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RECENT HISTORY OF A FRINGING REEF, BAHIA SALINA DEL SUR, VIEQUES ISLAND, PUERTO RICO

BY

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RECENT HISTORY OF A FRINGING REEF, BAHIA SALINA DEL SUR, VIEQUES ISLAND, PUERTO RICO

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Introduction

The effect of U. S. Navy training activities on the shallow-water reefs at the eastern end of Vieques Island, Puerto Rico, was investigated during a 1978 ecological survey that included the drilling of three short core holes into an Acropora palmata (Lamarck) reef off the east coast of Bahia Salina del Sur (Figure 1). Radiocarbon dates of five core samples yield new information on the accumulation rates of A. palmata reef sections and provide further evidence that framework communities of many sea-level reefs are migrating leeward over loose, back-reef sediments.

General Setting

Bahia Salina del Sur is a small, crescent-shaped embayment (approximately 1 km wide and 1 km long) on the south coast of Vieques Island and close to its eastern end (Figure 1). The Thalassia sea-grass and sand and rubble floor in this area do not exceed a depth of 7m (Raymond, 1978). Shallow reefs fringe the promontories on the eastern, western, and northern shores of the bay, and two extensive sand beaches border its northeastern and northwestern corners.

The fringing reef off the west side of the bay consists of a well-developed Acropora palmata community. Small coral heads grow beneath the open framework of A. palmata, which extends to a depth of 5m, where a halo of sand separates the reef from adjacent broad beds of Thalassia. This halo of sand may be related to the feeding activity of fish and sea urchins (Ogden and Zieman 1977).

Banks and mounds of Porites porites (Pallas)--which resemble the near-shore banks of Porites off the west coast of Barbados (Macintyre 1968) and off the southeast coast of St. Croix (Adey 1975)-- have developed around two distinct promontories on the north coast of Bahia Salina del Sur. Small scattered stands of Acropora palmata occur in association with these Porites buildups. During the May, 1978 survey it was observed that naval bombardment had destroyed the eastern end of this near-shore community. During a subsequent survey following Hurricane David, Raymond and Dodge (1980) found that storm waves had

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almost completely destroyed the entire north-shore Porites community, along with most of the A. palmata on the south coast of Vieques.

The reef cored during this study (designated S-5 reef in Antonius and Weiner's 1978 survey) juts out obliquely from about the center of the eastern shore of Bahia Salina del Sur and is protected in part by a large promontory that forms the eastern entrance to the bay and by the fringing reef adjacent to this promontory, which consists of Montastrea, Siderastrea, and Diploria coral heads. Additional protection is afforded by the A. palmata reef surrounding Roca Alcatraz, an island 1 km south of S-5 reef (figure 1). S-5 reef has the characteristic zonation of shallow-water Caribbean reefs dominated by Acropora palmata in the reef crest and shallow fore reef (Figures 2, 3D,E,F) (see, for example, Dahl et al. 1974; Adey 1975). At a depth of 4 m, the A. palmata community gives way to a mixed coral-head community that includes Montastrea annularis (Ellis and Solander), Diploria strigosa (Dana), and Siderastrea siderea (Ellis and Solander). Small scattered colonies of both Acropora cervicornis (Lamarck) and Acropora prolifera (Lamarck) were found in the shallow fore reef during the 1978 survey, but subsequently were almost entirely removed by storm surge associated with Hurricane David (Raymond and Dodge 1980). The seaward slope of S-5 reef levels off at a depth of 8 m, where it grades into the sediment floor of the bay (Figure 2). The back reef shoreward of the reef crest is composed of large colonies of Montastrea annularis on rubble and pavement, which grade into sand and rubble; only a few colonies of M. annularis occur at the inner limit of the drill-site transect (Figures 2, 3A,B,C).

Its faunal zonation indicates that S-5 reef has developed under moderate wave-energy conditions (Geister 1977). The algal ridges or Palythoa-Millepora reef-crest communities characteristic of high wave-energy reefs are absent here, as are Acropora cervicornis or Porites porites communities in low wave-energy reefs. Wave agitation does appear to be strong enough to prevent any significant accumulation of the fragile Acropora cervicornis either in the deeper fore-reef slope or in the protected back-reef sand flats.

Core Descriptions

Three core holes were drilled at 50-m intervals along a transect crossing S-5 reef and adjacent to the eastern coast of Bahia Salina del Sur (Figure 1)--two into the reef crest in a water depth of about 0.5 m and one into the shallow fore-reef slope in a water depth of 2 m below mean sea level (Figure 2).

Core hole 1, drilled in four intervals into the reef crest to a depth of 6.4 m, yielded the following material:

1. 0-.61 m.--This interval consisted of fresh sections of Acropora palmata with a comparable amount of fragments bored and encrusted by Homotrema rubrum, coralline algae, and serpulids.

2. .61-1.83m.--This section was made up of fresh and bored sections of Acropora palmata and Diploria strigosa, along with some encrusted (by Homotrema rubrum and coralline algae) rubble consisting of A. palmata, Diploria sp., and Porites porites.

3. 1.83-3.35--Sections of A. palmata and Diploria clivosa were found throughout and cave-in rubble at the top of this interval.

4. 3.35-6.40 m.--Only cave-in rubble was collected from this interval. On-site observations indicated that the drill had dropped through a section of sand at this point.

Core hole 2 consists of one core interval drilled to a depth of 1.83 m below the surface of the reef. Except for a 6-cm core of bored and encrusted Diploria strigosa, the material here was mainly A. palmata bored to various degrees by sponges, molluscs, and worms and encrusted by Homotrema rubrum, coralline algae, and serpulids.

Core hole 3, drilled to a depth of 4.88 m below the surface of the reef, consists of three core intervals:

1. 0-1.83 m.--This interval is characterized by extensive submarine lithification, so that core sections are predominently agglomerate limestone. These cores, which are identical to those described from the shallow fore reef off Galeta Point, Panama (Macintyre 1977), consist of extensively bored and cemented agglomerations of crustose coralline algae, Millepora sp., Porites sp., and Acropora palmata. The multicyclic boring and submarine lithification have in some places destroyed much of the original skeletal framework, which has been replaced by magnesium calcite cement. Other material collected from this interval consists of bored, infilled, and cemented A. palmata and other coral debris.

2. 1.83-3.35 m.--Core sections contained mainly Acropora palmata, both fresh corals and samples bored by sponges, worms, and molluscs. Extensive cave-in material was present at the top of this interval.

3. 3.35-4.88 m.--Extensive cave-in rubble occurred in this interval. Two cores of bored Acropora palmata were also collected here.

Radiocarbon Dates

Five radiocarbon dates were obtained from fresh samples of Acropora palmata, which had been collected from the base of core intervals so as to reduce the error in estimating the depths of recovery for the dated samples. Even so, it is not known whether the

last material to be cored is in place at the base of the core interval, since a core barrel can punch through a section of the reef and carry a sample below its real depth of recovery. The lack of any significant difference in the two dates from core hole 3, the poor recovery in the last core interval, and the drill-worn condition of the lower sample dated suggest that this core sample was carried below its true depth of recovery. Radiocarbon dates and the accumulation rates for the intervening reef sections are given in Table 1.

TABLE 1

RADIOCARBON DATES AND ACCUMULATION RATES,
BAHIA SALINA DEL SUR REEF

Sample	Core Depth Interval (m)	Estimated Depth of Recovery below Reef Surface (m)	Interval of Reef Section Dated (m)	Radio-carbon Date	Accumulation Rate (m/1000 yrs)
Hole 1:					
Core 1	0-.61	.61	0-0.61	190±90	3.21
Core 1	0-.61	.61	.61-1.83	190±90	0.62
Core 2	.61-1.83	1.83		2155±80	
Hole 2:					
Core 1	0-1.83	1.83	0-1.83	860±90	2.13
Hole 3:					
Core 2	1.83-3.35	3.35	0-3.35	2020±70	1.66
Core 2	1.88-3.35	3.35	3.35-4.88	2020±70	*
Core 3	3.35-4.88	4.88		2020±70	

*Estimates invalidated owing to poor recovery in this core interval.

Summary and Conclusions

Excluding the lowest section of core hole 3 (where the estimates were discounted as invalid) we calculated that the Acropora palmata framework of S-5 reef has an average accumulation rate of about 2m/1000 years, which is lower than the average of 3.9m/1000 years reported for the A. palmata facies of the fringing reef off Galeta Point, Panama (Macintyre and Glynn 1976). This difference can be attributed to the changing rates of sea-level rise in the late stages of the Holocene transgression. Sea-level curves established for several areas in the Atlantic and Pacific oceans show a distinct decrease in the rate of sea-level rise, from 3,000 to 4,000 years B.P. (Macintyre and Glynn 1976). As pointed out in the study of Galeta Reef, accumulation rates there decreased considerably about this period of time because changing sea levels reduced the availability of vertical space for reef development. Wherever A. palmata communities have experienced rapid changes in sea level, however--for example, at the shelf edge off Florida 7,000 to 9,500 years ago (Lighty et al. 1978)--the mean accumulation rates have been estimated at 6.6 m/1000 years, the maximum rate reported being 10.7 m/1000 years.

The dates from the Vieques cores suggest that shallow-water Acropora palmata framework that is less than 2,000 years old can be expected to have accumulation rates around 2m/1000 years. In addition, the penetration of more than 3 m of sand at the base of core hole 1 lends support to Shinn's (1980) observation that some shallow-water A. palmata framework may accrete leeward over back-reef sands "by corals establishing themselves on storm-derived rubble periodically transported onto the leeward side of the reef flat" (p. 651). Observations of S-5 reef before and after Hurricane David indicate that both dead and living A. palmata, along with coral head debris, migrated several meters over the back-reef sands in this area. Furthermore, the extensive and multicyclic cementation present at the top of the shallow fore-reef core hole 3 is a characteristic associated with slowly accumulating reef facies (Macintyre, 1977).

This combination of relatively little present-day reef growth in the shallow fore reef and leeward migration of the reef flat indicates that S-5 reef is in a mature stage of reef development, extending laterally into the Bahia Salina del Sur.

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References

Adey, W. H. 1975. The algal ridges and coral reefs of St. Croix: Their Structure and Holocene development. Atoll Res. Bull., 187:1-67.

Antonius, A. and A. Weiner. 1978. A quantitative biological and health assessment of selected coral reefs in Vieques (Puerto Rico) and the U. S. Virgin Islands. Report submitted to EG&G/U.S. Navy/U.S. Dept. of Justice, 1978.

Dahl, A. L., I. G. Macintyre, and A. Antonius. 1974. A comparative survey of coral-reef research sites. Atoll Res. Bull. 172:37-120.

Geister, J. 1977. The influence of wave exposure on the ecological zonation of Caribbean Coral Reefs. Pages 23-99, in D. L. Taylor, Editor, Proceedings, Third International Coral Reef Symposium, Volume 1, Miami, Florida: Rosentiel School of Marine and Atmospheric Science.

Lighty, R. G., I. G. Macintyre, and R. Stuckenrath. 1978. Submerged early Holocene barrier reef south-east Florida shelf. Nature 275:59-60.

Macintyre, I. G. 1968. Preliminary mapping of the insular shelf off the West coast of Barbados, W.I. Caribbean Jour. Sci., 8:95-100.

Macintyre, I. G. and P. W. Glynn. 1976. Evolution of modern Caribbean fringing reef, Galeta Point, Panama. Am. Assoc. Petroleum Geologists Bull. 60:1054-1072.

Macintyre, I. G. 1977. Distribution of submarine cements in modern Caribbean fringing reef, Galeta Point, Panama. Jour. of Sed. Petrology, 47:503-516.

Ogden, J. C. and J. C. Zieman. 1977. Ecological aspects of coral reef-seagrass bed contacts in the Caribbean. Pages 377-382. In D. L. Taylor, editor. Proceedings, Third International Coral Reef Symposium. Volume 1, Miami, Florida: Rosentiel School of Marine and Atmospheric Science.

Raymond, Bill, 1978, The marine sediments of a Naval Bombing range, Vieques, Puerto Rico: Report submitted to EG&G, U.S. Navy, U. S. Dept. of Justice, Dec. 1978.

Raymond, W. F. and R. E. Dodge. 1980. 1979 Hurricane damage to coral reefs of Vieques. Report submitted to U.S. Navy.

Shinn, E. A. 1980. Geologic history of Grecian rocks, Key Largo Coral Reef Marine Sanctuary. Bull. Mar. Sci. 30:646-656.

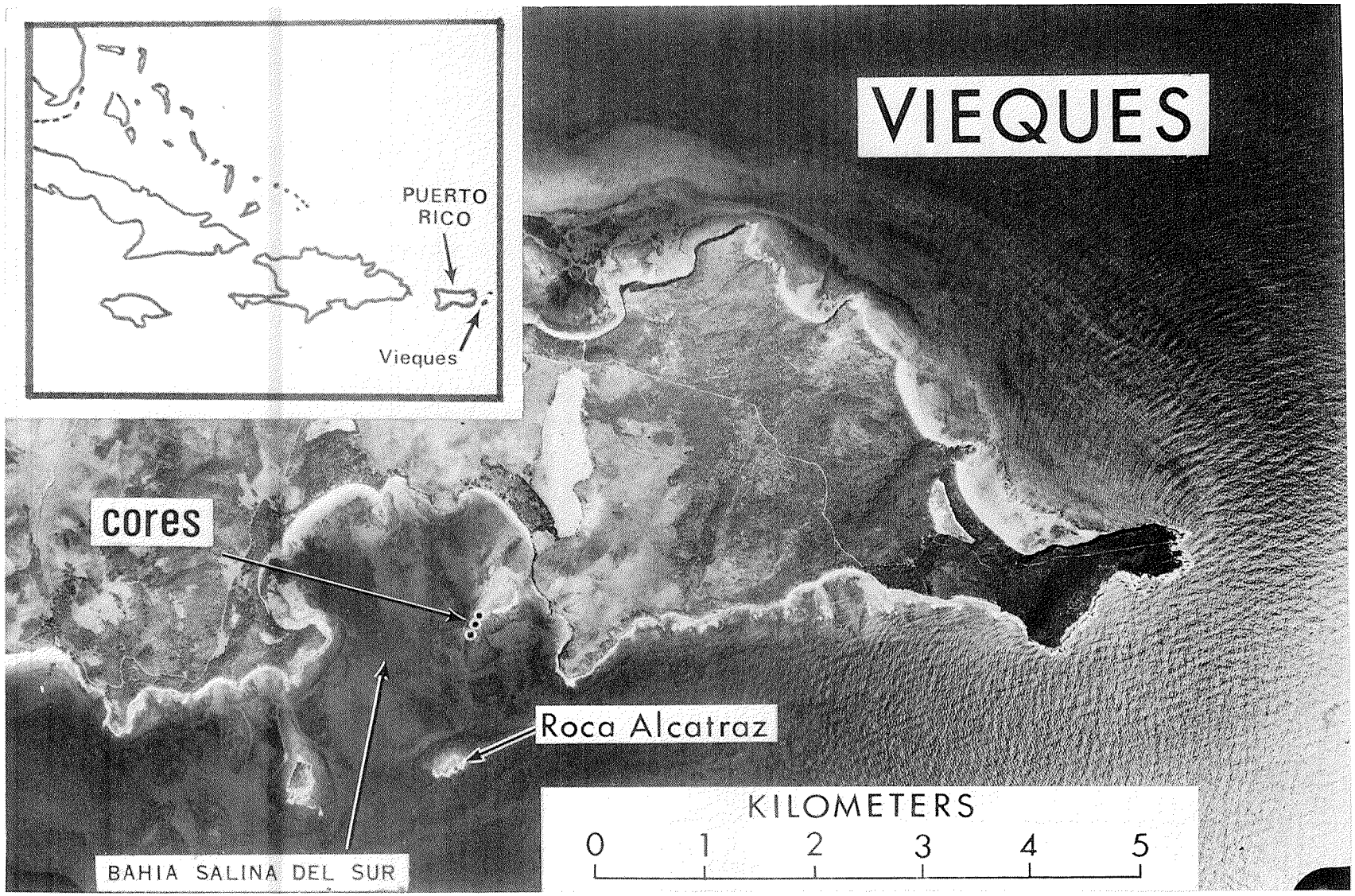

Figure 1. Index map showing location of Vieques Island, Bahia Salina del Sur, the distribution of fringing reefs in this bay, and the location of the three core holes drilled in this study.

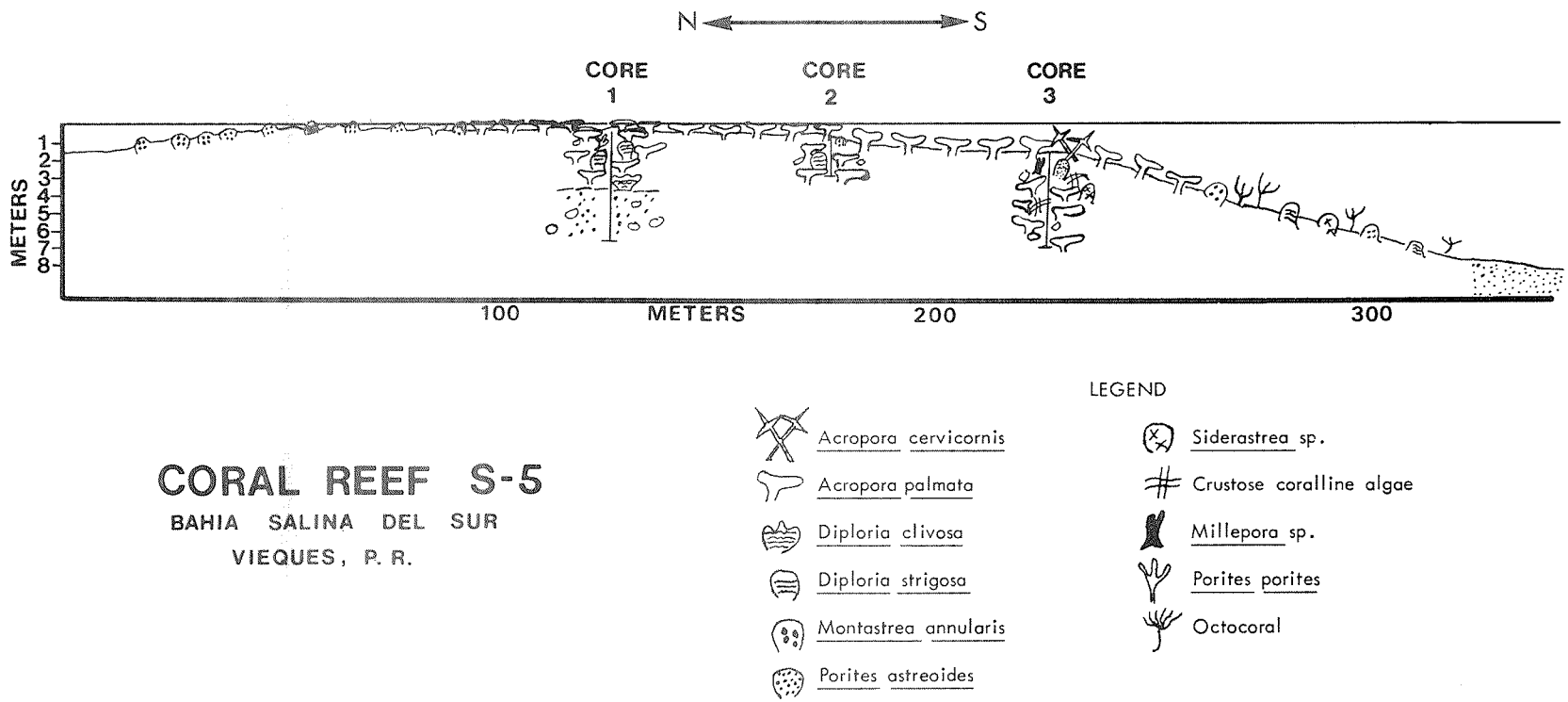

Figure 2. Schematic cross-section of S-5 reef along the core-hole transect, showing dominant reef components on the surface and those recovered from the core holes.

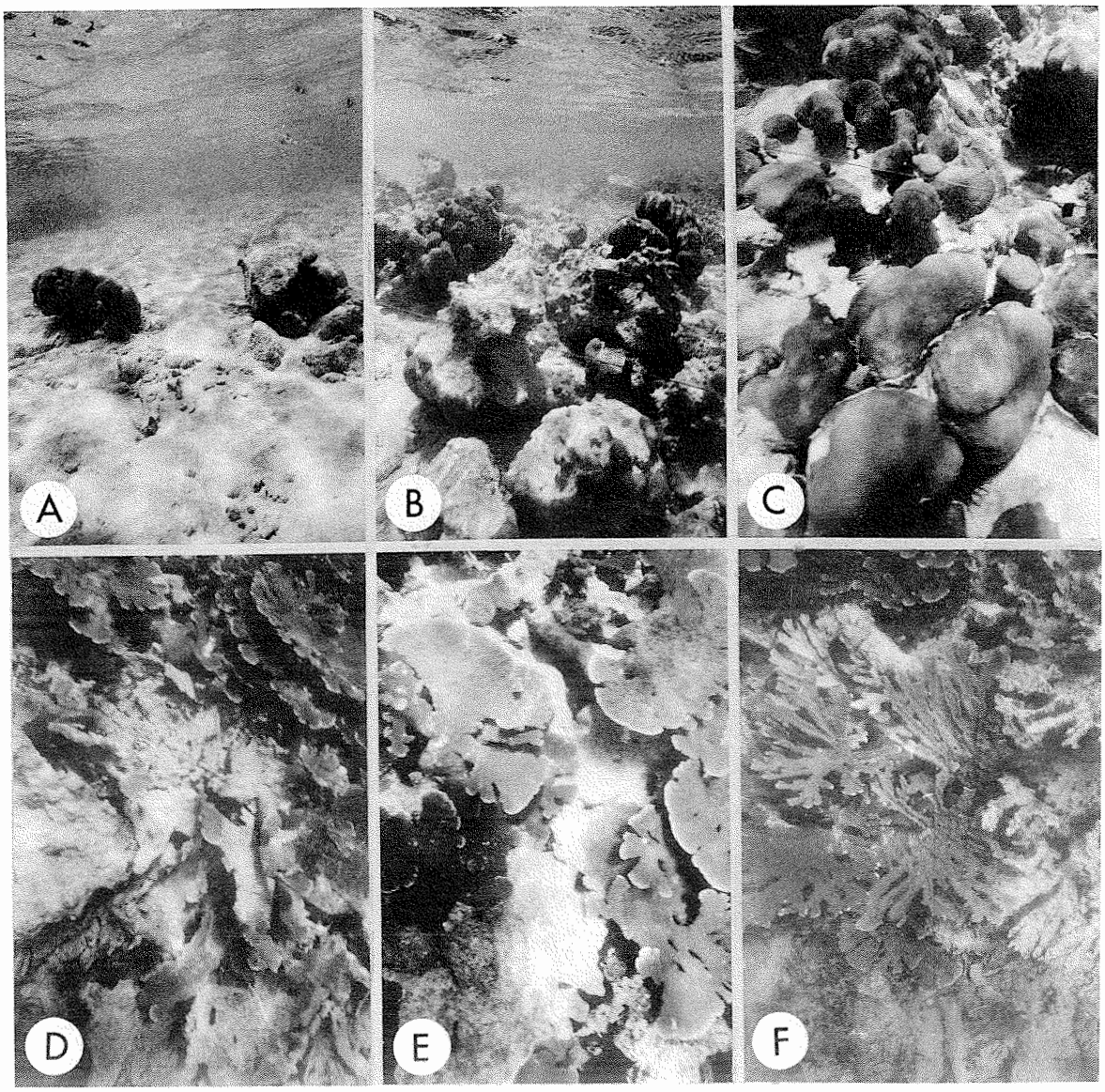

Figure 3. Bottom photographs of S-5 reef taken along transect shown in Figure 2. A. Isolated colonies of Montastrea annularis on sand and rubble bottom, at 5 m along transect. B. and C. Back-reef M. annularis colonies at 30 and 50 m, respectively. D, E, and F. A. palmata community on the reef crest in the vicinity of core hole 1 and 2, and on the shallow fore-reef, near core hole 3.