THIRD INTERNATIONAL SYMPOSIUM ON CORAL REEFS 1977

FIELD GUIDEBOOK TO THE REEFS AND REEF COMMUNITIES OF ST. CROIX, VIRGIN ISLANDS

W. Adey, W. Gladfelter, J. Ogden, R. Dill

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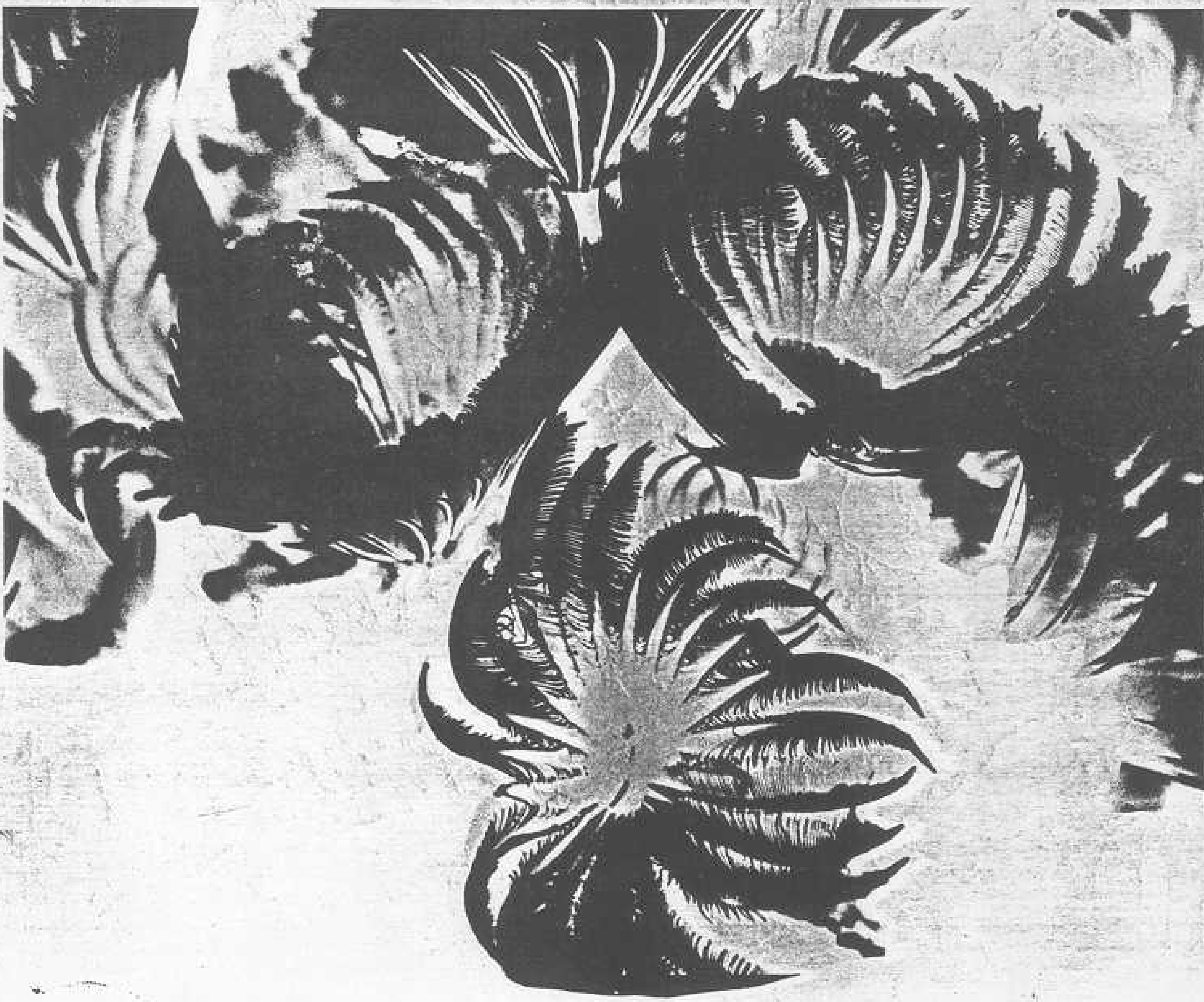

LOCALITIES TO BE VISITED

1. BOILER BAY
2. Bank Barrier Reef at ROBIN BAY and FANCY POINT
3. Shelf Edge Feature
4. BUCK ISLAND Reef; Northeast End.
5. Patch Reefs, TAGUE BAY
6. SALT RIVER Submarine Canyon
7. WEST END. ESTATE NORTHSIDE

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FIELD GUIDEBOOK TO THE REEFS AND REEF COMMUNITIES OF ST. CROIX, VIRGIN ISLANDS

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TABLE OF CONTENTS

INTRODUCTION

Regional setting and geology

The U.S. Virgin Islands are usually treated geographically as part of the Lesser Antilles, a Tertiary island arc system lying at the eastern boundary of the Caribbean plate. St. Croix, however, belongs geologically to the older, Greater Antillean islands and has been separated from that group along major zones of shear faulting (Figs. 1, 2).

The mountains at the east and west ends of St. Croix, and probably the whole island core as well, are largely formed by the weakly metamorphosed but uplifted, folded and faulted Cretaceous Caledonia, Cane Valley and Judith Fancy formations. These rocks are derived from volcanic and other narrow trench type sediments originally deposited on the deep ocean floor about 70-80 million years ago. The lower central and southwestern parts of the island are underlain by flat lying mudstones of the early Tertiary Jealousy Formation. These are also fairly deep water sediments probably largely derived by erosion of the uplifting Cretaceous formations. The Kingshill Marl forms a thin limestone cap on much of the central and southwestern low lands of St. Croix. The age and genesis of this formation is poorly known, but it is clear that much of the central area consists of Miocene deeper water limestones and largely carbonate-derived turbidites. However, to the south and west, Pliocene and Pleistocene reefoid formations peripherally cap the older Kingshill Marl (Figs. 3, 4).

A broad limestone platform, lying at a depth of 12 to 30 m below sea level extends nearly 20 km east-northeast from the eastern point of St. Croix and also rims the south coast of the island to a width of 2-4 km. Several to as much as 20 meters of Holocene carbonate sediments and reefoid limestones now cover much of this extensive shelf. Much of the thickness of the St. Croix shelf is probably reefoid, dating from the latest Tertiary to Pleistocene; however, it has not been cored to depth.

Climate

St. Croix is centrally situated in the northeast trade wind belt. From the late autumn through spring, the winds are markedly constant; they blow at a mean Beaufort (bf) strength of 3.6 to 3.8, from the easterly sector over 90% of the time. Occasionally colder continental fronts do extend to the Virgin Islands during this period, but they seldom reach the intensity of the storms referred to as "northers" in the Bahamas and Greater Antilles. The effect of a norther in St. Croix is usually a northerly shift or calming of the trade wind. As is characteristic in the West Indies region, the summer-autumn rainy season is characterized by passage of low

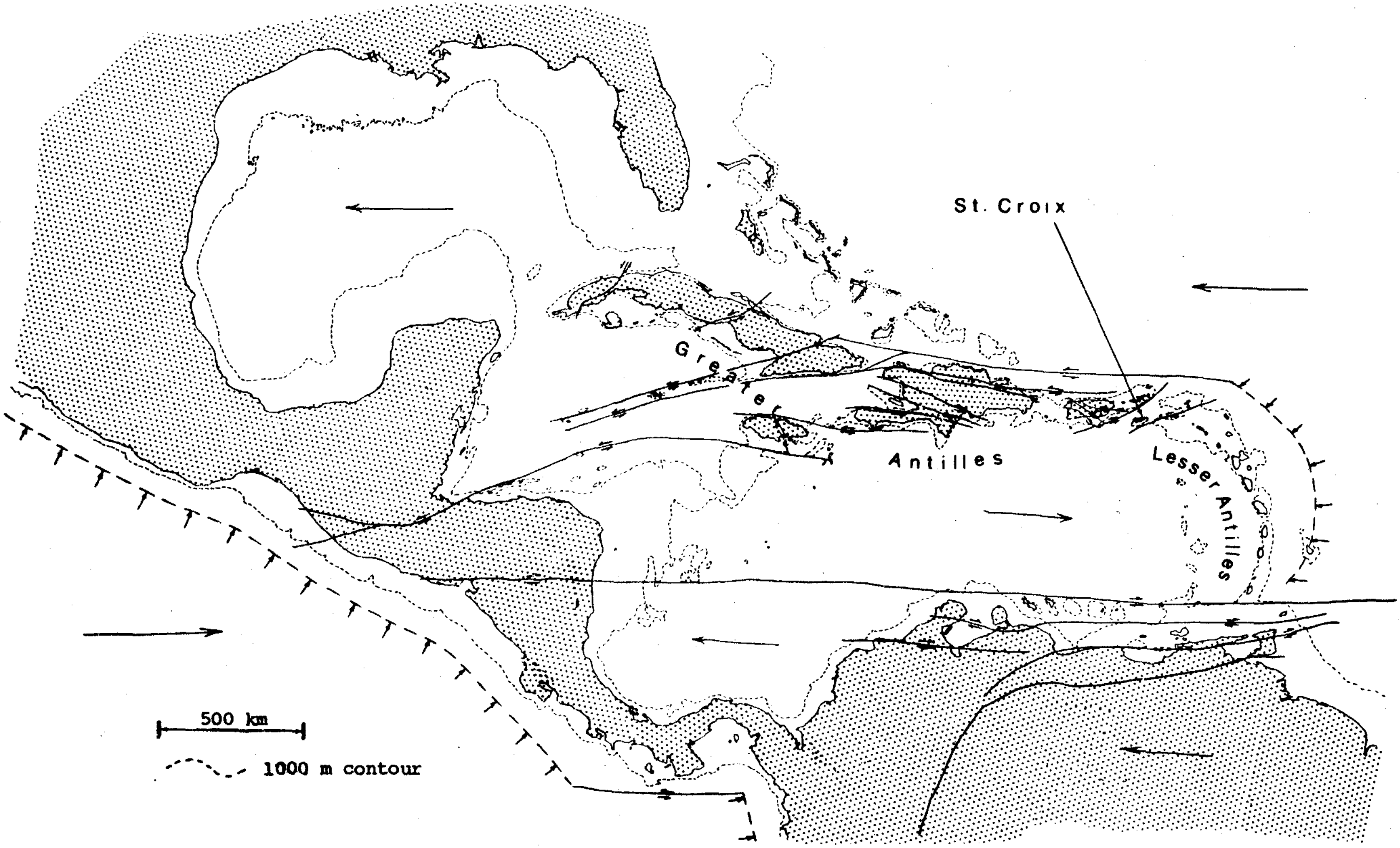


Figure 1. Caribbean plate showing the position of St. Croix relative to the Tertiary-Recent lesser Antillean volcanic arc and the older Greater Antillean fracture zone. After Turner, 1971.

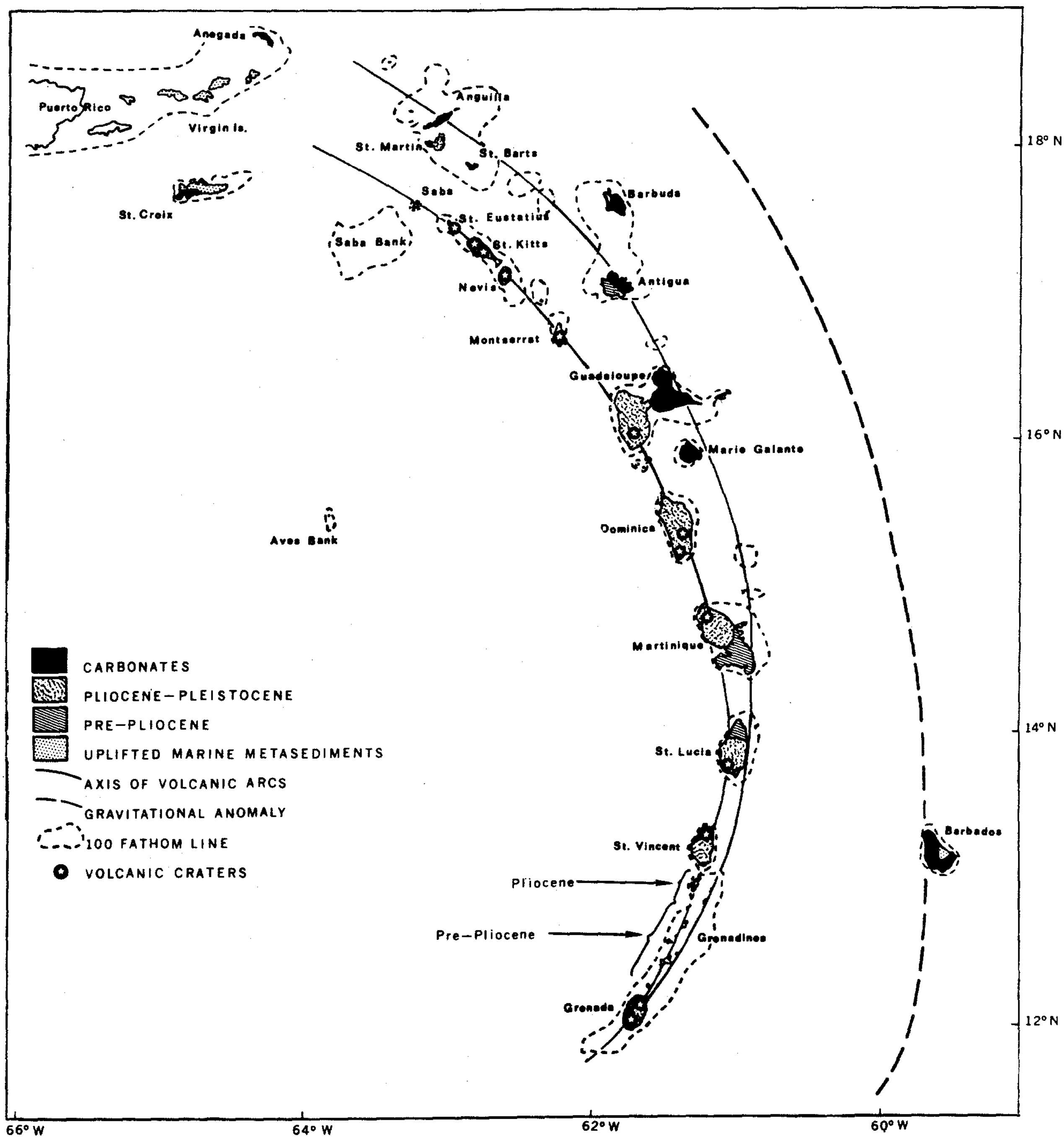


Figure 2. Lesser Antillean island arc showing the older (eastern) and younger (western) arc systems. In terms of basement genesis, St. Croix should be included with the Greater Antilles, the Mesozoic northern margin of the Caribbean plate, rather than the Lesser Antilles. However, being relatively small and isolated, the history of its limestone shelf during the Pliocene-Pleistocene is probably more similar to some of the islands of the older volcanic arc (e.g., Antigua). Adey and Burke, 1977.

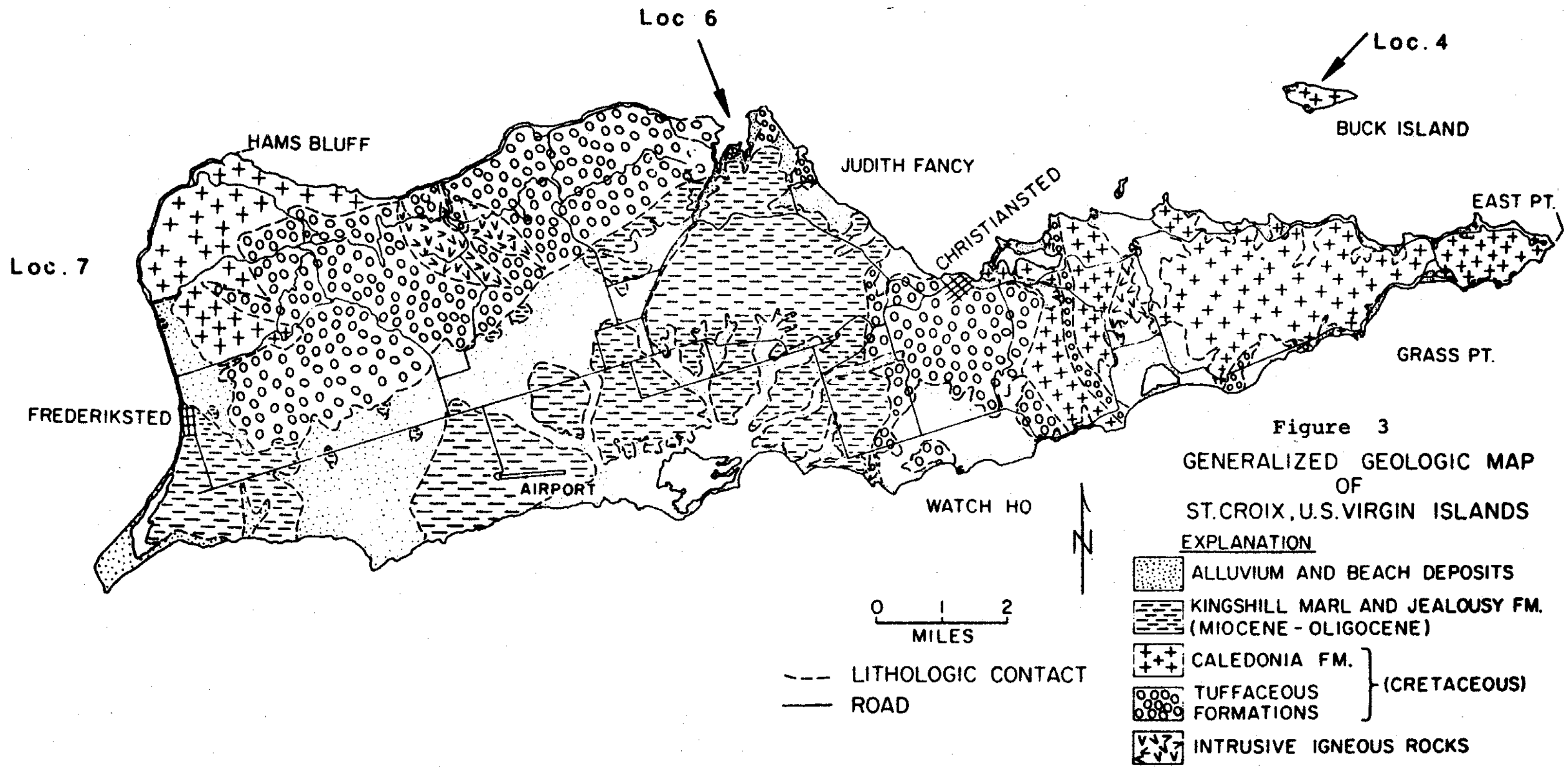


Figure 3
GENERALIZED GEOLOGIC MAP OF ST.CROIX, U.S. VIRGIN ISLANDS

After Whetton, 1974

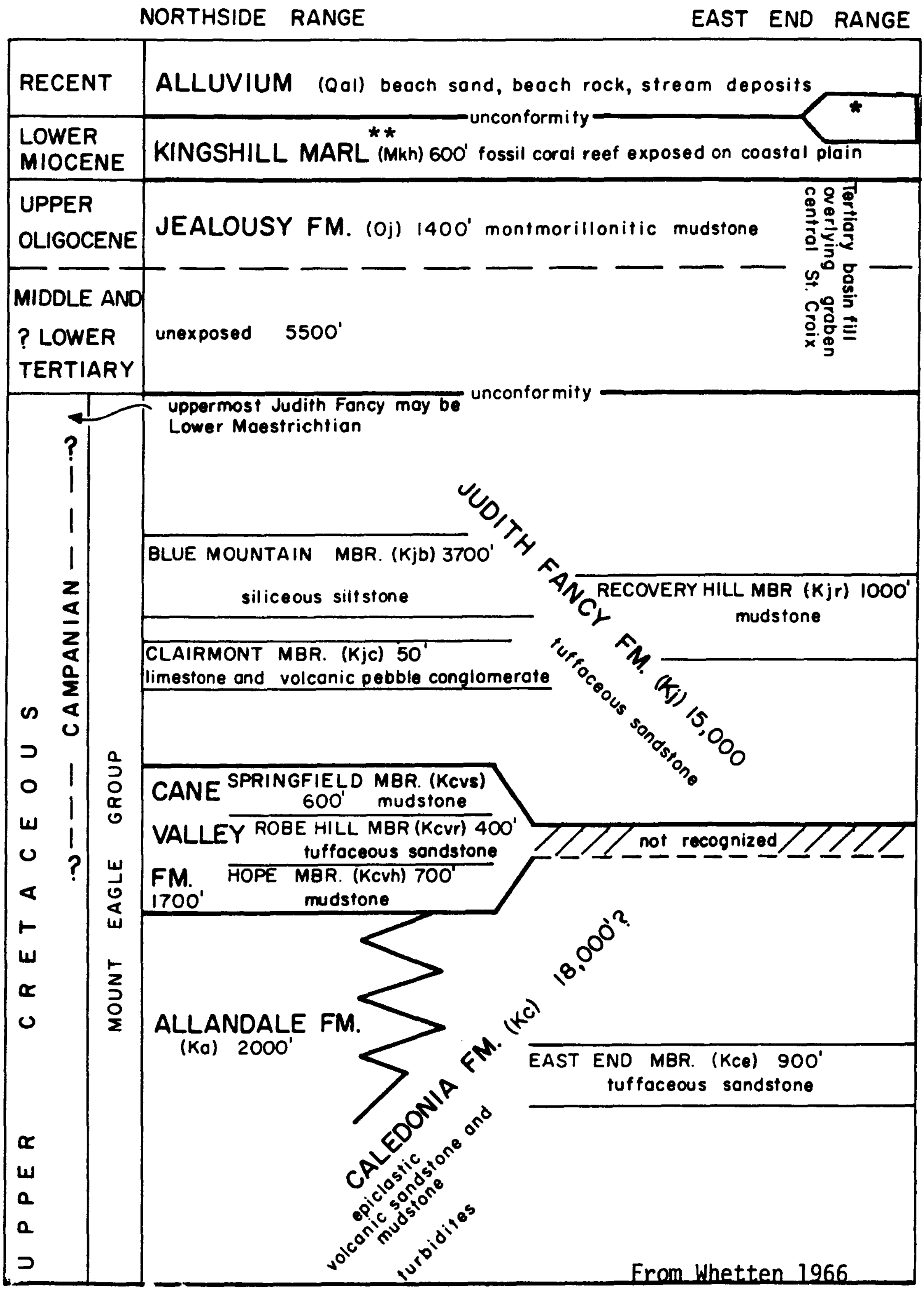


Fig. 4 STRATIGRAPHIC SECTION OF ST. CROIX.

pressure ridges from the equatorial Atlantic, the so-called easterly waves and reduction in wind strength and constancy of direction. However, unlike much of the central and western Caribbean, mean wind strength and easterly constancy remain over bf 3.2 and 85% respectively.

Seas at the eastern end of St. Croix are typically short and about a meter in height. Occasionally North Atlantic swells reach the northern and eastern parts of the island during the winter periods. These long period waves break in depths of 10 m or more on the shelf edge. However St. Croix is somewhat protected from the north and east by the northern Virgin Islands and the "rollers" do not have the effect that they have in much of the Lesser Antilles.

During the rainy season, hurricanes can hit this part of the Caribbean. However, in the Lesser Antilles they are normally of small diameter and affect only a narrow path. St. Croix has not had a major hurricane for 40 years.

Mean annual precipitation ranges from 60 cm in the east to 140 cm in the northwest and average monthly air temperatures are 24-28°C. Outside of small bays, sea water temperatures are probably only very rarely less than 25°C or greater than 28°C.

Caribbean and St. Croix reefs

The recent Climap investigations have indicated that during the glacial periods, Caribbean sea water temperatures were probably no more than 1-3°C lower than present. Also, it has been found that major barrier reefs existed as far north as Florida during the early Holocene. Holocene reef buildups of 10-30 m in thickness are known to be widespread in the Caribbean and algal ridges, which occur sporadically throughout the region, are abundant in the eastern Lesser Antilles. The major reef framework building organisms present today, the *Acropora* corals, *Millepora* and the corallines *Porolithon* and *Lithophyllum* in shallow water, and the more massive corals, especially *Montastrea*, in deeper water, are quite capable of producing extensive frameworks at upward-building rates of over 6-10m/thousand years under the right sea level and antecedent platform conditions.

The Caribbean-West Indies is geologically an active area. Much of the continental coast of South America, some of the coasts of the Greater Antillean islands as well as some of the young volcanic islands of the Lesser Antilles have unstable shorelines that are presently unsuitable for reef development. However, on more stable windward shores reef development is widespread. The extent of its occurrence on any stable shore is largely determined by pre-Holocene shoreline morphology and position relative to present sea level

(Fig. 5). A massive reef complex now rims the inner shelf of eastern St. Croix (Fig. 6). A number of reef localities and algal ridges have been cored and dated by carbon 14, and from these a generalized section of the eastern St. Croix reef-ridge structure and its history is shown in figures 7A and 7B.

It seems likely that many Pleistocene reef configurations are possible for the present island of St. Croix. The Holocene patterns will be demonstrated in these field trips. Given a stable sea level 10 meters lower than present, eastern and southern St. Croix would probably be characterized by a major barrier reef system capped by an algal ridge. With a stable sea level 10 meters higher, the island would probably have relatively little reef development, much like the island of St. Barts, 200 km to the east.

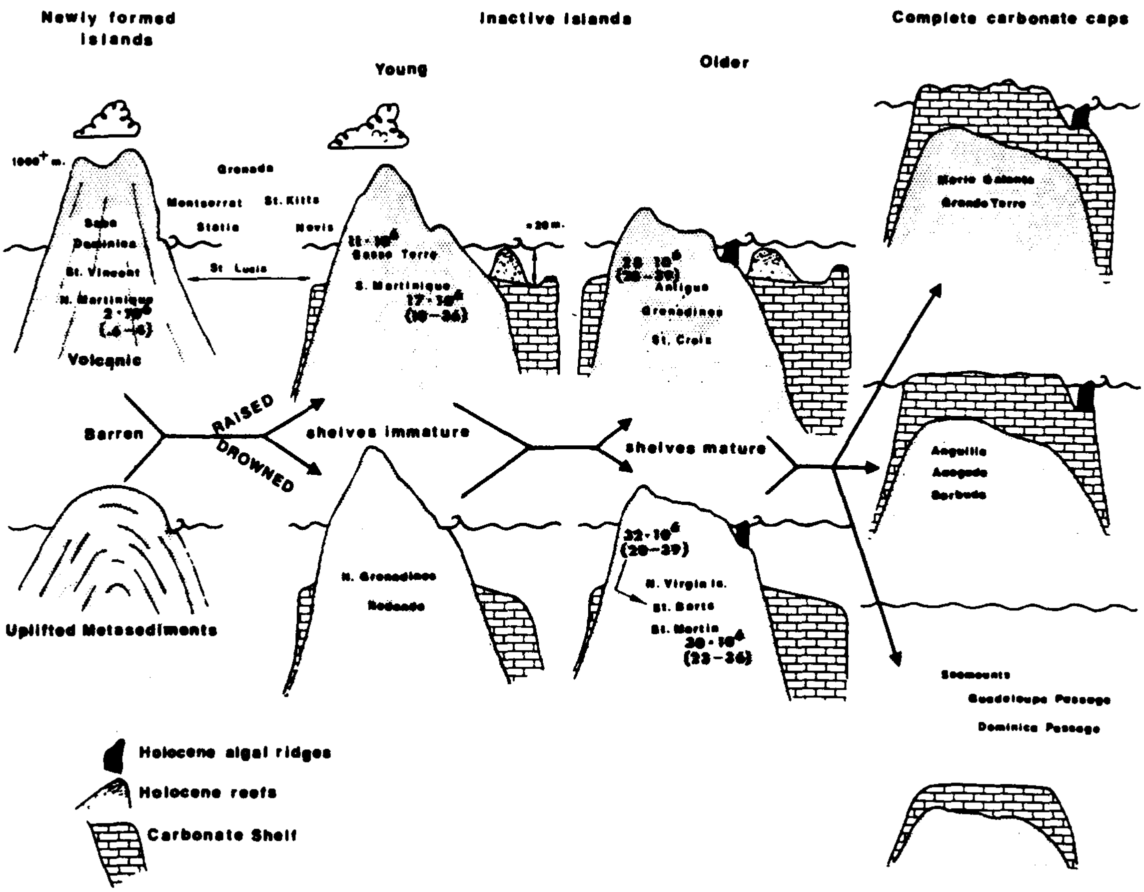


Figure 5. Development of major Holocene bioherms in relation to island geology and tectonics. Vertical scale for submarine sections is about 20X that of subaerial sections. K-Ar dates from Nagle (1976): for example, $32 \cdot 10^6$ years B.P. is mean; (25-37) is spread in million years. From Adey and Burke, 1977.

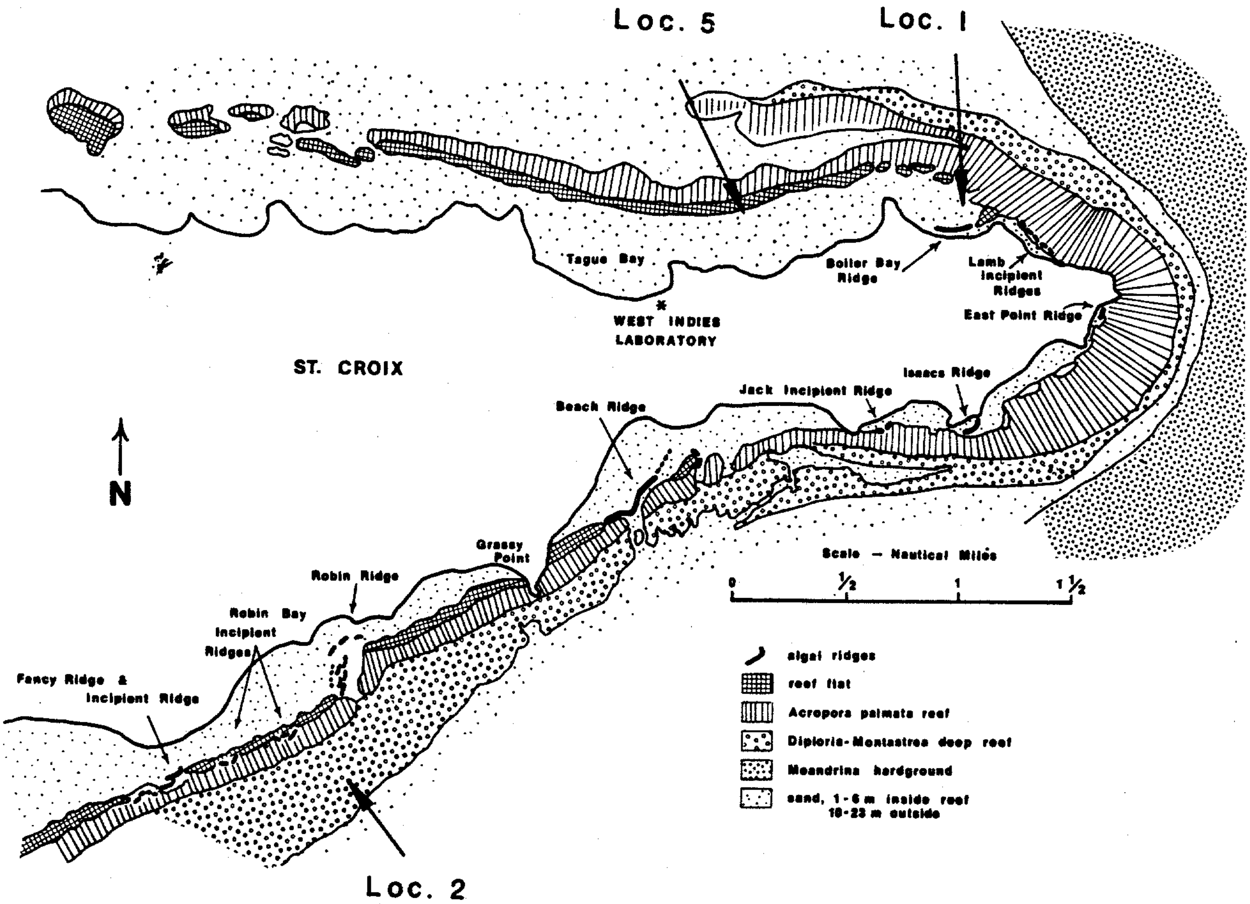


Figure 6. Coral reefs and algal ridges on the eastern end of St. Croix. Adey and Burke, 1976.

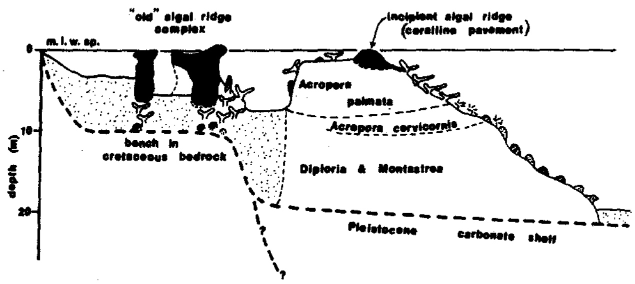


Figure 7A. Generalized section across algal ridge - coral reef complex in St. Croix. Adey and Burkė, 1976.

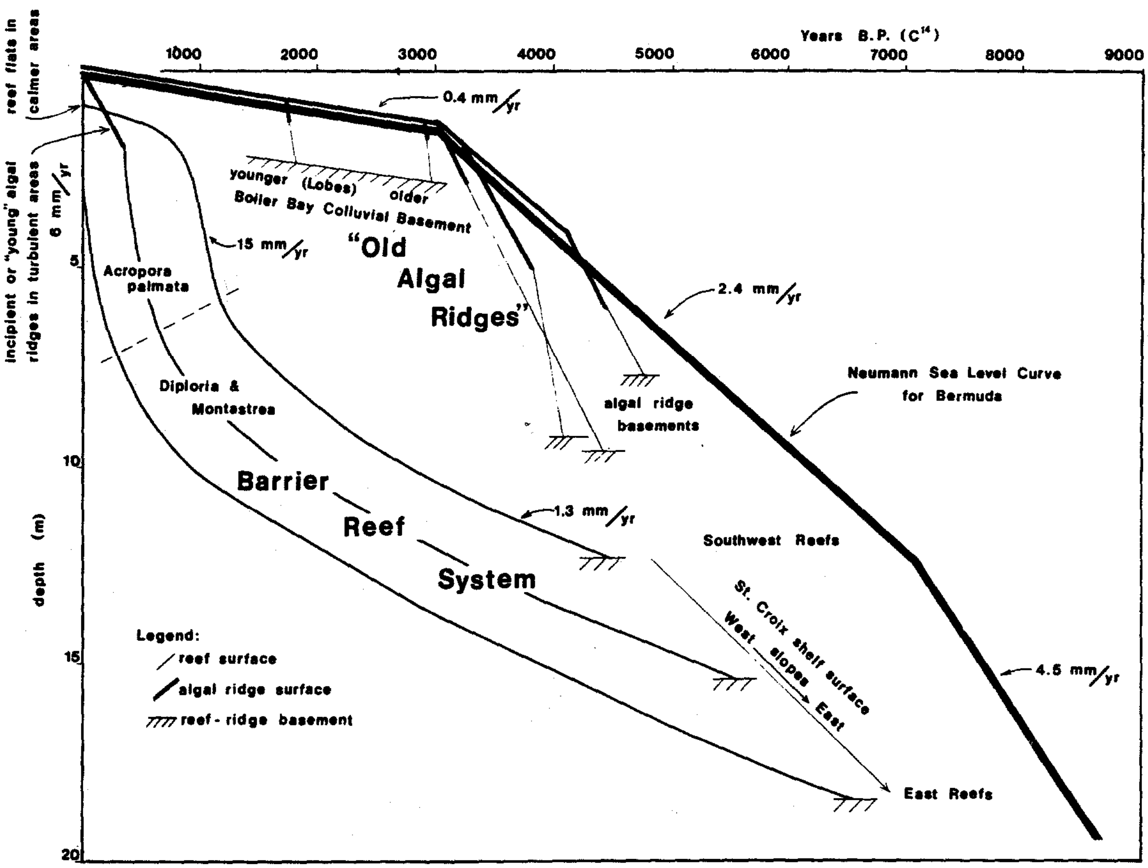


Figure 7B. Positions of the surfaces of major reefs and algal ridges relative to Holocene sea level on St. Croix as a function of time. Adey and Burke, 1976

BOILER BAY (Locale 1, Fig. 6)

Boiler Bay, at the northeast corner of St. Croix is very rich in its coral and algal reefoid populations, and it is presently dominated by a degenerating algal ridge (Fig. 8). The basal coral reef, underlying the algal ridge, consists primarily of Acropora palmata and Millepora. This reef facies formed about 1000 to 4000 years B.P. on a colluvial lag basement at a depth of only 3-4 m below present sea level. (The transected colluvium, as a bluff, is visible shoreward of the central part of the ridge.)

The algal ridge, composed largely of Lithophyllum congestum and to a lesser extent Porolithon pachydermum, ranges in thickness from 20-30 cm up to about 1.5 m (Fig. 9). Ages based on C^{14} dates of the underlying coral range from about 2500 years B.P to a little less than 1000 years B.P. Buildup of the seaward bank barrier reef in the last 1000 years has subsequently caused significant reduction in wave action, and Lithophyllum congestum and Porolithon pachydermum are no longer of importance on the surface of these ridges. Echinometra and other boring organisms are abundant on the margins and collapsed ridge lips are common (Fig. 10). The upper surface of the margins now range from mean low water springs to about 17 cm above that level (the maximum spring tide range in St. Croix is about 35 cm).

Extensive pavement areas occur between the individual lobes (boilers) of the algal ridge at a depth of 1-2 m. Presently these support a small standing crop of fleshy algal growth dominated by Sargassum spp. and cyclic blooms of Dictyota. Scattered Porites porites and Siderastrea sp. occur, but corals are generally sparse. The pavement itself has a thickness of one-half to one meter and is a sediment-filled and cemented framework of either Porites porites or Acropora cervicornis. Two C^{14} dates on coral from the pavement gave ages of 640 and 940 years B.P. Thus, within the past 1000 years, rich stands of these corals existed between the algal ridge boilers, a condition that still exists in the easternmost part of the bay.

In summary, the barrier reef in front of Boiler Bay has effectively begun to block wave action into the bay only during the past 300-500 years. Prior to that time the bay was quite open. About 4000 years B.P. rising sea level encountered the Boiler Bay colluvium. Within 1000 years, wave and current action had removed much of the weakly-consolidated portion, leaving a lag conglomerate of Caledonia cobbles and pebbles. With the partial protection of the bay, coral colonies, especially A. palmata, were soon flourishing, and by 3000 years B.P. incipient algal ridges and high boilers had begun to form. This process continued up to about 500 years B.P., with numerous small coralline mounds developing on Millepora and A. palmata colonies. Lithophyllum congestum, growing near sea level on the mounds developed mushroom-shaped pillars which

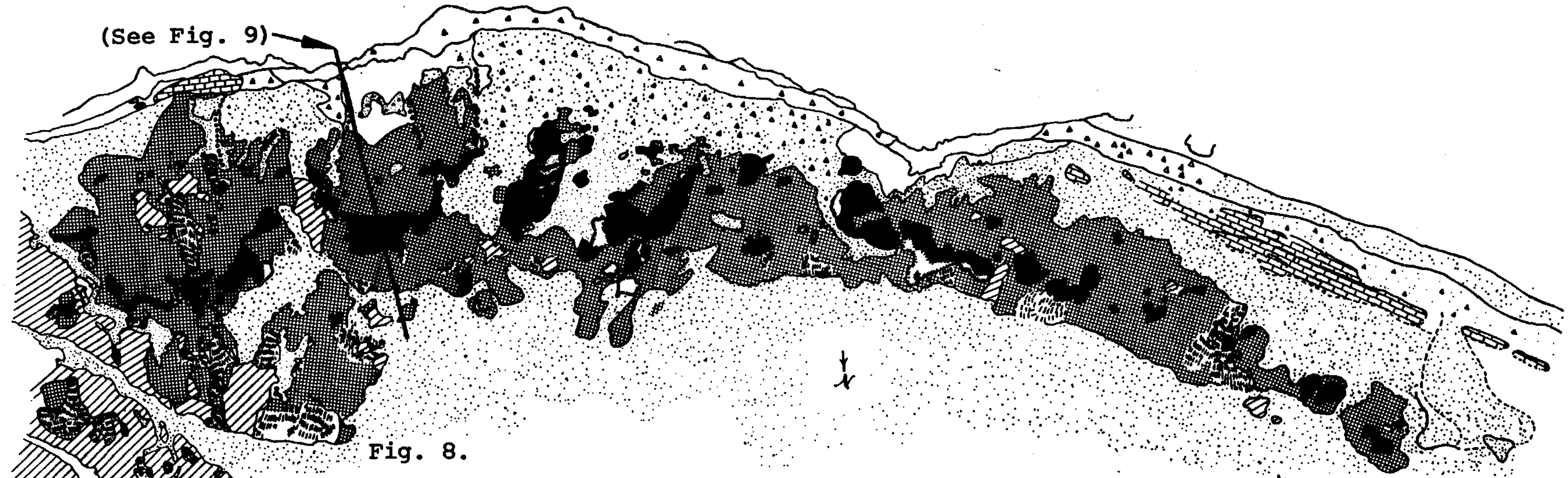


Fig. 8.

Generalized surface structure of algal ridge area in Boiler Bay. [black] coralline-constructed algal ridges; [grid] coral pavements, mostly Porites porites and Acropora cervicornis (small variety), some A. palmata; [||||] living A. palmata colonies; [hatched] dominantly live coral, mostly P. porites and A. cervicornis areas.

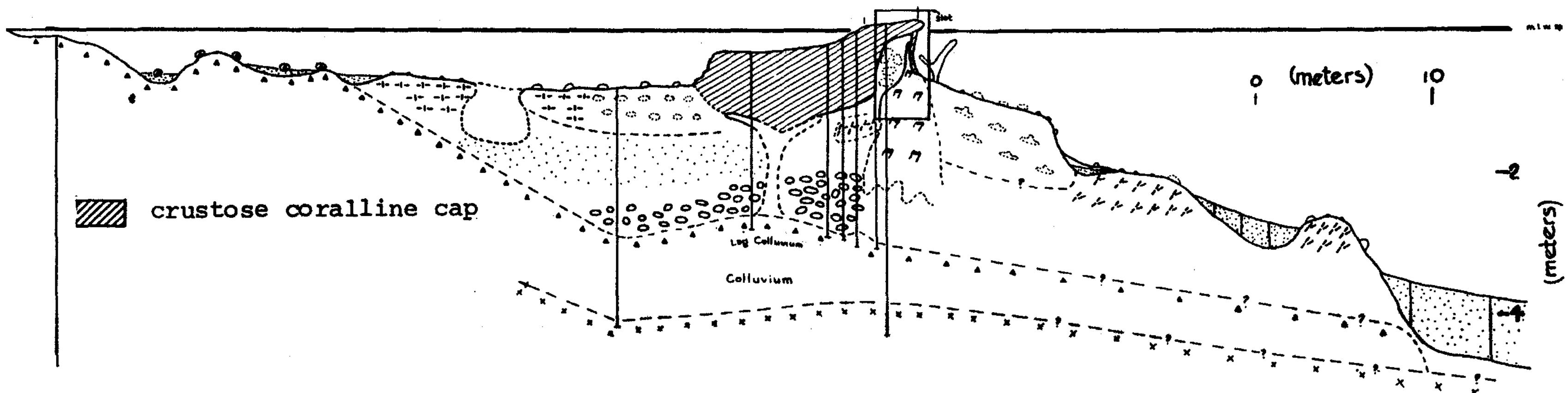


Figure 9. Section through Shark Reef algal ridge. The details of the nose area are based on a 60 cm wide [illegible] palmata immediately underlying the coralline cap was dated at [illegible] years B.P.

irregularly fused with their neighbors to produce the characteristic algal ridge morphology. Apparently about 1500 to 2000 years B.P. wave action had begun to be reduced around the boilers and dense thickets of the finger corals began to develop. The richest period, in terms of coral and coralline algae development in Boiler Bay, must have been about 1000 years B.P. Since that time and especially during the past 500 years, ridge degeneration, mostly as a result of wave blockage by the outer barrier, has become progressively more extreme. In the tropical reef environment, any factor that reduces grazing or increases algal growth rates, apparently leads to increased standing crops of fleshy algae. Many of the high algal ridges on Lesser Antillean islands directly open to the Atlantic sea and swell, are rather barren of larger fleshy algae, presumably as a result of physical removal by wave surge. On the other hand, intermediate energy algal ridges and similar structures such as exposed beach rock tend to be rich in fleshy algae often with wet standing crops of over 2-3 kg/m^2 (Fig. 11). A list of algae tabulated from the western Boiler Bay area by Isabella Abbott is given in figure 12.

Figure 10. Western section of Boiler Bay algal ridge. The lagoon in the foreground is about 5 m deep. Note the numerous broken lips on outer ridge margins on the center and far left. The irregular mound in the lower left was a young cup reef based on a large <u>Millepora</u> colony which has now collapsed.

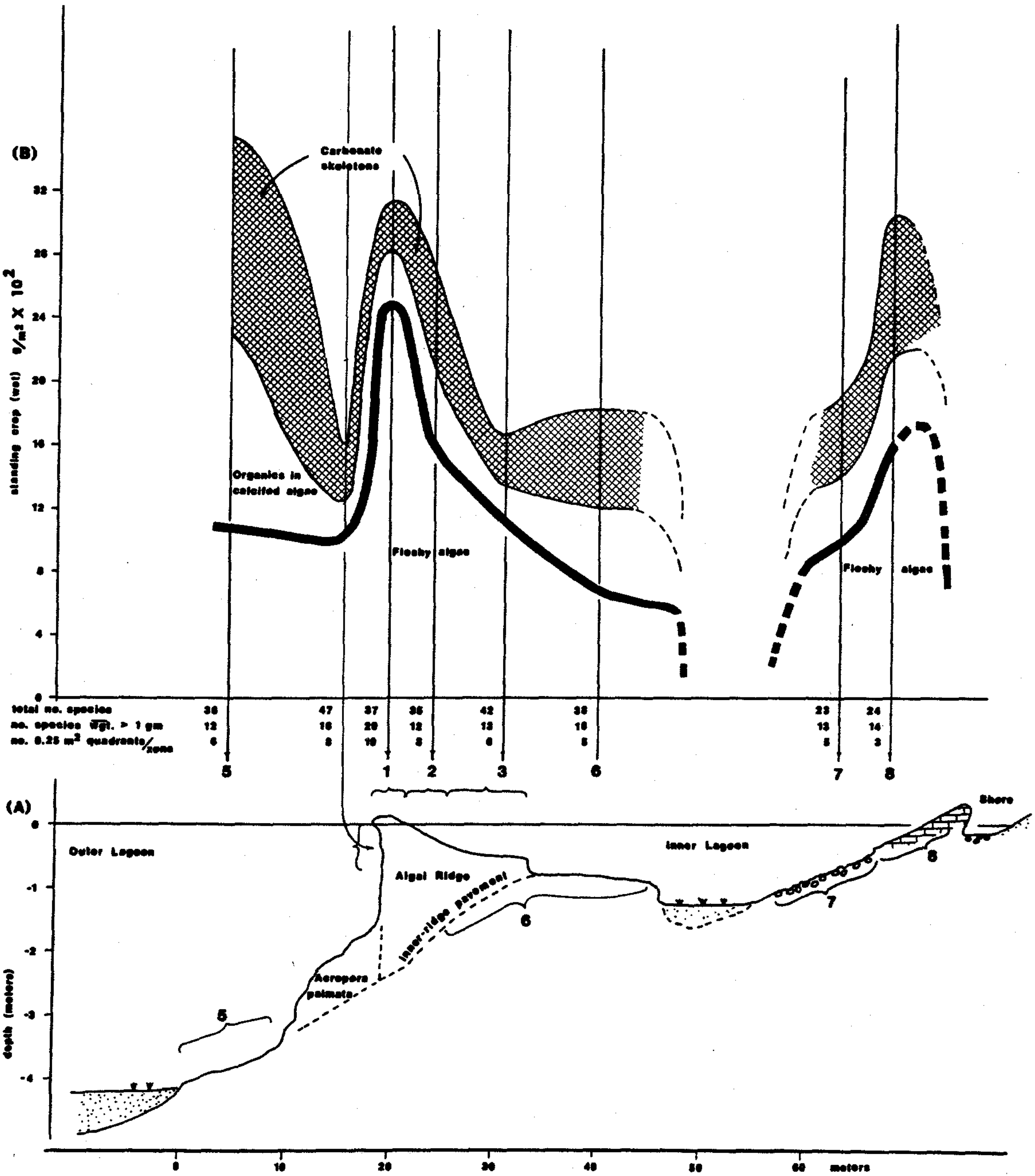


Figure 11. Generalized section across Boiler Bay algal ridges showing standing crops and numbers of macro algal species based on quadrats. From Connor and Adey, 1977.

Figure 12

A checklist of Marine Algae of the Boiler Bay study area, from collections made January 1-21, 1974

Species	Inshore Lagoon	Beach-rock	Channel	Algal Ridges
FLOWERING PLANTS				
Halodule wrightii	++		+	
Syringodium filiforme			++	+
Thalassia testudinum	++		+++	+
CYANOPHYCEAE (Bluegreens)				
Entophysalis deusta	+++	++++		
Microcoleus lyngbyaceus	++	+++		
Schizothrix calcicola		++		
CHLOROPHYTA (Green algae)				
Avrainvillea longicaulis				+
Avrainvillea rawsonii			+	
Bryopsis plumosa				++
Caulerpa cupressoides		+	+	
Caulerpa mexicana	+		++	
Caulerpa racemosa	+++	+++	++	++
Caulerpa sertularioides	+++	+		
Caulerpa vickersiae		+		
Chaetomorpha aerea	+			
Chaetomorpha brachygona	+			
Chaetomorpha linum	++	++++	++	
Cladophora corallicola				+
Cladophora sp.	+	+		
Cladophoropsis membranacea	++	+++		+
Dictyosphaeria cavernosa	++	+++	+	++
Dictyosphaeria vanbosseae		++		
Ernodesmis verticillata		++	+	++
Halimeda incrassata	+++		+	+
Halimeda monile			++	+
Halimeda opuntia	++++	++	++	++++
Halimeda tuna			+	++
Neomeris annulata	++	+		
Penicillus capitatus	++		+++	+++
Udotea conglutinata	++		++	++
Udotea flabellum	+++		++	+++
Valonia ventricosa		+		++

Species	Inshore Lagoon	Beach-rock	Channel	Algal Ridges
PHAEOPHYTA (Brown algae)				
Colpomenia sinuosa		++		++
Dictyopteris delicatula		++	++	++++
Dictyopteris justii				+
Dictyota ciliolata				+
Dictyota dentata		++	+	+++
Dictyota dichotoma		++		+++
Dictyota divaricata		++	++	++++
Dictyota linearis				+
Dilophus alternans		++++	++	+++
Dilophus guineensis		+++		+
Giffordia duchassaingianus	+++	++++		
Giffordia mitchelliae	++++	++		
Hydroclathrus clathratus		+		
Padina gymnospora				+
Padina sanctae-crucis	+++	++++	+++	+
Padina vickersiae				++
Ralfsia expansa		++		
Sargassum platycarpum			+++	+++
Sargassum polyceratium				++
Sargassum vulgare	++	++++	+++	+
Sphacelaria furcigera			++	
Sphacelaria tribuloides	++	+++	+	++
Turbinaria turbinata		++	+	++
RHODOPHYTA (Red algae)				
Acanthophora spicifera	+	++		++
Acrochaetium spp.	+	++		++++
Amphiroa fragilissima		++		++
Amphiroa rigida v. antillarum		++		+
Asparagopsis taxiformis				+
Centroceras clavulatum	+++	++++	++	++++
Ceramium byssoideum		+	+	+
Ceramium cruciatum				+
Ceramium leutzelburgii				++
Ceramium nitens		++		+
Ceramium tenuissimum		+		+
Chondria collinsiana		+++		++
Chondria curvilineata		++		+++
Chondria dasyphylla		++	+	
Chondria sedifolia		+		
Champia parvula				++
Chrysymenia sp.				+++
Coelothrix irregularis				+++
Crouania attenuata				+++
Digenia simplex	++		+	
Erythrocladia subintegra	++	++	++	++
Fosliella lejolisii	++	++	++	++

Species	Inshore Lagoon	Beach-rock	Channel	Algal Ridges
(Rhodophyta, contd.)				
Galaxaura comans			++	
Galaxaura cylindrica		+++	++	++
Galaxaura subverticillata		+++	++	++
Gelidiella acerosa		+++	++	+++
Gelidiopis intricata		+		++
Gelidium pusillum	+	+		+
Gracilaria mammilaris			+	+++
Griffithsia tenuis				+
Gymnothamnion elegans				+
Herposiphonia secunda		+		++
Herposiphonia tenella		+		++
Herposiphonia sp.				+
Heterosiphonia wurdemannii			+	++
Hypnea musciformis		++		+
Hypnea spinella		++		+
Jania adherens	++	++++	+	+++
Jania capillacea		++		++++
Laurencia microcladia				
Laurencia intricata		++		++++
Laurencia nana		+++		+++
Laurencia obtusa		++	+	++
Laurencia papillosa		++++	+	+++
Laurencia poitei				++
Laurencia scoparia		++		+
Liagora decussata		++	+	+
Liagora pinnata	+	++	+++	
Liagora valida		+	+	+
Lithophyllum congestum				+
Meritotheca floridana				+
Neogoniolithon decutescens	++	+++		
Nitophyllum sp.				+
Pleonosporium sp.			++	
Polysiphonia ferulacea	+	++++		
Polysiphonia sphaerocarpa				++
Polysiphonia sp.				+
Spermothamnion investiens		+		+
Spyridia aculeata				++
Tenaraea prototypa			+	++
Wrangelia argus				+++
Wrangelia penicillata				+
Wurdemannia miniata		+		++

ROBIN-FANCY (Locale 2, Fig. 6)

The Bank Barrier Reef at Robin Bay and Fancy Point

Based on C^{14} dating of coral samples from the ship channel in southwestern St. Croix and from a series of core holes along the northeastern bank barrier, it seems likely that this section of reef has been capped with 5-10 meters of *Acropora palmata* during the past 1000-1500 years (see Figs. 7A, 7B). The upper fore reef of the main barrier is presently dominated by *A. palmata* (Fig. 13, 15). In the mid to lower fore reef, *A. palmata* thins out (Fig.14) becoming interspersed with gorgonian covered pavements. Below 5-7 m the coral *Acropora cervicornis* becomes the dominant framework builder.

In the back reef *A. palmata*, *A. cervicornis* or *Porites porites* are the major framework elements. Here, however, fleshy algal turfs on dead coral can be conspicuous. In a recent field study the biotic composition of reef surface area, as well as algal standing crop and species composition were examined from numerous random one meter quadrats. Because of bottom irregularity, an average of 2-3 m^2 of macroscopic surface area was found within one meter square of bottom. This surface averaged 26% live coral (mostly *A. palmata*), 60-64% dead standing coral and rubble (with <11% sand) and 10-14% crustose coralline algae. Although scattered patches of the larger benthic algae (*Halimeda*, *Laurencia* and *Dictyota*) were present, thin algal turfs coated most of the available carbonate surface. These had a mean standing crop of 93 g wet weight (19 g dry weight). Turfs were dominated by the red genera *Jania*, *Gelidium*, *Amphiroa*, *Coelothrix*, *Crouania*, *Lophosiphonia* and *Herposiphonia* and the blue greens *Oscillatoria* and *Lyngbya*.

Productivity on this reef has been examined by several means. Community gross primary productivity by upstream-downstream analysis of oxygen concentration was found to be 36.1 g O_2/m^2/day in the back reef and 13.8 g O_2/m^2/day in the fore reef (with current flow across the reef from 3-9 m^3/m/min). Expected algal productivity, converted from dry standing crop, provided values of 21 g O_2/m^2/day for the back reef and 12 g O_2/m^2/day for the fore reef. In terms of upstream-downstream productivity a mean figure of 27% of primary productivity would thus be due to living corals (as compared to 26% measured area). Productivity chambers were also used to examine "in situ" gross primary productivity of the major reef elements in dark and light conditions. A mean value for live coral of 27% of total component productivity was obtained with 68% being attributed to algal mats and 5% to coralline.

It was concluded that 70-80% of the gross primary productivity on Robin Bay reef is accomplished by benthic algae. The algae and their frequency of occurrence is given in figure 15A.

Figure 13. Rich Acropora palmata stand in the upper fore reef on Robin Bay reef. Although the A. palmata is conspicuous, m^2 quadrats in this area have shown that only about 1/3 of the surface area is occupied by live coral.

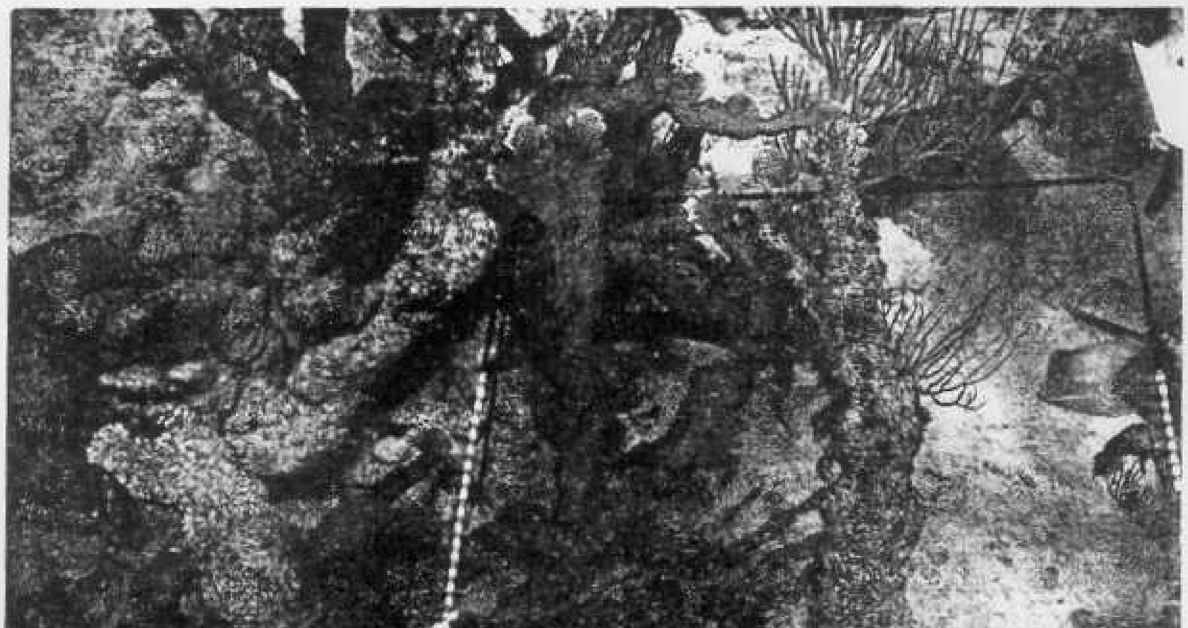


Figure 14. Overhead photograph in the mid fore reef. Although still in the A. palmata zone, the density of this species is lower here than in the upper part of the zone, with pavements and gorgonians becoming prominent. The relationship of live A. palmata to dead standing arms of the coral coated with coralline algae and fleshy algal turfs is typical.

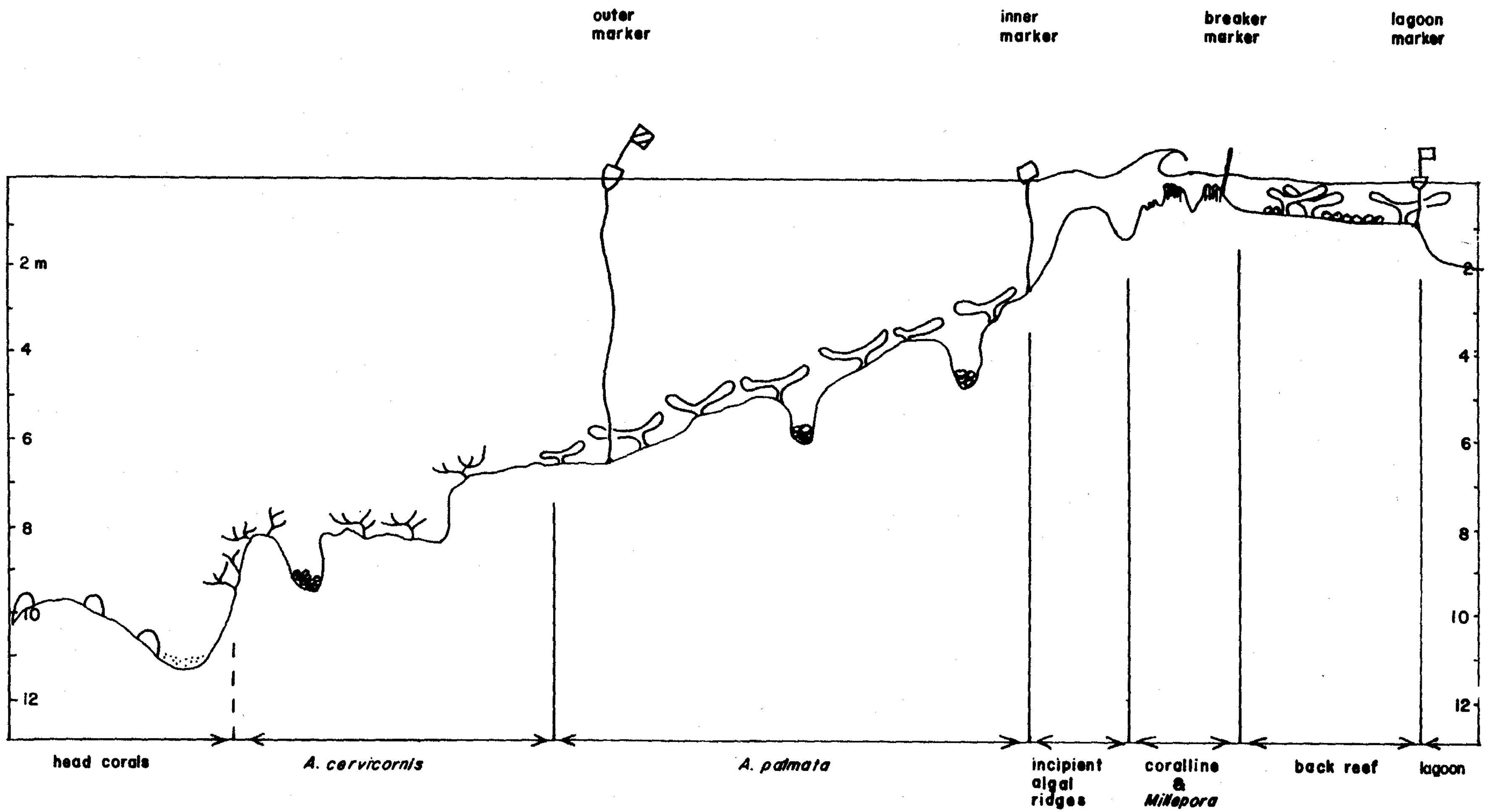


Fig. 15. Depth profile along Robin Bay reef transect.

Figure 15A. Fleshy and filamentous algae on Robin Bay reef. Frequency, number of quadrats/total quadrats; Mean abundance in quadrats of occurrence: *** - abundant; ** - common; * - occasional to rare.

Back Reef
16 quadrats

GREENS		
Ulva fasciata.............	1	*
Cladophora sp.	4	*
Chaetomorpha linum	1	*
Cladophoropsis sp.	5	*
Valonia ventricosa	5	*
Dictyosphaeria spp.	2	*
Ernodesmis verticillata	2	*
Boodlea spp.	2	*
Struvea spp.	3	*
Acetabularia spp.	3	**
Neomeris annulata	1	***
Caulerpa spp.	1	*
Udotea spp.	6	**
Avrainvillea spp.	2	*
Halimeda spp.	4	**
Penicillus spp.	2	**
BROWNS		
Dictyota bartayresii.......	6	**
Dictyopteris spp.	2	**
Padina sanctae-crucis	2	**
REDS		
Acrochaetium sp...........	1	*
Asparagopsis taxiformis (Falkenbergia)	2	*
Gelidium pusillum	6	**
Jania capillacea (incl. some J. rubens and J. adherens)	11	***
Amphiroa spp.	9	**
Hypnea cervicornis (incl. H. musciformis)	5	**
Champia parvula	5	*
Coelothrix irregularis	5	**
Crouania attenuata	1	*
Ceramium spp.	5	**
Centroceras clavulatum	2	*
Dasya spp.	2	*
Acanthophora spicifera	2	**
Laurencia spp.	6	**
BLUE GREENS		
Oscillatoria..............	4	**
Lyngbya	3	**
Calothrix	1	**
(also occurred)		
Symploca		
Scytonema		
Hormothamnion		

Fore Reef
15 quadrats

Chaetomorpha linum........	4	*
Enteromorpha sp.	1	*
Chadophoropsis sp.	9	**
Siphonocladus spp.	1	*
Valonia spp.	2	*
Ernodesmis spp.	1	*
Neomeris annulata	1	**
Dictyota (bartayresii)....	7	**
Dilophus spp.	8	***
Dictyopteris spp.	4	***
Lobophora	1	**
Acrochaetium..............	6	*
Galaxaura spp.	1	*
Asparagopsis taxiformis	2	*
Gelidium pusillum	8	**
Jania capillacea (incl. J. rubens and J. adherens)	11	**
Amphiroa (fragilissima)	7	**
Hypnea cervicornis (incl. H. musciformis)	1	*
Coelothrix spp.	3	*
Champia parvula	8	*
Crouania attenuata	6	*
Wrangelia argus	6	**
Griffithsia spp.	6	**
Gymnothamnion	2	*
Ceramium spp.	8	**
Centroceros spp.	6	*
Dasya spp.	2	*
Caloglossa leprieurii	1	*
Polysiphonia spp.	1	*
Laurencia spp.	2	*
Herposiphonia spp.	8	**
Lophosiphonia spp.	5	**
Oscillatoria.............	7	**
Isactis	4	**
Symploca	3	**
Lyngbya	3	**
Anacystis	2	*
Entophysalia	2	*
Calothrix	2	*
Hormothamnion	2	*
Phormidium	1	*
Scytonema	1	***
Amphithrix	1	***

The surf zone of the bank barrier reef is presently dominated by Millepora. However, at numerous spots on the seaward crest, mounds of crustose coralline (especially Porolithon pachydermum and Neogoniolithon megacarpum) are conspicuous. A few extend above mean low water and have developed heads of Lithophyllum congestum. Several of these mounds have been cored for over a meter and have been found to have coralline frameworks. A single mound (near Fancy Point) has been cored 2 m to the underlying Acropora palmata which dated 355 years B.P. These "incipient" algal ridges are presently developing at numerous points along the eastern bank barrier reef, suggesting that in 500-1000 years much of this outer reef crest will be occupied by an algal ridge.

Fancy Algal Ridge

In the region of this field trip, "old" algal ridges (Fig. 6) occur off Fancy Point and at the east end of Robin Bay. Two core holes, one to basement, have been placed in the Fancy ridge pair, and that is described first.

Figures 16 and 17 show the algal ridge pair and one of its associated incipient ridges off Fancy Mountain. These ridges are both relatively low and degenerating due to wave blockage by the A. palmata reef forming outside. The inner ridge is also partly blocked by the outer ridge, and reaches maximum heights of only +26 cm above m.l.w.sp., with an average elevation of +10 to +17 cm. The outer, more exposed, ridge averages +17 to +23 cm.

The core hole in the inner ridge returned Caledonia from near its base as shown. The coralline begins at 6 meters in the core, and L. congestum at 4 meters, indicating that the coral reef structure, developed on the ledge shown at about 4800 years B.P., had become an incipient ridge by 4500 years B.P. and finally a high ridge by 4300 B.P.

The core in the outer ridge is dominated by L. congestum only in the upper 1.5 meters and becomes mixed with Millepora and then Montastrea at 2.5 meters. Thus, the outer ridge is considerably younger than the inner, starting at about 3000 years B.P. Its position in line with the present Acropora palmata back reef crest and somewhat landward of a number of presently forming incipient ridges suggests the presence of a secondary bench or series of benches, in elevation somewhere between the high bench (with the inner ridge) at 8 meters and the outer shelf at approximately 15 meters.

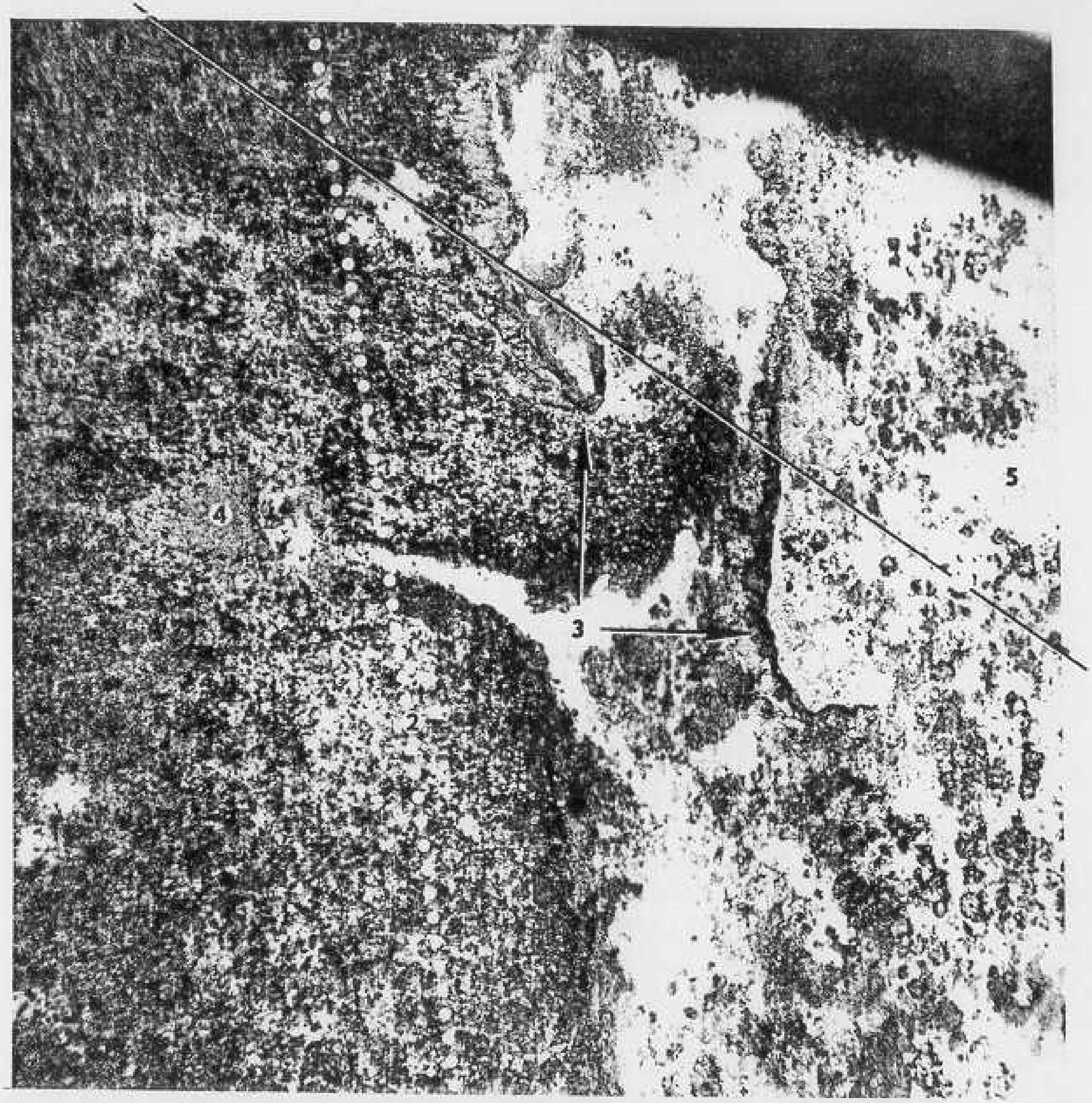


Figure 16.

Aerial view of Fancy algal ridge pair.

(1) Transect line (Fig. 17)
(2) Reef crest
(3) Algal ridges
(4) Incipient algal ridge
(5) Lagoon

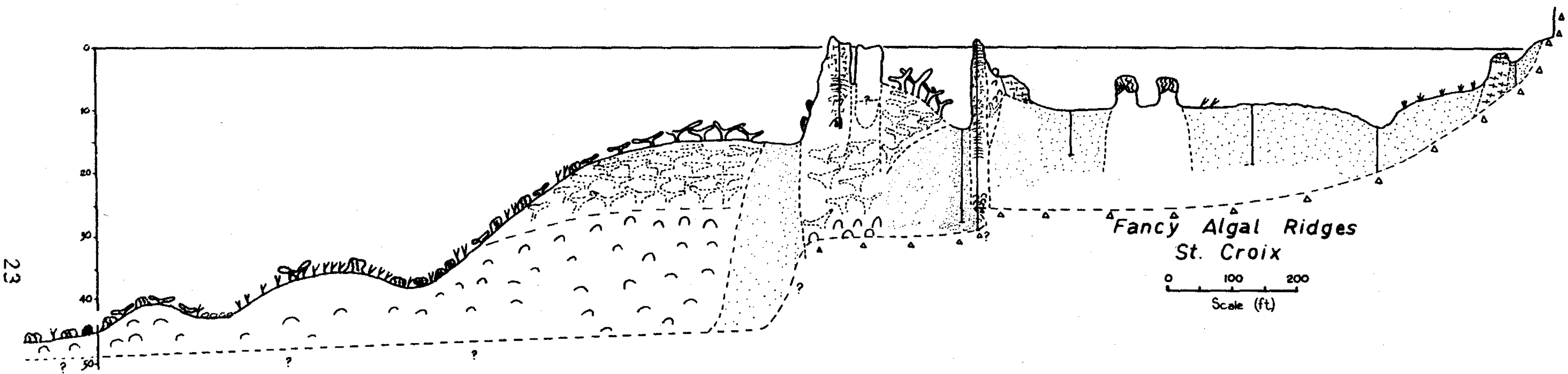


Figure 17. Section across Fancy algal ridge pair showing locations of core holes. Basement level (probably carbonate) under the reef is based on the ship channel section at Hess refinery and a series of cores on the northeast bank barrier. [symbol] Lithophyllum congestum; [symbol] primarily Porolithon pachydermum.

Robin Algal Ridge

Three holes have been cored in Robin algal ridge. However, as none of these reached basement, its genesis is still partly uncertain. A visit to this ridge is included here as it is the most exposed of the major "old" algal ridges on St. Croix and therefore somewhat more like the extensive algal ridges occurring on the Lesser Antillean islands of Barbuda, Grande Terre, Marie Galante and Martinique (Figs. 18, 19).

The deepest of the cores on the outer part of the high ridge, shown in figure 19, broke into an underlying cavern at about 3.5 meters and was terminated. The core in this case was dominated by branched heads of *Lithophyllum congestum* to a depth of about 2 meters with crust species and abundant *Homotrema* below. Using the Neumann sea level curve with *Lithophyllum congestum* as a sea level indicator, this ridge has been growing at or near mean sea level at least since 3300 years B.P. The two additional cores were less than 1 m deep, and were placed in the back ridge area. The surface of the cored back ridge is now about one meter below m.l.w.sp. and little living coralline is present. *Diadema antillarum* is abundant and the surface is obviously being removed by grazing, leaving it pitted and scraped. However, several centimeters down, the cores are dominantly crustose coralline, suggesting that this structure was once a high ridge, perhaps older than the outer series. It has been subsequently blocked from the required wave action by the development of the younger outer series. Shoreward of this second line, there is a third series of ridge-like structures which may also be degenerating high ridges.

At present, an active *Acropora palmata* reef is developing to seaward. This is shown on both figures 18 and 21. The surface of this reef is still 2-4 meters below sea level and only occasionally do waves break on it. However, it has probably reduced some of the wave energy delivered to the ridge complex already and could be partly responsible for the degeneration of the back ridge system. If this reef has a growth rate comparable to that of Long Reef (at Hess Channel), well developed reef flat will have formed within 600-800 years and Robin Ridge will be in full degeneration.

We cannot visit Isaac ridge during this field trip, but figure 20 is included to show the appearance of the south coast "old" algal ridges at mean low water springs.

Figure 18. Outer section of Robin algal ridge looking northeastward, showing the extensive bank barrier reef developing to seaward. (Dashed line indicates crest.)

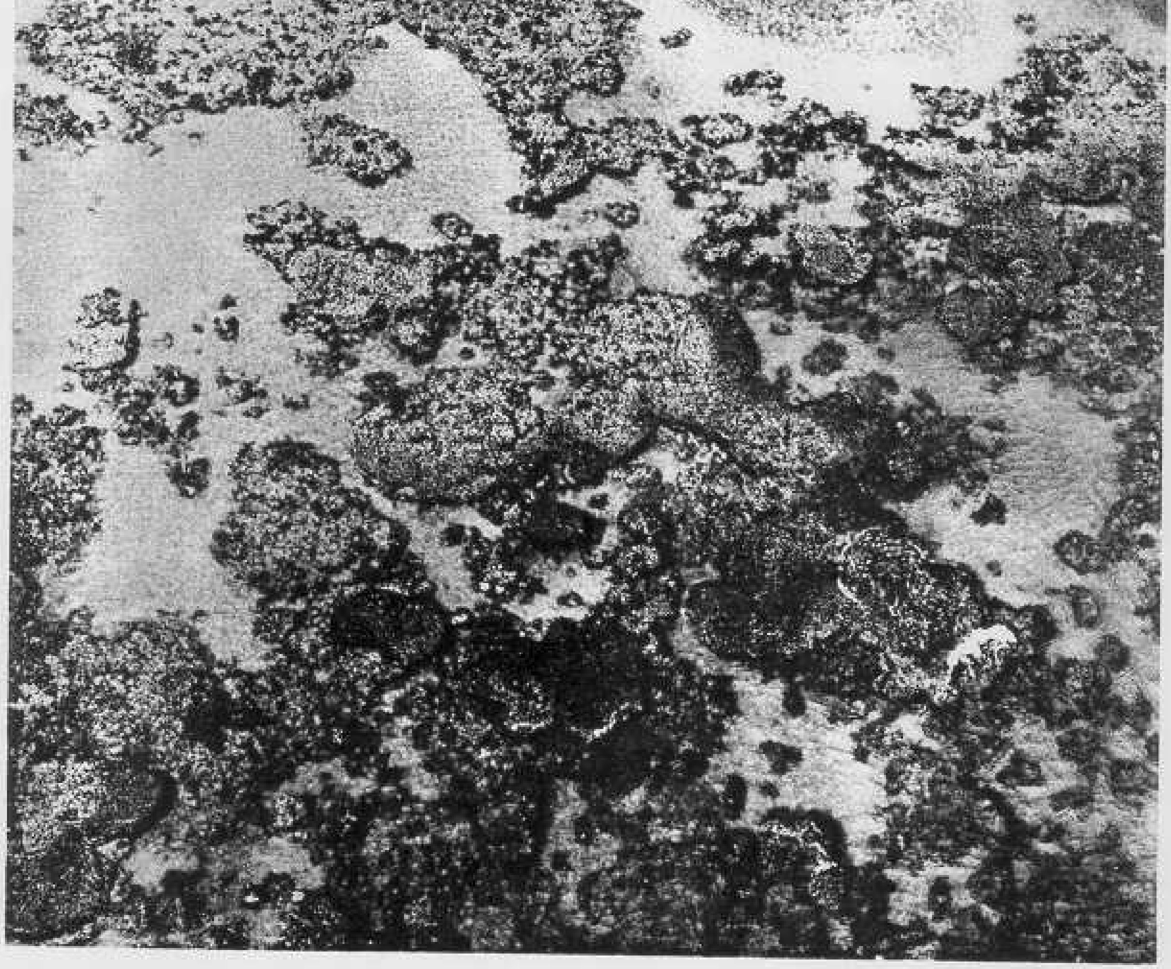


Figure 19. Central section of Robin algal ridge (lagoon at top). Note the complex fusion of the boilers. The progressive shoreward lightening of color on the algal ridge results from increased grazing in the quieter water and a reduction in red and brown fleshy algae. Note that both figures 18 and 19 were photographed on exceptionally quiet days.

Figure 20. Isaac Point algal ridge at mean low water springs. This ridge is difficult to reach with a large group and will not be seen on this field trip. It has been cored to basement (see Adey, 1975).

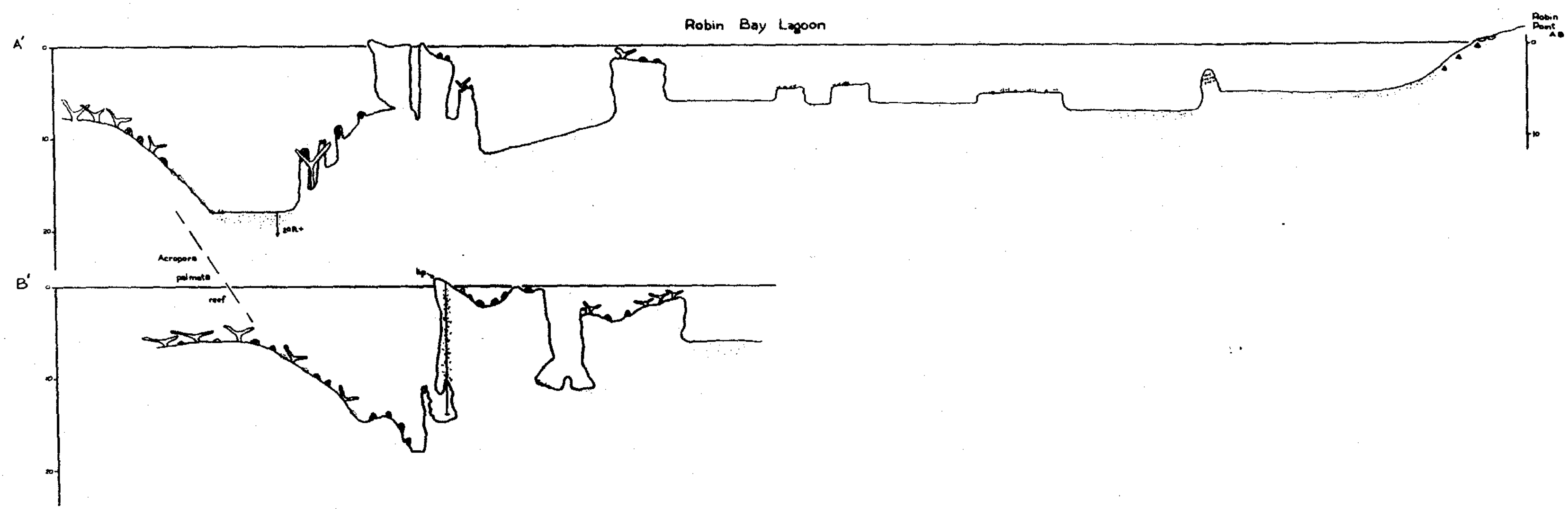


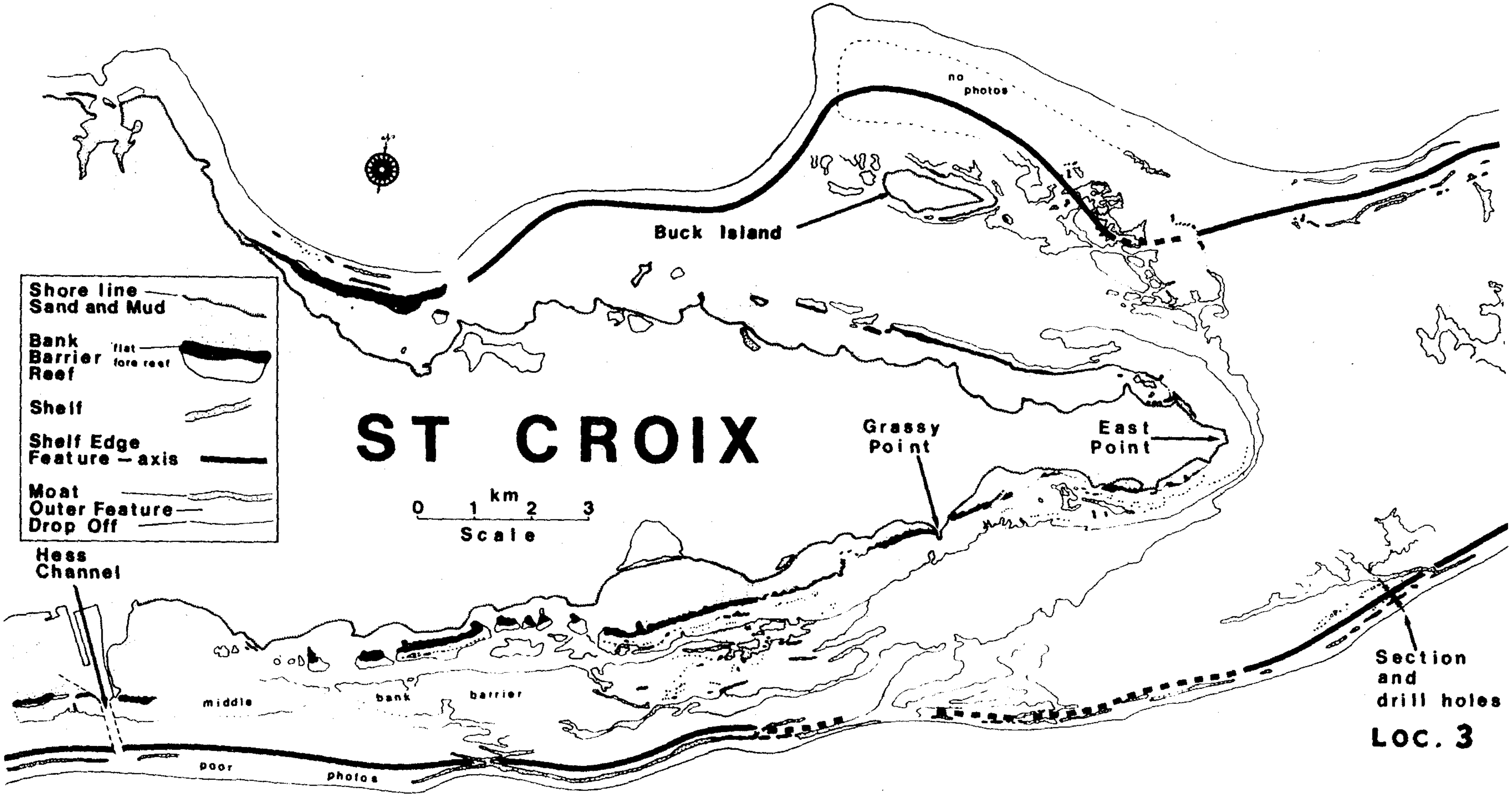
Figure 21. Sections across **Robin algal ridge**, shore to right and bank barrier reef to left. (From Adey, 1975.)

SHELF EDGE FEATURE (Locale 3)

Most of the St. Croix shelf is rimmed by a raised margin or shelf edge feature (Fig.22). This ridge-like complex rises from 5-10 m above the shelf flat which ranges from about 15-25 m in depth (Fig. 23). At Hess channel in the southwest, the shelf edge feature is a Pleistocene coral reef with only a scattered veneer of Holocene coral. In the southeast however, the main feature has a well developed, deeper water coral community rich in head coral species, especially *Montastrea annularis* and *Montastrea cavernosa*, and with an abundant but apparently superficial patchwork of *Acropora cervicornis* (Figs. 24, 25). Core holes in the main feature at a locality south southeast of East Point have shown an accumulation of at least 5-6 m of Holocene reef community similar to that now abundant on the surface. These data suggest that the feature was drowned in early Holocene by rising sea level but has begun to accumulate deeper water coral framework only in the mid to later Holocene.

Along the south and east outer margin of the main shelf edge feature, a narrow and occasionally broken ridge (as delimited by a conspicuous sand moat) extends along most of the shelf. A core hole in this outer feature shows a deeper water coral cap similar to that on the main feature. However, the bottom half of the 6 meter hole in the outer feature returned an *Acropora palmata* framework with encrustations of the shallow water coralline *Porolithon pachydermum*. In conjunction with C^{14} dating, it is apparent that this shallow water reef, which had been building at about the rate of early Holocene sea level rise, died as the main St. Croix shelf was flooded. A very marked and continued rise in the clay content of carbonate cements at the contact of the lower *A. palmata* facies and the upper head coral facies, suggests that sedimentation and perhaps other alterations of water quality resulting from shelf flooding caused the "death" of this extensive barrier reef. Renewed framework building of a deeper reef community did not develop until sea level was about 10 m above the old reef.

Figure 22. Eastern St. Croix shelf showing shelf edge feature. This map was derived from NOAA color aerial photographs. (From Adey et al., 3rd International Reef Symposium.)



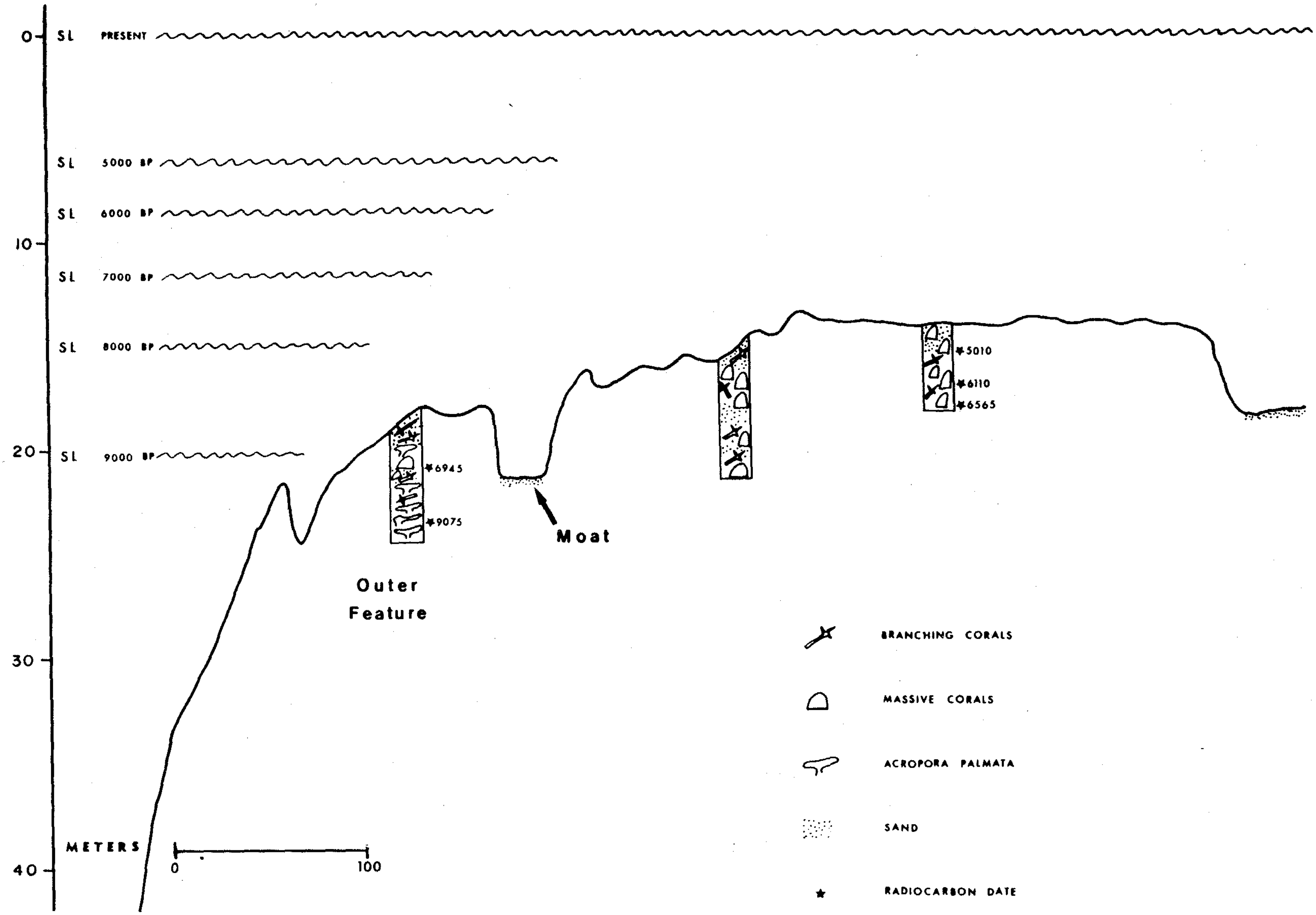
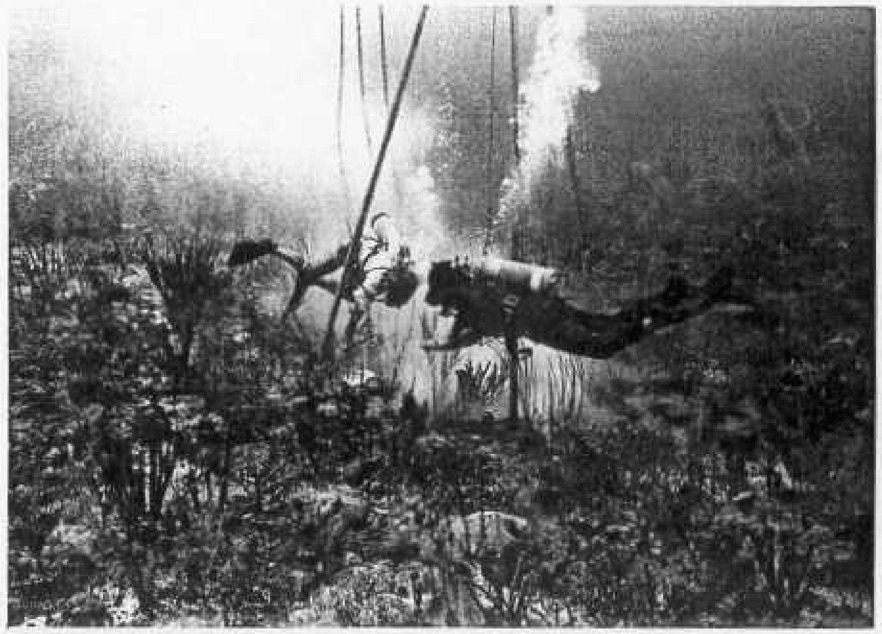


Figure 23. Shelf edge feature at locale 3 showing core holes, major corals encountered, C^{14} dates and the relative positions of Holocene sea levels.

Figure 24 (left). Surface of main shelf edge feature at drilling site. Note the small head corals and gorgonians that pepper the carbonate surface.

Figure 25 (below). Same area as shown in figure 24. Note that at this angle, the abundant patches of Acropora cervicornis are more apparent.



BUCK ISLAND REEF: NORTHEAST END (Locale 4)

Principal zones and faunal characteristics

A. Lagoon. Extends from shore to the reef and is generally 3-5 m deep and 100 m wide, with a more or less uniform bottom. The inner portion of the lagoon has a highly bioturbated sand bottom (due to callianassid shrimps) with little evident epifauna or flora; the outer portion is a flat carbonate pavement with scattered small to medium-sized coral heads and gorgonians over much of its area, and extensive dense thickets of Acropora prolifera covering the remainder.

B. Backreef. Is characterized by dense stands of Acropora palmata, large heads of Montastrea annularis and Diploria strigosa and "boilers" (algal ridges) probably composed of the former coral species consolidated by crustose coralline algae. In the lower more shaded portions of the grottos and stands of A. palmata are dense growths of the zoanthid Z. sociatus, flattened growth of P. astreoides and Agaricia sp. and numerous Isophyllia sinuosa. Large gorgonians (Pseudoplexaura spp.) are numerous here.

C. Reef top. Reaches the surface in many places but is 1 m deep in some parts. This shallow high energy zone is dominated by Millepora complanata, A. palmata and the zoanthid P. caribbea. In places an algal ridge has developed, especially toward the west.

D. Forereef. Composed primarily of dense stands of A. palmata on a shallow slope in the east. Toward the west coralline algal consolidation is pronounced, the forereef slope nearly vertical in places and has numerous small caves and grottos which shelter nocturnally active fishes and urchins.

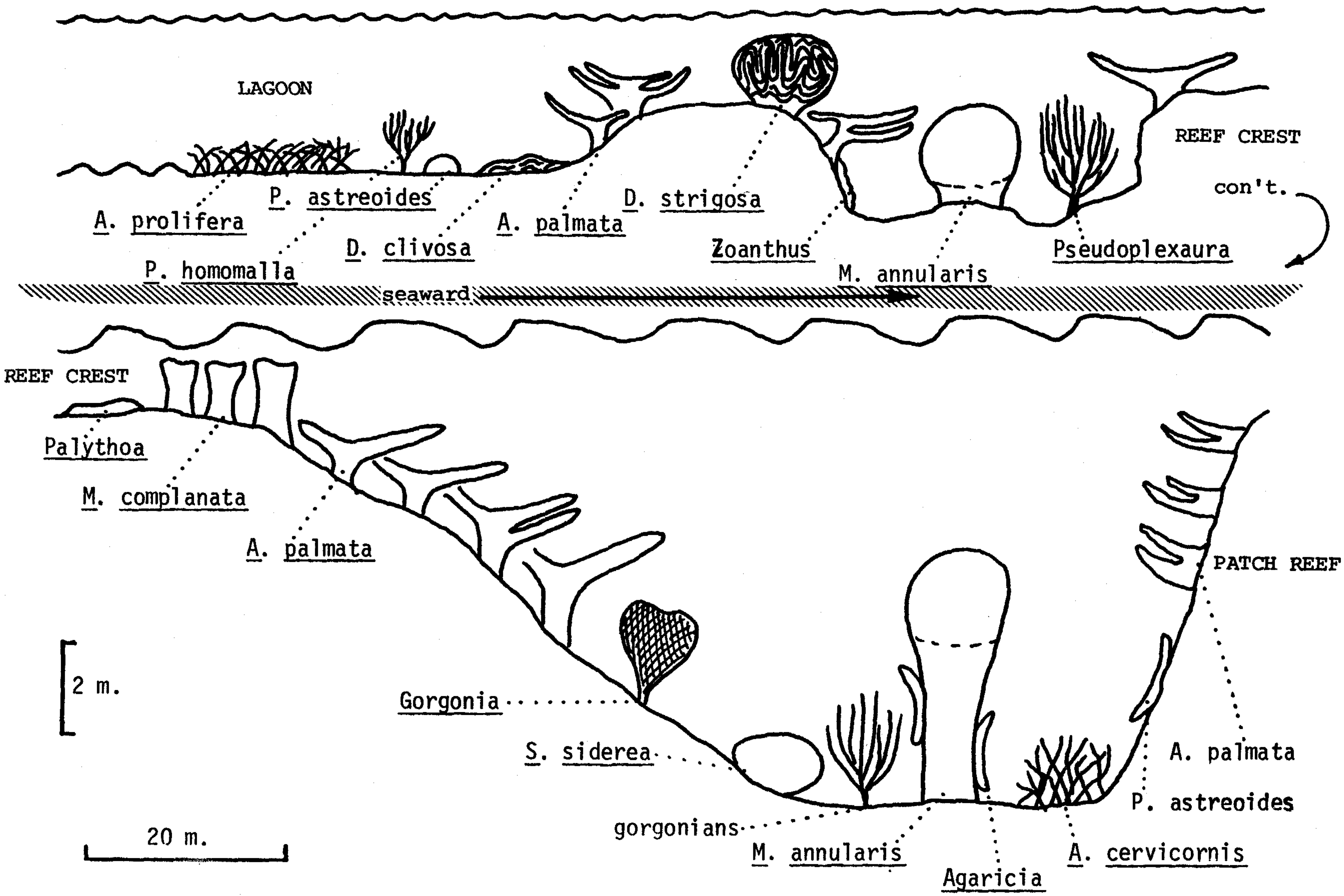
E. Bank Bottom. Begins at the base of the forereef at a depth of about 10 m. This zone is characterized by scattered large coral heads, clyindrical columns of M. annularis, numerous gorgonians, patches of bare pavement and sand. Numerous conical "haystacks" covered with A. palmata lie on the bank bottom to the north of the bank barrier reef, and extend nearly to the surface.

Abundant or noteworthy invertebrates and fish

A. Corals:

Acropora palmata — Occurs in dense stands and dominates much of the backreef and reeftop zones and most of the forereef.

Figure 26. Dominant invertebrates on a section of the Buck Island northeast reef.



A. prolifera Abundant in the lagoon, forming extensive, dense growths in many areas.

A. cervicornis Common; forms thickets on the bank bottom just off the base of the forereef.

Montastrea annularis Forms large heads on the backreef, especially to the west and large columns just off the base of the forereef.

Diploria strigosa Common on the backreef, forming large heads.

D. clivosa Common on the pavement region of the lagoon, forming flat, spreading colonies.

Porites astreoides Numerous on the pavement area of the lagoon; bright green heads about 0.3 m across.

Siderastrea siderea Forms large heads at the base of the forereef on the bank bottom, common.

S. radians Abundant near shore and in the lagoon zone; colonies small and flat.

Agaricia spp. Abundant on vertical surfaces on the backreef and forereef especially the sides of *M. annularis* columns just off the forereef.

Isophyllia sinuosa Colonies numerous in the deeper areas of the backreef.

Mycetophyllia ferox Common on the steeper parts of the forereef toward the west.

Mussa angulosa Common on the bank bottom.

Colpophyllia sp. Common on the bank bottom and base of the forereef.

B. Sea anemones:

Stoichactis helianthus Forms dense clusters on the bare, shallow areas of reef top, especially on coralline covered surfaces.

Bartholomea annulata Abundant in crevices in the lagoon and backreef areas.

Ricordea florida Forms clusters on deeper more vertical surfaces of the backreef and forereef.

C. Zoanthids:

Palythoa caribbea Most abundant on the shallow reef top and shallow forereef where colonies coalesce to form extensive mats.

Zoanthus sociatus Abundant in shady areas, common in the lagoon especially on backreef.

D. Gorgonians:

Pseudoplexaura sp. The largest and most numerous gorgonian in the lagoon and backreef areas.

Briareum asbestinum Numerous in the lagoon and backreef.

Erythropodium caribaeorum Forms mats in shady areas especially on the backreef.
Plexaura homomalla Second commonest "seawhip" on the backreef.
Plexaurella spp. Common on the pavement of the lagoon.
Gorgonia sp. Common on the forereef in certain areas.

E. Hydrozoans:

Millepora complanata Dominates the shallowest portions of the reeftop.

F. Echinoderms:

Diadema antillarum Abundant, but spends the day deep in the reef structure.
Echinometra lucunter Common near shore and in the very shallowest portions of the reeftop that have been consolidated by corallines.

G. Fishes:

Scaridae (parrotfishes) Abundant at this site especially lagoon and backreef; seen singly or in groups feeding on algal turf or occasionally live coral.

Sparisoma viride (stoplight parrotfish)
Scarus vetula (queen parrotfish)
S. croicensis (striped parrotfish)
S. coelestinus (midnight parrotfish)

Acanthuridae (surgeonfishes) Abundant, seen principally on backreef and lagoon in large schools.

Acanthurus coeruleus (blue tang)
A. bahianus (ocean surgeon)

Pomacentridae (damselfishes) Abundant all zones. Most are highly territorial and defend small areas of reef (generally a few m^2 at most).

Eupomacentrus fuscus (dusky damselfish)
E. planifrons (three-spot damselfish)
E. variabilis (cocoa d.f.)
E. leucostictus (Beaugregory)
Microspathodon chrysurus (yellowtail d.f.)
Abudefduf saxatilis (sergeant major) Commonest in the high energy zone of the shallow forereef.
Chromis cyanea (blue chromis) Numerous in front of and above the forereef.

Astrophyton muricatum These large basketstars are common on the sides and in the main cavity of Xestospongia.

H. Mollusca

Nerita spp. Abundant in the inter- and supratidal zone.
Littorina spp. "
Cittarium pica (West Indian topshell) common on encrusting corallines at the base of the vertical face of the shore platform (where not removed by man).
Cyphoma gibbosum Abundant and conspicuous on gorgonians.
Other conspicuous gastropods are rare or sporadic due to exploitation by man.

I. Crustacea

Crabs: Percnon gibbesi and Stenorhynchus hispidus are common near Diadema crevices and sometimes anemones.

Shrimps: A variety of small shrimps including the abundant Periclimenes pedersoni are common around sea anemones.

J. Fishes

(species which are uncommon elsewhere but likely to be seen here include)

Nystactichthys halis (garden eel)
Gymnothorax moringa (spotted moray)
Fistularia tabacaria (cornetfish)
Petrometopon cruentatum (graysby)
Rypticus saponaceus (soapfish)
Apogon maculatus (flamefish)
Amblycirrhitus pinos (red-spotted hawkfish)
Equetus punctatus (spotted drum)
E. acuminatus (cubbyu)
Opistognathus aurifrons (yellowhead jawfish)
Dactylopterus volitans (flying gurnard)
Holacanthus ciliaris (queen angelfish)

Labridae (wrasses) Abundant, especially backreef and lagoon.

Halichoeres bivittatus (slippery dick)

Thalassoma bifasciatum (bluehead)

Lutjanidae (snappers) This family is particularly well represented at this site, especially lagoon, backreef and forereef.

Lutjanus griseus (gray snapper) Commonest on the forereef around grottos and dense *A. palmata* stands near vertical walls.

L. apodus (schoolmaster)

L. analis (mutton snapper) Largest fish commonly seen in the lagoon.

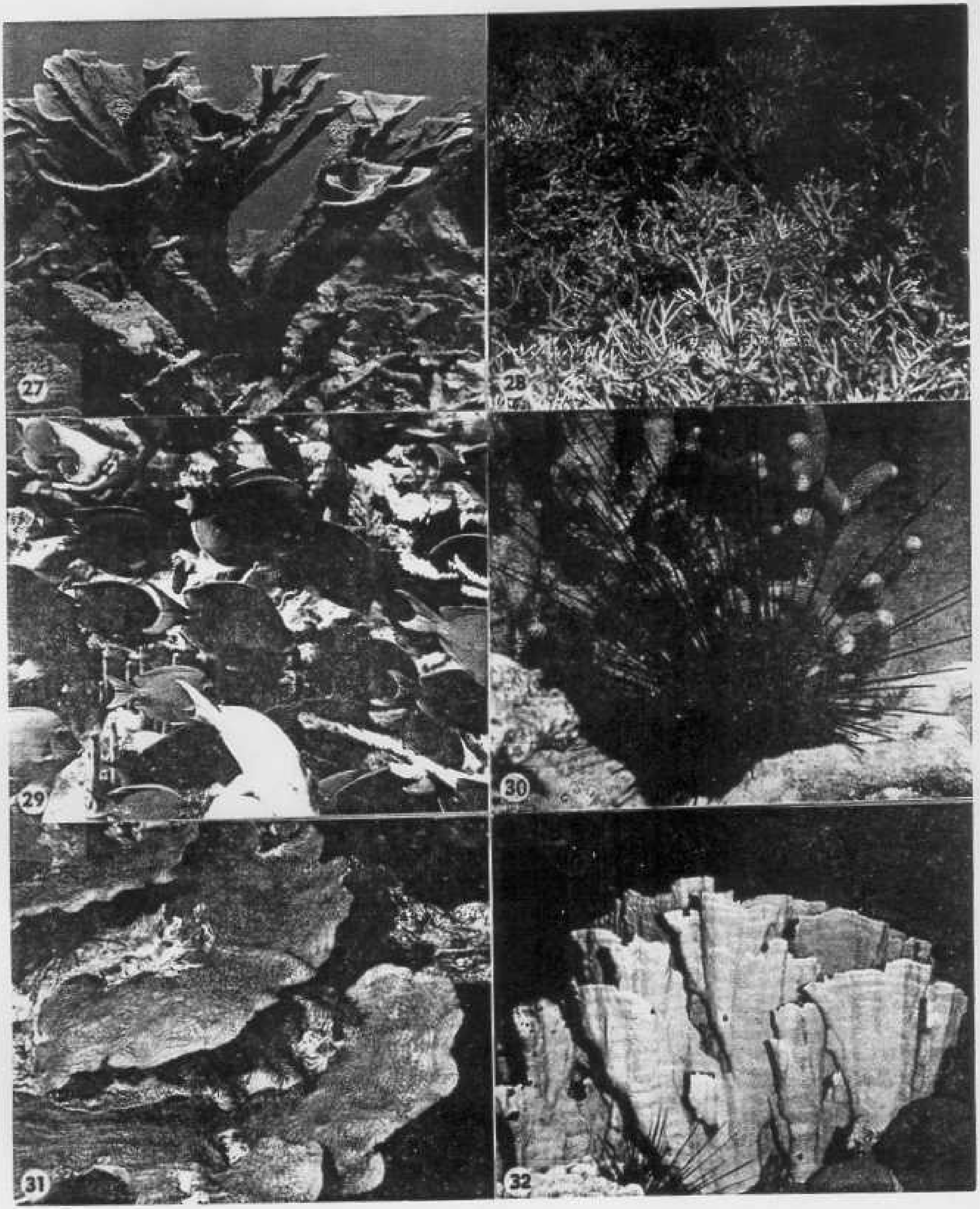
L. mahogoni (mahogany snapper) Same as *L. griseus*.

Ocyurus chrysurus (yellowtail snapper) Numerous in the lagoon.

Other fishes characteristic of this site include:

Malacanthus plumieri (sand tilefish) Numerous around sandy portions of the lagoon.

Kyphosus sectatrix (bermuda chub) Numerous in schools



Figures 27-32. Buck Island Reef.
27. *Acropora palmata* from fore reef. 28. *A. prolifera* from outer lagoon.
29. Acanthuridae are abundant grazers on the reef crest.
30. *Porites porites* and *Diadema antillarum*. 31. *Aragicia* sp.
32. *Millepora complanata* from the reef crest area.

ASPECTS OF THE ECOLOGY OF HERBIVORES
ON CARIBBEAN REEFS AND SEAGRASS BEDS
(Locale 5)

The purpose of this field trip is to examine some of the common vertebrate and invertebrate herbivores which are active in reef and seagrass communities. Several on-going experiments will illustrate the importance of herbivores to community structure and function.

The sites which will be visited are shown on the attached map of Tague Bay. The following brief account will touch on the highlights of what will be seen.

SITE 1: Smuggler's Cove Seagrass Beds

A. Seagrasses

Thalassia testudinum, turtle grass; broad, flat blade
Syringodium filiforme, manati grass; narrow, round blade
Halodule wrightii, shoal grass; narrow flat blade

B. Algae

1. Calcareous green algae

Halimeda jointed flakes
Penicillis "shaving brush" note snails in top of some plants
Udotea fan-shaped

2. Others

Amphiroa articulated red
Dictyota fleshy brown

C. Invertebrates

1. Infauna: time permitting will be sampled with a core.
2. Epifauna dominated by snails, especially *Cerithium litteratum*. Large snails such as the queen conch *Strombus gigas* may be seen. The urchin *Tripneustes ventricosus* is abundant.

D. Fishes

1. Day-active fishes: mostly small and inconspicuous

a) Parrotfishes. Note small resident species, the bucktooth parrotfish, *Sparisoma radians*.
b) Wrasses. Slippery dick, *Halichoeres bivittatus*; blackear wrasse *H. poeyi*.

c) Large predators include barracuda, various jacks, and mackerel.

2. Night active fishes: mostly invertebrate carnivores moving into the beds from reefs: grunts and squirrelfishes.

A series of corrals containing various densities of *Tripneustes ventricosus* will be examined. These are designated to show long term effects of grazing on community structure.

Several scars probably resulting from turtle grazing will be examined.

SITE 2: Tague Bay Patch Reefs

A. Patch Reef #3: This reef shows a typically high density of the urchin *Diadema antillarum* which can be seen to be actively eroding the reef surface. Nocturnal migrations of *Diadema* as well as the feeding activities of day-active fishes create a conspicuous halo about the reef.

1. Corals: *Acropora palmata*, *Porites porites*, *Diploria strigosa*

2. Fishes: note large schools of grunts associated with *P. porites* and *A. palmata*. These migrate into seagrass beds to feed at night.

B. Patch Reef #2: This reef was cleared of *Diadema* in April 1972 (over 7000 were removed). Note heavy cover of fleshy algae. These grow over and kill corals in the absence of grazing. After about a year the urchin *Tripneustes* moved from the surrounding seagrass bed onto the reef. Note the absence of a halo and the increased density of juvenile fishes associated with the algal cover.

SITE 3: Tague Bay forereef and deep seagrass bed

Thalassia is depth limited to less than 10 m. At this site (about 12-13 m) *Syringodium* is the dominant seagrass. It is separated from Tague Bay forereef by a large halo of rippled sand resulting from sand movement as well as grazing organisms.

SITE 4: Artificial reef

This reef was constructed of 400 concrete blocks in July 1976. Note fish density, halos and fleshy algal cover.

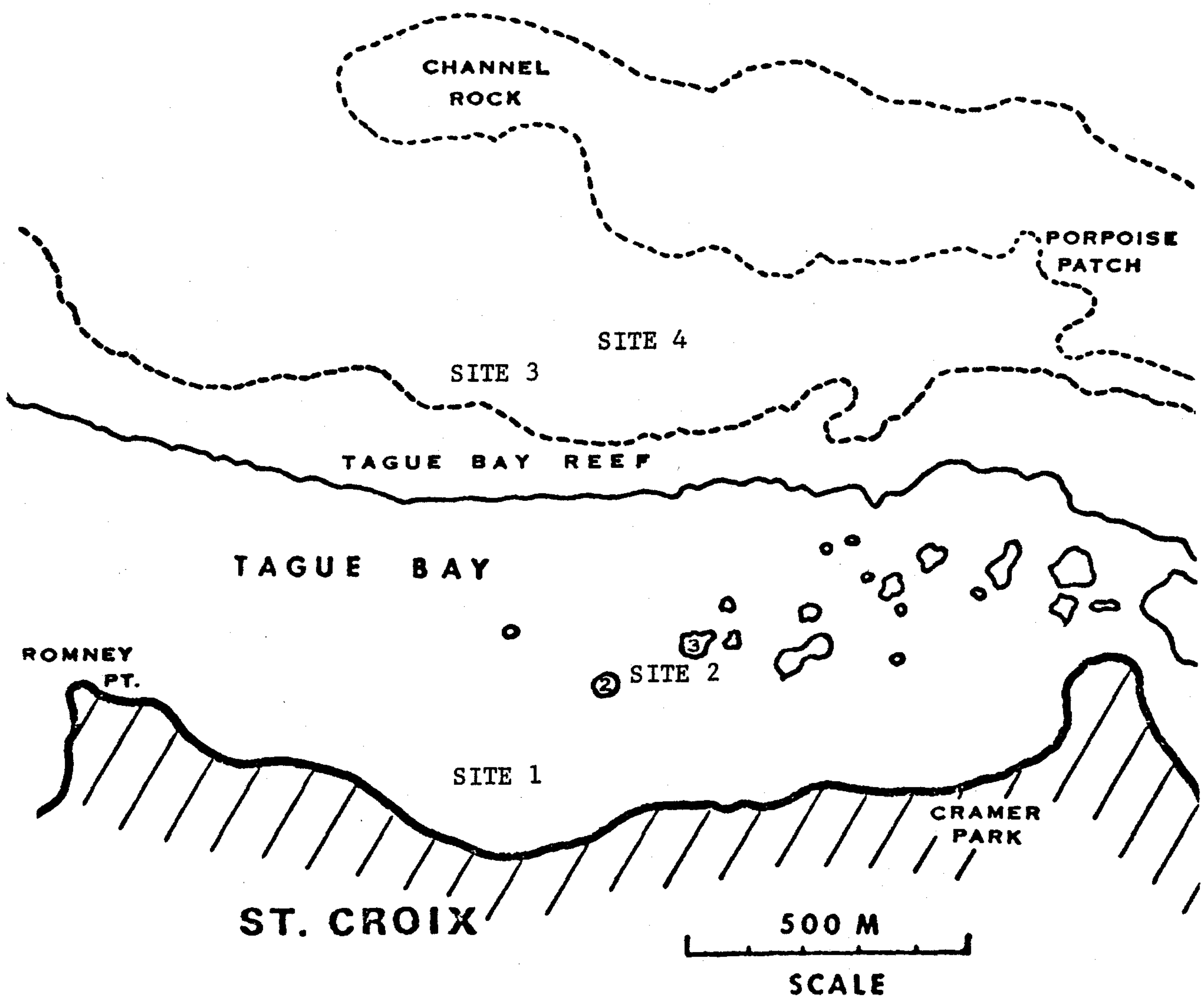


Figure 33. East Tague Bay area showing the sites to be visited at locale 5.

SALT RIVER SUBMARINE CANYON (Locale 6)

Salt River Submarine canyon extends northward into the Virgin Islands Basin on the north shore of St. Croix, U.S. Virgin Islands. The canyon heads at a coral reef that separates the open ocean from Salt River marine estuary. The shallowest depths are approximately 40 feet, and the deepest traceable extent is at about 10.000 feet where the canyon joins the larger Christiansted canyon, approximately 5 miles offshore.

The east wall starts at 15 feet and has a raised flange of Acropora palmata extending along its margin. Three hundred meters seaward of the reef, this embankment is cut by a shallow depression, or side tributary, filled with rounded coral cobbles. These cobbles form the gently sloping wall of the canyon down to a depth of about 120 feet. Cobbles are diverted down into the canyon from the White Horse shelf area and form a low bench or terrace along the eastern side of the canyon bottom. In the axis of the canyon the cobbles are blanketed by a thin layer of carbonate sand.

The west wall of the canyon is composed of carbonate rocks of coral reef origin. Overhanding cliffs cut by sediment filled side tributaries make this one of the most spectacular underwater areas on St. Croix. The upper lip of the canyon has a dense covering of hard coral and gorgonian fans. Many sponges are also found in this area. The rugged topography is formed of large blocks of wall material which have broken away from the steep slope sometimes extending out into the canyon. Many small caves have been formed where blocks have fallen across each other. At the base of the steep dropoff, the canyon is filled with a medium-sized biogenous carbonate sand. A small scour trough extends along the western margin of this sand fill, which is occasionally rippled by strong currents which flow both up and down the canyon in this region. Throughout most of the year large cone-shaped mounds formed by burrowing shrimps are found in the sedimentary fill at the bottom. At the very head of the canyon near the entrance into the Salt River estuary, coarse cobble and gravel make up the sediments which are occasionally rippled by long period oceanic swell.

The water masses in the canyon are controlled by tidal flow and by internal waves moving in along the thermocline.

Salt River Submarine canyon will be the site of the forthcoming Hydro-Lab project which should become operational sometime in January 1978. The field trip in this area will begin at a depth of about 20 feet on the western wall. Divers will descend over the steep dropoff down to a depth of approximately 135 feet where marker stakes have been placed in the sediments to record any downward movement of the sedimentary fill. As will be noted on the dive there has been very little motion of the sediments in this area over a period of about two years. However, downward displacement surface sediment is taking place by bioturbation. Divers should observe the asymmetrical shape of the large cone-shaped mounds and also the asymmetrical shape of the small mounds in the sediment coming down side tributaries. Movement by bioturbation is thought to be the major agent of sediment transportation in the canyon. Additional sediment transport, especially of fine-grained material, is accomplished by gravity flow and by density currents which are active in this area, especially during the rainy season.

After reaching the canyon bottom the divers will proceed from 135 feet up canyon at the base of the west wall, to a depth of about 70 feet where they will then ascend the wall up to the west rim and then swim back along the upper lip of the canyon to the point of descent back at the boats. Sample bags will be available for those persons who wish to collect sedimentary samples of the canyon fill. Because of the use of this area as a study area, and in the interest of conservation, no other sampling will be permitted in this area. It is hoped that in the future this region will be set aside as an underwater conservancy and become part of the Underwater Park system of the U.S. Virgin Islands.

Salt River Canyon: West Wall

I. Principal zones and faunal characteristics.

A. Upper rim of west wall, characterized by diversity of corals, gorgonians and sponges (east rim is better site for the latter) on relatively flat pavement.

B. Upper wall is broken into large blocks with steep channels descending in between; many vertical surfaces and overhangs. Platelike growths of *Agaricia* sp., gorgonians such as *Iciligorgia*, a variety of antipatharians cover the walls.

C. Lower slope is heavily sedimented, platelike *Agaricia* and antipatharians are common.

D. Canyon floor, a seaward sloping sand bottom, has populations of spatangoid urchins (*Meoma ventricosa* and *Plagiobrissus grandis*).

II. Invertebrates well represented or unique to this site.

A. Sponges

Verongia spp. Large, tubular sponges of several species one of which (with very thick walls) is unknown elsewhere on St. Croix.

B. Scleractinians

Tubastrea aurea Bright orange, common on shaded vertical surfaces and under overhangs.

Agaricia sp. Dominates much of the vertical wall at depths greater than 15 m forming large circular or semicircular plates.

Mycetophyllia spp. Common on the wall.

C. Sea anemones

Lebrunea danae Common.

D. Antipatharians

Stichopathes spp. Unbranched, whiplike colonies up to 3 m long are numerous at depths below 15 m.

Antipathes spp. At least 4 species present on more vertical sections, none are massive.

E. Gorgonians

Iciligorgia schrammi The only place on St. Croix where this unusual scleraxonia lives in abundance; common on vertical surfaces.

F. Echinoderms

Nemaster rubiginosa This crinoid is occasional on the west wall but numerous among corals and sponges on the east wall.

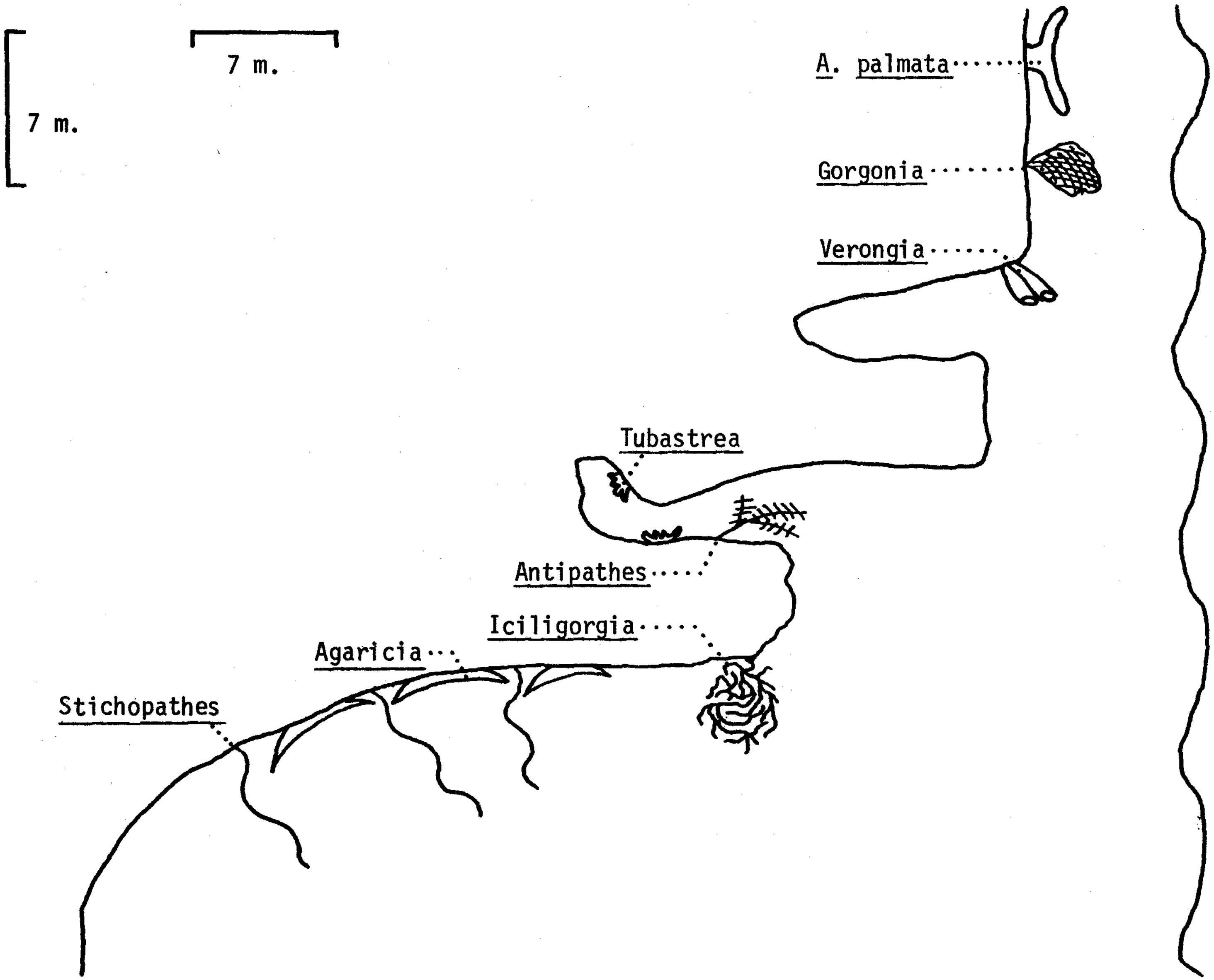


Figure 34.
SALT RIVER CANYON: WEST WALL

WEST END: ESTATE NORTHSIDE (Locale 7)

I. Principal zones and faunal characteristics

A. Raised Pleistocene platform, 1-2 m above sea level, shows good vertical zonation of intertidal and slightly subtidal invertebrates, especially gastropods and chitons. Shade-loving species such as the coral Tubastrea and anemone Anemonia are common on the vertical seaward face.

B. Subtidal eroded carbonate pavement, extending from base of shore platform seaward 50-100 m; depth 2 m near shore, sloping gradually seaward then more abruptly (15%) near outer edge to a depth of 8 m. Near shore are isolated medium to large sized colonies of Acropora palmata, mats of a thin encrusting sponge and numerous Diadema. Farther seaward is a high diversity of sponges and coral species not commonly seen elsewhere on St. Croix in shallow water.

C. Halo zone and grass bed (Syringodium). Fauna is sporadic but large gastropods (e.g., Cassis tuberosa, Strombus gigas), large holothurians (e.g., Actinopyga agassizi, Isostichopus badinotus) and garden eels can be found here.

II. Abundant or noteworthy invertebrates and fish

A. Sponges

Xestospongia mutabilis Large basket sponge, volume 1 m^3 or more, common on lower portion of slope, 6-8 m deep.

Neofibularia nolitangere Large moderately common at pavement-halo interface.

Hemectyon ferox Common, reddish brown with numerous raised oscules.

Callyspongia vaginalis Common, forms broad, irregular fan-like growths.

Geliodes sp. Common.

B. Scleractinians

Acropora palmata Medium to large colonies common near shore.

Dendrogyra cylindrus Pillar coral, moderately common, medium to large colonies scattered on pavement.

Meandrina meandrites Very common on subtidal pavement, seaward portion.
Diploria labyrinthiformis "
Siderastrea siderea "
Montastrea cavernosa "
Dichocoenia stokesi "
Eusmilia fastigiata "
Tubastrea aurea "

C. Sea anemones

Anemonia sargassensis Common in shaded areas on vertical edge of shore.
Bunodosoma granulifera Common on edge of shore.
Bartholomea annulata Common in crevices beneath corals and sponges.
Heteractis lucida Common in crevices beneath corals and sponges.
Condylactis gigantea " ; especially on lower edge of slope.

D. Zoanthids

Palythoa caribbea Common on pavement scattered among corals and sponges.
Parazoanthus spp. Common, sponge-inhabiting species.

E. Gorgonians

Gorgonia sp. Common on upper part of pavement.
Pterogorgia spp. "
Pseudopterogorgia Common on lower part of pavement.

F. Hydrozoans

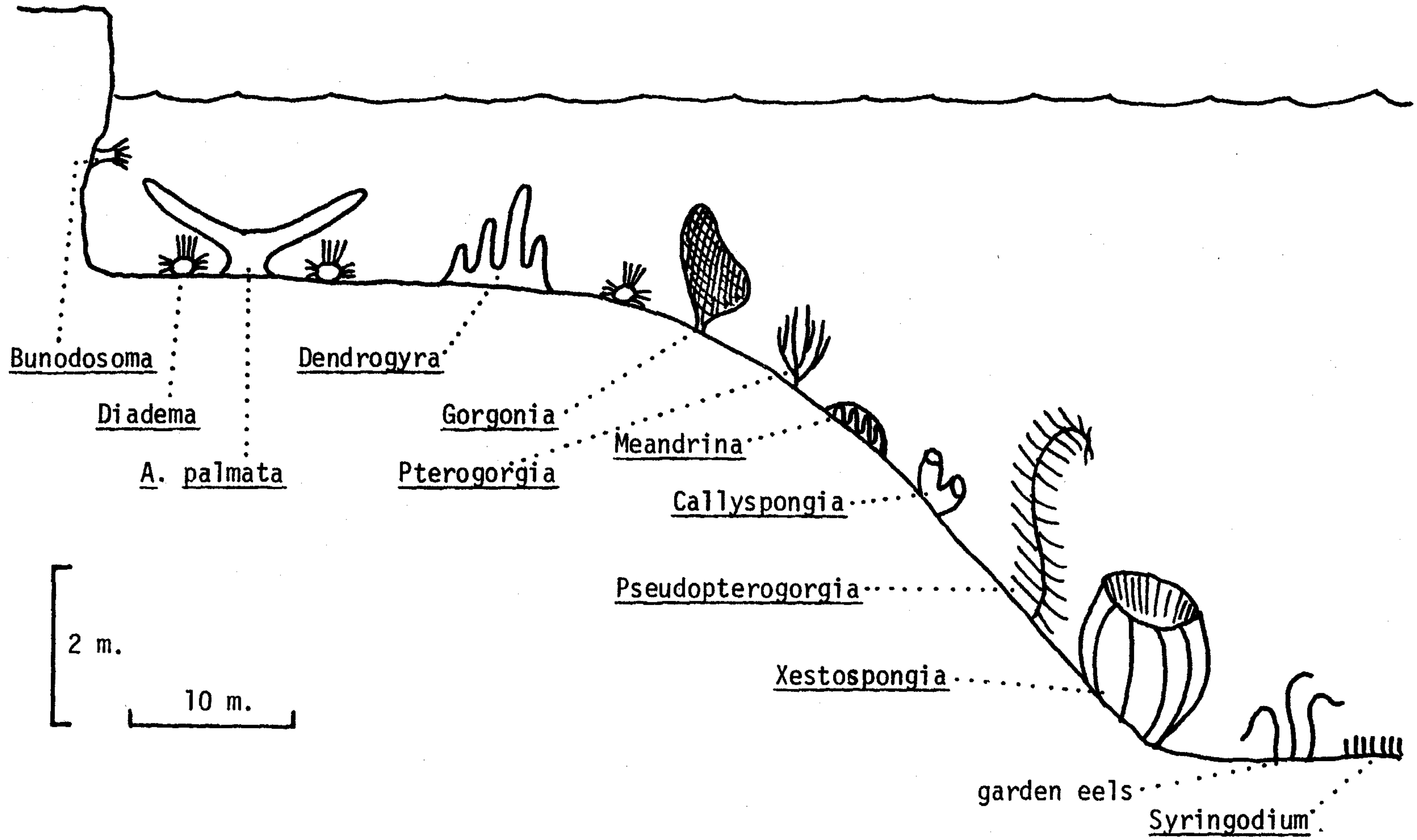
Millepora sp. The encrusting form of the firecoral is common here on the axial skeletons of gorgonians it has overgrown.

G. Echinoderms

Echinometra lucunter Common on the vertical wall of shore platform.
Diadema antillarum Small to medium sized individuals common on pavement especially on shoreward portion and under coral heads.
Eucidaris tribuloides This pencil-spined urchin is common wedged in crevices on the pavement and beneath sponges and corals.
Ophiothrix spp. These brittlestars are abundant on the sur face of sponges and *Millepora*.

Figure 35

WEST END: ESTATE NORTHSIDE



Astrophyton muricatum These large basketstars are common on the sides and in the main cavity of *Xestospongia*.

H. Mollusca

Nerita spp. Abundant in the inter- and supratidal zone.
Littorina spp.
Cittarium pica (West Indian topshell) Common on encrusting corallines at the base of the vertical face of the shore platform (where not removed by man).
Cyphoma gibbosum Abundant and conspicuous on gorgonians, other conspicuous gastropods are rare of sporadic due to exploitation by man.

I. Crustacea

Crabs: *Percnon gibbesi* and *Stenorhynchus hispidus* are common near *Diadema*, crevices and sometimes anemones.
Shrimps: A variety of small shrimps including the abundant *Periclimenes pedersoni* are common around sea anemones.

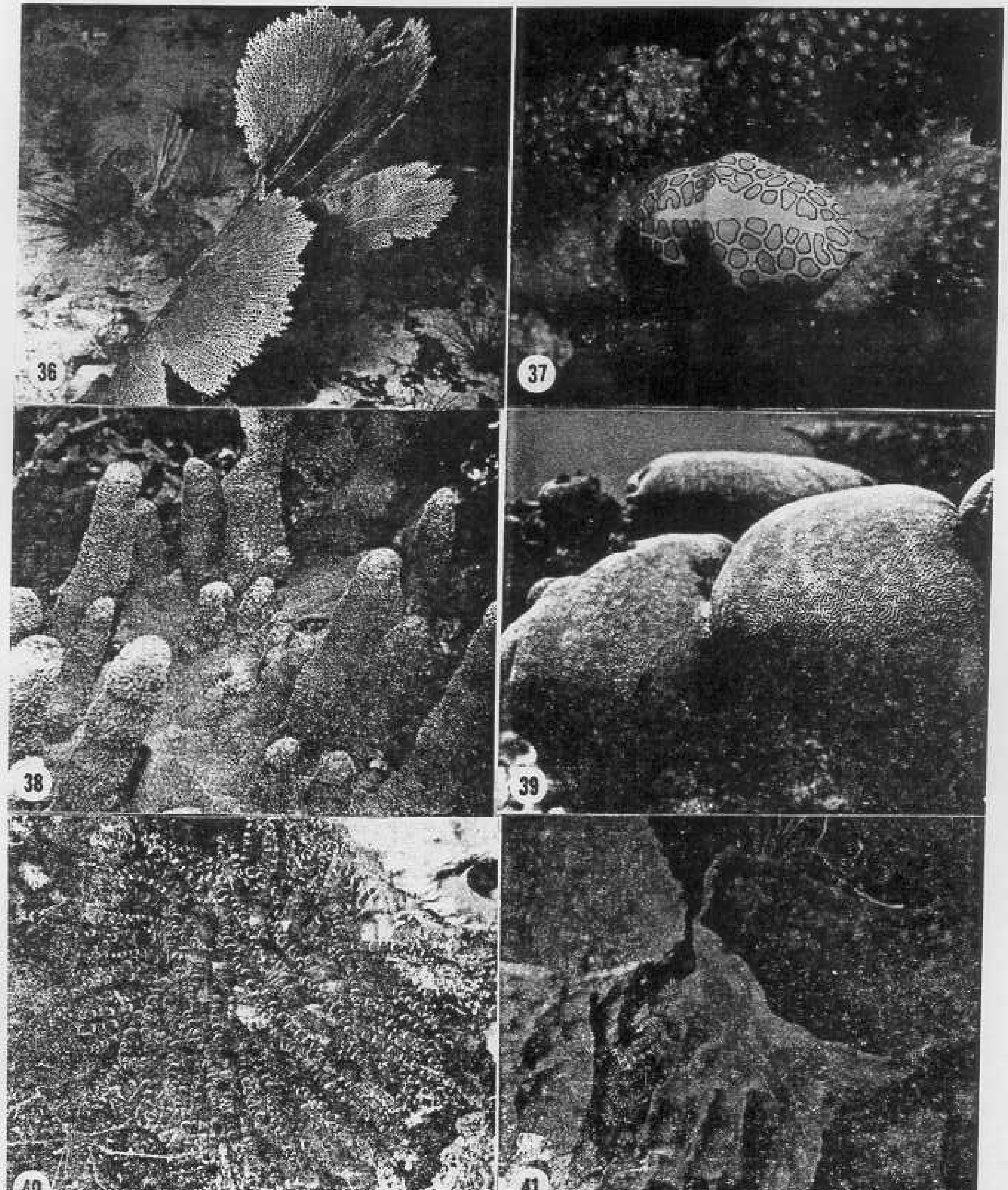
J. Fishes

(species which are uncommon elsewhere but likely to be seen here include)

Nystactichthys halis (garden eel)
Gymnothorax moringa (spotted moray)
Fistularia tabacaria (cornetfish)
Petrometopon cruentatum (graysby)
Rypticus saponaceus (soapfish)
Apogon maculatus (flamefish)
Amblycirrhitus pinos (red-spotted hawkfish)
Equetus punctatus (spotted drum)
E. acuminatus (cubbyu)
Opistognathus aurifrons (yellowhead jawfish)
Dactylopterus volitans (flying gurnard)
Holacanthus ciliaris (queen angelfish)

(opposite page)

Figure 36. *Gorgonia*, abundant on shallow pavements throughout Caribbean.
Figure 37. *Cyphoma gibbosum* on *Briarium asbestinum*.
Figure 38. *Dendrogyra cylindricus*.
Figure 39. *Diploria labyrinthiformis*.
Figure 40. *Bartholomea annulata*, common solitary, subcryptic anemone.
Figure 41. *Xestospongia mutabilis*.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41

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