend of the shoreline.

Morphologic features on the inner-shelf plain consist of a series of platforms or step-like flats (areas of reduced gradient), gentle slopes leading from one level to the next, and shoals. With few exceptions these features are not topographically prominent, and many are not evident on small or medium-scale charts.

Charted depths over the flats generally lie within ±5 feet of the average depth. The most irregular of those flats is the 50-foot flat which contains a large number of shoals in the section south of Sebastian Inlet (27°52'N). Inshore, the lower slopes of the shoals coalesce to form an irregular plateau-like inner level with depths of 30 to 40 feet MLW. Accretion in Canaveral Bight has also produced a higher, but smooth-surfaced, inner level of the 50-foot flat at around -40 feet MLW. Other flats on the shelf are generally less complex and contain few shoals.

Shoal ridges and hills are most extensively developed on the inner shelf south of Sebastian Inlet (Figure 5). Nearly all these shoals are linear and most have a north or northeasterly alignment. Two exceptions are Thomas Shoal off Sebastian Inlet and an unnamed smaller ridge between St. Lucie Shoal and Capron Shoal. These shoals lie with a northwesterly alignment suggesting possibly different genetic processes or time of formation. In profile, inner-shelf shoals show a smooth regular surface, and both symmetrical and asymmetrical cross-sectional form. Where asymmetry exists, the steeper flanks face east or southeast. Seismic data indicate the shoals to be superposed on the surface of the flat.

d. Outer-Shelf Zone - Little is known of the composition and topography of the outer-shelf zone. Published hydrographic charts show deeper parts of the outer shelf at a scale too small for any but gross definition of bottom topography. Large-scale coverage to depths of about 130 feet permits definition of the main shelf features, but does not detail the irregular bottom. A survey of Florida's offshore fisheries by Moe (1963) contains much valuable general information on the bottom characteristics of outer shelf fishing grounds. Cores and geophysical lines obtained for this study are mostly from the inner margin of the Continental Shelf with few reaching the outer zone.

Available information shows that the outer shelf is dominantly a zone of highly discontinuous broken topography of generally low relief (10 to 20 feet). Moe (1963) documents descriptions of numerous rocky or coral reef patches, ridges, ledges, cliffs and depressions. These data, provided by fishermen who frequent these grounds, indicate that the angularity of many relief features is a striking characteristic. Linear trends of ridges or abruptly steepening slopes are characteristic of the outer-shelf zone. These features are discontinuous and highly irregular, but there is evidence of fairly persistent ridges lying in depths of 70 to 90 feet MLW.

Separating the features of positive relief are areas of reduced gradient in the general overall seaward inclination of the bottom, referred to as "flats". Outer-shelf flats are not necessarily flat in terms of surface detail. Descriptions of reefs or "ridges" at depths consistent with the flats (Moe, 1963) indicate that they may be highly irregular. The flats develop to their greatest extent northward of Fort Pierce; southward the flats either pinch out or continue only as narrow features as the outer-shelf zone becomes progressively narrower until at about 27°00'N it can no longer be divided into discrete sub-units (Figure 5).

Very little direct data on the outer-shelf bottom composition is available. The few cores within the Fort Pierce grid recovered from this zone contain both consolidated and unconsolidated white calcareous sediment (Type E material, described later) either for the total depth of the core or commencing 1 foot or so below the bottom. Descriptions of the area by fishermen generally characterize the bottom as "coral" or "reef rock", or hard sand, shell and gravel (Moe, 1963). Such descriptions are not inconsistent with the characteristic "E" type sediment contained in CERC cores from this region.

2. Shallow Subbottom Structure

a. General - Information about sediment thickness is from chart notations, core samples and continuous seismic profiles. Figure 6 shows a dual-channel seismic reflection record typical of the profiles in Fort Pierce grid area. Cross-section profiles along survey tracklines are presented in Appendix A. These profiles are characteristic of the study area, and show the position and alignment of the bottom-water interface and subbottom acoustic interfaces within sediment and rock masses.

Seismic reflection profiles do not provide direct evidence of the character of bottom and subbottom materials. Normally, direct evidence must be gathered by drilling or coring into subbottom strata, or by tracing a stratum to an exposure which can be sampled more directly. The correlation of sediment or rock characteristics between data points is made easier by seismic data, since, in some cases, it is possible to continuously define the strata identified in the core. Nevertheless, even where good acoustic definition is available, considerable error is found where lateral changes in sediment or rock character occur within the same bounding acoustic interfaces.

Delineation of acoustic interfaces by seismic-reflection profiling is a reasonably accurate and straightforward procedure where reflections are continuous or interconnected by survey tracklines. Interpolations between parallel survey lines or between gaps in a line must be based on an assumption of continuity of slope or elevation, or on an assumed configuration

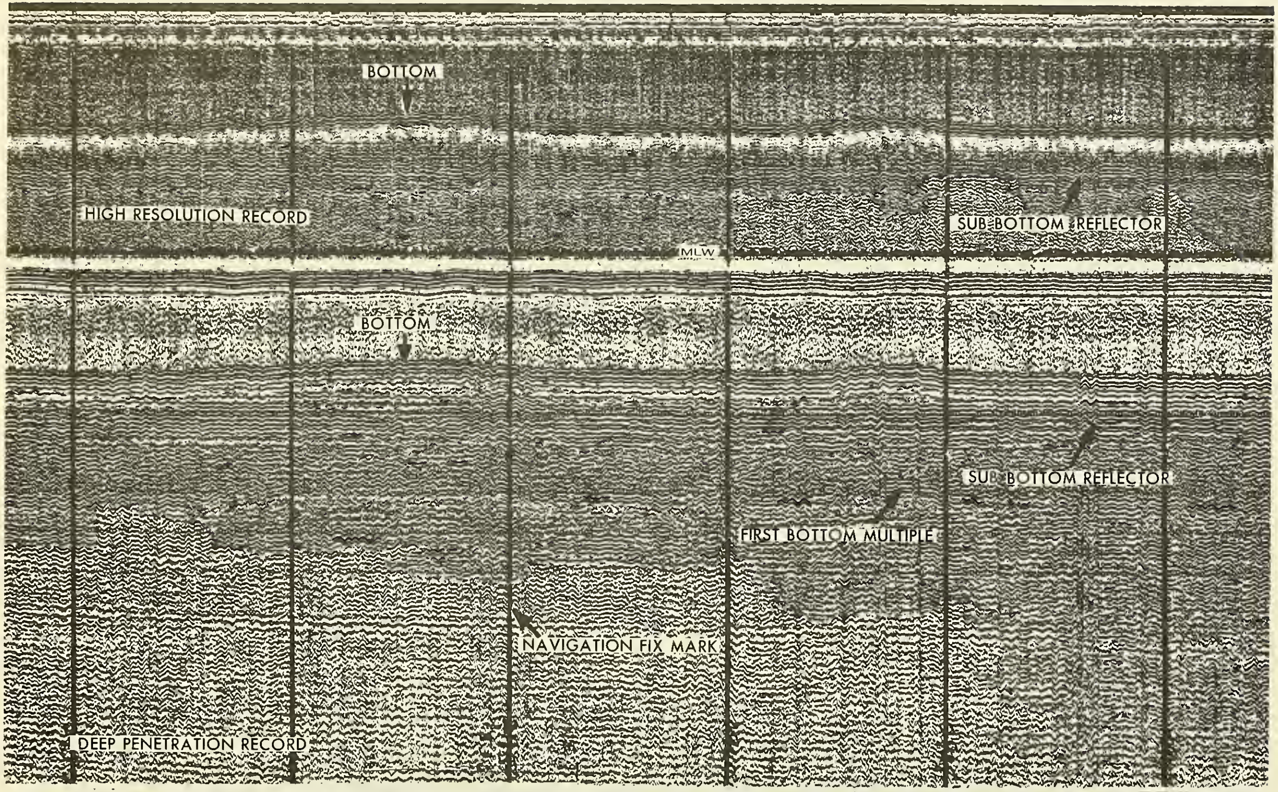
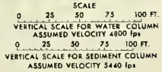


Figure 6. Section of a Dual Channel Seismic Reflection Record Obtained in the Study Area. Record is approximately shore-parallel; Line 13, fix 2947 to 2952.



which is geologically reasonable. Subbottom reflecting horizons on the seismic records are occasionally interrupted by absorption or scattering of the signal near the bottom-water interface with consequent partial or total loss of subbottom resolution. It is difficult in these cases to trace the same reflecting horizon with any assurance.

Acoustic contrasts usually indicate lithologic differences in layers bounding the reflecting surface because of relationships between physical and acoustic properties of rock and sediments. However, acoustic boundaries can exist without significant lithologic contrast, and conversely, lithologically different beds may be acoustically similar. The working assumption in interpretation of seismic reflection records is that all reflecting surfaces are geologically significant boundaries.

Many strong and persistent reflectors appear on the seismic reflection records. Three reflectors were selected for mapping in the Fort Pierce grid area because of their extent and pertinence to study objectives. Selected profiles (Appendix A) show all strong reflectors in addition to the ones mapped and specifically identified.

b. Fort Pierce Grid Area - A schematic profile of typical reflectors in the Fort Pierce grid is illustrated by Figure 7. The shallowest mapped reflector (referred to as the "blue" reflector) lies just beneath the Shelf surface and outcrops at -60 to -70 feet MLW (Figure 8). Almost all cores which reached the blue reflector encountered "rocky" material at the reflector level, usually light gray or white calcarenite or sediment containing calcarenite fragments.

While the overlying inner-shelf surface is marked by many low ridges, swales and hills, the blue reflector has an even surface and passes without apparent distortion under shelf irregularities. The seaward dip of about 4 feet per mile (1 on 1,300 slope) is parallel to the general dip of the surface of the inner-shelf zone. The blue reflector was selected as a base for the isopach map in the Fort Pierce grid (Figure 9) because it is the surface of a stratum which persists over a large area, and because the physical characteristics of the stratum and its depth constitute a horizon below which dredging for beach material is presently considered impractical.

Lying about 10 to 30 feet below the blue reflector and parallel to it, is a second prominent reflector, called the "yellow" reflector (Figure 10). The yellow reflector is identifiable throughout the Fort Pierce grid, northward to Cape Kennedy and possibly beyond. It can be followed south as far as Jupiter Inlet. Because the yellow reflector is of regional extent and generally conforms to the attitude of upper subbottom strata, it is of stratigraphic interest. No cores have penetrated the yellow horizon or below it within the Fort Pierce grid area. Consequently, the nature of the sedimentary material at or below the acoustic horizon is unknown. The seaward dip of the yellow reflector is about 4 feet per mile (1 on 1,300) to -110 feet MLW, thence increases to more than 10 feet per mile (1 on 500). Between the blue and yellow horizons is a layer characterized by

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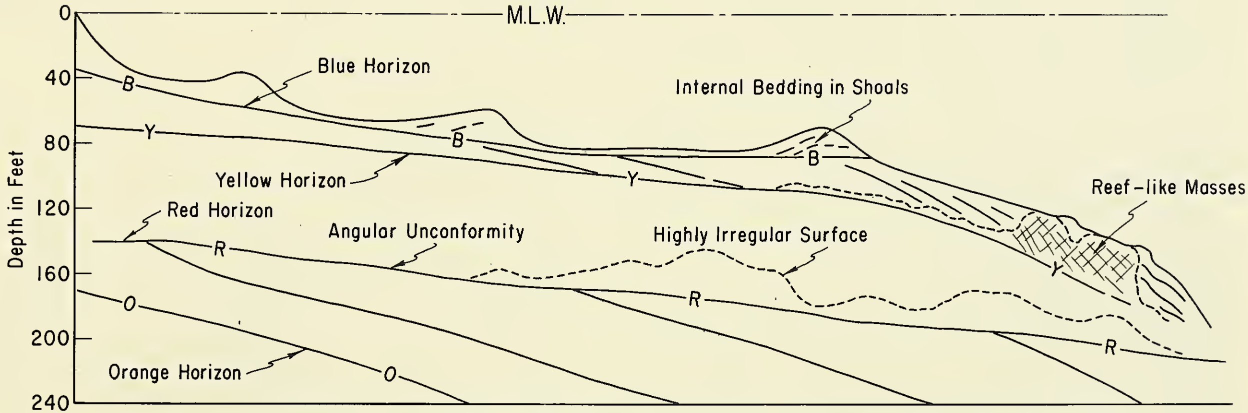


Figure 7. Schematic Profile Showing Characteristics of Prominent Shallow Acoustic Reflectors underlying the Bottom.

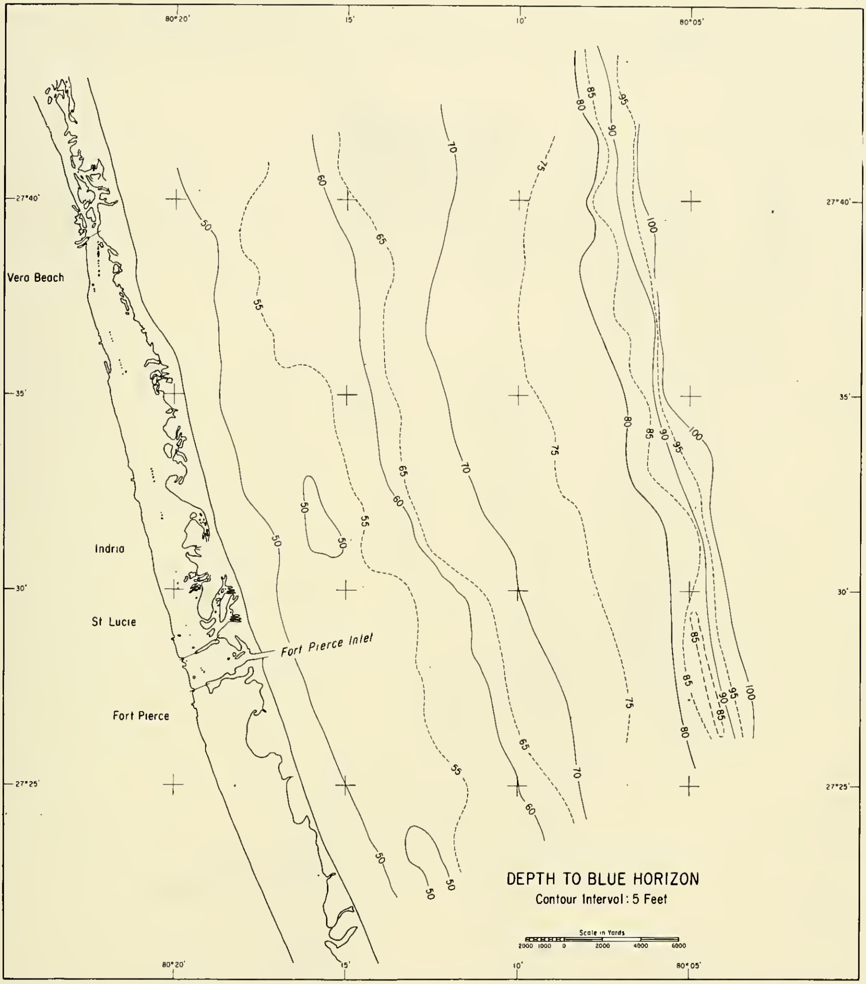


Figure 8. Contour Map of the Surface of the Blue Acoustic Reflector. Depths are in feet below MSL. No marked structure evident, but note abrupt change in dip at 80-foot depth. Locus of change coincides with line separating inner and outer Shelf.

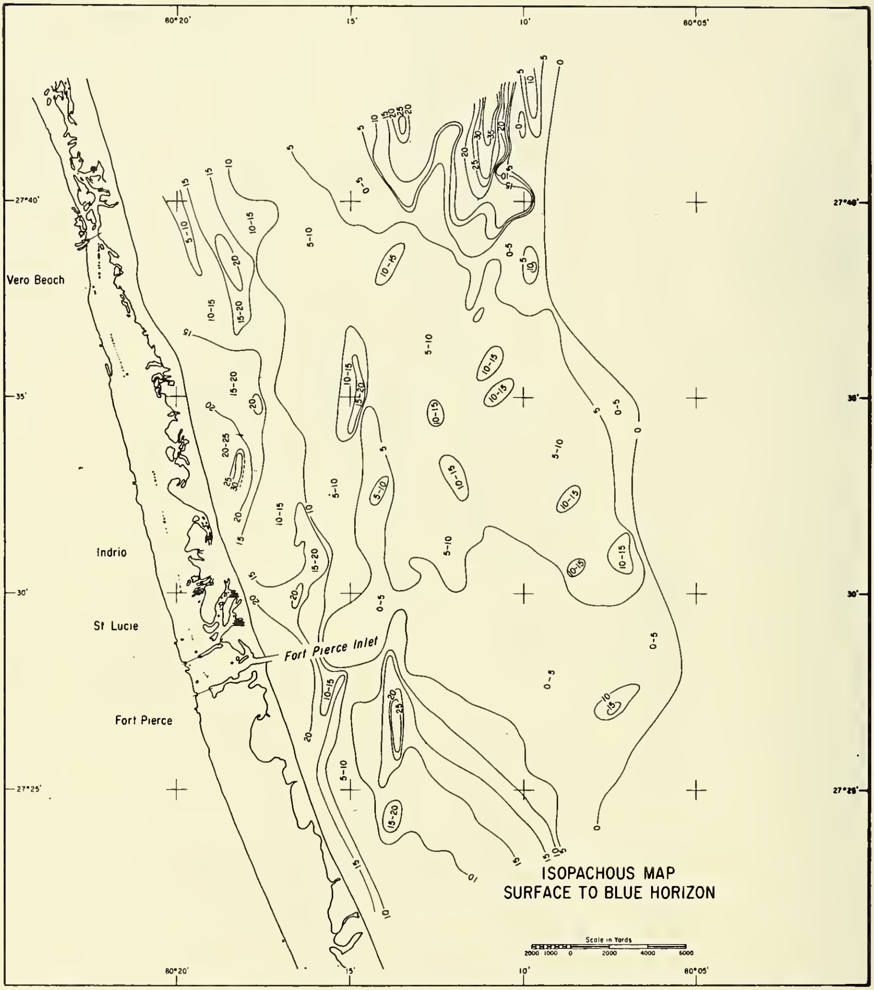


Figure 9. The Isopachous Map of the Interval from the Water-Sediment Interface to the Top of the Shallow Blue Acoustic Reflector. Shows a marked similarity to bottom morphology of the Fort Pierce Grid Area.

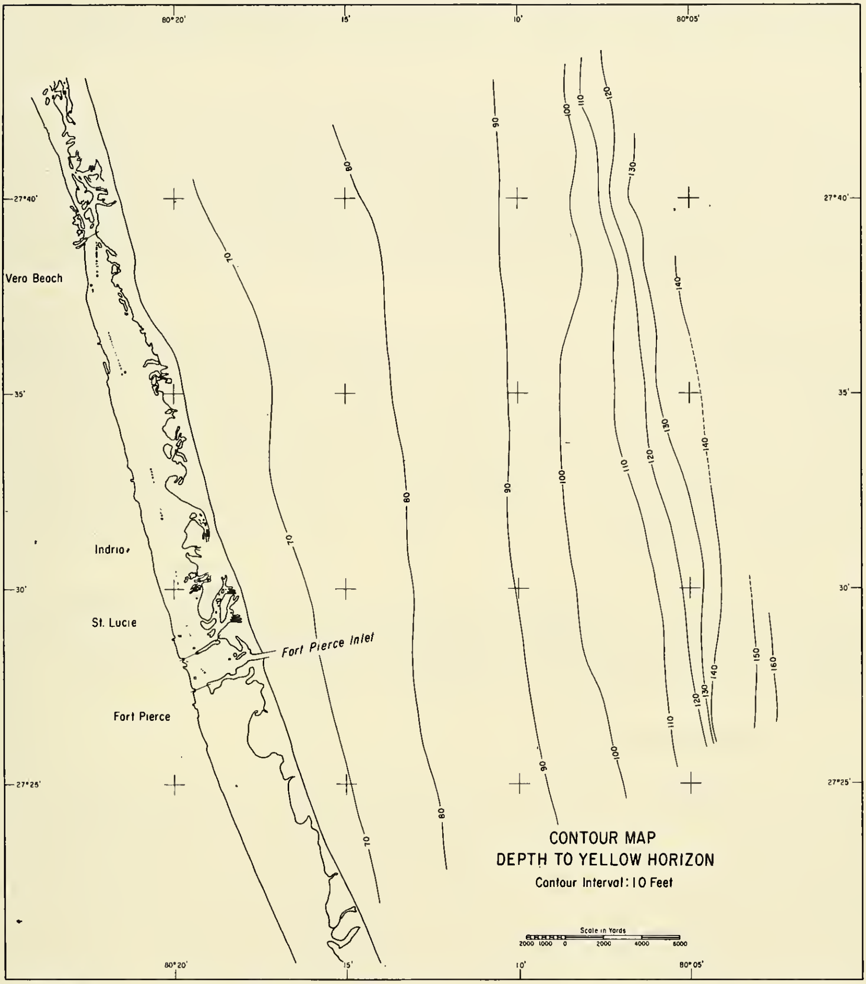


Figure 10. Contour Map of the Surface of the Yellow Reflecting Horizon, Depths are in feet below MSL. Note similarity of structure to the superposed "blue" horizon (compare with Figure 8).

internal bedding features, mostly consisting of high angle to low angle bedding planes inclined seaward. Sandwiched as it is between the blue and yellow reflectors, this unit is probably a distinct stratigraphic unit.

At a depth of about 140 feet MLW nearshore, and sloping seaward to about 220 feet MLW, is a zone representing an apparent unconformity. Strata below this zone dip more steeply eastward and southward than the overlying strata. The acoustic reflection of the dividing surface is difficult to delineate in detail because it is commonly masked by strong multiple reflections of the bottom-water interface; consequently, this surface can be defined only as a zone separating two sets of strata with generally contrasting inclinations.

The section below the probable unconformity contains numerous prominent reflectors more-or-less parallel to one another and dipping eastward and southward. A map of a reflector in this series, called the "orange" reflector (Figure 11) illustrates the structural configuration of the deeper strata, at least to the 500-foot depth of penetration of geophysical records of the ICONS program. Dip of the orange reflector and associated strata is about 7 feet per mile (1 on 750). Beyond the point at which the reflector dips below the range of the records, similar dipping reflectors overlap one another to the seaward limit of the records (see Appendix A profiles).

A somewhat deeper reflector is visible in the northwest corner of the Fort Pierce grid. Although it dips below the record margin a short distance southward, it has been tentatively mapped northward as far as Fernandina. This reflector is believed to lie at or near the Eocene - post-Eocene boundary (Meisburger and Duane, 1969).

c. Reconnaissance Areas

(1) General - From Fort Pierce grid north to Canaveral Bight and south to Palm Beach, the field survey consists only of "zigzag" seismic reconnaissance lines intended to serve as a link between detailed survey areas (Figures 2 b and c). These lines extend no more than 3.5 miles seaward of the shoreline and cover a limited shelf zone everywhere but on the narrowed shelf south of St. Lucie Inlet. Thirteen cores in the section between Fort Pierce grid and Canaveral Bight provide some data on the composition of the inshore bottom and near subbottom of the area. Only two cores were taken from the reconnaissance area south of Fort Pierce grid, an area also deficient in other sources of sediment data, e.g., hydrographic charts and literature. Because data are sparse for the reconnaissance areas, the following discussion is necessarily in broad terms.

(2) Fort Pierce to Cocoa Beach - The blue reflector in the Fort Pierce grid can be identified on the reconnaissance lines for about 10.5 miles north of grid line A. At this point the reflector surface apparently feathers out against the rising yellow reflector of the Fort Pierce grid area. Consequently, sediment below the blue reflector is interpreted

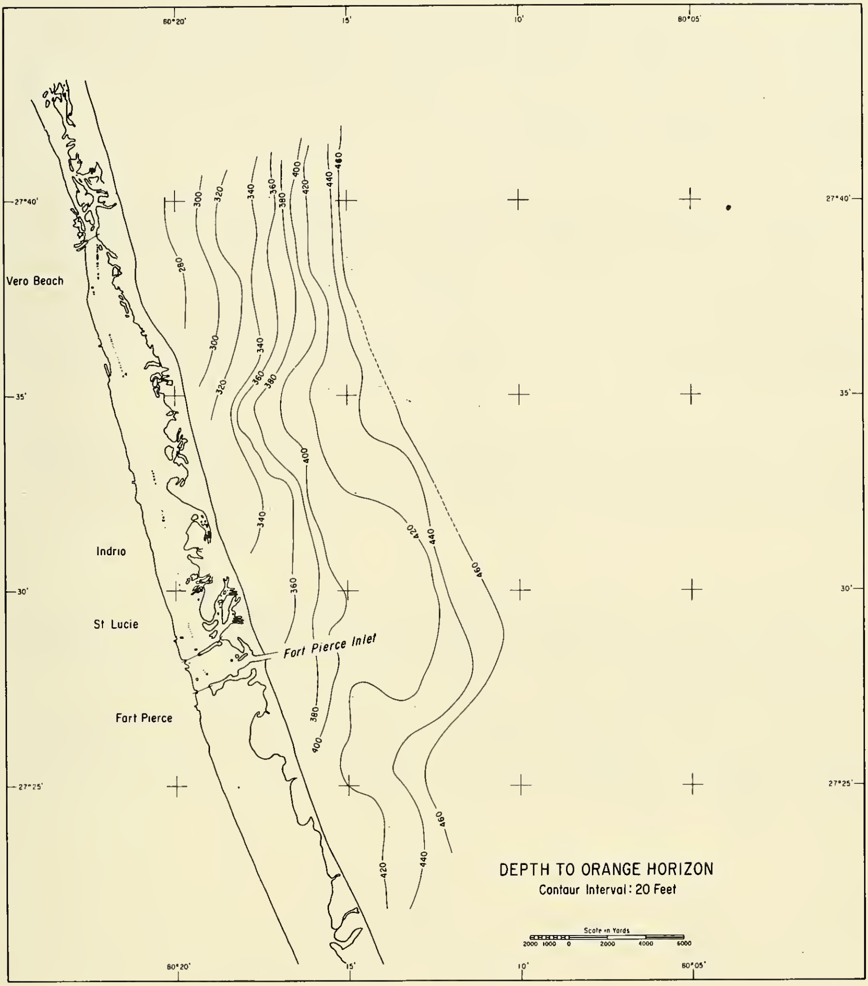


Figure 11. Contour Map of the Surface of the Orange Reflecting Horizon. Depths are in feet below MSL. Note change in dip and strike of this horizon compared to shallower yellow and blue reflectors (compare with Figures 10 and 8).

to wedge out and be supplanted by the sediment stratum below the yellow reflector. The uppermost prominent and continuous reflector of the sub-bottom section, whether overlying sediments characteristically associated with the yellow or blue reflectors, is interpreted to be associated with a single geologic event and to be a continuous surface within study limits. Figure 12, a surface and isopach map of overlying sediment thickness, follows this surface throughout.

Few shoals are crossed by the Fort Pierce-Canaveral Bight reconnaissance lines; thus the sediment overlying the isopach reflector (which is relatively flat) remains generally thin except under the shoreface where it thickens greatly shoreward. Thomas Shoal, which lies on this section of the shelf, was not covered by the survey and is thus not assessable in this study as a source of beach sand. However, analogy with similar offshore shoals in the grid area suggests that Thomas Shoal may contain suitable fill material. The only shoal crossed by a reconnaissance line is centered about 2,000 yards northeast of Sebastian Inlet.

(3) Fort Pierce to Palm Beach - In the reconnaissance area south of Fort Pierce Inlet, the blue reflector can be followed with reasonable confidence southward to the vicinity of Palm Beach. As far as can be determined, this reflector is continuous with the "bedrock" reflector traced from Palm Beach southward to Key Biscayne by Duane and Meisburger (1969).

Figure 13 is a surface and isopach map of sediment thickness over the blue horizon between Fort Pierce and Palm Beach. As in the Fort Pierce grid, the blue reflector has a nearly level seaward dipping surface over which sediment accretions are thickest under shoal ridges and hills.

South of Jupiter Inlet, the shoals, ridges, and hills characteristic of the shelf to the north are no longer apparent, and the blue surface is apparently covered only nearshore where a thick wedge of sand overlaps the inner part of the shelf.

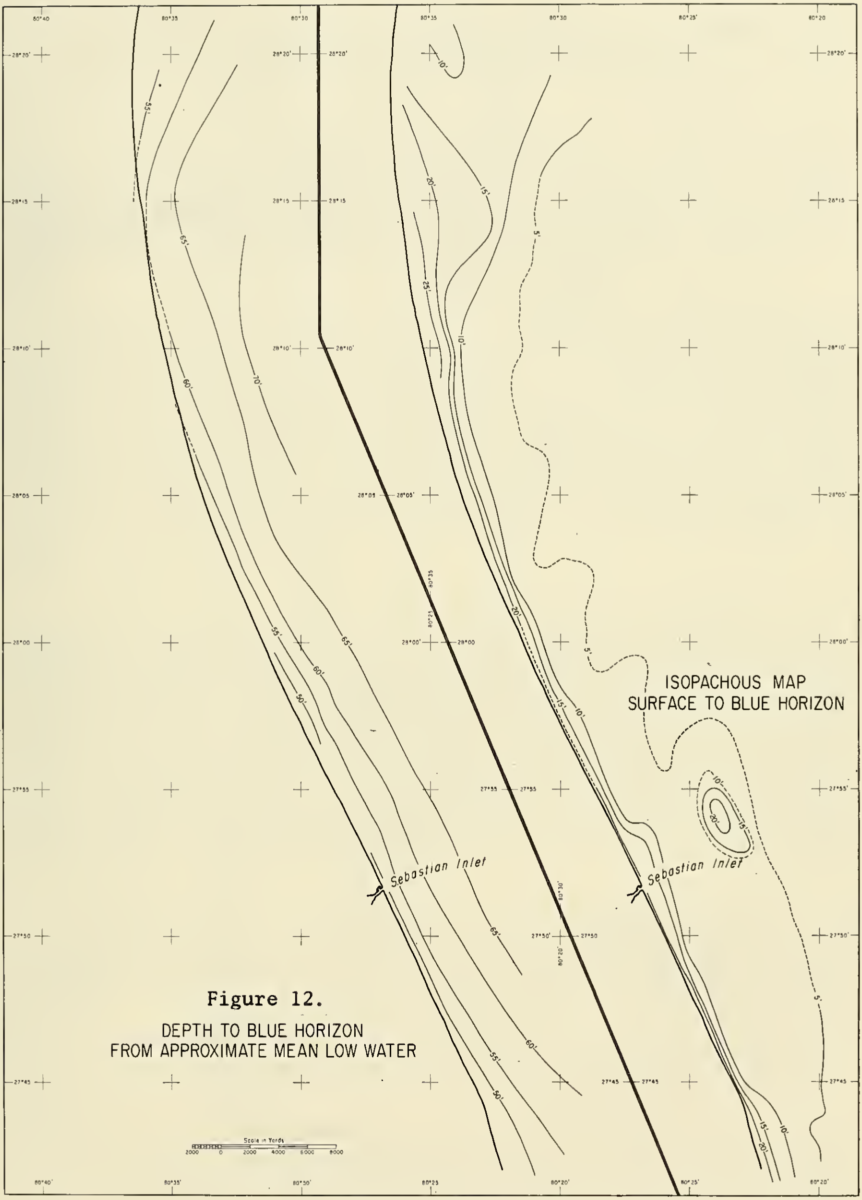


Figure 12.

DEPTH TO BLUE HORIZON
FROM APPROXIMATE MEAN LOW WATER

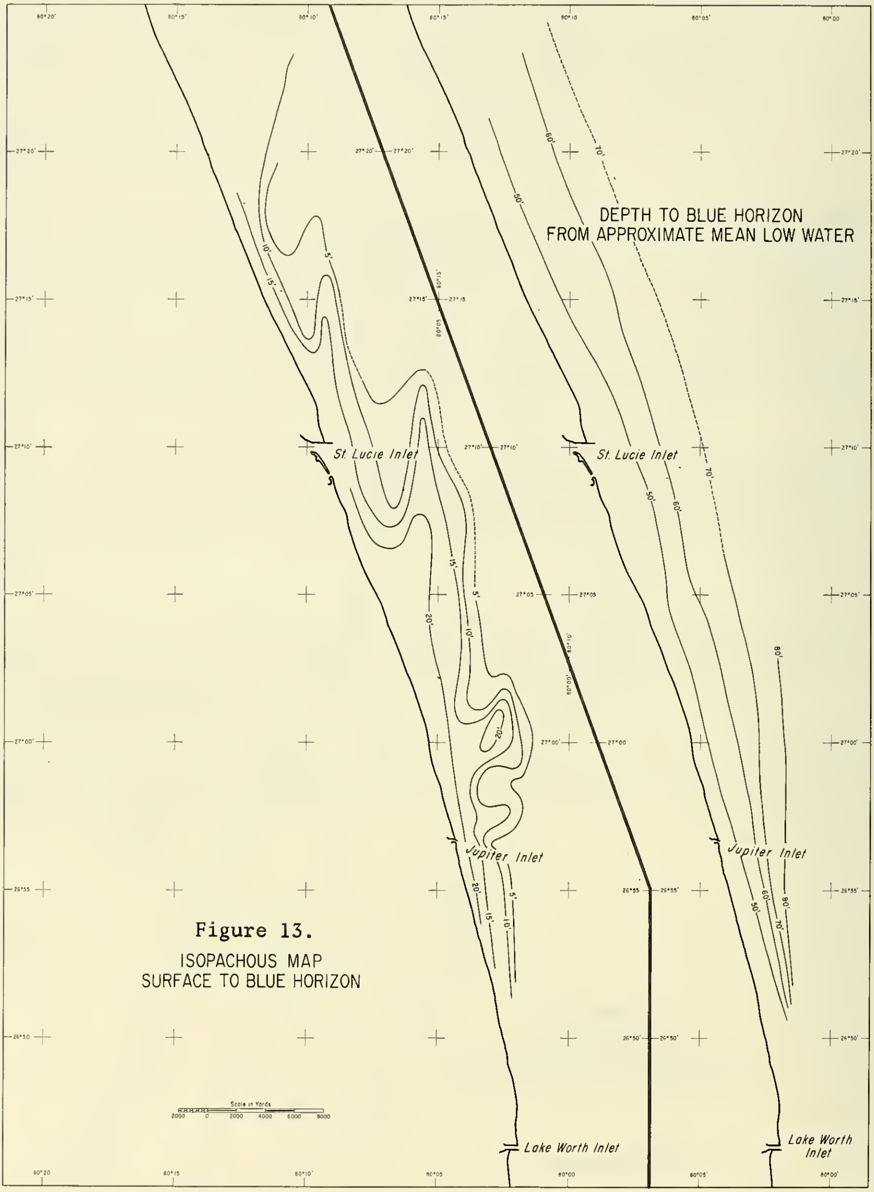


Figure 13.

ISOPACHOUS MAP
SURFACE TO BLUE HORIZON

Section III. CHARACTERISTICS OF SURFACE AND SHALLOW SUBBOTTOM SEDIMENTS OF THE CONTINENTAL SHELF

1. General

The main source of information on sediments in the study area is the collection of CERC ICONS cores. Additional descriptive data on surface sediments is contained in reports by Hathaway (1966) and Moe (1963), and on hydrographic chart coverage of the study area. Size analysis data of representative samples from the Florida ICONS cores are presented in Appendix B; core descriptions are in Appendix C.

Nearly all bottom and subbottom material recovered in cores from the study area consisted of unconsolidated or semi-consolidated clastic sediments ranging in size from silt to fine gravel. Treatment of representative samples with dilute HCl showed that these sediments are generally over 50 percent acid-soluble. Acid-soluble constituents, identified by visual analysis, are biogenic, with a minor but locally important content of oolitic material. Broken mollusk shell, barnacle plates and foraminifers dominate those biogenic constituents which are large and complete enough to be readily identified. The insoluble fraction of sediments from the study area consists almost entirely of clear quartz sand ranging from angular to well-rounded grains.

Important biogenic constituents in the Fort Pierce sediments were identified by examination of the >2 mm fraction of 46 representative sediment samples. Important contributing organisms are listed in Table II, and some of the more common forms are shown in Figures 14 and 15. Identification of biogenic constituents was based largely on Abbott (1954 and 1968); Morris (1951); Perry and Schwengel (1955); and Ryland (1967); nomenclature follows Abbott (1954). Dr. Joseph Rosewater and Mr. Walter J. Byas of the Mollusk Division, Smithsonian Institution verified the identification of a reference set of specimens. Most biogenic constituents in the finer (>2mm) fraction appear to be broken or smaller particles of the types of organisms identified.

b. Fort Pierce Grid - Several sediment types can be recognized in the Fort Pierce grid area. Based largely on color and gross composition, sediments in cores from the Fort Pierce grid are of five main types. In usual stratigraphic sequence these are: 1) Type A - clean, poorly sorted, brown, shelly sand; 2) Type B - gray, fairly well-sorted, calcareous sand; 3) Type C - silty gray sand and shelly gravel; 4) Type D - clean, light gray, fine to medium-grained, well-sorted calcareous sand; 5) Type E - white to light gray, generally poorly sorted, calcareous mud, sand, or gravel - often lithified.

The relative stratigraphic position of these types is uniform throughout the study area. Such similarities point to a regional environmental uniformity during time of deposition of sediments of a given category. However, similar depositional conditions may have been recurrent or migratory, leaving deposits of similar material but unrelated in age. Likely

TABLE II

CONSTITUENTS MOST COMMONLY FOUND IN COARSE FRACTION (> 2mm)
FORT PIERCE SEDIMENTS

MOLLUSCA

Pelecypods

Anadara transversa Say

Anomalocardia cuneimeris Conrad

Anomia simplex Orbigny

Cardita floridana Conrad

Chione intapurpurea Conrad

Chione grus Holmes

Corbula dietziana C. B. Adams

Crassinella lunulata Conrad

Donax variabilis Say

Glycymeris pectinata Gmelin

Mulinia lateralis Say

Nucula proxima Say

Venericardia perplana Conrad

Gastropods

Crepidula fornicata Linne

Olivella

OTHER

Barnacle plates and valves of the acorn barnacle.

Algae-amorphous calcareous fragments of probable algal origin.

Bryozoa - encrusting and small hermispheric lunulütiform types.

Echinoids - spines and dermal plate fragments.

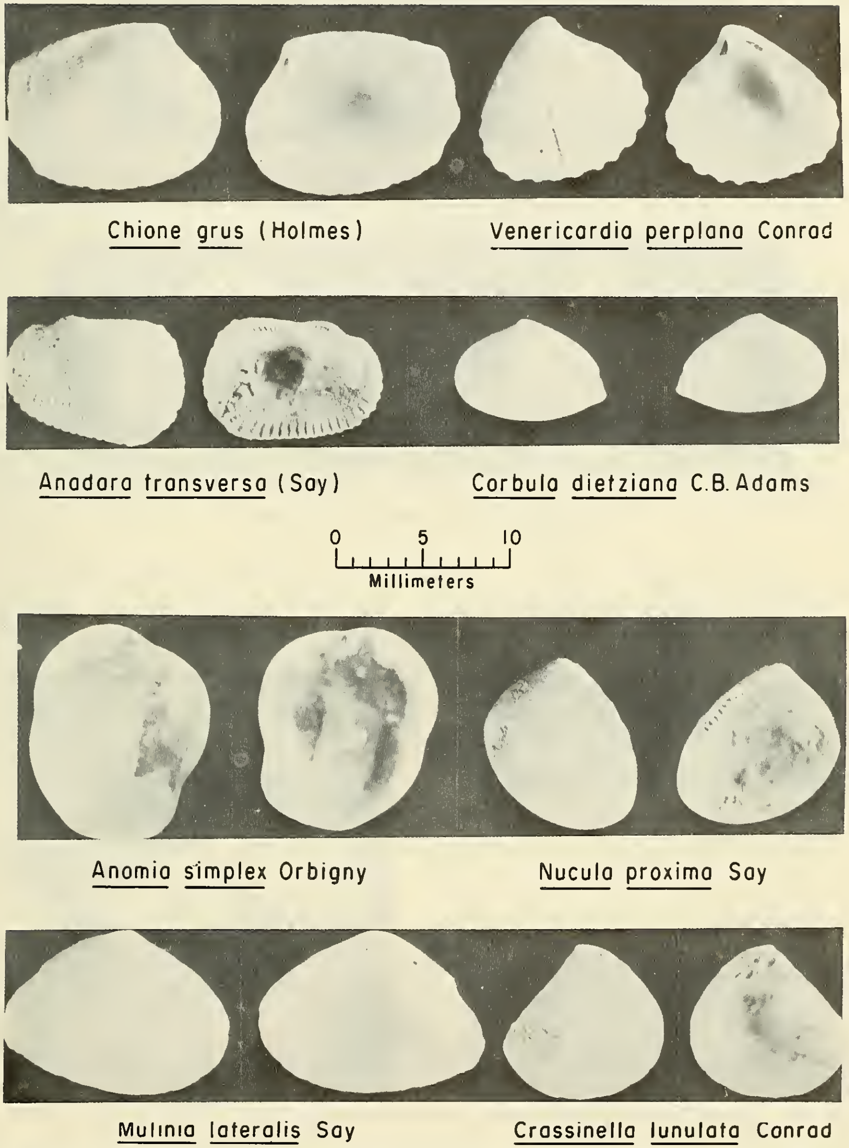


Figure 14. Exterior and Interior Views of Valves of Pelecypods Commonly Found in Whole or Fragmented Sediments from the Study Area.

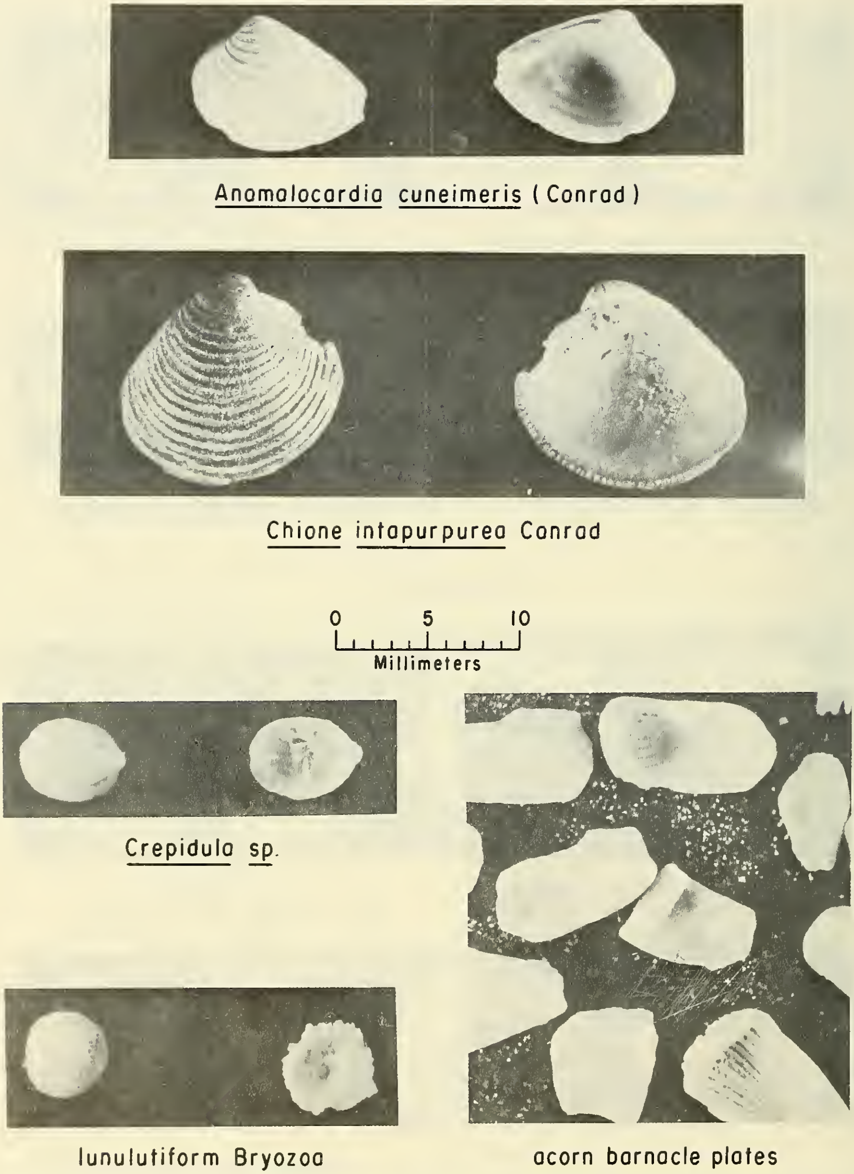


Figure 15. Views of Pelecypod and Skeletal Fragments of other Organisms which are Prominent Constituents of Sediment from the Study Area.

common factors creating similarity in sediment type are: 1) age of deposit; 2) sediment source; 3) environment and circumstances of deposition; and 4) post-depositional history. Interpolations of sediment distribution patterns between core sites have been based partly on the assumption that these apparent relationships are real.

A small number of sediment samples from Fort Pierce grid cores do not fit into a classification. These sediments have been designated "U" (unclassified) in the core descriptions of Appendix C. Most of the unclassified sediments are either quartzose fine sands, found only in the shoreface area, or silty cohesive very fine sands which are more widely distributed (Wentworth classification is used throughout).

All sediments within the Fort Pierce grid area having a brown coloration and devoid of silt or clay are classed as Type A (Figure 16). The group is variable in nature, but in most places is medium to very coarse, poorly sorted calcareous sand. Quartz is present in all samples, but the content ranges widely from a few percent to over 40 percent (Appendix B). The quartz grains are clear and colorless with a great variety of shapes. Large, well-rounded grains with frosted surfaces occur in many samples where they are mixed with the more common subangular to subrounded particles of quartz. Size analysis of insoluble residues from selected samples of Type A sediment are presented in Appendix B.

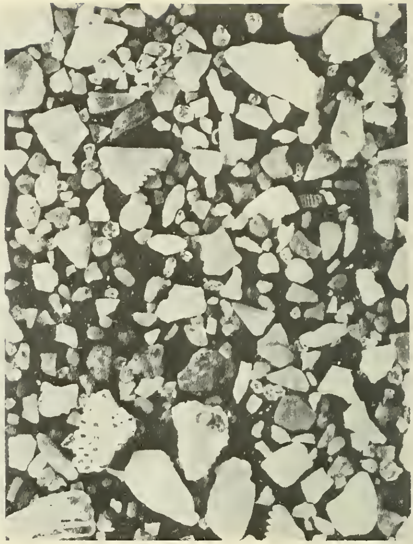
Type A sediment contains the largest variety of organisms; most species listed in Table II are represented. Barnacle plates are very abundant, making up 50 to 70 percent of the identified fragments. *Crassinella lunulata*, *Chione grus*, *Anomia simplex* (usually fragmented), *Anadara transversa*, and *Crepidula fornicata* are best represented. The skeletal fragments are mainly shades of brown, pink, white or gray with both rounded and freshly broken fragments mixed. Dark gray and brown well-worn shell fragments, with boring and solution holes, are scattered throughout, but not in large quantities. Foraminifers are rare.

Nonskeletal carbonate material in the form of ooliths and pellets occur in Type A sediments, and locally in large quantities. Ooliths are especially common in samples from shoals near the seaward edge of the inner shelf.

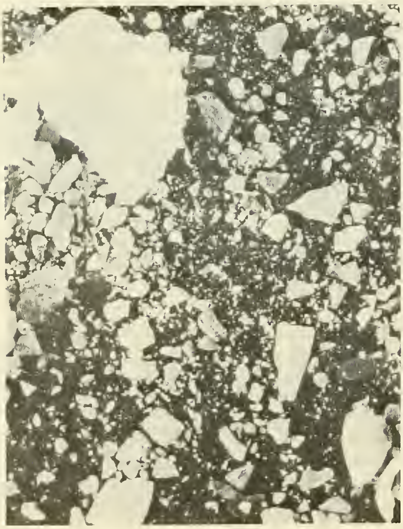
Although ubiquitous throughout the inner shelf area, Type A sediments have not been recognized in the few cores obtained from the outer shelf area (-70 to -230 feet MLW). Where found, Type A sediment is always uppermost in the column. Over the flats, it usually occurs as a relatively thin blanket deposit less than 5 feet thick. Over shoals, it thickens appreciably, and seismic data indicates that some smaller shoals are entirely composed of this material.

Type B sediment is a gray calcareous sand usually fairly well sorted, but may be silty or poorly sorted in some places (Figure 17). This material underlies Type A sediment where found. The position, size similarity, and composition of Type B material suggests that it is a facies of Type A

Core 67A -3 Feet



Core 76 -1.0 Feet



Core 87 Top

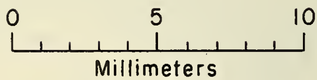
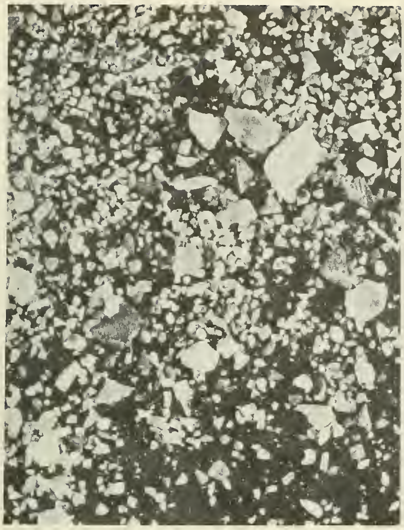
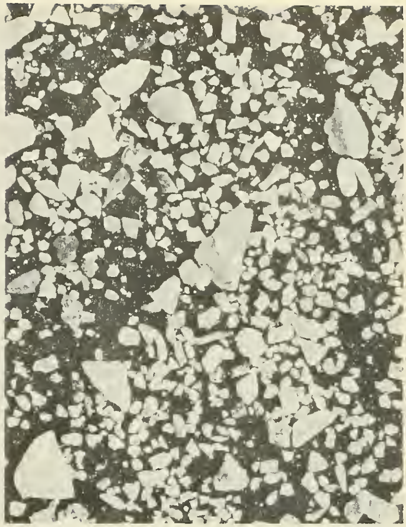


Figure 16. Views of Sediment Classed as Type A. Note differences within the class.



Core 73B - 5 Feet



Core 67A - 6 Feet

Core 41 - 7 Feet

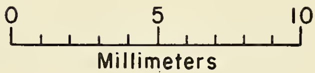


Figure 17. Views of Sediment Classed as Type B. Note greater uniformity within the class.

sediment. The chief difference between Types A and B is the color of Type B constituent particles which range from white through gray to black (contrasted to the predominant reddish and brown colors of Type A material).

Some finer samples of Type B material resemble the fine, well-sorted, carbonate sand described below as Type D, and a relationship may exist. In many places, however, where both types B and D occur in the same core, they are separated by a silty, sandy shell gravel (Type C) and the B sediment is darker in color, less well sorted and richer in barnacle plates than the D material.

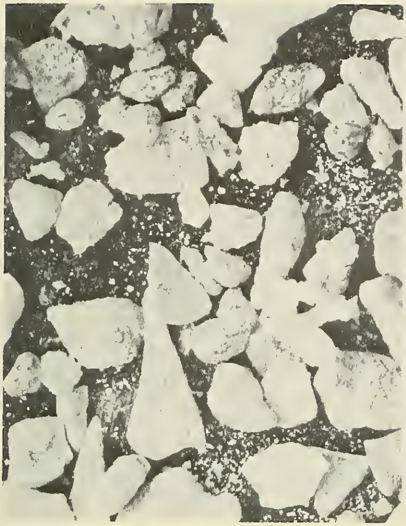
Type C sediment is characteristically gray, silty, very coarse skeletal sand to sandy shell gravel (Figure 18). Usually, it is slightly cohesive when wet, and dries to friable lumps of silt, sand and shells. Quartz particles, present in small quantity, range from silt-size to very coarse, irregular, but well rounded grains. Size analysis of insoluble residues from typical Type C sediment are contained in Appendix B.

Biogenic remains in Type C sediment show close similarity to the Type A assemblage. *Anadara transversa*, *Anomia simplex*, *Chione grus*, *Crassinella lunulata*, and *Crepidula fornicata* common in Type A sediment, are also well represented in Type C. Barnacle plates are abundant (25 to 50 percent) but less so than in Type A. *Venericardia perplana* and fragments of *Chione intapurpurea* appear to be more common than in other sediment types. The condition of shell fragments varies from relatively "fresh" to gray or black well-worn pieces, often pitted by sponge and algal borings. Dark colors predominate. Nonskeletal carbonate material consists mostly of sparse pelletoid and oolitic-shaped grains which occur in some cores. Type C sediments are common throughout the inner-shelf area, but are rarely exposed at the surface.

Type D sediment is light gray or pale brownish gray, fine-to-medium, well sorted calcareous sand (Figure 19). Locally, it contains shells and shell fragments in sufficient quantity to constitute a second size mode, but most often the sediment has few large inclusions. Constituent particles are generally rounded and sometimes polished. White, gray or black colors predominate, and the contrasting light and dark colors often impart a "salt and pepper" aspect to this sediment.

Most Type D particles are calcareous and of probable organic origin, although few are identifiable except for small foraminifers. These foraminifers are relatively abundant in the finer fraction, and are of diagnostic value since small species rarely occur in other sediment types of the study area.

Crepidula fornicata is probably the most common mollusk overall in Type D sediment; however, at least locally, *Mulinia lateralis* is most abundant. *Venericardia perplana* and a small species of *Olivella* are also common. *Crassinella lunulata* an ubiquitous species in all other sediment



Core 42 - 2 Feet

Core 78 -1.0 Feet

Core 40 - 5 Feet

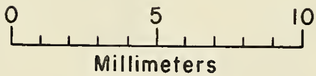
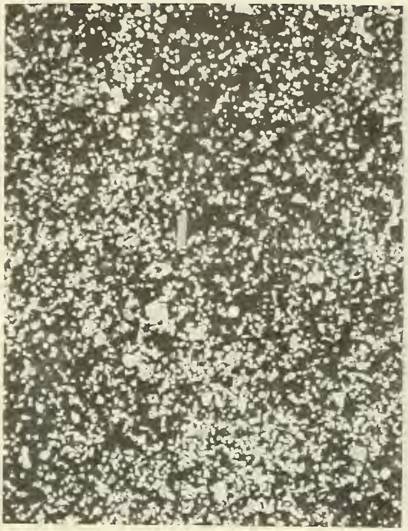
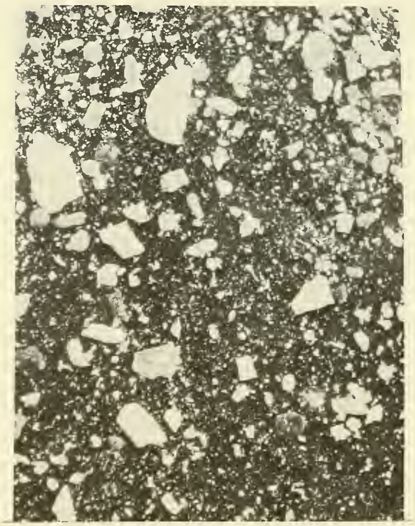


Figure 18. Views of Sediment Classed as Type C.



Core 36 -7 Feet

Core 77 -5 Feet



Core 79 -8 Feet

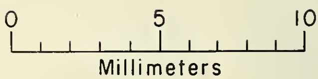


Figure 19. Views of Sediment Classed as Type D.

types of the area is rare in Type D sands, as are barnacle plates which occur in quantity in Types A, B, and C sediment.

Type E material is characterized by its white or very light gray color. This material is highly variable in size and in its degree of lithification (Figure 20). In typical cores, layers of lithified and semi-lithified material are interspersed with sediment layers. Many of the unlithified layers contain granules and pebbles of calcarenite probably weathered or redeposited from the lithified layers.

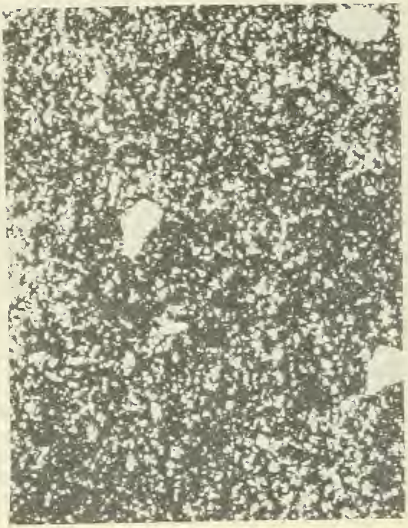
The size range of Type E material varies from silty calcareous clay to coarse calcareous sand, shell gravel and pebbles. Most of the sand-size material is biogenic. Fragmentation of the skeletal sand-size material is usually well advanced and identifiable fragments are sparse.

Indurated Type E rocks appear in cores in the form of layers or discrete pebbles and angular fragments mixed with unconsolidated sediments, generally similar to that comprising the indurated material. Indurated fragments obtained from cores on the outer shelf consist of white medium-grained calcarenite containing shell fragments, foraminifers, quartz, and many oolitic or pelletoid grains. Individual grains are frequently well worn, and many are polished. Cementation occurs only at points of grain contact, and there is little if any infilling of interstices.

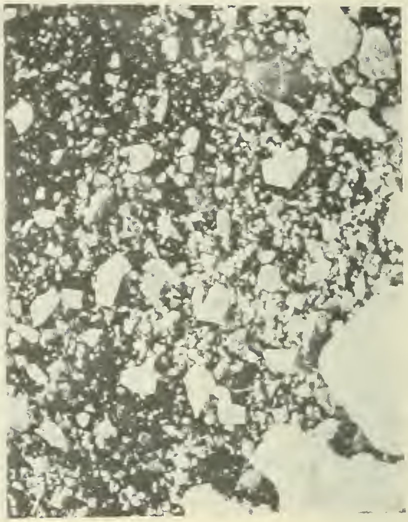
Type E material occurring in cores of the inner shelf is more variable. In places it consists of white calcareous silty or sandy clay which dries to a very hard rocklike substance. Other E sediments and indurated material from the inner shelf generally are light gray or tan, and the indurated material is finer grained, denser and more compact than that from the outer shelf area. Redeposition of calcium carbonate in interstices appears to have accounted for greater density although grain size and sorting may be equally important.

It is difficult in most cases to determine if indurated fragments in Type E material are the result of the coring tube penetrating lithified layers or if the fragments are redeposited from a higher source. In a few cases, a solid plug of rock in the core is evidence of penetration of an indurated layer. Angular "fresh" appearing fragments also evidence the breaking up of a layer by penetration of the corer. Occasional rounded pebbles of calcarenite are probably redeposited.

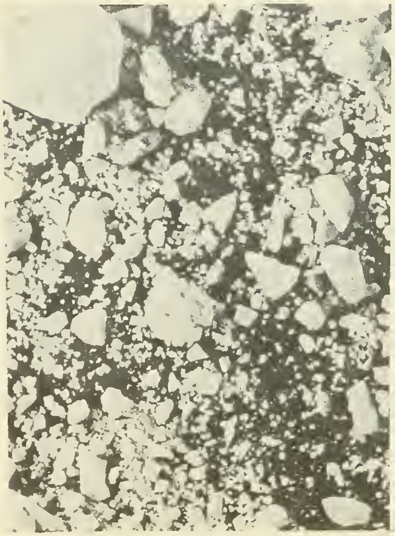
Type E sediments are most variable in terms of coarse constituents. Fragments of calcarenite, rare in other types, are common. *Mulinia lateralis* and *Glycymeris pectinata* are the most common pelecypods. *Crepidula fornicata* is common, as are fragments of other species of gastropods. Barnacle plates are absent in some samples and abundant in others. Skeletal fragments are for the most part white - or near white - often worn and occasionally partly embedded in calcareous material.



Core 44 - 5 Feet



Core 42 - 8 Feet



Core 90 - 9 Feet

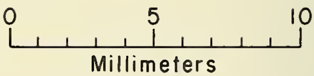


Figure 20. Views of Sediment Classed as Type E. Views are of unconsolidated "facies". Type also occurs as lithified "facies" within the study area.

Type E material is the most widely distributed of all sediment types in the Fort Pierce grid area. It occurs at the surface in many places, usually on the outer shelf. The pattern of occurrence and its association with the blue reflector strongly suggests that this material continuously underlies the entire grid area.

Among the unclassified sediments a number contain quartzose sand. These samples are all from shoreface cores, and possibly represent material winnowed from the quartzose deposits of the present beach. Shells of mollusks, particularly Crepidula fornicata and Mulinia lateralis, are mixed with the sand matrix, but the sand fraction itself contains little carbonate material. This sediment is designated U1 in Appendix C.

Most of the remaining unclassified samples are silty, cohesive, very fine sands which do not appear to be restricted to any particular area or stratigraphic position. They are possibly localized deposits of fine material winnowed from overlying or adjacent units and are designated U2 in Appendix C.

c. Reconnaissance Areas - Almost all cores taken on the Fort Pierce-Cocoa Beach reconnaissance lines contain gray, silty, clayey material in the upper layers. Varying amounts of shell are mixed with the silt-clay matrix; generally shell increases in size and density with depth. In some respects this material resembles Type D material. In most places, it is underlain by a light tan to white calcareous clayey unit containing many broken shell fragments, some of which are chalky and very friable. When dry, this material is extremely hard.

No material closely resembling Fort Pierce type sediments is contained in these cores from the reconnaissance area. It is thought significant that the disappearance of Type A material coincides with the disappearance of shoals in the inshore area, and (with the exception of Thomas Shoal) from the offshore area. The relationship of this sediment type and surface topography appears to be close.

Cores north of about 28°10'N (Canaveral Bight) indicate that the Bight area is blanketed with a deep deposit of relatively uniform clayey silt containing few shells. This deposit probably forms the shallow inner level of the 50-foot flat in Canaveral Bight. The fineness of the material suggests it has been deposited in a low energy environment created by Canaveral Peninsula and its off-lying shoals.

Core 181, which penetrated material differing from that found in other cores of the reconnaissance area, contains the only sand potentially usable for beach fill. A layer of quartzose, medium-to-coarse sand with varying amounts of shell fragments in the upper and lower parts of the core appears to be suitable for fill. A thin layer of clayey sand containing woody material overlies the first quartzose layer. The extent, form and orientation of this deposit cannot be determined from available data. It is, however, a promising place for further investigation, should offshore sand supplies be needed in the general vicinity. The lower part of a nearby core, Core 182, also contains somewhat anomalous material in the form of a shell gravel consisting almost entirely of well preserved shells of Mulinia lateralis, some shells of Donax variabilis and quartz. Whether this stratum is a facies of the material found in the adjacent Core 181 is not known.

Very little data is available on sediments in the reconnaissance area southward from Fort Pierce grid to Palm Beach. Only two cores were taken in this area - both near the southern border of the grid. Moe (1963) reports a rolling sand and shell bottom in the area with coral rock reefs at 30, 70, and 130 to 140 feet; the shallow reef is obscured by sedimentation in many places. Material found blanketing the shelf at Palm Beach and southward to Boca Raton consists of a fine, well sorted, gray quartzose sand dissimilar to any sediment found in Fort Pierce grid except perhaps Type D. A transitional zone between the typical Type A surface sediment of Fort Pierce grid and the gray sand body at Miami Beach must occur in the reconnaissance area. If the presence of Type A sediment is indicated by shoals (as seems to be the case), this sediment type probably persists as far south as 27°05'N because shoals similar in form to those found in the Fort Pierce grid occur here.

Section IV. INTERPRETATION

1. Sediment Distribution and Origin

a. Fort Pierce Grid Area

(1) Bedding Sequence and Extent - The usual vertical sequence of cored sediment layers in Fort Pierce grid from the lowest is, E, D, C, B, and A. The stratum containing Type E material is believed to be continuous throughout; other sediment types recognized are not everywhere present and it appears from seismic and core data that none extend far seaward of the inner shelf (Figure 21). Type E material is found in 23 of the 62 cores from the grid area, and in these it persists to the bottom of the core. In the remaining 39 cores - particularly those of the inner shelf shoals - overburden thickness prevents core penetration to Type E level. Cores and geophysical profiles from the outer shelf and descriptive data from the study by Moe (1963) indicate that extensive exposures of Type E material may occur in that zone. A large area of exposure or near exposure on the inner shelf is centered about 5 miles east of Fort Pierce Inlet (Figure 21). Elsewhere on the inner shelf, local exposures may occur in swales between shoal areas.

Type D sediment occurs in 17 cores from the grid area. Where recovered, Type D sediments are either the bottom layer in the core or overlie Type E material. The close resemblance of sediments in many samples of Type D with underlying E material, suggests that it may be derived partly from reworking of this underlying stratum.

Type C sediment is second only to Type A in frequency of occurrence in the Fort Pierce grid cores. It is probably nearly continuous throughout the inner shelf area. Only Types A and B, and occasional miscellaneous unclassified sediments, overlie the C layer. Surface exposures of the material are uncommon.

Type A sediment is the characteristic surface sediment of the inner shelf area. Nearly all inner-shelf cores contain A sediment as the surface layer. Usually Type A sediment overlies Types B or C, but it is also found in direct contact with Types D and E.

Thickness of the sediment layers revealed by Fort Pierce cores is variable. Type A sediments vary from a foot to at least 12 feet in depth and possibly reach more than 30 feet in places. The thickness of the Type A layer is generally related to shelf topography, being thick under shoals and thin in the flats and swales. Sediment Types B, C, and D are relatively thin bedded - average sections are about 5 feet or less. The E layer has not been completely penetrated by cores, thus there is no direct evidence of thickness. Available data indicate a thickness of over 10 feet.

Most of the sediments which were not classifiable consisted of silty, cohesive, fine sands and probable mixtures of sediment types

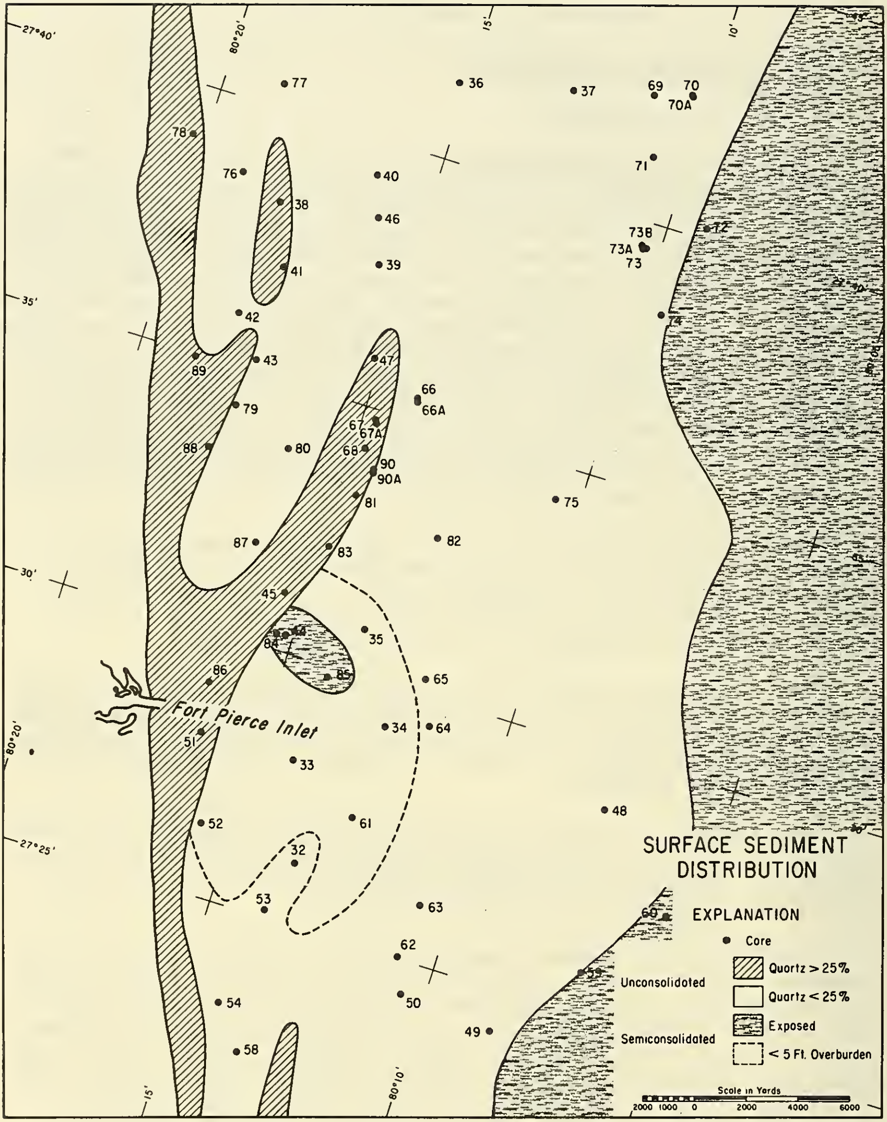


Figure 21. Generalized Map of the Surface Sediment Distribution in the Fort Pierce Grid Area.

classified above. Type U1 sediment is found in a few cores, but only from the shoreface area. The high quartzose content suggests this material may be largely derived from quartz-rich deposits on the present beach.

The source of most sediment particles found in Fort Pierce grid cores is the benthic biota. Organisms contributing to the material - insofar as can be determined - are indigenous to the area. Quartz, the only noncarbonate element present in significant quantity, must have been derived from the Piedmont Province since no primary quartz-bearing rocks crop out on the Florida Peninsula (Puri and Vernon, 1964 and Pilkey, et al. (1969). Net drift of sediment on the east Florida coast is southward (Watts, 1953; Giles and Pilkey, 1965; Bruun, Geritsen and Morgan, 1958). Studies of the southern Atlantic Shelf indicate that shelf sediment transport parallel to shore may not be an important process (Pilkey, 1968 and 1969). Thus, movement, if any, is probably in a general onshore-offshore direction.

The dominant carbonate suite may have been created in recent times by organisms inhabiting the area of accumulation or may have originated outside the grid area and subsequently entered as detrital sediments. A third possibility is that the skeletal fragments were reworked from older underlying formations. Available information indicates all three processes probably played a part in sedimentation of the inner shelf area, and through time the dominant depositional process may have differed for different sediment types.

The deepest, and presumably oldest, stratum reached by Fort Pierce cores is the stratum containing Type E material. The top of this stratum is tentatively correlated with the blue acoustic reflector (Figures 7, 8, and 9). It is believed that the E stratum was deposited during or prior to the late Wisconsin regression commencing some 30,000 years Before Present. One evidence of this minimum age is that indurated layers occur within the Type E stratum. Induration of clastic carbonate sediments strongly - but not conclusively - indicates exposure to subaerial or littoral conditions (Ginsburg, 1957; Friedman, 1964), therefore suggesting exposure during the late Wisconsin regression or earlier. A further indication is that projected depths of the blue reflector under the coastal ridge are equal to or below the top of the Anastasia formation in the coastal region; Anastasia rocks are presumably Sangamonian (last interglacial) and possibly earlier in age (Cooke, 1945; Puri and Vernon, 1964).

Type E material from the outer shelf does not resemble descriptions given to Anastasia rocks in the coastal area. However, the Anastasia is lithologically variable and little is known concerning its character - or existence - seaward of the coastline. Two cores from the inner shelf area, 45A and 34, contained plugs of rock in the cutter head which resemble rocks presumed Anastasia found near the shore at Fort Pierce. Elsewhere the Type E material of the inner shelf is not inconsistent with the wide-ranging lithologic description of the Anastasia Formation in coastal Florida.

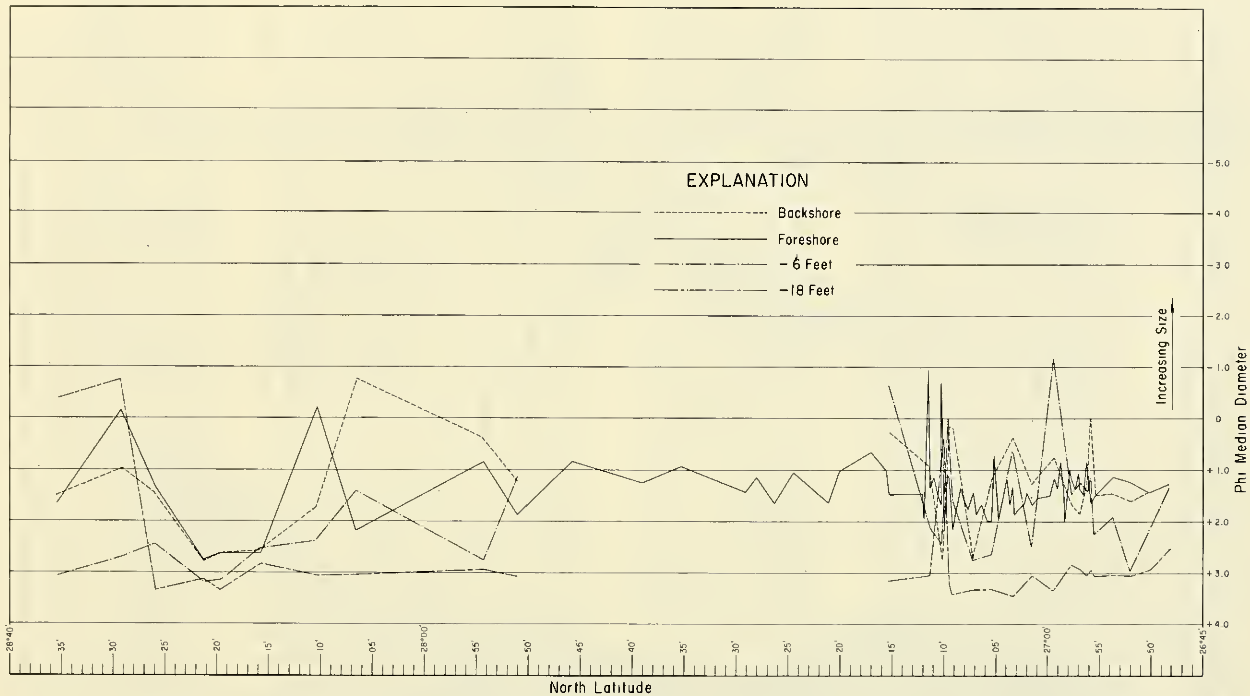


Figure 22. Median Diameter of Sediments Comprising the Beach and Shoreface in the Study Area. Location is indicated by latitude. Except for data from 27°15'N to 27°50'N, information obtained from published Corps of Engineer beach erosion control studies.

Unconsolidated sediments lying above the blue reflector may have originated largely outside the area of deposition or have been largely derived from local sources. Since no streams discharge directly on the Florida coast south of Jacksonville Beach, this common source of terrigenous sediment is not considered active here. Pleistocene drainage may have played some part as a previous source, but no evidence of important contributions from this source is available.

A possible source of sediment from outside the grid area is littoral drift alongshore coupled with offshore transport to the shelf area. Existing beach sediments north of Cape Kennedy are considerably finer and more quartzose than those of the study area, thus could be contributing only minor amounts of material presently on the beach and shelf in the Fort Pierce grid. Net littoral transport in southeast Florida is southward (Watts, 1953); thus, drift from the south is also an improbable source of beach sand near Fort Pierce. The most likely sources of beach sand are coastline erosion and local shell production. Shelly quartzose sand similar to that of the beaches is available in preserved Pamlico Age sands of the coastal upland. Storm wave erosion of this source could play a significant role in littoral sedimentation. Shell production is high, especially in the vicinity of the inlets. Additional shell and quartz debris is probably derived locally from erosion of coquina outcrops reported in the shallow waters close inshore (USCE, 1967 and 1968); although some of these outcrops may in fact be sabellariid reefs (Kirtley and Tanner, 1968).

Some cores from the shoreface area contain quartzose sand similar to the beach sands. Elsewhere on the shelf, good evidence of beach-derived sand is lacking. The coarser texture of shelf surface sediment compared to the beach, and progressive diminution of sand size transported from shore into the sublittoral shoreface as evidenced by the size data of Figure 22, tends to indicate that large quantities of littoral sand are not reaching the shelf proper at the present time. In addition, the rounded and polished character of shell fragments in beach sand, though present in shelf surficial sediments, is not characteristic. Difference in quartz-carbonate ratios between the beach and offshore surficial sediments is substantial. If sand does reach the shelf from onshore deposits, it is greatly diluted by carbonate material derived from other sources.

If the sediment were derived from outside the area, the most probable sources are the adjacent shelf areas to north and south. Characteristics of the shelf to the south of the Fort Pierce grid to north of Palm Beach are not well known, but south of Palm Beach, reliable information is available. Between Miami and Boca Raton (24°45'N to 26°20'N) the nearshore shelf contains white to gray calcareous sand alternating with rocky ridges and flats (Duane and Meisburger, 1969). Examination of representative samples from this shelf shows that the major constituents are _Halimeda_ segments and mollusk shells.

Halimeda and other common constituents such as _alcyonarian sclerites_ and large peneroplid foraminifers are missing in Fort Pierce grid samples.

Barnacle plates, one of the most common constituents of Fort Pierce grid cores, are uncommon in the Miami-Boca Raton shelf sediments. It is interesting to note that De Palma (1969) found large quantities of barnacles on test panels off Fort Lauderdale. Their scarcity in CERC sediment samples from the Palm Beach-Miami area may be a result of the inability of the barnacles to successfully compete with other organisms living on the natural substrata.

North of Boca Raton, the inner part of the shelf is covered by a blanket of homogeneous fine gray quartzose sand. The outer part of the shelf has not been sampled by cores, but is believed to contain material similar to shelf sediments south of Boca Raton.

Except for some similarity of Type D sediment at Fort Pierce grid to the well sorted gray sands between Palm Beach and Boca Raton, there is no evidence in sediment constituents of significant interchange between these regions. The similarity between Type D sand and the southern gray sands is largely in coloration and sorting. The chief dissimilarity is in the larger grain size of the material at Fort Pierce and the higher quartz content of the sand found south of Palm Beach. While the gray sand occurring off Palm Beach could be the product of southward transportation of Type D material (with concomitant downdrift reduction in size and carbonate content), it does not seem possible that the gray sands off Palm Beach could have been the source of Type D material.

Another possible source of sediment for Fort Pierce grid is on the shelf to the north. Cores from Cape Kennedy are now under study for a forthcoming ICONS report, but only preliminary analysis is available. These analyses show that sand similar to that found at Fort Pierce is present at Cape Kennedy; however, much dissimilar material is also present. On the whole, Cape Kennedy sediments are more quartzose than those at Fort Pierce and cores from the Fort Pierce-Cape Kennedy reconnaissance lines do not contain material which obviously indicates transfer of sediments within the depth range sampled (40 to 55 feet).

If material is being brought down presently from the Cape Kennedy shelf to Fort Pierce grid it must be transported outside the area covered by cores. It is significant that the shelf between Cape Kennedy and Fort Pierce is slightly deeper and generally free of the topograhic irregularities which would be expected if shoals were migrating southward from the Cape Kennedy area (Figure 5). Also if any large quantities of sand were moving, either in waves or by sheet flow, southward from Cape Kennedy, one would expect that infilling of the deeper embayed section of the shelf off Canaveral Bight by sandy sediment would occur before much material was transported further southward. Fine sediments (silt and clay) ponded in Canaveral Bight are evidence that sand is not now being bypassed through this area either from north or south.

Material may have been exchanged between the Cape Kennedy and Fort Pierce areas at a past time of lowered sea level, but firm evidence of continuity or direct relationship requires additional sediment samples and more detailed analysis of constituents. Poorly sorted sediments such as Type C could not have been transported as entities from one locale to the other since the transportation processes would have better sorted the material. The similarities between some sediments in the two areas can be attributed as well to common factors in the depositional environment and history as to actual interchange of material.

The foregoing discussion leads to a conclusion that most particles in the shelf sediments of Fort Pierce grid are locally produced and - at least at present - only relatively small quantities of sediments are entering the grid from adjacent shelf areas or from the littoral stream.

(3) Rate of Accumulation - If the surface of the stratum containing Type E material is indeed pre-Holocene, the overlying sediments represent accumulation during, and subsequent to, passage of the Holocene sea across the shelf platform. Since nearly all non-Type E sediments lie on the inner shelf, deposition in this zone would have commenced when relative sea level rose above -70 feet MLW. Assuming that this region has been structurally stable during the period in question, the onset of transgression across the inner shelf would have occurred at about 8,200 years Before Present according to data from Curray (1964) and about 7,200 years Before Present based on the sea level curves of Milliman and Emery (1968). Both curves indicate a rate of rise which would have brought the sea landward across most of the inner shelf (to -40 feet MLW where the slope changes from 1 on 1,300 to 1 on 80) about 1,000 years after the onset. Using an average sediment thickness above the blue reflector estimated from the isopach map of Figure 8 to be about 7 feet and a sedimentation time of about 7,000 years, the average rate of accumulation is only about 1 foot in 1,000 years.

It seems unlikely that sedimentation of the inner shelf has progressed at a steady rate during this period. Increasing depth over the shelf during the last transgression and ancillary variations of conditions affecting local shell production probably also affected accretion rates so that periods of relative increase or decrease in rate of accumulation are likely to have occurred continuously.

2. Sand Requirements

In a 1965 appraisal of Florida beach conditions (USCE, 1965), the Jacksonville District, Corps of Engineers, listed about 50 percent of the shoreline within the limits of this study as subject to severe erosion. The beach was found to be generally narrow and low, and dune heights rarely exceed +15 feet.

Beach Erosion Control studies have been completed for only two of the four counties in the study area: Brevard County (USCE, 1967) and Martin County (USCE, 1968). Sand requirements for beach mourishment summarized earlier (Duane, 1968) are in Table III. The total sand requirements for Martin County and that part of Brevard County south of Canaveral Harbor

TABLE III

FILL REQUIREMENTS FOR MARTIN COUNTY, AND BREVARD COUNTY SOUTH OF CANAVERAL HARBOR INLET

Martin County Area	Initial Fill*	Annual Nourishment	50-year Nourishment*
Jupiter Island	2.43	.15	7.5
Jensen Beach	.22	.024	1.2
Stuart Beach	.17	.024	1.2
Total	2.82	.198	9.9
Total initial and nourishment fill in 50 years			12.72
Brevard County (south of Canaveral Harbor Inlet)			
City of Cape Canaveral	.988	.240	12.00**
Patrick AFB	.70	.082	4.1
Indialantic and Melbourne Beaches	.603	.068	3.4
Total	2.291	.390	19.5
Total initial and nourishment fill in 50 years of which 12,000,000 would be furnished by sand transfer			21.79

* x10^6 Cubic yards
** To be furnished by sand transfèr plant at Canaveral Harbor

Inlet amounts to 34.5 million cubic yards for initial restoration and 50 years of nourishment. Of this total, about 12 million cubic yards may be furnished by sand bypassing at Canaveral Harbor (USCE, 1967); the remainder must come from borrow sources.

Figure 22 shows the median diameter of sand on the beaches and in the nearshore area. Figures 23 and 24 show typical beach material from the study area. In general, the data indicate that desirable borrow material for projects in the area should have a median diameter in the range 0.3 to 0.5 mm (1.74 to 1.0 phi) and contain the same size classes as the original beach material.

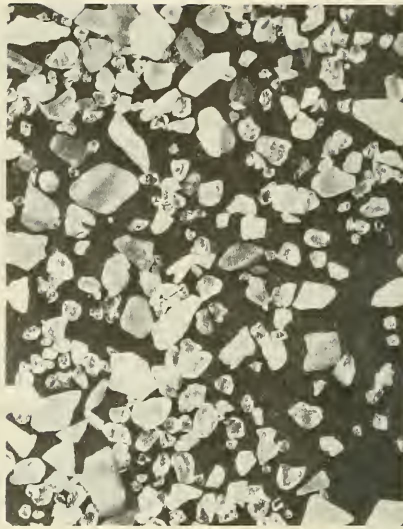
3. Suitability

Sand from beaches bordering the study area is not closely similar to any sediment found in the offshore surface or subsurface deposits (Appendix B). Type A sediment is the closest in character to the beach deposits, but significant differences between the two exist. Generally, the beach sands are better sorted and more quartzose than those found offshore in the study area. Quartz content of several midtide samples from the area is around 65 percent compared to 20 to 30 percent or less in offshore surficial sediments. Shell fragments which are important, but not dominant, constituents of the beach sediment are mostly finely broken, well rounded and polished. Beach drift shells collected near Fort Pierce Inlet contained many thick-walled pelecypods such as Arca zebra, Noetia ponderosa and Glycymeris. Such species are probably well represented in the shell fraction of beach sands since the thick walls provide sizeable grains resistant to fine fragmentation. Thin walled shells readily break down into fine fragments under the vigorous regimen of the littoral environment.

Because the offshore potential borrow sands contain significantly more shell material than the adjacent beaches, it is important to know if this material is likely to break up into fine fragments under wave attack on the beach face. For Type A sediment - and this is the only well-suited fill material - the probability is that most of the shell fraction will withstand wave attack on the beach as well as do the shell fragments in the existing beach material. The major shell constituent of Type A sediment is the barnacle plate which appears to be resistant to mechanical degradation, especially in comparison to algal material such as Halimeda found in abundance in the Miami area.

Species of Arca, and large speciments of Crepidula should also provide suitable sand fragments, while more friable materials such as the shells of Anomia simplex, may be soon lost from the sand fraction. It is estimated that on the whole, Type A sediment should not initially lose more than a small fraction of its sand-size material due to abrasion, and that the remaining material will not degrade at a greater rate than the existing beach sand.

Beach Sample 012-36



Beach Sample 012-78

Beach Sample 012-71

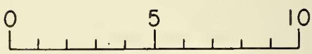


Figure 23. Sediment Characteristic of Beaches from the Study Area. Locations are shown on Figure 25.

Beach Sample 012-64

Beach Sample 012-62

Beach Sample 012-60

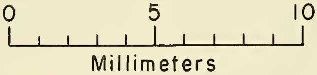


Figure 24. Sediment Characteristics of Beaches from the Study Area. Locations are shown on Figure 25.

The size of quartz particles in beach sands and those found in selected offshore sediments are within the same size range (Appendix B). In fact, the quartz fraction (insoluble residue) alone of Type A sediments on Bethel Shoal has a median (and mean) diameter equal to or coarser than the beach sands.

4. Potential Borrow Areas

Three of the 12 shoal areas within the Fort Pierce grid are judged to contain the best material for restoration and nourishment of beaches (Figure 25). Two of these: Capron Shoal and the middle section of Indian River Shoal lie close inshore; the third, Bethel Shoal, is located well offshore. Bottom topography, isopach maps and selected profiles for each of these three sites are presented in Figures 26 through 35.

Bethel Shoal contains an estimated volume of 175 x 10^6 cubic yards of unconsolidated material above the blue horizon (Figure 26). Good Type A material was obtained in cores 69 and 71 on the upper part of the shoal to a minimum depth of 10 feet. The lateral extent and total depth of this better material is not accurately known because of limited core data. Estimates based on an assumption that the base of the better material is either at the first or second continuous subbottom reflector within the shoal proper (reflectors x and z, Figure 27) give volumes of 16.5 x 10^6 cubic yards and 55.2 x 10^6 cubic yards respectively (Figures 28 and 29). On the basis of existing data, it seems most probable that the volume above the first reflector is the best estimate and that below this reflector the material is considerably finer in texture.

Capron Shoal, centered about 4 1/2 miles southwest of Fort Pierce Inlet and 3 miles offshore, contains an estimated volume of 112 x 10^6 cubic yards of sediment above the blue reflector (Figures 30 and 31). Cores 32 and 53, taken near the crest of Capron Shoal, contain about 7 feet of Type A sediment. Underlying the Type A layer is a Type D strata of poorer quality. The base of usable material is believed to correlate with a reflector in the shoal proper (first subbottom reflector) in Figure 31. Volume above this reflector is 65.4 x 10^6 cubic yards (Figure 32).

Core 38 in the middle section of Indian River Shoal contains suitable material to the bottom of the core (10 feet long) (Figure 33). It is believed that the material rests directly on the blue reflector (Figure 34). Assuming that it does extend to the blue reflector, the volume of usable sand in middle Indian River Shoal is 10.3 x 10^6 cubic yards (Figure 35). Elsewhere, Indian River Shoal may contain comparable material; cores 41 and 43 on the shoal section south of the middle contain fair material (Type A).

In addition to the three possible borrow sites above, other shoal areas in the Fort Pierce grid, all containing Type A sediment, may be

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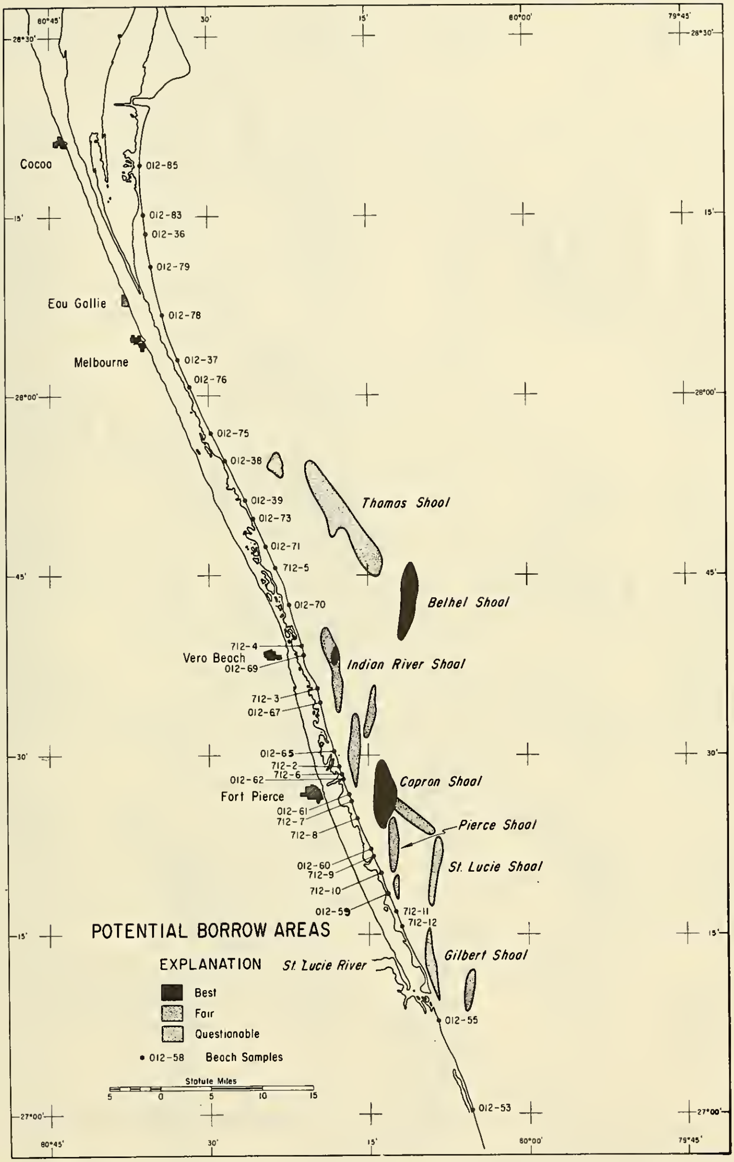

Figure 25. Map of Potential Borrow Sites in Study Area. Note locations of beach samples illustrated in Figures 23 and 24.

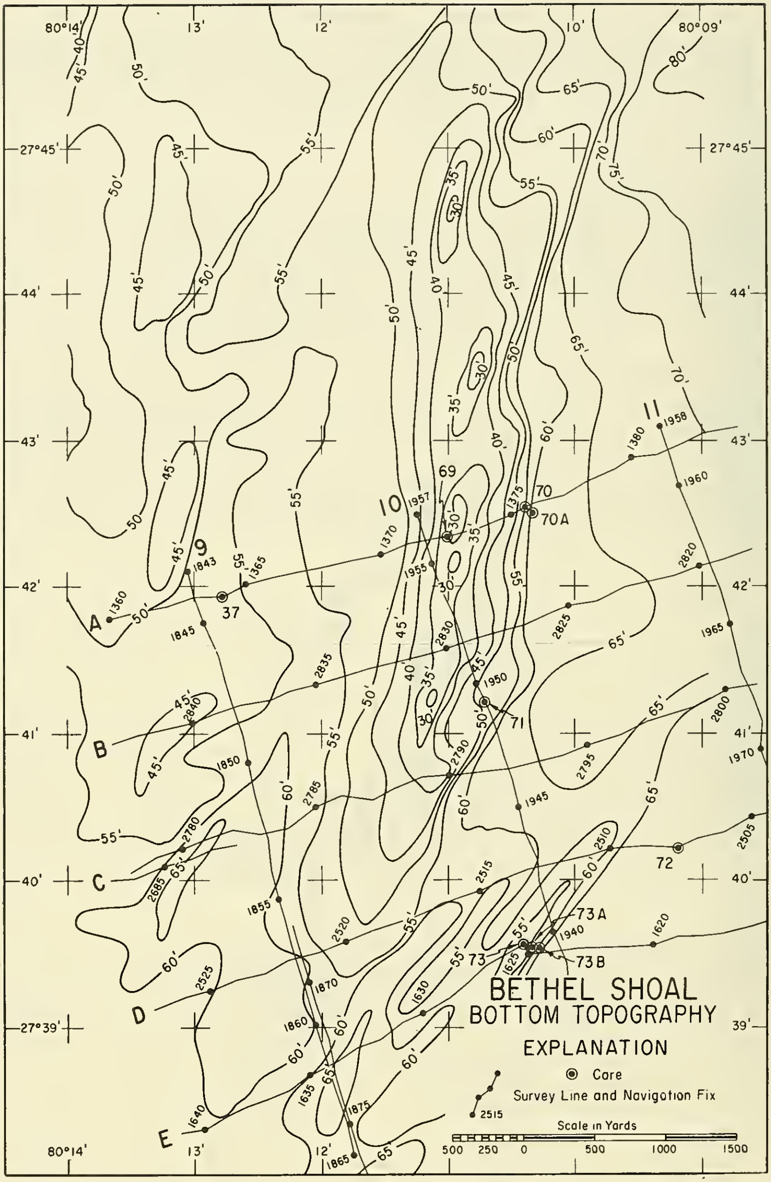

Figure 26. Bethel Shoal is Judged to Contain Sediment Suitable for Beach Nourishment.

Figure 27. Line Profiles Showing Acoustic Reflectors in the Bethel Shoal Area. See Figure 26 for location of tracklines. Granulometric data for sediments in cores are in Appendix B.

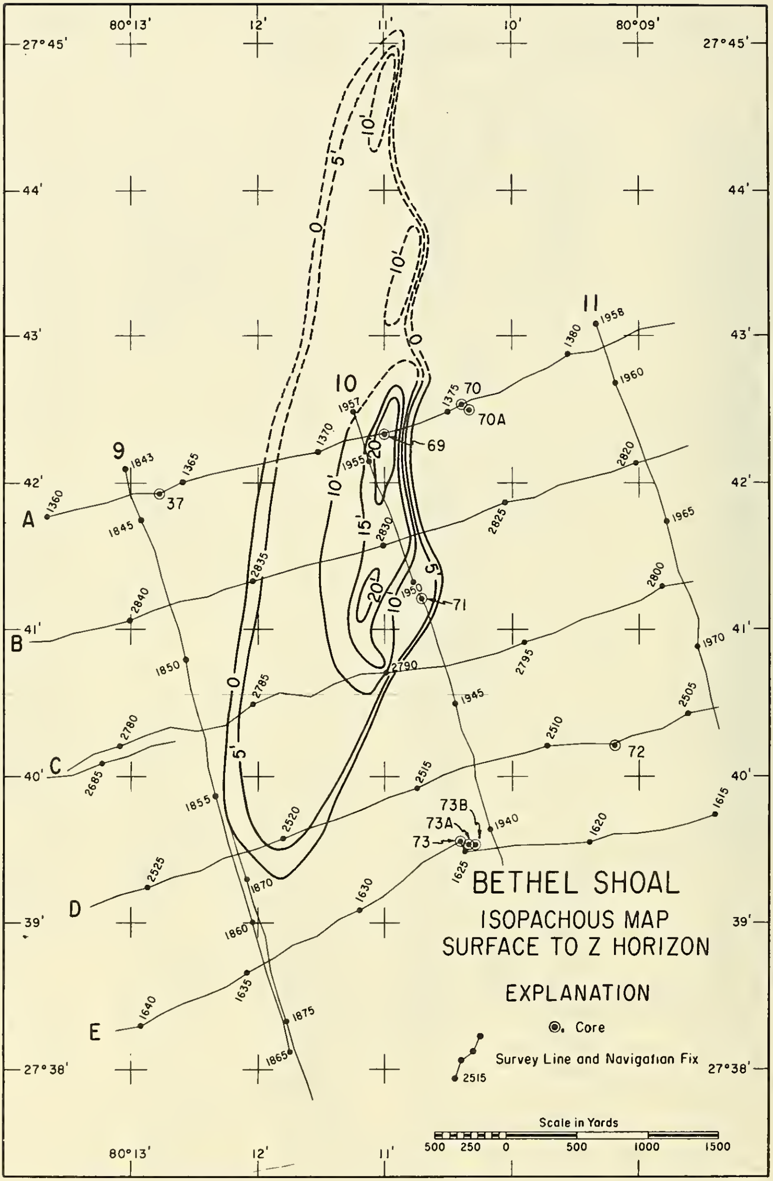

Figure 28. Isopachous Map of Sediment Thickness between the Water-Sediment Interface and the "Z" Horizon Underlying Bethel Shoal.

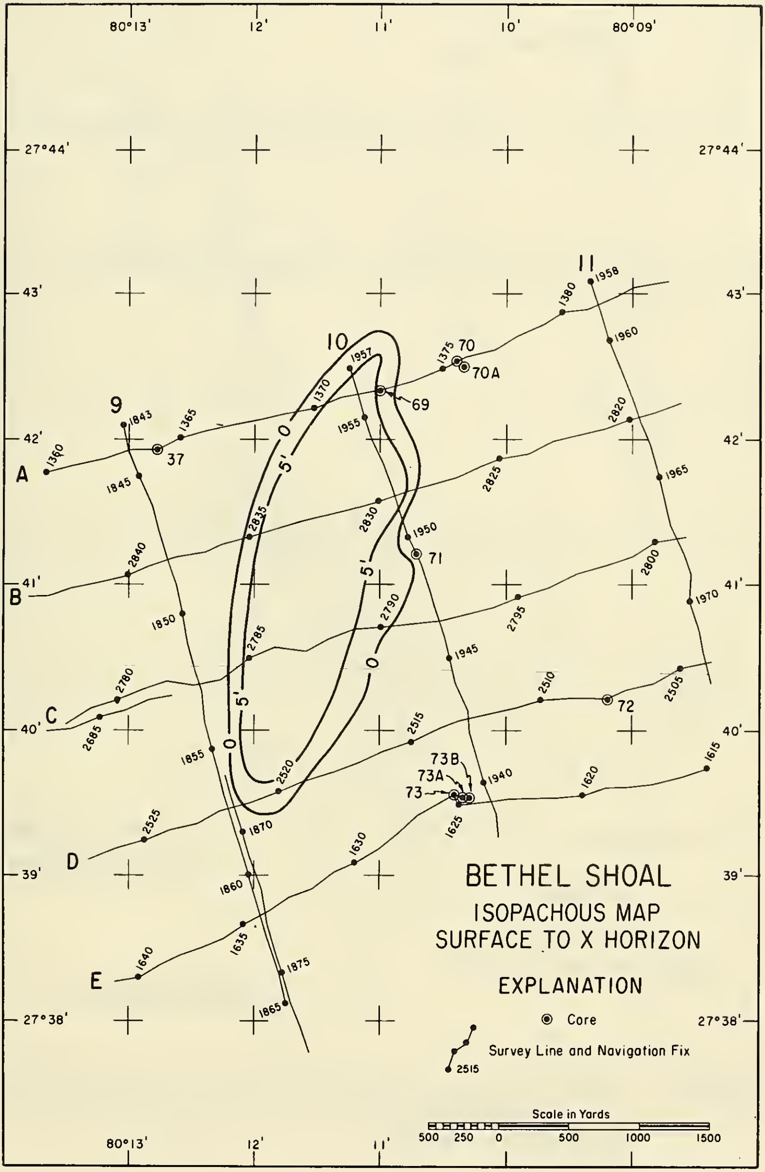

Figure 29. Isopachous Map of Sediment Thickness between the Water-Sediment Interface and the "X" Horizon Underlying Bethel Shoal.

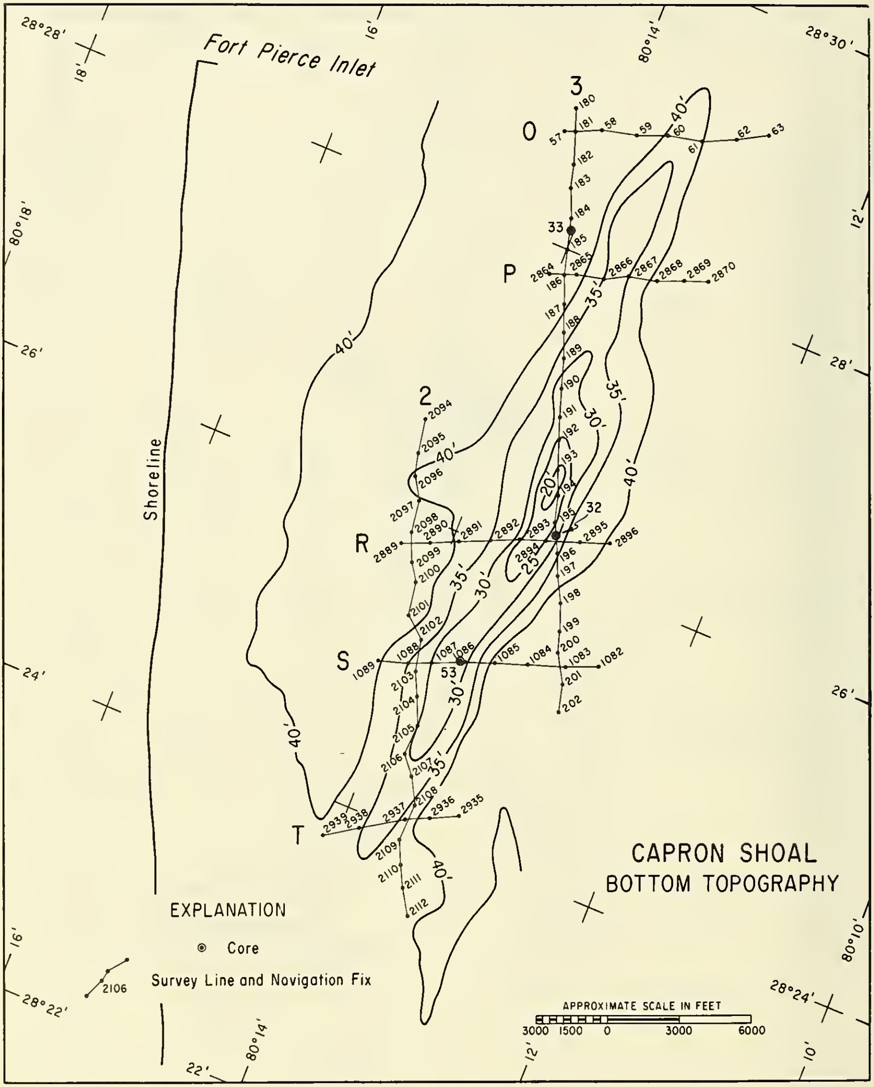

Figure 30. Bottom Topography and Survey Control in the Capron Shoal Area. Capron Shoal contains sand considered suitable for beach nourishment.

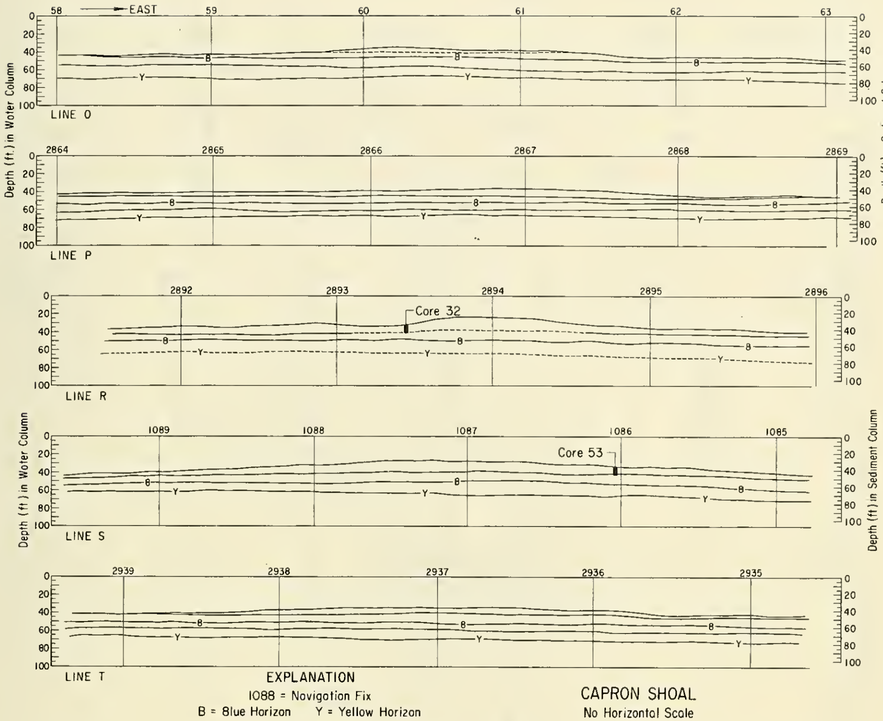

Figure 31. Line Profiles showing Horizons in the Capron Shoal Area.

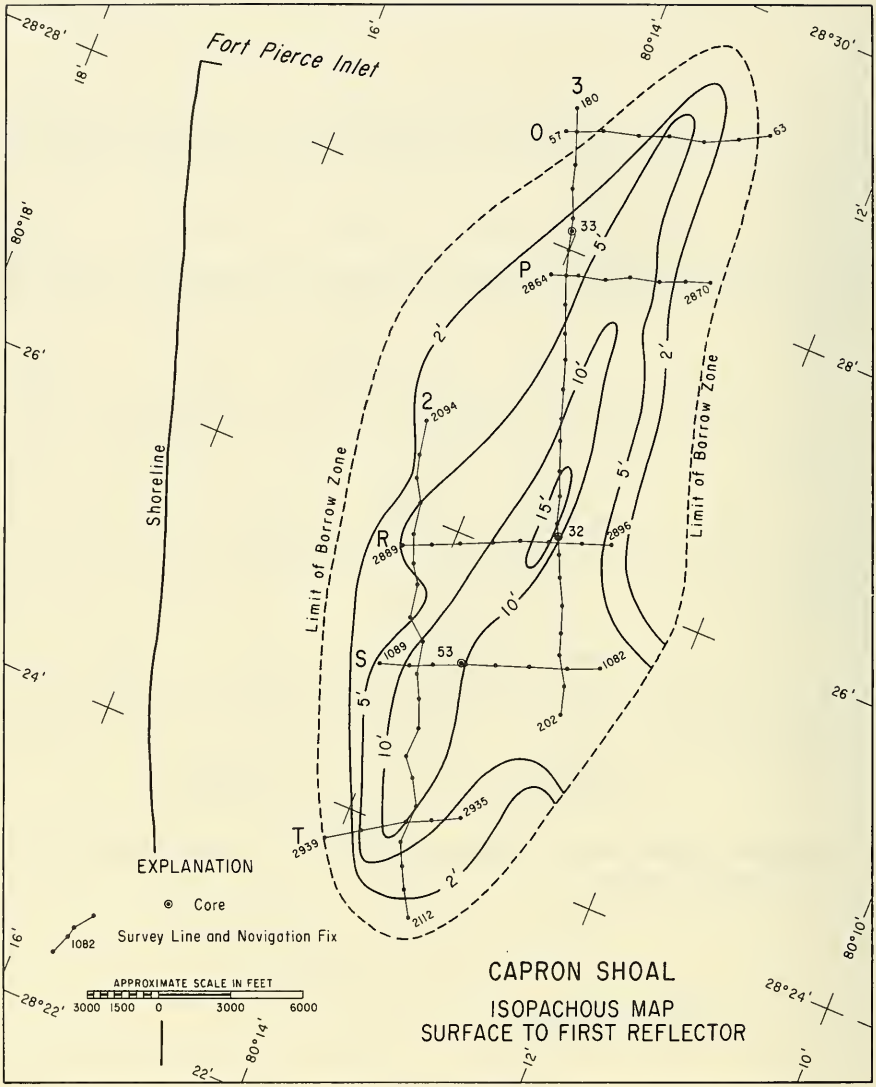

Figure 32. Isopachous Map of Sediment Thickness between the Water-Sediment Interface and the First Underlying Acoustic Reflecting Surface in the Capron Shoal Area.

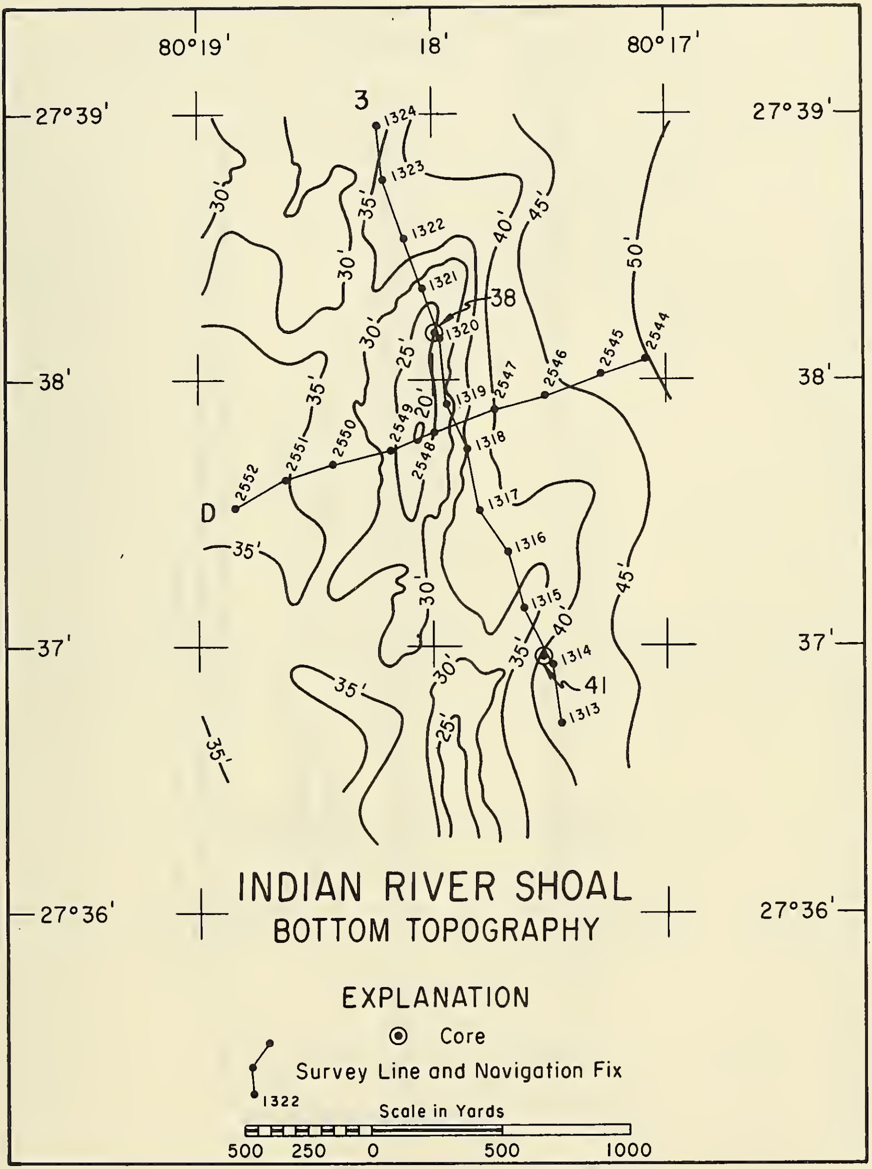

Figure 33. Bottom Topography and Survey Control in the Central Part of the Indian River Shoal Area. This part of the Shoal contains sand suitable for beach nourishment.

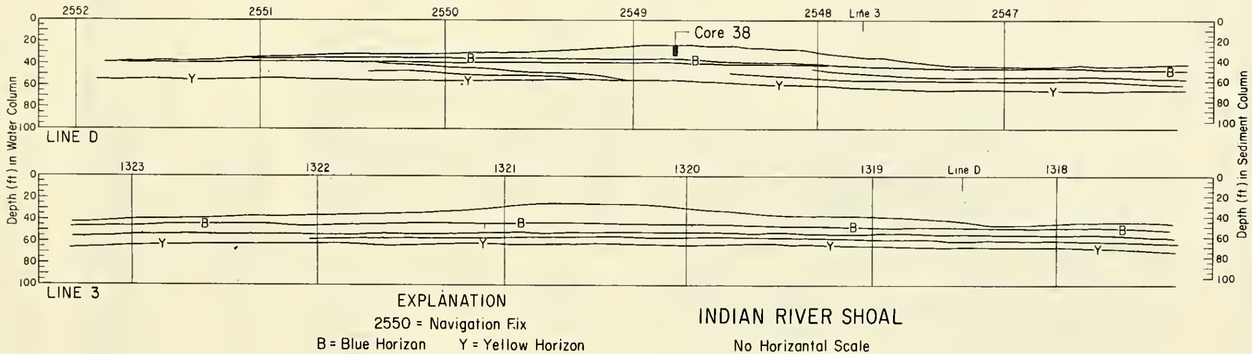

Figure 34. Line Profiles Showing Horizons under the Control Part of Indian River Shoal. See Figure 33 for location of tracklines and Appendix B for granulometric analyses of sediment.

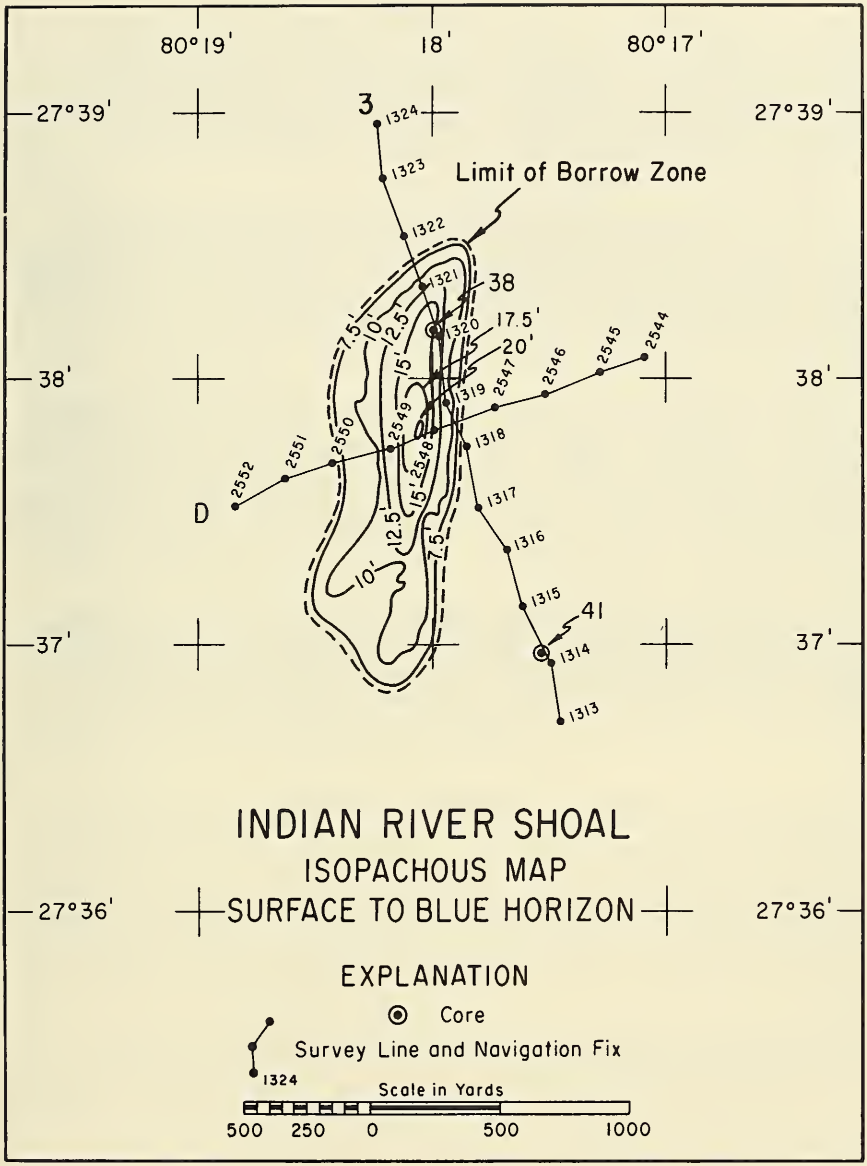

Figure 35. Sediment Thickness between Water-Sediment Interface and Blue Horizon in Central Part of Shoal.

potential sources for sand fill (Figure 25). Core 50 in the long northwesterly trending shoal between St. Lucie and Capron Shoal contains excellent material in the upper 4 feet. Cores 67, 68, and 83 from a nameless shoal 6 miles northeast of Fort Pierce Inlet recovered Type A sand to a depth of about 6 feet. Core 87 in another nameless shoal extending northeastward from Fort Pierce Inlet contained 5 feet of suitable material.

Except for Thomas Shoal, there are no large shoals between Fort Pierce grid and Canaveral Bight. Since the reconnaissance lines covering this area are all close inshore, no data is available on Thomas Shoal. Cores from the Fort Pierce-Cape Kennedy reconnaissance lines are for the most part devoid of material suitable for beach fill. Only core 181 south of Sebastian Inlet contains material of possible value - a 2-foot layer of coarse quartzose sand overlain by about a foot of silty sand.

South of Fort Pierce grid only two cores were obtained between the grid and Palm Beach. One of these - core 55 - located near the landward base of Pierce Shoal contains about 8 feet of good Type A material. Data elsewhere on Pierce Shoal and on three other large shoals of the Fort Pierce-Palm Beach reconnaissance areas - St. Lucie and Gilbert Shoals and an unnamed shoal 4 miles east of St. Lucie Inlet - is lacking. By analogy with the grid area these shoals are expected to be good prospects which warrant further investigation.

Although the shoal areas are the most favorable sites for borrow, suitable Type A sediment is widely distributed between shoals in the form of a thin blanket deposit. Effects of exploitation of offshore deposits for large volume supply is presently under investigation.

Section V. SUMMARY

Between Palm Beach (26°48'N) and Cape Kennedy (28°27'N) the south-eastern Florida Coast is bordered by a submerged plain extending to the top of the Florida-Hatteras slope. The top of the slope occurs at about -80 feet MLW and 2 miles offshore near Palm Beach, and at about -230 feet MLW, 38 miles offshore at its widest point south of Cape Kennedy.

Based on coastal well logs and seismic reflection records, strata underlying the submerged plain to -500 feet MLW are judged to range from Eocene to Holocene in age. These strata all dip generally eastward, but below a presumed unconformity ranging in depth from about -140 to -220 feet MLW, strata dip southeastward and the rate of dip is nearly doubled.

The surface of the Shelf plain is topographically divisible into a narrow sloping shoreface, inner and outer Shelf zones and the Shelf marginal zone. The Shelf margin and outer Shelf have irregular surface topography and many indications of "rocky" bottom. The inner shelf is mostly mantled by unconsolidated sediments forming many shoal ridges and hills interspersed with relatively flat areas. The shoreface consists mainly of a sloping sedimentary apron connecting the Shelf plain and the littoral zone.

Shallow subbottom strata beneath the Shelf surface appear on siesmic profiles as thinly bedded and generally parallel to one another. Internal bedding features are common and usually consist of high and low angle sea-ward dipping bedding planes. The uppermost continuous reflector dips from about -40 feet MLW under the shoreface to apparent outcrop around -65 feet. Cores penetrating to the reflector level indicate that it is composed of variable carbonate sediments with locally lithified layers. This unit is tentatively dated as pre-late Wisconsin.

Sediments above the upper continuous and regional reflector reach a maximum thickness of 30 feet under shoals, and thin to as little as 1 foot over flats and swales between shoals. In limited areas on the inner Shelf (i.e., -40 to -70 feet MLW) and in most places on the outer Shelf (-70 feet MLW to Shelf edge), there is no sediment cover over the continuous reflector. The sediment mantle of the inner Shelf consists primarily of sand, silty sand, and shell gravel. Main constituents of this sand are calcium carbonate skeletal fragments; ooids and quartz are the most important secondary constituents.

Sediment on beaches adjacent to the study area consists of quartzose sand and shell fragments, the latter generally broken, well-rounded and polished. Median size of midtide samples generally lies in the 0.3 to 0.5 mm (1.74 to 1 phi) range.

Surficial sediments in the Fort Pierce grid area between the 40 and 60-foot water depth contours consist primarily of coarse, brown shell sand forming an irregular blanket deposit varying in thickness from

1 foot to at least 10 feet, and possibly as much as 30 feet. Thickness of the deposit is closely related to topography, being at a maximum under topographic highs. Most of the sand in the surficial layer, Type A, is usable for beach fill on adjacent beaches, but the characteristics vary considerably. The best material can be obtained only by selective borrow.

Sand suitable for beach restoration exists on Bethel Shoal (minimum volume 16.5 x 10 cubic yards); Capron Shoal (minimum volume 65.4 x 10^6 cubic yards) and the middle section of Indian River Shoal (minimum volume 10.3 x 10 cubic yards). Good material is indicated in a northwesterly trending shoal between Capron and St. Lucie Shoals, in an unnamed shoal lying 6 miles northeast of Fort Pierce Inlet, and in an unnamed shoal extending northeast from Fort Pierce Inlet. By analogy, Pierce Shoal, St. Lucie Shoal and Gilbert Shoal are considered good prospects for beach fill even though direct evidence is lacking.

Some shelf material seaward of 70-foot water depth may be suitable for borrow. However, careful survey of potential borrow sites is needed because of the large number of indurated strata in these deeper water deposits and the variable extent and thickness of unconsolidated strata.

Shelf sediments in the grid area are judged to be largely relict, and little active sedimentation now takes place outside the shoreface, i.e., beyond -40 feet MLW. Rate and volume of sediment generated by the benthic fauna is not known. Sand removed from the shelf is not likely to be replaced quickly nor by sand-sized material from sources outside the grid.

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APPENDIX A

SELECTED GEOPHYSICAL PROFILES

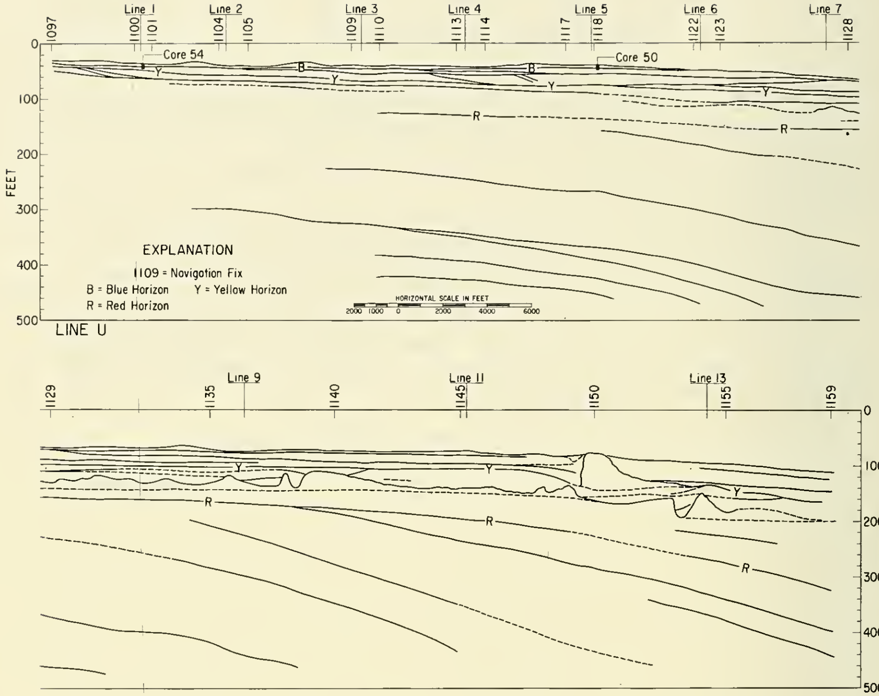
Appendix A contains line profile drawings of selected seismic reflection records from the Fort Pierce grid area.

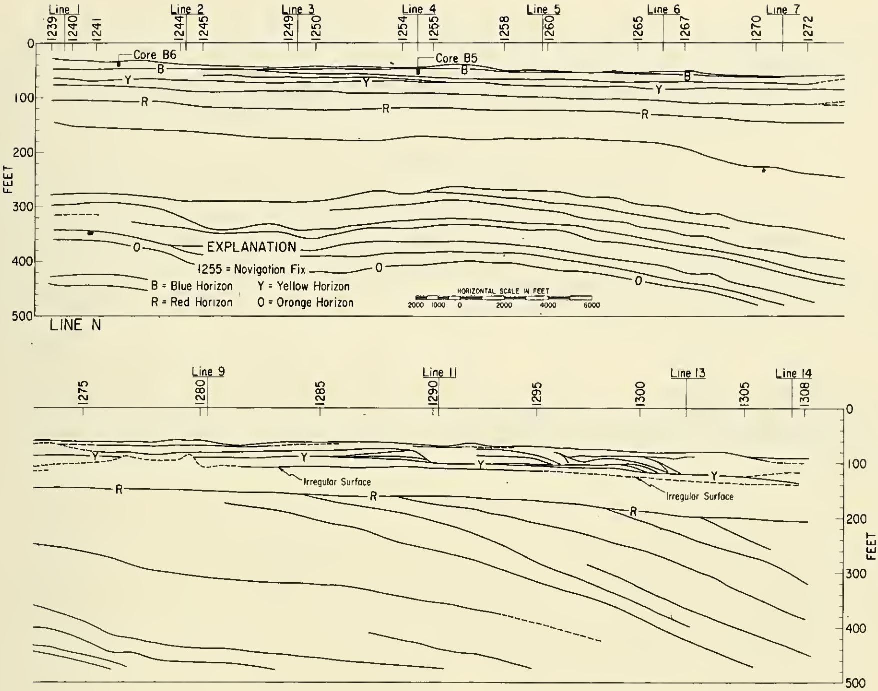
Fix numbers and point of crossing lines are plotted along the upper margin of the profile.

The bottom and all subbottom reflectors are delineated and those reflectors mentioned in the text are identified by letter symbols.

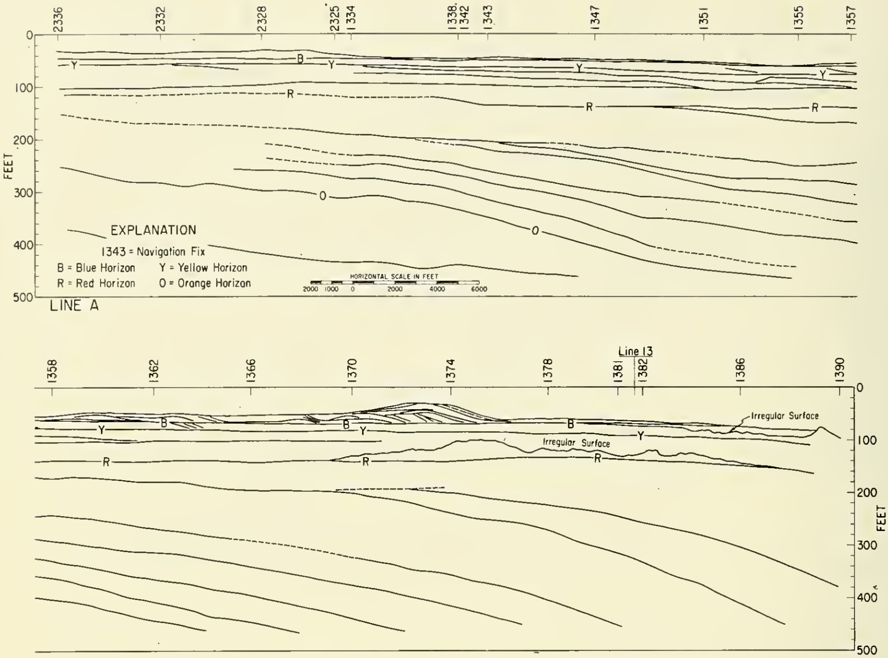
All depths are in feet below mean sea level; and based on an assumed sound velocity of 4,800 feet per second in water and 5,440 feet per second in the subbottom.

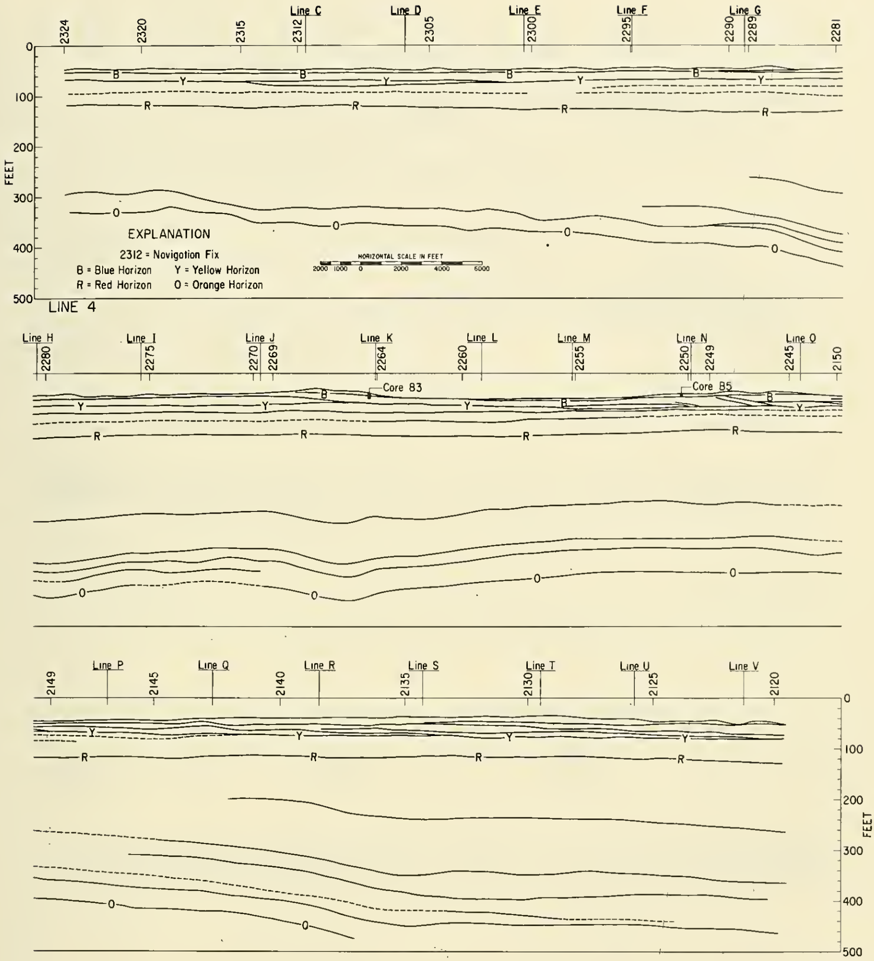
Position of lines and fixes are plotted on Figure 2.


Line 1
Line 2
Line 3
Line 4
Line 5
Line 6
Line 7
1097
1100
1101
1104
1105
1109
1110
1113
1114
1117
1118
1122
1123
1128
Core 54
Core 50
B
Y
R
FEET
0
100
200
300
400
500
EXPLANATION
1109 = Novigotion Fix
B = Blue Horizon
Y = Yellow Horizon
R = Red Horizon
HORIZONTAL SCALE IN FEET
2000 1000 0 2000 4000 6000
LINE U
Line 9
Line 11
Line 13
1129
1135
1140
1145
1150
1155
1159

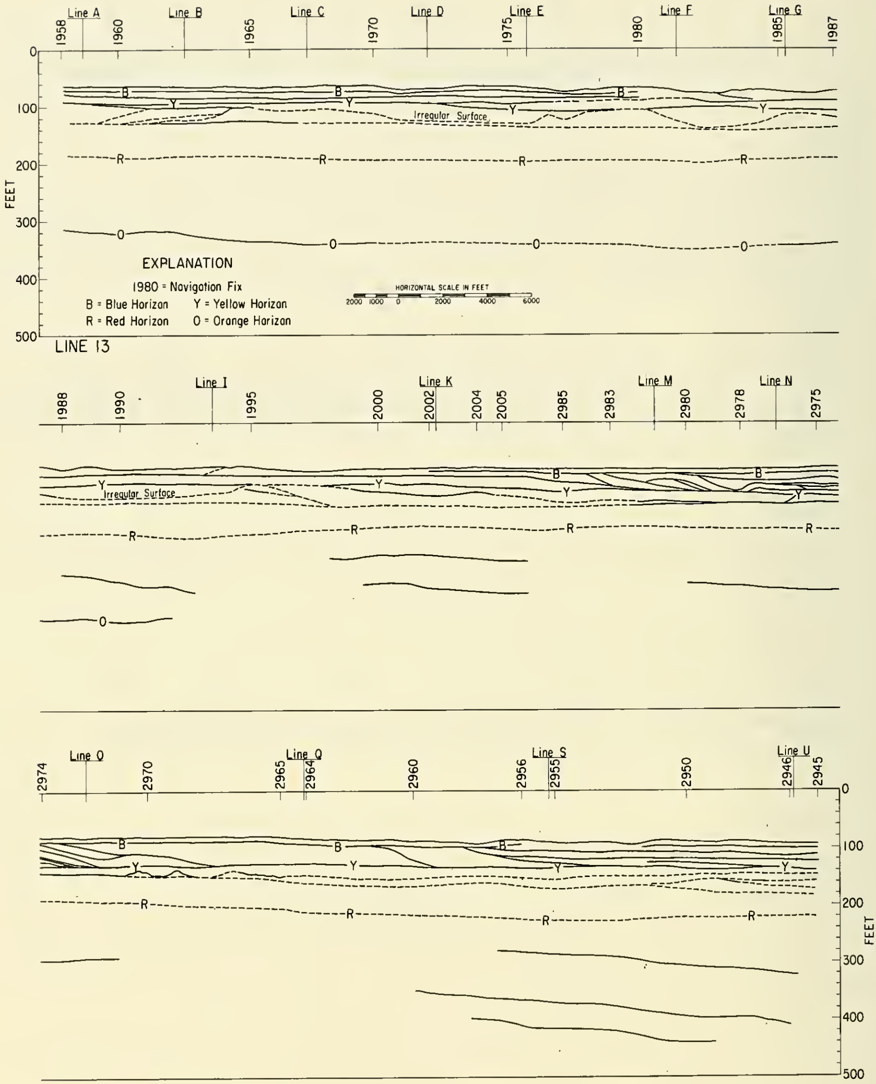


Line 1
Line 2
Line 3
Line 4
Line 5
Line 6
Line 7
1239
1240
1241
1244
1245
1249
1250
1254
1255
1258
1260
1265
1267
1270
1272
Core B6
Core B5
B
Y
R
O
FEET
0
100
200
300
400
500
EXPLANATION
1255 = Novigotion Fix
B = Blue Horizon
Y = Yellow Horizon
R = Red Horizon
O = Oronge Horizon
HORIZONTAL SCALE IN FEET
2000 1000 0 2000 4000 6000
LINE N
Line 9
Line 11
Line 13
Line 14
1275
1280
1285
1290
1295
1300
1305
1308
Irregular Surface
Irregular Surface


2336
2332
2328
2325
1334
1338
1342
1343
1347
1351
1355
1357
0
100
200
300
400
500
FEET
B
Y
R
O
EXPLANATION
1343 = Navigation Fix
B = Blue Horizon
Y = Yellow Horizon
R = Red Horizon
O = Orange Horizon
HORIZONTAL SCALE IN FEET
2000 1000 0 2000 4000 6000
LINE A
Line 13
1358
1362
1366
1370
1374
1378
1381
1382
1386
1390
Irregular Surface
Irregular Surface



Line C
Line D
Line E
Line F
Line G
2324
2320
2315
2312
2305
2300
2295
2290
2289
2281
FEET
0
100
200
300
400
500
B
Y
R
O
EXPLANATION
2312 = Navigation Fix
B = Blue Horizon
Y = Yellow Horizon
R = Red Horizon
O = Orange Horizon
HORIZONTAL SCALE IN FEET
2000
1000
0
2000
4000
6000
LINE 4
Line H
Line I
Line J
Line K
Line L
Line M
Line N
Line O
2280
2275
2270
2269
2264
2260
2255
2250
2249
2245
2150
Core 83
Core B5
Line P
Line Q
Line R
Line S
Line T
Line U
Line V
2149
2145
2140
2135
2130
2125
2120



Line A
Line B
Line C
Line D
Line E
Line F
Line G
1958
1960
1965
1970
1975
1980
1985
1987
FEET
Irregular Surface
EXPLANATION
1980 = Navigation Fix
B = Blue Horizon
Y = Yellow Horizon
R = Red Horizon
O = Orange Horizon
HORIZONTAL SCALE IN FEET
2000 1000 0 2000 4000 6000
LINE 13
Line I
Line K
Line M
Line N
1988
1990
1995
2000
2002
2004
2005
2985
2983
2980
2978
2975
Line O
Line Q
Line S
Line U
2974
2970
2965
2964
2960
2956
2955
2950
2946
2945

APPENDIX B

GRANULOMETRIC DATA

Appendix B contains the results of size and acid solubility analysis of selected samples from the study area.

Beach samples (Tables B-2, B-4) are identified by the CERC identity number and are plotted on Figure 25.

Offshore samples are identified by core number, CERC identity number, and sample interval within the core. These samples are plotted by core number on Figure 2.

TABLE B-1

GRANULOMETRIC DATA FOR SELECTED OFFSHORE SAMPLES (Total Sample)

Core No.	CERC ID No.	Interval (ft)	Type	Median (ϕ)	Median (mm)	Mean (ϕ)	Mean (mm)	Standard Deviation (ϕ)	Standard Deviation (mm)	Percent Acid Soluble
32	35	1	A	.65	.637	.79	.577	.64	1.558	83
32	35	5	B	1.09	.469	1.18	.442	.79	1.728	
38	42	1	A	1.06	.481	1.05	.482	.50	.482	
38	42	6	A	1.03	.489	1.07	.477	.61	1.525	
40	44	3	C	0.25	.840	0.48	.716	.68	.624	
41	45	7	B	.87	.548	.78	.508	.78	1.718	
42	46	4	C	1.47	.360	1.43	.371	.87	.547	95
42	46	8	E	1.43	.371	1.64	.320	.55	.683	
44	48	5	E	2.42	.187	1.90	.268	1.56	2.942	
53	58	1	A	.90	.536	.99	.504	.52	1.434	
53	58	6	A	1.01	.498	1.06	.481	.58	1.493	
67A	74	4	A	1.19	.437	1.24	.422	.60	1.514	
67A	74	6	B	1.07	.477	1.19	.437	.69	1.610	
69	76	0	A	1.15	.450	1.30	.407	.55	1.461	
69	76	9	A	.55	.681	.72	.606	.52	1.435	
71	79	1	A	.96	.514	1.05	.482	.48	.716	
71	79	8	A	.90	.535	1.06	.479	.51	.702	
76	86	0	A	.00	.999	.15	.904	.60	1.518	
77	87	5	D	1.46	.363	1.61	.328	.63	1.545	
78	88	1	C	1.44	.369	1.57	.338	.84	1.796	
79	89	8	D	.68	.624	.77	.588	.86	1.813	
87	97	0	A	.50	.709	.65	.639	.70	1.622	
90	100	9	E	1.21	.432	1.47	.360	1.11	2.166	

TABLE B-2

GRANULOMETRIC DATA FOR SELECTED BEACH SAMPLES (Total Sample)

CERC Sample No.	Median (ϕ)	Median (mm)	Mean (ϕ)	Mean (mm)	Standard Deviation (ϕ)	Standard Deviation (mm)	Percent Acid Soluble
012-53	1.44	.369	1.51	.352	.41	1.33	32
012-55	2.19	.219	2.10	.233	.73	1.66	-
712-12	.96	.513	1.05	.482	.43	1.347	55
712-11	.68	.625	.80	.575	.48	1.395	-
012-58	.93	.526	.96	.514	.50	1.416	48
712-10	1.05	.483	1.20	.435	.49	1.408	44
712-09	1.63	.324	1.63	.323	.54	1.458	-
012-60	1.06	.480	1.15	.451	.52	1.429	41
712-8	1.08	.473	1.22	.430	.48	1.393	36
712-7	1.63	.322	1.65	.318	.55	1.467	35
012-61	1.15	.451	1.17	.446	.54	1.456	40
012-62	1.37	.386	1.36	.391	.69	1.614	32
712-6	1.15	.449	1.21	.432	.47	1.388	40
712-2	1.42	.373	1.52	.349	.57	1.482	30
012-65	.91	.534	1.02	.494	.69	1.617	45
012-67	1.34	.395	1.36	.389	.52	1.438	31
712-3	.95	.518	1.03	.490	.44	1.358	-
012-69	1.07	.475	1.13	.456	.44	1.354	34
712-4	1.26	.417	1.33	.398	.49	1.406	33
012-70	.85	.556	.90	.537	.38	1.304	34
712-5	.85	.554	.96	.513	.45	1.370	39
012-71	.59	.655	.74	.600	.53	1.445	42
012-73	.21	.863	.33	.795	.55	1.466	53
012-39	.56	.679	.69	.620	.48	1.392	42
012-38	1.01	.495	1.10	.465	.44	1.357	26
012-75	.63	.648	.73	.604	.62	1.540	46
012-76	.25	.839	.32	.803	.62	1.540	58
012-37	1.49	.356	1.52	.348	.35	1.277	22
012-78	.58	.670	.67	.628	.49	1.407	36
012-79	1.35	.393	1.40	.375	.32	1.245	12
012-36	1.94	.261	1.94	.260	.43	1.350	15
012-83	2.44	.185	2.41	.188	.33	1.255	12
012-85	2.47	.180	2.45	.183	.32	1.244	7

TABLE B-3

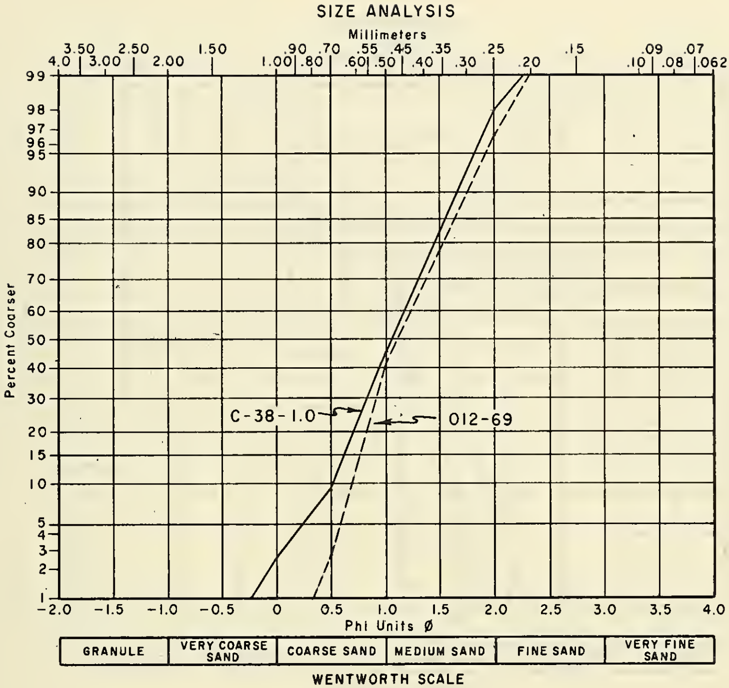
GRANULOMETRIC DATA FOR SELECTED OFFSHORE SAMPLES (Insoluble Fraction)

CORE No.	CERC ID No.	Interval (ft.)	Type	Median (ϕ)	Median (mm)	Mean (ϕ)	Mean (mm)	Standard Deviation (ϕ)	Standard Deviation (mm)	Percent Acid Soluble
32	35	0	A	1.53	.346	1.57	.337	.69	1.610	83
38	41	0	A	1.40	.363	1.50	.353	.30	1.229	70
41	45	0	A	1.67	.320	1.70	.308	.29	1.227	67
51	56	0	A	2.33	.198	2.35	.197	.48	1.391	54
53	58	0	A	1.35	.393	1.51	.352	.50	1.412	80
67A	74	0	A	1.62	.325	1.63	.322	.33	1.261	69
69	76	0	A	1.15	.450	1.30	.407	.55	1.461	86
69	76	5	A	1.28	.411	1.44	.368	.54	1.456	86
70	77	0	A	1.93	.262	2.06	.240	.44	1.360	79
70	77	4	B	1.85	.277	2.11	.232	.81	1.757	85

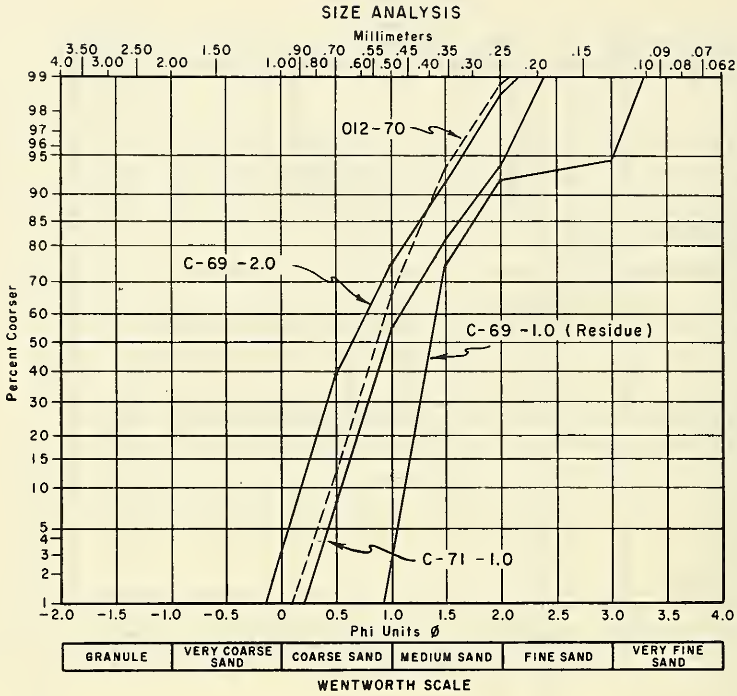
TABLE B-4

GRANULOMETRIC DATA FOR SELECTED BEACH SAMPLES (Insoluble Fraction)

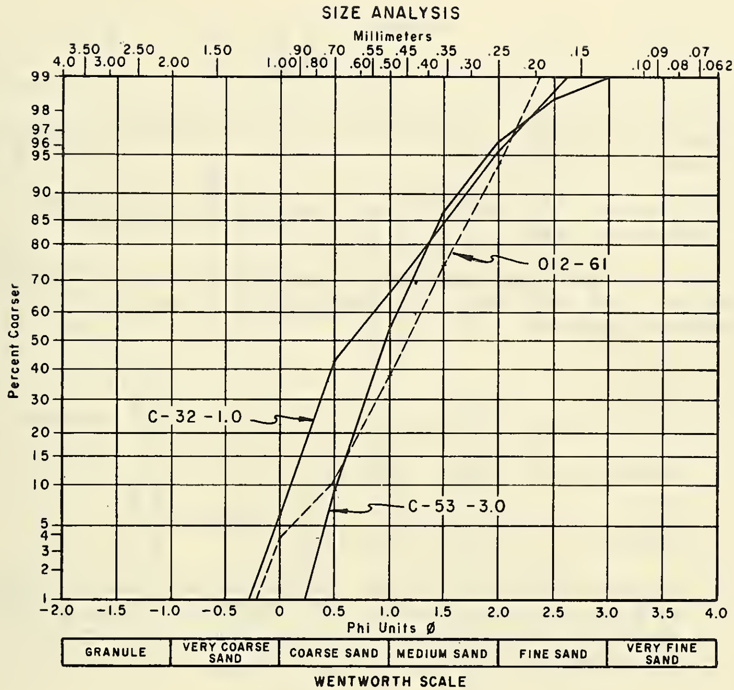
CERC Sample No.	Median (ϕ)	Median (mm)	Mean (ϕ)	Mean (mm)	Standard Deviation (ϕ)	Standard Deviation (mm)	Percent Acid Soluble
712-2	1.72	.303	1.75	.297	1.56	1.477	30
712-4	1.38	.384	1.46	.363	.47	1.387	33
712-5	1.05	.483	1.14	.454	.43	1.344	39
712-6	1.28	.411	1.35	.391	.49	1.407	40
712-7	1.72	.304	1.74	.299	.57	1.480	35
712-8	1.26	.416	1.37	.387	.42	1.340	36
712-10	1.42	.374	1.50	.353	.40	1.324	44
712-12	1.25	.420	1.33	.398	.44	1.360	55



Graphic size distribution curves for a typical sample from Indian River Shoal and a nearby beach area (dashed line). Location of samples is shown on Figure 2 and 25.



Graphic size distribution curves for typical samples from Bethel Shoal and from a beach in the northern part of Fort Pierce Grid area (dashed line). Size distribution of the acid insoluble residue (mostly quartz) for one of the shoal samples is also included. Location of samples is shown on Figures 2 and 25



Graphic size distribution curves for typical samples from Capron Shoal and a nearby beach (dashed line). Location of samples is shown on Figures 2 and 25.

APPENDIX C

SEDIMENT DESCRIPTIONS

Appendix C contains visual description of sediments contained in cores from the study area.

Core number, CERC identification number, and sample depth in core are listed to the left.

Visual descriptions are based on both megascopic and microscopic examination. The descriptive statement generally contains (in order) the following elements:

1. Color

2. Color code per Munsell Soil Color Charts (1954 edition)*

3. Dominant size or size range.

4. Major compositional element or elements with the dominant constituent listed first.

5. Phrases identifying readily recognized constituent elements with an estimated frequency of occurrence in terms of total particles. The frequency terms indicate the following percentages:

    a. Profuse, 30-50% of total particles

    b. Common, 10-30% of total particles

    c. Sparse, 2-10% of total particles

    d. Trace, less than 2% of total particles.

The cores are plotted on Figures 2 and 3.

* Munsell Soil Color Charts, 1954 Edition, Munsell Color Co., Inc., Baltimore, Maryland

Core No.	CERC ID No.	Interval (ft.)	Description
32	35	0-4	Light brownish gray (10 yr 6/2), coarse calcareous sand; barnacle plates, mollusk shell common; quartz sparse; trace echinoids, foraminifers. (A)
		4-7	Gray (10 yr 6/1), coarse calcareous sand; barnacle plates, mollusk shell common; quartz, ooliths sparse, trace echinoids, foraminifers. (B)
		7-10 btm	Gray (N6), silty calcareous shell sand and gravel; trace fine quartz sand. (C)
33	36	0-1	Light brown (7.5 yr 6/4) coarse calcareous sand; barnacle plates, mollusk shell, large rounded quartz grains common; trace foraminifers. (A)
		1-2	Gray (10 yr 6/1) slightly plastic, silty fine calcareous sand; quartz grains, barnacle plates sparse. (B)
		2-4	Gray (10 yr 6/1) medium calcareous sand; blue-gray to black ooliths, quartz grains common, mollusk shell, barnacle plates sparse. (B)
		4-8	Gray (10 yr 5/1) silty, sandy shell gravel, mollusk shell common. (C)
		8-9	Brown peat
		9-10 btm	White (10 yr 8/2) sandy calcareous silt, trace quartz.(E)
34	37	0	White (10 yr 8/2), plastic silty sand; quartz sparse.(U)
		1-2	Light gray (10 yr 7/2), very coarse calcareous sand; quartz grains, barnacle plates common (A)

Core No.	CERC ID No.	Interval (ft.)	Description
34	37	2-4	White (10 yr 8/2) calcareous shell gravel with fine grained calcarenite pebbles. (E)
		4-5	White (10 yr 8/2) slightly silty very fine calcareous sand with large calcarenite pebbles (E)
		5-8	White (10 yr 8/2) slightly silty coarse calcareous sand with calcarenite and mollusk fragments (E)
		8-10.5 btm	Semiconsolidated calcarenite. (E)
35	38	0-8	Light brownish gray (10 yr 6/2) medium to coarse calcareous sand, barnacle plates common; echinoid fragments, foraminifers sparse (A)
		8-9.5	Light gray (10 yr 8/1) fine calcareous sand with pebbles of fine-grained calcarenite. (E)
36	39	0-1	Pale brown (10 yr 6/3) coarse to very coarse calcareous sand; worn calcarenite fragments common; mollusk shell, barnacle plates, large rounded quartz grains sparse. (A)
		1-2	Light gray (10 yr 7/1), sandy shell gravel, barnacle plates, mollusk shell common. (B)
		2-3	Gray (10 yr 6/1) medium calcareous sand; quartz grains, foraminifers, echinoids, barnacle plates mollusk shell, gray ooliths sparse (D)
		3-7 btm	Light gray (10 yr 7/1) fine calcareous sand, quartz grains common, mollusk shell, barnacle plates, echinoids sparse (D)

Core No.	CERC ID No.	Interval (ft.)	Description
37	41	0-10	Light brownish gray (10 yr 6/2) coarse to very coarse calcareous sand; quartz grains profuse; barnacle plates, mollusk shell, gray and brown ooliths common (A)
		10-11.5 btm	Gray (10 yr 5/1) coarse calcareous sand; barnacle plates, quartz grains common; mollusk shell, echinoids, gray ooliths sparse (B)
38	42	0-10.3 btm	Very pale brown (10 yr 7/3), very coarse calcareous sand; barnacle plates, quartz profuse, mollusk shell common; foraminifers sparse; becomes paler brown and with less quartz downhole (A).
39	43	0-2	Very pale brown (10 yr 7/3), coarse to very coarse calcareous sand; large well-rounded quartz grains profuse; barnacle plates, mollusk shell common (A).
		2-3	Gray (1/6), slightly silty fine to very fine coarse calcareous sand; barnacle plates, mollusk shell, quartz grains common (B).
		3-7	Gray (10 yr 6/1) silty fine to very coarse calcareous sand; quartz grains, barnacle plates, mollusk shell common (C)
		8-9.4 btm	White (10 yr 8/2) fine calcareous sandy shell gravel; mollusk shell common; echinoids, foraminifers sparse, trace gray ooliths (D)
40	44	0-3	Pale brown (10 yr 6/3) coarse to very coarse calcareous sand and shell gravel; barnacle plates, mollusk shell, large well-rounded quartz grains common (A)

Core No.	CERC ID No.	Interval (ft.)	Description
40	44	3-8	Gray (10 yr 6/1) slightly silty, very coarse calcareous sandy shell gravel; mollusk shell, barnacle plates common; quartz grains sparse (C).
		8 btm	Light gray (10 yr 7/1) well-sorted calcareous sand; foraminifers, echinoids, quartz grains, gray ooliths sparse (D)
41	45	0-7	Light gray (10 yr 7/2) coarse calcareous sand; quartz grains profuse; barnacle plates, mollusk shell common; foraminifers sparse (A)
		7-10	Gray (10 yr 6/1) coarse to very coarse calcareous sand; quartz grains, barnacle plates, mollusk shell common (B)
		10-10.6 btm	Light gray (10 yr 7/1) silty sandy calcareous shell gravel with fragments of fine-grained calcarenite (C)
42	46	0-2	Light brownish gray (10 yr 6/2) very coarse calcareous sand; mollusk shell, barnacle plates, quartz grains common (A)
		2-4	Light gray (10 yr 7/1) well sorted medium sand; foraminifers, mollusk shell, quartz grains sparse (C)
		4-8	Light gray (10 yr 7/2) very coarse calcareous sand; quartz grains, mollusk shell sparse (D)
		8-10.4 btm	White (10 yr 8/2) coarse calcareous sand and gravel; echinoids, foraminifers sparse; trace quartz, mollusk shell (E)

Core No.	CERC ID No.	Interval (ft.)	Description
43	47	0-1	Very pale brown (10 yr 7/4) coarse to very coarse sand; barnacle plates, quartz grains common; foraminifers, mollusk shell sparse (A)
		1-2	Very pale brown (10 yr 8/3) coarse calcareous sand and shell gravel; mollusk shell, barnacle plates common; quartz grains sparse, trace foraminifers (A)
		2-8	Light brownish gray (10 yr 6/2) well-sorted calcareous sand; quartz grains, foraminifers, echinoids sparse (B)
		9-10	Light gray (10 yr 7/1) cohesive sandy silt; quartz, mollusk shell common; sparse foraminifers (U2)
		10-11	Light gray (10 yr 7/1) silty sandy shell gravel; mollusk shell, barnacle plates common (C)
		11-0 btm	Gray (10 yr 6/1) medium calcareous sand and shells; mollusk shell common; trace foraminifers, quartz (D)
44	48	0-1	White (10 yr 8/2) silty very fine to coarse calcareous sand; trace quartz grains, foraminifers (E)
		1-5	White (10 yr 8/1) silty fine to coarse calcareous sand; barnacle plates common (E)
		5-10 btm	White (10 yr 8/1) silty very fine well-sorted calcareous sand; trace quartz grains (E)
45A	50	0-5	Light brownish gray (10 yr 6/2); coarse calcareous sand; quartz grains, barnacle plates, mollusk shell common (A)
		5-6	Very pale brown (10 yr 8/3) calcareous quartzose sand; a mollusk shell common (U1)

Core No.	CERC ID No.	Interval (ft.)	Description
45A	50	6-6.3 btm	Gray coarse grained coquina rock
46	51	0-1	Light gray (10 yr 7/2) very coarse calcareous sand; quartz grains profuse; mollusk shell, barnacle plates common; trace bryozoa (A)
		1-2	Very pale brown (10 yr 8/3); silty sandy shell gravel; mollusk shell profuse; trace bryozoa (C)
		2-5	Gray (10 yr 6/1) silty sandy shell gravel; barnacle plates, mollusk shell common; quartz grains sparse (C)
		5-6	Gray (10 yr 6/1) very coarse calcareous sand; quartz grains, foraminifers sparse; trace echinoids (D)
		6-9.6 btm	Gray (10 yr 6/1) well-sorted calcareous sand; quartz grains common; foraminifers, echinoids sparse; trace barnacle plates, gray oolites (D)
47	52	0-4	Pale brown (10 yr 6/3); very coarse calcareous sand; barnacle plates, large rounded quartz grains, mollusk shell common; trace bryozoa (A)
		4-11	Gray (10 yr 6/1) slightly silty coarse calcareous sand; barnacle plates, quartz grains common; foraminifers sparse (B)
		11-11.3 btm	Gray (10 yr 6/1) clayey very cohesive silt (U)
48	53	0-2	Light gray (10 yr 7/2); slightly silty fine calcareous sand; quartz grains, mollusk shell common; foraminifers, ostracods, echinoids sparse (U)

Core No.	CERC ID No.	Interval (ft.)	Description
48	53	2-3	Light gray (10 yr 7/1) slightly silty very coarse calcareous sand; large echinoid fragments common; quartz grains, mollusk shell, blue-gray and black ooliths sparse; trace bryozoa (B)
		3-5	Gray (10 yr 6/1) silty, sandy calcareous shell gravel; mollusk shell, barnacle plates common; quartz grains, blue-gray ooliths sparse (C)
		5-6	Very pale brown (10 yr 8/3) fine calcareous sand and shell gravel; mollusk shell, foraminifers common; quartz grains, small white ooliths sparse (D)
		6-9	Gray (10 yr 6/1) fine to very coarse sand and shell fragments; mollusk shell, barnacle plates, white and gray ooliths common; quartz grains sparse (D)
		9-10	Light gray (10 yr 7/2) fine calcareous sandy shell gravel; mollusk shell profuse; barnacle plates common; quartz grains, foraminifers, white and gray ooliths sparse (U)
		10 btm	White (10 yr 8/1) well sorted fine calcareous sand, quartz grains, ooliths, foraminifers, echinoids common (E)
49	54	0-3	Very pale brown (10 yr 7/3), well-sorted coarse calcareous sand; barnacle plates, quartz grains common; trace foraminifers (A)
		3-4	Gray (10 yr 6/1) well sorted fine sand; quartz grains common; echinoids, barnacle plates, foraminifers sparse (B)
		4-6	Gray (10 yr 6/1) silty sandy calcareous shell gravel; barnacle plates, mollusk shell common, foraminifers, quartz grains sparse (B)

Core No.	CERC ID No.	Interval (ft.)	Description
49	54	6-10.2 btm	Gray (10 yr 6/1) silty shell gravel; profuse mollusk shell (C)
50	55	0-6	Light yellowish brown (10 yr 6/4) very coarse well sorted calcareous sand; quartz grains, barnacle plates, mollusk shell common (A)
		6-9 btm	Gray (10 yr 6/1) slightly silty very coarse calcareous sand; barnacle plates common; quartz grains sparse (B)
51	56	0-5	Light gray (10 yr 7/2) medium well sorted calcareous sand; mollusk shell, echinoids common (A)
		5-8	Light gray (10 yr 7/1) coarse calcareous sand; quartz grains profuse; barnacle plates, mollusk shell sparse (A)
		8-10.6 btm	Gray (10 yr 6/1) medium to coarse calcareous sand; barnacle plates, quartz grains common; echinoids, foraminifers, mollusk shell sparse (C)
52	57	0-1	White (10 yr 8/2) plastic calcareous silt (E)
		1-7	White (N/8) silty calcareous clay (F)
		7-10	White (10 yr 8/1) silty, clayey very fine calcareous sand (E)
		10 btm	White (10 yr 8/1) silty calcareous sand with calcarenite pebbles and massive mollusk fragments (E)
53	58	0-8	Very pale brown (10 yr 7/3) coarse calcareous sand; quartz profuse; barnacle plates, ooliths sparse (A)
		8-9	Light gray (10 yr 7/1) very coarse sand; barnacle plates, quartz common; mollusks shell sparse (A)

Core No.	CERC ID No.	Interval (ft.)	Description
53	58	9-10	Gray (10 yr 6/1) coarse calcareous sand; quartz profuse; barnacle plates common; foraminifers sparse; trace ostracods, ooliths (B)
		10-10.4 btm	Gray (10 yr 6/1) coarse sandy shell gravel; mollusk shell, barnacle plates common (C)
54	59	0-6	Very pale brown (10 yr 7/3) silty shelly quartzose sand; barnacle plates, mollusk shell common (U1)
		6-8	Gray (10 yr 5/1) plastic cohesive silty very fine sand; trace shell (U)
		9-9.5	Very pale brown (10 yr 7/3) fine to very fine slightly silty quartzose sand; trace shell (U1)
55	60	0-5	Pale brown (10 yr 6/3) coarse to very coarse calcareous sand; barnacle plates, mollusk shell profuse; quartz common; trace ooliths (A)
		5-8	Gray (10 yr 6/1) medium to coarse calcareous sand; quartz profuse; barnacle plates, mollusk shell common (A)
		9-10.5 btm	Gray (N5) coarse calcareous sand; barnacle plates, mollusk shell, quartz common (B)
56	61	0-3	Gray (10 yr 6/1) fine to very fine silty quartzose sand; small shell fragments common (U1)
		3-6	Gray (10 yr 6/1) silty sandy shell gravel; mollusk shell profuse; quartz common (C)
		6-8	Gray (10 yr 6/1) silty fine quartzose sand; mollusk shell profuse (U1)

Core No.	CERC ID No.	Interval (ft.)	Description
56	61	8-9	Very pale brown (10 yr 6/1) silty coarse to very coarse calcareous sand; mollusk shell profuse; quartz sparse (C)
		10-10.8 btm	Gray (10 yr 5/1); plastic cohesive sandy silt; small calcareous fragments common (U2)
57	62	0-2	Light yellowish brown (10 yr 6/4) coarse calcareous sand and shell gravel; barnacle plates, mollusk shell common; quartz sparse (A)
		2-5	Gray (10 yr 6/1) silty calcareous shell sand and gravel; mollusk shell common; trace quartz (C)
		5-9	White (10 yr 8/1) sandy calcareous silt; trace quartz (E)
		9-10 btm	Light gray (10 yr 7/1) very fine calcareous quartzose sand; small shells profuse(E)
58	63	0-1	Brown (10 yr 5/3) coarse calcareous sand; quartz, mollusk shell, barnacle plates common; ooliths sparse (A)
		1-2	Gray (10 yr 6/1) very coarse calcareous sand; mollusk shell, barnacle plates common (B)
		2-4	Light brownish gray (10 yr 6/2) slightly silty very coarse calcareous sand; barnacle plates common; quartz sparse (D)
		4-8 btm	Very pale brown (10 yr 7/3) silty fine to very fine quartzose sand; small mollusk shell profuse (U1)
59	64	0-5	Very pale brown (10 yr 8/3) fine calcareous sand; quartz grains, ooliths sparse (E)
		5-7	Same with mollusk shells (E)

Core No.	CERC ID No.	Interval (ft.)	Description
59	64	7-10	White (10 yr 8/2) fine calcareous sand; quartz profuse (E)
		10-11.6 btm	White (10 yr 8/1) fine calcareous sand, containing large shell fragments and calcarenite fragments (E)
60	65	0-2	White (10 yr 8/2) medium calcareous sand; mollusk shell common; trace quartz grains, ooliths (E)
		2-5	Same with large fragments of calcarenite (E)
		5-11.2 btm	White (10 yr 8/2) medium to coarse calcareous sand; barnacle plates, mollusk shell common; quartz grains, ooliths sparse; some large calcarenite fragments (E)
61	66	0-1	Light gray (10 yr 7/2) slightly silty calcareous sandy shell gravel; quartz grains, mollusk shell common (U)
		1-8	Gray (10 yr 6/1) silty calcareous sandy shell gravel, mollusk shell, barnacle plates common; quartz grains sparse (C)
		8-10.8 btm	Light gray (10 yr 7/1) fine calcareous sand, shells, pieces of calcarenite, quartz grains common (E)
62	67	0-1	Yellowish brown (10 yr 5/4) coarse calcareous sand; barnacle plates, mollusk shell, quartz common; sparse ooliths (A)
		1-7	Light gray (10 yr 7/2) slightly silty coarse sand and shell gravel; mollusk shell, barnacle plates, quartz sparse (A)
		7-10.6	Gray (10 yr 6/1) silty sandy shell gravel; barnacle plates, mollusk shell common; quartz sparse (C)

Core No.	CERC ID No.	Interval (ft.)	Description
63	68	0-1	Light yellowish (10 yr 6/4) very coarse calcareous sand; barnacle plates, mollusk shell common; quartz sparse (A)
		1-4	Gray (10 yr 6/1) silty very coarse calcareous sand; mollusk shell common; trace quartz (C)
		4-10.5 btm	Gray (10 yr 6/2) silty cohesive fine to very fine calcareous quartzose sand; less silty 8-10 ft. (U2)
64	69	0-1	Yellowish brown (10 yr 5/4) very coarse calcareous sand; quartz common; mollusk shell, barnacle plates sparse (A)
		1-2	Light gray (10 yr 7/2) slightly silty very coarse calcareous sand (B)
		2-6	Gray (10 yr 6/1) silty sandy calcareous shell gravel (C)
		6-8	Gray (N6) medium calcareous sand; sparse quartz, mollusk shell; trace echinoids, foraminifers (D)
		8-9 btm	Light gray (10 yr 7/1) silty calcareous sand and gravel; gravel consists of calcarenite fragments, coarsest at bottom (E)
65	70	0-2	Pale brown (10 yr 6/3) coarse to very coarse calcareous sand; quartz, barnacle plates, mollusk shell common; sparse bryozoa (A)
		2-5	Gray (10 yr 5/1) coarse to very coarse calcareous sand; quartz, mollusk shell, barnacle plates common (B)
		5-6	Gray (10 yr 6/1) coarse calcareous sand; barnacle plates common (B)

Core No.	CERC ID No.	Interval (ft.)	Description
65	70	6-8.2 btm	Gray (10 yr 6/1) silty, sandy calcareous shell gravel; mollusk shell common (C)
66A	72	0-1	Gray (10 yr 6/1) silty very coarse calcareous sand; mollusk shell, quartz common (A)
		1-3	Gray (10 yr 6/1) silty sandy shell gravel; mollusk shell common; sparse quartz (C)
		3-5	Gray (10 yr 5/1) slightly silty medium calcareous sand; quartz, mollusk shell, foraminifers sparse (D)
		5-8 btm	Light gray (10 yr 7/1) fine to medium calcareous sand; quartz, foraminifers common; sparse echinoid parts, mollusk shell, barnacle plates (D)
67A	74	0-2	Pale brown (10 yr 6/3) coarse calcareous sand; quartz, mollusk shell,barnacle plates common; trace foraminifers (A)
		2-5	Light brownish gray (10 yr 6/2) coarse calcareous sand; profuse quartz; barnacle plates common (A)
		5-6	Light gray (10 yr 7/2) very coarse calcareous sand; quartz, barnacle plates, mollusk shell common; sparse foraminifers (B)
		6-8	Gray (10 yr 5/1) coarse calcareous sand; barnacle plates, mollusk shell,quartz common (B)
		8-9.8 btm	Gray (10 yr 6/1) silty sand calcareous shell gravel; barnacle plates, mollusk shell common; quartz sparse (C)

Core No.	CERC ID No.	Interval (ft.)	Description
68	75	0-9	Very pale brown (10 yr 7/3) medium to coarse calcareous sand; profuse quartz, barnacle plates common; mollusk shell sparse, trace foraminifers; becomes better sorted 6-9 ft. (A)
		9-10.0 btm	Gray (10 yr 6/1) medium calcareous sand; quartz common, barnacle plates, mollusk shell sparse; becomes silty and slightly plastic at 10 ft. (D)
69	76	0-11.3 btm	Light yellowish brown (10 yr 6/4) coarse to very coarse calcareous sand; quartz, brown and gray ooliths, mollusk shell, barnacle plates common, ooliths decrease toward bottom (A)
70	77	0-3	Light brownish gray (10 yr 6/2) medium sand; quartz, small black and gray ooliths common; barnacle plates, mollusk shell sparse, trace foraminifers (A)
		3-4	Gray (10 yr 5/1) slightly silty calcareous sand and shell gravel; quartz, mollusk shell, barnacle plates common (B)
		4-6	Dark gray (10 yr 4/1) medium calcareous sand; quartz and small black and gray ooliths common; sparse barnacle plates, mollusk shell (B)
		6-9.3 btm	Gray (10 yr 6/1) medium to coarse calcareous sand; quartz common, mollusk shell, barnacle plates sparse (B)
70A	77	0-3	Very pale brown (10 yr 7/3) medium calcareous sand; barnacle plates, foraminifers, mollusk shell common; quartz sparse.
		2-5	Gray (10 yr 5/1) medium calcareous sand; quartz, barnacle plates, mollusk shell common. (B)

Core No.	CERC ID No.	Interval (ft.)	Description
70A	77	5-6	Dark gray (10 yr 5/1) medium calcareous sand; small black and gray ooliths, quartz common; sparse foraminifers (B)
		6-7	Dark gray (10 yr 4/1) medium calcareous sand; quartz, barnacle plates common; sparse foraminifers, mollusk shell, small gray and black ooliths (B)
		7.0-8.5 btm	Gray (10 yr 5/1) coarse to very coarse calcareous sand; mollusk shell, barnacle plates common; foraminifers, quartz sparse (B)
71	79	0-10.8 btm	Light yellowish brown (10 yr 6/4) very coarse calcareous sand; quartz, mollusk shell, barnacle plates common; trace foraminifers, ooliths (A)
72	80	0-5	Mixed gray and white, very coarse calcareous sand; sparse ooliths and barnacle plates (E)
		5-7	Same, but all particles are white (10 yr 8/2) and well worn (E)
		7-11	Same, mixed with large mollusk shell and fragments (E)
73	81	0-8	Light brownish gray (10 yr 6/2) coarse calcareous sand; quartz, barnacle plates, small black and gray ooliths common, trace foraminifers (A)
		8-9.4 btm	Gray (10 yr 5/1) coarse calcareous sand; quartz, barnacle plates, mollusk shell common; trace foraminifers (B)
73A	82	0-9.5 btm	Gray (10 yr 6/1) medium to coarse calcareous sand; quartz common; barnacle plates, ooliths common; trace foraminifers (B)

Core No.	CERC ID No.	Interval (ft.)	Description
73B	83	0-5	Light brownish gray (10 yr 6/2) medium calcareous sand; quartz, barnacle plates, black and gray ooliths common; foraminifers, mollusk shell sparse (A)
		5-9	Same, but coarser and grayer (10 yr 6/1) (B)
		9-9.7 btm	Light gray (10 yr 7/1) coarse calcareous sand and gravel; ooliths common in sand fraction, mollusk shell common; contains 1/2-inch pebbles of calcarenite (E)
74	84	0-3	Light brownish gray (25 yr 6/2) silty plastic clay (U2)
		3-6	Light gray (10 yr 7/2) medium calcareous sand; quartz, barnacle plates, small black and gray ooliths common; trace foraminifers, becomes slightly silty at -4 ft. (B)
		6-8	Gray (10 yr 6/1) sandy, silty calcareous gravel; mollusk shell common; quartz, barnacle plates sparse; material well worn, broken (C)
		8-10.3 btm	Very pale brown (10 yr 8/3) fine calcareous sand; quartz, small ooliths common; trace foraminifers (E)
75	85	0-2	Light brownish gray (10 yr 6/2) very coarse calcareous sand; quartz, barnacle plates, mollusk shell common; trace ooliths (A)
		2-3	Gray (10 yr 6/1) sandy silty shell gravel; barnacle plates, mollusk shell common (C)
		3-6	Gray (10 yr 5/1) slightly silty very coarse calcareous sand; barnacle plates, mollusk shell, quartz common; ooliths sparse (C)

Core No.	CERC ID No.	Interval (ft.)	Description
75	85	0-2	Light brownish gray (10 yr 6/2) very coarse calcareous sand; quartz, barnacle plates, mollusk shell common; trace ooliths (A)
		2-3	Gray (10 yr 6/1) sandy silty shell gravel; barnacle plates, mollusk shell common (C)
		3-6	Gray (10 yr 5/1) slightly silty very coarse calcareous sand; barnacle plates, mollusk shell, quartz common; ooliths sparse (C)
		6-8	Gray (10 yr 6/1) silty sandy shell gravel; barnacle plates, mollusk shell common (C)
		8-9.8 btm	White (10 yr 8/2) medium calcareous sand; quartz, ooliths common (E)
76	86	0-2	Very pale brown (10 yr 7/3) very coarse calcareous sand; mollusk shell, quartz, barnacle plates common (A)
		2-3	Light gray (10 yr 7/1) silty shell gravel; mollusk shell common (C)
		3-5	Light brownish gray (10 yr 8/3) medium calcareous sand; quartz common (B)
		5-10.3 btm	Very pale brown (10 yr 8/3) fine sand and shell gravel; quartz, mollusk shell common; sparse barnacle plates (U)
77	87	0-1	Shell gravel with broken, worn mollusk shells up to 3/4 inches (A)
		1-10	Very pale brown (10 yr 7/3) medium calcareous sand; quartz common (D)

Core No.	CERC ID No.	Interval (ft.)	Description
77	87	10-10.3 btm	Light gray (10 yr 7/2) slightly silty very coarse sand and shell gravel; mollusk shell, barnacle plates common; quartz sparse (E)
78	88	0-1	Light gray (10 yr 7/2) slightly silty calcareous sand; quartz, barnacle plates, mollusk shell common (U)
		1-6	Gray (10 yr 6/1) silty sandy shell gravel (C)
		6-9	Gray (N6) coarse calcareous sand; mollusk shell common; sparse quartz (D)
		9.7 btm	Gray (N6) medium calcareous sand (D)
79	89	0-3	Very pale brown (10 yr 7/3) slightly silty coarse calcareous sand; quartz common; sparse barnacle plates, mollusk shell (A)
		3-5	Very pale brown (10 yr 7/3) silty sandy shell gravel; mollusk shell common; sparse quartz (C)
		5-9.2 btm	Very pale brown (10 yr 7/3) coarse to very coarse calcareous sand, mollusk shell common (D)
80	90	0-7	Gray (10 yr 5/1) silty coarse to very coarse shell sand and gravel (C)
		7-11.0 btm	White (10 yr 8/1) silty sandy shell gravel, cohesive when wet; calcarenite pebbles near bottom (E)
81	91	0-3	Light brownish gray (10 yr 6/2) coarse calcareous sand; barnacle plates, quartz, mollusk shell common, trace foraminifers (A)

Core No.	CERC ID No.	Interval (ft.)	Description
81	91	3-6	Gray (10 yr 6/1) slightly silty medium calcareous sand; mollusk shell, quartz sparse, trace foraminifers (B)
		6-7	Gray (10 yr 5/1) coarse to very coarse calcareous sand and shell gravel; quartz, barnacle plates, mollusk shell common (C)
		7-10 btm	Gray (10 yr 6/1) fine to medium calcareous sand and shell gravel; quartz, mollusk shell sparse; trace foraminifers (D)
82	92	0-4	Light yellowish brown (10 yr 6/2) coarse to very coarse calcareous sand; profuse quartz; barnacle plates, mollusk shell common, sparse ooliths, rare foraminifers (A)
		4-7	Light brownish gray (10 yr 6/2) silty fine to medium calcareous sand; barnacle plates, mollusk shell, echinoid fragments, quartz, foraminifers sparse (U)
		6-7	Same, but large mollusk fragments common.
		7-7.8 btm	Light gray (10 yr 7/2) very fine calcareous sand; mollusk shell, quartz, echinoid parts common; sparse foraminifers, ostracods (D)
83	93	0-7	Gray (10 yr 5/1) medium to coarse calcareous sand; profuse quartz (A)
		7-8	Gray (x16) coarse, well-sorted sand; barnacle plates, mollusk shell common (B).
		8-9.0 btm	White (10 yr 8/2) silty, very fine calcareous sand, quartz, mollusk shell, calcareous fragments rare (E)
84	94	0-2	White (10 yr 8/1) calcareous sandy silt (E)
		2-3	Light gray (10 yr 7/1) silty, very fine sand; quartz sparse, foraminifers rare (E)

Core No.	CERC ID No.	Interval (ft.)	Description
84	94	3-10.0 btm	White (10 yr 8/1) silty fine calcareous sand; sparse quartz, mollusk fragments; calcarenite pebbles (E)
85	95	0-1.5	Light gray (10 yr 7/2) slightly silty, fine to medium calcareous sand; quartz, mollusk shell common; sparse barnacle plates (E)
		1.5-10	White (10 yr 7/2) calcareous sand; quartz, well worn mollusk shell, and calcarenite pebbles common (E)
		10-11.0 btm	Very pale brown (10 yr 7/3) medium calcareous sand; quartz mollusk shell common (E)
86	96	0-1	Very pale brown (10 yr 7/3) medium calcareous quartzose sand; mollusk shell common (A)
		1-4	Light brownish gray (10 yr 6/2) coarse calcareous sand; profuse quartz; barnacle plates, mollusk shell, common (A)
		4-6	Gray (10 yr 5/1) medium calcareous sand; quartz, barnacle plates, mollusk shell common (B)
		6-8	Light gray (10 yr 7/1) very fine calcareous quartzose sand; sparse foraminifers (U1)
87	97	0-6	Light brownish gray (10 yr 6/2) very coarse shell sand and gravel; barnacle plates, quartz common (A)
		6-9.3 btm	Gray (10 yr 6/1) medium to coarse calcareous sand; quartz, mollusk shell, barnacle plates common, sparse foraminifers (B)
88	98	0-3	Light gray (10 yr 7/2) medium quartzose sand; mollusk shell common (U1)

Core No.	CERC ID No.	Interval (ft.)	Description
88	98	3-5	Gray (10 yr 6/1) very fine to coarse sand and shell gravel: quartz, mollusk shell common (C)
		5-8.3 btm	Light gray (10 yr 7/1) fine shelly quartzose sand; mollusk shell common (U1)
89	99	0-1	Grayish brown (10 yr 5/2) very coarse calcareous sand and shell gravel; quartz profuse in sand fraction; mollusk shell, barnacle plates common (A)
		1-5	Gray (10 yr 6/1) fine to coarse sand and shell gravel; sand fraction quartzose, mollusk shell common (U1)
		5-9.6 btm	Gray (10 yr 6/1) fine to very fine calcareous quartzose sand; mollusk shell sparse (U1)
90	100	0-1	Gray (10 yr 5/1) coarse calcareous sand; quartz, mollusk shell, barnacle plates common (A)
		1-3	Gray (10 yr 6/1) sandy clayey silt (U2)
		3-4	Gray (10 yr 5/10) silty, sandy shell sand and gravel; mollusk shell common; sparse quartz (C)
		4-7	Gray (10 yr 6/1) fine to medium calcareous sand; quartz profuse; sparse foraminifers, echinoid parts, mollusk shell (D)
		7-9 btm	Light gray (10 yr 7/1) calcareous sand; fragments of calcarenite (E)
178	199	0-1	Gray (10 yr 6/1) muddy medium quartz sand; mollusk, barnacle fragments common.

Core No.	CERC ID No.	Interval (ft.)	Description
178	199	1-3	Gray (N5) sandy shell gravel; sand fraction chiefly carbonate, profuse quartz; trace echinoid fragments.
		3-7	Gray (N6) semi-indurated calcareous silt; mollusk fragments common.
		7-8	Gray (N5) muddy shell gravel; carbonate sand profuse; trace echinoid spines.
		8-9	Light gray (10 yr 7/2) fine to coarse semi-indurated calcareous sand; carbonate fraction highly altered and weathered.
		9 btm	Light gray (N7) fine to medium semi-indurated calcareous sand; quartz common.
179	200	0-4	Light gray (10 yr 7/1) calcareous mud.
		4-6	Gray (10 yr 5/1) muddy poorly sorted medium calcareous sand; mollusk fragments common; medium well-rounded quartz grains sparse.
		6-7 btm	Light gray (N7) poorly sorted silty calcareous coarse sand and gravel; mollusk fragments common, frequently bleached and altered.
180	201	0-4	Gray (10 yr 5/1) poorly sorted coarse muddy calcareous sand; sand chiefly worn rounded mollusk fragments; trace ooliths.
		4-9	Gray (N5) muddy shell gravel: gravel chiefly mollusk fragments.
		9-12	Light gray (N7) medium gravelly quartz-calcareous sand; sparse calcareous mud; trace ooliths.

Core No.	CERC ID No.	Interval (ft.)	Description
181	202	0-1	Dark grayish brown (10 yr 4/2) sandy mud, sand components include coarse quartz grains and worn carbonate grains.
		1-4	Dark grayish brown (10 yr 4/2) medium silty quartz sand; worn carbonate grains common.
		4-5	Gray (10 yr 5/1) medium silty quartz sand; coarse to very coarse mollusk fragments common.
		5-6	Brown (7.5 yr 5/2) fine quartz sand; trace organic material.
		6-10	Same as 4 feet
		10-11 1/2 btm	Dark gray (10 yr 4/1) medium quartz-calcareous sand, trace ooliths.
182	203	0-6	Gray (10 yr 6/1) sandy calcareous mud.
		6-9	Gray (10 yr 5/1) poorly sorted muddy sandy shell gravel; gravelly fragments are broken, angular mollusk shell.
		9-11 btm	Dark gray (10 yr 4/1) quartz sand-shell gravel; gravel components are broken mollusk fragments.
183	204	0-4	Light gray (10 yr 7/1) poorly sorted fine silty calcareous sand; mollusk fragments common; barnacle fragments sparse; trace echinoid spines.
		4-6	Light gray (10 yr 7/1) moderately well-sorted medium quartz sand; profuse mollusk fragments, highly bored and altered.
		6-7	Dark brown (10 yr 3/3) well-sorted fine-medium quartz sand organic detritus common.

Core No.	CERC ID No.	Interval (ft.)	Description
183	204	7-9	Very dark grayish brown (10 yr 3/2) very fine to fine organic enriched quartz sand (sandy peat) same as 7 in color
		9-10	Dark brown (10 yr 3/3) very fine quartz sand. Coarse well-rounded quartz grains and worn carbonate grains.
		10 btm	Light gray (10 yr 7/1) fine-medium silty calcareous sand; mollusk fragments, foraminifers, and well-rounded quartz grains common.
184	205	0-2	Olive gray (5 yr 5/2) sell-sorted fine quartz sand; carbonate grains common.
		2-3	Dark gray (5 yr 4/1) poorly-sorted silty gravelly quartz sand; carbonate sand profuse; shell gravel consists of whole and broken mollusk shell.
		3-6 btm	Light gray (5 yr 7/2) medium silty calcareous sand; quartz grains profuse; coarse mollusk fragments common.
185	206	0-1	Gray (10 yr 7/2) fine silty quartz sand.
		1-2	Very dark grayish brown (10 yr 3/3) fine organic-enriched quartz sand.
		3-5	Grayish brown (10 yr 5/2) moderately well-sorted very fine silty quartz sand.
		5 8 1/2 btm	Light gray (10 yr 7/2) moderately well-sorted fine calcareous sand; quartz grains profuse; heavy minerals, phosphorite grains, foraminifers sparse.

Core No.	CERC ID No.	Interval (ft.)	Description
186	207	0-6	Gray (10 yr 5/1) fine silty quartz sand; altered shell fractions common.
		6-7 1/2 btm	Light brownish gray (10 yr 6/2) medium to coarse calcareous sand; calcareous silt, quartz sand common; calcareous fraction is highly bleached and altered.
187	208	0-8 btm	Olive gray (5 yr 5/2) very fine silty calcareous quartzose sand; carbonate sand grains common.
188	209		No data.
189	300	0-8 btm	Gray (10 yr 5/1) very fine silty calcareous quartz sand; carbonate sand grains common; carbonates chiefly angular mollusk fragments.
190	301	0-2	Light brownish gray (2.5 yr 6/2) well-sorted fine quartz sand; heavy mineral, phosphorite, carbonate grains sparse.
		2-5	Grayish brown (2.5 yr 5/2) coarse sandy shell gravel; sand fraction in equal portions of angular carbonate and quartz grain; shell gravel is angular and rounded mollusk fragments.
		5-9	Dark gray (10 yr 4/1) calcareous mud, predominantly coarse silt.

UNCLASSIFIED
Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)* Coastal Engineering Research Center (CERC) Corps of Engineers, Department of the Army Washington, D. C. 20016	2a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED 2b. GROUP

3. REPORT TITLE
GEOMORPHOLOGY AND SEDIMENTS OF THE INNER CONTINENTAL SHELF, PALM BEACH TO CAPE KENNEDY, FLORIDA

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

5. AUTHOR(S) *(First name, middle initial, last name)*
Meisburger, E. P.
Duane, D. B.

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
February 1971	117	41

8a. CONTRACT OR GRANT NO. DA-08-123-CIVENG-65-57 between Alpine b. PROJECT NO. Geophysical Associates and Coastal Engineering Research c. Center. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Memorandum No. 34 9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*

10. DISTRIBUTION STATEMENT
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11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY

13. ABSTRACT

The Inner Continental Shelf off eastern Florida was surveyed by CERC to obtain information on bottom morphology and sediments, subbottom structure, and sand deposits suitable for restoration of nearby beaches. Primary survey data consists of seismic reflection profiles and sediment cores. This report covers that part of the survey area comprising the inner Shelf between Palm Beach and Cape Kennedy.

Sediment on beaches adjacent to the study area consists of quartzose sand and shell fragments. Median size of midtide samples generally lies in the range between 0.3 to 0.5 mm. (1.74 to 1.0 phi) diameter.

The Shelf in the study area is a submerged sedimentary plain of low relief. Ridge-like shoals generally of medium-to-coarse (0.25 to 1.0 mm.) calcareous sand resting on the seaward dipping subbottom strata contain material suitable for beach restoration. A minimum volume of 92.2 x 10^6 cubic yards of suitable sand is available within study limits.

DD FORM 1 NOV 65 1473 REPLACES DD FORM 1473, 1 JAN 64, WHICH IS OBSOLETE FOR ARMY USE.

UNCLASSIFIED
Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Submarine Geology Continental Shelf Seismic Reflection Sediment Cores Artificial Beach Nourishment Palm Beach-Cape Kennedy, Florida						

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