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LOUIS S. KORNICKER

F. BONET

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CHARLES M. HOSKIN

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LOUIS S. KORNICKER
Institute of Marine Science
Port Aransas, Texas

F. BONET
Instituto de Geologia
Escuela Nacional de Ciencias Biologicas
Mexico, D.F.

ROSS CANN
Columbia University
New York, New York

AND

CHARLES M. HOSKIN
Institute of Marine Science
Port Aransas, Texas

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Abstract

A geological study was made of the Alacran Reef, a complex of living coral reefs situated on the Campeche Bank north of the Yucatan Peninsula. The paper contains a map showing the distribution and bathymetry of reef zones; profiles of the reef outer slope, reef front, lagoon, and area between the mainland and the reef; analyses of typical reef sediments; photographs of characteristic reef features; and a list of reef corals, mollusks, and other invertebrates. The reef has the form of an atoll, with a central "lagoon" having a maximum depth of about 75 feet. The reef outer slope rises from a water depth of about 160 feet to 20–50 feet where there is a marked decrease in slope. The decrease in slope approximately coincides with the depth of a sharp break in the slope on the Campeche Bank between Progreso and the reef which suggests that they may have a common origin; possibly both are the result of marine erosion during a low stand of the sea during the Pleistocene. The arcuate shape and

northwesterly orientation of the Alacran Reef results from its being in the northeast trade wind belt. Alacran Reef as a whole is probably in an earlier phase of development than all the rest of the reefs of the Campeche Bank and the reefs of Veracruz and Anton Lizardo.

Introduction

Alacran Reef is a complex of coral reefs located about 70 miles north of the port of Progreso, Yucatan, Mexico, and about 30 miles south of the scarp forming the northern edge of the Campeche Bank (Figure 1). Alacran Reef is larger than three other coral reefs Cayo Arĉas, Triangulos, and Cayo Arenas situated near the bank edge east and south of Alacran Reef. It is the only reef along the Mexican coast having a topographic feature that resembles a lagoon.

The reefs of the Campeche Bank seem to have received less scientific attention than other reefs in the world, *e.g.*, the fairly comprehensive bibliography of organic reefs, bioherms, and biostromes compiled by the Seismograph Service Corporation and edited by W. E. Pugh (1950) contains no references to the reefs of the Campeche Bank. Alacran Reef was visited in 1878 by Alexander Agassiz (1879), who briefly described the reef in a letter written to C. P. Patterson, Superintendent U.S. Coast Survey, Washington, D.C. Agassiz (1888) described the reef in more detail in Volume 1 of "Three Cruises of the United Coast and Geodetic Survey Steamer 'Blake'."

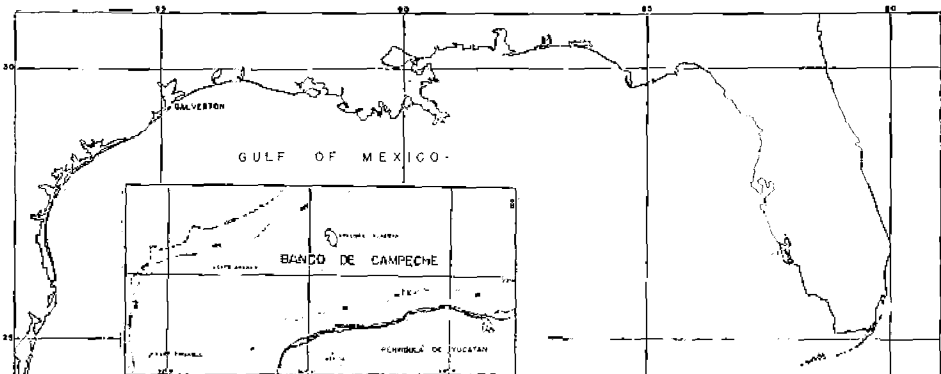


FIG. 1. Map showing location of the Alacran Reef. Bathymetry in the vicinity of Alacran Reef is shown on Chart 1290, 1942, of the United States Hydrographic Office.

Present day areas where carbonates are being deposited hold considerable interest for geologists principally because of the abundance of carbonate rock in the geologic record (Le Blanc and Breeding, 1957). The Campeche Bank may afford sedimentary conditions more like the widespread carbonate shelves of earlier geologic times than the Bahama Banks which are completely isolated from the continent, or Florida Bay whose sediments seem unique in many respects (F. Lozo, written communication, 1957).

The writers are participants in a scientific investigation of the geology and biology of Alacran Reef and surrounding waters sponsored by the Instituto de Geologia of Mexico. The present contribution, resulting from field work on the reef during June, 1959, consists of a map of the reef prepared on a photogrammetric base, fathometric profiles across the reef and between the reef and the mainland, and a general description of the reef.

Acknowledgments

This work was financed by grant number NSF-G 8902 from the National Science Foundation. Field work on the Alacran Reef would not have been possible without the groundwork laid by Ing. Guillermo P. Salas, Director, Instituto de Geologia, Mexico. We are most appreciative of the tireless efforts of Director Salas in behalf of the investigators taking part in the expedition.

The present contribution concerning the submarine topography of the reef was helped considerably by the able assistance of Ing. Amado Yañez of the Instituto de Geologia, and by the loan of a fathometer by this Institute when our instrument was in need of repair. Dr. Robert L. Folk, who is studying the processes involved in the formation of the sand islands of the reef, gave us a clearer picture of sedimentary processes at work on the reef.

Other participants whose work contributed to the success of the expedition were Dr. Henry Hildebrand; Ing. Humberto Chavez; Ing. Julio Monges; Ing. Carlos Cañon Amara; Ing.Rafael Marquez C.; Sr. C. Duran; Sr. A. Arias; Sr. R. Bravo; Sr. A. Diaz; and Messrs. J. Dan Powell, Henry Compton and Thomas Wright. Of special note was the help of Captain J. Lezama and Lieutenant J. Becerril, of the Mexican Navy, whose understanding of the problems involved and interest made the operation move smoothly and swiftly. We are also appreciative of the hospitality and assistance received from C. Lic. Joaquin R. De LaGala, C. Administrador de la Aduana in Progreso, and personnel of the Mexican Government stationed on the island of Perez, especially Sr. Cándido Sánchez Cabañas and Lieutenant Gorge E. Roff. Much of the logistical work on the Yucatan Peninsula was done by Sr. F. Javier Campos, Jr. and Sr. F. Javier Campos, Sr. whose assistance was invaluable. Mr. Charles D. Wise has reviewed the manuscript and assisted with basic logistics.

The field work of Charles M. Hoskin was partly supported by an award from the National Research Council, Foreign Field Research Program. The analyses of sediments presented in this paper were made by Mr. Hoskin preliminary to a comprehensive study of the submarine sediments of Alacran Reef for a dissertation in geology at The University of Texas. Dr. Henry Hildebrand is studying the fish and crustaceans of Alacran Reef and collected some of the octacorals reported in this paper. The octacorals were

identified by Dr. F. M. Bayer through the courtesy of Dr. Fenner A. Chase and the United States National Museum.

We are very grateful for criticism of the manuscript by Dr. Henry Hildebrand, Dr. John Imbrie, Dr. Robert L. Folk, and Dr. Harry S. Ladd.

The Campeche Bank

The Yucatan Peninsula separates the Gulf of Mexico on the north and west from the Antillean Sea on the east. The land is low-lying, under 650 feet in height, and is made of Tertiary limestone with karst topography. The country is almost devoid of rivers. The peninsula extends out under the gulf for an average distance of about 125 miles to form the Campeche Bank and then descends abruptly into the deep water of the gulf (Schuchert, 1935).

The origin of the escarpment bounding the Campeche Bank has not been established with certainty. A long held theory of faulting (Schuchert, 1935 and Alvarez, 1949) has recently been challenged by Miller and Ewing (1956) who conclude from magnetic measurements made on the northern edge that scarps bounding the Campeche Bank are not tectonic. According to Miller and Ewing (1956), the observed magnetic anomalies can be accounted for if the edges of the Campeche Bank are formed on a row of basaltic volcanoes which subsided as lime formed; a similar origin was suggested for the eastern edge of the Bahamas. Newell (1955) concluded that the Bahama rim escarpment is the front of a drowned barrier reef, probably of late Tertiary age. It is not unlikely that the Campeche Bank escarpment has a similar history. It may be mentioned in this connection that in two deep corings made by Petroleos Mexicanos (Sacapuc and Chicxulub) near Progreso, Yucatan; an andesitic flow has been found under a thick sequence of Tertiary sediments (Sansores, 1959).

A series of bottom profiles was constructed from the records of a Bendix 0-300 foot depth recorder. A profile between Alacran Reef and Progreso, Yucatan (Figure 2) shows that the bottom slopes sharply away from land to a depth of approximately 40 feet and then the slope decreases and remains fairly constant for the remaining distance to Alacran Reef. The depth of the sharp break in slope approximately coincides with the lower edge of the reef front (Figure 3, A-J) which suggests that they may have a

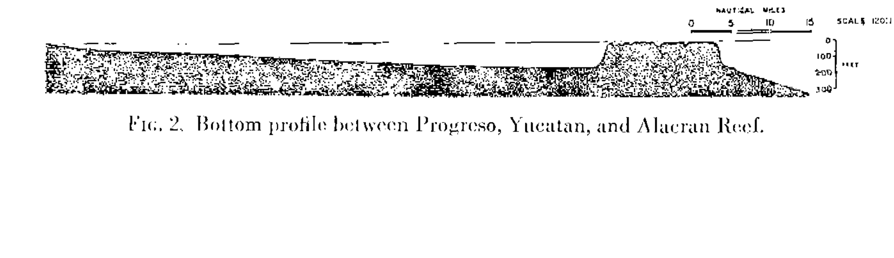


Fig. 2. Bottom profile between Progreso, Yucatan, and Alacran Reef.

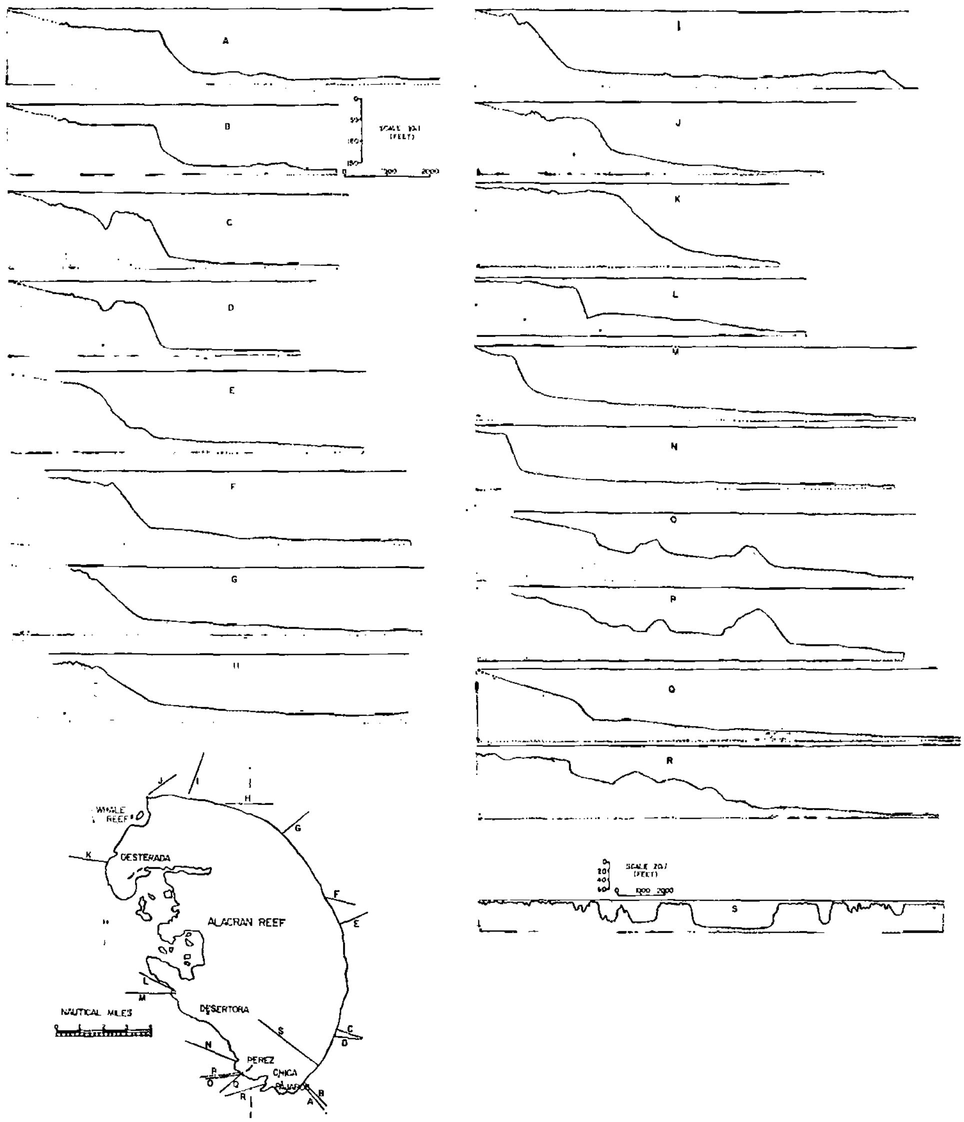


FIG. 3. Bottom profiles at Alacran Reef and location map.

common origin; possibly both are the result of marine erosion during a low stand of the sea during the Pleistocene. The bottom between Progreso and Alacran Reef has minor depressions and prominences which seem more abundant at about 75 feet depth. These may be remnants of karst topography formed during exposure of the Campeche Bank during some glacial period. Sampling over a prominence using a Van Veen dredge indicated a rock bottom. Several profiles made between Progreso and the reef indicated that the strip containing many prominences and depressions was more or less linear and paralleled the coast. Sediments were absent over much of the bottom between Progreso and the reef. Where present, the sediment consisted of bioclastic, well-sorted, medium to fine grained carbonate sand. The strong water currents between Progreso and the Alacran Reef probably exert a winnowing action on bottom sediments.

The Campeche Bank is in the northeast tradewind belt. These winds probably account for the arcuate shape and orientation of Alacran Reef. Year-round westward moving water currents across the Campeche Bank probably also influence the shape and orientation of the reef.

Alacran Reef Outer Slope and Reef Front

The outer slope is the steeply descending part of the reef below the dwindle point of abundant living coral and coralline algae (Tracey, Cloud, and Emery, 1955). The upper margin of the outer slope of Alacran Reef is marked by an abrupt decrease in slope at 30 to 50 feet depth on the windward side of the reef and somewhat shallower on the lee side, 20 to 30 feet depth (Figure 3). On the windward side of the reef the outer range of *Acropora palmata* approximately coincides with the upper margin of the outer slope.

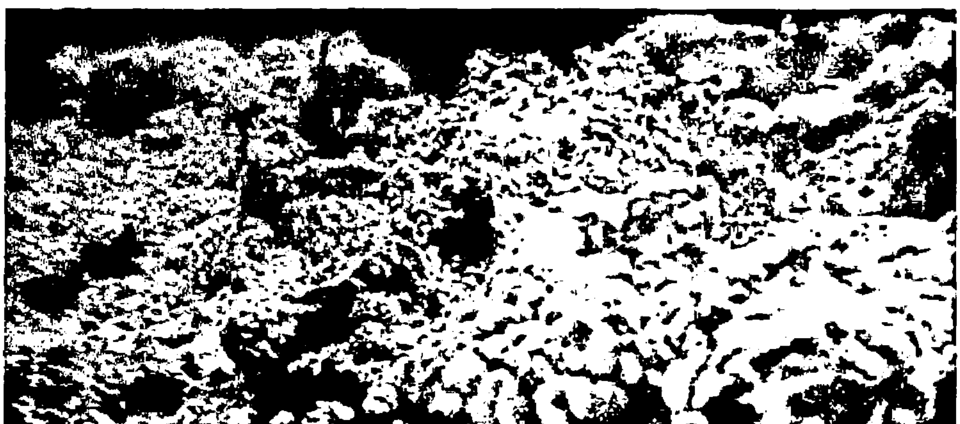


FIG. 5. Proliferous growth of soft, encrusting coral coating overhanging ledge in shallow water of inner edge of reef near Pajaros.

FIG. 6. Typical growth of *Acropora palmata* on the southern end of reef near Pajaros.

FIG. 7. Natural bridge in reef caused by erosion or coral overgrowth. Sea fan is obscure in left foreground. Soft, encrusting corals coat reef rock.

Because of the clarity of the water it was possible to make observations of the bottom from the water surface in water 90 feet deep. At this depth a large part of the bottom consists of open sand areas, and the only corals observed were massive types. At a 60 foot depth, which is considered the upper part of the outer slope, massive corals, sea pens, and sea whips are abundant and a low algal growth covers about 50 per cent of the bottom. The sea floor at the base of the outer slope is at a depth of approximately 160 feet. In general, the outer slope is more gentle at the lower part, probably as a result of talus accumulation. On the sea floor out from the outer slope, local topographic rises probably represent embryo reefs which are not living at the present time (Figure 3, L).

The reef front is the upper seaward face of the reef, extending above the dwindle point of abundant living coral and coralline algae to the reef edge (Tracey, Cloud, and Emery, 1955). The reef front of the Alacran Reef includes a shelf up to three-quarters of a mile wide. On the windward side of the reef the inner limit of the shelf might be considered as the intertidal zone. On the lee side of the reef the inner margin of the shelf is the lagoon because here the reef edge is below water (Figure 4). Zones of organic life more or less parallel the windward side of the reef. Below the intertidal zone in about four feet of water *Acropora palmata* is common but an encrusting soft coral is the dominant organism (Figure 5). *Acropora palmata* becomes dominant in about 15 feet of water and then decreases in abundance disappearing at the upper edge of the outer slope (Figure 6). Gorgonians are common from the intertidal zone (Figure 7) to about 45 feet water depth. Massive corals including *Diploria* and *Montastrea* are abundant on the shelf. *Millepora* was observed down to about 45 feet water depth. *Halimeda* is extremely abundant especially in the shallower part of the shelf.

The shelf on the lee side of Alacran Reef contains patch reefs that almost reach the surface in water as deep as 14 feet but dwindle in deeper water. Beds of *Thalassia* and *Sargassum* cover much of the bottom. *Acropora palmata, Diploria* and *Montastrea, Gorgonia, Millepora*, and sea whips are abundant on the patch reefs. *Acropora palmata* which grows in a stunted condition on Alacran Reef, is scarce on the bottom between the reefs. Rock ledges two feet or more in height are quite common on the lee shelf. The windward shelf sediments are very coarse sands and gravels composed mostly of *Acropora* fragments, mollusk hash, Foraminifera, and *Halimeda* plates (Table I and Figure 8). The leeward shelf sediments contain similar components but are finer with a smaller component of *Acropora* fragments and a greater component of Foraminifera tests. Reef front grooves running perpendicular to the reef edge were observed along the northern part of the windward upper shelf.

An interesting topographic feature at Alacran are "ridges" around the southern end of the reef, both on the windward side (Figure 3, C and D) and lee side (Figure 3, O and P). These ridges have their tops almost at the same level as the deeper part of the lagoon and with the bottom of the marginal channel. These features may be the remnants of a platform cut by waves during a low stand of the sea.

Alacran Reef Seaward Margin and Reef Flat

The seaward reef margin is the seaward edge of the reef flat (Tracey, Cloud, and Emery, 1955). The windward edge of the Alacran Reef is marked by breakers and is

TABLE 1

Composition and descriptive parameters of Alacran Reef sediments[a]

	Sediment from windward reef front	Sediment from windward reef flat	Sediment from *Thalassia* patch on inner reef flat	Sediment from lagoon bottom at 65 feet water depth	Sediment from central depression at a lagoon patch reef
Composition %					
Halimeda	50.0	17.8	33.6	10.5	36.6
Mollusks	13.8	19.3	25.4	31.0	16.5
Coral	16.8	25.1	26.2	14.5	20.3
Foraminifera	16.2	22.0	7.9	21.0	14.6
Coralline algae	1.2	4.6	2.2	9.4	3.9
Ostracodes	....	1.0	0.7	6.3	0.7
Spicules	0.6	5.4	1.5	5.8	1.9
Sediment Parameters					
Mean grain size					
Phi (-log₂ diam.)	0.07	1.33	0.87	4.08	— 0.58
mm	1.05	0.40	0.56	0.06	1.55
Grain size name	Very coarse sand	Medium sand	Coarse sand	Coarse silt	Very coarse sand
Inclusive	1.32	0.92	1.39	0.70	1.39
Graphic standard deviation[b]	Poorly sorted	Moderately poorly sorted	Poorly sorted	Moderately sorted	Poorly sorted
Inclusive	0.40	0.01	— 0.30	— 0.74	0.86
Graphic skewness†	Strongly fine skewed	Nearly symmetrical	Coarse skewed	Strongly coarse skewed	Strongly fine skewed

[a] *Table 1 is solely the work of Charles M. Hoskin.*

[b] See Folk, R. L., and Ward, W. C., 1957, Brazos River bar: a study in the significance of grain size parameters: Jour. Sed. Pet., 27, 3 26.

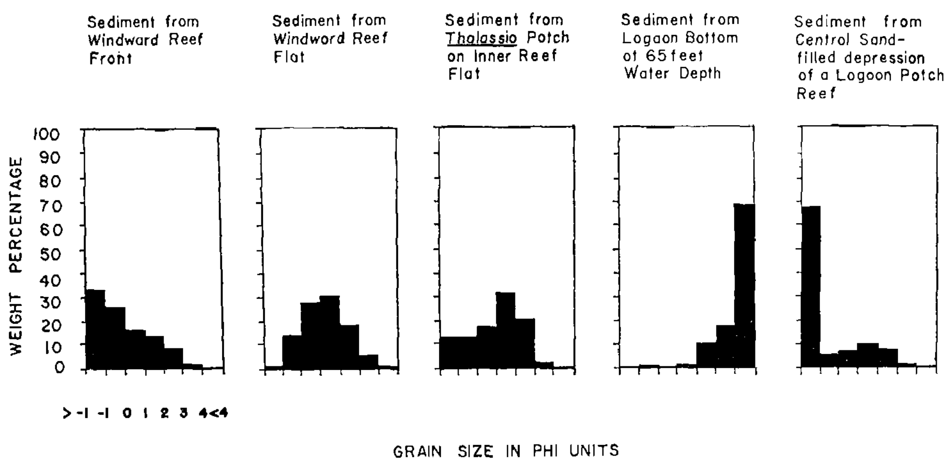


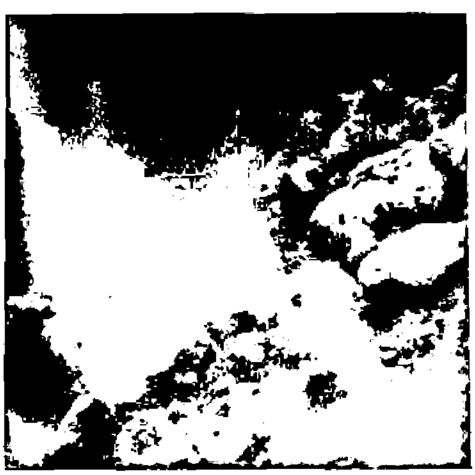
FIG. 8. *Histograms showing the size distribution of selected sediments.*

above water at low tide. No distinct coralline lip was noted, but a coralline alga, probably *Porolithon*, coated rocks and shells at, and immediately below, the water surface. Two major surge channels break the reef front. Investigation of the northernmost channel with an aqualung provided the following detailed description of this channel:

The channel begins on the slightly submerged reef flat as a broad, more or less triangular, depression with the apex of the triangle toward the reef front. The depression narrows and steepens until what might be termed the head of a "canyon" is reached where the width of the canyon floor is about 60 feet (Figure 9). The walls here slope downward from the reef flat at an angle of about 20° to the floor which lies in about 36 feet of water. The walls have lateral projections formed by coral growth. The canyon narrows seaward to a width of about 30 feet and the walls become steeper, finally becoming vertical at the seaward reef margin. The floor of the canyon slopes downward in an undulating fashion, and is covered with coarse, white calcareous sand and blocks of reef rock (Figure 10). In places these blocks are so large that they almost close the canyon at the floor. Turbulence created by these large blocks in the currents flowing through the canyon may cause the undulations in the canyon floor. At the seaward reef margin the canyon seems to widen, probably fanning out to merge with the outer shelf. Numerous caves and tributary channels may be seen cutting back into the vertical sides of the canyon. Exploration of one of these caves revealed several large holes in the roof through which daylight streamed. The caves seem to be formed by the growth of coral over tributary channels, the roof holes being places which have not yet been overgrown.

The windward edge of the reef is marked by an accumulation of coral boulders two feet and more in diameter. These boulders are covered with encrusting soft coral below the intertidal zone. Massive corals, *Acropora palmata, Millepora, Gorgonia*, and *Halimeda*, are abundant below low tide level. The mollusks *Littorina ziczac* and *Nodilittorina tuberculata* were collected in the intertidal zone near the reef edge from marble blocks which had been the cargo of a ship wrecked on the reef.

The reef flat behind the seaward reef margin contains considerable coral rubble. Coral boulders one to three feet in diameter are abundant and spaced at one foot intervals or less. Larger boulders are scattered over the reef flat (Figure 11). The coral rubble is principally composed of worn fragments of *Acropora*. The boulders are not nearly so abundant as in other reefs of the gulf, for instance in Arrecife de Enmedio (Anton Lizardo group). The coral rubble is principally composed of worn fragments



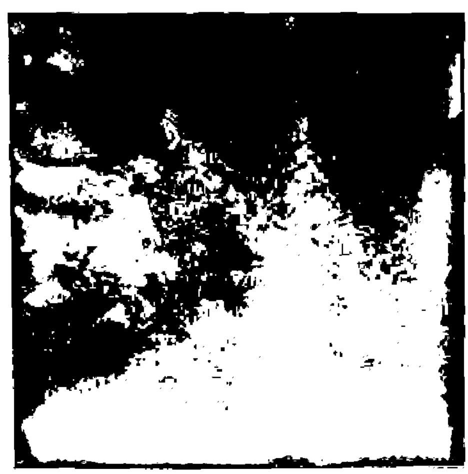


FIG. 9. Wall at head of the canyon through reef front where water depth is about 36 feet.

FIG. 10. Canyon head where wall and bottom meet in about 36 feet of water.

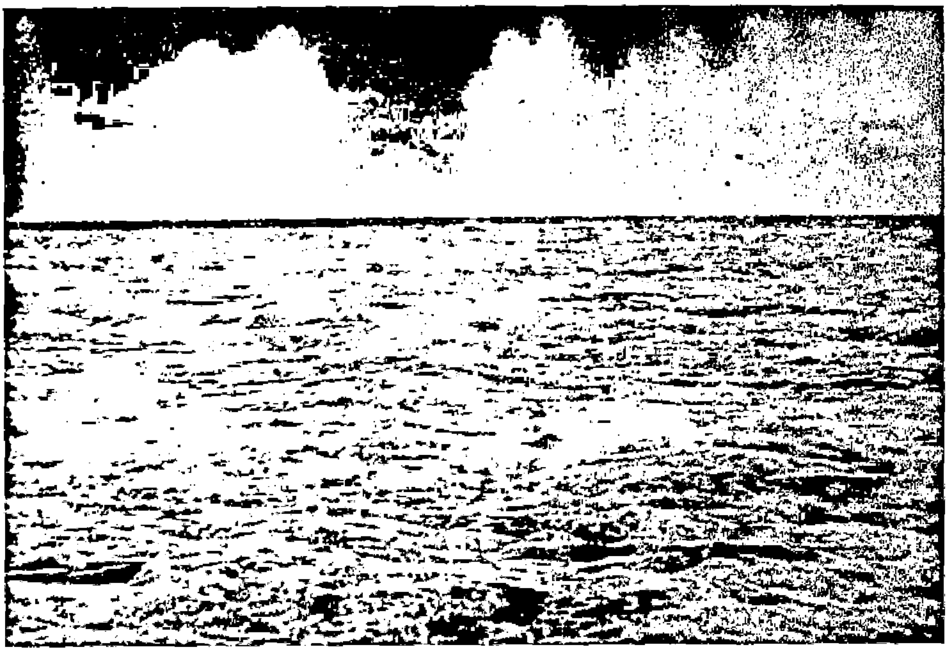


FIG. 11. Reef flat behind seaward reef margin at low tide with water less than one foot in depth. Rubble about one foot in length is exposed in the lower part of photograph and boulders are exposed in the upper part.

of *Acropora*. Sea urchins, the snails *Asteraea* and *Strombus*, and the alga *Halimeda* are common on the reef flat. Many of the coral fragments and rubble are coated by a moss-like alga and coralline alga (*Porolithon?*). Coralline algae are not as abundant on the reef flat at Alacran as on the Veracruz and Anton Lizardo reefs. The algae *Sargassum* and *Turbinaria* were observed on the reef flat but they may have been recently washed over from the reef front. Sand on the reef flat is medium to coarse in size and consists of tabular flakes of mollusk shells, *Halimeda*, Foraminifera, and fragments of coral. A reef flat is essentially absent from the lee side of Alacran Reef. The reef flat near Chica is cut by narrow channels (Figure 12).

A discontinuous channel varying considerably in width and depth lies behind the outer reef flat and parallels the seaward reef edge. The channel is missing from most areas but in places it is a major topographic feature, 1000 feet wide and 42 feet deep. Spot sediment sampling indicates that the bottom of the channel contains only a thin veneer of sand. Patch reefs and pinnacles of coral project upward from the channel bottom.

The inner reef flat is considered as the area bounded on its outer side by the reef flat channel or outer reef flat, where the channel is missing, and on the inner side by the lagoon. An inner reef flat is not present on the lee side of the lagoon. The lagoonal boundary of the inner reef flat is poorly defined but in the accompanying map (Figure 4 inside of back cover) it is marked by an increase in the area covered by water deeper than that found on the reef flat. The inner reef flat is shallow with the water usually less

Fig. 12. Channel in reef flat at southern end of reef near Chica. Grouper is about one foot in height. Channel wall is covered with a proliferous growth of *Millepora*.

than six feet deep. Patch reefs are extremely abundant. The inner reef flat at the northern end of the reef supports extensive beds of *Thalassia*. Sand in the *Thalassia* is coarse and composed principally of *Halimeda* plates, mollusk hash, and Foraminifera.

Alacran Reef Lagoon[1] and Sand Islands

The lagoon of Alacran Reef is well defined at its western boundary of the precipitous lagoon slope of the lee shelf whose inner edge lies in about 12 feet of water. The surface of the lagoon floor is undulating with maximum depth at about 75 feet. The east-central portion of the lagoon is partly filled by an anastomosing network of reef which is apparently filling in the lagoon, although visual inspection shows that living corals are found only in isolated patches. The main trend of the lagoonal reef network more or less

[1] The term lagoon is used for convenience and is not meant to suggest close relationship with lagoons of Pacific atolls.

parallels the longitudinal reef axis. As the upper edge lies close to the water surface, navigation in a shallow draft skiff across the lagoon is difficult, especially at low tide.

Every "pool" in the network as well as the lagoon as a whole, acts as a sediment trap, which is being filled in by the loose sediments abraded from the windward edge of the reef. The "pools" of the network are far shallower than the lagoon proper indicating that they are being filled more rapidly. As this "filling in" action proceeds, the reef flat will gain in extension at the expense of the lagoon so that the end result will be a leveling of all the surface of the reef and the complete obliteration of the lagoon, *i.e.*, its transformation into a typical table reef.

Prolific coral reefs grow along the lagoon reef margin off the island of Perez. Massive corals are dominant along the margin of one reef about 50 feet east of Perez (Figure 13), whereas *Acropora cervicornis* is dominant on the margin of an adjacent reef about 150 feet east of Perez (Figure 14). The outer slopes of both reefs descend steeply to the lagoon floor which is 25 to 35 feet deep along the slope base. The slope of the *Acropora* reef is covered with a tangled accumulation of *Acropora*. The prolific coral growth along the margins of these reefs occurs where the water is three to four feet deep. The shallow subtidal flats between the reef and the sand beach of Perez support *Thalassia*, *Halimeda*, *Porites furcata* (Figure 15), and isolated coral heads (Figure 16). Holes occupied by octopi are common on these flats and are marked by an accumulation of pebbles and disarticulated clam shells.

The subtidal area on the lagoon side of the islands is in many places covered with a pavement of fragments of *Acropora cervicornis* two to four inches in length. The inter-

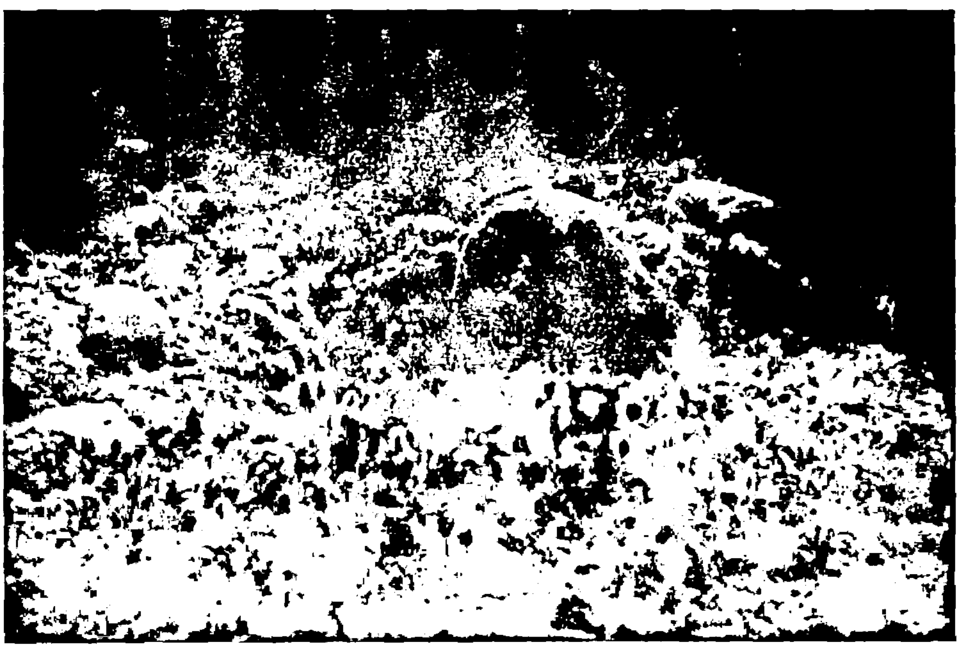


FIG. 13. Inner edge of lagoon reef composed of massive corals east of Isla Perez. Large corals belong to the genus *Diploria*. Water depth is about three feet.

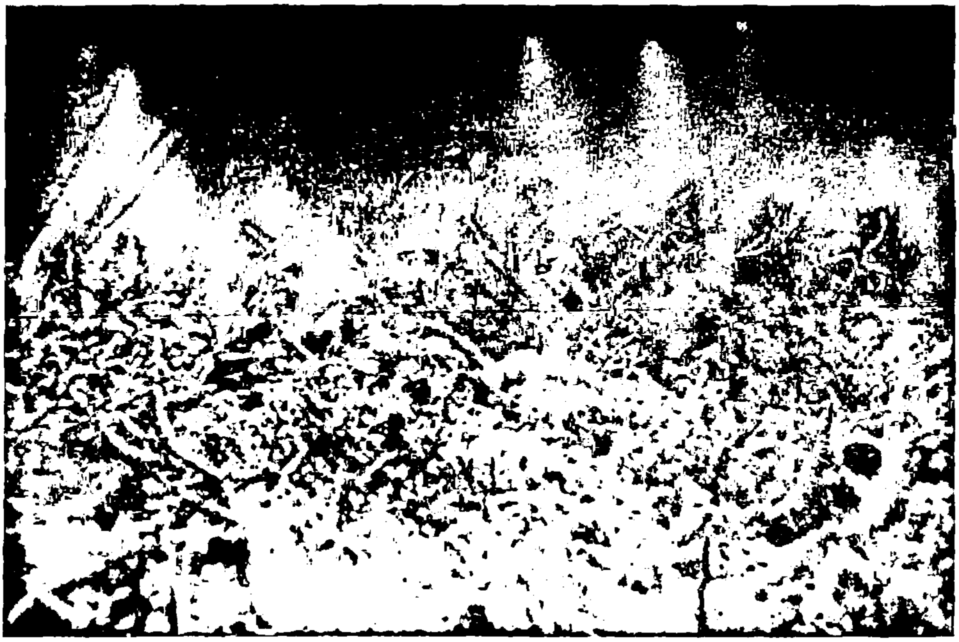


FIG. 14. Tangled accumulation of *Acropora cervicornis* on lagoonal reef adjacent to the islands of Perez. Water depth of photographed area is about 12 feet.

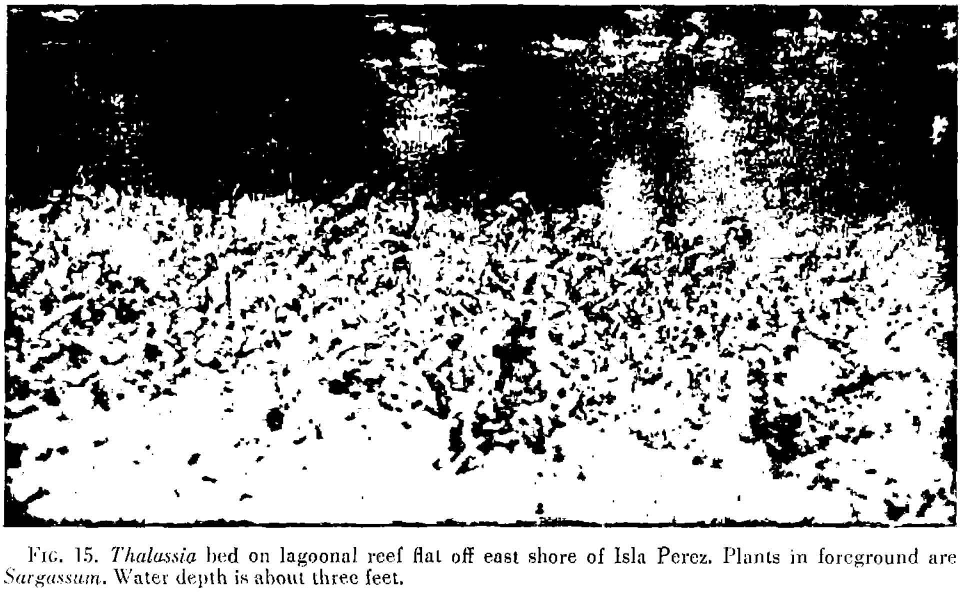


FIG. 15. *Thalassia* bed on lagoonal reef flat off east shore of Isla Perez. Plants in foreground are *Sargassum*. Water depth is about three feet.

FIG. 16. Massive corals on lagoonal reef flat east of Isla Perez.

tidal area, on the other hand, is usually sand with an abundance of *Halimeda* plates. If the lagoon reefs of Perez are considered typical of one type of lagoon reef margin, the area east of Desertora might be considered typical of another type. Here the bottom slopes gradually to where the water depth is about 22 feet and then slopes more sharply until a floor is reached at about 33 feet. Massive corals, sea fans, sea whips, the algae *Turbinaria* and *Penicillus*, and the hydrozoan *Millepora* occur as scattered growths on the shelf above the shelf margin with abundance greatest in water about seven feet deep.

Patch reefs are common in the lagoon. These rise sharply from the bottom and many almost break the water surface. The reef base often has a smaller diameter than the upper part (Figure 17). A typical patch reef is about 150 feet in diameter and rises to about one foot from the water surface from a 35 foot depth. The patch reefs are usually round with coral growth restricted to the outer rim and have a centrally depressed, coarse sand-filled area several feet lower than the coral rim. Sand mounds probably formed by worms are abundant on the surface of the central depressions. Massive corals are dominant on most patch reefs. Isolated groupings of coral heads are scattered on the lagoon floor (Figure 18).

Lagoonal sediments are quite variable with a silt sized calcium carbonate flour containing aragonite needles in some of the deeper areas, and coarser bioclastic sand adjacent to islands and reefs.

Alacran Reef contains five islands: Perez, Desertora, Desterrada, Pajaros, and Chica. These are sand cays without exposures of lithified rock of any type. The islands are low-lying and their outlines seem to vary seasonally with storms and changing wind direc-

FIG. 17. Profile of the end of a circular patch reef in lagoon north of Isla Perez.

tions. All cays support abundant vegetation and are nesting grounds for many species of birds, including the Sooty Tern (*Sterna fuscata*), Frigate bird (*Fregata magnificens*), Brown Noddy Tern (*Anoüs stolidus*), Royal Tern (*Thalasseus maximus*), Laughing Gull (*Larus atricilla*), Blue Faced Booby (*Sula dactylatra*), Brown Booby (*Sula leucogaster*) (identifications by J. D. Powell). A small shallow pond on Pajaros is surrounded by mangroves. Ponds on the islands are depressions formed apparently by the building up of coral and shell ramparts or spits around their margins. Although they are probably of a temporary nature, some of the mollusks (*Batillaria minima* and several nerites) collected on Alacran Reef seemed restricted to these ponds. The larger islands of Perez, Desertora, and Desterrada are situated on the leeward shelf. The islands of Chica and Pajaros are located on the southern tip of the inner reef flat. A sand bar called Desaparecida Bar forms an island during the summer but is cut down by wave action and disappears below water during the northerly winter winds. The beaches around the islands consist of a hash of mollusk shells and coral fragments. Low beach ridges of shell or fragments of staghorn coral are common (Figures 19 and 20).

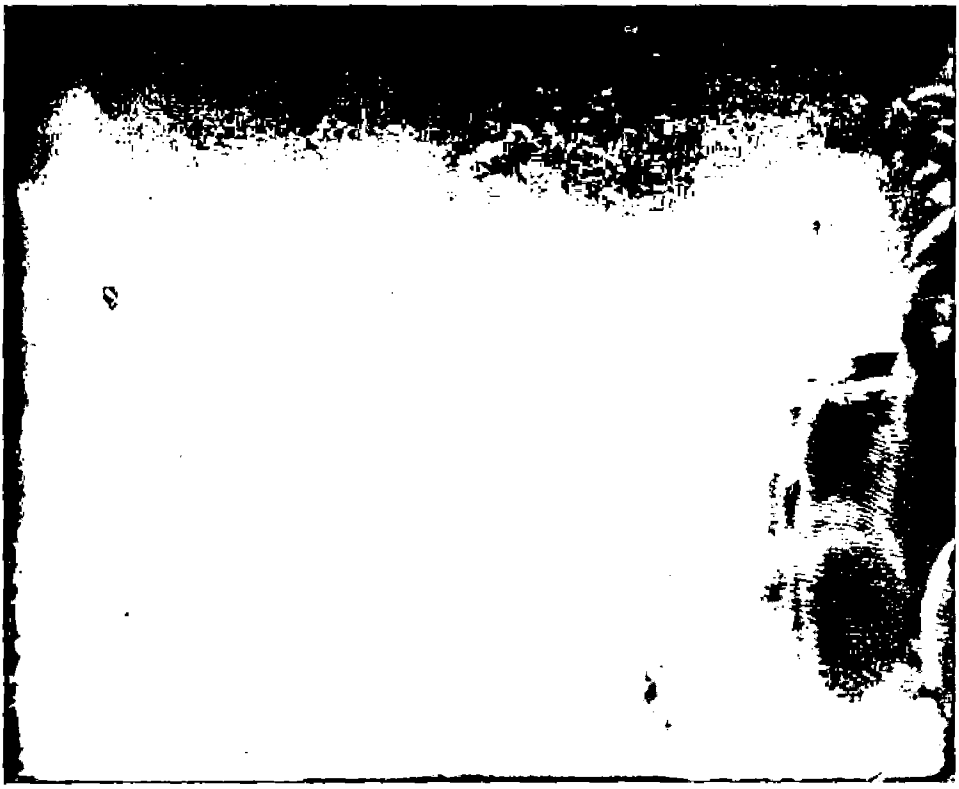


FIG. 18. Large coral head of *Diploria* on lagoon floor near Isla Perez. Water depth is about five feet.

Alacran Reef as a whole is probably in an earlier phase of development than all the rest of the reefs of the Campeche Bank and the reefs of Vera Cruz and Anton Lizardo. This relative immaturity of Alacran Reef may be accounted for by its far greater size in relation with the other reefs, and it does not necessarily imply that it started later.

List of Species Identified

Collection of specimens from the Alacran Reef in July, 1959, was a joint effort by members of the expedition. Special credit is due Mr. Thomas Wright who curated the collection in the field. All corals listed were observed alive on the reef. Many of the Mollusca were not collected alive, but probably are living in the area. We are indebted to Dr. T. E. Pulley and Mrs. Winnie H. Rice for identifying the Mollusca. Dr. Federico Bonet identified many of the stony corals in the field. The senior author keyed out the stony corals brought back from the reef and accepts full responsibility for any misidentifications. Dr. Donald F. Squires verified the presence on the reef of *Acropora palmata, Acropora cervicornis, Agaricia agaricites, Porites porites* var. *furcata, Diploria clivosa, Montastrea annularis, Favia fragum,* and *Millepora* from specimens or photographs he examined. Octacorals were identified by Dr. F. M. Bayer through the courtesy

FIG. 19. Windward lagoonal beach on southern part of the island of Perez. Inset is closeup of sediment which is composed principally of fragments of *Acropora cervicornis* about three inches in length.

of Dr. Fenner A. Chace, Jr., Smithsonian Institution, United States National Museum. Bryozoa were identified by Dr. Alan Cheetham, Louisiana State University. The specimens listed below are deposited with the invertebrate collection at the Institute of Marine Science. A duplicate set of the octocorals has been deposited with the Division of Marine Invertebrates, United States National Museum. Marine plants were identified by L. Huerta who has made collections from many Mexican reefs (1958) The Polychaeta were identified by E. Rioja (1958). The Echinodermata were identified by M. E. Caso.

COELENTERATA

Hydrozoa

Millepora alcicornis Linnaeus

Anthozoa

Zoantharia

Acropora palmata (Lamarck)
Acropora cervicornis Lamarck
Agaricia agaricites (Linnaeus)
(varieties not differentiated)

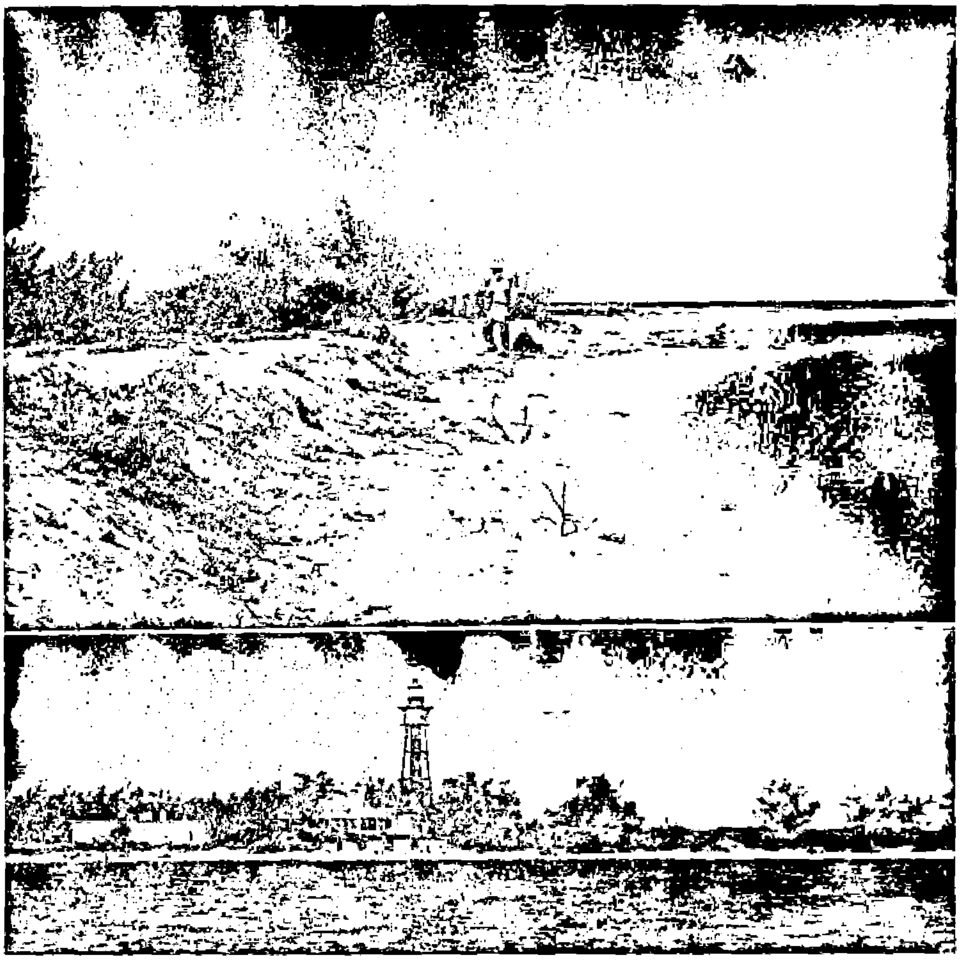


FIG. 20. Lee beach on southern part of the island of Perez where sediments consist principally of a hash of mollusk shells. Insert in lower part of photograph shows the inhabited part of Perez. The buildings face the lagoon.

Siderastrea radians (Pallas)
Siderastrea siderea (Ellis and Solander)
Porites astreoides Lamarck
Porites porites var. clavaria Lamarck
Porites porites var. furcata Lamarck
Favia fragum (Esper)
Diploria clivosa (Ellis and Solander)
Diploria strigosa (Dana)
Diploria labyrinthiformis (Linnaeus)
Colpophyllia amaranthus (Muller)
Manicina areolata (Linnaeus)
Montastrea cavernosa (Linnaeus)
Montastrea annularis (Ellis and Solander)
Mussa angulosa (Pallas) Oken
Eusmilia fastigiata (Pallas)

Octocorallia

(Identified by F. M. Bayer)

Briareum asbestinum (Pallas)
Plexaura homomalla (Esper)
Plexaura flexuosa Lamouroux
Eunicea tournefortí Milne Edwards and Haime
Eunicea calyculata (Ellis and Solander)
Plexaurella dichotoma (Esper)
Pseudoplexaura laevigata (Moser)
Pseudoplexaura porosa (Houttuyn)
Pseudopterogorgia americana (Gmelin)
Pterogorgia citrina (Esper)
Pterogorgia anceps (Pallas)
Gorgonia ventalina Linnaeus

POLYCHAETA

(Identified by E. Rioja)

Eurythoe complanata (Pallas)
Hesione picta Müller
Nereis riisei Grube
Eunice schemocephala Schmarda
Nematonereis hebes Verrill
Thelepus setosus (Quatrefages)
Branchiomma bairdi (M. Intosh)
Sabella melanostigma Smarda

Materials collected by F. Bonet *et al.*, in May 1955.
Additional material collected in 1959 is now in study.

BRYOZOA

(Identified by Alan Cheetham)

Cheilostomata

Rhynchozoon rostratum (Busk)
Ellisina latrióstris (Osburn)
Hippopodina feegeensis (Busk)
Celleporaria magnifica (Osburn)
Styloma spongites (Pallas)
Tremogasterina mucronata (Smitt)
Celleporaria albirostris (Smitt)
Cleidochasma porcellana (Busk)
Parasmittina trispinosa (Johnston)
Escharoides costifera (Osburn)
Scrupocellaria maderensis Busk
Tetraplaria dichotoma (Osburn)

Cyclostomata

Lichenopora buski Harmer

MOLLUSCA

(Identified by T. E. Pulley and W. H. Rice)

Gastropoda

Emarginula phrixodes Dall
Diodora minuta Lamarck
Diodora listeri Orbigny
Lucapina suffusa Reeve
Lucapina philippiana Finlay
Hemitoma emarginata de Blainville
Acmaea jamaicensis Gmelin
Acmaea cf. *postulata pulcherrima* Guilding
Calliostoma zonamestum A. Adams
Calliostoma jujubinum Gmelin
Calliostoma sp.
Tegula fasciata Born
Cyclostrema cancellatus Marryat
Arene cruentata Muhlfeld
Turbo castaneus Gmelin
Caecum cf. *nebulosum*
Modulus modulus Linné
Batillaria minima Gmelin
Cerithium literatum Born
Cerithium variabile C. B. Adams
Cerithium sp.
Seila adamsi H. C. Lea
Alaba sp.
Triphora decorata C. B. Adams
Epitonium sp.
Melanella sp.
Cheilea equestris Linné
Hipponix antiquatus Linné
Strombus gigas Linné
Astraea longispina Lamarck
Astraea americana Gmelin
Astraea caelata Gmelin
Tricolia sp.
Nerita peloronta Linné
Nerita versicolor Gmelin
Nerita tessellata Gmelin
Neritina virginea Linné
Smaragdia viridis Linné
Littorina ziczac Gmelin
Nodilittorina tuberculata Menke
Rissoina (represented by three species)
Vermicularia knorri Deshayes
Caecum cf. *floridanum* Stimpson
Caecum cf. *cooperi* S. Smith
Strombus costatus Gmelin
Strombus raninus Gmelin
Trivia suffusa Gray
Cyphoma gibbosum Linné
Polinices lacteus Guilding
Sinum perspectivum Say
Natica canrena Linné
Cassis madagascariensis Lamarck
Cymatium martinianum Orbigny
Cymatium cynocephalum Lamarck
Tonna maculosa Dillwyn
Tonna galea Linné
Murex pomum Gmelin
Murex sp.

Drupa nodulosa C. B. Adams
Thais deltoidea Lamarck
Columbella mercatoria Linné
Anachis sp.
Nitidella nitidula Sowerby
Bailyn intricata Dall
Busycon contrarium Conrad
Busycon spiratum Lamarck
Nassarius ambiguus Pulteney
Leucozonia nassa Gmelin
Fasciolaria tulipa Linné
Fasciolaria hunteria Perry
Pleuroploca gigantea Kiener
Xancus angulatus Solander
Olivella nivea Gmelin
Prunum labiatum Valenciennes
Hyalina avena Valenciennes
Conus spurius atlanticus Clench
Conus mus Hwass
Monilispira sp.
Bulla sp.
Atys caribaea Orbigny
Atys sandersoni Dall
Haminoea succinea Conrad
Odostomia sp.
Cavolina sp.

Amphineura

Ischnochiton sp.

Scaphopoda

Dentalium sp.

Pelecypoda

Arca zebra Swainson
Arca umbonata Lamarck
Barbatia cancellaria Lamarck
Barbatia domingensis Lamarck
Glycymeris pectinata Gmelin
Modiolus americanus Leach
Lithophaga nigra Orbigny
Isognomon alatus Gmelin
Pinctada radiata Leach
Pinna carnea Gmelin
Chlamys imbricata Gmelin
Lyropecten antillarum Recluz
Spondylus americanus Hermann
Lima scabra Born
Ostrea frons Linné
Lucina pensylvanica Linné
Codakia orbicularis Linné
Divaricella quadrisulata Orbigny
Chama maccrophylla Gmelin
Trachycardium isocardia Linné
Trigoniocardia media Linné
Laevicardium laevigatum Linné
Antigona listeri Gray
Chione cancellata Linné
Petricola lapicida Gmelin
Tellina radiata Linné
Tellina interrupta Wood
Tellina candeana Orbigny
Arcopagia fausta Pulteney
Apolymetis intastriata Say

ECHINODERMATA
(Identified by M. E. Caso)

Brissus unicolor (Leske)
Eucidaris tribuloides (Lamarck)
Ophiothrix suensonii Lütken
Holothuria mexicana Ludwig
Euapta lappa (J. Müller)

MARINE PLANTS
(Identified by L. Huerta)

Algae

Ulva fasciata Delile
Enteromorpha lingulata J. Agardh
Valonia ventricosa J. Agardh
V. ocellata Howe
Dictyosphaeria favulosa (J. Agardh) Decaisne
Halimeda opuntia f. triloba Barton
H. tridens Lamouroux
Dictyota linearis Greville
Sargassum vulgare var. foliosissimum J. Agardh
Sargassum fluitans Boergesen
Turbinaria tricostata Barton
Liagora farinosa Lamouroux
L. pinnata Harvey
Amphiroa fragilissima Lamouroux
Hypnea cervicornis J. Agardh
Acanthophora spicifera Boergesen
Laurencia papilosa Greville

Spermatophyta

Diplanthera wrightii (Ascherson) Ascherson
Thalassia testudinum Koenig and Sims

Literature Cited

Agassiz, Alexander. 1878–1879. Letter No. 1 to C. P. Patterson, Superintendent Coast Survey, Washington, D. C. Harv. Mus. Comp. Zool., 5(6): 1–19.

————, 1888. Three Cruises of the United States Coast and Geodetic Steamer "Blake." Harv. Mus. Comp. Zool., 1(1): 70–73.

Alvarez, Manuel, Jr. 1949. Tectonics of Mexico. Amer. Ass. Petrol. Geol. Bull., 33: 1319–1335.

Huerta, L. 1958. Contribucion al conocimiento de las algas de los bajos de la Sonda de Campeche, Conzumel e Isla Mujeres. An. Esc. Nal. Cien. Biol., 9(1–4): 115–123.

Le Blanc, Rufus J. and Julia G. Breeding. 1957. Regional aspects of carbonate deposition, a symposium. Soc. Econ. Paleo. Miner., Spec. Publ. 5.

Miller, E. T. and M. Ewing. 1956. Geomagnetic measurements in the Gulf of Mexico and in the vicinity of Caryn Peak. Geophysics, 21: 406–432.

Newell, N. D. 1955. Bahamian platforms, *in* The crust of the earth, a symposium. Special Paper Geol. Soc. Amer., 62: 303–315.

Pugh, W. E. 1950. Bibliography of organic reefs, bioherms, and biostromes. Seismograph Service Corporation, Tulsa, Okla., 130 pp.

Rioja, E. 1958. Estudios anelidologicos. XXII. Datos para el conomiento de la fauna de Anelidos Poliquetos de las costas orientales de Mexico. An. Inst. Biol., 29: 219–301.

Sansores, E. 1959. Breves notas sobre la Geología de la peninsula de Yucatan. En: Excursión C-7. Bol. Asoc. Mex. Geol. Petr., Mexico, 11(7–8): 485–491.

Schuchert, Charles. 1935. Historical geology of the Antillean-Caribbean Region. New York, John Wiley & Sons, 811 pp.

Tracey, J. I., Jr., P. E. Cloud, Jr. and K. O. Emery. 1955. Conspicuous features of organic reefs. Atoll Res. Bull., 46: 4.