TR-189

TECHNICAL REPORT

OCEAN BOTTOM RECONNAISSANCE OFF THE EAST COAST OF ANDROS ISLAND, BAHAMAS

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MAY 1966

U. S. NAVAL OCEANOGRAPHIC OFFICE
WASHINGTON, D. C. 20390
Price $1.10

ABSTRACT

A visual and photographic survey of the shore and ocean bottom to 600 feet (100 fathoms) depth was performed off selected sites on the east coast of Andros Island, Bahamas. Climatology and oceanographic conditions are also presented. Survey methods employed both SCUBA divers and a manned submersible (Perry Cubmarine PC3-B) to provide direct visual observation and measurement of bottom features.

The Andros shoreline was observed to vary considerably in morphology and composition: barrier reef development ranges from well-developed to virtually non-existent from north to south along Andros Island. A marginal escarpment commencing offshore between 14 and 16 fathoms was observed to descend almost vertically to 100 fathoms. Various morphologic features of the escarpment suggest a lowering of sea level and subsequent subaerial and intertidal erosive processes which have been active in the recent geologic past.

ERRATA - TR 189

Page			
9	1st Paragraph, last sentence	Read:	"easterly" for "westerly"
12	Figure 5, caption	Read:	"Fresh Creek" for "Deep Creek"
25	2nd paragraph, 4th sentence	Read:	"Visibility" for "Visability"
55	Plate 25(A)	Read:	"CAVES" for "CORES"
	Plate 25(D)	Read:	"ESCARPMENT" for "EXCARPMENT"

FOREWORD

This report presents the results of visual and photographic underwater surveys from the shoreline to a depth of 600 feet along selected routes off the eastern coast of Andros Island, Bahamas. Additional oceanographic and meteorological data are included which were obtained during previous surveys. This is the U. S. Naval Oceanographic Office's first survey utilizing SCUBA equipped divers and submersibles and represents a further expansion of our data collection and survey capabilities to provide a more lucid presentation of ocean environmental characteristics.

The survey was performed to provide information applicable to the installation of submarine cables in support of the U. S. Navy's Atlantic Undersea Test and Evaluation Center.

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INTRODUCTION

Between 5 through 20 May 1964, the U. S. Naval Oceanographic Office in conjunction with the U. S. Naval Photographic Center performed an onshore and underwater cable route survey off the eastern coast of Andros Island, Bahamas. Surveys commenced ashore and proceeded underwater offshore along predesignated bearings to a depth of 130 feet. Survey sites were Salvador Point, Big Wood Cay, Golding Cay, and Deep Creek. Following this phase of the survey a similar operation was pursued off Fresh Creek and High Point Cay in June 1965. In addition, a manned submersible (Perry Cubmarine PC3-B) was employed to investigate the bottom to a depth of 600 feet off Fresh Creek, Big Wood Cay, and Golding Cay (Figures 1 and 2).

The purpose of the survey was to provide information on the nature of the bottom for future submarine cable installations off Andros Island in support of the U. S. Navy's Atlantic Undersea Test and Evaluation Center (AUTEC). Additional information regarding oceanography and climatology was obtained prior to these operations to fulfill other project requirements.

FIELD METHODS

SCUBA surveys to a depth of 130 feet were conducted from aboard R/V AQUANAUT out of Nassau, New Providence Island. Predesignated onshore cable termination sites were located using aerial photographs and survey monuments from previous site surveys. Survey tracks were established by positioning a transit over the onshore site marker and sighting along the proper bearing. At a measured distance from the shoreline, and guided by shore signals, styrofoam marker buoys were placed at intervals along the track. Subsequent to installation of the buoys, divers took still and motion pictures, samples, and measurements of the bottom at each buoy and between buoys where a change in bottom characteristics occurred.

Diving operations with PC3-B commenced immediately seaward of the barrier reef off Fresh Creek, in the center of the boat channel

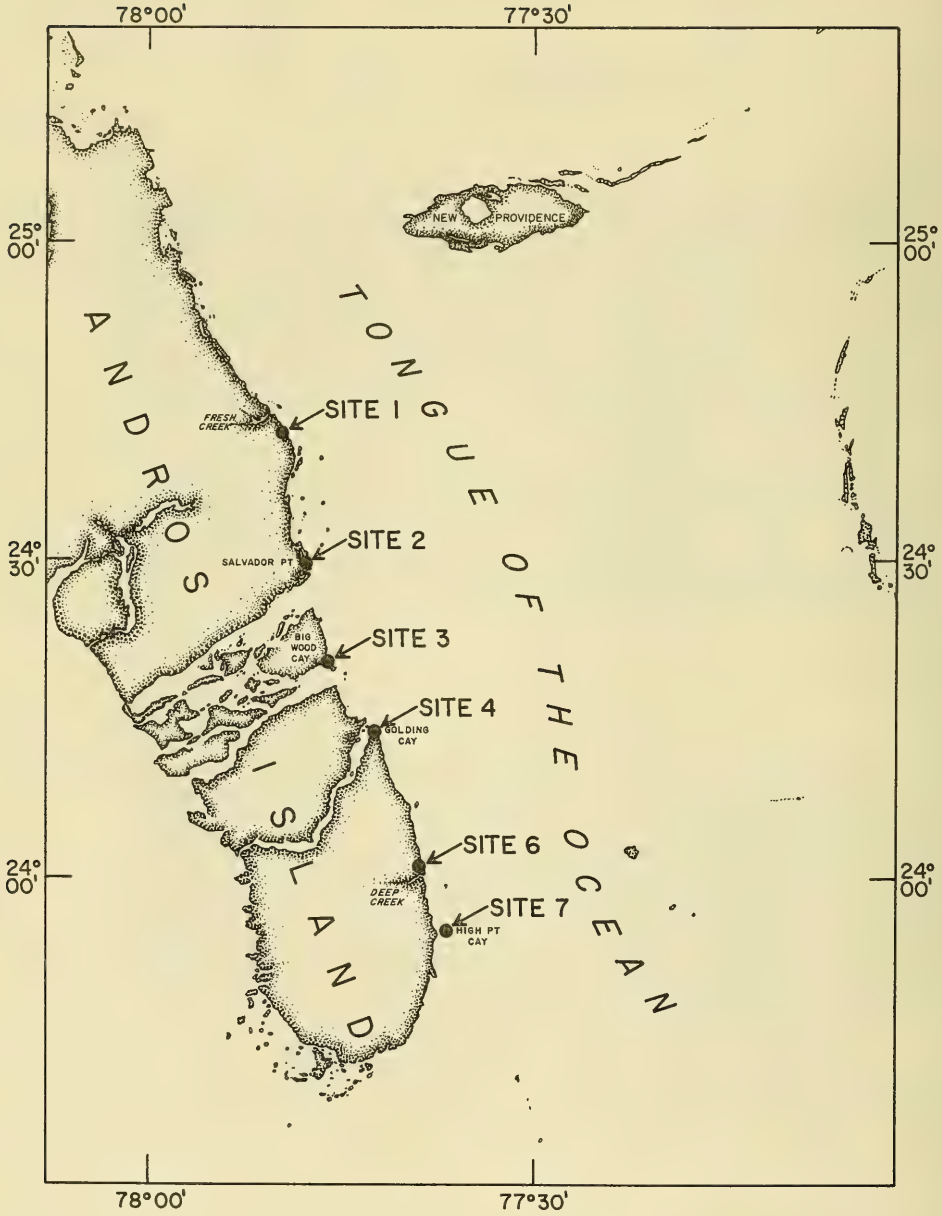

FIGURE 1. LOCATION OF SITES

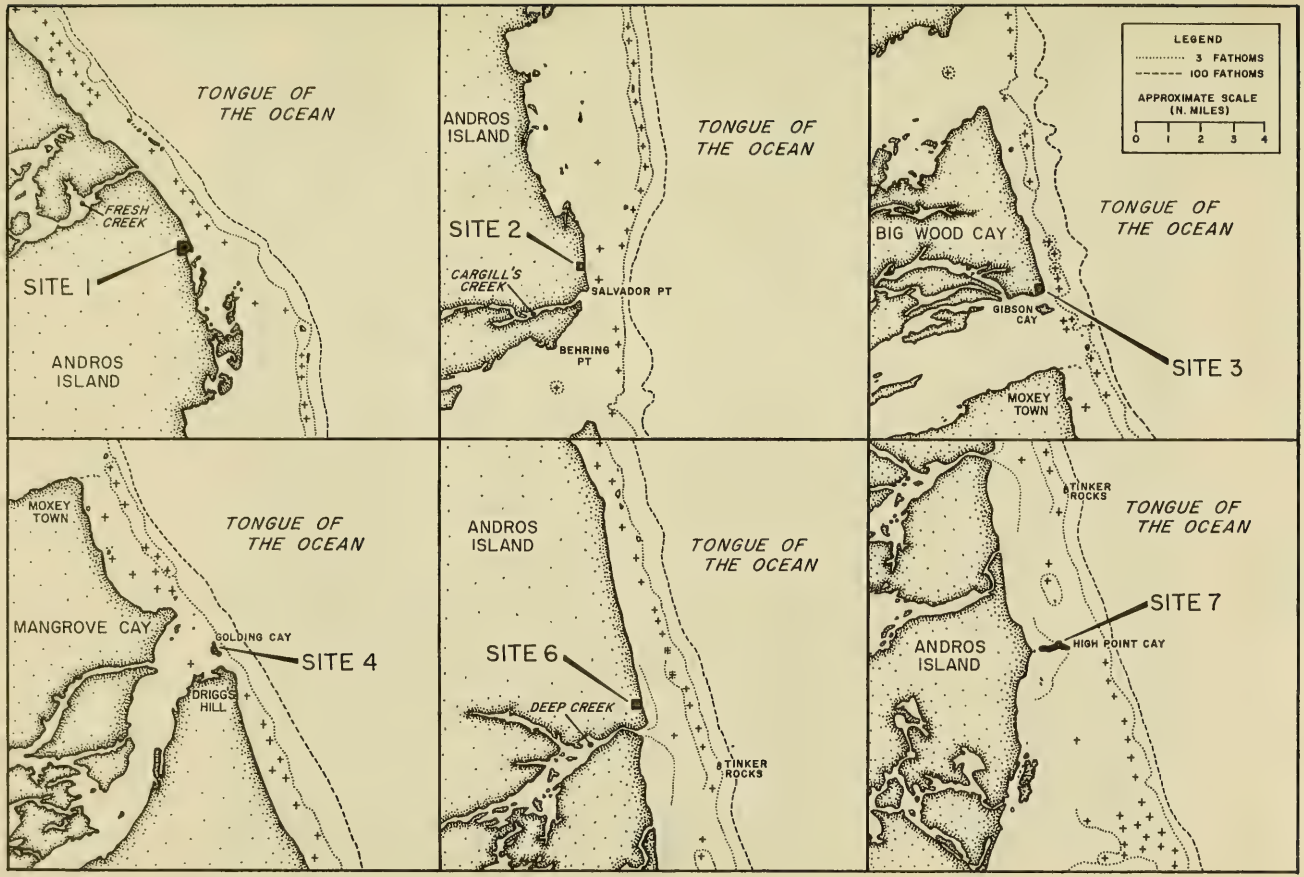

FIGURE 2. SKETCH CHART OF SITES

between Big Wood and Gibson Cays, and several hundred yards east of the center of Golding Cay. In all cases the commencement point was established with Decca Mark X and the submersible then proceeded due east along the bottom to a depth of 600 feet.

Still photographs ashore were taken with a Press Type 4" x 5" still picture camera; underwater stills were taken with a 35 mm "Calypso" camera. Motion pictures were made underwater with a "Sampson" underwater camera using artificial and natural light.

GEOLOGIC SETTING

Andros is the largest of the Bahamian islands. It is centered at approximate latitude 24°29'N., and longitude 77°52'W., on the Great Bahama Bank, and constitutes the western land boundary along the majority of the Tongue of the Ocean (Figure 1). Barely more than 30 miles wide, the island is approximately 90 miles long. A network of tidal channels and marshes, calcareous mud, and mangrove thickets characterize the geography of the west coast of the island. Conversely, the east coast is well defined by alternating deposits of sand and beachrock. A barrier-type reef extends along the eastern coast of Andros and is separated from the island by a shallow lagoon which does not exceed 3 fathoms in depth.

A major part of the island is covered by low shrubs and trees supported by a well-indurated, medium to fine-grained, oolitic limestone. There is virtually no topsoil covering the limestone country rock; instead, a few inches of humus collects here and there in the cavities and depressions honeycombing its surface.

The lagoon averages one mile wide and a maximum 2 to 3 fathoms deep. The lagoon floor is an extension of the Andros country rock and is covered by a varying thickness of medium- to coarse-grained calcareous sand. In some areas (Fresh Creek, Salvador Point, Deep Creek) the sand is as much as 5 feet thick, while in other areas (Big Wood Cay; Golding Cay; High Point Cay) only a thin, shifting veneer is present.

The reef off the eastern coast of Andros extends from the Berry Islands in the north to Pigeon Cay in the south. It varies in development, does not present a solid barrier throughout, and is more pronounced at some locations than at others. According to Newell et al (1957), the reef consists of a narrow ridge of oolite which rises in places to form small cays, and in certain areas has been overgrown with algae-coral encrustations which form a broad underwater ridge several hundred feet wide.

Seaward of the reef an outer platform extends eastward a quarter of a mile or more. The platform terminates abruptly at a depth between 14 and 16 fathoms where a sharp break-in-slope occurs which serves as the boundary delineating deep from shallow water. At the break-in-slope an escarpment descends almost vertically to depths between 100 and 120 fathoms. Below this depth, the slope gradient decreases continuously toward the deep sea floor in the center of the Tongue of the Ocean. The uniform slope seaward of the outer platform is interrupted in several places by terraces which parallel the barrier reef.

PREVIOUS STUDIES

Prior to this study, considerable effort was expended on AUTEC site surveys in connection with base construction and dredging. Other studies, not connected with the project, provided oceanographic information of general and specific interest.

NAVOCEANO performed bathymetric surveys of the lagoon and reef areas off all the sites, as well as in the Tongue of the Ocean, which provided coverage of the areas studied herein. Private organizations performed surveys of the land sites for construction purposes and provided detailed topographic maps. In some instances, the contractors made soil borings in the lagoon to determine the unconsolidated sand thickness.

Newell et al (1957) charted the entire Andros reef and their results provided an excellent and detailed guideline for this study.

Tidal measurements initiated by NAVOCEANO (IMR 0-21-64) in 1963 have been reported and are continuing at Salvador Point and Fresh Creek.

DeLeonibus (1960) calculated theoretical wave heights under varying conditions of wind and fetch in the Tongue of the Ocean.

Meteorological data were provided by the Bahamas Meteorological Service which maintains a permanent observation station at Mangrove Cay, Andros Island, and other islands throughout the Bahamas.

CLIMATOLOGY AND OCEANOGRAPHY

Monthly air temperatures, humidity, rainfall, and wind speed over a four year period at Mangrove Cay is presented in Table 1. Seasonal and annual wind roses as measured from November through October 1963 are shown in Figure 3. No wind directions were available from 1957 to 1960.

Winds approaching hurricane strength are most probable in the months of August, September, and October when 79 percent of the hurricanes occur. An average of two hurricanes invades the Bahamas annually.

TIDES

Tidal corrections to be applied to tide predictions at Hampton Roads, Virginia, from Fresh Creek, Salvador Point, and Pigeon Cay are presented in Table 2. Tides in the Bahamas are semi-diurnal with a diurnal inequality, and show a mean range of approximately 3 feet. Tidally induced currents in the lagoon are generally low speed (<0.2 kts). In the Andros Bights (e.g., between Big Wood and Gibson Cays) the current can reach 1 knot.

Table 1 Summary of meteorological observations 1957-1960 Mangrove Cay, Andros Island Standard Time GMT
Observations taken 29 feet above mean sea level at hourly intervals
Mean pressure at MSL - 1016.6

	Air Temperature(°F)						Relative Humidity(%)					Rainfall(ins.)			Mean Wind
Month	07h.	Mean 13h.	19h.	Extreme Max.	Extreme Min.	Monthly Mean	Extreme Max.	Extreme Min.	07h.	Mean 13h.	19h.	Total	max./ day	No. of Days Rained	Speed (kts)
January	67.6	79.3	70.4	81.0	61.9	71.4	87.0	51.0	87.0	70.1	83.0	2.61	0.89	6.25	6.1
February	67.3	78.8	71.3	82.5	62.3	69.2	90.0	54.1	86.0	68.0	86.0	1.46	0.59	6.0	5.6
March	69.1	80.6	73.3	84.7	65.0	74.8	92.0	56.0	86.3	64.5	81.5	1.80	0.85	6.75	5.2
April	74.5	82.1	76.5	85.8	70.4	74.3	91.0	63.8	82.8	70.8	81.3	3.64	1.17	8.75	5.9
May	77.7	84.5	78.2	87.7	72.2	79.9	91.3	64.8	82.0	69.8	79.8	7.72	2.83	12.5	5.4
June	80.3	84.7	80.8	89.4	73.6	81.5	94.8	67.5	86.3	74.5	83.8	6.46	1.55	13.35	5.8
July	81.6	87.8	82.3	90.6	74.9	82.7	94.0	70.8	80.8	71.0	82.3	5.48	1.89	14.0	5.1
August	80.8	86.6	82.4	91.4	76.0	83.3	95.3	72.5	85.3	72.5	81.5	4.91	1.40	15.25	4.7
September	78.8	87.0	82.0	90.0	73.6	82.3	92.8	67.8	83.8	71.3	80.5	9.19	2.75	20.25	5.1
October	76.5	85.6	78.9	88.6	84.5	73.6	82.9	65.3	86.5	71.8	81.5	7.23	2.15	13.5	4.5
November	74.5	83.9	76.8	86.6	69.2	77.9	89.8	60.8	86.5	69.8	84.0	2.73	0.79	11.0	6.4
December	69.8	78.8	72.0	81.6	60.4	71.0	86.5	48.8	85.5	68.0	80.0	1.93	0.78	9.2	7.4

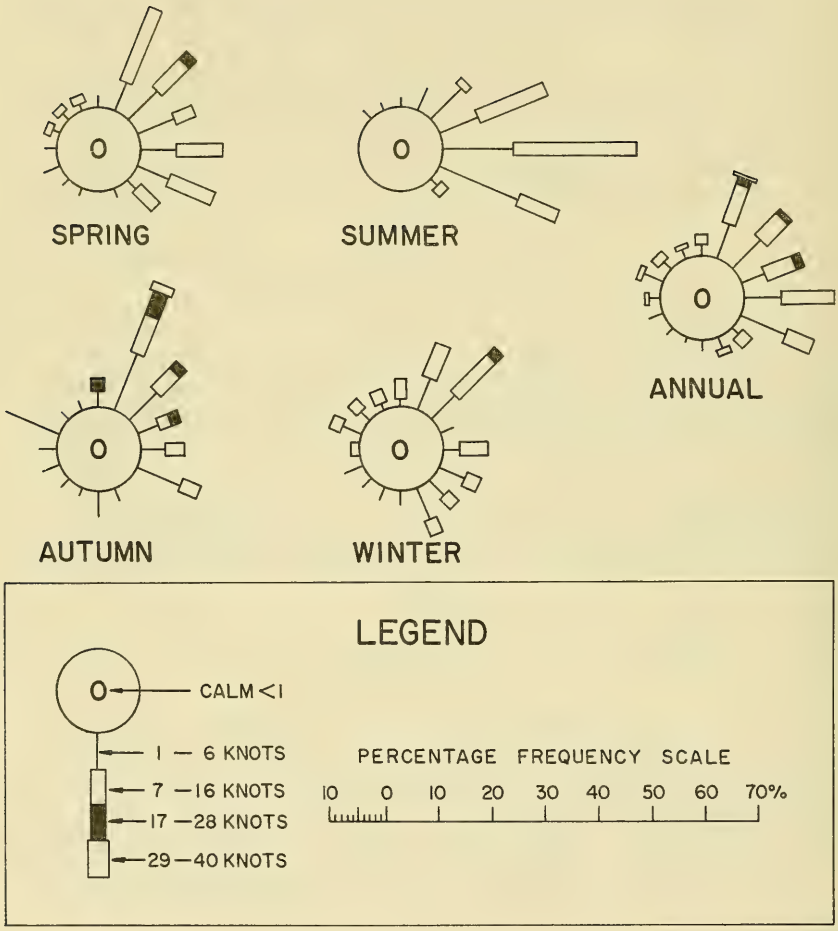

FIGURE 3. SEASONAL AND ANNUAL WIND ROSE AT MANGROVE CAY, ANDROS ISLAND, NOV. 1962 THROUGH OCT. 1964.

Table 2
Tidal Differences Relative to Hampton Roads Predictions

	High Water			Low Water		
	Time		Height	Time		Height
	hr.	min.	ft.	hr.	min.	ft.
Fresh Creek	-1	12	+0.6	-1	36	+0.7
Salvador Point	-1	41	+0.9	-1	42	+0.7
Pigeon Cay	-1	05	+0.9	-1	05	+0.7

WAVES

The barrier reef provides an effective breakwater for waves generated in and outside of the Tongue of the Ocean. Consequently, much of the shoreline on Andros is protected. A wave height of one foot inside the windward lagoon is rare. Along the eastern shore of Golding Cay and High Point Cay, where there is a sheer rock wall over 15 feet high, waves may, however, exceed the one foot height. There is no barrier reef to protect either island. Consequently, the seaward side of the island receives the full force of all westerly waves.

In the Tongue of the Ocean, theoretical wave heights of 11.3 feet can be generated at a wind speed of 26 knots. DeLeonibus (1960) presented Figure 4 which represents observed seasonal wave heights, direction, and frequency in the Tongue of the Ocean. From the same report (Ibid.) Table 3 summarizes the most probable wave heights from all directions for wind speeds ranging from 10 to 26 knots under unlimited duration at the downwind edge of the fetch.

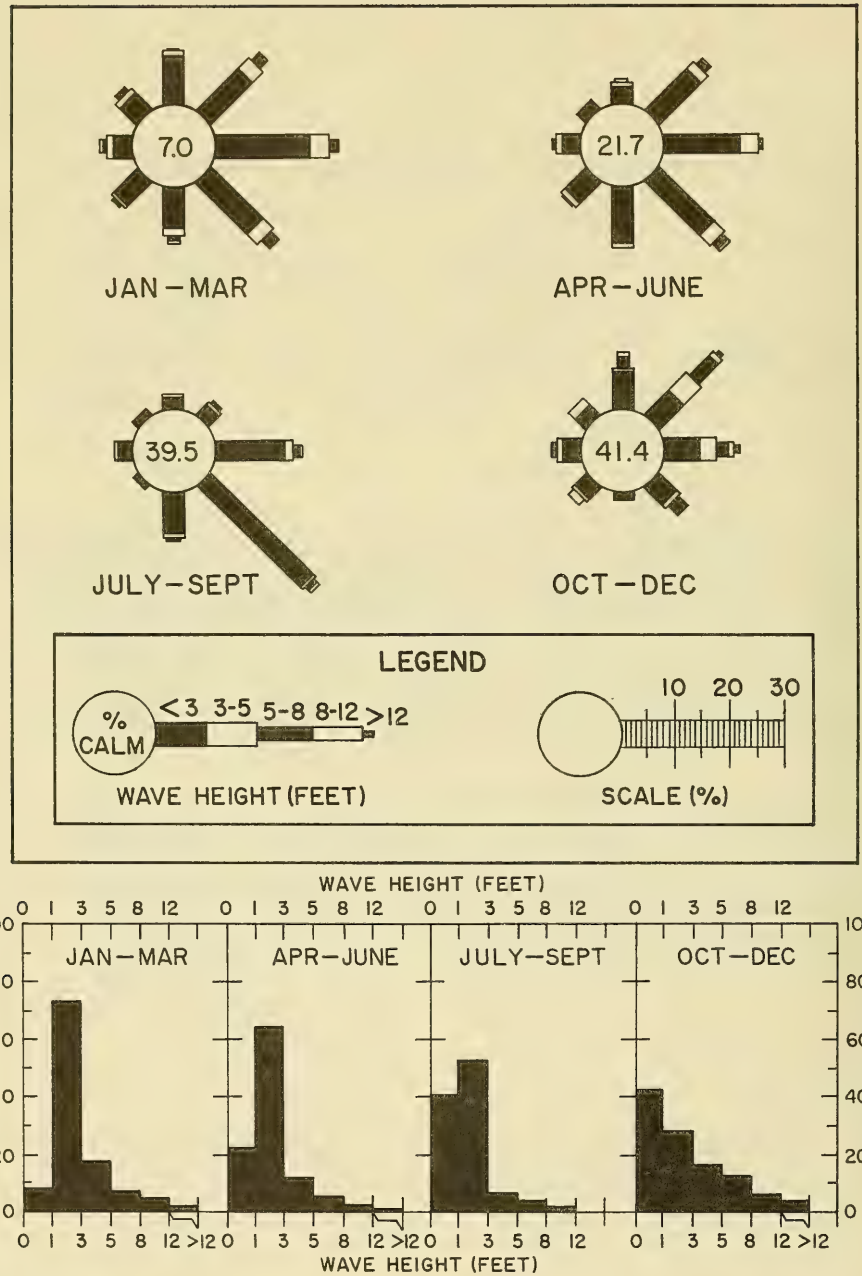

FIGURE 4. OBSERVED SEASONAL WAVE HEIGHTS, DIRECTION AND FREQUENCY IN THE TONGUE OF THE OCEAN.

Table 3
Comparison of Possible Wave Heights in the
Tongue of the Ocean for Different Fetch Orientation

Wind Direction	Max. Fetch Length (N.M.)	Wind Speed (knots) 10	14	18	22	26
		Significant Wave Heights (ft)				
NW - SE	120	1.4	3.2	6.1	10.0	11.3
N - S	70	1.4	3.2	6.1	6.2	6.3
NE - SW	20	1.4	2.8	3.0	3.4	4.3
E - W	20	1.4	2.8	3.0	3.4	4.3

Some swell can occur as a result of persistent northeasterly winds and a considerable amount may be refracted around Clifton Point on the western end of New Providence Island into the TOTO.

FRESH CREEK (SITE 1)

Site 1 is two miles south of the entrance to Fresh Creek on Andros Island. No specific bearing was followed during the Site 1 survey. Instead, the entire area delineated in Figure 5 was reconnoitered and representative bottom photographs were taken. Survey efforts concentrated on the barrier reef and outer platform where divers were towed underwater on plane boards normal to the reef along tracks positioned with Decca.

The backshore area consists of a sand dune 3 to 4 feet high covered by low shrubs and bushes which terminate sharply at the beach face (Plate 1). The beach consists of a medium-grained, calcareous sand sloping gently seaward. The first several hundred yards into the lagoon a clean, sandy bottom is present; proceeding toward the reef the sand thickness decreases and overlies the extension of Andros country rock into the lagoon. The lagoon bottom supports a thinly populated community of various marine organisms. In places where the bottom has little or no sand veneer the organisms have concentrated to form a local topographic high 3 to 5 feet above the general lagoon depth of

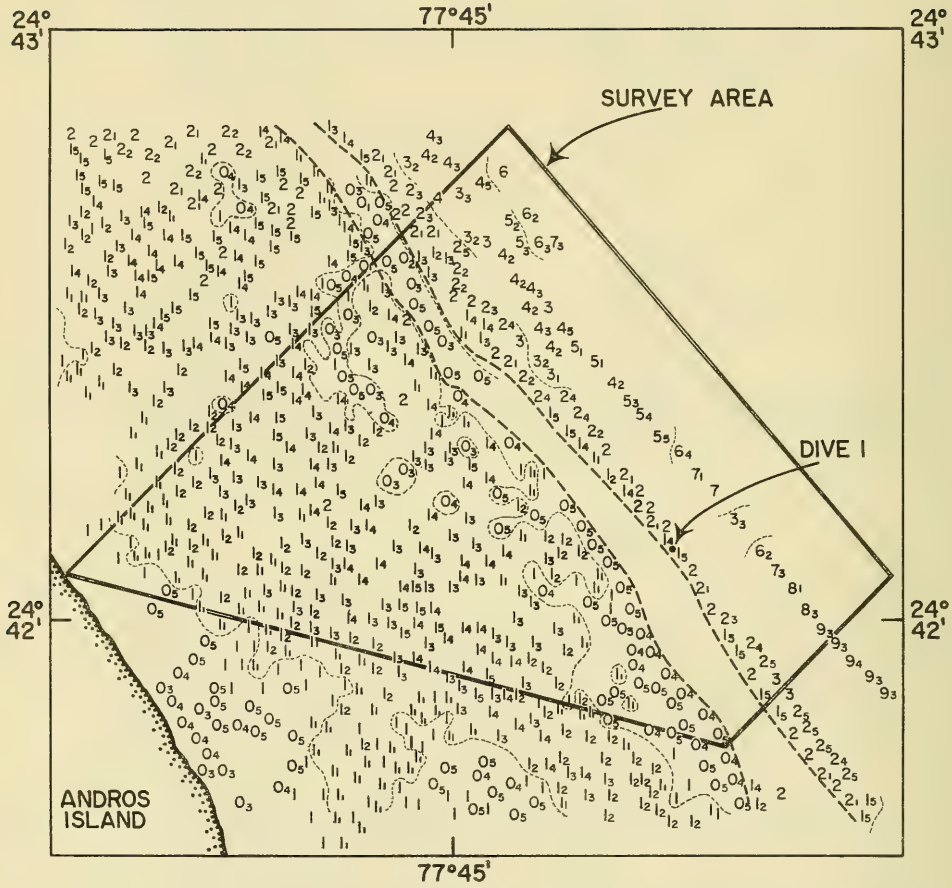

FIGURE 5. DEEP CREEK. BATHYMETRY AND SURVEY AREA. DEPTH IN FATHOMS AND FEET. SOUNDING DATUM M.S.L. -0.5 FEET. APPROXIMATE SCALE 1:17,500.

10 feet.

In the Bahamas, localized areas of luxuriant marine growth (corals, algae, sea fans, etc.) are called "heads." This term will be applied to describe such features here.

The lagoon is 1500 yards wide and transition from lagoon to reef is abrupt and marked by a sharp decrease in depth and an increase in bottom organisms.

Ranging between 200 to 400 feet wide, the barrier reef provides a sharp delineation between lagoon and outer platform (Plate 1). The reef is dominantly populated by Milleporidae, Acropora Palmata, Agaricia agaricites and various alcyonarians (Plate 2). At low tide the reef breaks the surface in several areas and, although a few channels provide passage between lagoon and outer platform, generally presents a solid barrier in the area reconnoitered. Approximately 100 yards south of the southern boundary of the area studied, the solidarity of the reef gives way to scattered heads separated by wide channels 10 to 12 feet deep.

A sharp increase in depth, and a decrease in coral abundance, marks the eastern or seaward termination of the reef and commencement of the outer platform (Plate 2). Extending approximately 500 yards from barrier reef to marginal escarpment, the outer platform ranges from 10 feet to 120 feet deep, and terminates sharply into a precipitous upper marginal or rim escarpment. Between the barrier reef and 20 feet depth the outer platform consists of a hard bottom covered by a thin veneer of coarse sand with occasional gorgonians and scattered massive corals, e.g., Diploria strigosa. In depths greater than 20 feet the population of corals and other marine organisms gradually increases to the point where, between 40 and 60 feet, a virtual forest of corals is present. This "coral forest" is dominated by tall columnar forms of Montastrea annularis. These range from 15 to 20 feet high and are dissected by blindly terminating channels 5 to 10 feet wide and floored by a loose, coarse sand (Plate 3). The luxuriance and variety of marine life on this area of the outer platform is extraordinary and attests to the vigorous water circulation necessary to support such a community. Between 60 and 80 feet in depth the coral abundance gradually decreases and gives way to low (2 to 4 ft. high) heads arranged generally in a spur and groove configuration normal to the reef. From

100 to 120 feet in depth the hard outer platform departs from its gentle seaward slope. There it assumes a dip between 30° and 40° which terminates at 120 feet where a terrace approximately 150 feet wide extends to 130 feet depth at the top of the rim escarpment (Plate 3). The face of this escarpment is discussed on page 24.

SALVADOR POINT (SITE 2)

Site 2 is located 16 miles south of Site 1 and 35 miles south-southwest of New Providence Island. The shoreward cable termination is at latitude 24°29'25"N., and longitude 77°43'9.28"W. This co-ordinate is 250 yards inland of the high water line and approximately 500 yards north of the settlement of Cargill's Creek.

Backshore area of Site 2 consists of a 6 foot sand dune which slopes at approximately 7° to the high water line (Plate 4). The sand is medium-coarse grained calcarenite which overlies, in excess of 3 feet at the crest, a well-indurated beach rock. The beach face terminates abruptly at the low tide terrace and is replaced by a hard limestone dipping gently (2-3°) seaward. Beachrock comprising the low tide terrace is well lithified and sculptured with depressions and cavities a few inches deep and over 1 foot across. The low tide terrace terminates approximately 350 feet seaward of the beach face (marking the limit of Mean Low Water). A few hundred feet seaward of the foreshore termination the bottom consists of a mixed community of small corals, calcareous algae, and sea fans growing on submerged beachrock. This mixed community diminishes 200 feet seaward of MLW and is replaced by a medium-grained sand and grass association. A typical section of the lagoon bottom off Salvador Point is shown in Plate 5. There is little variation in the sand-grass association along the track surveyed, and all indications suggest a stable bottom. Bathymetry of the area from the shoreline to the break-in-slope is presented in Figure 6.

Near the barrier reef (Buoy 8) a large head supporting corals and hydrocorals of the genera Diploria, Favia, and Millepora as well as alcyonarians and other organisms appears (Plate 6). This is the only departure from the sand-grass association.

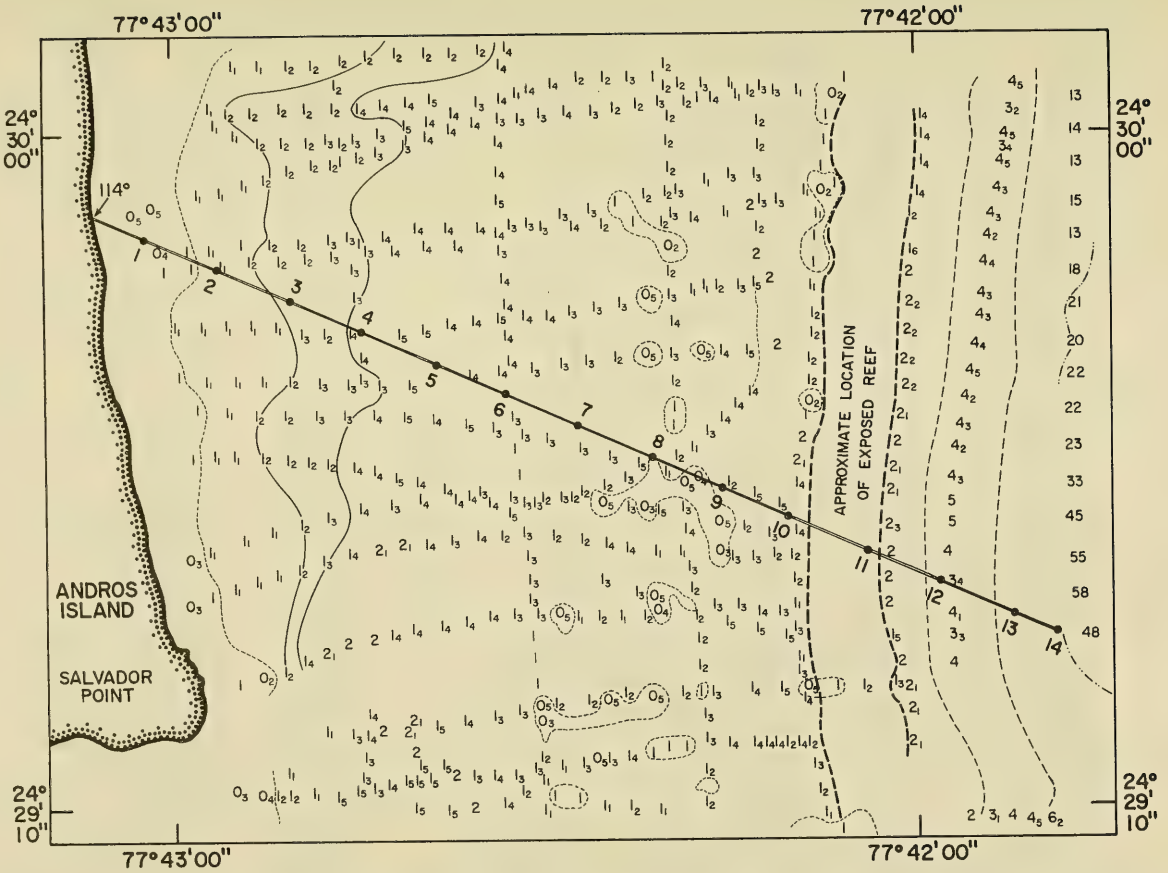

FIGURE 6. SALVADOR POINT. BATHYMETRY, SURVEY TRACK AND LOCATION OF MARKER BOUYS. DEPTH IN FATHOMS AND FEET. SOUNDING DATUM M.S.L. -0.5 FEET. APPROXIMATE SCALE 1:12,800.

Transition from lagoon to barrier reef is abrupt and characterized by a sharp decrease in depth and change in bottom characteristics. The reef is extremely rough with numerous corals and reef debris up to 3 to 4 feet across (Plate 6). The most shallow portion of the reef is 300 to 400 feet wide and, in some areas, awash at low tide.

Immediately seaward of the reef a sharp increase in depth occurs, and at 14 to 16 fathoms the break-in-slope is reached. Below the break-in-slope the bottom is essentially vertical to 100 fathoms.

Immediately adjacent to the seaward side of the reef, on the outer platform, are coral heads ranging from 2 to 10 feet high which present an extremely angular, irregular, hard bottom. Seaward, this association gives way to a spur and groove configuration in which the coral heads are dissected into channels 15 to 20 feet deep and wide. The bottoms of the grooves or channels are hard and covered by a thin, shifting veneer of sand, loose cobbles, and boulders. The spur and groove configuration is obscured near the break-in-slope owing to an increase in sedentary organisms.

In essence, the barrier reef and the outer platform consists of a hard, irregular bottom incised by channels and grooves, and reflects an area subject to vigorous water turbulence.

BIG WOOD CAY (SITE 3)

The survey at Site 3 commenced ashore at approximate latitude 24°20'18.3"N., and longitude 77°41'00.45"W., 300 yards west of the eastern shoreline on the southeast tip of Big Wood Cay. Bathymetry along the survey track of 058° to the break-in-slope is shown in Figure 7.

Loose sand overlying a well-indurated limestone composes the backshore. Immediately west of the dune crest a stand of palm trees gives way to thick, dense shrubs (Plate 7). A few hundred feet inland the sand covering is absent and rough, angular limestone supports thickets of mangroves and other low brush.

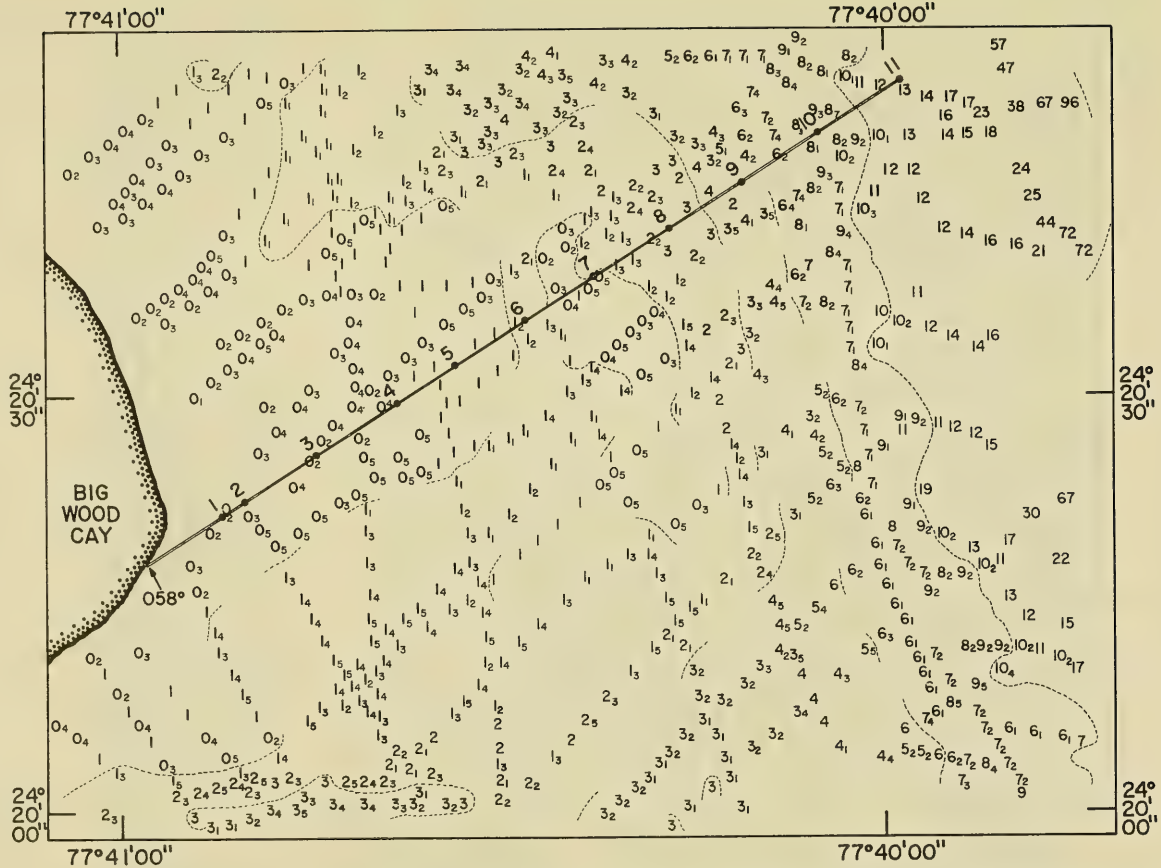

FIGURE 7. BIG WOOD CAY. BATHYMETRY, SURVEY TRACK AND LOCATION OF MARKER BOUYS. DEPTH IN FATHOMS AND FEET. SOUNDING DATUM M.S.L. -0.5 FEET. APPROXIMATE SCALE 1:12,400.

The beach face is steep and consists of an unconsolidated, medium-grained calcareous sand. This is a relatively narrow zone with the lateral distance from crest to the commencement of the low tide terrace approximately 30 feet. At the low tide terrace, the sand terminates abruptly and is replaced by a hard, well eroded limestone. The low tide terrace is 275 feet wide along the survey track and is similar in appearance and composition to the terrace off Salvador Point. Occasional tide pools are present in the beachrock which provide local topographic irregularities.

The lagoon bottom between Big Wood Cay and the offlying reef varies substantially from the bottom off Salvador Point. Here the bottom consists of hard, eroded, and fractured rock which supports numerous and varied organisms. Sea fans and whips dominate the area and scattered coral heads provide relief of from 1 to 2 feet. Plates 8 and 9 are typical of the bottom throughout the lagoon. Lack of a thick sand covering and marine grasses indicates strong water circulation. Circulation is periodic and controlled by the ebb and flood of the tide in the channel between Gibson and Big Wood Cays where a current speed of 1 knot can be observed.

The barrier reef is less distinct along the survey track off Big Wood Cay than at Salvador Point, and is delineated by an increase in coral abundance and species. A few hundred yards north and south of the survey track, the reef is well-developed and stands a few inches above the water surface at low tide. Seaward of the reef the outer platform is similar to that described at Salvador Point. The bottom changes from a forest of coral heads off-reef to a spur and groove configuration in intermediate areas, and finally to a texturally rough and abrupt break-in-slope (Plates 10 and 11).

GOLDING CAY (SITE 4)

Golding Cay is a small island located in the entrance to South Bight. The cay is 600 yards long and 430 yards wide at the maximum. It is 25 feet high in the center and rises abruptly on the east from water depths in excess of 25 feet and slopes more gradually

westward into the shallow South Bight.

The survey commenced at latitude 24°13'08.6"N., and longitude 77°36'11.0"W., and followed a bearing of 125° from the eastern side of the island. The surface of the cay is covered with low shrubs and bushes, except the eastern margin where various grasses prevail. No soil covers the cay, but instead a hard, extremely rough, irregular limestone constitutes the surface (Plate 12). The eastern shore of the cay is distinctly different from the shore at the previously discussed sites. Instead of a sandy, gently sloping beach, an essentially vertical, bare rock wall descending to a water depth of 25 feet is present. No barrier reef protects the cay from surf action. Therefore the full force of all waves coming in from the Tongue of the Ocean is sustained along the eastern shore (Figure 8).

Between Golding Cay and the rim escarpment, the sea bottom supports a luxuriant and varied community of organisms. From the shore to approximately 1,500 yards seaward, the bottom is hard, rough, and covered with coral heads as much as 10 to 15 feet in height and diameter (Plate 13). Locally, ripple-marked, sandy areas separate the heads (Plate 13D). Approximately 1,400 yards from shore, the virtually continuous coral growth breaks into isolated clumps separated by areas of coarse sand. Beyond this to the break-in-slope, a barren sand with scattered gorgonians and soft green algae prevails (Plate 14). The outer platform edge displays an increase in organisms and a rough, hard surface (Plate 15).

DEEP CREEK (SITE 6)

Site 6 is located on the Andros shoreline, 60 miles south of New Providence Island and 1 mile north of the entrance to Deep Creek. The survey track commenced at latitude 24°00'23.3"N., and longitude 77°31'44.0"W., and proceeded along bearing 035°. Bathymetry along the survey track is presented in Figure 9. The backshore area consists of low shrubs and bushes growing atop a well-indurated, eroded limestone (Plate 16). Seaward, the bushes give way to a row of coconut trees and then to an area approximately 100 yards wide consisting of sand dunes 5

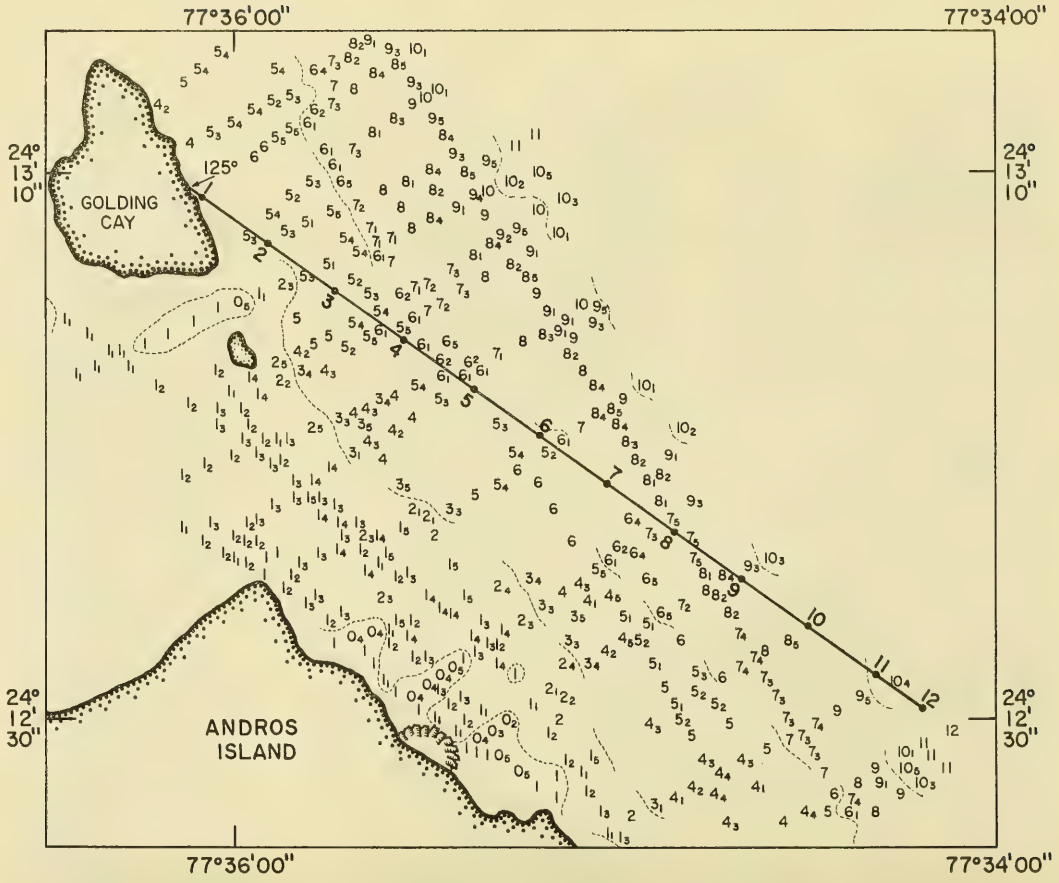

FIGURE 8. GOLDING CAY. BATHYMETRY, SURVEY TRACK AND LOCATION OF MARKER BOUYS. DEPTH IN FATHOMS AND FEET. SOUNDING DATUM M.S.L. -0.5 FEET. APPROXIMATE SCALE 1:12,200.

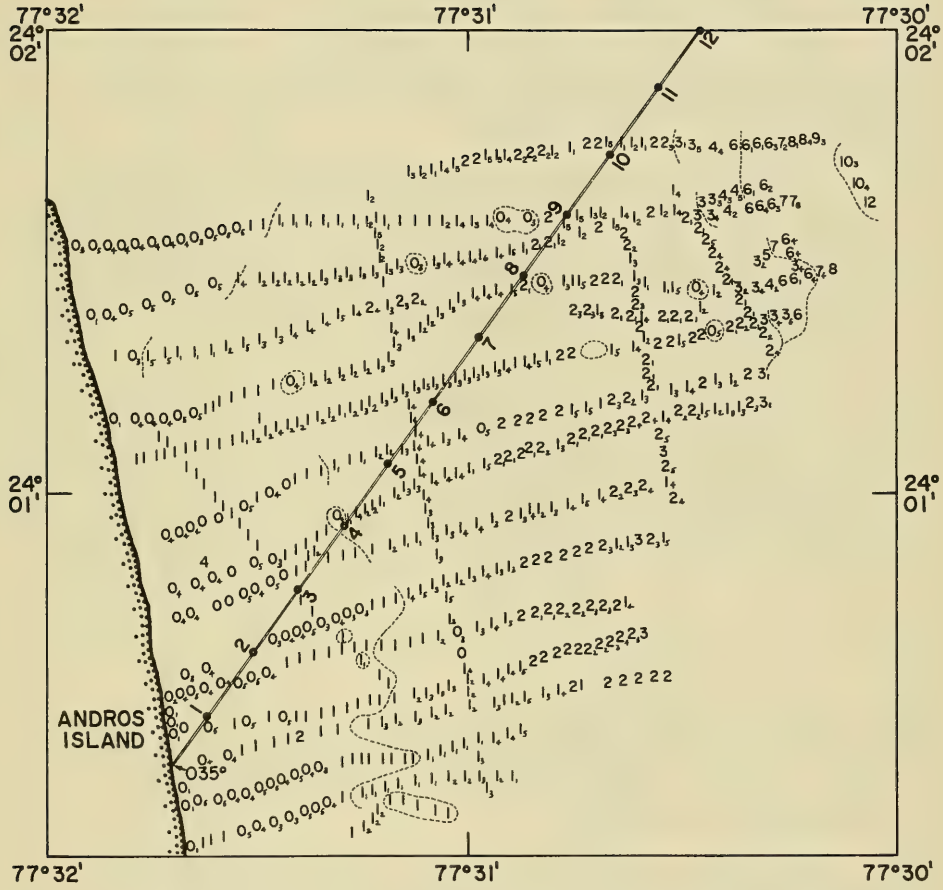

FIGURE 9. DEEP CREEK. BATHYMETRY, SURVEY TRACK AND LOCATION OF MARKER BOUYS. DEPTH IN FATHOMS AND FEET. SOUNDING DATUM M.S.L. -0.5 FEET. APPROXIMATE SCALE 1:25,100.

feet above mean sea level. The shoreline is straight, smooth, and dips gently seaward.

The country rock, as at the other sites, continues out into the lagoon to the barrier reef and is covered with unconsolidated sand ranging in thickness from 1.5 feet nearshore to 5 feet at 1 mile offshore.

The entire lagoon bottom along the survey track consists of a clean, ripple-marked calcareous sand (Plate 17). Scattered throughout the lagoon are irregularly shaped patch reefs (heads) ranging from a few feet to 300 feet across and, in many instances, awash at low tide. The contact between sand and heads is sharply defined and the change in relief is abrupt. The patch reefs support a striking variety of sedentary and free-swimming organisms.

At Buoy 10 (1.6 miles from shore) a dense growth of grass appears which gradually transcends seaward into corals and other organisms (Plate 18). Buoy 10 is at the approximate location of the barrier reef. The reef is not well-developed along this track, and no distinct change in bathymetry marks its boundaries. Seaward of Buoy 10 dense coral growth dominates, and assumes the same pattern as at Golding Cay, e.g., isolated heads and sand areas. This pattern continues to the rim escarpment.

HIGH POINT CAY (SITE 7)

High Point Cay is the southernmost site studied and is a small cay located approximately 700 yards east of Andros Island and 50 miles south of Site 1 at Fresh Creek. The cay is 1,700 yards long, 300 yards wide and reaches an elevation of 50 feet on the eastern end (Figure 10).

The survey commenced at latitude 23°54'01"N., and longitude 77°29'20"W., on the north shore of the eastern end of the cay.

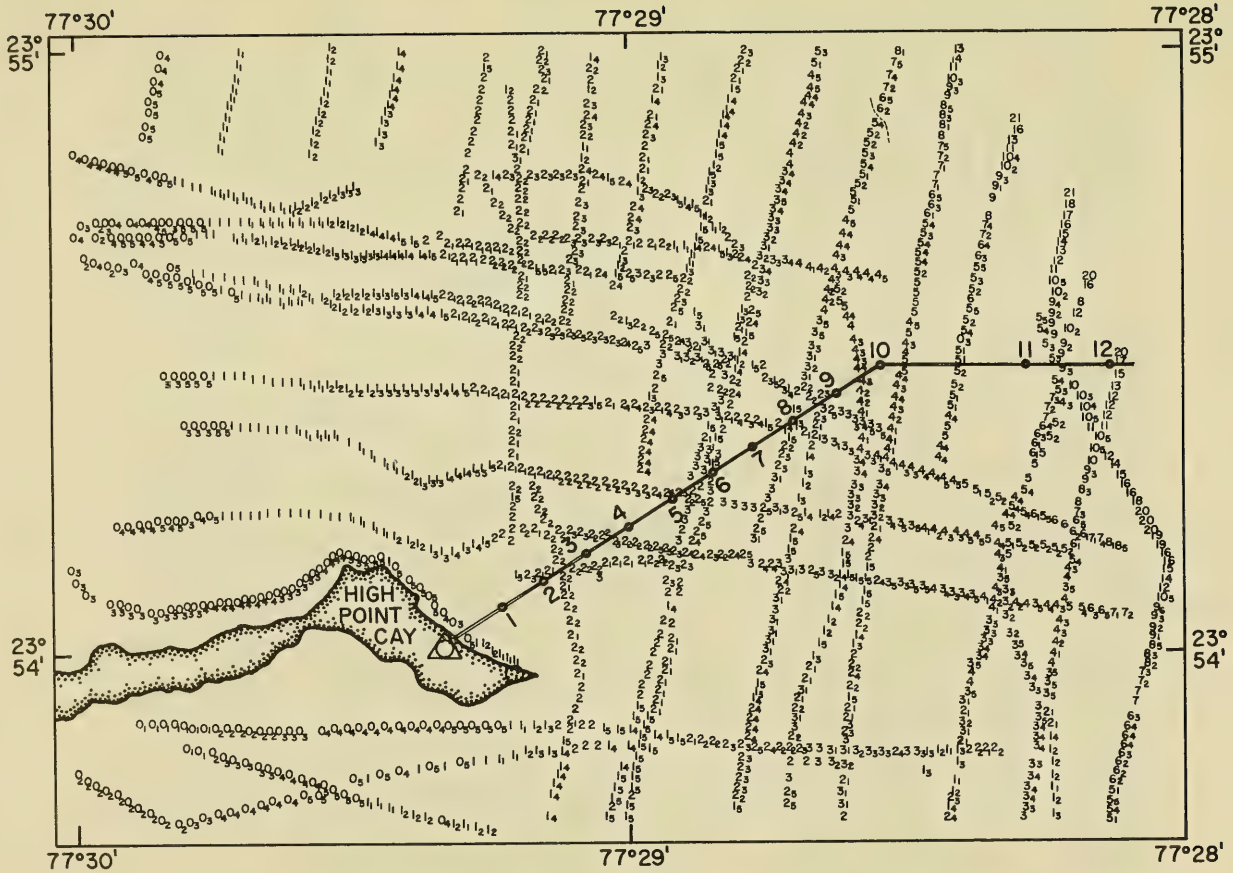

FIGURE 10. HIGH POINT CAY. BATHYMETRY, SURVEY TRACK AND LOCATION OF MARKER BOUYS. DEPTH IN FATHOMS AND FEET. SOUNDING DATUM M.S.L. -0.5 FEET. APPROXIMATE SCALE 1:17,000.

At this point the elevation is 47 feet and the shoreline descends almost vertically to a depth of 5 feet below mean low water. The base of the shoreline below water level is undercut approximately 4 feet and is thoroughly pitted with small angular cavities (Plate 19).

Proceeding along bearing 057° for a distance of 1,750 yards the bottom consists of a hard limestone covered by a thin veneer of coarse sand. Occasional solitary corals occur along the track to Buoy 8. In addition there are isolated heads supporting a sparse marine community (Plates 20 and 21 A & B). In the vicinity of Buoy 9, the bottom changes to a head-sand association. The heads are generally 4 to 5 feet high and up to 10 feet across. Proceeding due east from Buoy 10 the heads increase in abundance to the break-in-slope which occurs at Buoy 12, where the bottom consists entirely of hard, angular corals and algae supporting a variety of soft, sedentary organisms (Plates 21 C & D to 23).

UPPER MARGINAL (RIM) ESCARPMENT

The upper marginal escarpment is that area between the break-in-slope at the eastern edge of the outer platform (14 to 16 fathoms depth) and the TOTO flanks to 100 fathoms depth. The 100 fathom contour is arbitrarily selected due to the depth limitation of the surveying vehicle. The concensus of opinion (Schalk, 1946, Armstrong, 1953, Newell and Rigby, 1953), places the bottom limit around 100 fathoms. Athearn (1963) presented and discussed in detail the bathymetry of the TOTO and stated that the slopes appear to be nearly vertical in the upper 100 fathoms with a distinctly less steep slope below. Detailed bathymetric surveys by NAVOCEANO off the sites discussed here show results compatible to those of Athearn (Ibid.) and places the lower limit of the rim escarpment between 110 and 130 fathoms in depth.

Four areas of the rim escarpment were studied by proceeding due east from the following locations to a depth of 600 feet:

	Dive No.	Latitude(N)	Longitude(W)	Depth(ft)
Fresh Creek	1	24°42.1'	77°44.6'	11
Fresh Creek	2	24°43.0'	77°45.3'	12
Big Wood Cay	3	24°20.0'	77°41.25'	16
Golding Cay	4	24°13.2'	77°36.0'	30

A sketch showing the major features and their depth of occurrence is presented in Plate 24 which is a composite representation of the wall as derived from data collected on all dives. Regionally, little difference is present in the rim characteristics at all four locations. The spur and groove configuration which is distinct and extends to the break-in-slope at dive location 1 is less distinct at dive 2 and not present at dives 3 and 4. Also present at dive 1 is a well-defined notch in the wall which commences at 170 feet and ends abruptly at 200 feet. This notch is continuous for more than 100 yards on both sides of the survey line and penetrates in excess of 20 feet into the wall. On the remaining dives no well-defined notch was observed. The similarity of this notch to the intertidal notches observable at the base of present day Bahamian cays and islands is striking, (see Plate 19C of High Point Cay) and strongly suggests formation at a previous lower sea level.

Typically, the rim escarpment between the break-in-slope and 400 to 450 foot depths consists of a hard rock wall texturally rough and thoroughly sculptured by caves, small terraces, and notches ranging from a few feet to 20 and 30 feet magnitude and covered with a thin veneer of sand in the crevices and on the terraces (Plate 25 A&B). Between 400 and 450 feet in depth these features gradually diminish and, while not completely absent, give way to a wall of smoother appearance, though still texturally rough. This configuration continues to 600 feet and at least 20 to 30 feet deeper. Visability at the 600 foot depth was between 20 and 30 feet with ambient light. Occasional large blocks of rock can be observed at this depth which have broken off from above and slid down the escarpment. Although the wall still appears vertical at the 600 foot level an increase in the coverage and thickness of the sand veneer suggests a decrease in the slope gradient.

At the 350 foot level minor undulations trending parallel to the wall are apparent. These undulations are no more than

1 foot from crest to trough and 6 feet across and are present beyond the 600 foot depth (Plate 25C). It is tempting to consider these as the commencement of the gullies described by Athearn (1963) which are present in the slopes below 100 fathoms and which reach a magnitude of 600 feet in height and 1 mile wide.

Direct measurement of the wall's slope gradient was not possible from the submersible. When the submersible proceeded horizontally at a distance of 4 or 5 feet from the wall, above the 400 foot level, the course lead frequently into a cave or under an overhang. If the submersible was held a few feet from the wall the view through the bottom viewing port showed nothing but water directly below. Although this is a very rough measurement at best, some definitive measurement was provided at dive site 3 off Middle Bight where several underwater cables leading from shallow to deep ($>$ 100 fms) water were present. From the top of the rim escarpment to 600 feet the cables were 30 to 60 feet away from the wall and never were observed to lay against the wall (Plate 25). Since the cable length is sufficient to allow the cable to lay on the bottom, this arrangement attests to the steep slopes present in the upper 100 fathoms.

Marine organisms such as algae and coral are present in abundance to 200 feet and decrease decidedly below this depth. A specimen of the reef coral Agarcia sp. was observed at 340 feet while gorgonians and sponges were observed to 540 feet. Below 500 feet the wall is essentially devoid of sedentary organisms visable to the naked eye.

A representative sequence of photographs showing the rim escarpment off dive site 4 (Golding Cay) is shown in Plates 26 and 27.

SUMMARY AND CONCLUSIONS

A graphic presentation of the major shoreline, lagoon, reef, and outer (seaward) platform features of the sites studied is presented in Plate 28. Although a detailed survey of the lagoon off Fresh Creek is not presented, it is almost identical to the survey off Salvador Point. Salient characteristics of the areas studied are as follows:

a. Where the barrier reef is well developed the lagoon bottom tends toward a thick sand accumulation and stability. An exception is Big Wood Cay which is atypical because of strong tidal currents sweeping the Middle Bight Channel.

b. The barrier reef becomes less distinct proceeding from north to south along Andros Island.

c. Where no barrier reef is present, e.g., Golding Cay and High Point Cay, the bottom is characterized by scattered large coral-algal heads and a thin veneer of coarse sand.

d. The outer platform supports a more luxuriant coral-algal and marine community where barrier reef development is strongest.

e. Dominant reef corals in the major zones are:

Lagoons - Favia fragum, Siderastrea radians, Manicina areolata, Porites porites, and occasional Diploria strigosa.

Barrier Reef - Millepora sp., Agaricia agaricites var. crassa, Acropora palmata.

Outer Platform - Montastrea annularis, Porites astreoides, Acropora cervicornis.

Rim Escarpment - Montastrea cavernosa, Agaricia sp.

f. The outer platform slopes gently seaward and is interrupted in some areas by terraces running parallel to the reef. The surface of the platform is hard, texturally rough, and has numerous local topographic irregularities (e.g., spurs and grooves, scattered and closely spaced coral heads).

The upper marginal or rim escarpment commences generally between 14 and 16 fathoms and descends almost vertically to depths in excess of 100 fathoms. The escarpment face is thoroughly sculptured by caves, terraces, and notches strongly suggesting former exposure to sub-aerial or intertidal erosion. Below 450 feet in depth these features diminish in size and frequency, and the wall, while still texturally rough, appears somewhat smoother and sediment accumulation is greater.

Below 500 feet large marine organisms are not present and a desolate, barren bottom is evidenced. Occasional large blocks of reef rock or sections of the wall which have broken off from above and slid downslope are present at the 600 foot level.

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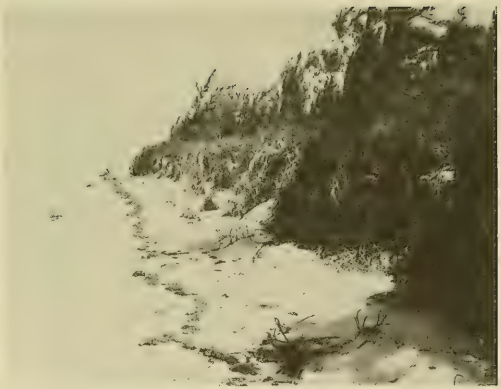
A



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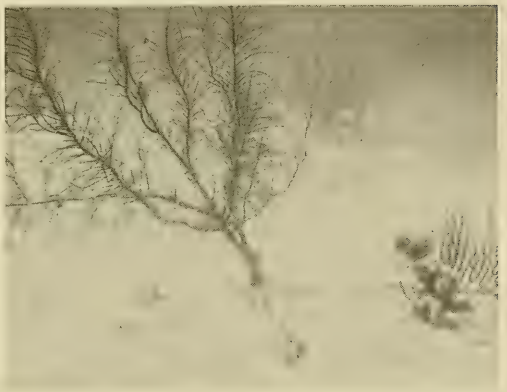
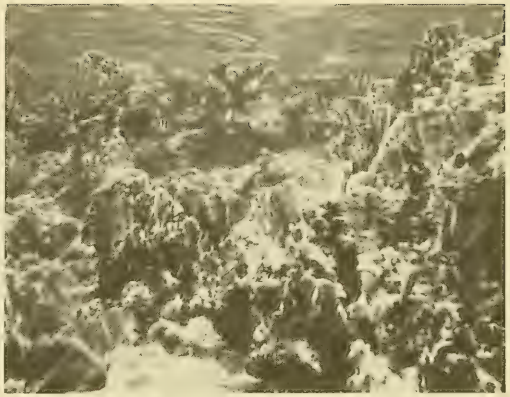


D

PLATE I. FRESH CREEK (A) AERIAL VIEW OF MAIN BASE SITE AND TURNING BASIN, (B) BEACH FACE, (C) AERIAL VIEW OF LAGOON AND BARRIER REEF, (D) TYPICAL AREA OF LAGOON BOTTOM, DEPTH 6 FEET.



A

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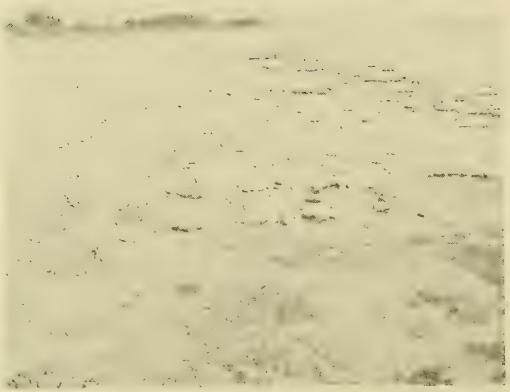
PLATE 2. FRESH CREEK BARRIER REEF (A) AS VIEWED FROM LAGOON, DEPTH 5 FEET, (B) ACROPORA PALMATA AWASH AT LOW TIDE, (C) OUTER PLATFORM ADJACENT TO BARRIER REEF, DEPTH 8 FEET, (D) OUTER PLATFORM BETWEEN 40 AND 60 FEET DEEP.

A B C D

PLATE 3. FRESH CREEK (A) ONE OF THE BLIND CHANNELS IN THE ZONE OF LUXURIANT CORAL GROWTH BETWEEN 40 TO 60 FEET DEPTH, (B) OUTER PLATFORM, DEPTH 110 TO 130 FEET, (C) DETAILED VIEW OF OUTER PLATFORM SHOWING HARD BOTTOM AND THIN SAND VENEER, (D) VERTICAL DOWNWARD VIEW OF EDGE OF OUTER PLATFORM AT 130 FEET. NOTE TERRACE TO RIGHT OF PHOTOGRAPH APPROXIMATELY 15 FEET DEEPER.

A

B



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D

PLATE 4. SALVADOR POINT (A) AERIAL VIEW OF SITE 2 AND TURNING BASIN, (B) VIEW OF BEACH FACE PRIOR TO CONSTRUCTION, (C) LOW TIDE TERRACE, (D) BEACHROCK COMPRISING LOW TIDE TERRACE. HAMMER IS 14 INCHES LONG.

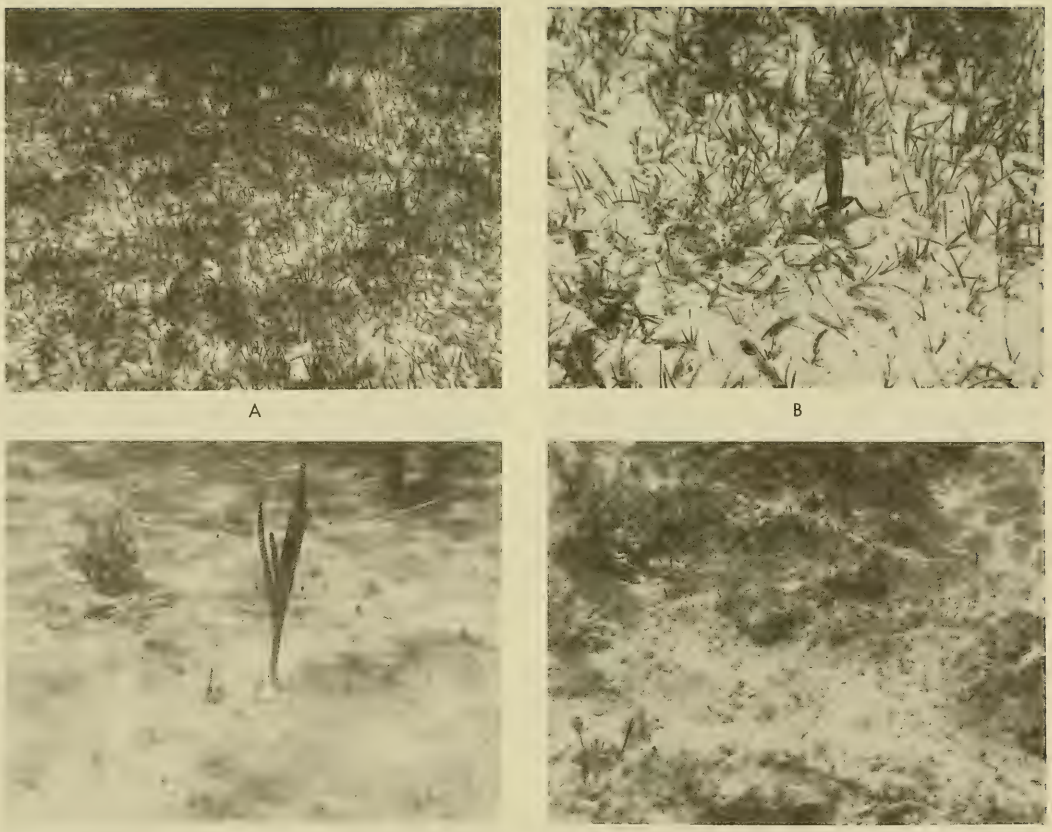


PLATE 5. SALVADOR POINT (A) & (B) TYPICAL LAGOON BOTTOM, BUOY 6, DEPTH 9 FEET. KNIFE HANDLE IS 4 INCHES LONG. (C) & (D) EXTREMITIES OF PATCH REEF, BUOY 8, DEPTH 5 FEET.

A

B

C

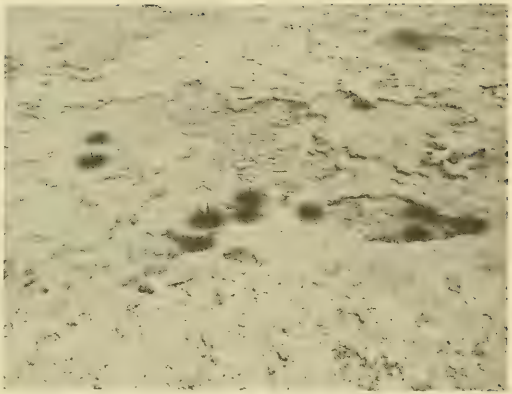
D

PLATE 6. SALVADOR POINT (A) & (B) PATCH REEF, BUOY 8, DEPTH 3 FEET, (C) BARRIER REEF ON LAGOON SIDE, AND (D) SEAWARD SIDE. DEPTH 5 FEET. LARGE CORAL IN FOREGROUND IS ACROPORA PALMATA.

A B C D

PLATE 7. BIG WOOD CAY (A) AERIAL VIEW OF SITE 3, TURNING BASIN, AND LAGOON. (B) BEACH FACE. (C) LOW TIDE TERRRACE BEACH ROCK. (D) DETAILED VIEW OF BEACHROCK, POLE IS MARKED AT I-FOOT INTERVALS.

A



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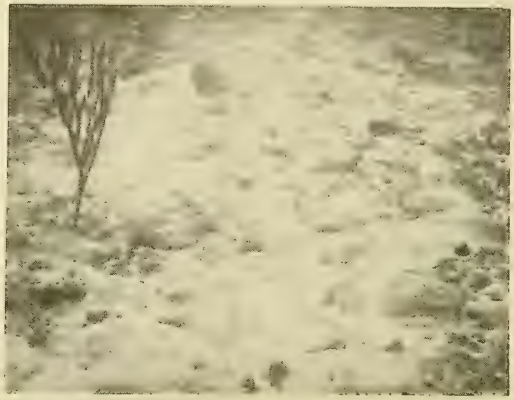

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PLATE 8. BIG WOOD CAY (A) LOW TIDE TERRACE VIEWED SHOREWARD, (B) TERRACE TIDE POOL WITH SEA URCHINS, (C) & (D) LAGOON BOTTOM BETWEEN BUOYS 1 TO 4, DEPTH 4 FEET (LOW TIDE).

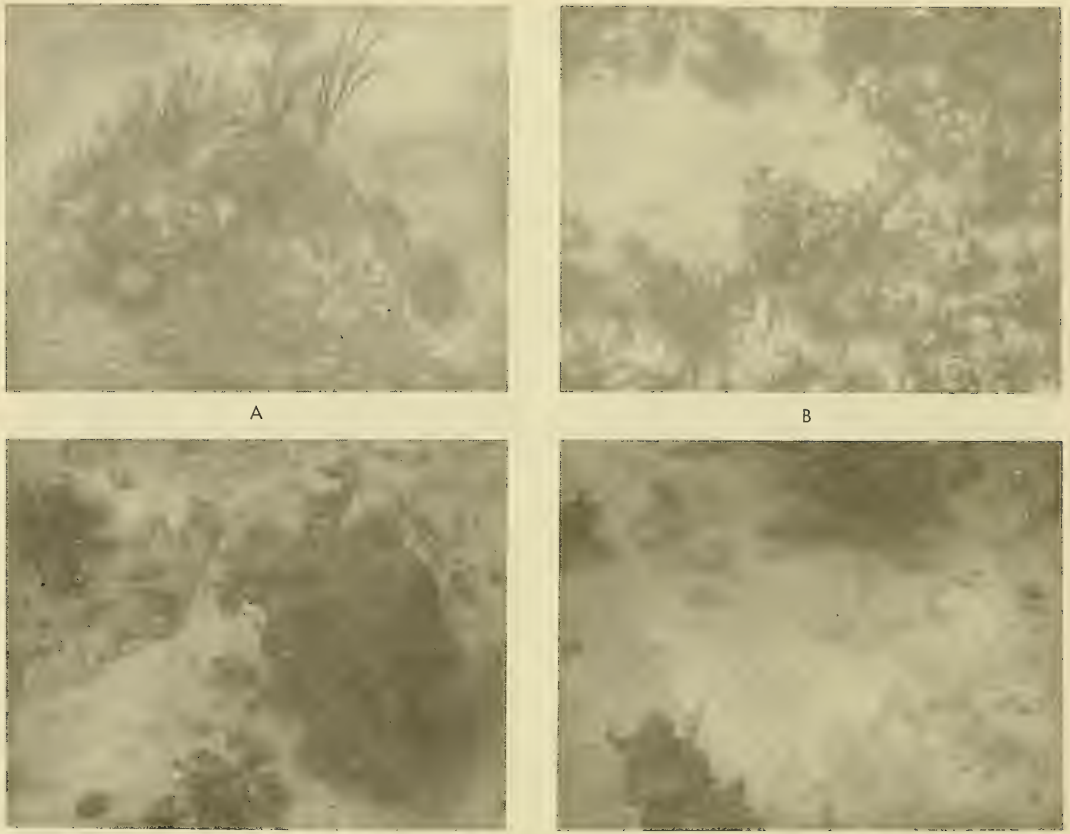
A

B

C

D

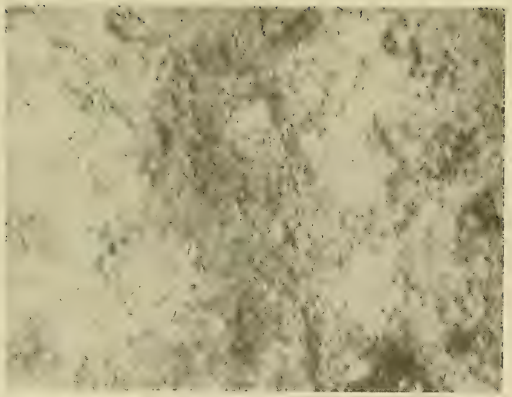
PLATE 9. BIG WOOD CAY (A) LAGOON BOTTOM BETWEEN BUOYS 1 TO 4, DEPTH 4 FEET (LOW TIDE), (C) & (D) LAGOON BOTTOM AT BUOY 5, DEPTH 5 FEET. ROUNDED CORAL (DIPLORIA CLIVOSA) IS 1 FOOT ACROSS.



A B C D

PLATE 10. BIG WOOD CAY (A) & (B) OUTER PLATFORM, DEPTH 18 FEET. HEAD IN (A) IS 8 FEET LONG AND 4 TO 5 FEET HIGH. DOMINANT CORAL IN (B) IS MONTASTREA ANNULARIS. (C) & (D) DEPTH 24 FEET SHOWING HEADS AND RIPPLE MARKED SAND ASSOCIATION.

A



B

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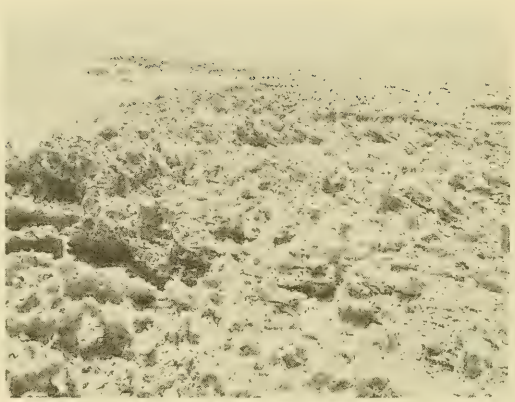
D

PLATE II. BIG WOOD CAY (A) VIEW INTO SURGE CHANNEL AT 50 FEET DEPTH, (B) DETAILED VIEW OF HARD ROCK CONSTITUTING SURFACE OF SURGE CHANNEL WALLS, (C) OUTER PLATFORM AT 85 FEET DEPTH, (D) VIEW OVER RIM ESCARPMENT, DEPTH 90 FEET.



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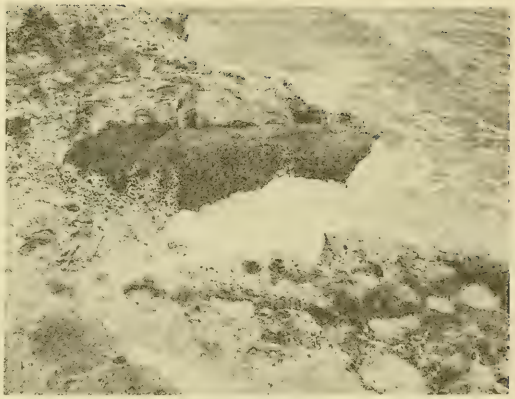

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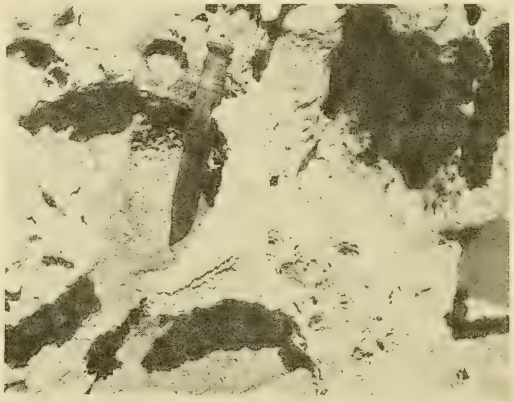


C

D

PLATE 12. GOLDING CAY (A) & (B) EASTERN SHORELINE, (C) & (D) DETAILED VIEW OF CAY ROCK. KNIFE IS 8 IN. LONG.

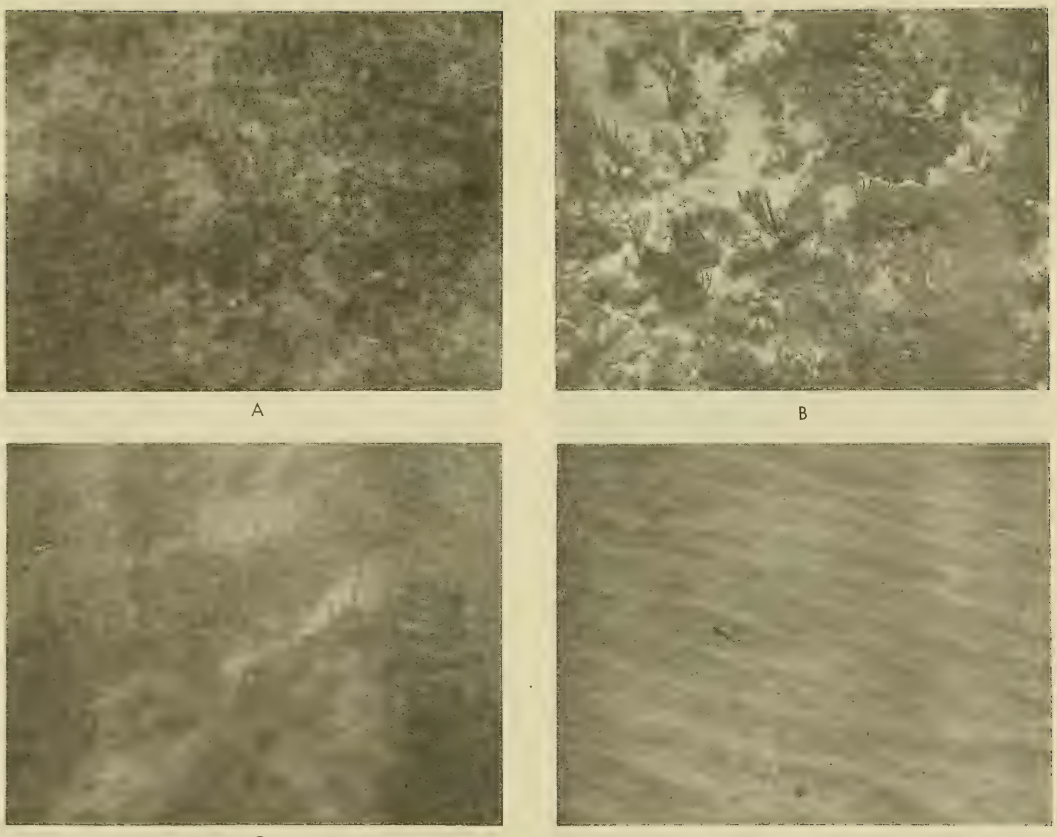
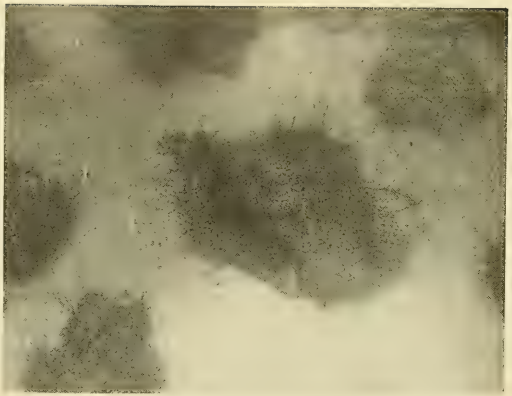


PLATE 13. GOLDING CAY (A) & (B) BOTTOM AT 25 AND 30 FEET DEPTH ADJACENT TO CAY, (C) BOTTOM AT BUOY 4, DEPTH 36 FEET, SHOWING SPUR AND GROOVE CONFIGURATION, (D) BOTTOM AT BUOY 3, DEPTH 30 FEET SHOWING RIPPLE MARKED SANDS.



A

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PLATE 14. GOLDING CAY (A) BOTTOM AT BUOY 8, DEPTH 45 FEET. HEADS ARE 3 TO 5 FEET HIGH AND 6 TO 8 FEET ACROSS. (B) & (C) BOTTOM BETWEEN BUOYS 9 AND 11, DEPTH 50 TO 60 FEET. (D) BOTTOM BETWEEN BUOYS 11 AND 12, DEPTH 120 FEET.

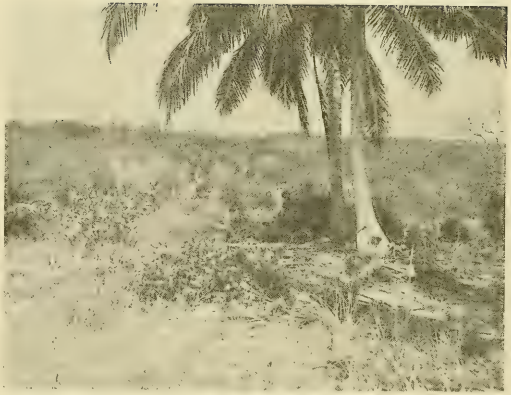
A

B

C

D

PLATE 15. GOLDING CAY (A) LARGE CORAL HEAD AT 125 FEET DEPTH DOMINANTLY COMPOSED OF MONTASTREA CAVERNOSA. (B) & (C) OBLIQUE VIEW DOWN RIM ESCARPMENT FROM EDGE OF OUTER PLATFORM. (D) VIEW ALONG WALL OF RIM ESCARPMENT, DEPTH 130 FEET.



A

B

C

D

PLATE 16. DEEP CREEK (A) BACKSHORE AREA. (B) DETAILED VIEW OF COUNTRY ROCK. KNIFE IS 8 INCHES LONG. (C) & (D) VIEWS OF BEACH FACE.

A

B

C

D

PLATE 17. DEEP CREEK (A) TYPICAL LAGOON BOTTOM, DEPTH 6 FEET. (B) CONTACT BETWEEN SAND AND STUNTED PATCH REEF. (C) LAGOON HEAD, DOMINANT CORAL PORITES ASTREOIDES. (D) LAGOON HEAD, DOMINANT CORAL ACROPORA PALMATA.

A

B

C

D

PLATE 18. DEEP CREEK (A) GRASS AND SAND BOTTOM AT BUOY 10, DEPTH 11 FEET. (B) SEAWARD OF SAND-GRASS AREA SHOWING HARD, ROUGH BOTTOM, DEPTH 15 FEET. (C) & (D) OUTER PLATFORM SPURS AND GROOVES AND ISOLATED HEADS, DEPTH 30 FEET. BUOY 11.

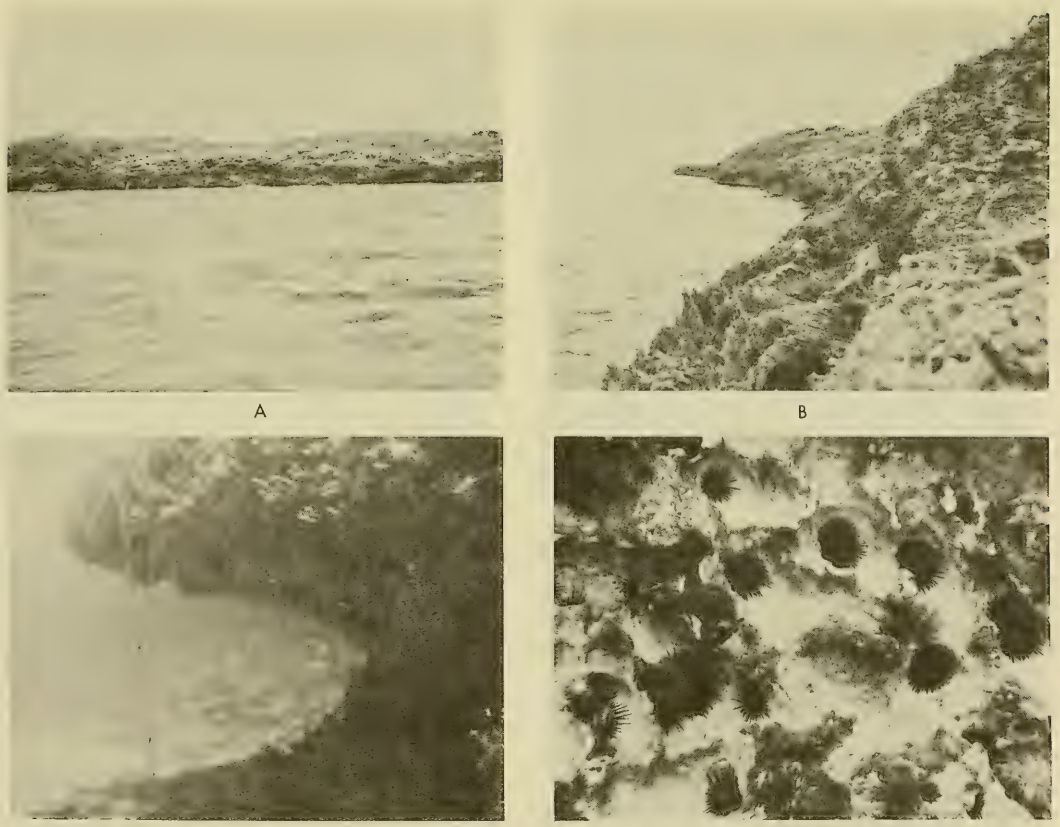
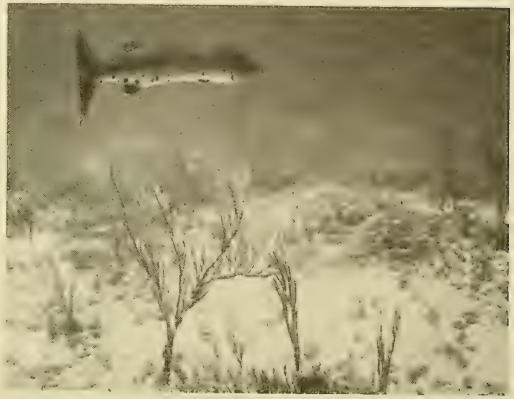


PLATE 19. HIGH POINT CAY: (A) AND (B) NORTH SIDE OF CAY, BLUFFS 15-20 FEET HIGH. (C) UNDERCUT BLUFFS, WATER DEPTH 6 FEET. POLE IS MARKED AT 1 FOOT INTERVALS. (D) DETAILED VIEW OF WALL AT UNDERCUT SHOWING ROUGH, ANGULAR SURFACE AND SEA URCHINS.

A

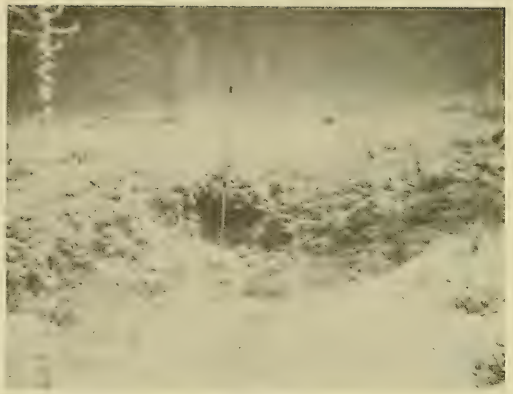
B

C



D

PLATE 20. HIGH POINT CAY (A) & (B) BUOY 3. DEPTH 12 FEET. CORAL IN (B) IS DIPLORIA LABRYNTHIFORMIS. (C) & (D) BUOY 4, DEPTH 15 FEET.



A

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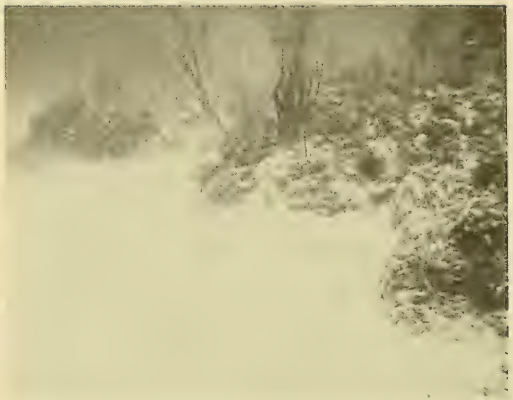
PLATE 21. HIGH POINT CAY (A) & (B) BUOY 7, DEPTH 24 FEET. THIN SAND VENEER OVER HARD ROCK. (C) & (D) BUOY 9, DEPTH 30 FEET. COMMENCEMENT OF LARGE HEADS AND IRREGULAR BOTTOM TOPOGRAPHY.

A



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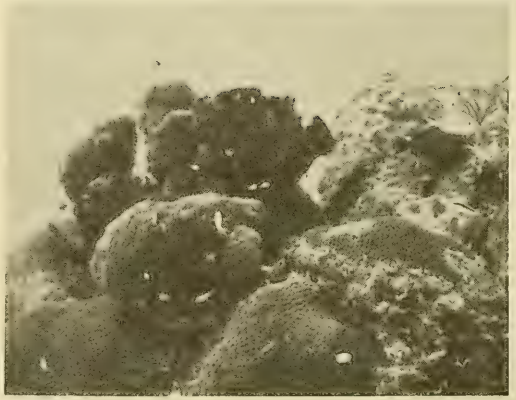


C

D

PLATE 22. HIGH POINT CAY (A) & (B) BUOY 10, DEPTH 37 FEET. (C) BUOY 11, DEPTH 60 FEET. (D) SEAWARD OF BUOY 11, DEPTH 90 FEET.

A

B

C

D

PLATE 23. HIGH POINT CAY, SERIES OF PHOTOGRAPHS SHOWING EDGE OF OUTER PLATFORM AT 130 FEET DEPTH. NOTE UNDERCUT WALL AT PLATFORM'S EDGE IN (A).

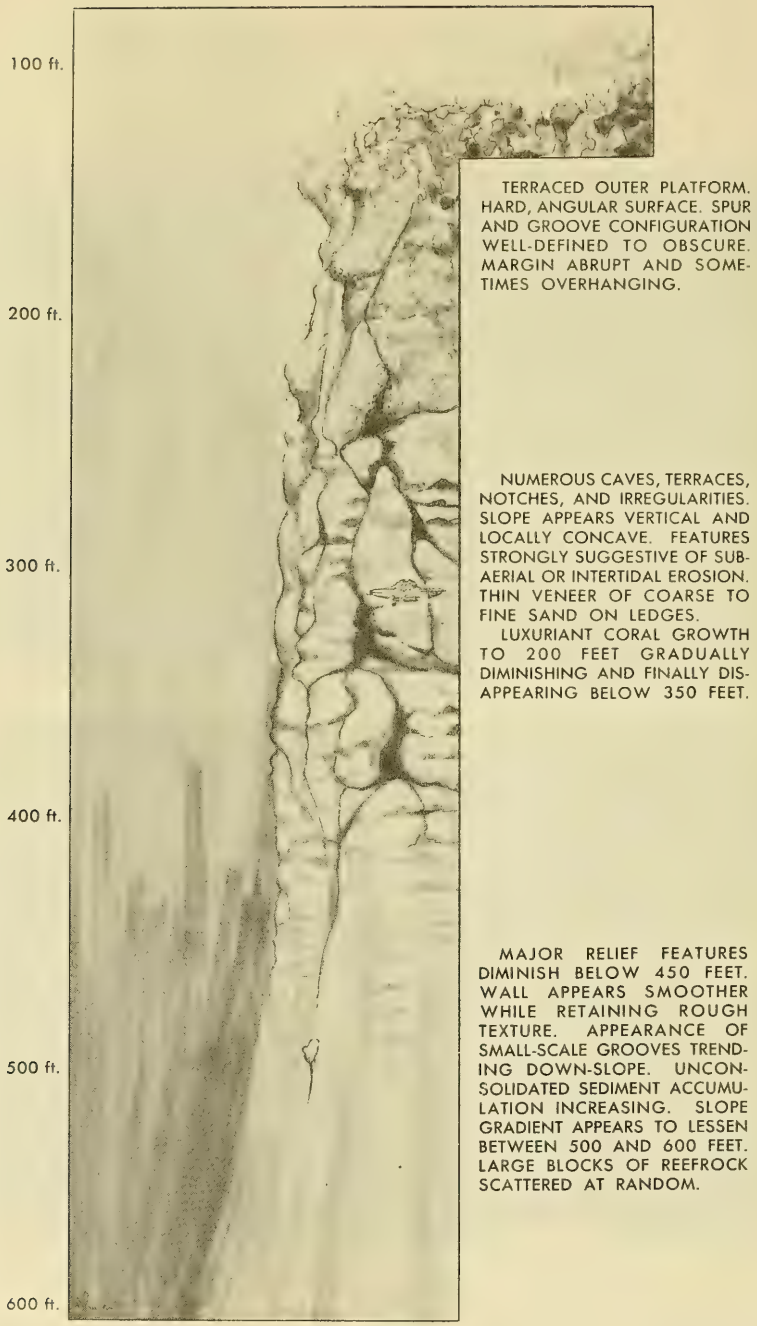
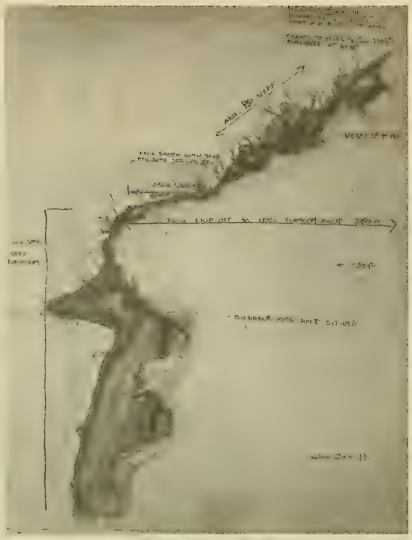


PLATE 24. TONGUE OF THE OCEAN, WESTERN MARGINAL (RIM) ESCARPMENT FROM OUTER PLATFORM EDGE TO 600 FEET DEPTH.

A



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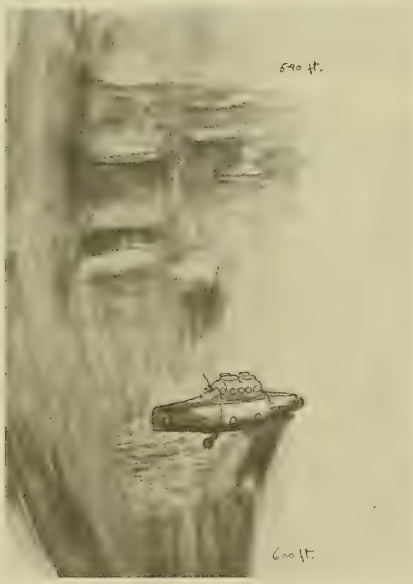
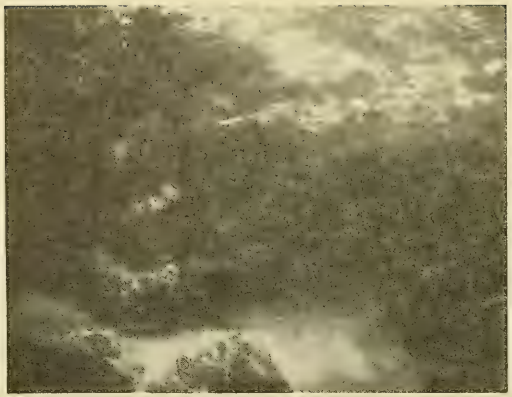


D

PLATE 25. TONGUE OF THE OCEAN, DRAWINGS SHOWING MAJOR FEATURES OF RIM ESCARPMENT. (A) CORES, TERRACES AND SAND FLOWS BETWEEN 130 AND 450 FEET. (B) PROFILE OF SAME AREA SHOWN IN A. (C) ESCARPMENT AND CABLES OFF BIG WOOD CAY. (D) SHOWING THE SMOOTHER NATURE OF THE EXCARPMENT BELOW 450 FEET.



A

B

C

D

PLATE 26. REPRESENTATIVE PHOTOGRAPHS OF MARGINAL ESCARPMENT OFF GOLDING CAY. (A) 210 FEET. (B) 242 FEET. (C) 270 FEET. (D) 312 FEET.

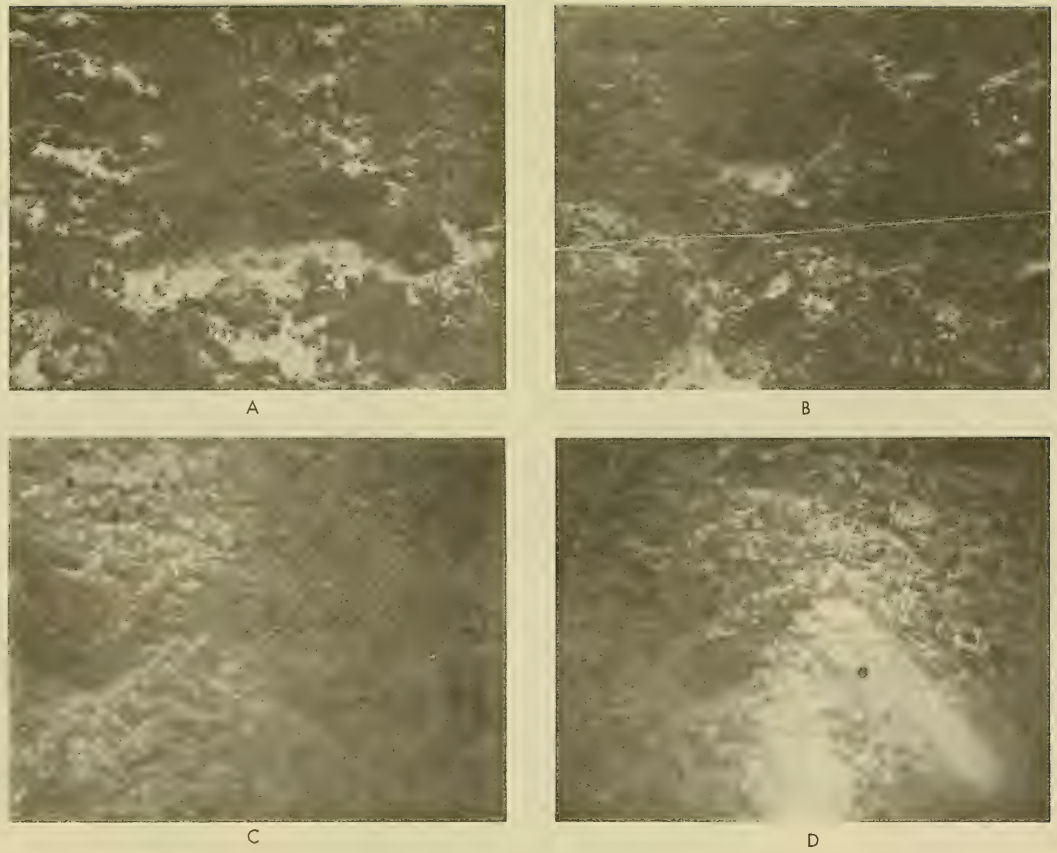
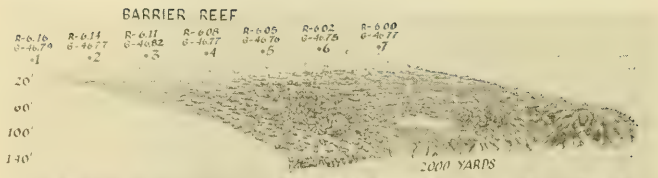


PLATE 27. REPRESENTATIVE PHOTOGRAPHS OF MARGINAL ESCARPMENT OFF GOLDING CAY. (A) 343 FEET. (B) 349 FEET. (C) 447 FEET. (D) 450 FEET.



BARRIER REEF TO MARGINAL ESCARPMENT

SALVADOR POINT SITE *2

BIG WOOD CAY SITE *3

GOLDING CAY SITE *4

DEEP CREEK SITE *6

HIGH POINT CAY SITE *7

PLATE 28. DRAWINGS SHOWING MAJOR FEATURES ALONG THE SHALLOW WATER SURVEY TRACKS.

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)*: U. S. Naval Oceanographic Office

2a. REPORT SECURITY CLASSIFICATION: Unclassified

2b GROUP: ---

3. REPORT TITLE: Ocean Bottom Reconnaissance off the East Coast of Andros Island, Bahamas

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

5. AUTHOR(S) *(Last name, first name, initial)*: Busby, Roswell F.; Bright, Chester V.; and Pruna, Andres

6. REPORT DATE	7a. TOTAL NO. OF PAGES	7b. NO. OF REFS
March 1966	59	6

8a. CONTRACT OR GRANT NO.

b. PROJECT NO.

c.

d.

9a. ORIGINATOR'S REPORT NUMBER(S): Technical Report 189

9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*

10. AVAILABILITY/LIMITATION NOTICES: None

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY: Bureau of Ships

13. ABSTRACT

A visual and photographic survey of the shore and ocean bottom to 600 feet (100 fathoms) depth was performed off selected sites on the east coast of Andros Island, Bahamas. Climatology and oceanographic conditions are also presented. Survey methods employed both SCUBA divers and a manned submersible (Perry Cubmarine PC3-B) to provide direct visual observation and measurement of bottom features.

The Andros shoreline was observed to vary considerably in morphology and composition: barrier reef development ranges from well-developed to virtually non-existent from north to south along Andros Island. A marginal escarpment commencing offshore between 14 and 16 fathoms was observed to descend almost vertically to 100 fathoms. Various morphologic features of the escarpment suggest a lowering of sea level and subsequent subaerial and intertidal erosive processes which have been active in the recent geologic past.

DD FORM 1 JAN 64 1473

UNCLASSIFIED

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
AUTEC, Bahamas, Bottom Reconnaissance, Andros Island, Cable Surveys						

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OCEAN BOTTOM RECONNAISSANCE OFF THE EAST COAST OF ANDROS ISLAND, BAHAMAS, by Roswell F. Busby, Chester V. Bright, and Andres Pruna, March 1966. 59 p., 10 figs., 28 plates (TR-189)

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2. Andros Island, East Coast-Bottom Reconnaissance

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ii. authors: Roswell F. Busby, Chester V. Bright, Andres Pruna

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