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ECOLOGICAL COMMUNITY TYPE MAPS AND BIOLOGICAL COMMUNITY
DESCRIPTIONS FOR BUCK ISLAND REEF NATIONAL MONUMENT AND
PROPOSED MARINE SITES IN THE BRITISH VIRGIN ISLANDS

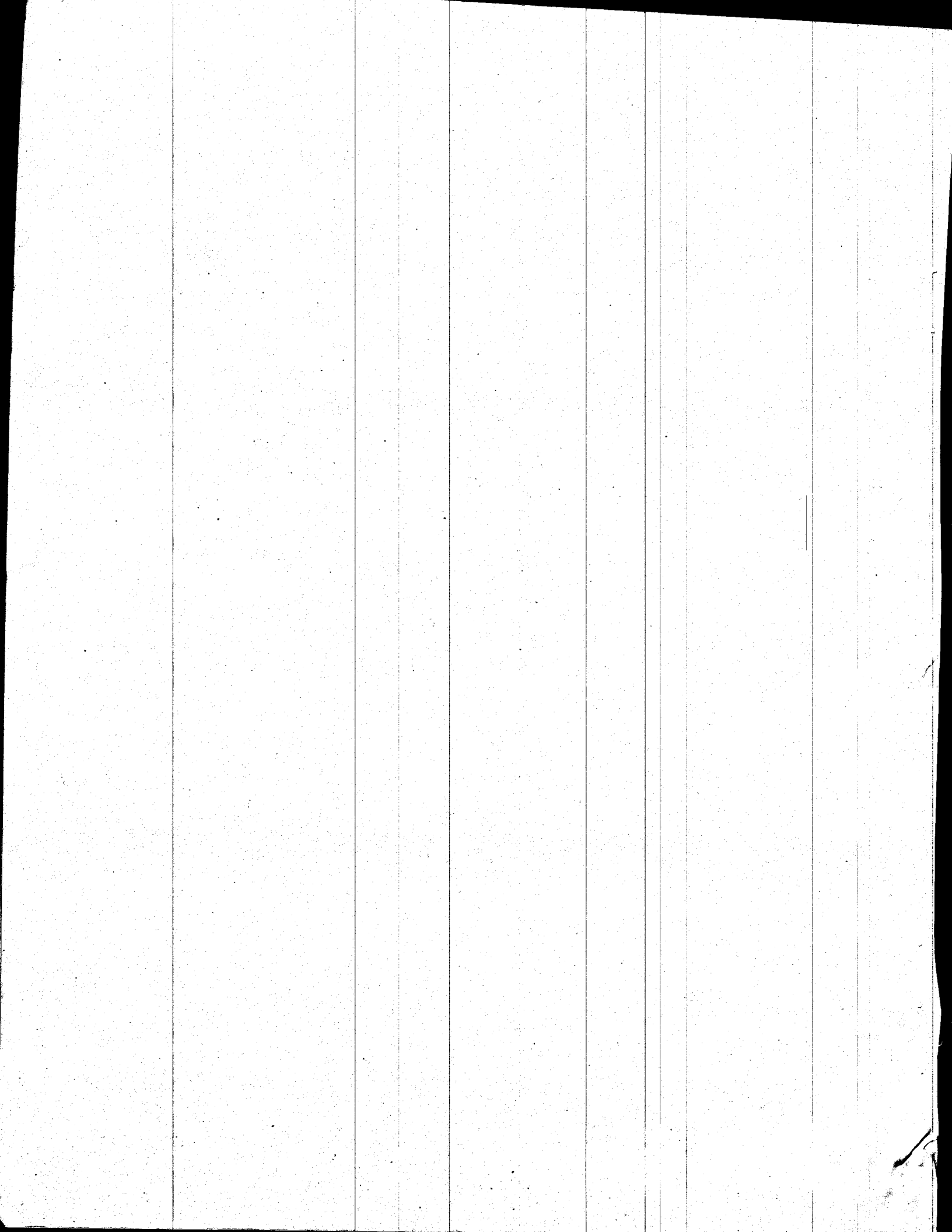
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U.S. MAN AND THE BIOSPHERE PROGRAM



Virgin Islands National Park

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Abstract

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ECOLOGICAL COMMUNITY TYPE MAPS AND BIOLOGICAL COMMUNITY DESCRIPTIONS FOR BUCK ISLAND REEF NATIONAL MONUMENT AND PROPOSED MARINE PARK SITES IN THE BRITISH VIRGIN ISLANDS

The marine communities of proposed or existing park sites in the British Virgin Islands (BVI) and St. Croix in the U.S. Virgin Islands (USVI) have been surveyed and described. The ten sites in the BVI include Anegada, North Sound, The Baths, Salt Island, Norman Island, Tobago, Little Jost Van Dyke, Cane Garden, Beef Island, The Dogs; Buck Island Reef National Monument. St. Croix was also included in the survey.

A standard procedure was used to describe each site. This is presented in the methods section. Maps outlining the marine communities were drawn from projections of color aerial vertical photographs on existing survey maps of the area outlining land masses. These "working maps" were groundtruthed. The marine communities of each of the eleven sites are presented (1) in a 1:5300 scale map outlining the biological communities, and (2) a text describing the contained communities in both qualitative and quantitative ways. Several transects running from the shoreline seaward across a sequence of marine communities were surveyed in detail. For each transect a 1:1200 profile (showing depth, community type, and substrate) was generated.

Abundance of dominant benthic species, depth, substrate type (e.g., sand, dead coral, live coral) and habitat complexity were noted for each community along the transect and presented in tabular form. Black and white photographs of most of the communities appear as plates. There is a preliminary evaluation of the condition of the biological communities at each site.

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Note: Enclosed maps are reductions of originals
prepared at 1:5300 scale. Copies of originals
are available upon request.

FOREWORD

Virgin Islands National Park was designated as an International Biosphere Reserve by the United Nations Educational, Scientific and Cultural Organization (UNESCO) in June, 1976. However, the formal dedication did not take place until May, 1983. The standardized, single-page description of the area which was issued by UNESCO under the Man and the Biosphere Program, MAB Project 8, in 1976 is entirely inadequate for the purpose of meeting Biosphere Reserve Objectives.

The purpose of the present (VIRMC I) project was to provide more detailed descriptions of the Reserve's physical and biological features as well as certain aspects of human use, such as fishing and boating. Inherent in the concept of the Reserve is the belief that it is intimately related to the nearby British Virgin Islands and that it should also fit within a future multi-site Lesser Antillean Biosphere Reserve.

The following reports are included in the VIRMC I Research Series Reports.

The West Indies Laboratory (Fairleigh Dickinson University) prepared the reports for "Ecological Community Type Maps and Biological Community Descriptions for Buck Island Reef National Monument and Proposed Marine Park Sites in the British Virgin Islands," "Trends in Recreational Boating in the British Virgin Islands. A Preliminary Assessment of Impact from Human Activities on Anchorages and Development of a Monitoring Program for Safe Anchorages," "Geographic Range and Research Plan for Monitoring White Band Disease," and "Marine Ecosystems of the Lesser Antilles - Identification of Representative Sites."

The Division of Fish and Wildlife (Department of Conservation and Cultural Affairs, Government of the U.S. Virgin Islands) prepared, "Map of Fishery Habitats Within the Virgin Islands Biosphere Reserve," "Fisheries Habitat of the Virgin Islands Region of Ecological Importance to the Fishery Resources of the Virgin Islands Biosphere Reserve," "Utilization of the Virgin Islands Biosphere Reserve by Artisanal Fishermen," and "Long-Term Monitoring of Fisheries in the Virgin Islands Biosphere Reserve."

The Caribbean Research Institute (College of the Virgin Islands) prepared, "Marine Community Descriptions and Maps of Bays Within the Virgin Islands National Park/Biosphere Reserve," and "Collection of Common Organisms Within the Virgin Islands National Park/Biosphere Reserve."

The Island Resources Foundation prepared, "Assessment of Fish and Shellfish Stocks Produced in the Virgin Islands Biosphere Reserve," "Socioeconomic and Cultural Role of Fishing and Shellfishing in the Virgin Islands Biosphere Reserve Area," "Characterization of Lesser Antillean Regional Fisheries," as well as the Synopsis and Executive Summary.

Field work for the project was carried out during the period December, 1983, through October, 1984. Copies of the individual reports can be obtained from: The Virgin Islands National Park; Red Hook Headquarters; P.O. Box 7789, St. Thomas, Charlotte Amalie, VI 00801.

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A number of persons throughout the greater Caribbean region responded to our requests for information. They are acknowledged by name in the appropriate sections of our reports. Mike Robblee of the US National Park Service, Everglades provided literature about damage to tropical marine ecosystems due to boat anchoring activities.

OBJECTIVES

Tropical marine ecosystems are an important segment of the Lesser Antillean Biosphere. Knowledge of the location and structure of these ecosystems in the region is necessary to ensure a representative selection of sites within a Biosphere Reserve (cf. Gladfelter et al., 1985). During the last decade tourism has increased in both the US and British Virgin Islands. A major component of this increase consists of the sailing fleet (cf. Lund et al., 1985), resulting in greater impacts on the marine ecosystems through anchoring, litter and sewage disposal, and more coastal construction to support the boating public.

In this report we have mapped and described the coastal areas comprising the present and proposed marine park sites of the British Virgin Islands (BVI) and of Buck Island Reef National Monument, St. Croix, USVI. Our methods and presentation of results have been closely coordinated with those of Beets et al. (1985) who mapped the coastal zone of St. John, USVI, much of which is currently included in the Virgin Islands National Park which in turn is the first designated component of a Lesser Antillean Biosphere Reserve. A comparison of our results with those of Beets et al. (1985) should reveal if St. John contains representative examples of all the communities found in Antillean Marine Ecosystems or if some elements commonly found elsewhere are not found on St. John. Our methods of mapping and ground truthing and our preliminary evaluations of these coastal marine ecosystems are contained here. The development of methods

rubble talus from shore.

- 3) Lagoon: The relatively quiet shallow water area between the shore zone and offshore reef. The lagoon/reef boundary is marked by a change in slope.
- 4) Shallow bay: The relatively quiet shallow water area adjacent to the shore zone and shoreward of a line between two projecting points of land.
- 5) Reef: A major geomorphic feature generated from live coral growth. It is an actively growing wave resistant structure.
- 6) Bank: The area seaward of the reef or seaward of the shore zone, if no reef is present, extending to the shelf edge.
- 7) Shelf edge reef: A coral reef located at the shelf edge and extending as deep as 500 m.

Appropriate upper case letter designations were given to each major zone with lower case letters for each subzone. For example, the intertidal reef within the shore zone is "Si"; S=shore zone and i=intertidal reef. Wide lines on the maps distinguish the major zones and narrow lines distinguish the subzones.

Employing this technique a 1/5300 scale map of each of the proposed park sites was made. The aerial photographs and the maps aided in the selection of sites to be ground truthed.

Ground Truthing

General confirmation of our aerial photograph interpretation was done by field spot checking the biological communities labeled

on the 1/5300 scale maps.

Heavily visited sites or those containing many of the communities found at that site were selected for transect study. For each transect a qualitative description of the biological community of each zone was written. A table presenting the estimated percent cover of eleven characteristic groups of organisms which colonize the substrate in these zones follows each qualitative description. Each group has been assigned an initial designation (Table 2). The hydrocoral Millepora was included with the stony corals because it is functionally similar (it is a primary organic and carbonate producer) and it is such a dominant member of the coral reef community. Dead coral was defined as coral which is still standing but no longer alive. The substrate covered by gorgonians was estimated as the percent area covered by the crown of the colony. Solid pavement and partially consolidated coral rubble, characteristically colonized by algal turf, was categorized as pavement.

Each table presents a species list. The names of the organisms have been shortened for presentation in tabular form (Table 3). Dominant species were defined as those which contribute 10% or more to the live cover of that group of organisms. A "+" indicates the presence of an organism, however, if an organism is dominant this is indicated by an "*". Thus, special record was made in the tables where groups of organisms were particularly common and mention of this was also made in the qualitative descriptions in the text.

General observations of community composition, unique or

spectacular characteristics, and presence of white band disease was also noted in the text. The depth range for each zone was recorded in the tables.

Included in the table is a habitat complexity rating of 1 to 5 to represent the least complex to the most complex habitat respectively. The criteria for defining habitat complexity are as follows:

- 1 - Flat sand beds, lagoon pavement, and pavement with no relief.
- 2 - Low profile reef. For example, Acropora prolifera or Porites porites stands (extensive but small pore spaces, good habitat for juvenile fish).
- 3 - Partially consolidated coral rubble (larger pore spaces, usually a dead or damaged reef of type 4 or 5).
- 4 - Medium profile active reef (Montastrea annularis reef).
- 5 - Any habitat with maximum porosity generated from 3-dimensional active coral growth (i.e. A. palmata reef) and/or bioerosion (i.e. large pore spaces and caverns which penetrate through a reef).

Detailed profiles of each transect were drafted. The vertical axis is 1/120 scale and the horizontal axis is 1/1200 scale. The profiles present a qualitative view of the zones, topography, and community structure. The list of symbols which was developed to represent the dominant organisms within the zones is shown in Table 4. Symbols for the species of Diploria are identified by the initials of the species printed within the

symbol.

Black and white underwater photographs were taken to illustrate representative communities in each zone of each transect. Some areas were too turbid to be photographed. Sand bottom areas and sparse pavement were not photographed.

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TABLE 1

Zone and Subzone Designations

A) Shore Zone	S
1) Beach rock	Sb
2) Sand	Ss
3) Mangrove	Sm
4) Pavement	Sp
5) Gravel/cobble	Sg
6) Bedrock	Sbr
B) Subtidal Bedrock	SR
C) Lagoon	L
1) Sand	Ls
2) Pavement	Lp
3) Seagrass bed	Lg
4) Patch reef	Lpr
a) pavement	Lprp
5) Fringing reef	Lf
D) Shallow Bay	SB
1) Sand	SBs
2) Pavement	SBp
3) Seagrass bed	SBg
4) Patch reef	SBpr
5) Mud	SBm
6) Algae	SBa
7) Fringing reef	SBf
E) Reef (fringing and barrier)	R
1) Backreef	Rb
a) head coral/grotto	Rbh/Rbg
b) pavement	Rbp
2) Reef crest	Rc
3) Forereef	Rf
a) upper (arborescent)	Rfu
b) lower (massive)	Rfl
c) pavement	Rfp
4) Sand	Rs
5) Gorgonian reef	Rgo
6) Pavement	Rp
F) Bank	B
1) Gorgonian/coral flat	Bgo
2) Pavement	Bp
3) Sand	Bs
4) Seagrass bed	Bg
5) Patch reef	Bpr
a) crest	Bprc
b) forereef upper/lower	Bprf/Bpru/Bprl
6) Bank reef (linear aspect)	Br
a) crest	Brc
b) forereef upper/lower	Brf/Brfu/Brfl
c) backreef	Brb
7) Algal plane	Ba
G) Shelf Edge Reef	SER

TABLE 2

Substrate Cover Designations

HC.....	Live hard coral
Go.....	Gorgonian coral
Z.....	Zoanthids
A.....	Macroalgae
Sm.....	Mangrove
G.....	Seagrass
DC.....	Dead coral
T.....	Pavement/turf
S.....	Sand
Sbr.....	Shore bedrock/cobble
Sb.....	Beachrock

TABLE 3

Acronyms for Organisms

Hard Coral Species	Acronym
<u>Acropora cervicornis</u>	Acer
<u>Acropora palmata</u>	Apal
<u>Acropora prolifera</u>	Apro
<u>Agaricia spp.</u>	Aga
<u>Colpophyllia natans</u>	Col
<u>Dendrogyra cylindrus</u>	Den
<u>Dichocoenia stokesii</u>	Dic
<u>Diploria clivosa</u>	Dcli
<u>Diploria labyrinthiformes</u>	Dlab
<u>Diploria strigosa</u>	Dstr
<u>Eusmilia fastigiata</u>	Eus
<u>Favia fragum</u>	Fav
<u>Helioseris cucullata</u>	Hel
<u>Isophyllastrea rigida</u>	Isas
<u>Isophyllia sinuosa</u>	Iso
<u>Madracis decactus</u>	Mdec
<u>Madracis mirabilis</u>	Mmur
<u>Manicina areolata</u>	Mac
<u>Meandrina meandrites</u>	Mea
<u>Millepora spp.</u>	Mil
<u>Montastrea annularis</u>	Mann
<u>Montastrea cavernosa</u>	Mcav
<u>Mussa angulosa</u>	Mus
<u>Mycetophyllia sp.</u>	Myc
<u>Porites astreoides</u>	Past
<u>Porites divaricata</u>	Pdiv
<u>Porites porites</u>	Ppor
<u>Scolymia sp.</u>	Sco
<u>Siderastrea radians</u>	Srad
<u>Siderastrea siderea</u>	Ssid
<u>Stephanocoenia michelini</u>	Ste
<u>Tubastrea aurea</u>	Tub
Gorgonian Genera	
<u>Briareum</u>	Bri
<u>Erythropodium</u>	Ery
<u>Eunicea</u>	Eun
<u>Gorgonia</u>	Gor
<u>Muricea</u>	Mur
<u>Plexaura</u>	Ple
<u>Plexaurella</u>	Plxl
<u>Pterogorgia</u>	Ptg
<u>Pseudopterogorgia</u>	Pst
<u>Pseudoplexaura</u>	Psl

TABLE 3 (continued)

Other Organisms	
<u>Acanthophora</u> spp.	Aca
<u>Anemones</u>	ane
<u>Antipathes</u> spp.	Ant
<u>Caulerpa cupressoides</u>	Ccup
<u>Caulerpa serrulata</u>	Cser
<u>Colpomenia</u> spp.	Cop
<u>Diadema antillarum</u>	Dia
<u>Dictyota</u> spp.	Dit
<u>Digenia simplex</u>	Dsi
<u>Echinometra</u> spp.	Eci
<u>Goniolithon</u> spp.	Gon
<u>Gracilaria</u> spp.	Gra
<u>Halimeda</u> spp.	Ham
<u>Halodule wrightii</u>	Hal
<u>Halophila baillonis</u>	Hap
<u>Hypnea</u> spp.	Hyp
<u>Laurencia</u> spp.	Lar
<u>Lobophora</u> sp.	Lob
<u>Neogoniolithon</u> sp.	Neo
<u>Padina</u> spp.	Pad
<u>Palythoa caribbea</u>	Pal
<u>Pinna carnea</u>	Pca
<u>Penicillus capitatus</u>	Pen
<u>Stichopathes</u> sp.	Sti
<u>Syringodium filiforme</u>	Syr
<u>Thalassia testudinum</u>	Tha
<u>Udotea</u> spp.	Udo
<u>Zoanthus sociatus</u>	Zoa
<u>Sponges</u>	spg

TABLE 4

Symbols for Dominant Organisms and Substrate

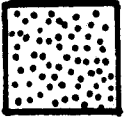
Hard Coral spp.

	<u>Acropora cervicornis</u>
	<u>A. palmata</u>
	<u>A. prolifera</u>
	<u>Diploria spp.</u>
	<u>Millepora</u>
	<u>Montastrea annularis</u>
	<u>M. cavernosa</u>
	<u>Porites divaricata</u>
	<u>P. porites</u>
	<u>P. astreoides</u>
	<u>Agaricia spp.</u>
	<u>Siderastrea sideres</u>
	<u>Colpophyllia natans</u>
	<u>Favia fragum</u>

Other Organisms

	<u>Gorgonians</u>
	<u>Echinometra</u>
	<u>Zoanthids</u>
	<u>Halimeda</u>
	<u>Penicillus</u>
	<u>Udotea</u>
	<u>Sea Grass</u>
	<u>Mangrove</u>

Substrate Types

	<u>Sand</u>
	<u>Pavement/Coral Rubble/Turf</u>
	<u>Bedrock</u>
	<u>Beach Rock</u>

RESULTS

ANEGADA

Introduction

Horse Shoe Reef, extending southeast from the tip of the Island of Anegada, constitutes the major portion of this proposed marine park site (Fig. A). The reef system is 17.5 km in length and covers an area of nearly 30 km². Aerial photograph interpretation revealed seven major distinguishing reef patterns. Due to the large size of Horse Shoe Reef and our time and personnel constraints we chose to ground truth the biological communities in one area within each of the seven representative sites. We studied several reefs in each of these areas to ensure a representative description.

Horse Shoe Reef is shaped like a large arc extending from its southeast tip (14 km from Pajaros Point, Virgin Gorda), where the reef lies at 30 m depth (site 1), in a northwest direction 17.5 km toward the eastern tip of Anegada. Along this portion of Horse Shoe Reef a graded series of patch reefs occur from relatively deep water (15 m), near the southeast tip (site 2), to emergent patch reefs (site 3, The White Horse). About half way along the reef system, on the windward side, small patch reefs (ca. 10 m across) occur while larger ones (ca. 100 m across) are present on the leeward side (site 4). The distance between these small patch reefs gradually decreases in a northerly direction eventually forming a contiguous series of reefs which ultimately coalesce into a barrier reef (site 5). This barrier reef extends around the entire north side of Anegada Island. The large patch reefs, on the leeward side of Horse Shoe Reef,

eventually fuse to form a contiguous series of reefs on the south side of Anegada Island (site 7). A large lagoon lies around the southeast end of Anegada, between the windward and leeward barrier reefs. Site 6 is located in this lagoon.

The research presented in this report concentrates on Horse Shoe Reef. A survey of the reefs south and north of Anegada, excluding Horse Shoe Reef, was carried out in 1975 (Cambridge, 1975). The geographical areas surveyed in this study overlap our areas only at site 6. Another study was conducted at Anegada (West Indies Laboratory, 1983). This study overlapped more geographically with our survey, and should also be consulted as baseline data when coastal marine resource management stages are being developed.

Site 1

This entire site is a reef pavement transition to a lower forereef (Fig. A1; Profile A1). The depth ranges from 15 m to 30 m and the site we dove was at 20 m depth. The scleractinian and gorgonian community is diverse; 25 coral species and 7 gorgonian genera were identified (Table A1; Plate A1-a). Live coral covers 30% of the substrate and gorgonians account for 25% of the substrate cover.

The dominant corals are Montastrea annularis and Acropora cervicornis. The presence of two morphological types of M. annularis was noted; a tablelike form, grey in color produces a colony (up to 1.5 m across) with extensive space under its edges, and a smaller, green knobby form was also

observed (Plate A1-a). Subsequently, these two morphs were noted elsewhere on Horse Shoe Reef and in the BVI (e.g. The Dogs).

A significant amount of A. cervicornis is dead (Plate A1-b). It was noted that ca. 5% of the live A. cervicornis present is infected with white band disease (Davis et al. 1985). Diadema spines and tests littered the bottom.

Site 2

Deep patch reefs rise abruptly to 5 m depth from 15 m depth off the gorgonian/coral flat surrounding them (Fig. A2). The sloping upper forereef joins the top of the patch reef which is generally barren pavement. The profile prepared for this site is representative of the patch reefs in this area (Profile A2; Table A).

Reef Pavement

The reef pavement which caps the deep patch reefs is composed primarily of partially consolidated Acropora palmata rubble, encrusted by coralline algae and zoanthids (Plate A2-a,b). Six other coral species were noted but seem to be recent recruits and are in very low abundance (Table A). Live coral cover in this zone is less than 10%.

Upper Forereef

Dense coral and gorgonian growth nearly completely encircles the pavement caps and slopes down to the flat bank (Plate A2-c). A. palmata is the dominant coral and, with eight other species, produces a live coral cover of 40% (Table A). These reefs rise abruptly off the nearly flat bank with the upper

forereef maintaining as much as a 45° slope.

Gorgonian/Coral Flat

Montastrea annularis and A. cervicornis comprise a significant amount of the 10% live coral cover on this nearly flat bank (Plate A2-d). An intermediately diverse population of gorgonians produces 15% of the substrate cover (Table A). Seventy percent of the bank is well consolidated dead coral (primarily A. cervicornis) colonized by algal turf with some areas covered by a thin veneer of sand (5%).

Site 3 (The White Horse)

The White Horse is a small coral rubble island (ca. 15 m across) which rises no more than 1 m above sea level. The marine communities were examined in a transect which runs from west to east (Profile A3; Table A).

Backreef

From the west a gorgonian/coral flat slopes gradually to a plateau of backreef coral rubble. This backreef area supports a considerable level of live coral cover. Acropora prolifera colonizes 20 - 30% of the substrate in places. Diploria species and Montastrea annularis cover an additional 15% to generate a total live coral cover of 35 - 45%. Twenty percent of the substrate here is colonized by gorgonians. As The White Horse is approached, live coral cover decreases and the backreef is dominated by A. prolifera and the hydrocoral Millepora (Plate A3-a). The substrate contains many pits inhabited by

chitons.

Upper Forereef

The shallowest portion of the east side of the island is a coral rubble area similar to that on the west side. This shallow area is colonized by large stands of A. palmata and the hydrocoral Millepora (Plate A3-b). On the deeper upper forereef, A. palmata becomes the only live coral (50% cover; Plate A3-c). Large branches of this coral lie dead, are partially consolidated, and cover the remaining 50% of the substrate.

Lower Forereef

The lower forereef slopes at an angle of about 30° to 20 m depth (Plate A3-d). This area is quite similar to the gorgonian/coral flat west of the backreef described above. Dense thickets of A. cervicornis lie on the sandy slope. Small heads of Montastrea annularis are common and Diploria species also contribute to the live coral cover of 25%. Gorgonians add another 5% to the substrate cover; Gorgonia, Eunicea and Pseudopterogorgia are the most common of these.

The deeper edge of this slope is colonized by unusually large heads of M. annularis (1.5 m across) of the knobby morphology.

Site 4

Site 4 is characterized by shallow patch reefs which range in size from 100 m diameter, which are widely spaced, to 10 m diameter, which are in close proximity to one another (Fig. A4;

Profile A4). The large shallow patch reefs are located at the west side of the site and a gradient is evident in which the reefs gradually get smaller and closer together as the east side of the site is approached. A gradient of size, symmetry and orientation of the patch reefs at Anegada has been studied by other researchers (Brown and Dunne, 1980). The large patch reefs on the west side have the reef crests, upper and lower forereefs oriented in a southeast direction. The reef pavement is oriented to the northwest edge of the reef. The small patch reefs on the east side of the site are symmetrically capped by the reef crest or have the reef crest oriented to the northeast.

The reefs end abruptly in a well defined line on the east side of this site and the sea floor drops away to 10 - 15 m depth (Profile A4). Two transects were constructed at site 4; one transect crosses a large shallow patch reef on the west side of the site (Profile A4-west), and the other crosses the interface between the small shallow patch reefs and the open sea on the east side of the site (Profile A4-east).

West Transect

The large shallow patch reefs rise from 8 m depth off a gorgonian/coral flat (Fig. A4; Profile A4-west; Table A). A steep forereef interfaces with the reef crest (1 m depth) which is located on the southeast side of the reef. To the northwest, the reef is capped with pavement (4 m depth). The reef crest/reef pavement transition is nearly vertical in some instances while the junction maintains a more gradual slope in others (Plate A4-a).

Reef Pavement

The reef pavement is flat and supports 10% live coral cover. The algal flora on this pavement is extensive and is dominated by erect foliose species.

Reef Crest

Acropora palmata and the hydrocoral Millepora dominate the live coral cover (45%) on the reef crest (Plate A4-b). Algal turf (20% cover) populates the outer edges of the reef crest which drops to an upper forereef area at 1 m depth.

Forereef

Dominant colonies of A. palmata and a lower abundance of A. cervicornis constitute virtually 100% of the upper forereef in this zone (Plate A4-c). Montastrea annularis dominates the 80% live coral cover of the lower forereef. The average live coral cover on the forereef is 90%.

Gorgonian/Coral Flat

Due to the presence of locally dominant species, live coral can contribute as little as 10% to the substrate cover on one portion of the bank and yet may account for as much as 60% on another (Table A). The overall live coral cover for the area is, however, 40%. A relatively high diversity of gorgonians contribute 10% to the total cover, even in the areas where the substrate is mostly sand (10% cover; Table A).

East Transect

This area is a complex system of shallow patch reefs which lie close together and are separated by bank pavement and sand (Fig. A4). The patch reefs terminate to the northeast. Here a well defined lower forereef slopes seaward to a gorgonian/coral flat at 10 - 15 m depth (Profile A4-east; Table A).

Bank Pavement

Bank pavement lies between the patch reefs in the southwest region of the transect and is predominantly sand (40% cover) and algal turf (40% cover). A low live coral cover of 10% persists and is dominated by colonies of Montastrea annularis (ca. 1 m across; Plate A4-f). Gorgonians (10% cover) are dominated by Pseudopterogorgia and Pseudoplexaura. Sponges are large, diverse, and a major feature in this community.

Backreef

The lee side of the patch reefs is predominantly composed of partially consolidated dead branches of Acropora palmata. Many branches are 0.5 m thick and resemble piles of tree trunks lying at the base of the patch reefs. Little live coral is present in these areas (ca. 10% cover). Montastrea annularis is the dominant coral at the backreef base and A. palmata is noticeably more abundant at the shallower depths of the backreef.

Reef Crest

Habitat complexity is extremely high on the reef crests (0.5 m depth; Plate A4-e). Pore spaces extend into caves which open

into caverns within the center of many of these reefs.

The reef crest is dominated by the hydrocoral Millepora. Porites astreoides and small stands of A. palmata are the only other colonies contributing significantly to the 40% live coral cover. The remaining 60% of the reef crest is covered with algal turf; a combination of filamentous red algae and calcareous greens. Asparagopsis cover was extremely high in local areas, perhaps a result of the Caribbean-wide Diadema death. Zoanthus covers most of the sides of the holes which extend into the reef's interior.

Upper Forereef

Impressive stands of Acropora palmata grow in a ring around the upper edge of the patch reefs, with a concentration of live colonies on the northeast side (Plate A4-d). These large colonies of A. palmata form thick, multilayered stands which cover the entire surface.

Reef Grotto

An increase to 5 m depth between the patch reefs forms reef grottos which open toward the sea. The grotto floors are predominantly aggregates of consolidated A. palmata branches which have formed pavement and support a diverse coral community (Table A). The dominant coral here is Montastrea annularis and, in some areas, has formed small reefs which extend nearly to the sea surface. Live coral cover on the M. annularis reefs approaches 50%. Large colonies of Agaricia which have developed on the reef sides contribute significantly to the high

Percent live coral cover. Other areas in the grottos are nearly devoid of live coral. A gradient from 0 to 50% coral cover is thus present and is skewed toward the lower percentages to produce a total live coral cover of approximately 15%.

Gorgonians are present (15% cover).

Dead coral (25% cover) consists primarily of unconsolidated Acropora palmata branches. Algal turf (35% cover) in this zone is heavily grazed. Small patches of sand (10% cover) occur in the lowest parts of the grottos.

Gorgonian/Coral Flat

The patch reefs end abruptly along the northeast side of the site and the sea floor slopes steeply to 10 - 15 m depth (Plate A4-g). Here the vertical relief, and the diversity of corals and gorgonians are high (Table A).

Live coral cover (25%) is dominated by conspicuously large colonies of M. annularis and A. palmata. The pillars of M. annularis rise 6 m off the sea floor. Stands of A. palmata reach from 10 m depth to within 3 m of the surface and are surrounded on all sides by dead broken branches radiating away from the central colony. The base of the piles of broken A. palmata branches may be 7 to 10 m across. The M. annularis pillars often have significant sized branches of A. palmata growing from them forming complex reefs which harbor a high diversity of smaller corals (Table A). Gorgonians are also large and account for 25% of the substrate cover. Acropora palmata and A. cervicornis contribute significantly to

the dead coral cover of 25%. Algal turf (15% cover) is heavily grazed. Patches of sand account for the remaining 10% of the substrate cover.

Site 5

Site 5 is located in the area where the small shallow patch reefs of site 4 converge, resulting in a long, narrow series of reefs (Fig. A5). A linear reef was surveyed on each side, the southwest side being shallower (5 - 7 m depth) than the northeast location (10 m depth). The transect at this site begins in lagoon sand on the southwest side of the most seaward linear reef and crosses the backreef, reef crest, forereef, bank sand, and bank patch reefs (Profile A5; Table A).

Lagoon Sand

The substrate on the southwest side of the linear reef is composed of sand (70% cover) or patch reef. The sand is barren with the exception of a fine algal turf (10% cover). Acropora cervicornis patches occur which range from completely dead to healthy. Reefs composed of Montastrea annularis colonize this zone and heads of Diploria species also contribute to the live coral cover of 5%. Dead coral accounts for 15% of the substrate cover.

Backreef

The backreef rises abruptly out of the sand and is riddled with caves, some of which penetrate through the reef (Plate A5-b). About half of the live coral cover of 10% can be attributed to A. palmata and half to M. annularis. Some

heads of M. annularis nearly reach the surface and have approximately 80% local live coral cover (Plate A5-a). High density live coral cover areas, however, are few and the backreef dead coral cover zone is 35%.

Reef Crest

A. palmata dominates the live coral cover of 25% on the reef crest. Other reef crest species include Porites astreoides, Millepora, P. porites, D. clivosa, D. strigosa, D. labyrinthiformes, and Favia fragum.

Forereef

Due to the damping of wave action by offshore patch reefs, the water motion is low and the forereef bears a substantial sediment burden (Plate A5-c). Many of the A. palmata colonies present are broad and delicately branched.

Montastrea annularis and A. palmata dominate the 30% live coral cover here. Gorgonians are present on the forereef with 5% cover. Dead coral and algal turf contribute 15% and 50% respectively to the total substrate cover. Large caves and pore spaces which riddle the reef create a high habitat complexity. The forereef drops nearly vertically to 7 m depth ending abruptly in sand similar to the sand/backreef interface.

Dense Asparagopsis growth was prevalent in the subzone and a thick mat of filamentous red algae was conspicuous in patches at the deeper part of this area. Few live Diadema were noted but many tests and spines were seen. Excessive algal growth is a probable consequence of the Caribbean-wide Diadema death.

Bank Patch Reefs

Northeast of the linear reefs, at 10 m depth, are many small bank patch reefs (ca. 10 m across), some of which have converged to form short linear reefs (ca. 100 m long). These reefs are composed of actively growing, healthy coral colonies dominated by Acropora palmata. The deeper stands of A. palmata, isolated to the east, are fringed by large platelike colonies of P. astreoides ca. 2 m below the surface. The reef crests are 100% live coral with the hydrocoral Millepora often emergent at low tide. The reef sides are covered by 75% live coral, also heavily dominated by A. palmata.

The areas between the reefs are primarily sand (50% cover) or coral rubble (40% cover), and are scattered with gorgonians (5% cover). Large heads of Colpophyllia are common and contribute to the live coral cover of 5%. Asparagopsis was present on much of the dead Acropora palmata.

Site 6

Encircling the southeast point and extending along the south shore of Anegada is a large lagoon (3 - 4 m depth). It is bordered on both sides by barrier reefs and is a system of patch reefs, coral heads, algal and seagrass planes (Fig. A6; Profile A6; Table A).

Our aerial photographs show that the area is streaked with dark patches which are aligned in a north-south direction on the east side of the island and swing around to an east-west direction off of the southeastern tip of Anegada, following the

contour of the point. The dark streaks consist of linear patches of algae and seagrasses which are aligned with the direction of the current. Each patch is dominated by one or two algal or seagrass species. The diversity of the dominant species of macroalgae in the lagoon is estimated to be higher than any other area visited in the BVI. The most conspicuous seagrasses and algae were collected including 4 genera of grasses and 16 species of macroalgae (Table A). Commercially significant queen conch were noted here in addition to milk conch and king helmets.

Large Montastrea annularis colonies are common in the area. Coral heads composed of Diploria labyrinthiformes and Colpophyllia are present as well.

Patch reefs are large, convoluted, and bioeroded. They are surrounded by a grazing halo.

The shore line along the southern tip of Anegada is bordered by a fringing reef which is composed primarily of Porites porites and P. divaricata. Several calcareous red and green algae are common in this zone. Thalassia grows commonly among the coral rubble of this reef and is dense in the sandy area bordering the beach. The beach is littered with commercially harvested conch shells.

Site 7

Site 7 is a portion of the barrier reef which shelters the southwest side of Anegada (Fig. A7). Numerous patch reefs are located on the northeast edge of the reef in the lagoon previously described (site 6). From the north, the reef zones are lagoon patch reef, backreef, reef crest and forereef. The patch reefs converge with the northeast edge of the barrier reef. South of the reef is a grazing halo and a gorgonian/coral flat (Profile A7; Table A).

Lagoon Patch Reef

The patch reefs to the northeast of the barrier reef are small (ca. 10 m dia.) and composed of 100% live Montastrea annularis (Plate A7-a). As the barrier reef is approached the patch reefs become larger (20 - 30 m dia.) and more complex. The largest of these have a lower forereef, upper forereef and reef crest with characteristics indistinguishable from the analogous zones on the barrier reef and are therefore described in that section.

Backreef

An inconsistency in depth occurs where the backreef interfaces with the sand. The sand in concave portions of the backreef is shallower (2 m depth) than it is in the convex portions of the backreef (5 m depth). Acropora cervicornis colonizes the sandy shallow areas in the backreef indentations. Montastrea annularis and A. palmata dominate the live coral cover (15%) where the backreef drops abruptly to 5 m depth

(Profile A7; Plate A7-b).

Reef Crest

Acropora palmata, M. annularis, and the hydrocoral Millepora are the dominant corals contributing to the live coral cover of 30% on the reef crest. Porites astreoides is also common.

Forereef

Acropora palmata is present on the upper portion of the inclined forereef. Large pieces of A. palmata coral rubble, covered with coralline algae and boring sponges, constitute part of the base of the slope (Plate A7-c). Dead P. porites accounts for most of the remainder of the rubble on the lower forereef. Approximately 15% of the A. palmata and 10 - 15% of the P. porites present is alive. Stands of P. porites and A. prolifera colonize the level sand area in front of the forereef. Diadema spines were noted in the area.

Bank Sand

Isolated colonies of Montastrea annularis and five other less common corals populate this gently sloping, predominantly sandy area (Table A).

Gorgonian/Coral Flat

A rich gorgonian/coral flat extends seaward from the bank sand at a very gradual slope (Plate A7-d,e). Bioeroded pillars of M. annularis contribute to the total live coral cover of 70%. Five percent of the substrate is colonized by gorgonians.

Narrow sand channels (15% cover) colonized by Halimeda are found between the near vertical coral pillars.

Summary

Horse Shoe Reef extends 17.5 km southeast of the southeast tip of Anegada and occupies an area of nearly 30 km². From the southeast point swinging northwest to the island, it is a complex system of deep lower forereefs, deep large patch reefs and shallow large patch reefs which grade into small patch reefs. The small patch reefs get closer together until they coalesce to form a linear reef which ultimately becomes a major barrier reef system extending along both the north and south sides of the island forming a huge lagoon. The seven areas selected as representative sites correspond with the brief descriptions above. Each site was ground truthed and found to have unique and spectacular features.

The deep lower forereef (site 1) is particularly diverse in its hard coral fauna; 25 species of hard coral were identified here. Site 2, the deep large patch reefs, rise abruptly from the sea floor and are rich in live coral cover. Site 3, The White Horse, is the only island exposed on Horse Shoe Reef and is nearly 100% surrounded by an Acropora palmata reef which has 100% live coral cover. Site 4 is particularly complex with large shallow patch reefs (ca. 100 m) grading into small shallow patch reefs (ca. 10 m). The eastern side of site 4 is dominated by 4 to 5 m tall colonies of coral, grottos and caves. Both hard and soft corals are very diverse. The linear reefs to the north of site 4 are the location of site 5. Massive stands

of A. palmata form patch reefs to the east and to the west and both linear and patch reefs are riddled with caves. Site 6, a turquoise lagoon, is streaked with grass and algae and speckled with patch reefs and coral heads. The entire site is no more than 4 m deep and displays a greater variety of large invertebrates than any other site. Site 7, the barrier reef on the south side of Anegada, is a maze of patch reefs, linear reefs and barrier reefs bordered by a gorgonian coral flat. Some of the most striking vertical relief we saw at Anegada was at site 7.

The entire Horse Shoe Reef area is the largest and most spectacular reef system in the BVI. Any degradation of this area would be an irreplaceable loss to the tourist and islander alike.

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Figure A

Location of research sites 1 thru 7 at Horse Shoe Reef

Figure A1

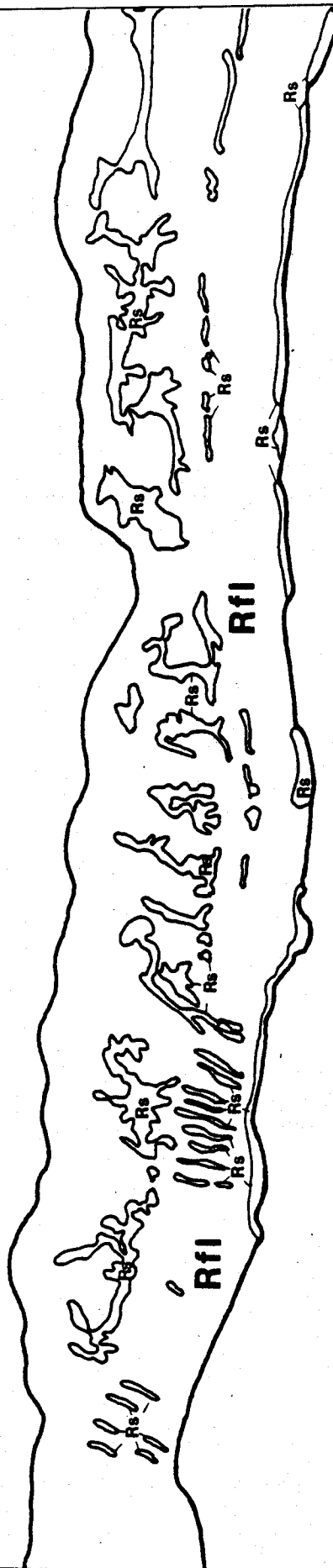
ANEGADA Site A1

Scale in Meters



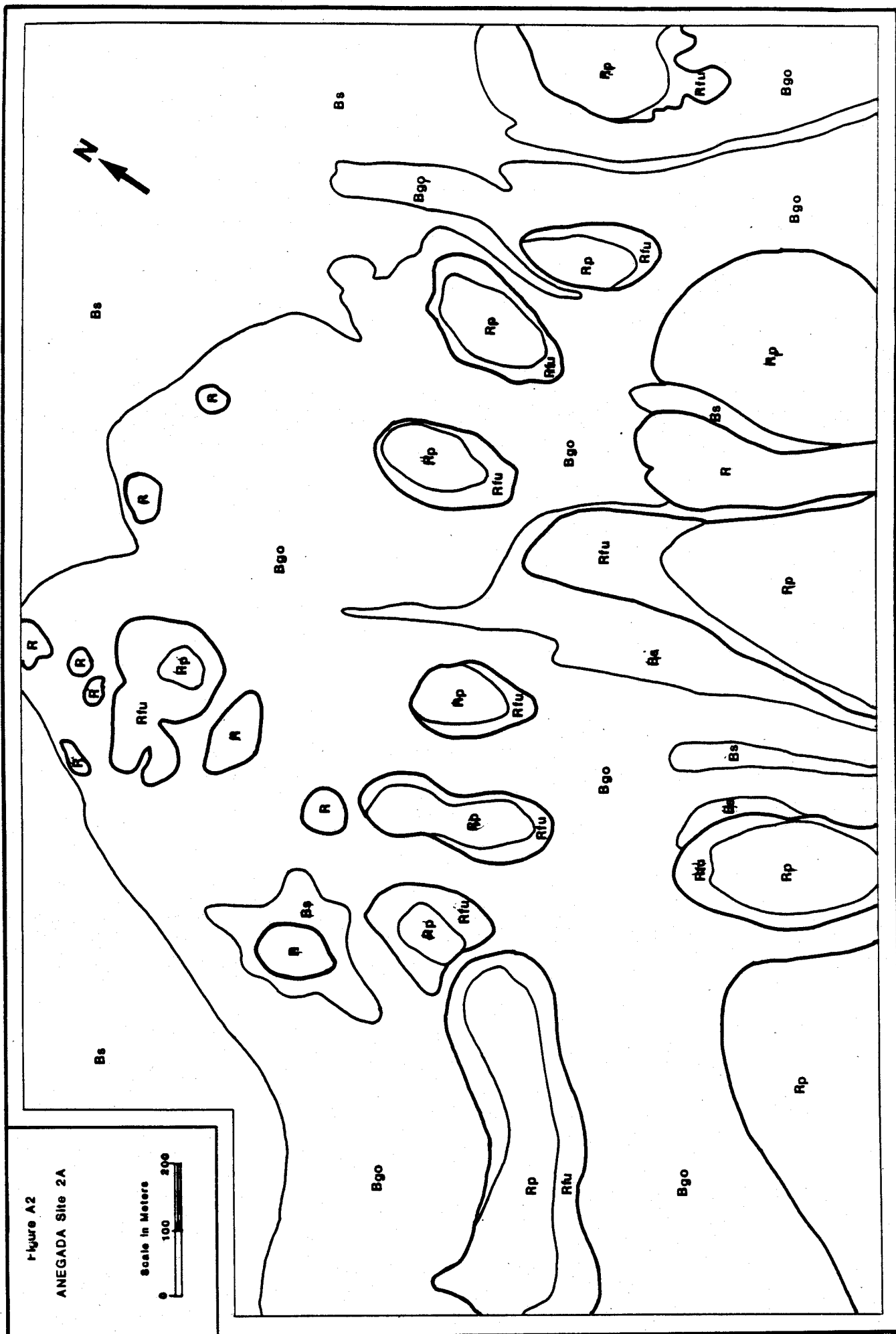
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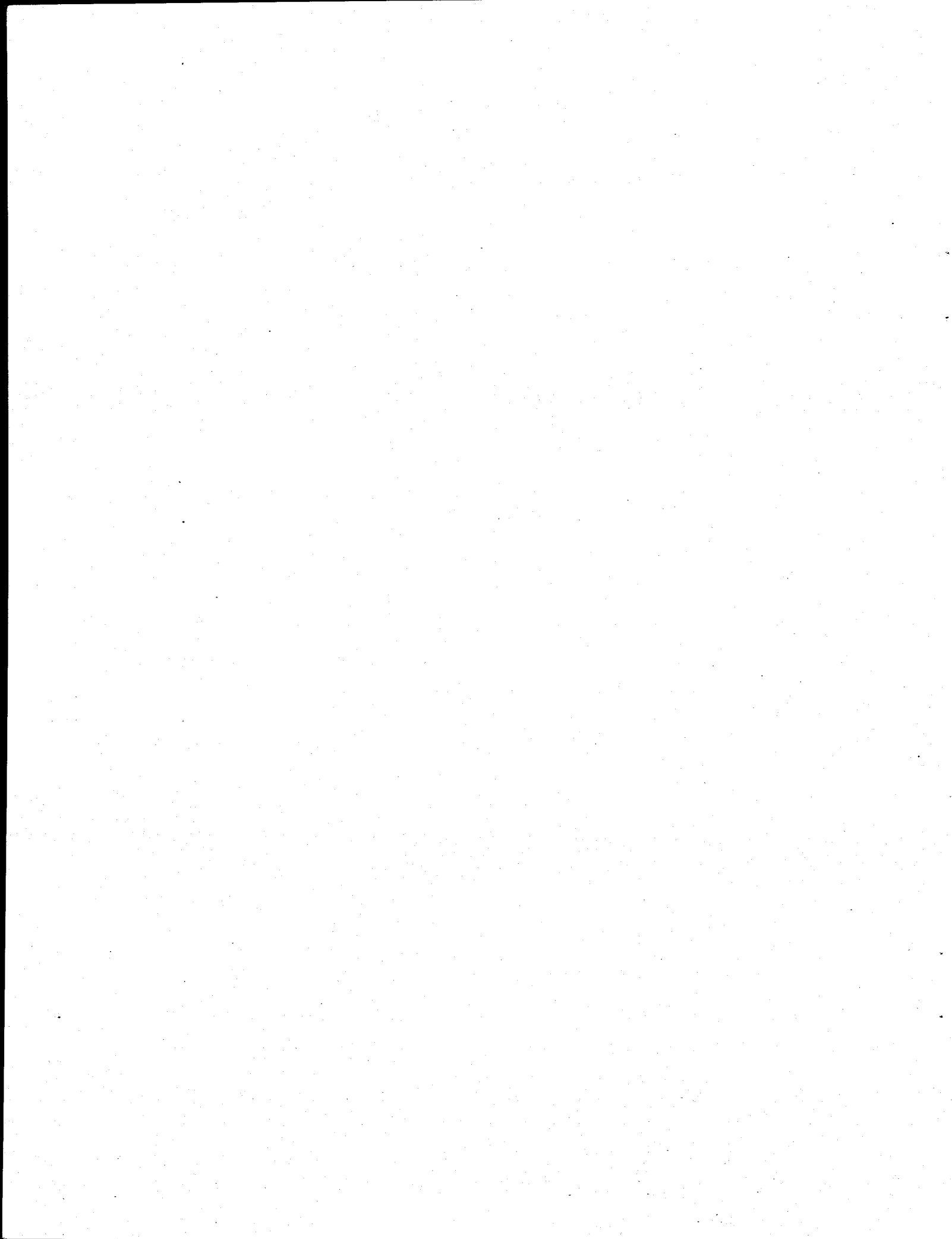
Rp



Bgo

Bgo





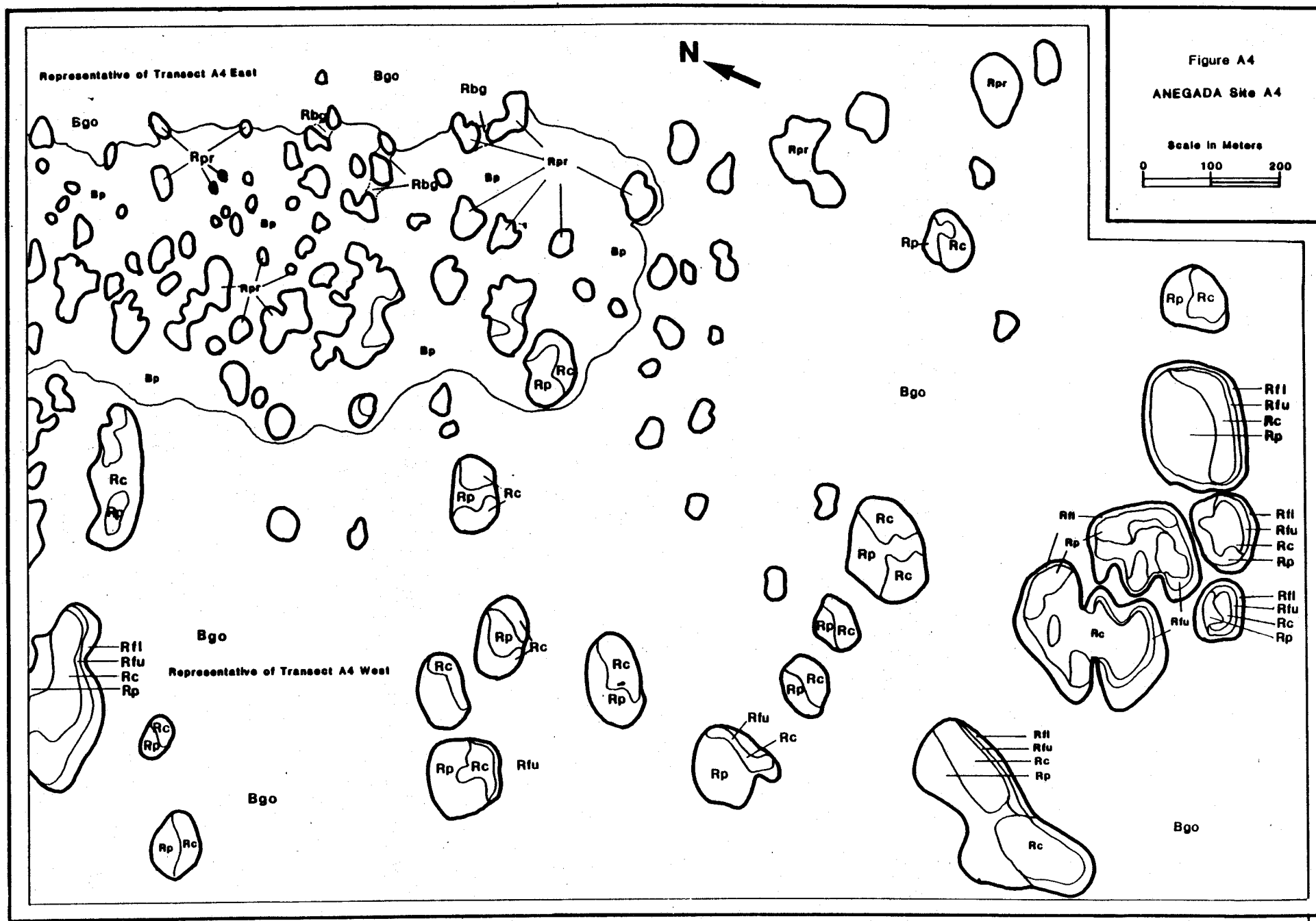
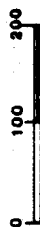


Figure A5

ANEGADA Site 5

Scale in Meters



N

Bgo

Bgo

Numerous Bank Patch Reefs

Numerous Bank Patch Reefs

Rbp

Lpr

Ls

Ls

Ls

Lpr

Ls

Lpr

Lpr

Lpr

Lpr

R

R

R

R

R

R

R

R

R

R

R

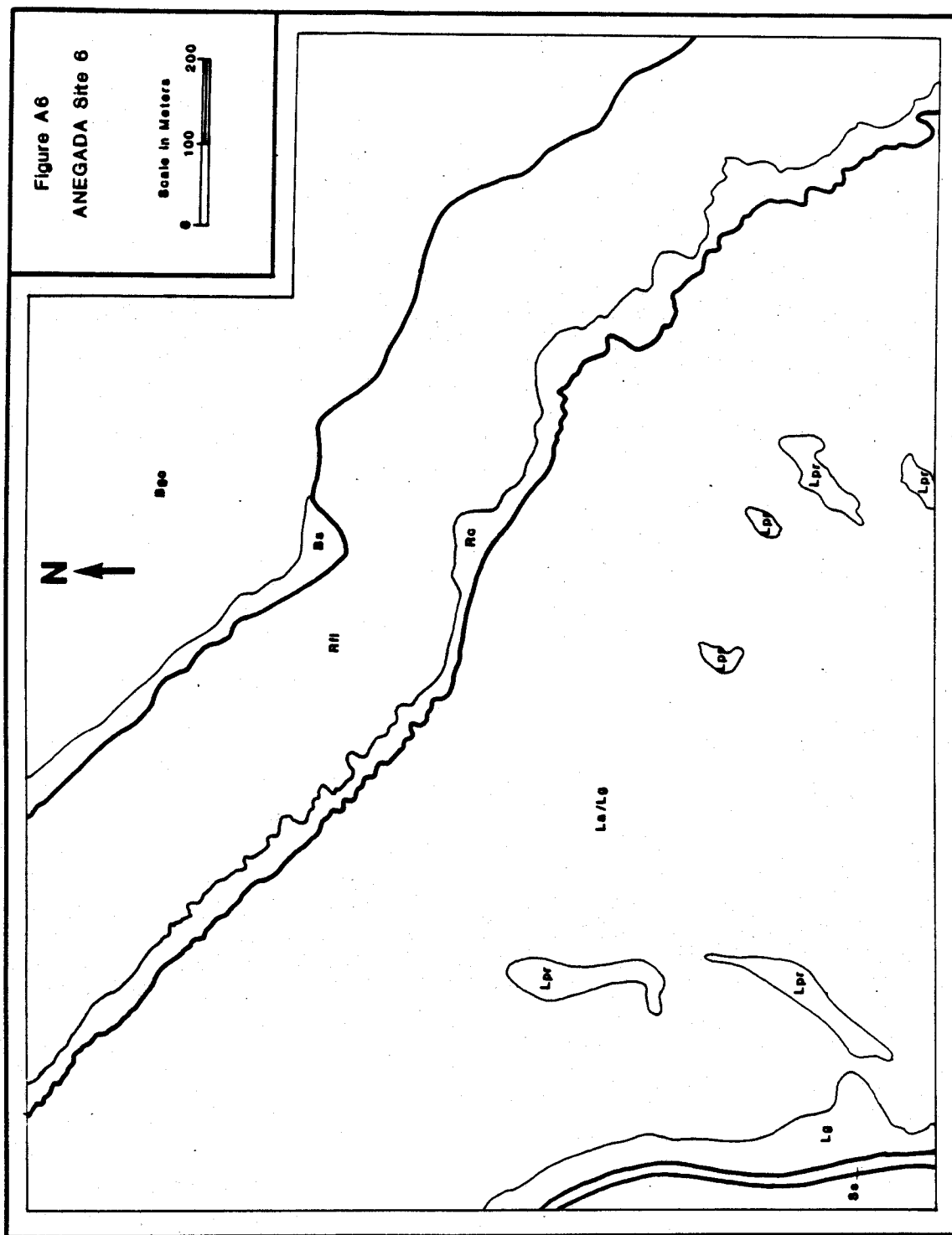
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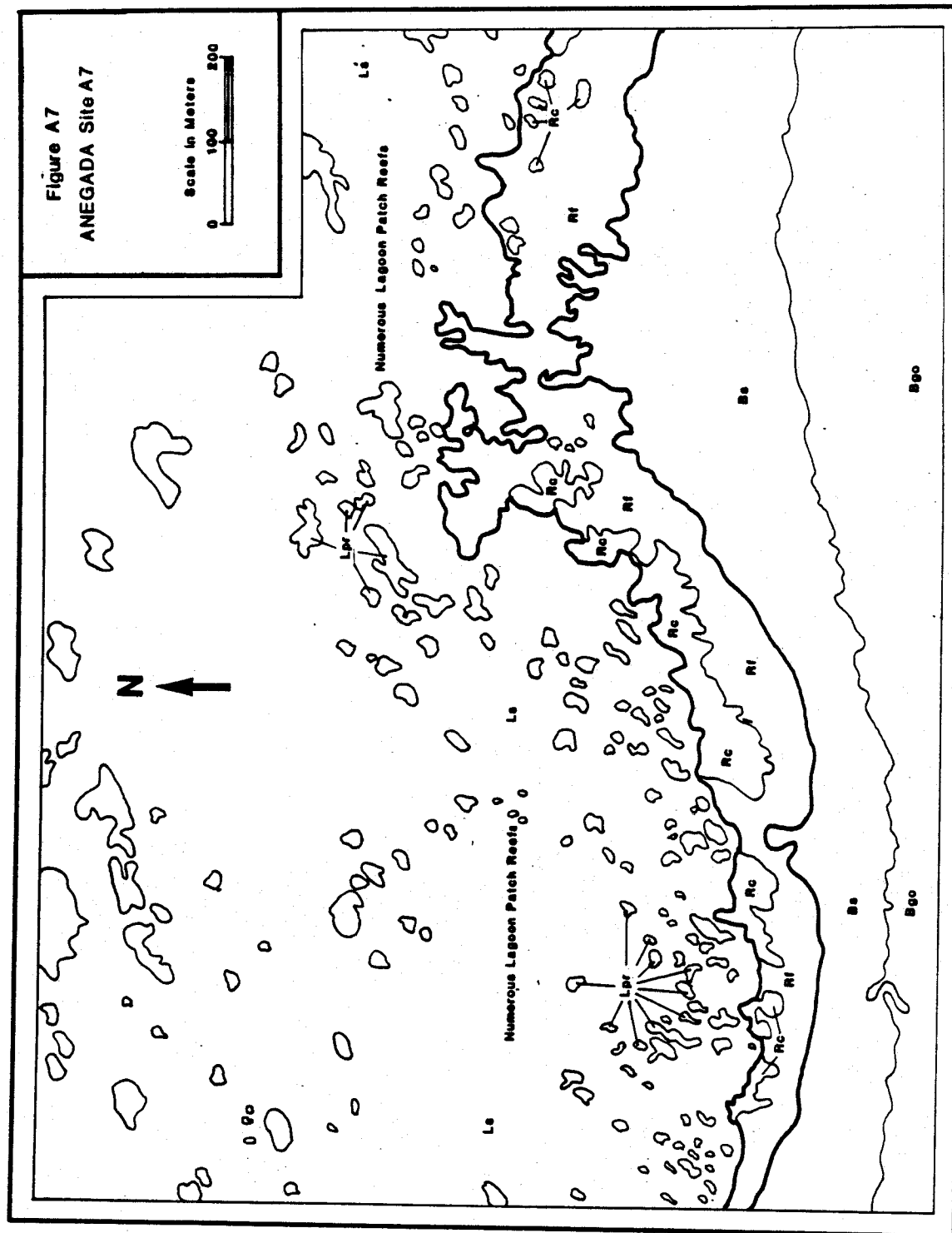
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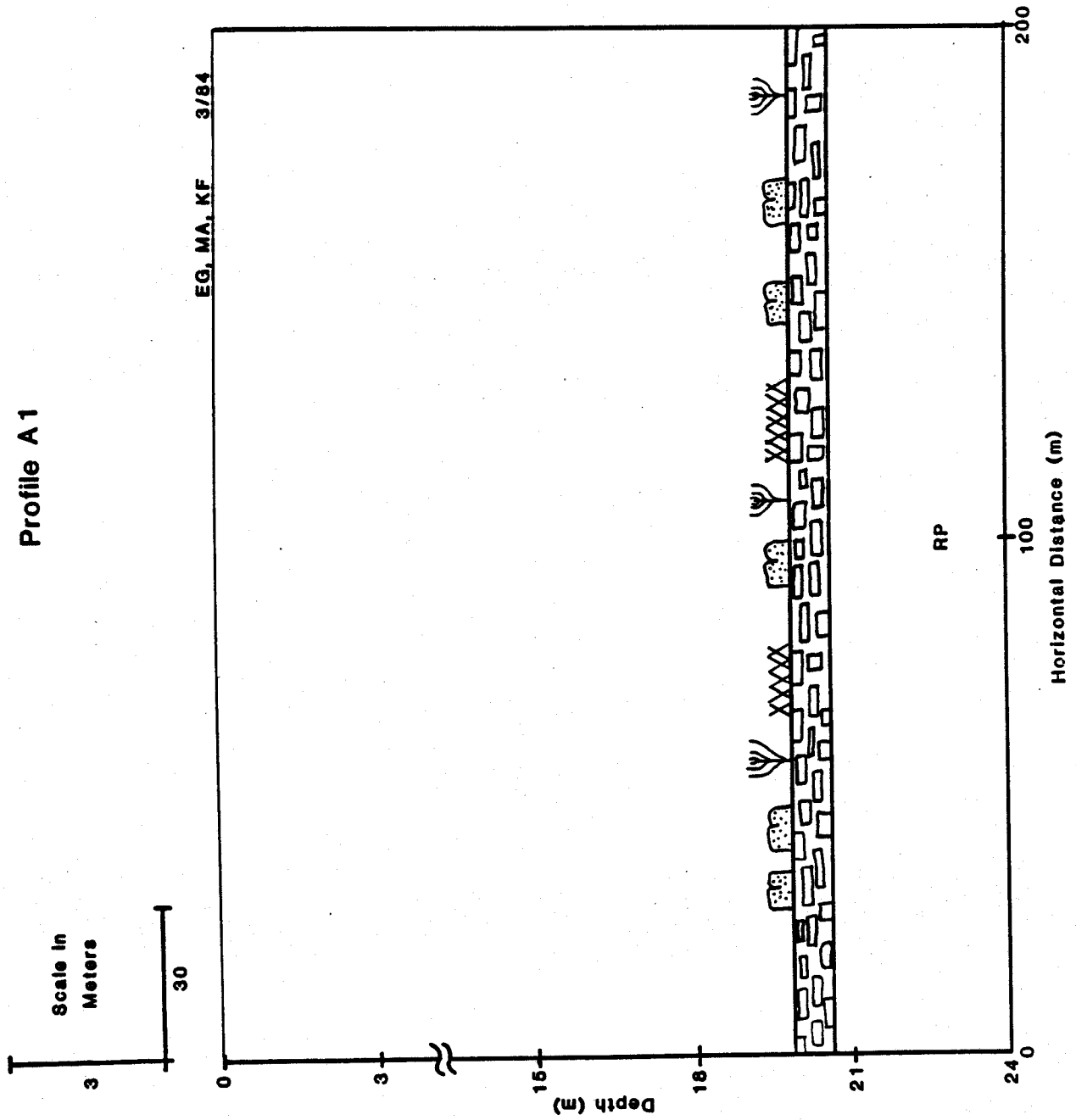
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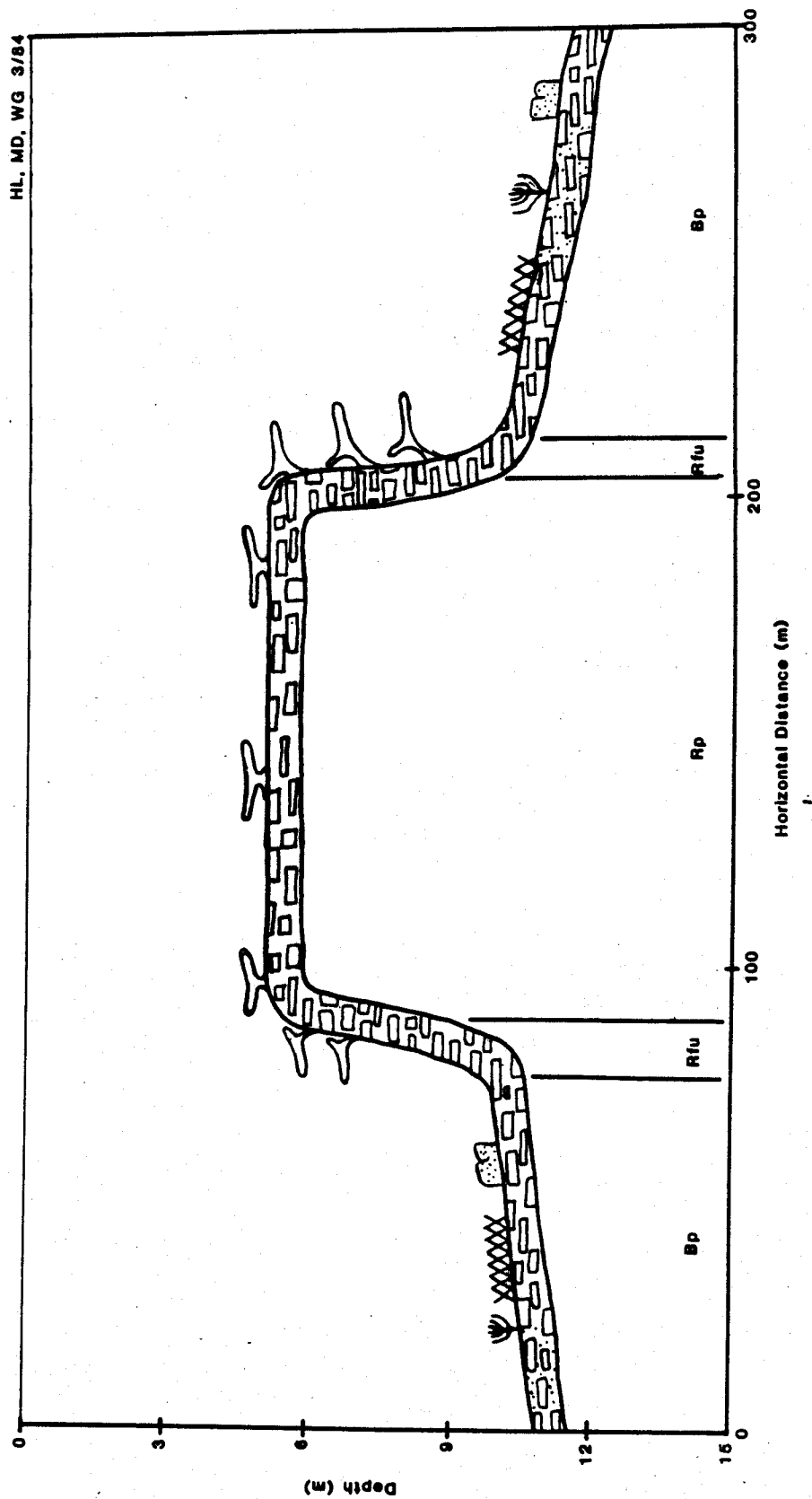
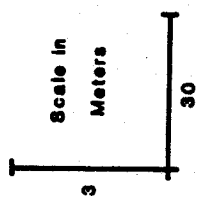




Profile A 1

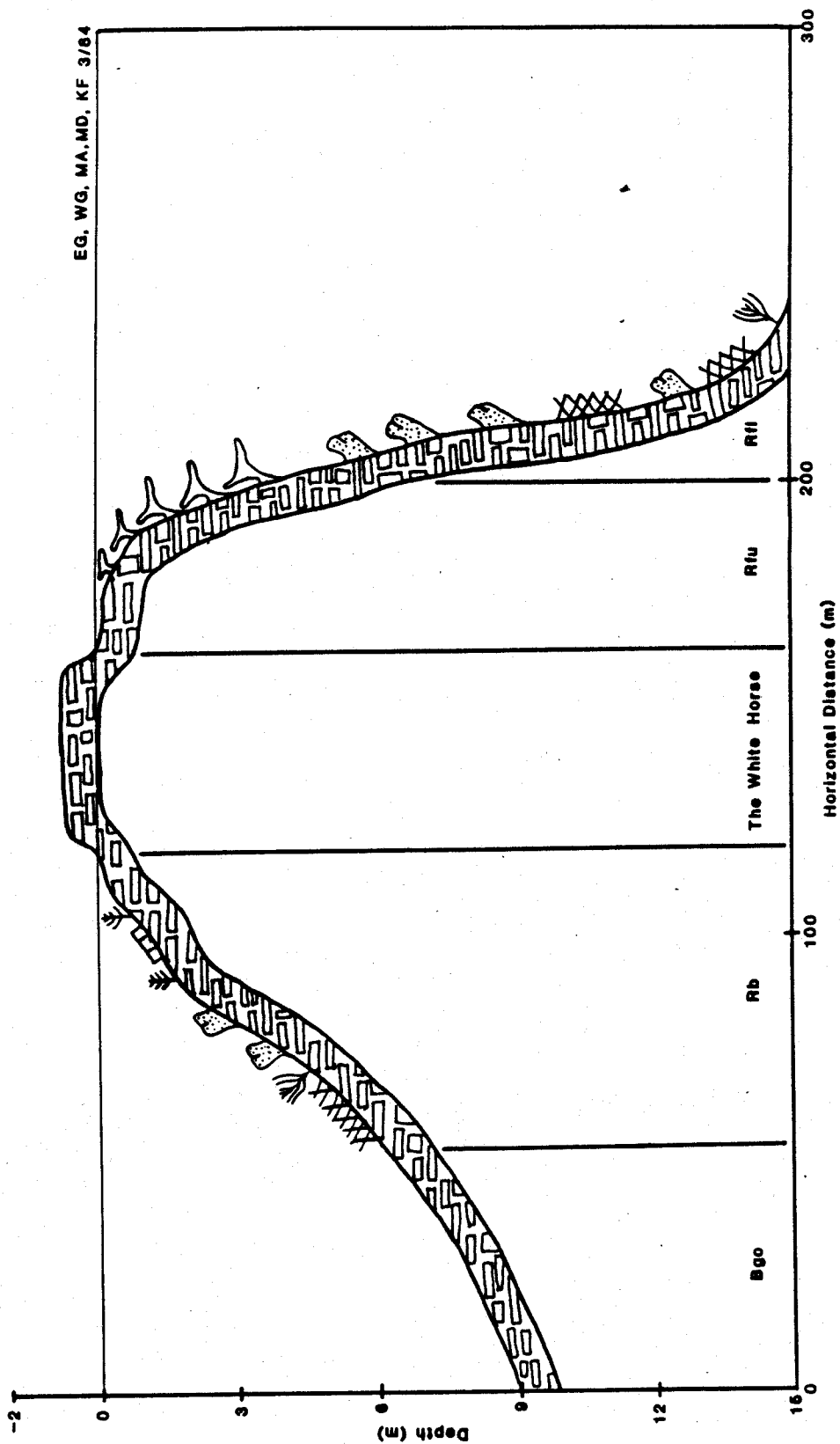
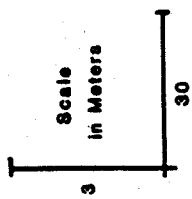


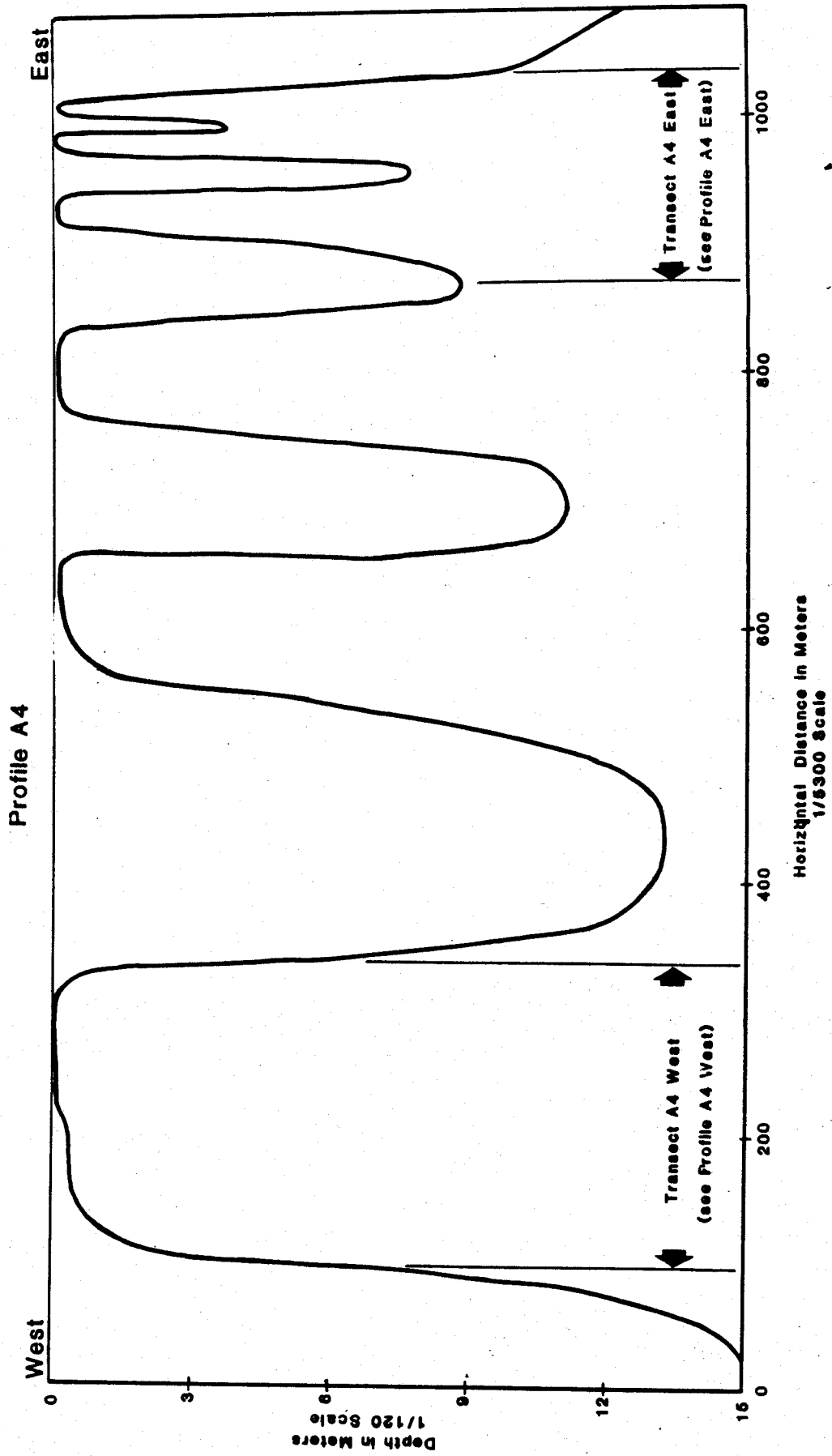
Profile A2



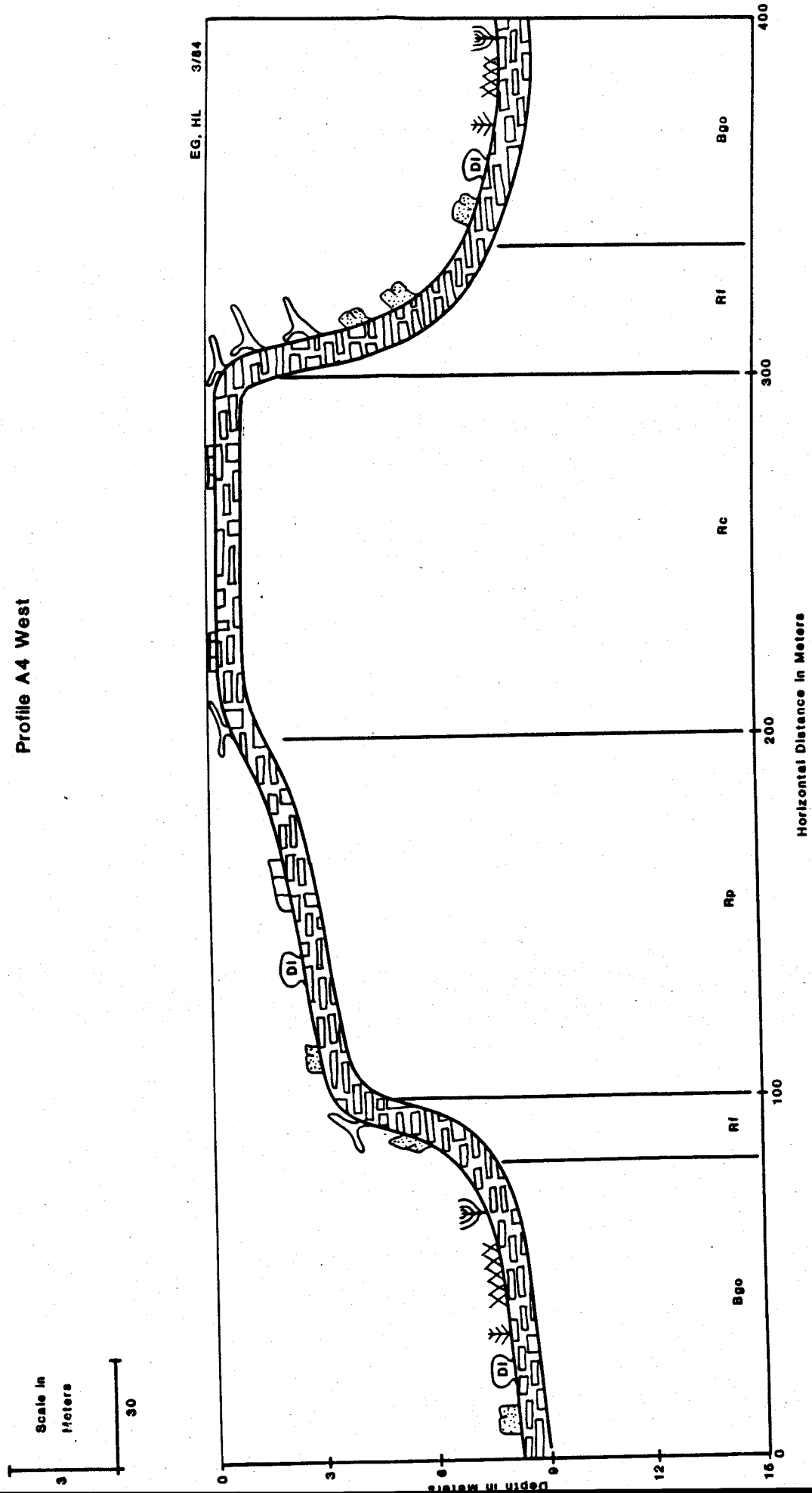
HL, MD, WG 3/84

Profile A3

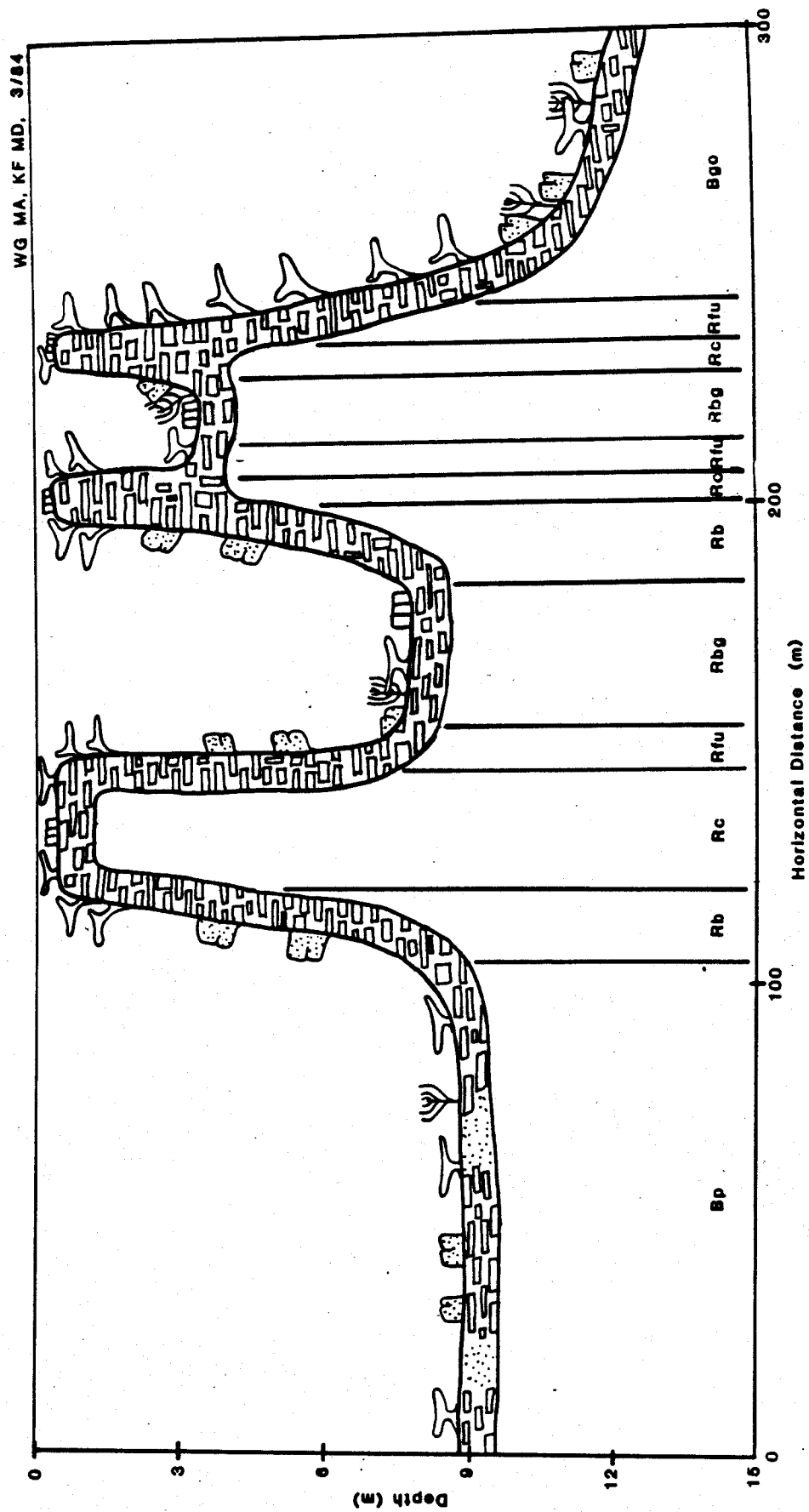
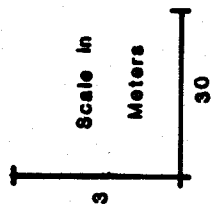




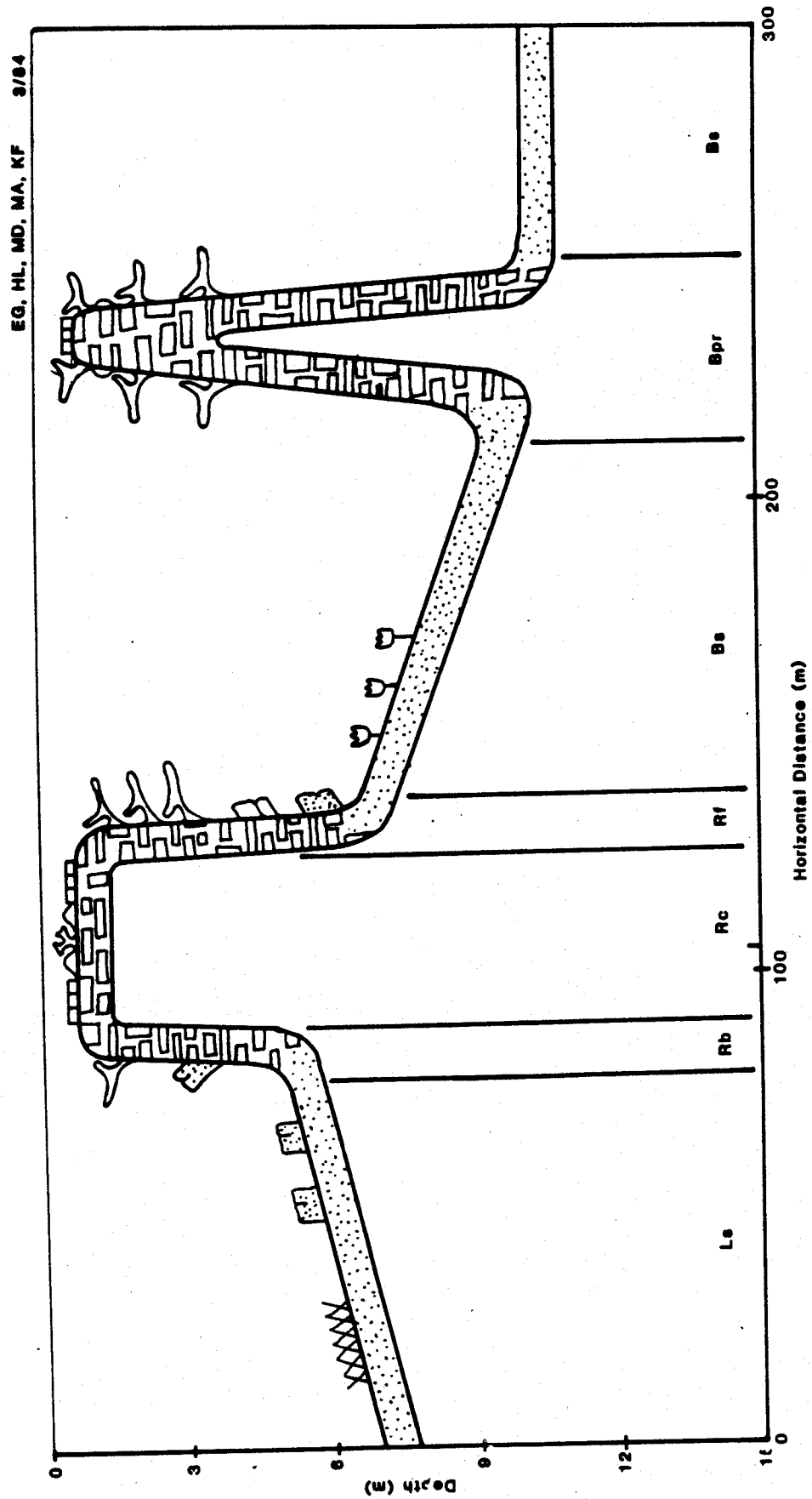
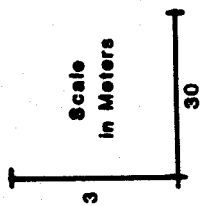
Profile A4 West



Profile A4 East

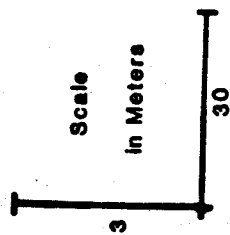


Profile A5

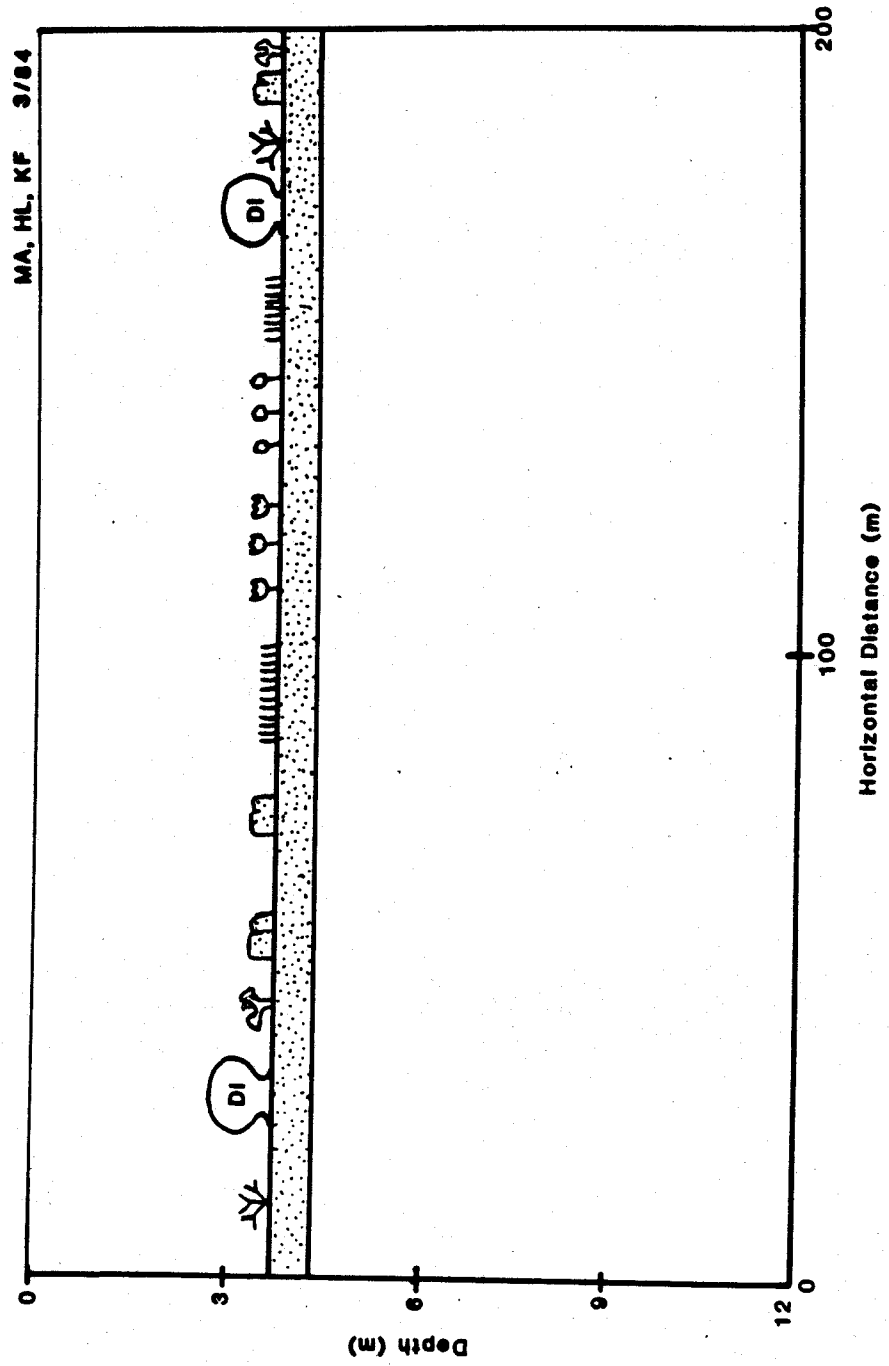


EG, HL, MD, MA, KF 3/84

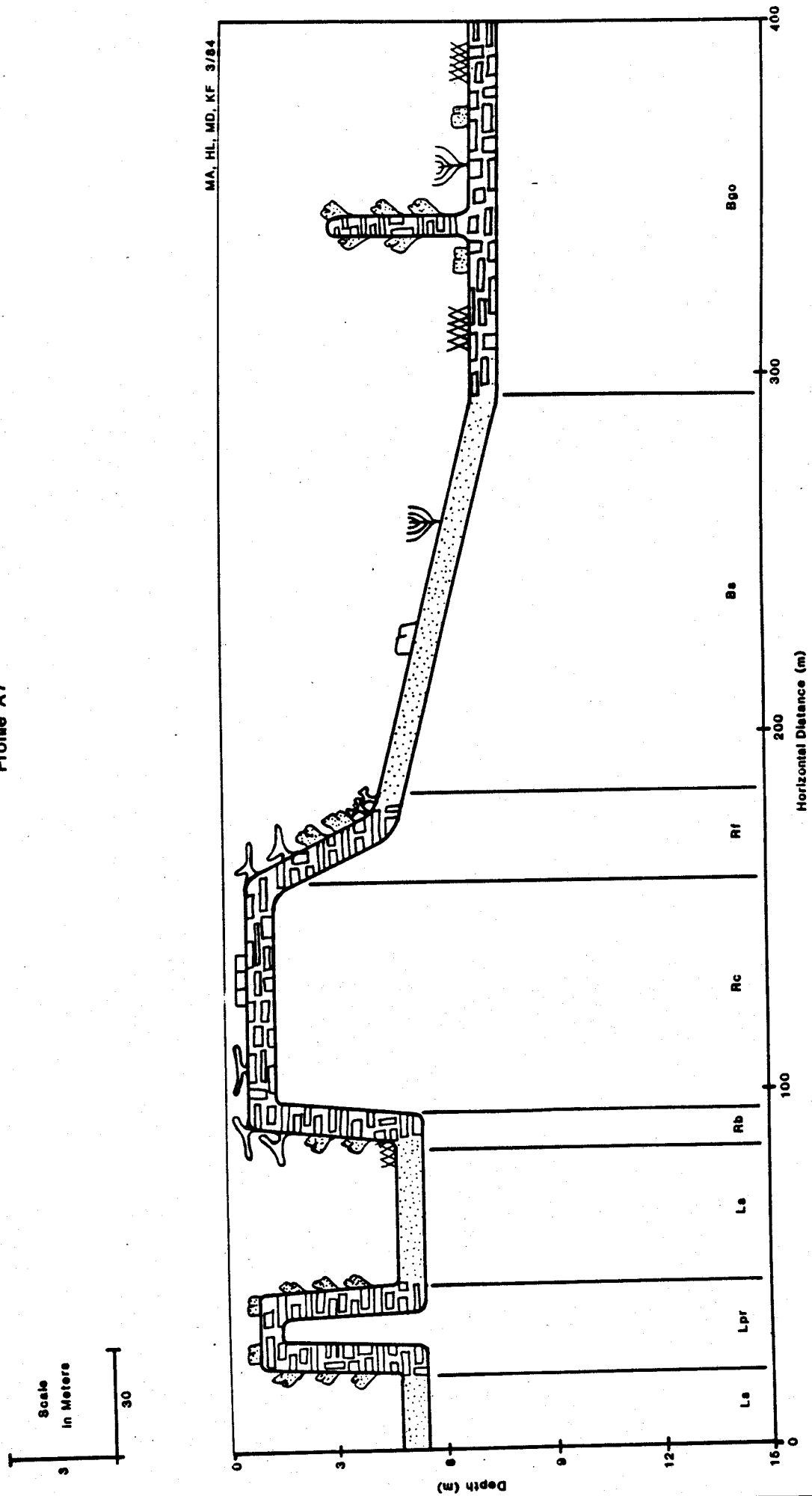
Profile A6



MA, HL, KF 3/84



Profile A7



Data from transects A1 - A7

50



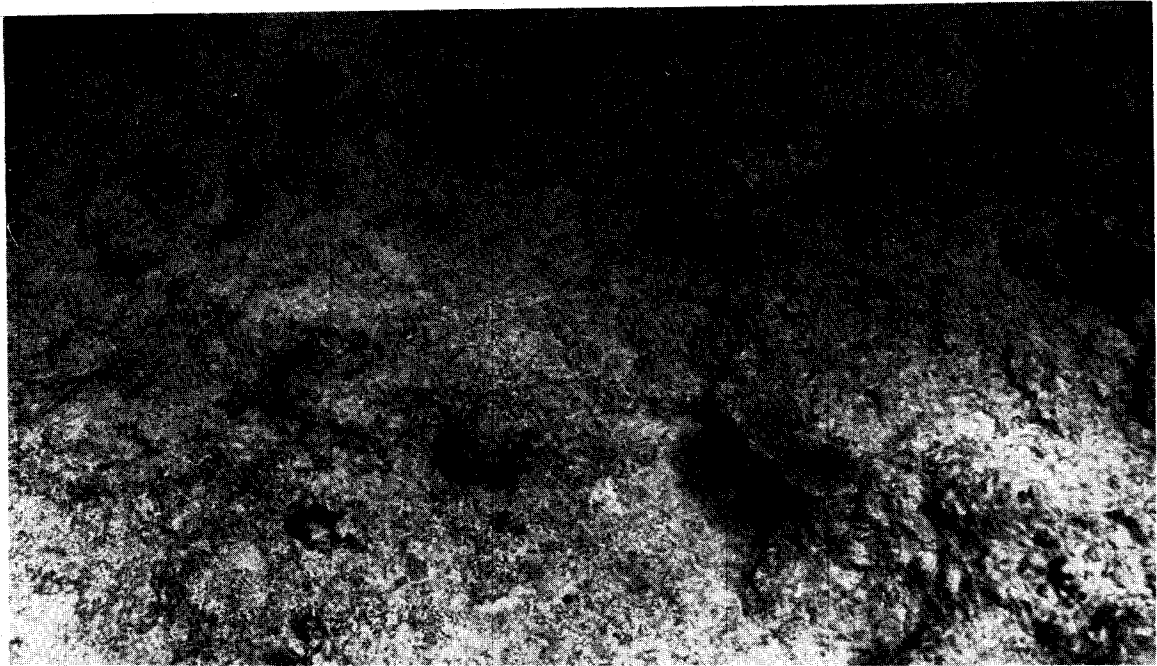
A1-a



A1-b

Plate A1-a,b Anegada Site 1

A1-a,b: Reef pavement



A2-a



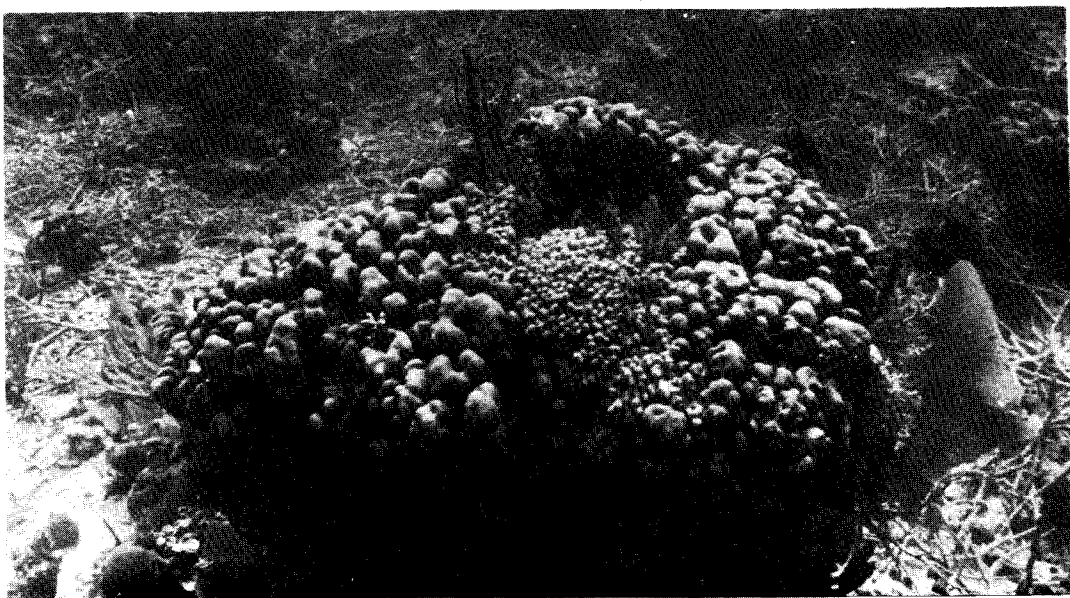
A2-b

Plate A2-a,b Anegada Site 2

A2-a,b: Reef pavement



A2-c



A2-d

Plate A2 -c,d Anegada Site 2

A2-c: Upper foreereef, A2-d: Gorgonian coral flat



A3-a



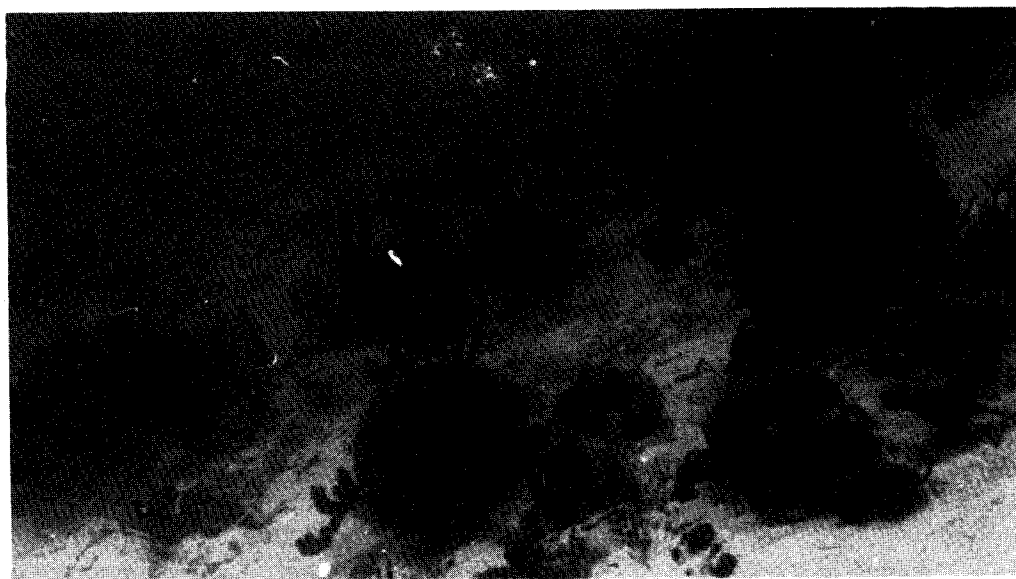
A3-b

Plate A3-a,b Anegada Site 3

A3-a: Backreef, A3-b: Upper forereef



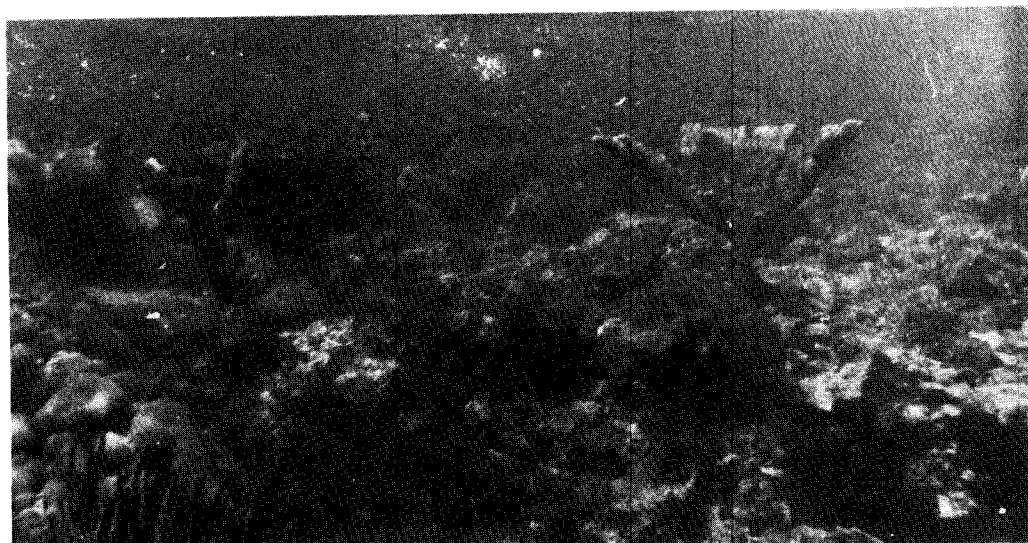
A3-c



A3-d

Plate A3-c,d. Anegada Site 3

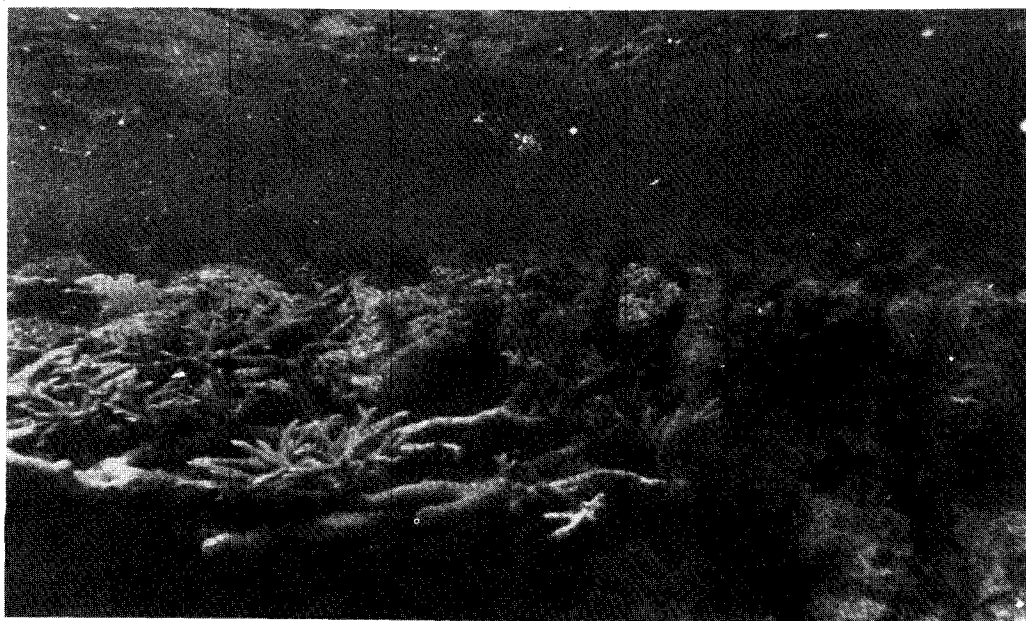
A3-c: Upper foreereef, A3-d: Lower foreereef



A4-a



A4-b



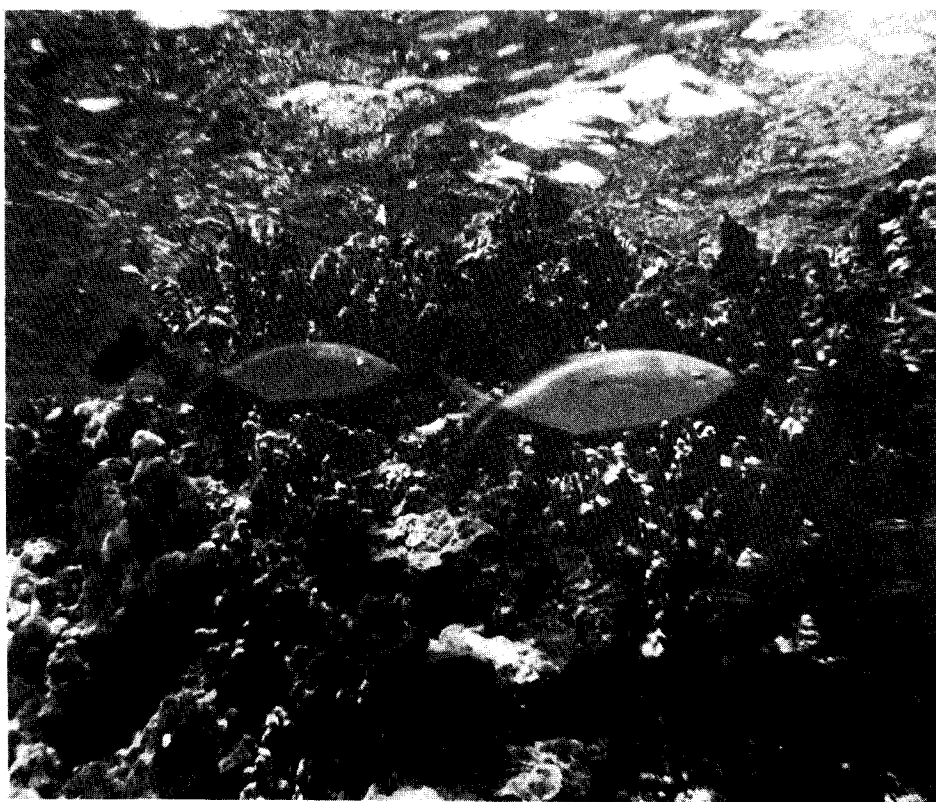
A4-c

Plate A4-a,b,c (West) Anegada Site 4 West

A4-a: Reef pavement, A4-b: Reef crest, A4-c: Foreereef



A4-d



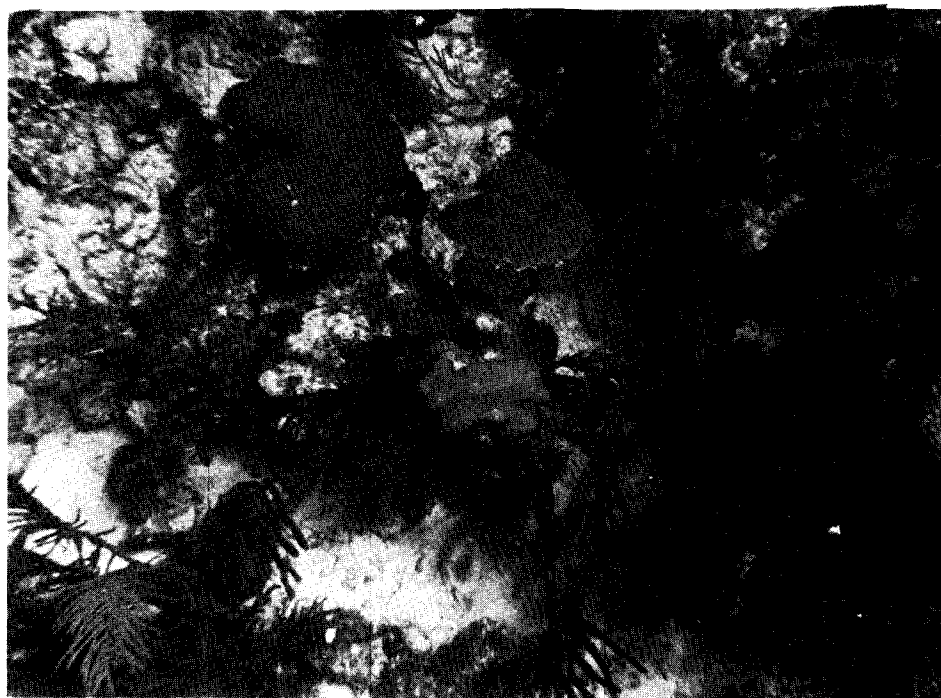
A4-e

Plate A4-d,e (East) Anegada Site 4 East

A4-d: Upper forereef, A4-e: Reef crest



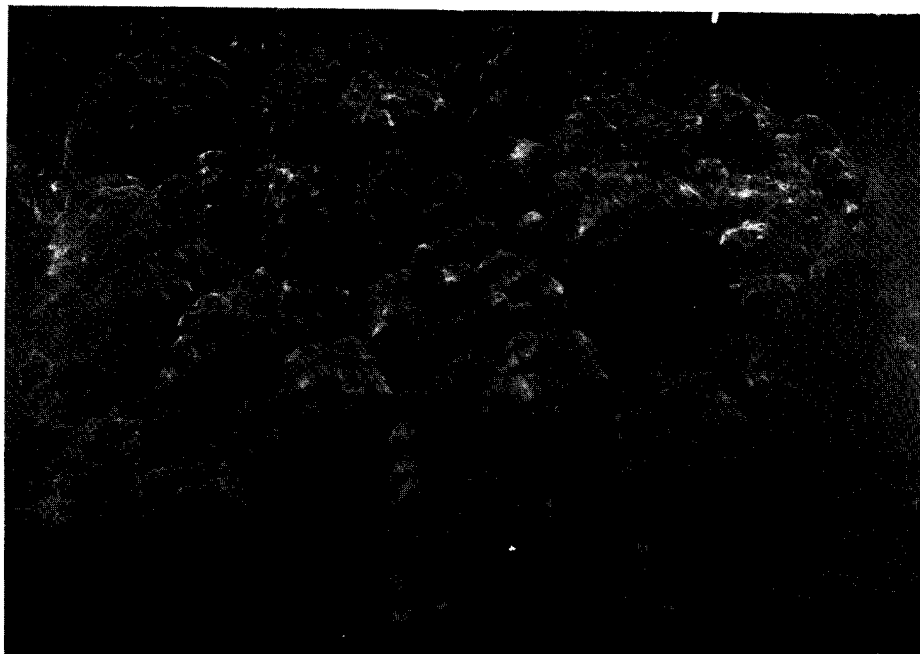
A4-f



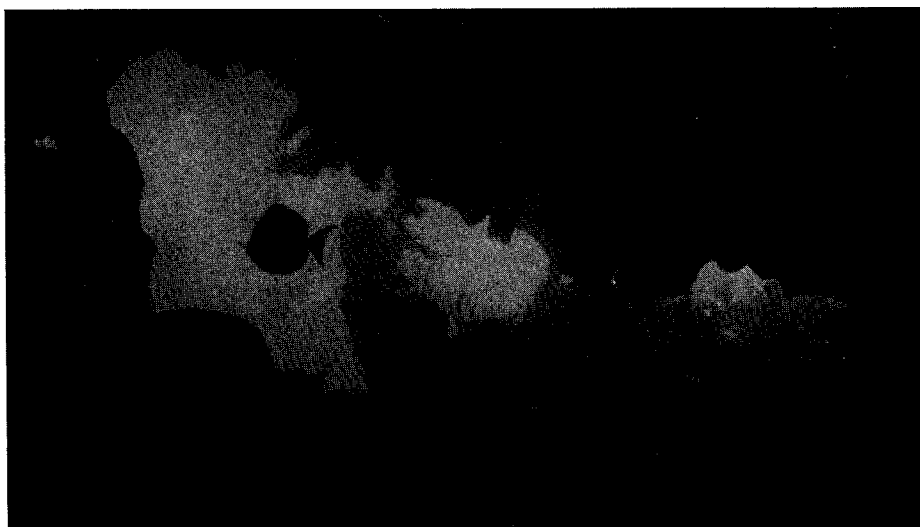
A4-g

Plate A4-f,g (East) Anegada Site4 East

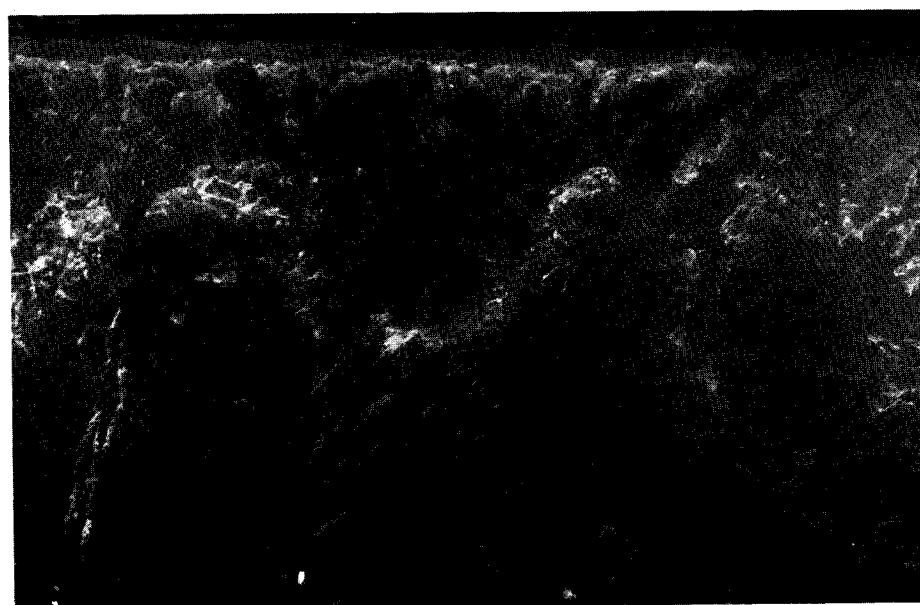
A4-f: Bank pavement, A4-g: Gorgonian coral bank



A5-a



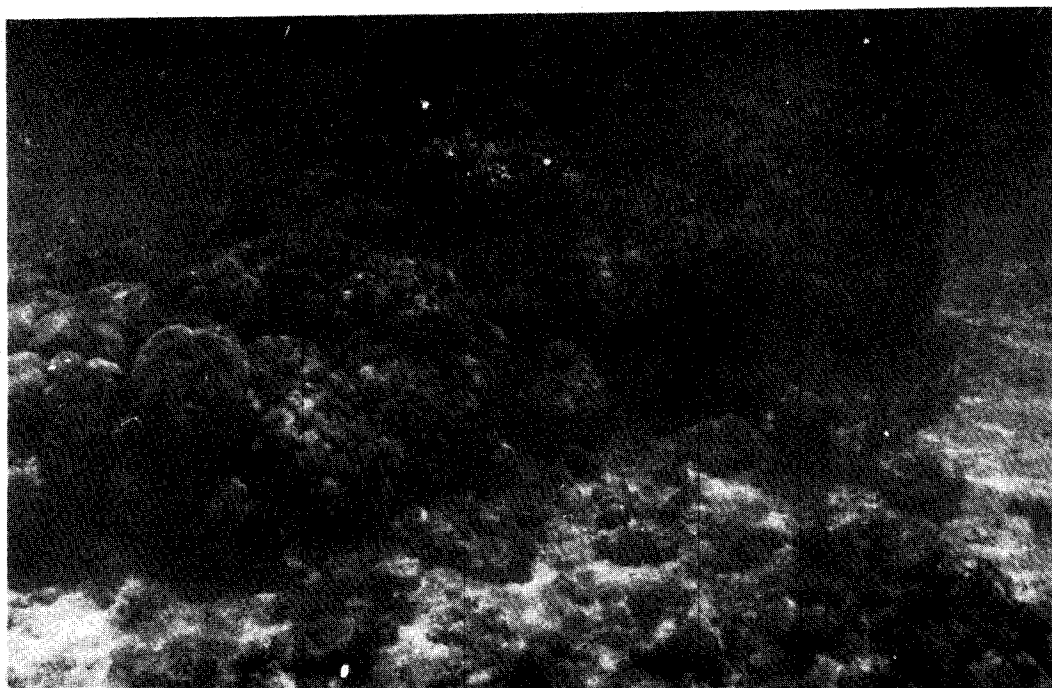
A5-b



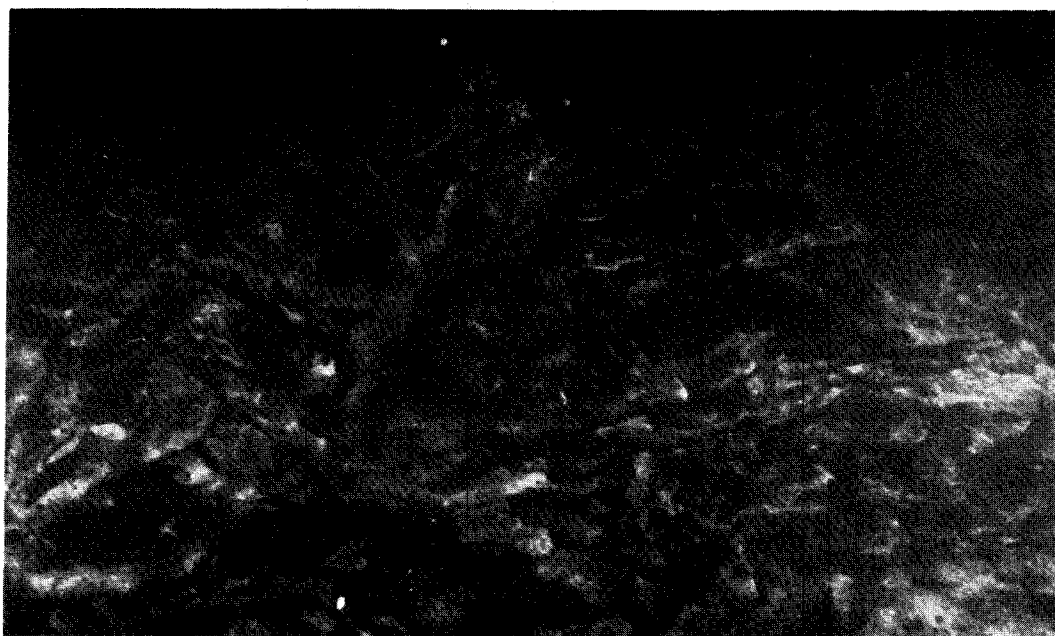
A5-c

Plate A5-a,b,c Anegada Site 5

A5-a: Backreef, A5-b: Backreef, A4-c: Forereef



A7-a



A7-b

Plate A7-a,b Anegada Site 7

A7-a: Lagoon patch reef, A7-b: Backreef



A7-c



A7-d



A7-e

Plate A7-c,d,e Anegada Site 7

A7-c: Lower forereef, A7-d,e: Gorgonian coral flat

NORTH SOUND

Introduction

The proposed marine park site at North Sound extends beyond the north coast of Virgin Gorda and includes all of the sound from the length of the east shore of Mosquito Island east to Prickly Pear and Necker Islands, and on to Eustatia Reef, ending at Pajaros Point (Fig. B). Excellent overnight anchorages, access to accommodations at the Ritter End resort of North Sound, and SCUBA diving operations attract numerous pleasure boaters to the site (cf. Lund *et al.* 1985).

Three transects were constructed at North Sound. A transect crosses the unnamed reef off of the southeast shore of Necker Island. Another transect at Mosquito Island follows an east-northeast heading from Drake's Anchorage across Colquhoun Reef. A third transect heads north-northeast from south-southwest of Eustatia Reef. This proposed marine park site has previously been surveyed in a report on the status of marine ecosystems of North Sound (Rogers *et al.*, 1982) which should be consulted when baseline data are being analysed for developing coastal marine resource management strategy.

Transect B1

Transect B1 runs southeast from the southeast tip of Necker Island and crosses the lagoon patch reefs, backreef pavement, reef crest, upper forereef, forereef pavement, and bank sand zones (Fig. B1; Profile B1; Table B).

Lagoon Patch Reefs

Patch reefs (1 - 5 m across) colonize approximately 15% of the lagoon. A moderate number of coral species contribute to the live coral cover of about 40% on the patch reefs (Table B). Dominant among these are Montastrea annularis, Porites astreoides, Acropora prolifera, and A. palmata. Sand (10% cover), coral rubble colonized by algal turf (40% cover), and gorgonians (5% cover) occur between the reefs. Zoanthus (2% cover), sponges, and coralline and foliose algae are also present.

Backreef Pavement

Greater than 90% of the backreef pavement is composed of coral rubble colonized by algal turf. Because it is in a late stage of consolidation into a uniform hardground, identifiable species of rubble are few. The pavement is bored into by Echinometra and slopes gradually from 5 m to 1 m depth.

Reef Crest

The general depth of the reef crest is less than 1 m and a substantial sand beach has developed in one area. The backreef/reef crest/forereef transition imparts a gradient in which an increasing size of coral rubble is evident. Porites porites and fragmented A. palmata, perhaps a result of storm damage (Rogers et. al., 1982), are the main identifiable rubble. Live colonies of A. palmata and encrusting patches of Diploria clivosa and P. astreoides contribute to the live coral cover of less than 5%.

At the seaward edge of the reef crest are large standing colonies of dead A. palmata. The coral rubble here is encrusted with black boring sponges.

Upper Forereef

No steep forereef exists. Stands of A. palmata and other smaller colonies of coral contribute to the live coral cover of 5%. A significant portion of the A. palmata in this zone shows evidence of white band disease (cf. Davis et al., 1985). The coral rubble here is more abundant and much larger (average 1 - 2 m length) than that in the shallower areas.

Forereef Pavement

The forereef maintains a gradual slope from 3 to 17 m depth. The pavement here is sparse, although M. annularis and live healthy stands of A. palmata are present in the shallower area. The overall live coral cover on the forereef pavement is about 10%. Patches of sand (5% cover), and expanses of pavement and coral fragments covered with algal turf (70% cover) separate the live coral colonies. Gorgonian abundance (5% cover) increases with depth.

Bank Sand

The forereef pavement joins a sand bank which extends from a depth of 17 m out to sea. A sparse algal turf community exists here.

Transect B2

Transect B2 begins at the lagoon pavement on the north end of Drake's Anchorage, Mosquito Island, and crosses from west to east over the backreef, reef crest, and forereef zones of Colquhoun Reef (Fig. B2; Profile B2; Table B).

Lagoon Pavement

The presence of live coral, dead coral, and coral rubble colonized by algal turf (25% cover) forms an irregular pavement surface. Anemones, Echinometra and black boring sponges sparsely populate the pavement. Sand patches (about 35% cover) occur. An emergent sandy shoal that has developed in the middle of the lagoon is frequented by dinghies from the boats anchored at nearby Drake's Anchorage.

A 75% dead, standing Porites divaricata and P. porites fringing reef is surrounded by a dense Thalassia bed on the north end of the lagoon (0 - 2 m depth). This reef contributes greatly to the total dead (20%) and live (10%) coral cover of the area. A small population of sea cucumbers was noted here. The coralline algae Neogoniolithon is conspicuous in this and other scattered patches of Thalassia. Virtually no seagrass is present in the anchorage; it seems the only existing seagrass beds (total cover of 10%) are in shallow areas which are unsuitable anchorage sites.

Backreef

The lagoon pavement/backreef transition is gradual. Coral rubble and live coral cover increase as the reef crest is

approached. Thickets of P. porites (10 m dia.) dominate the live coral cover of 20%. Halimeda colonizes the sandy areas at the base of the backreef.

Reef Crest

Colquhoun reef crest is ca. 30 m wide and ranges in depth from 0.5 - 1.5 m. Thickets of P. divaricata (3 m across) have a live coral cover of about 50% but these coral thickets alternate with substrate composed of coral rubble (75%) and sand (20% cover). Live corals produce a combined substrate cover of less than 5%. Very little standing dead coral exists in the center of the reef crest. Towards the forereef there are upright colonies of predominantly dead Acropora palmata. These resemble the dead stands of this coral on the reef crest/forereef interface of transect B1.

Upper Forereef

In the shallower depths (1.5 m), standing colonies of dead A. palmata contribute to the total dead coral cover of 50% on the forereef (Plate B2-a). Beginning in 2 - 3 m depth, A. palmata is again present but is nearly 100% alive (Plate B2-b). The hydrocoral Millepora is abundant throughout the area. Live coral cover averages 25% when considering both the shallower and deeper parts of the upper forereef. Gorgonians account for 5% of the substrate cover.

Forereef Pavement

Coral species diversity increases with depth on Colquhoun forereef, yet live coral cover decreases to 10% from a depth of 3

to 13 m. Montastrea annularis is the dominant coral here. Colonies of this species are large and spaced 7 - 10 m apart. The areas between the coral heads are primarily composed of sand (10%), gorgonians (25%), and other coral species (Table B).

Lower Forereef

Colquhoun lower forereef is impressive in terms of the scleractinian community composition and structure. Coral density (total live cover of 55%), diversity (see Table B2) and size are significant (Plate B2-c). Gorgonians contribute 20% to the total substrate cover.

Transect B3

The transect near Pajaros Point crosses the lagoon and Eustatia Reef in a north-northeasterly direction but does not include Eustatia Reef crest (Fig. B3; Profile B3; Table B). The portions of the reef crest emergent with fragments of Acropora palmata and scattered A. palmata rubble on the forereef are probable indications of impact from Hurricane Frederic (Rogers et. al., 1982).

Backreef Pavement

The majority of the backreef is structurally massive; Montastrea annularis, Diploria, and Siderastrea species are well represented. Acropora palmata is the dominant branching coral contributing to the live coral cover of 20%. Dead stands of A. palmata account for a large portion of the dead coral cover of 10%. Much of the substrate, colonized by algal turf (45%), is composed of fragmented A. palmata.

Upper Forereef

Toppled, fragmented, and dead A. palmata colonies are prevalent in the shallower portions (<2 m depth) of Eustatia forereef. Filamentous algae colonize some of the coral fragments and account for 75% of the substrate cover. Other coral fragments are encrusted by coralline algae. Live A. palmata, the hydrocoral Millepora, and Palythoa compose the majority of the live cover here of less than 10%. Gorgonians contribute less than 5% to the total substrate cover.

Forereef Pavement

Structurally impressive mounds (ca. 4 m by 10 m) and corresponding troughs (2 m deep) of Porites porites resemble spur and groove formation. Algal turf has colonized the sides and bases of the mounds (65% cover) and some sand has accumulated on the trough floors (5% cover). Live corals and gorgonians account for 20% and 10%, respectively, of the substrate cover on the forereef pavement.

Lower Forereef

At 6 m depth, a shift to a zone with a higher density and diversity of coral species is immediately apparent (Table B). The sizes of some coral and gorgonian species are particularly impressive; one Montastrea annularis colony 3 m tall on the upslope face measures 5 m on the downslope side, and a Gorgonia 2 m in diameter was noted. Live coral cover reaches 50% and the habitat complexity is maximum. At ca. 17 m depth the sloping forereef meets a sparsely populated, flat sand bank.

Summary

A great range of marine environments is encountered within the boundaries of the proposed park site at North Sound. Very fine silty mud comprises the floor of the sound at the Bitter End anchorage, and a gradient of other sand size substrates, with or without grassbeds (mostly without, if deeper than 1 - 1.5 m), are found throughout the sound and in the outlying areas of the park site. Extensive lagoons with fringing reefs, patch reefs, and pavements support diverse juvenile fish populations at Colquhoun Reef and, although less so, at Necker Island and Eustatia Reef. Shallow reefs within the survey, some with extensive hurricane damage, have forereef communities of varying complexities. All in all, this area provides an array of very diverse environments to be observed, and hopefully preserved.

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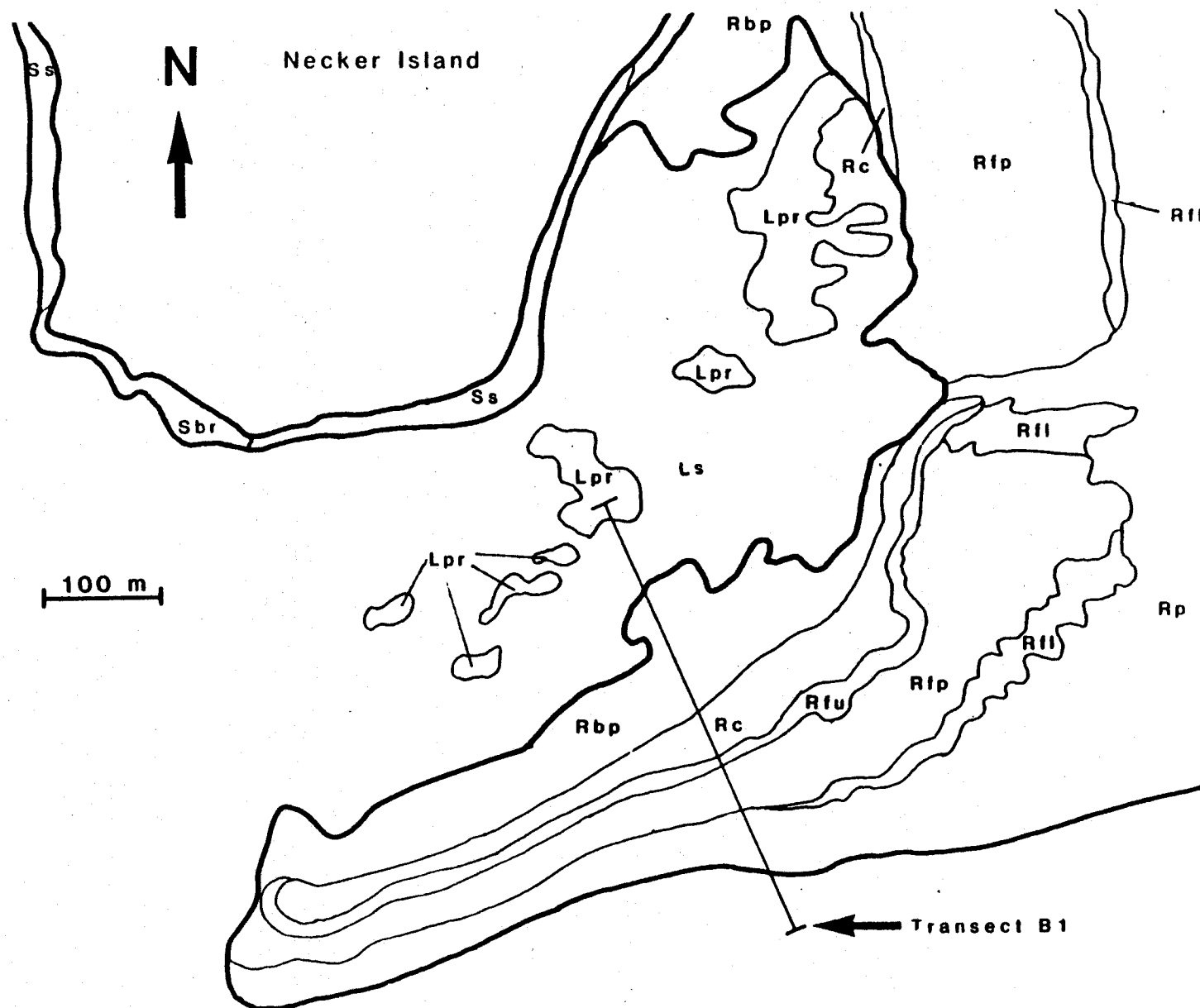


Figure B1

Location of transect B1 at Necker Island

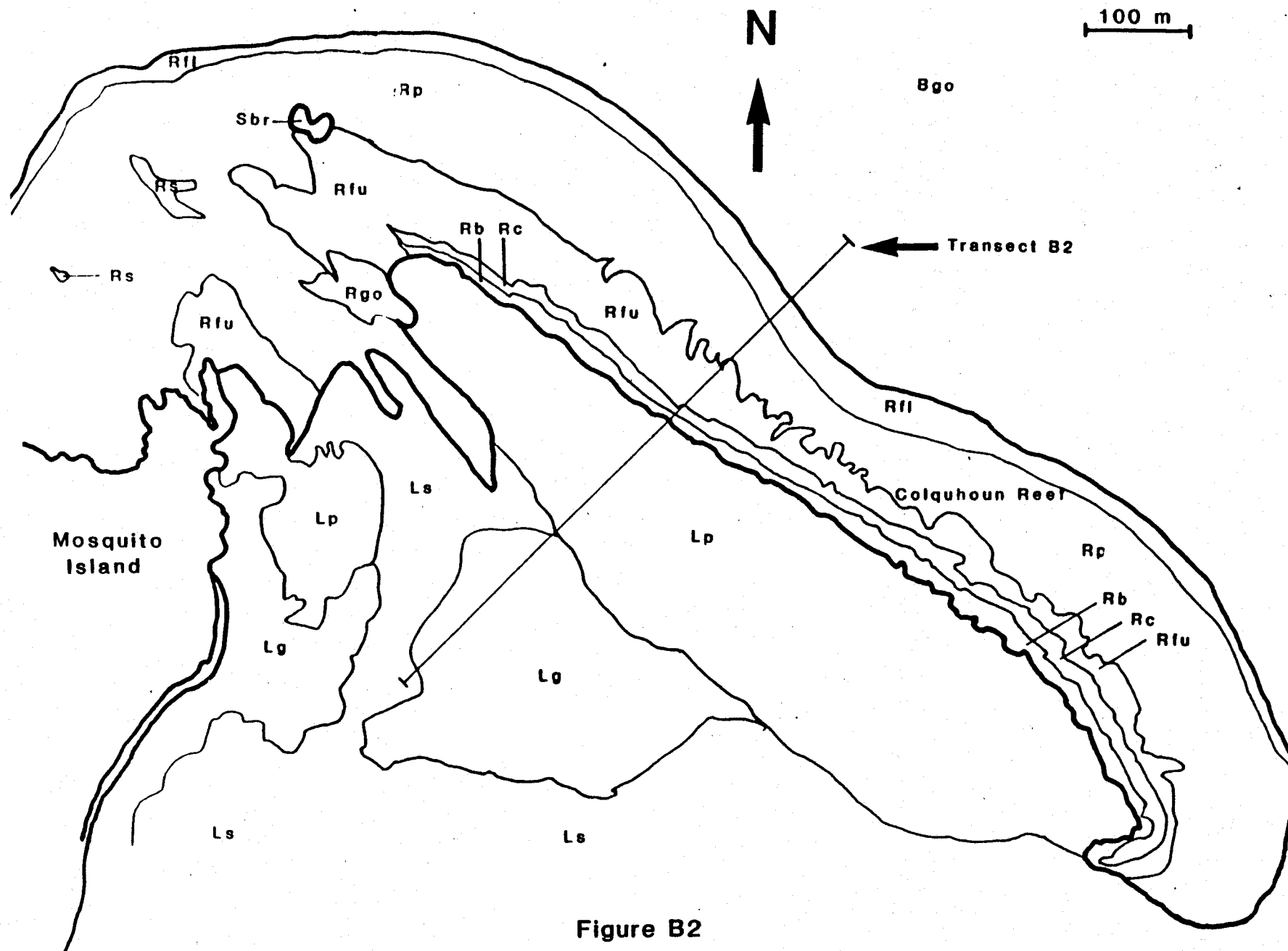


Figure B2

Location of transect B2 at Mosquito Island

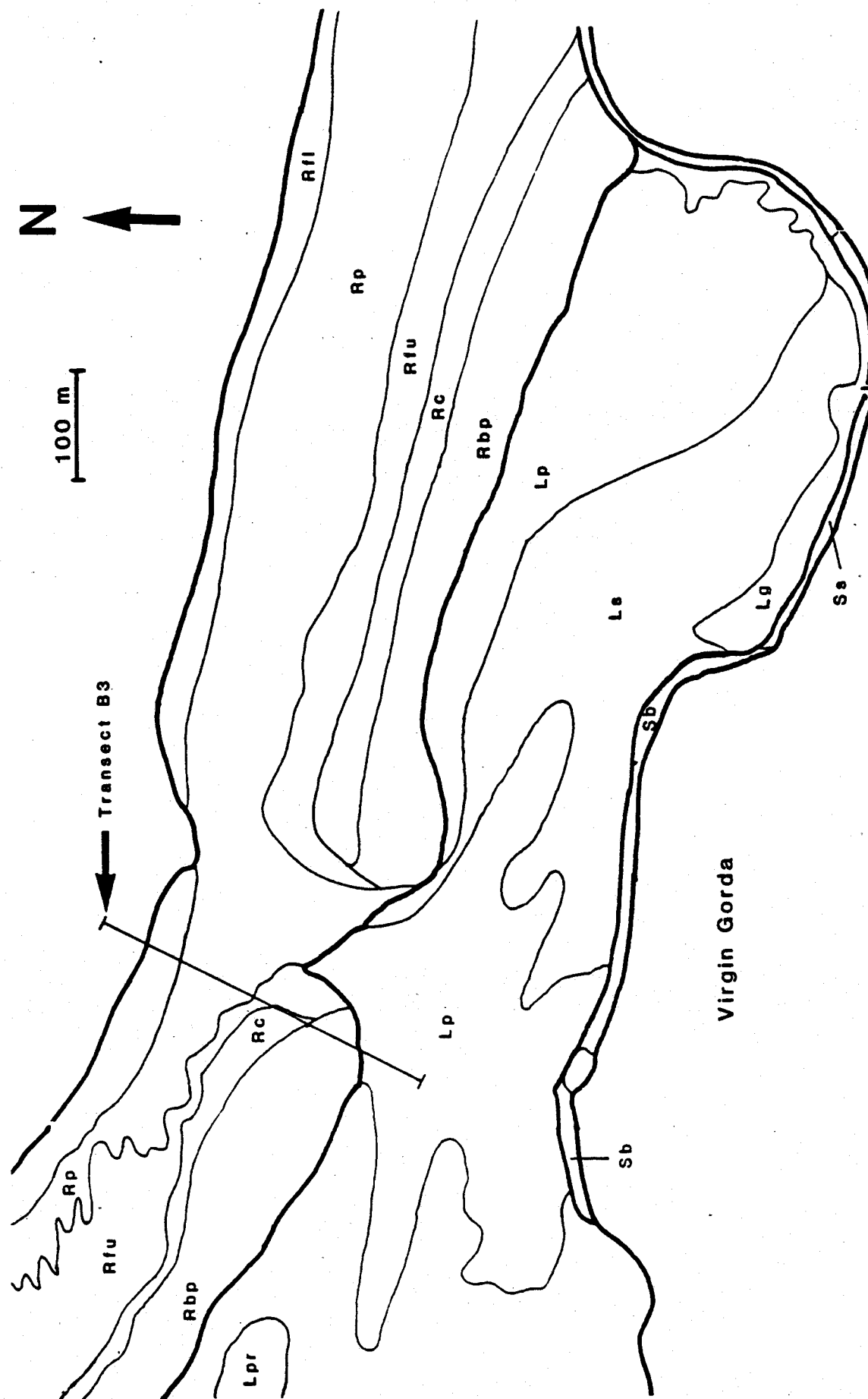
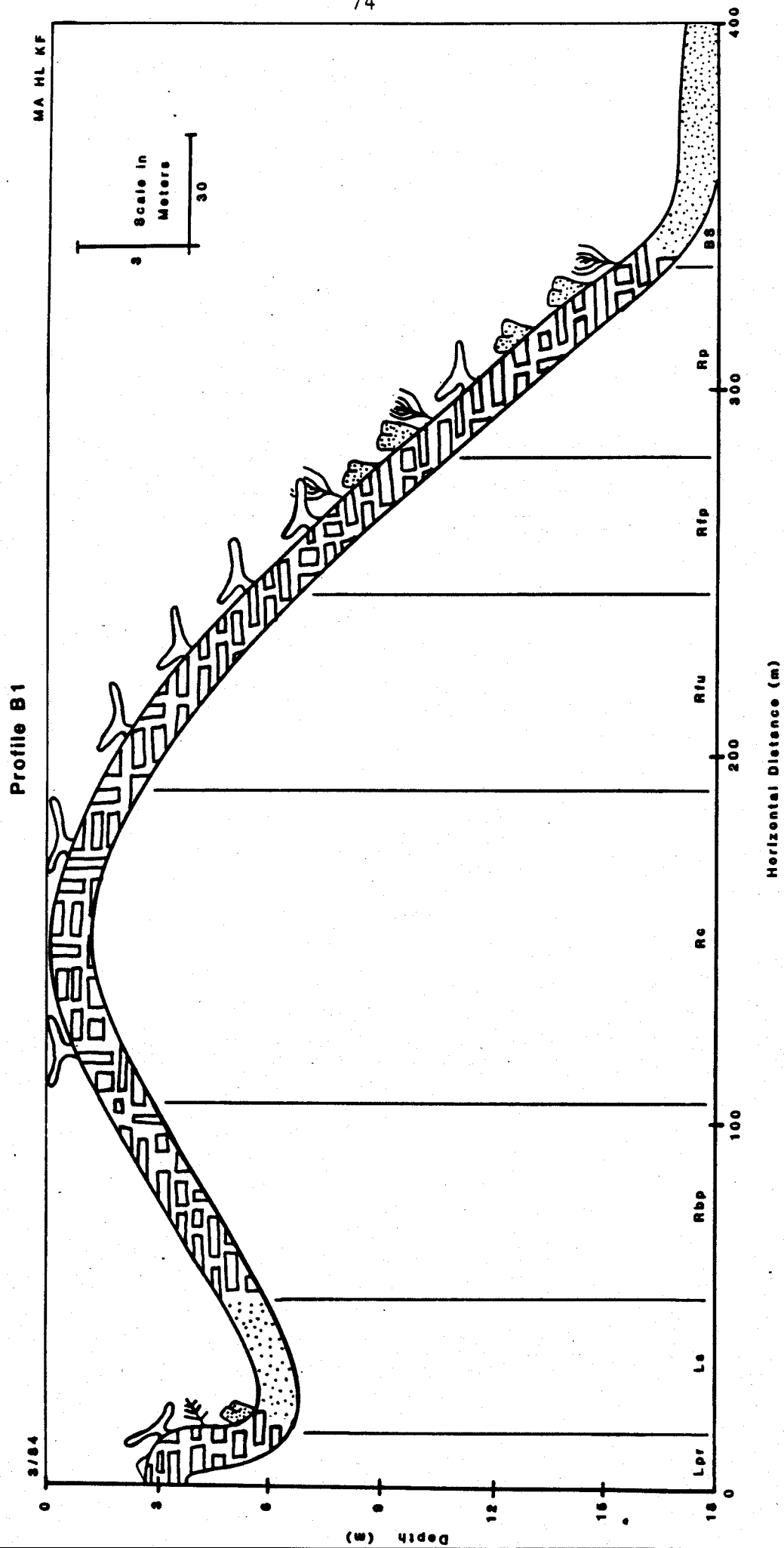
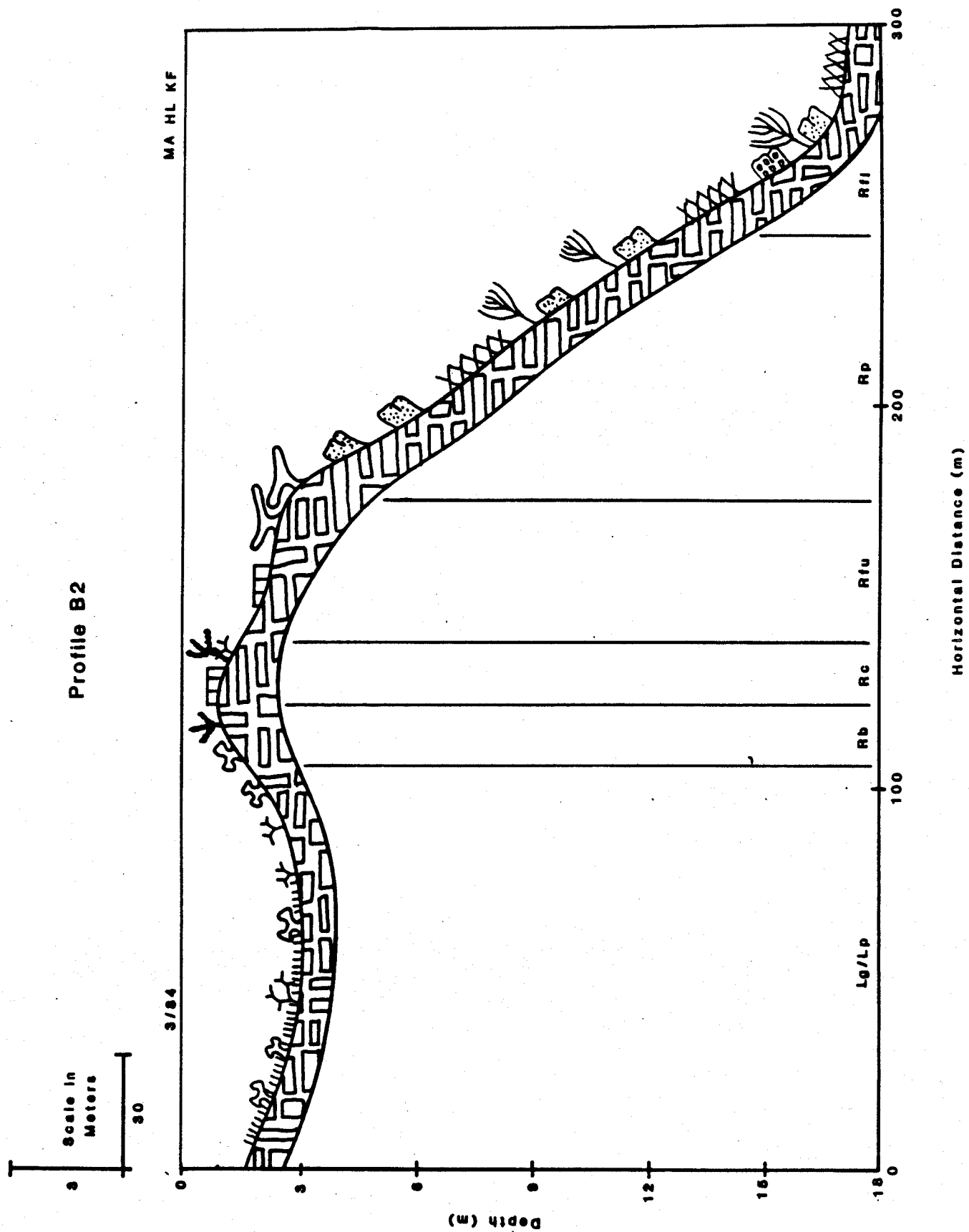


Figure B3

Location of transect B3 at Eustasia Reef in North Sound





Profile B3

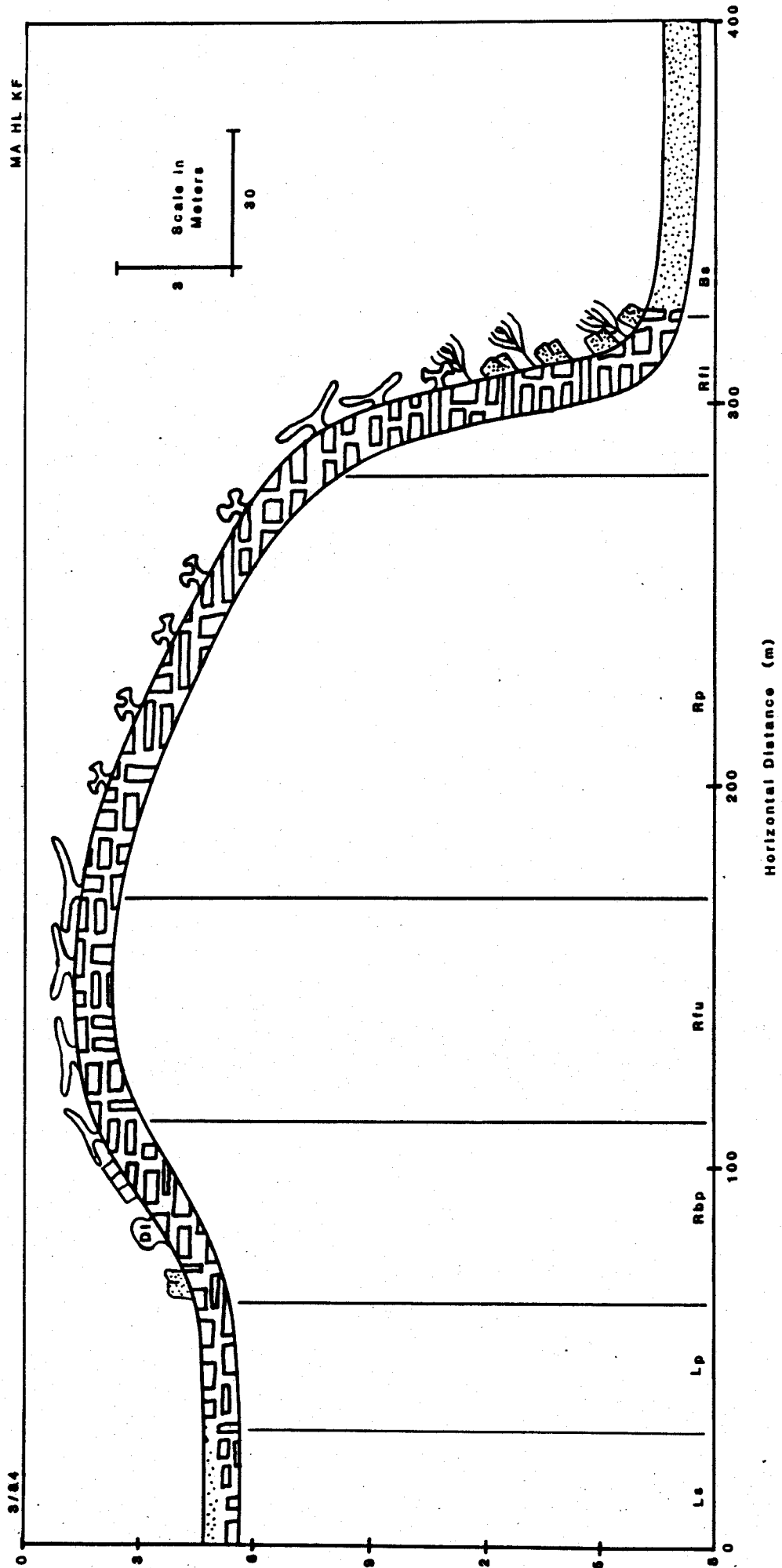


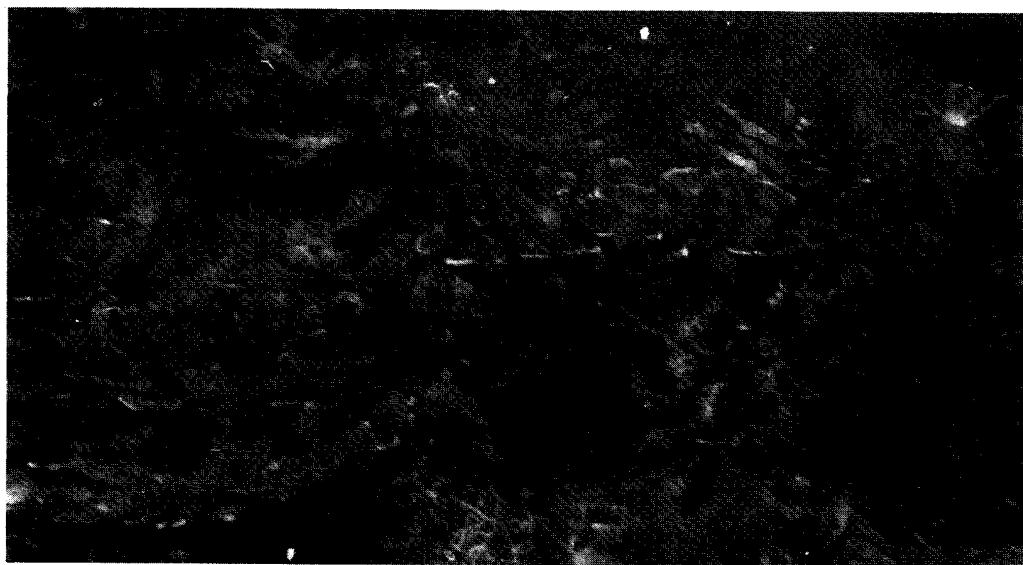
Table 8

Data from transects B1 - B3

Site		B1						B2						B3							
Zone		Lpr	Rbp	Rc	Rfu	Rfp	Bs	Lp	Rb	Rc	Rfu	Rfp	Rfl	Ls	Lp	Rbp	Rfu	Rfp	Rfl	Bs	
Depth Range		5	5-	1-	1-	3-	17+	0-	2-	0.5-	1.5-	3-	13-	5	5	5-	2	2-	6-	17+	
(m)		1	0	3	17			2	0.5	1.5	3	13	17			2	6	17			
HARD CORALL	Acer			+		+					+	+	+	+	+	+				+	
	Apal	*	+	*	*	*	*			+	*			+	+	*	*			+	
	Appro	*					+													+	
	Aga	+				+							+	+						+	
	Col					+	+					+	+	+							
	Den													+							
	Dic													+	+						
	Dcli		-	+	+	+	+					+	+	+		+					
	Dlab	+				+	+		+		+	+	+	+		*				+	
	Dstr	+	+			+	+		+		+	+	+	+		+				+	
	Eus																			+	
	Fav	+	+			+										+				+	
	Hel												+	+							
	Isas													+							
	Iso													+	+						
	Mdec	+									+	+	+	+							
	Mea	+											+	+						+	
	Mil	+			+	+	+		+	*	*	*	+	+		*	+			+	
	Mann	*				+	*		+			+	*	*	+	+	*				*
	Mcasv	+												+	+						+
	Mus	+												+	+						+
	Myc	+												+	+						
	Past	*	+	*		+	*				+								+		
	Pdiv								*		*									+	
	Ppor	+	+	*			*		*	*	+				+	+	+		*	*	*
	Srad	+								+							+				
	Ssid	+				+								+			+				+
	Tub													+							
TOTAL # SPP.		17	6	6	11	11		2	6	5	9	16	17	4	4	11	2	2	15		
GORGONIAN	Bri	+			+	+		+				+		+	+		+	+			
	Erv												+								
	Eun																	+	+		
	Gor	+			+	+		+			+	+	+	+	+	+		+	+		
	Mur				+	+												+	+		
	Ple											+	+			+		+	+		
	Plxl					+					+	+	+			+					
Ptg																					
Pst					+						+	+	+						+		
Psl																					
TOTAL # SPP.		2			3	5					3	5	5	2	2	3	1	5	5		
COVER	% HC	40	10	5	5	10		10	18	5	25	10	55	2	10	20	10	20	50		
	% Go	5			5	5			2		5	25	20	2	5	8	5	10	10		
	% Z	2		2												3	5		2		
	% G							10													
	% DC			40	50	10		20	15	5	50	15	10			10	5				
% T	41	90	53	40	70		25	35	70	15	40	10			35	45	75	65	38		
% S	12				5	100	35	30	20	5	10	5	96	50	14		5			100	
Habitat Complexity		3	1	3	4	3	1	2	3	2	5	3	4	1	1	4	3	4	5	1	
OTHER	ane							+													
	Eci		+					+													
	Ham	+	+						*	*											
	Neo							+													
	Pal			+																	
	Pen								+	+						+	+		+		
	spg	+		+				+													
Tha							*							+	+	+					
Udo								+	+												
Zoa	+									+											



B2-a



B2-b



B2-c

Plate B2-a,b,c Colquhoun Reef, Mosquito Island

B2-a,b: Upper foreereef, B2-c: Lower foreereef

THE BATHS

Introduction

The proposed marine park site at The Baths, on the southwest shore of Virgin Gorda, includes the Islands of Fallen Jerusalem, Broken Jerusalem, and Round Rock (Fig. C). The primary use is for day activities.

Three transects were established at this site. One proceeds off the shore at the white sand beach north of The Baths. Another traverses the substrate upon which most visitors to The Baths anchor and the site of a long term monitoring photo-transect (Lund et al. 1985). A third transect heads due west across a cove on the southwest shore of Fallen Jerusalem.

Transect C1

Transect C1 heads seaward from the south end of the sand beach at Valley Trunk Bay (Fig. C1, Profile C1, Table C).

Subtidal Bedrock

Bedrock boulders, the larger of which (3 - 4 m dia.) rise to within 1 m of the surface, lie on a sand substrate (5 m depth). Live corals (less than 15% cover), gorgonians (5% cover), and algal turf (80% cover) colonize the bedrock substrate (Plate C1-a). No coral species is noticeably dominant.

Reef Pavement

A sparsely populated pavement zone slopes gradually to 13 m depth. Live corals (5% cover), gorgonians (10% cover), and algal turf (75% cover) colonize the substrate (Plate C1-b).

Lower Forereef

Beginning at 13 m depth the lower forereef maintains a 20 - 30° slope to 20 m depth where it interfaces with bank sand. Live coral and gorgonian cover both increase to 15% here. Vertical relief is greater on the lower forereef than it is on the reef pavement (Plate C1-c).

Transect C2

Rounded, wave-washed boulders are interspersed with beaches of sand and form pools in the shore zone. These are the features for which the baths are named and for which they are heavily frequented (Lund et al. 1985). The transect begins in the subtidal bedrock zone, crosses the pavement where visiting boaters anchor, and terminates at the base of the lower forereef (Fig. C2, Profile C2, Table C).

Subtidal Bedrock

The sand between the boulders (58% cover) is sparsely populated by Diploria strigosa, D. clivosa, Porites astreoides, Montastrea annularis, and gorgonian colonies. Coral rubble, bedrock cobble, relatively small boulders, and some litter occur here also.

The bedrock boulders (5 m across) rise ca. 3 to 5.5 m from 7 m depth and less. Coral and gorgonian colonization is prolific on the sides of the boulders and relatively sparse on the tops. Algal turf (10% cover) is present on surfaces not covered by corals or gorgonians and it was noted that little biomass occurs in the crevices between the rocks. Included in

the live coral cover (20%) and gorgonian cover (10%) here are the communities colonizing the sand substrate. The boulders occur as far as 30 m from the shore.

Reef Pavement

The pavement that occurs from 7 m to 13 m depth is the hard ground anchorage used by the majority of the visiting boaters. Note was made of garbage, overturned coral heads, and anchor dragging scars. The 12 coral species identified colonize the hard substrate, and yet account for less than 2% of the pavement surface (Table C). Gorgonian cover also accumulates to less than 2%. The long term monitoring photoquadrat of hard ground anchorage was done in this zone (Lund et al. 1985).

Lower Forereef

The lower forereef slopes at 20° from 13 m to 17 m depth. Coral and gorgonian cover increase to 20% and 10%, respectively, in this zone and coral rubble colonized by algal turf contributes 60% to the total substrate cover. The presence of dead coral (10% cover), a few rock boulders, and litter were noted. A flat sand bank abuts the base of the lower forereef.

Transect C3

The bedrock boulders, composing Fallen Jerusalem, extend subtidally in all directions from the island. A transect proceeds due west, from the beach in a cove located on the southwest shore of Fallen Jerusalem, across subtidal bedrock and pavement (Fig. C2; Profile C3; Table C).

Subtidal Bedrock

A moderately high diversity of corals (20% cover) and gorgonians (10% cover) colonize the bedrock boulders and the seafloor (7 m depth) in this zone (Table C). Stands of Acropora palmata, many capping the larger boulders, and Montastrea annularis are the dominant corals here. The substrate in the center of the cove is sand (25%), a single channel of which extends seaward.

Reef Pavement

Boulders do not occur beyond 7 m depth, where a flat expanse of sparse pavement slopes gradually to 17 m depth. Coral covers 15% of the substrate and gorgonians 30% at the deeper pavement edge. Orange sponge encrusts some pavement areas.

Summary

One of the most frequented sites for cruising in the British Virgin Islands, the beautiful sandy beaches and large wave-washed boulders and bathing pools of The Baths serve as a strong attraction for day use tourists. Impact from human use in the area is evident in the scattered litter and minimal live coral growth in the heavily travelled hard ground anchorage. The biological communities in outlying areas of the proposed park site, however, appear to be less stressed and flourish virtually untouched by human presence.

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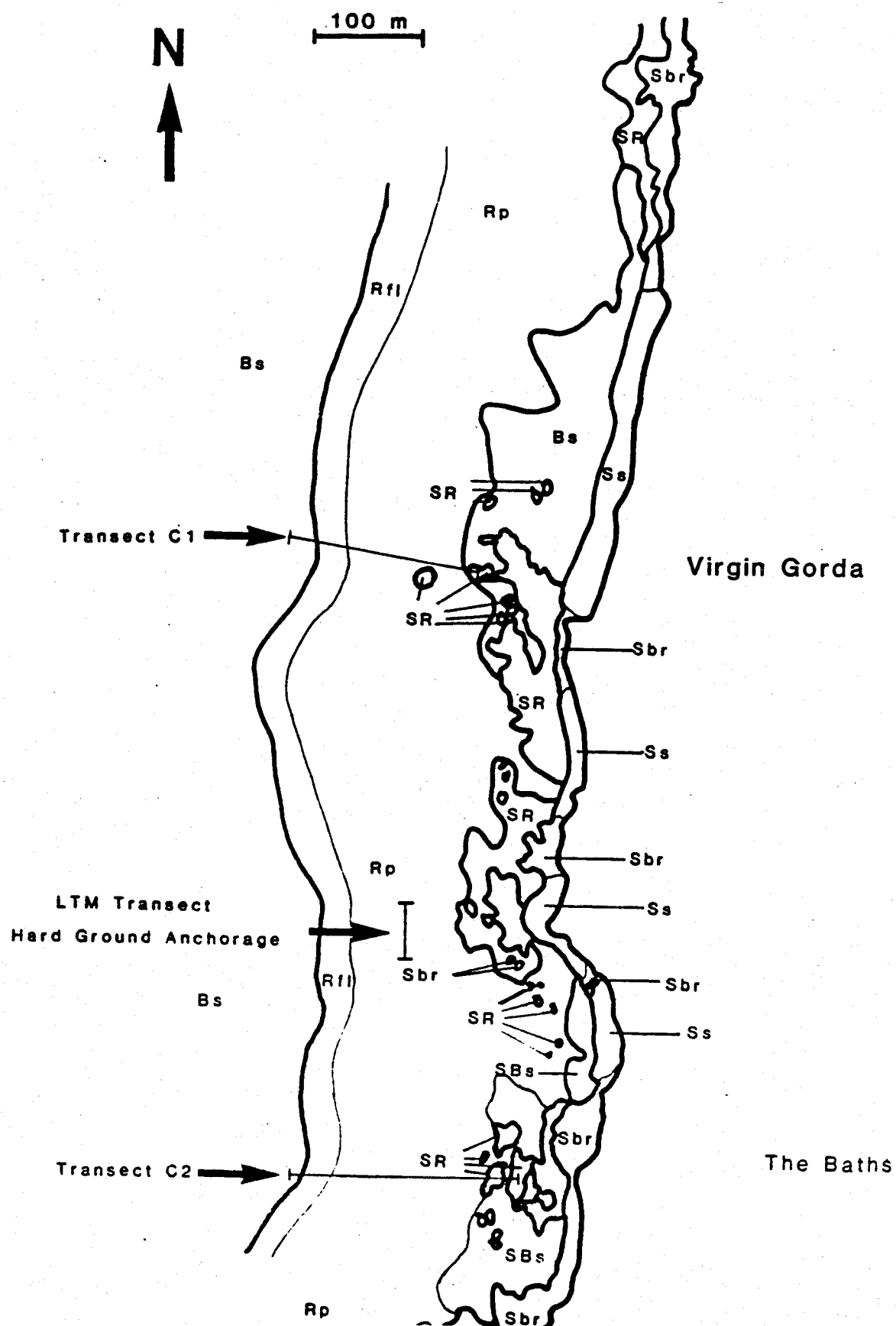
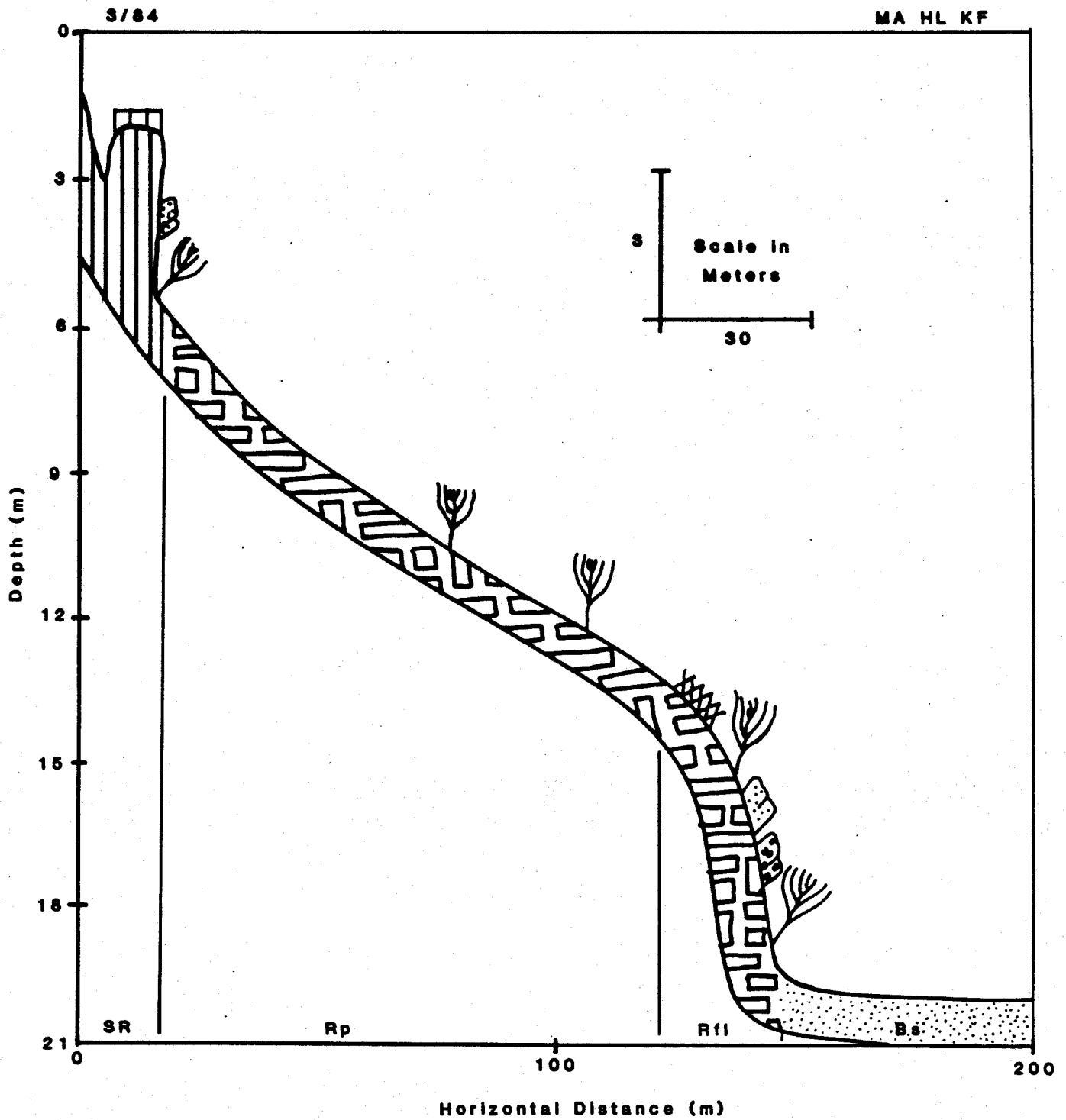
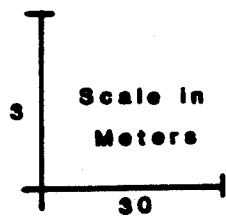


Figure C1

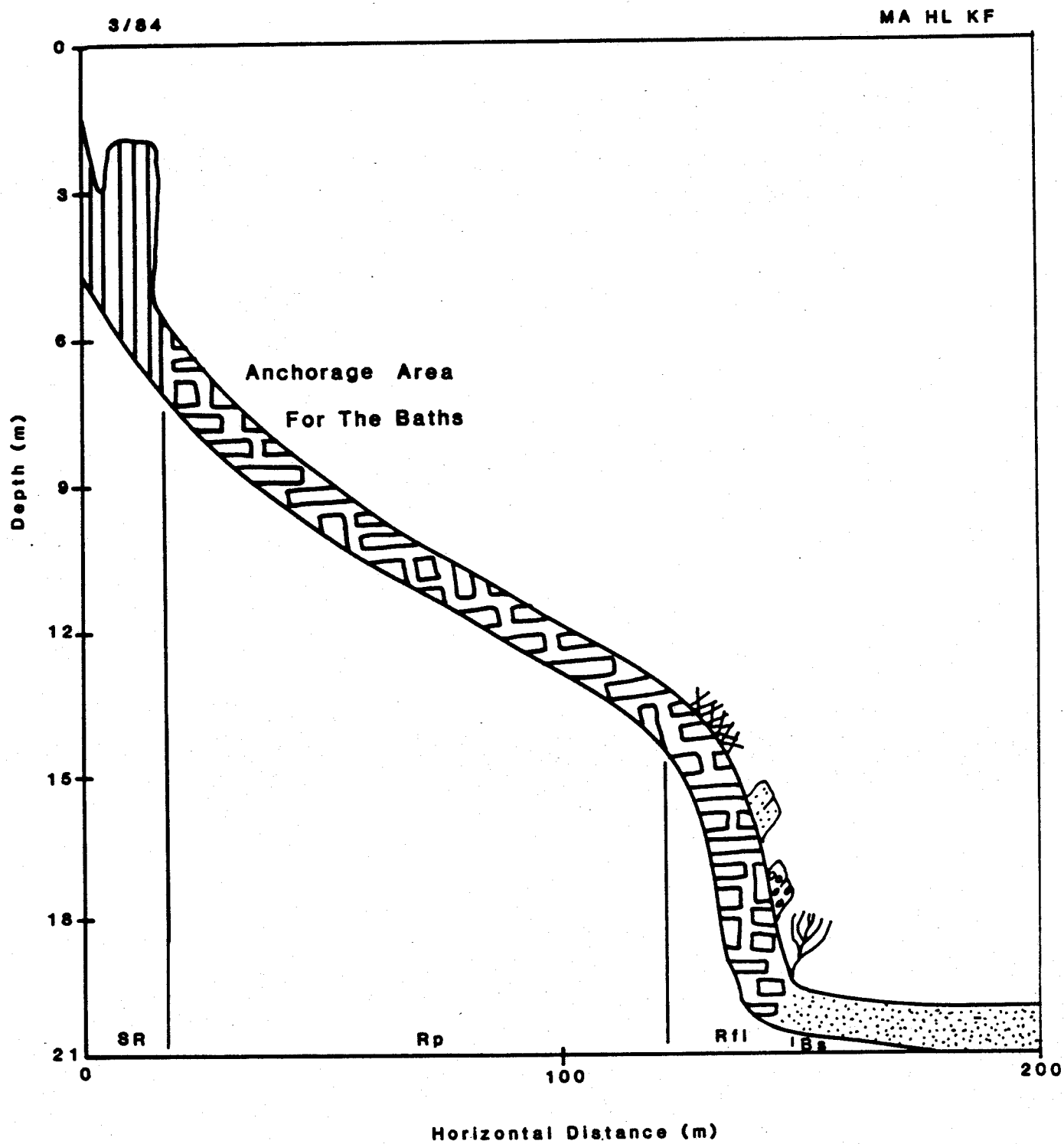
Location of transects C1 and C2 at The Baths

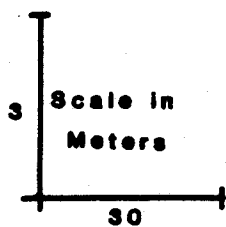
Profile C1





Profile C2





Profile C3

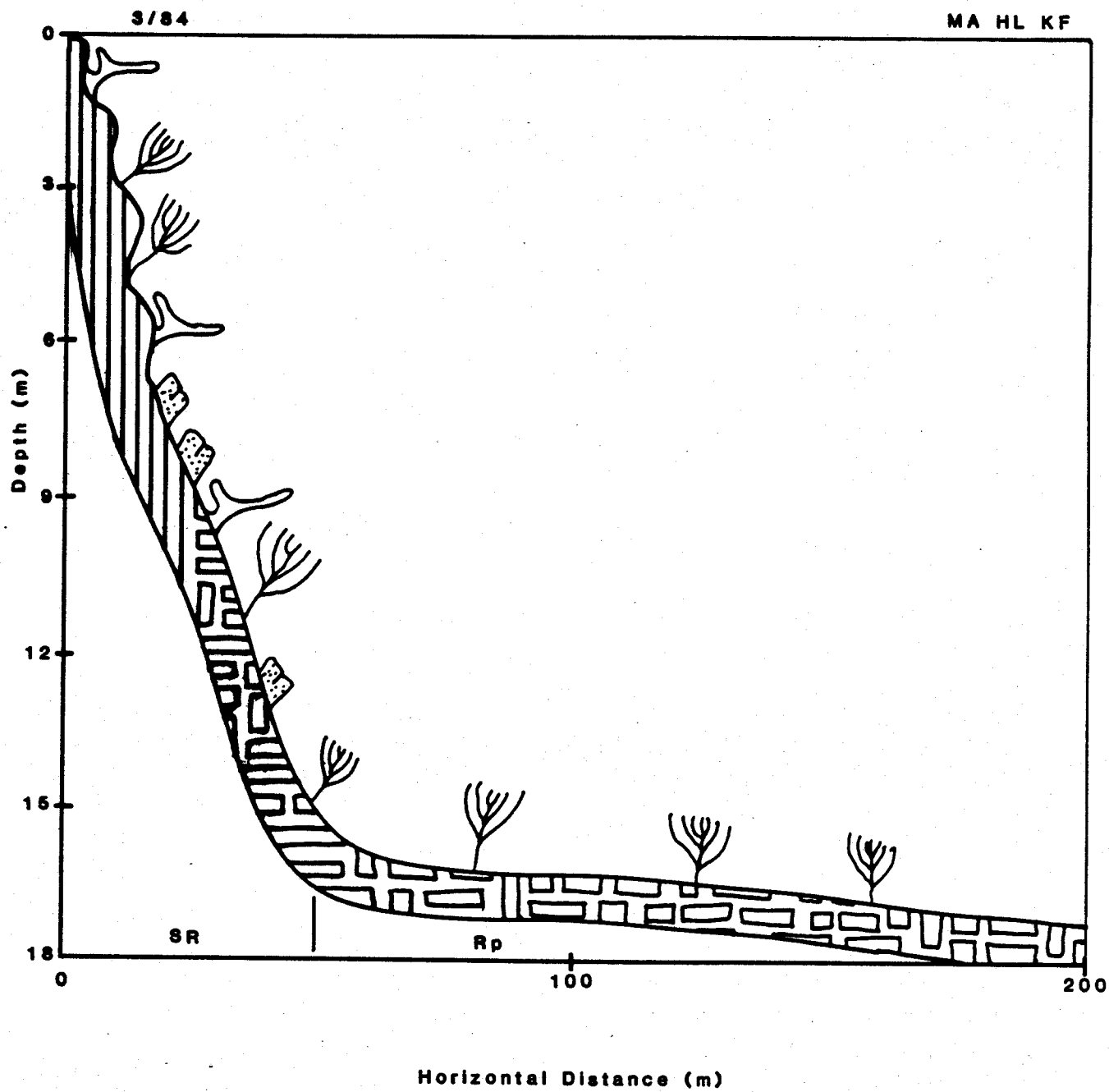


Table C

Site		C1			C2			C3	
Zone		SR	Bp	Rf1	SR	Rp	Rf1	SR	Rp
Depth Range (m)		0-5	5-13	13-20	0-7	7-13	13-17	0-7	7-17
HARD CORAL	Acer			+		+		+	+
	Apal				+			+	+
	Apro			+				+	+
	Aga					+	+	+	+
	Col		+			+	+	+	+
	Den		+						
	Dic	+	+	+		+	+	+	+
	Dcli	+			+	+		+	+
	Dlab	+	+	+	+	+	+	+	+
	Dstr	+	+	+	+				
	Fav	+	+			+		+	+
	Iso			+		+			
	Mac				+				
	Mea						+	+	+
	Mil	+			+	+		+	+
	Mann	+	+	+	+	+	+	+	+
	Mcav			+	+		+	+	+
	Mus			+				+	+
	Myc			+			+		
	Past		+	+			+		
	Ppor				+	+		+	+
	Srad	+	+		+		+	+	+
	Ssid	+	+	+	+	+		+	+
TOTAL # SPP.		9	10	13	12	12	10	17	17
GORGONIAN	Bri	+							
	Erv		+						
	Eun	+	+	+		+	+	+	+
	Gor	+	+	+	+	+	+	+	+
	Mur						+	+	+
	Ple	+		+	+		+	+	+
	Plxl					+			
	Ptg								
	Pst		+	+	+	+	+	+	+
	Ps1		+	+					
TOTAL # SPP.		4	5	5	3	4	5	5	5
COVER	% HC	15	5	15	20	2	20	20	15
	% Go	5	10	15	10	2	10	10	30
	% Z				2			2	
	% DC		10	10		5	10		
	% T	80	75	60	10	86	60	44	45
	% S				58	5		24	10
Habitat Complexity		2	1	2	2	1	2	2	2
OTHER									
	Eci				+				
	Pal				+			+	
	spg				+		+		+
EISMS	Zoa							+	

Data from transects C1 - C3



C1-a



C1-b



C1-c

Plate C1-a,b,c The Baths

C1-a: Shore Bedrock C1-b: Bank pavement, C1-c Lower forereef

SALT ISLAND, THE RMS RHONE, AND DEAD CHEST ISLAND

Introduction

The proposed marine park site at Salt Island extends from Groupers Nest, the northeast tip of the island, west along the north coast and south to the wreck of the RMS Rhone. The park boundary extends westward, across Salt Island Passage, to include the entire Island of Dead Chest (Fig. D). Five transects were established within this site.

The small Island of Dead Chest (34 acres) has a predominantly rocky coastline with rocky intertidal areas. The northwest side of the island, bordered by cobble beaches, is the site of transect D1 (Fig. D1). The offshore region here is characterized by a primarily sandy substrate which interfaces with bank pavement.

A fringing reef on the north shore of Dead Chest Island has a lower forereef which connects with bank pavement. A large outcropping of bedrock on the seaward edge of the bank pavement supports another reef and forereef area. Transect D2 was established here (Fig. D1).

A narrow finger of emergent bedrock, extending from the southeast tip of Dead Chest, partially protects the southern side of the island from prevailing seas (Fig. D1). A fringing reef forms a small lagoon at the base of the bedrock finger and the entire sea floor between the southeast and southwest tips of the island is a flat sparse pavement with bedrock boulders. This is the site of transect D3 (Fig. D1).

Our research sites on Salt Island include the north side of the island from Groupers Nest to Man Head, Salt Island Bay and Lee Bay (Figs. D2, D3).

The rocky shore line from Groupers Nest to Man Head is partially exposed to prevailing winds. Offshore, the majority of the sand substrate is densely populated by seagrass.

A cobble beach separates the rocky headlands delineating Lee Bay, the site of transect D4 (Fig. D3). Seaward of the cobble beach a pavement zone interfaces with a dense seagrass bed. The point on the south side of the bay is the location of the famed wreck of the RMS Rhone and is visited by as many as 100 divers a day (Putney, pers. comm).

The rocky headland separating Lee Bay and Salt Island Bay extends offshore to where a small fringing reef has developed beyond which the substrate is a combination of sparsely populated bedrock and pavement.

Transect D5 is located 0.5 km southwest of Man Head in Salt Island Bay (Fig. D2). The predominantly sand substrate in the bay supports a dense population of seagrass. To the southwest of Man Head the shore and intertidal areas are rocky. A palm tree lined sandy beach occupies the southernmost part of the bay. A small landing dock accommodates dinghy traffic and there is a fishing village on shore here.

DEAD CHEST ISLAND

Transect D1

The small cove on the northwest side of Dead Chest Island, the site of transect D1, provides the only moderately sheltered

anchorage on the island (Fig. D1; Profile D1; Table D).

Shore Zone

A cobble beach extends into the water and is barren except for the algal turf growing here.

Bank Sand

The cobble interfaces with a sand bank at less than 1 m depth. The sand (90% cover) is sparsely populated by seagrasses (i.e. Halodule), macroalgae (i.e. Halimeda), and also by a few live coral species (5% cover) of which Montastrea annularis is dominant. Coral rubble colonized by algal turf (5% cover) is present. The sand bank extends seaward to 3 m depth.

Bank Pavement

Bedrock pavement begins at 3 m depth and, along with a single channel of sand, extends seaward to 10 m depth. Live coral density increases with distance from shore and averages, in this zone, to 25% cover. Acropora palmata, M. annularis, and the hydrocoral Millepora are dominant. Gorgonians account for 5% of the live cover. Algal turf and sand contribute 60% and 10% respectively to the total substrate cover.

Transect D2

Bedrock boulders and solid bedrock compose a major portion of the north coast of Dead Chest Island. A fringing reef (ca. 3 m width) is present at the shore, beyond which lies a strip of pavement extending to 3 m depth. The outer edge of the pavement

drops abruptly to 5 m depth and is severely undercut forming a ledge which is too deep, in places, to see the back. Seaward of the ledge is a lower forereef, bank pavement and an offshore bedrock outcropping which is fringed by another lower forereef and topped with reef pavement (Fig. D1; Profile D2; Table D).

Shore Zone

The shore zone is a combination of bedrock boulders and cobble lying as an overburden on a solid bedrock substrate. A very small, predominantly Acropora palmata reef (1 m depth) fringes the intertidal area.

Reef Pavement

Seaward of the fringing reef, a sheet of reef pavement extends to 3 m depth. The majority of the live corals here (20% cover) are healthy and colonize the outer edge of the pavement. Large stands of A. palmata are dominant with smaller stands scattered on the shallower pavement. Some dead coral (15% cover) and gorgonians (5% cover) occur here also.

Upper Forereef

At 3 m depth the pavement drops vertically to 5 m depth forming a precipice which extends around the east side of the island. The precipice, composed of bedrock boulders cemented together, is capped with healthy A. palmata stands and is undercut at the base of the dropoff forming a deep ledge.

A. palmata dominates the live coral cover of 30%. Dead coral accounts for 50% and gorgonians are fairly abundant contributing 10% to the substrate cover.

Lower Forereef

Extending seaward from the ledge a distance of ca. 50 m, and along the base of the precipice in both directions, is a grandiose lower forereef community (Plate D2-a,b). The composition and exceptional health of coral colonies in this zone is impressive. A relatively high diversity of coral species contribute to the live coral cover of 80% (Table D).

Montastrea annularis of uncommonly large mushroom shaped colonies rise 5 m from the sea floor, have 100% local live coral cover, and are the dominant coral species in this community. Several heads of Colpophyllia up to 1.5 m across and 3 m long were noted. In the spaces where live coral is not growing, gorgonians (10% cover), small sand patches, dead coral (5% cover), and algal turf (5% cover) occur. Many ledges and caves formed by the overhanging coral heads contribute to the generation of a high habitat complexity.

Gorgonian/Coral Flat

A strip of pavement borders the seaward edge of the lower forereef at 14 m depth. The transition between the two subzones is rather abrupt and the pavement is quite representative of the pavement seen in most areas of the BVI. Gorgonians (15% cover) are a major feature in this community and live corals (15% cover) are dominated by M. annularis. Several caves are formed from ledges of eroded pavement (Plate D2-c,d).

Lower Forereef

A bedrock outcropping rises from 14 m to ca. 5 m depth at the northeast tip of the transect. The base of the outcropping is fringed by a lower forereef which extends from 14 m up to 10 m depth (Plate D2-e). The lower forereef supports a live hard coral cover of ca. 20% and is dominated by M. annularis. Isolated colonies of A. palmata are also found in this zone.

Reef Pavement

The pavement capping the bedrock outcropping is colonized by corals (15% cover) and gorgonians (10% cover). Montastrea annularis is well represented and A. palmata colonies rise nearly to the surface from the shallowest parts of the bedrock outcropping. Diploria species are also common.

Transect D3

An emergent bedrock finger extends to the south from the east edge of the rocky shore zone. A reef that fringes the shore at the middle of the shallow bay also connects with the finger of emergent bedrock at its southernmost tip. Behind the reef is a small lagoon (Fig. D1; Profile D3; Table D).

Reef Zone

The fringing reef, primarily comprised of Acropora palmata, displays a substantial healthy live coral cover of ca. 25% and represents a typical upper forereef community. The top of the reef is no deeper than 0.5 m and is emergent with the hydrocoral Millepora.

Bank Pavement

The upper forereef drops to a sparse reef pavement at 1.5 m depth and slopes gently to the southwest to ca. 10 m depth where it interfaces with sand approximately 100 m offshore. The shallower portion of the substrate is composed of 0.5 - 0.75 m high boulders cemented into place by the pavement, and is strewn with loose boulders. Fewer boulders are seen as the distance from shore increases. Live coral cover, on the other hand, increases with distance from shore (averages 15%) and is dominated by M. annularis. Gorgonians (5% cover), Diadema and Echinometra are present.

The pavement rises at a gentle grade to the east and west of the transect. All sides of the cove are bordered with bedrock outcroppings colonized by hermatypic corals. There is some spur and groove development along the outcroppings. Fragmented A. palmata branches lie in the grooves.

SALT ISLAND

Transect D4

This transect proceeds from the shore of Lee Bay on Salt Island, across an expanse of pavement, a strip of sand, and ends in a dense seagrass bed at 8 m depth (Fig. D2; Profile D4; Table D). The wreck of the RMS Rhone lies to the east of the transect.

Shore Zone

The bedrock boulder and cobble beach maintains a gentle slope offshore to 5 m depth where it interfaces with pavement.

Bank Pavement

A sparse pavement occurs from 5 - 8 m depth. The hydrocoral Millepora contributes significantly to the live coral cover of 15%. Gorgonians (5% cover) and some sponges are present. Several small patches of sand (5% cover) lay as a thin cover on the pavement.

The consolidation of coral rubble and boulders has formed ledges up to 1 m in height. These run parallel to the existing shore line and perhaps represent previous shore zones.

Bank Sand

Adjacent to and extending seaward of the pavement is a sand halo (ca. 8 m width). Virtually no corals or gorgonians colonize this zone. The sand is devoid also of seagrass and macroalgal growth.

Bank Seagrass Bed

A dense seagrass bed, composed primarily of Thalassia and Syringodium, extends seaward of the sand halo to 10 m depth. Three algal species were identified here; they contribute little to the live cover, however (Table D). Boat anchor dragging scars are clearly evident in the seagrass bed. Garbage littering the bottom is also an indication of human impact in this subzone.

Transect D5

This transect proceeds from the shore of Salt Island Bay across a dense seagrass bed, over an area of small patch reefs and ends at 20 m depth where the seagrass bed continues seaward (Fig. D3; Profile D5; Table D).

Shore Zone

Talus from the bedrock cliffs which border the shore zone has formed a rocky intertidal which extends offshore to 1.5 m depth. The hydrocoral Millepora and Porites porites are the dominant live corals (5% cover). Algal turf covers 92% of this rocky substrate and Palythoa is present with approximately 3% cover.

Shallow Bay Seagrass Bed

A narrow sand halo separates the seagrass bed from the rocky intertidal. The seagrass bed is healthy, dense, colonizes 100% of the substrate, and is dominated by Thalassia and Syringodium. The corals Manicina and Acropora cervicornis, and occasional sponges, most conspicuously Xestospongia nuta, are present. Filamentous algae, Udotea, Penicillus, and Halimeda are common.

Shallow Bay Patch Reefs

Several patch reefs (up to 10 m across) almost entirely composed of dead Porites porites occur at 12 m depth. The hydrocoral Millepora creates a very low live coral cover of 1% and gorgonians are virtually absent. Algal turf covers 99% of these predominantly dead reefs. Each reef is surrounded by a sand halo.

Beyond the patch reefs the seagrass bed resumes its robust composition as on the shoreward side. The water here is clear and at 20 m depth the view in any direction is of more seagrass.

Summary

The biological communities established in the area of the wreck of the RMS Rhone are particularly sparse. The wreck itself provides a spectacular dive. The hard corals growing on the wreck are small, though represent a variety of species. The wreck is a very popular tourist attraction and is visited by as many as 100 divers a day.

The north side of Dead Chest Island is another unusually high quality site for diving. The lower forereef is populated by a particularly rich community of hard corals. These corals are as large and healthy as was observed at any site in the BVI. Several caves with lobsters in them were seen.

One small cove on the northwest side of Dead Chest Island offers limited anchoring but is rarely used for this purpose. The south side of the island has an emergent bedrock finger which provides minimal protection of this area from prevailing open ocean conditions. The fringing reef along this bedrock outcrop creates a small lagoon and the sea floor to the south of the rest of the island is a sparse pavement.

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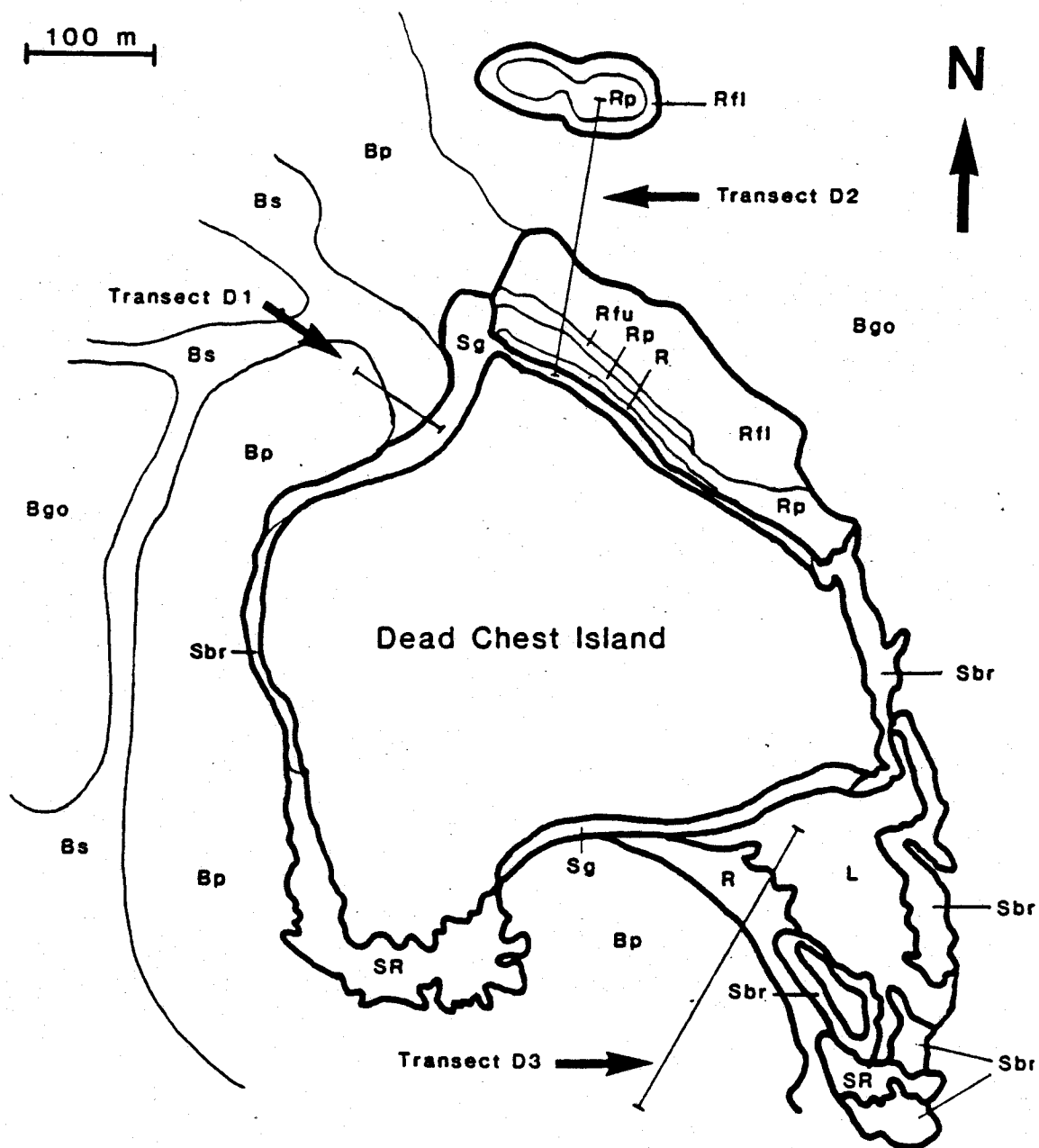


Figure D1

Location of transects D1, D2 and D3 at Dead Chest Island

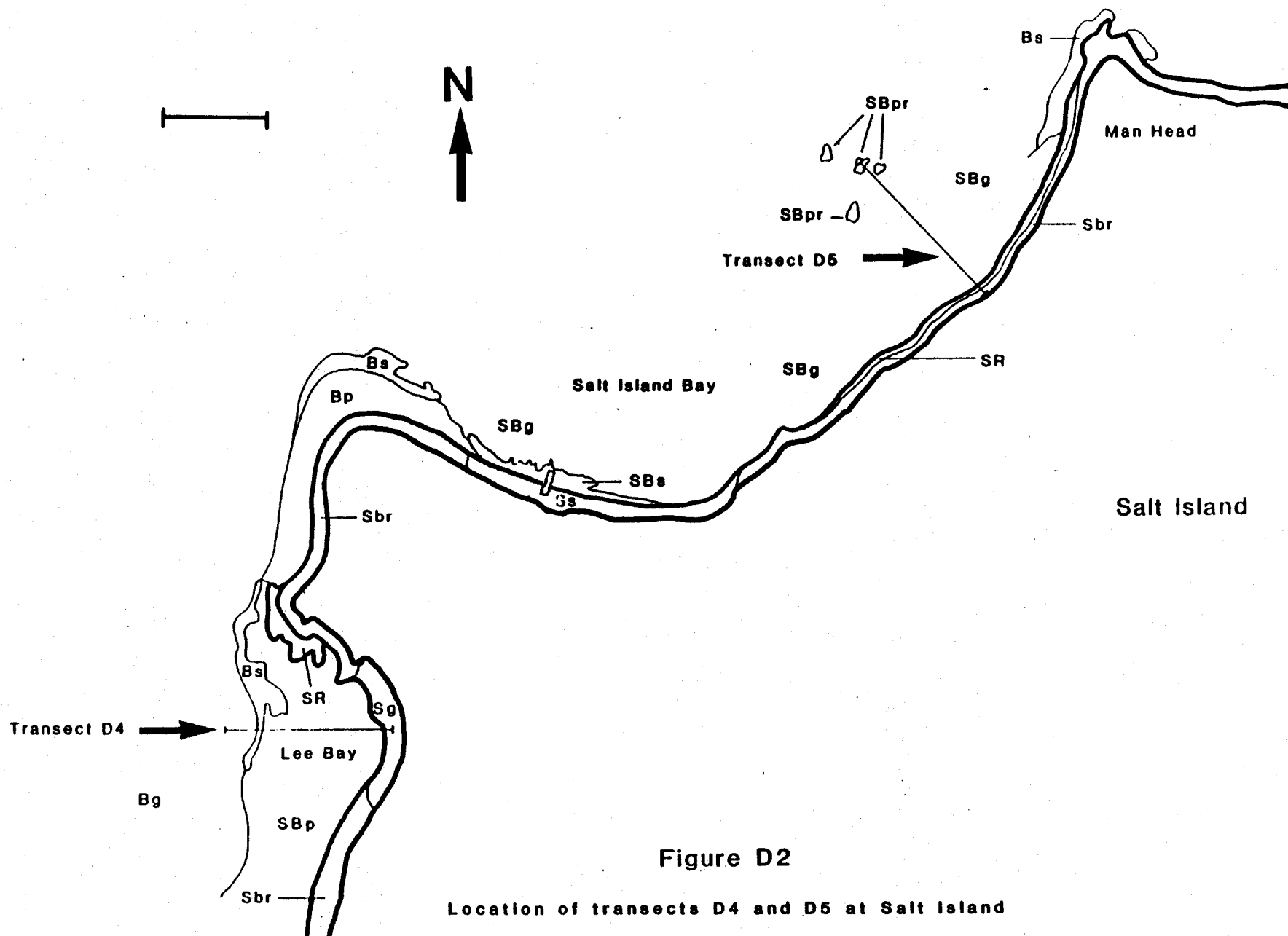
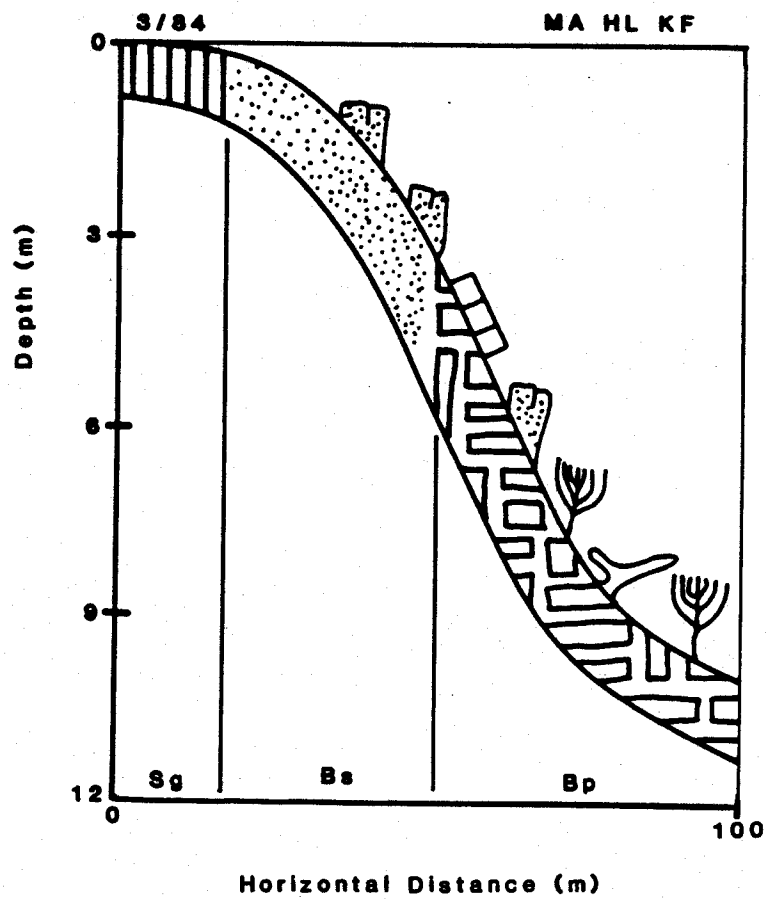
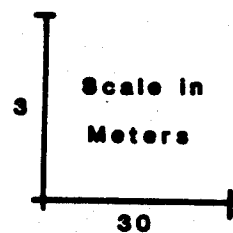


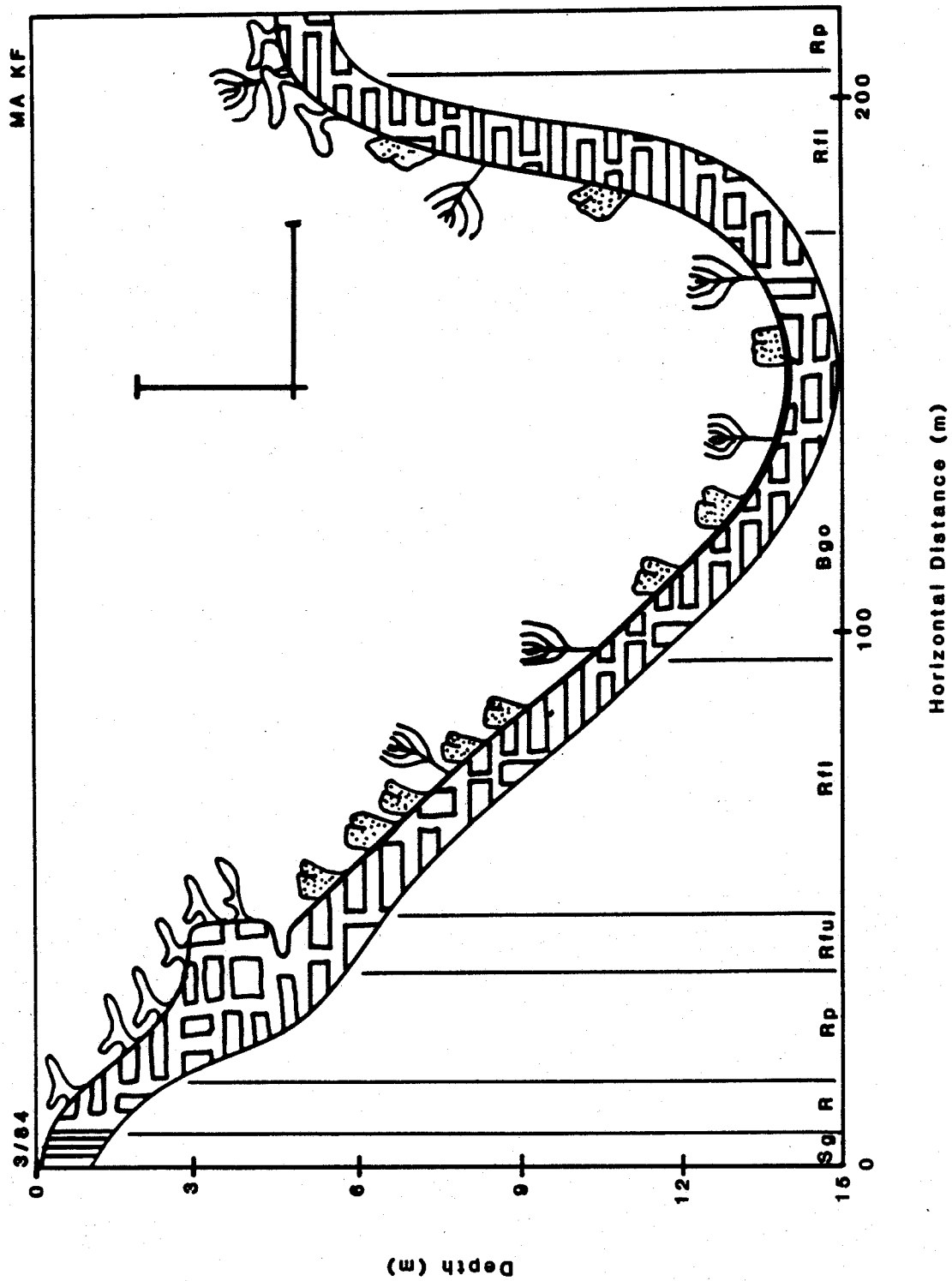
Figure D2

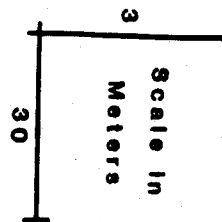
Location of transects D4 and D5 at Salt Island

Profile D1

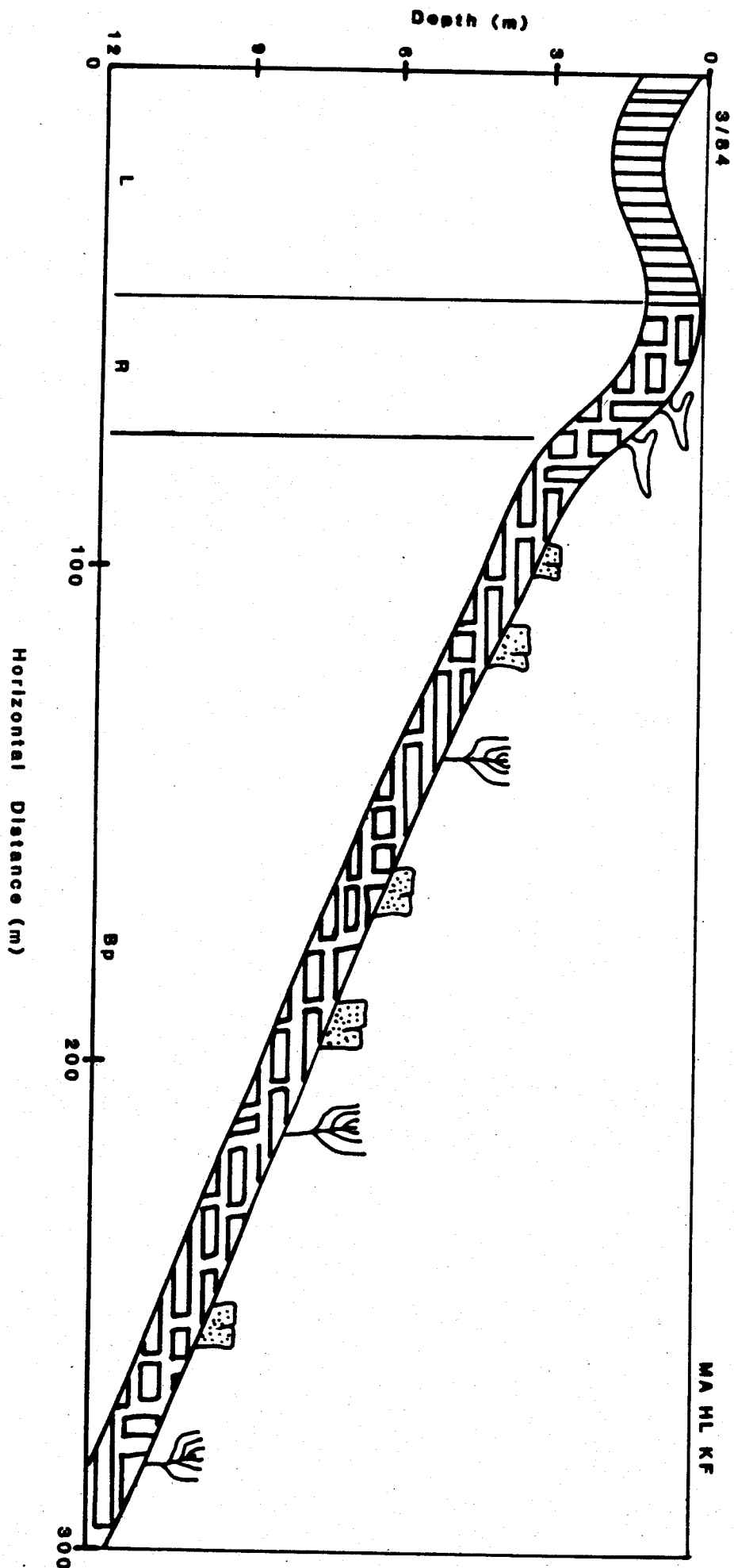


Profile D2

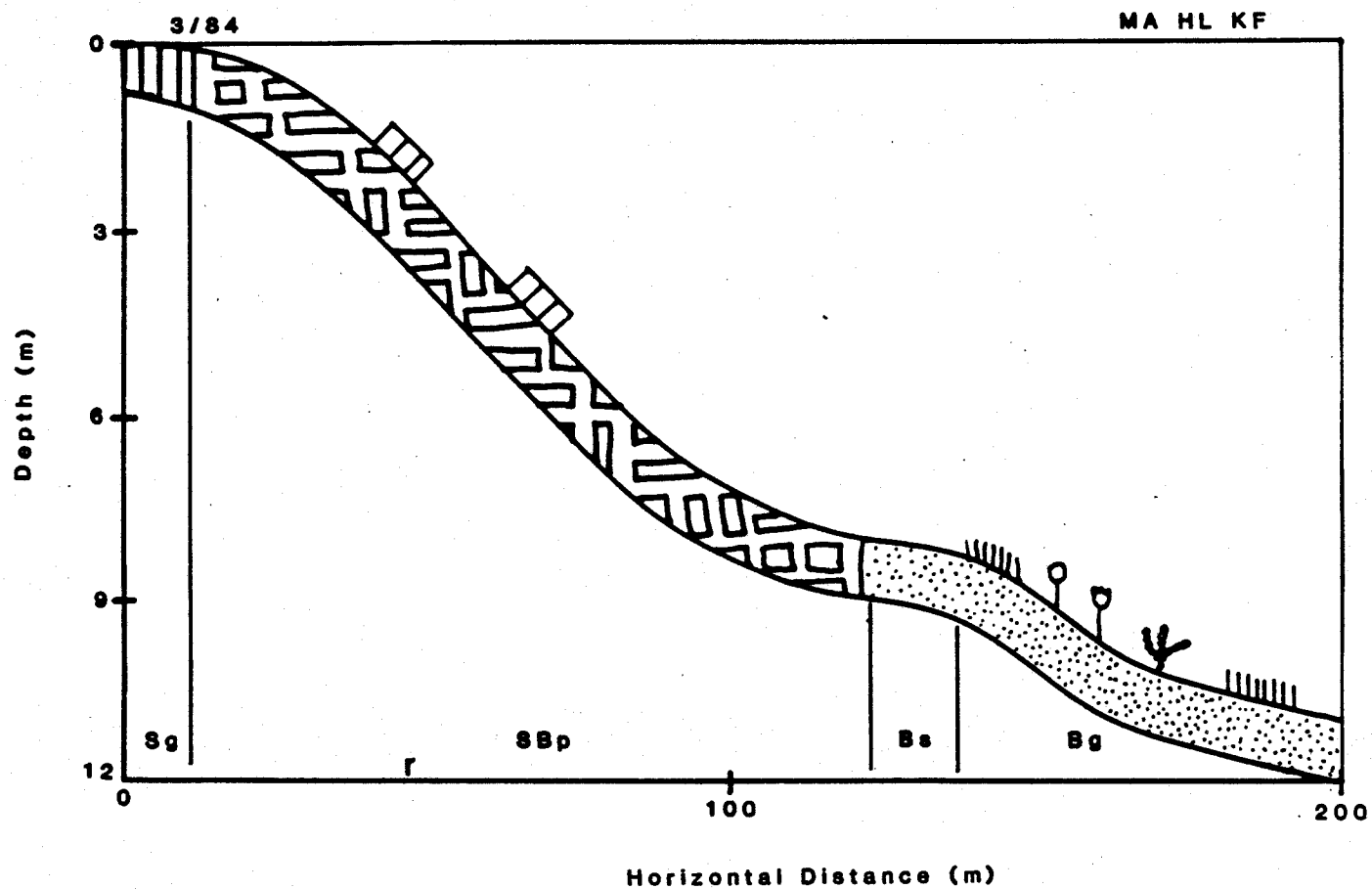
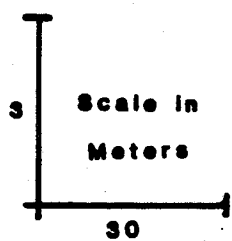




Profile D3



Profile D4



Profile D5

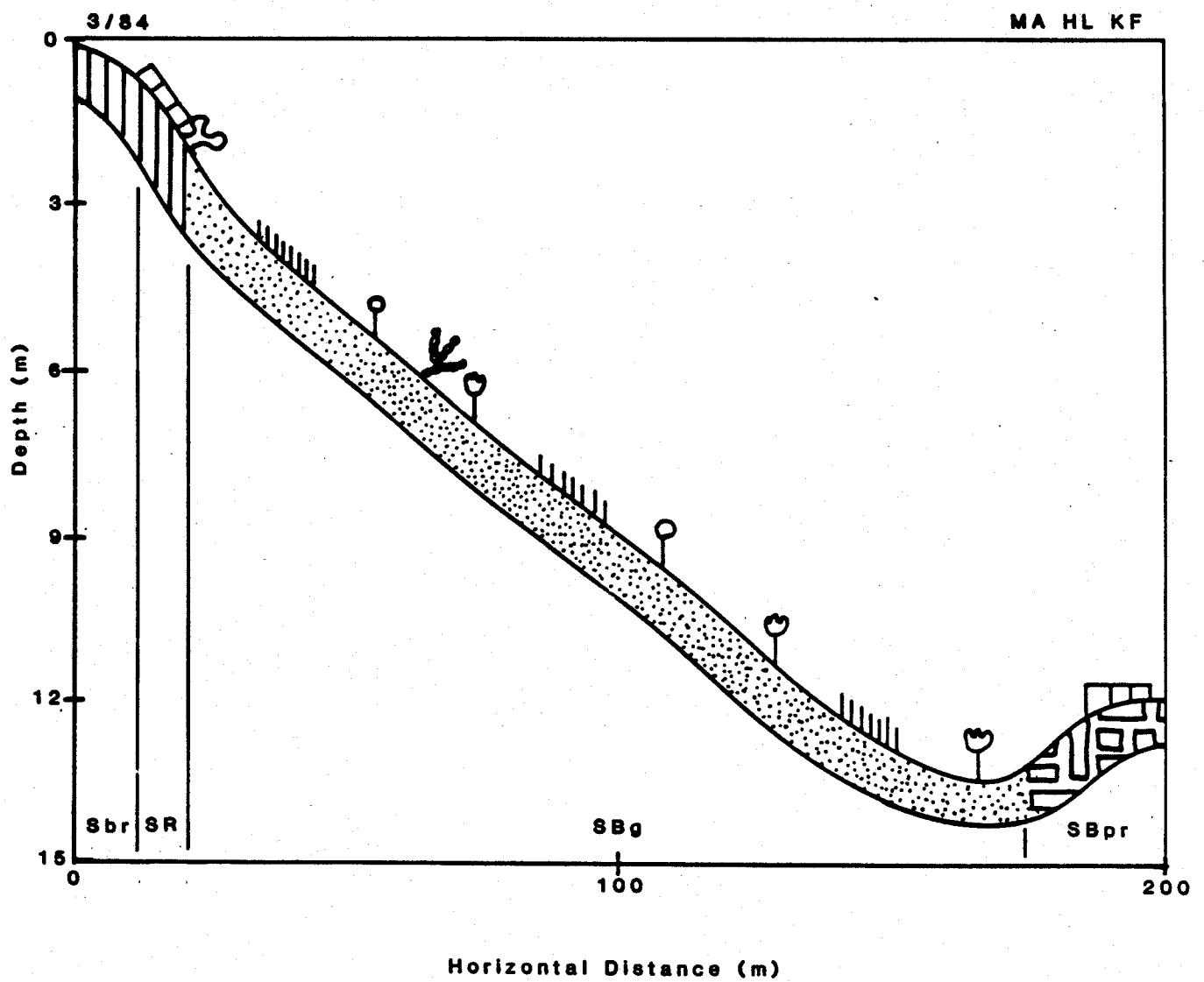
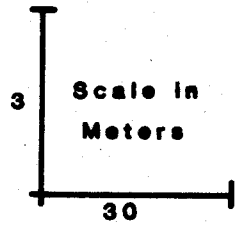


Table D

Data from transects D1 - D5

Site		D1			D2							D3			D4				D5					
Zone		Sg	Bs	Bp	Sbr	R	Rp	Rfu	Rfl	Bgo	Rfl	Rp	Sbr	R	Bp	Sbr	SBp	Bs	Bg	Sbr	SR	SBg	SBpr	
Depth Range (m)		0	0-3	3-10	0	0-1	1-3	3-5	5-10	10-14	14-5	0	0-1.5	1.5-10	0	0-8	8-10	0	0-1.5	1.5-20	20-13			
HARD CORAL	Acer		+	+					+	+												+		
	Apal			*		*	*	*	+		+	*	*									+		
	Apro		+	+					+					+										
	Aga									+		+										+		
	Col								+	+	+	+												
	Den			+			+		+	+		+												
	Dic			+						+		+										+		
	Dcli			+					+	+				+			+					+		
	Dlab		+	+					+	+		+		+			+					+		
	Dstr			+					+	+		+		+			+					+		
	Fav					+	+	+														+		
	Isas										+												+	
	Iso								+		+													
	Mdec								+		+				+									
	Mac																					+	+	
	Mea		+										+											
	Mil			+			+		+	+				+	+			*				*	+	
	Mann			*	+			+	*	*	*	*	*		*	*		+				*		
	Mcav			+								+										+		
	Mus											+												
Myc								+			+													
Past			+			+	+	+				+		+			+				+			
Ppor			+			+	+	+				+					+				*		+	
Srad			+			+	+					+												
Ssid		+	+				+					+									+			
Ste									+															
TOTAL # SPP.		6	16		1	7	7		17	9	9	14	2	9		10				12	2	2		
GORGONIAN S	Bri								+			+												
	Ery																							
	Eun			+								+												
	Gor			+			+	+	+	+	+	+												
	Mur			+			+	+	+					+										
	Ple																							
	Plxl								+	+	+													
Ptg																								
Pst								+	+	+	+		+			+								
Psl																								
TOTAL # SPP.		3							5	4	3	4	2			1								
COVER	% HC	5	25		20	20	30	80	15	20	15	25	15		15				5			1		
	% Go		5			5	10	10	15	10	10		5		5									
	% Z																			3				
	% G																	100			100			
	% DG																							
	% T	5	60		20	15	50	5				25	50	80		75				92		99		
	% S		90	10	60	60	10	5	70	70	75					5	100							
% Sbr	100			100							100				100				100					
% Sb																								
Habitat Complexity		1	1	2		3	2	5	4	2	3	2	1	3	2	1	1	1	2	1	2	2	2	
OTHER	Dia																							
	Eci												+					+				+		
	Ham		+																					
	Hal		+														+				+			
	Pal			+			+						+					+				+		
	Pen																+					+		
	spg																		+			+		
	Syr																		+			+		
Tha																		+			+			
Udo																						+		
Zoa											+													



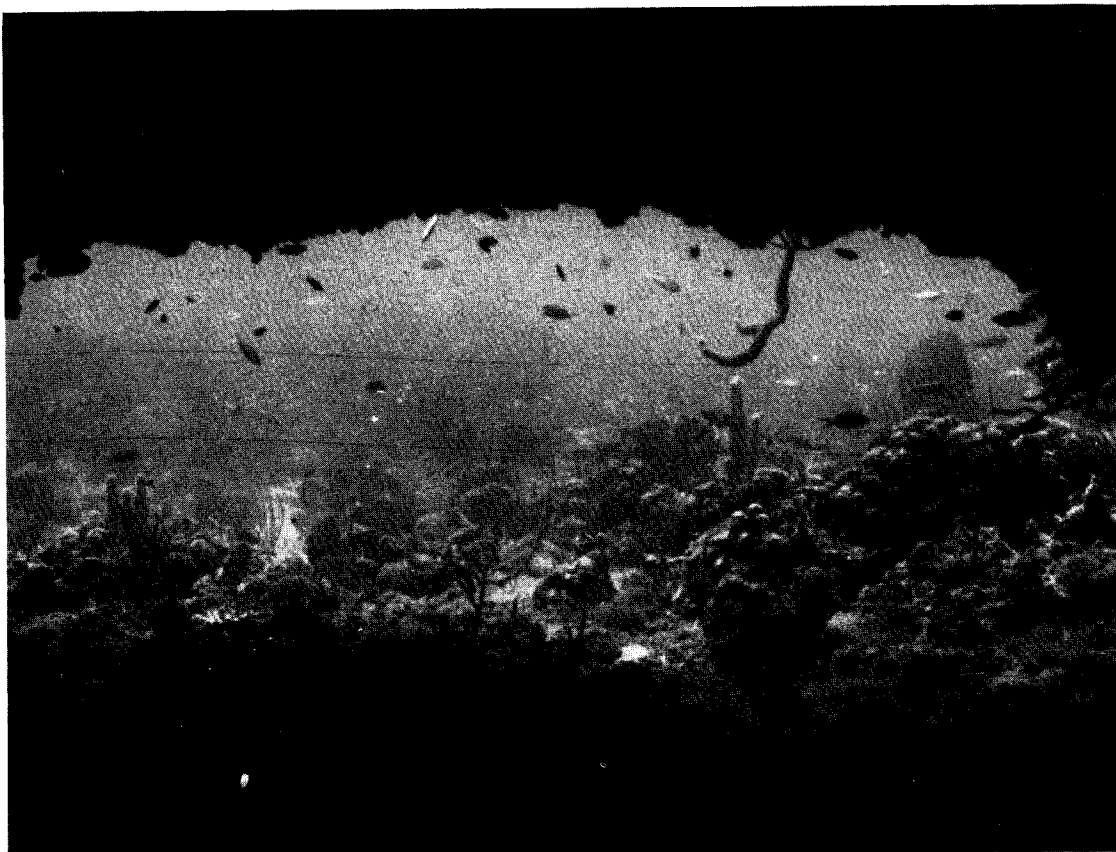
D2-a



D2-b

Plate D2-a,b

Dead Chest Island: lower forereef



D2-c



D2-d

Plate D2-c,d

Dead Chest Island: Gorgonian coral flat

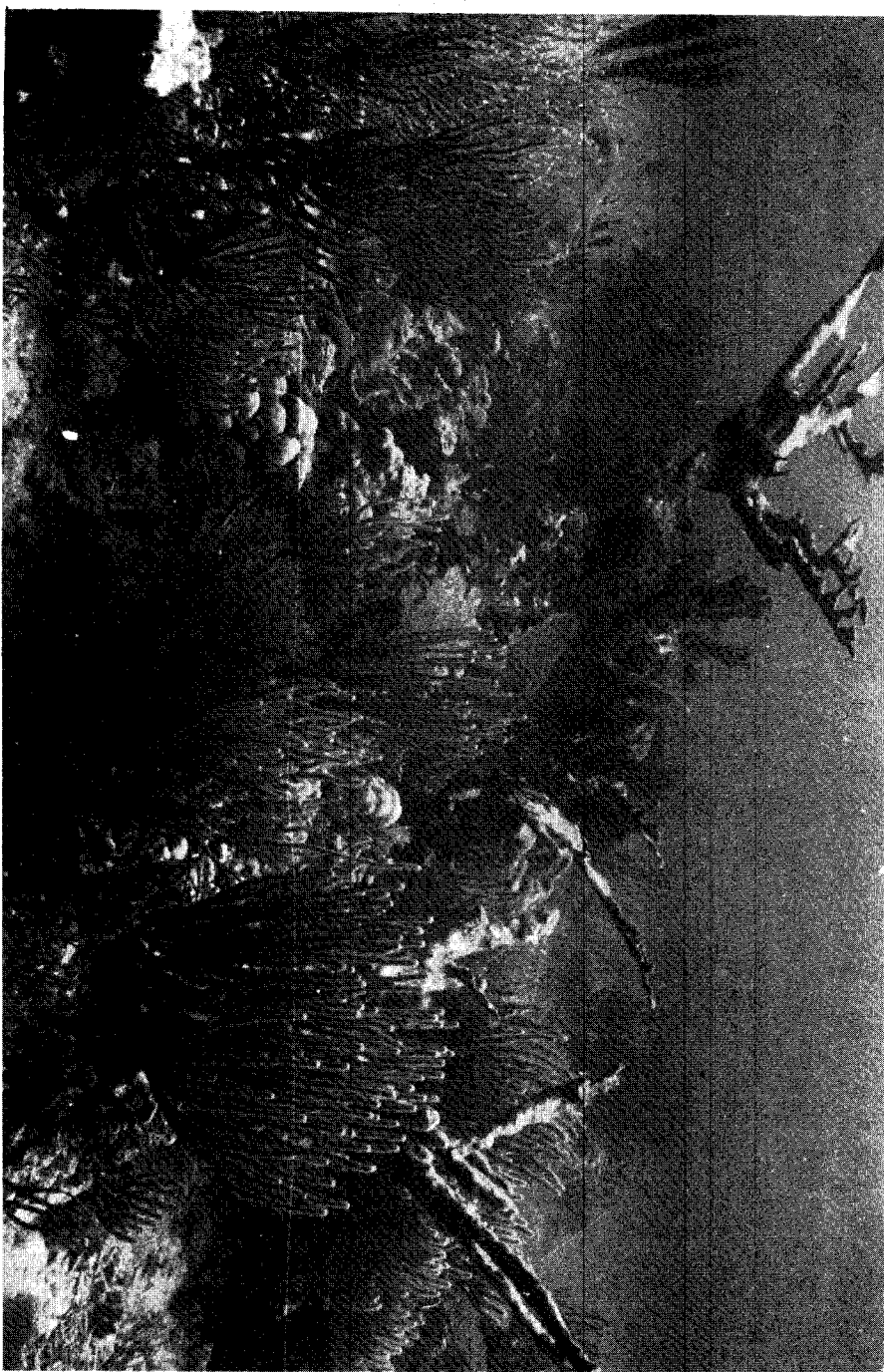


Plate D2-e

Dead Chest Island: Lower foreereef

D2-e

NORMAN ISLAND, PELICAN ISLAND AND THE INDIANS

Introduction

The proposed marine park site at Norman Island extends west, from the tip of Water Point to Treasure Point, to the west end of the island, The Carval, and north to include Pelican Island and the small group of emergent bedrock pinnacles called The Indians (Fig. E). The Bight, delineated by Water Point to the east and by Treasure Point to the west, and Privateer Bay, defined by Treasure Point to the east and The Carval to the west, are two popular anchorages included in this proposed park site.

The central shore line of Privateer Bay is predominantly cobble. Consolidated bedrock boulders extend into the subtidal zone to 2 m depth. A sheer dropoff to 3 m depth parallels the shore line and a pavement area lies between this precipice, and a dense Thalassia bed, which begins at 4 m depth. Many turtle grazing scars are evident in the seagrass bed and several turtles were seen in the area.

Treasure Point rises vertically from the sea on the eastern end of Privateer Bay and is perforated by 3 sea caves which are noted for their popularity among tourists. This is the site of transect E1 (Fig. E1; Profile E1).

The south side of The Bight is bordered by rocky cliffs which extend into an intertidal pavement area and interface with a sand bottom at 10 m depth. The sea floor here is colonized by algae and slopes to 16 m depth. No distinct lower forereef exists between the pavement and sand zones.

Rocky cliffs also merge with subtidal pavement on the north side of The Bight. At 10 m depth the pavement here interfaces with a steep lower forereef, which drops to the shallow bay algal plain at 15 m depth. This area is the site of transect E2 (Fig. E2; Profile E2).

Two sand beaches occur along the predominantly cobble strewn southeast shore of The Bight. Visiting boaters frequently anchor in the sand substrate offshore of the beaches.

Pelican Island, located approximately 1.5 km due north of Privateer Bay, is joined by a submarine bedrock outcropping to The Indians, located ca. 300 m west of Pelican Island. Transect E3 traverses the bedrock, pavement, and sand substrate occurring between Pelican Island and The Indians (Fig. E3; Profile E3).

The northwest subtidal bedrock zone of Pelican Island (north of transect E3) is composed of an impressive series of cobble terraces extending to 3 m depth where it interfaces with pavement. A lower forereef occurs here. A rocky shore zone borders the remainder of Pelican Island's coast and converges intertidally with a shallow reef. The adjoining pavement also interfaces with a lower forereef and converts into bank sand at ca. 20 m depth.

Previous research conducted at the proposed marine park site at Norman Island includes Teytaud (1983) and West Indies Laboratory (1982). Teytaud's study contains comprehensive information on socio-economic features and goals for management. West Indies Laboratory's study includes information which

compliments our biological survey and should also be consulted when management strategy is being developed.

NORMAN ISLAND

Transect E1 (Treasure Point Caves)

Transect E1 extends due west from The Caves at Treasure Point on Norman Island (Fig. E1). It crosses a shore bedrock zone which drops vertically to 5 m depth, and then traverses some boulders which rise from 8 m to within 2 m of the surface. The transect proceeds onto a shallow bay pavement (ca. 10 m depth) upon which day use boaters anchor (Profile E1; Table E).

Subtidal Bedrock

A vertical bedrock wall plunges to 5 m depth and slopes gradually to 8 m depth beyond that. The hydrocoral Millepora and Montastrea annularis dominate the live coral cover of 25%. Gorgonian cover (5%) is dominated by Eunicea and Gorgonia. Palythoa is common and contributes 10% to the total substrate cover.

Several boulders that lie at 8 m depth (15 - 20 m offshore) rise to within 2 m of the surface and have a live coral cover of 30%. Encrusting patches of the hydrocoral Millepora contribute significantly to the high percentage of live coral cover. Montastrea annularis is also plentiful, large colonies of Mycetophyllia and Isophyllia are established toward the base of the largest boulder, and an impressive colony of Dendrogyra (2 m tall) is present. Palythoa, again, contributes 10% to the substrate cover in this zone.

Bank Pavement

A pavement which occurs seaward of the boulders is subject to anchoring activity by day use boats. Live coral cover (10%) is dominated by the hydrocoral Millepora and Montastrea annularis. Acropora cervicornis is locally dominant in small patches and tall Dendrogyra pillars are common. Both Zoanthus and Palythoa (5% cover) form substantial mats and, although gorgonian cover is not great (5%), diversity is moderately high (Table E).

Transect E2 (Water Point)

The Bight at Norman Island is a large cove bound by two points (Fig. E). Water Point (to the northeast) protects the bay from prevailing weather, providing excellent anchoring conditions. The Bight has thus become a favorite anchorage and was selected as the location for transect E2 (Fig. E2).

The transect extends southeast from the center of Water Point and crosses the shore, subtidal bedrock, pavement, lower forereef, sand, and an algal plane (Profile E2; Table E).

Shore Zone

In the bedrock shore zone, a distinct region virtually completely covered by crustose coralline algae is visible.

Subtidal Bedrock

Several large boulders, submerged in the shallow subtidal area, provide substrate for a live coral cover of 40% (Plate E2-a). Few gorgonians exist here (ca. 2% cover) and small sand

patches (10% cover) lie between the boulders. Palythoa (2% cover) was noted and the remaining substrate is colonized by algal turf.

Shallow Bay Pavement

The pavement extending seaward of the subtidal bedrock supports an unusually high percentage of M. annularis (Plate E2-b). Areas of high density M. annularis cover (up to 80% locally) contribute significantly to the total live coral cover of 35%. Most of this coral is in the knobby form and creates heads up to 6 m across.

Lower Forereef

A shift to a zone with an increase in coral and gorgonian species diversity, but a decrease in live coral cover, occurs where the sea floor slopes at 30° from 10 m to 15 m depth (Profile E2; Table E; Plate E2-c). Live coral cover is 20% and approximately half of that is due to M. annularis. Colonies of M. cavernosa were noted and sponges are large and diverse on the lower forereef.

Shallow Bay Sand

A strip of sand (15 m width) at the base of the lower forereef is devoid of colonizing flora and fauna. Perhaps this is a grazing halo effect from cryptic grazing organisms living in the lower forereef.

Shallow Bay Algal Plain

Seaward of the bare sand is an extensive plane with 100% algal cover.

PELICAN ISLAND

Transect E3 (Indians to Pelican)

Due west of Pelican Island there is a series of 4 bedrock pinnacles known as The Indians (Fig. E). The vertical sides of the pinnacles extend 8 - 10 m above the sea surface and, on the eastern side (facing Pelican Island), drop to ca. 5 m depth. As Pelican Island is approached, a pavement area occurs beyond which another abrupt outcropping of bedrock drops shoreward to more bank pavement, and then to a small patch of bank sand. A sloping sheet of subtidal bedrock, east of the sand, rises shoreward and extends into the shore zone of Pelican Island.

Transect E3 begins in the shore zone on the eastern side of the northernmost pinnacle and extends into the bedrock shore zone on Pelican Island (Profile E3; Table E).

Shore Zone on Pinnacle

The vertical pinnacle shore consists of a splash zone which emerges 2 - 3 m above sea level. Abundant periwinkles and coralline algae are present.

Subtidal Bedrock

The vertical wall of the shore zone extends to 5 m depth (Plate E3-a). Montastrea annularis and the hydrocoral Millepora are the dominant live corals here (30% cover).

Eunicea and Gorgonia are the dominant gorgonians (10% cover), and Zoanthus and Palythoa are present in this zone (5% cover).

Bank Pavement

The base of the pinnacle wall interfaces with a flat, moderately sparse section of pavement (ca. 5 m depth) to the east of The Indians (Plate E3-b). The live coral cover of 10% is dominated by M. annularis and the gorgonians present contribute 5% to the total substrate cover. Several patches of zoanthids account for no greater than 2% of the pavement surface.

Subtidal Bedrock

A subtidal bedrock outcropping rises from the pavement at 5 m depth to 0.5 m depth (Plate E3-c). The top of the outcropping nearly reaches sea level and M. annularis, the hydrocoral Millepora and particularly healthy stands of A. palmata are dominant among corals (20% cover).

Bank Pavement

The pavement, east of the bedrock outcropping, ranges from 2 m to 7 m depth (Plate E3-d). Live corals create a cover of 25%, gorgonians account for 10%, and Palythoa colonizes ca. 5% of the substrate. An abundance of sand (5% cover) increases with depth in the bank pavement zone. Unconsolidated coral rubble (mostly fragmented A. cervicornis and A. palmata) and some barren boulders occur on the deeper bank pavement.

Bank Sand

The unconsolidated coral rubble area interfaces with a sand bank at 7 m depth. Live coral cover (ca. 2%) and gorgonian cover (ca. 3%) are low.

Bank Pavement

Bank pavement occurs, for the third time along transect E3, east of the sandy area. The pavement maintains a gradual slope from 7 m up to 3 m depth. Corals (15% cover) and gorgonians (10% cover) are present and patches of sand contribute 10% to the substrate cover.

Subtidal Bedrock

Outcroppings of subtidal bedrock occur next to the shore of Pelican Island (1 m depth). It is a sand scoured area and the hydrocoral Millepora dominates the live coral cover of less than 5%. No gorgonians are present. Sand (5% cover), and bedrock colonized by algal turf (90% cover) account for the remaining substrate composition.

Shore Zone

With the exception of one small sand beach, the shore zone on Pelican Island is entirely composed of bedrock and cobble.

Summary

Norman Island possesses one of the most popular overnight anchorages, The Bight, and one of the most frequently visited day anchorages, Privateer Bay, in the BVI. The park site in its entirety, however, is an attractive one from the stand point of both the cruising vessel mariner and the day use sailor.

The Bight provides a secure overnight anchorage. It has a sloping sand bottom leading to a beach which is excellent for swimmers and waders. The marine communities along the sides of this bay are relatively untouched due to the preference of boaters to anchor near the back of the bay.

One of the more popular sites in the BVI, The Caves, are located on the northeast cliffs of Privateer Bay. This site provides visitors with a hard ground day anchorage area which presently supports extremely low levels of hard and soft corals. The back of Privateer Bay is bordered by a cobble beach and a pavement area slopes toward the sea. Beyond the pavement is a rich grass bed which supports a substantial population of turtles.

Pelican Island and The Indians provide some of the most excellent snorkeling in the BVI. The area is little used and has only moderate live coral cover but the bedrock outcroppings provide small areas which have vertical walls with extremely aesthetical coral garden arrangements.

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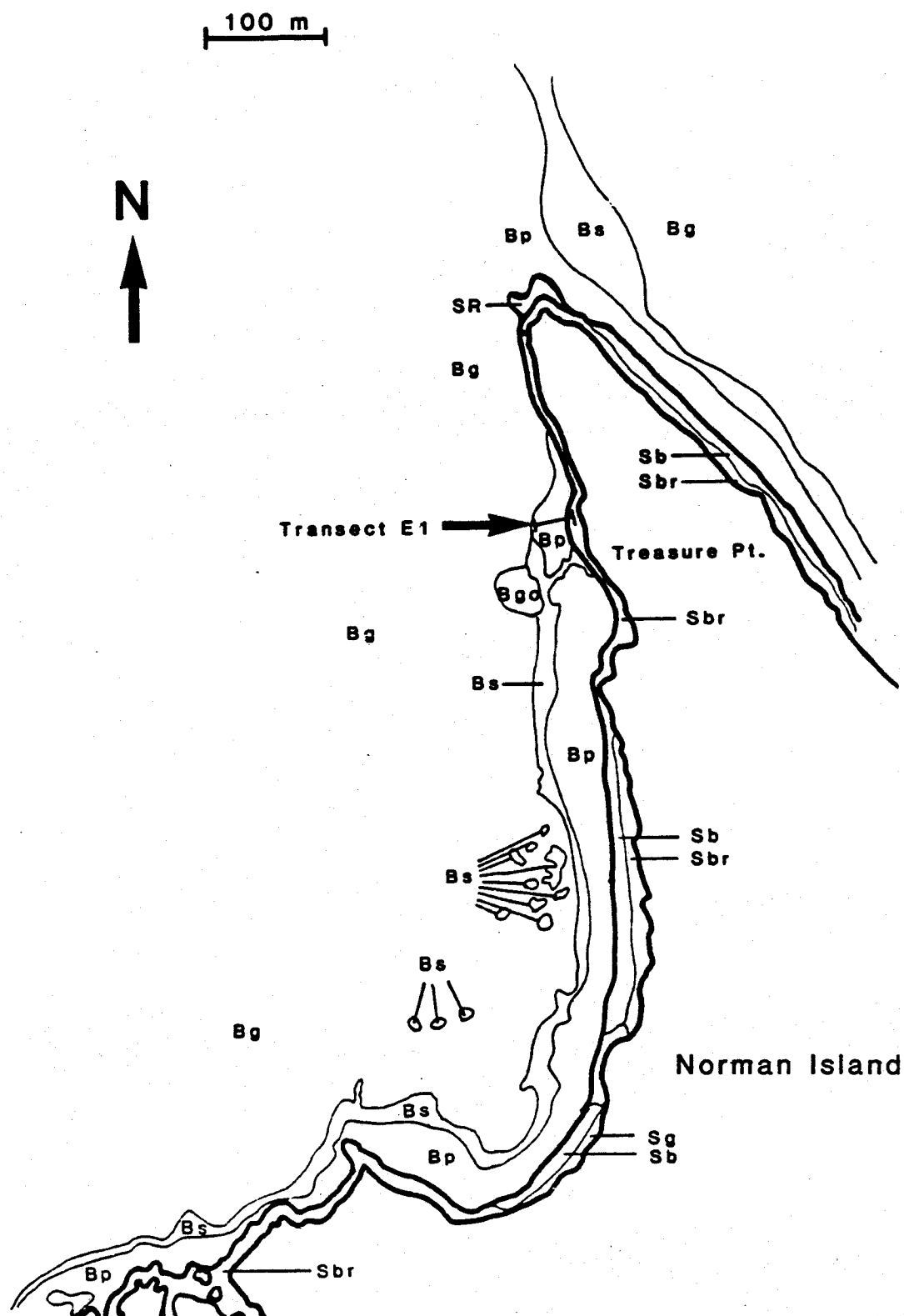


Figure E1

Location of transect E1 at Norman Island

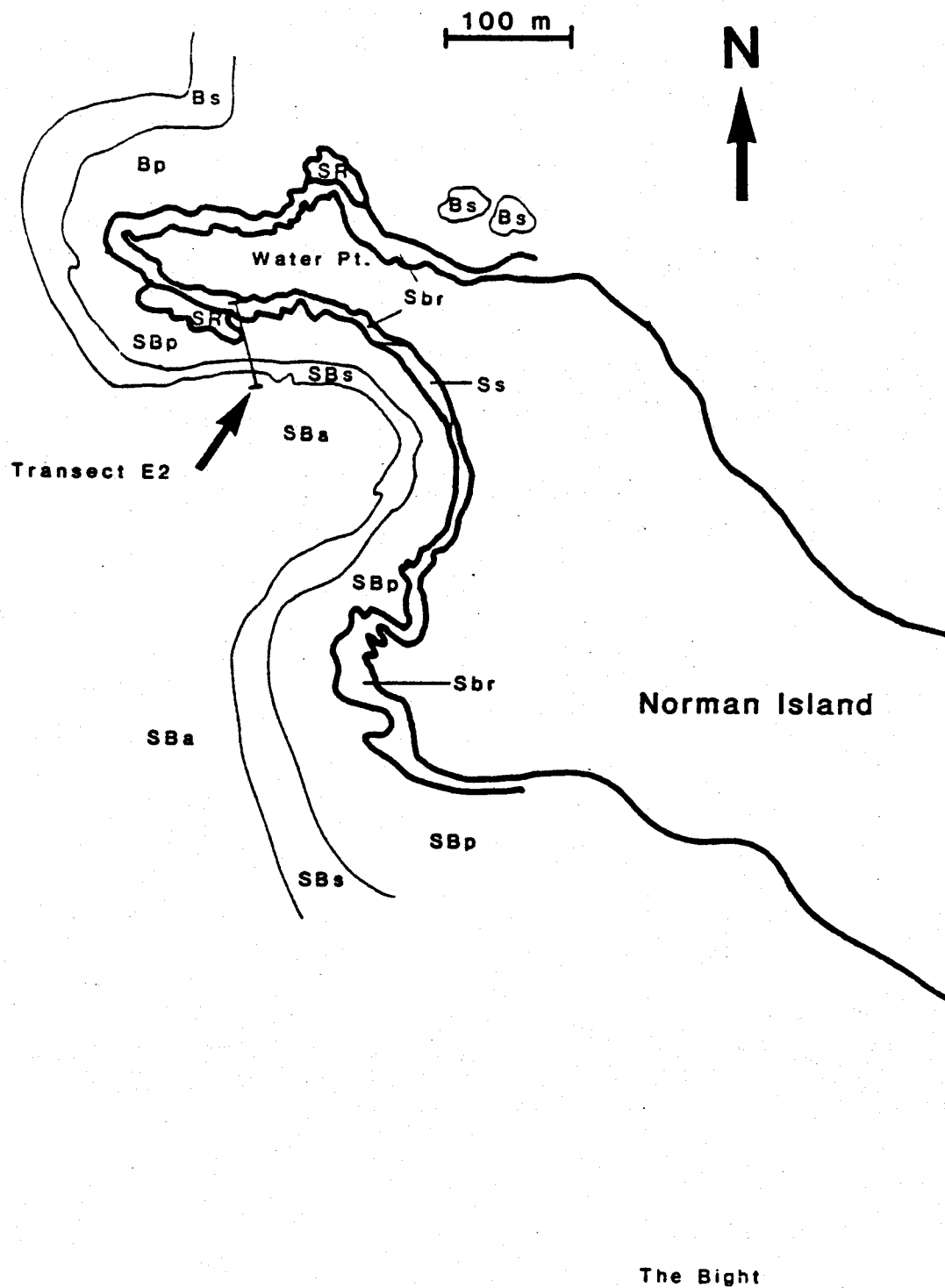


Figure E2

Location of transect E2 at Norman Island

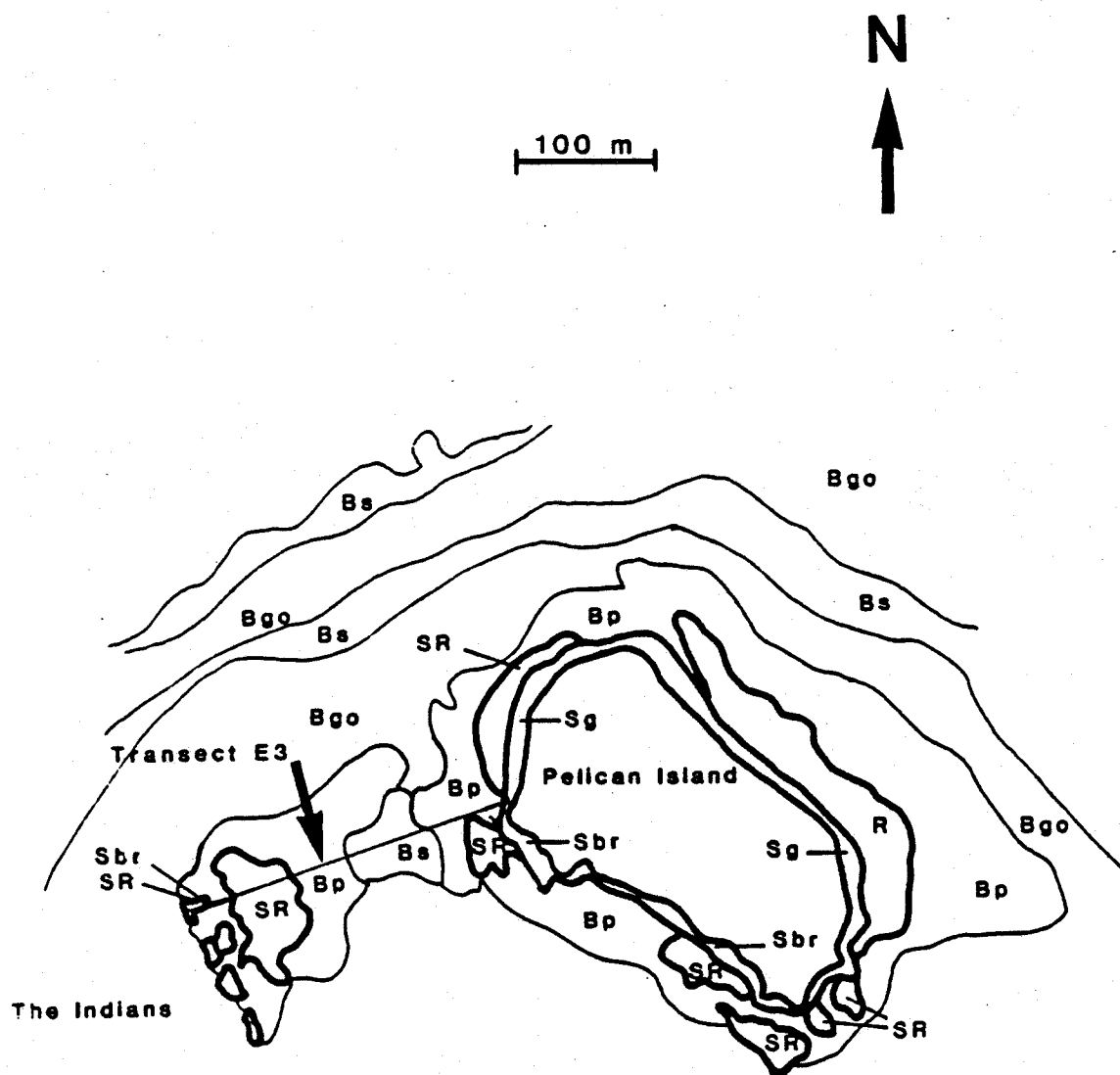
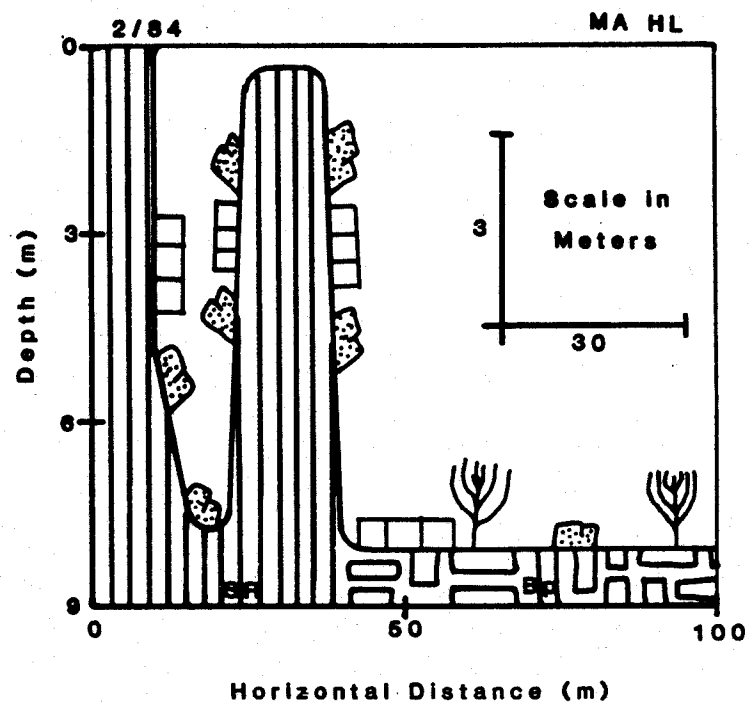


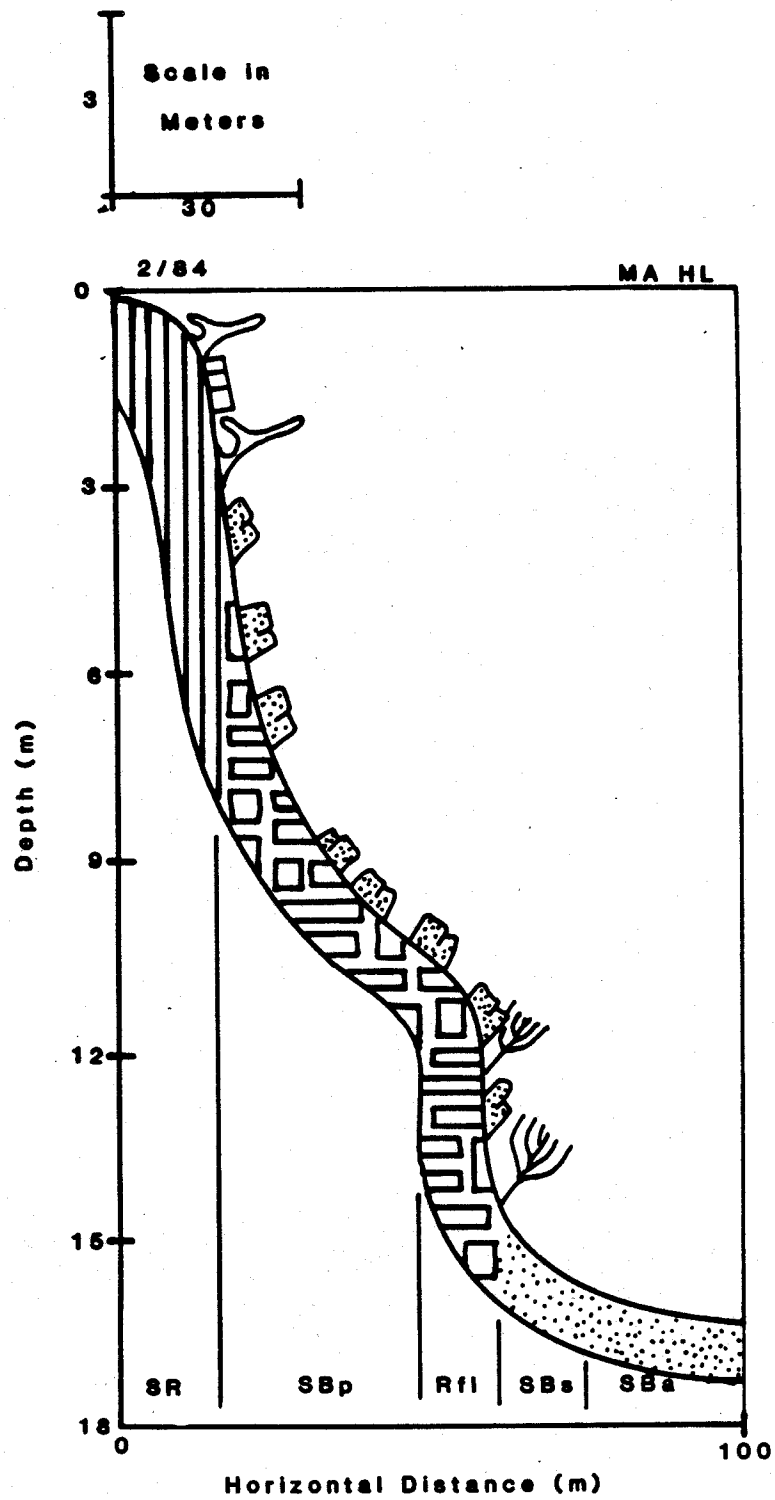
Figure E3

Location of transect E3 at Pelican Island

Profile E1



Profile E2



Profile E3

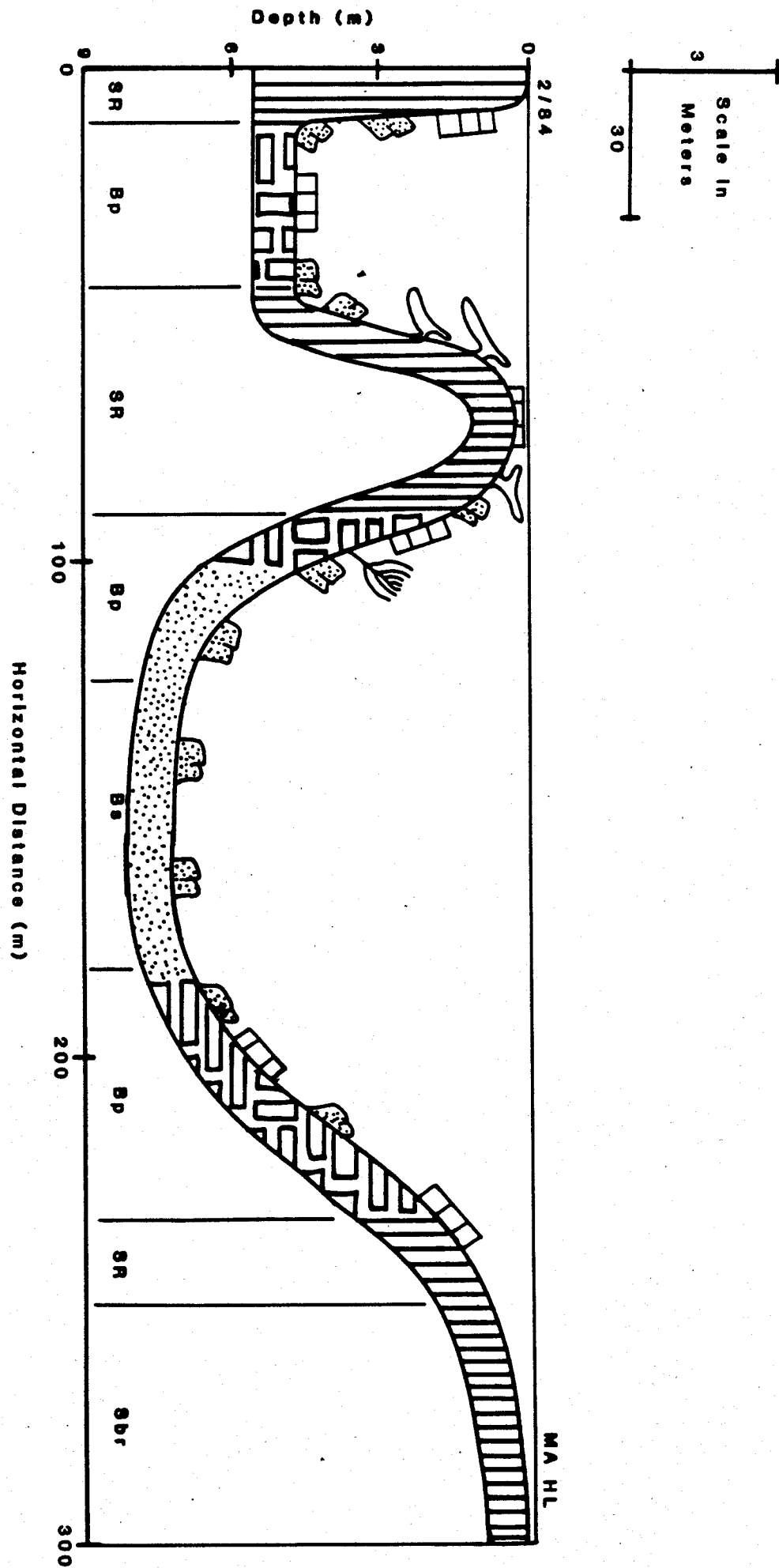


Table E

Data from transects E1 - E3

Site		E1			E2						E3									
Zone		Sbr	SR	Bp	Sbr	SR	SBp	Rfl	SBs	SBa	Sbr	SR	Bp	SR	Bp	Bs	Bp	SR	Sbr	
Depth Range (m)		0	0-8		0	0-3	3-10	10-15	15	16	0	0-5	5-10	10-15	15-20	20-25	25-30	30-35	35-40	
			8			3	10	15				5		0.5	7		3	3		
HARD CORALL	Acer		+	+			+	+					+	+	+	+	+			
	Apal		+			*								*	+		+	+		
	Apro											+	+	+						
	Aga					+		+				+	+					+		
	Col		+	+									+							
	Den			+									+				+			
	Dcli		+	+		+		+				+	+		+	+				
	Dlab		+	+		+	+	+				+	+	+	+	+	+			
	Dstr		+	+			+	+				+	+	+		+	+	+		
	Eus														+		+			
	Fav					+						+	+	+	+		+	+		
	Iso		+	+										+						
	Mdec								+											
	Mil		*	*		*	+					*	*	*	*		*	*		
	Mann		*	*		*	*	*				*	*	*	*	*	*	*	+	
	Mcav								+				+				+			
	Myc		+	+					+			+								
	Past			+		+			+			+				+		+		
	Pdiv														+					
	Ppor			+		+	+	+				+	+							
	Sco												+							
	Srad			+			+	+				+	+	+						
	Ssid		+	+		+		+						+		+		+		
TOTAL # SPP.			12	14		10	7	13				12	14	12	12	7	10	6		
GORGONIAN S	Bri			+			+					+								
	Ery																			
	Eun		+				+	+				+		+	+					
	Gor		+	+			+	+				+		+	+		+			
	Mur			+				+				+					+			
	Ple																			
	Plxl			+				+							+					
	Ptg			+				+												
	Pst			+				+												
Psl																				
TOTAL # SPP.			2	6		3	6					4	2	3		2				
COVER	% HC		25	10		40	35	20				30	10	20	25	2	15	5		
	% Go		5	5		2	5	5				10	5	5	10	3	10			
	% Z		10	5		2						5	2	10	5					
	% A					100				100										
	% DC							45												
	% T		60	55		46	30	25				55	83	65	55		65			
	% S			25		10	30	5	100						5	95	10	5		
% Sbr		100									100						90	100		
Habitat Complexity		1	2	2	1	2	2	3	1	1	1	2	2	2	2	1	2	2	1	
OTHERS	Pal		+	+		+						+		*	+					
	spg							+												
	Zoa			+								+	+				+			



E2-a



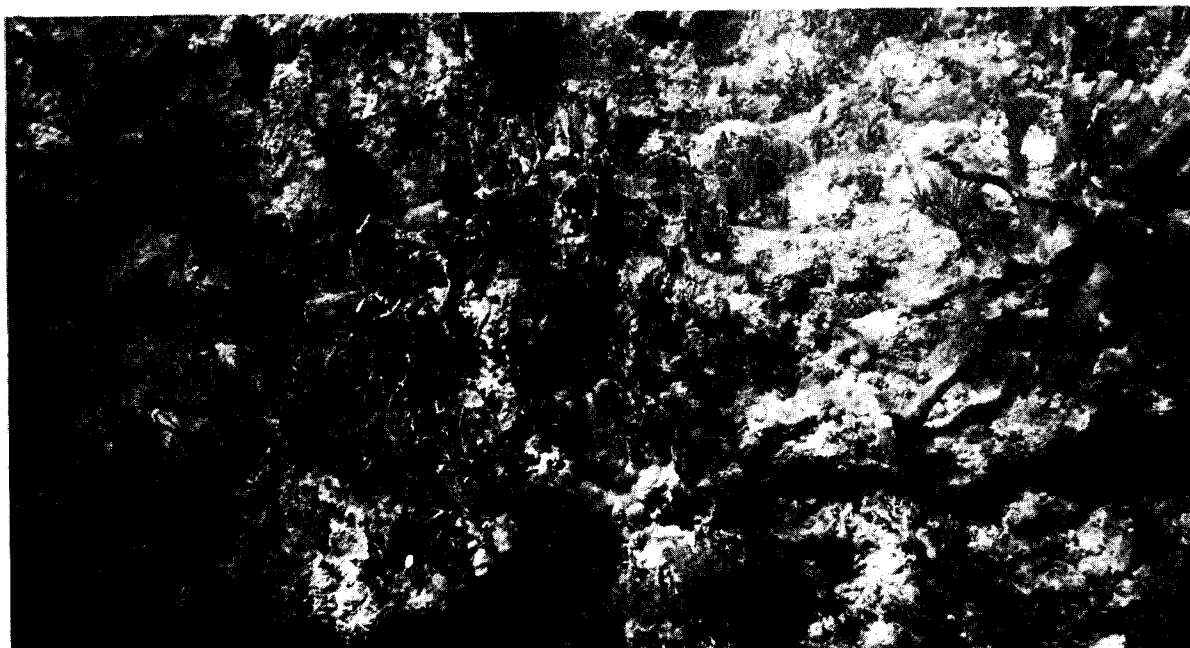
E2-b



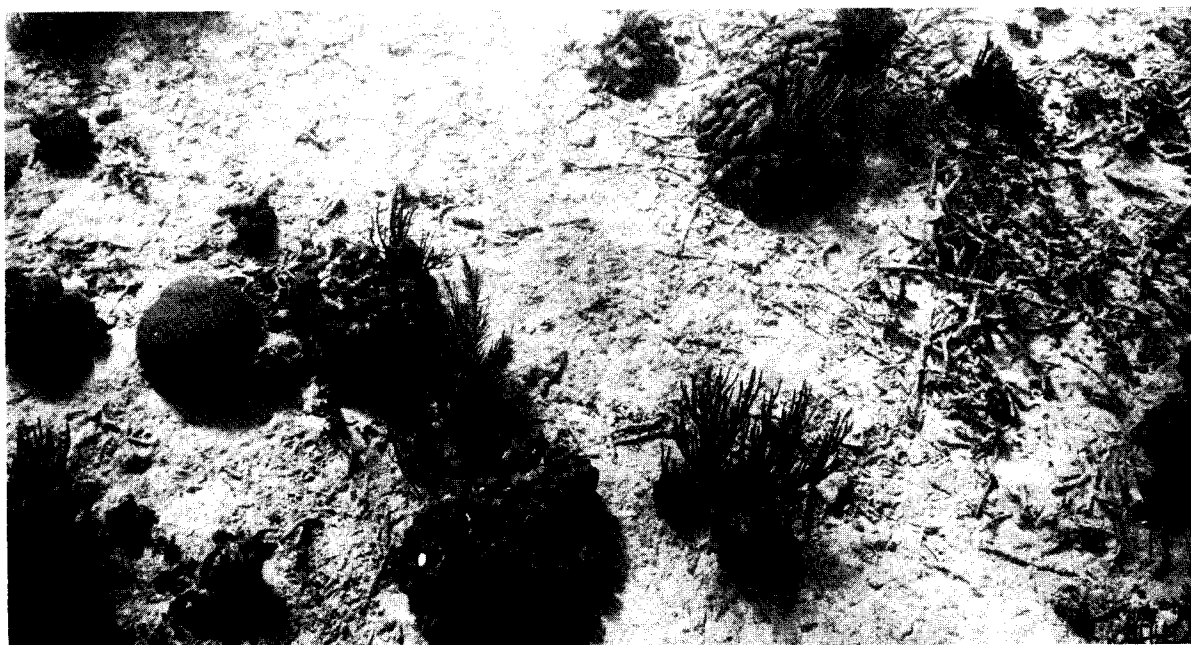
E2-c

Plate E2-a,b,c: Norman Island

E2-a: Subtidal bedrock, E2-b: Shallow bay pavement, E2-c: Lower foreereef



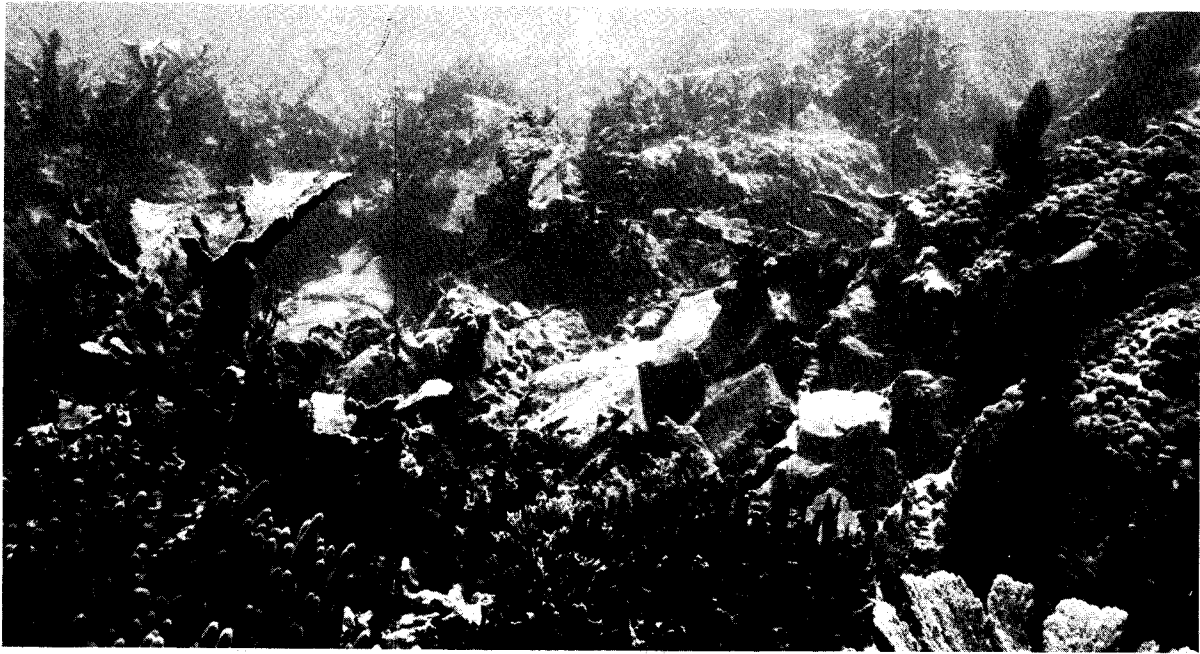
E3-a



E3-b

Plate E3-a,b Pelican Island

E3-a: Subtidal Bedrock, E3-b: Bank pavement



E3-c



E3-d

Plate E3-c,d; Pelican Island

E3-c; Subtidal Bedrock, E3-d Bank Pavement

THE TOBAGOS

Introduction

The proposed marine park site at The Tobagos includes Great Tobago, Little Tobago, and Watson Rock (Fig. F). Coastal regions throughout the site were ground truthed. A transect was established was on the leeward (west) side of Great Tobago.

The bedrock cliffs bordering the islands of Little Tobago and Watson Rock drop vertically to the sea and extend subtidally to great depths at a nearly vertical slope. A shallow coral reef is located on the southeast coast of Little Tobago.

The south side of Great Tobago is a complex system of shallow reefs, bank pavement, and sand channels. Pavement on the east side of the island drops to an algal flat in deep water (ca. 25 m). A fringing reef borders the island on its central eastern side. The cliffs on the north shore of the island drop precipitously subtidally.

The bedrock cliffs on the southwest side of the island border a rocky cove and extend subtidally to a depth of 5 to 7 m. A healthy Acropora palmata reef fringing the cliffs in the back of the cove rises to a depth of about 2.5 m. Boulders on the southern end of the cove occur on both sides of a cave which passes through the south end of the island. The bottom in this area is extremely scoured and the rocks are colonized nearly 100% by algal turf. A gorgonian bank seaward of the reef supports live coral cover of about 15%.

Bedrock cliffs border all but a small section of the northwest shore of Great Tobago. Boulder and gravel talus extend

subtidally from the cliffs to ca. 7 m depth where a reef maintains a 30' slope seaward to 17 m depth. Beginning at 17 m depth, the slope increases to 60' and the lower forereef drops to a sand bottom at 27 m depth. One sand cove creates a gap in the rocky northwest shore and is the site of transect F1.

Transect F1

A transect established in the only sandy cove on the northwest shore of Great Tobago crosses 6 subzones (Fig. F1; Profile F1; Table F). The sandy shore connects with a shallow bay sand zone, pavement abuts the sand, and a reef and forereef follow. The sixth zone found seaward of the reef is bank sand. A series of ledges run parallel to shore in the bank sand at ca. 25 m depth (R. Boulon, pers. comm.).

Shore Zone

Bedrock boulders (25% cover) are deposited in the sand which composes 50% of the narrow shore zone. Gravel (25% cover) is present and primarily occupies the periphery of the beach.

Shallow Bay Sand

At 3 m depth dead isolated head corals (10% cover) projecting 0.75 m above the sand are partially colonized by corals (1% cover) and gorgonians (1% cover; Plate F1-a). The sand (90% cover) reaches 4 m depth at which point a low lying reef rises abruptly to 3 m depth.

Shallow Bay Pavement

The 1 m. precipice at the sand/pavement interface is composed

primarily of Montastrea annularis and is highly convoluted. The top of the vertical rise has characteristic pavement composition and slopes gently to 6 m depth (Plate F1-b). Live corals here (10% cover) include Diploria strigosa, D. clivosa, and M. cavernosa. Gorgonians (5% cover) and the zoanthids Palythoa and Zoanthus (2% cover) are also present.

Reef Zone

A shift to a zone with a conspicuous increase in gorgonian abundance and diversity begins at ca. 6 m depth (Table F; Plate F1-c). Although gorgonian holdfasts account for only 10% of the substrate cover, the crown of the colonies (60 - 75% cover) obscure the view of pavement in strips up to 5 m wide.

Beginning at ca. 7.5 m depth gorgonians become less abundant (10% cover). Live coral cover (25%) is dominated by M. annularis and colonies of Diploria species are common. The bioerosion of reefs has formed caverns and deep ledges. Some spur and groove development begins here.

Lower Forereef

Portions of the substrate on the lower forereef are composed of consolidated Acropora cervicornis, a probable indication that this zone was once a massive A. cervicornis reef. Heads of Diploria species (ca. 1.5 m across) are present and M. annularis colonies of the plate morphology create a spur and groove formation which maintains a 45 - 60° slope to 20 m depth (Plate F1-d). The degree of habitat complexity within the grooves (up to 3 m deep) is maximum. Live coral cover is 40% in

this zone and, although gorgonians are low in abundance (5% cover), some Gorgonia measured 2 m across. Sponges in this area are large and the community is diverse.

Bank Sand

Offshore of the forereef is an extensive sand bank. Burrowing activity is high.

Summary

Bordered nearly 100% by bedrock shore line, Great Tobago, Little Tobago, and Watson Rock exhibit near-vertical cliffs which lead to a deep sparse sandy bank. The remoteness of The Tobagos and the lack of many calm, sheltered sandy anchorage sites provide an opportunity for isolated day trips for hikers, divers, and snorkelers.

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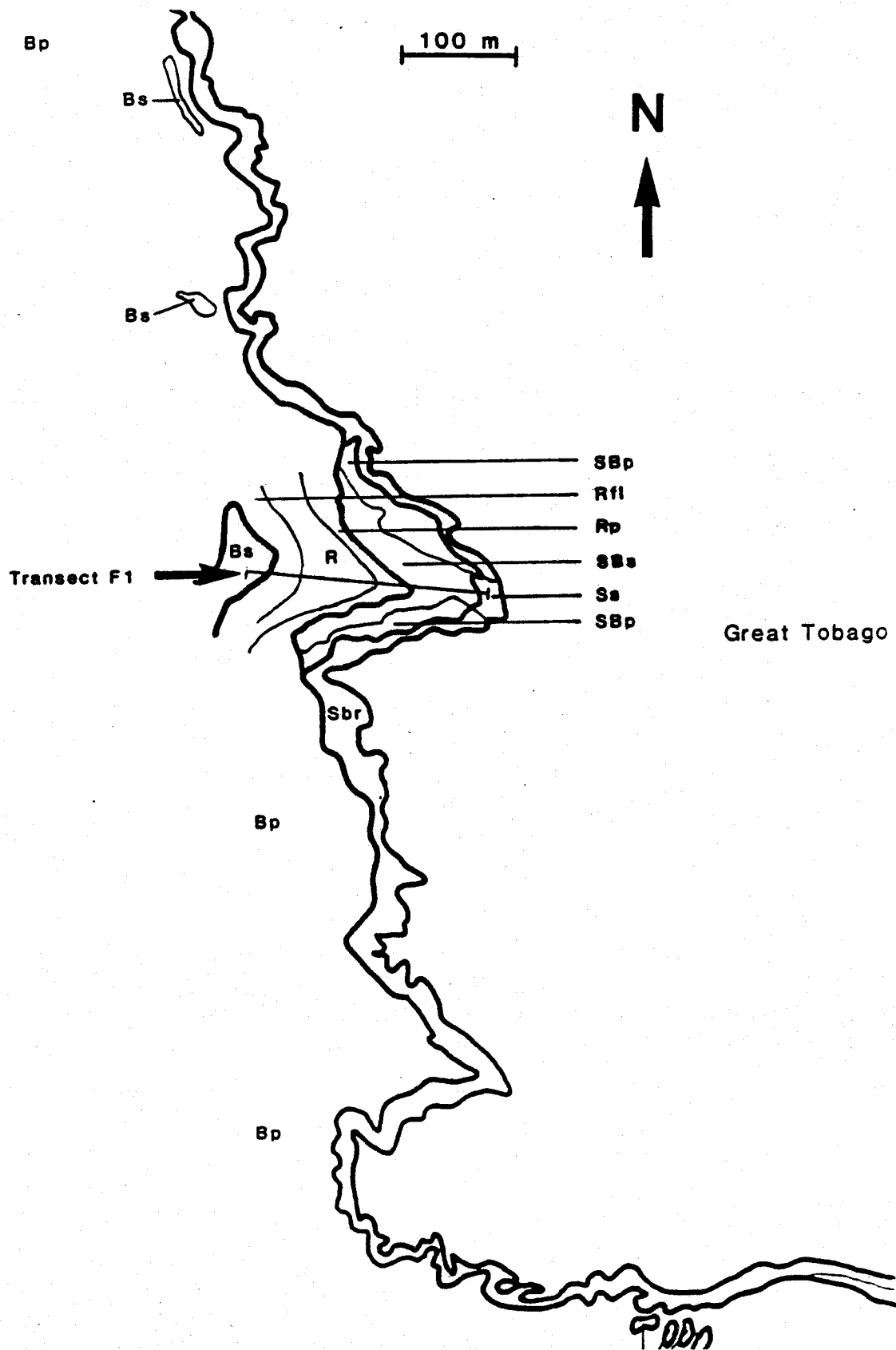


Figure F1

Location of transect F1 at Great Tobago

Profile F1

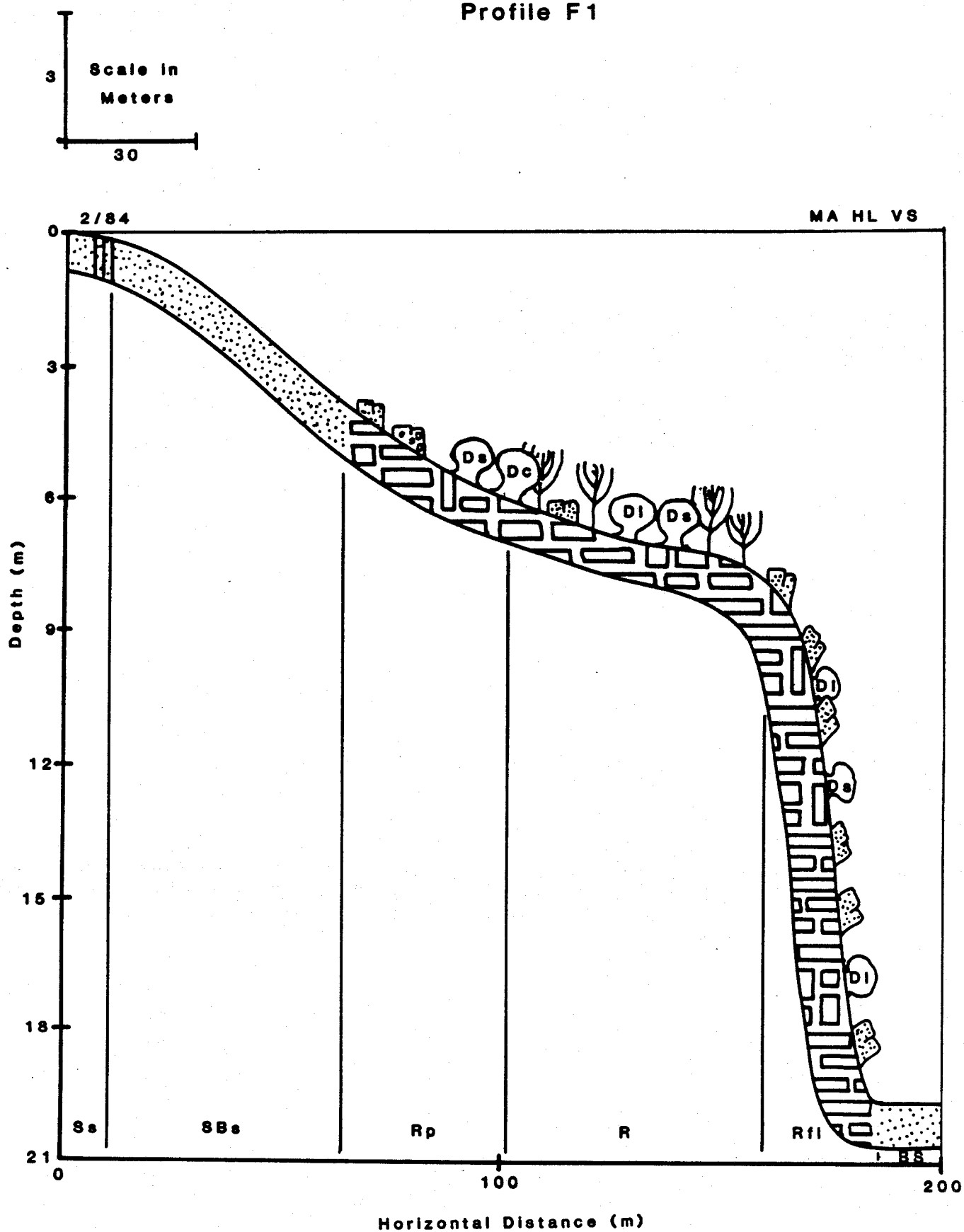
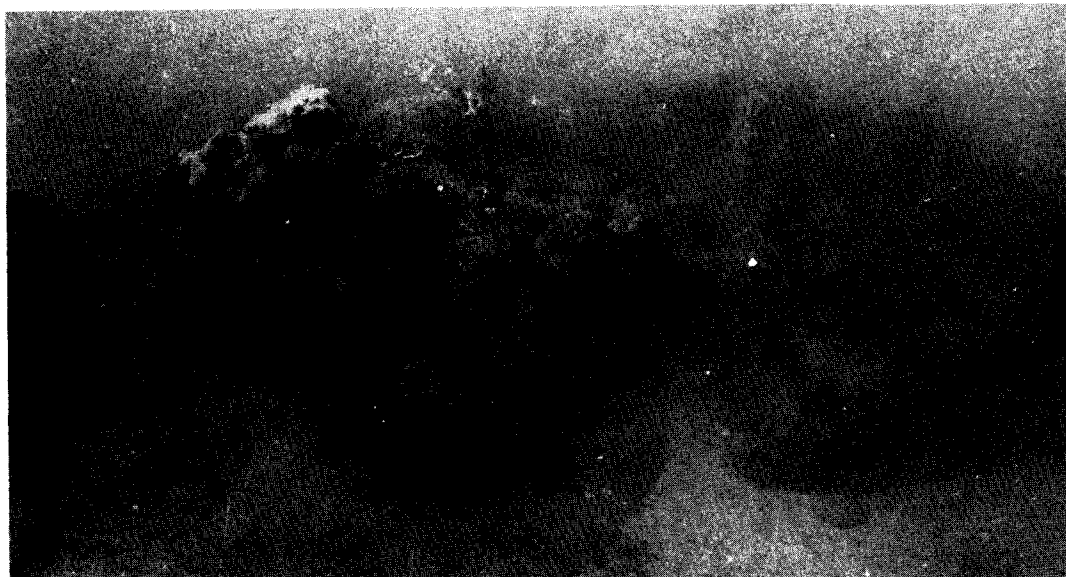
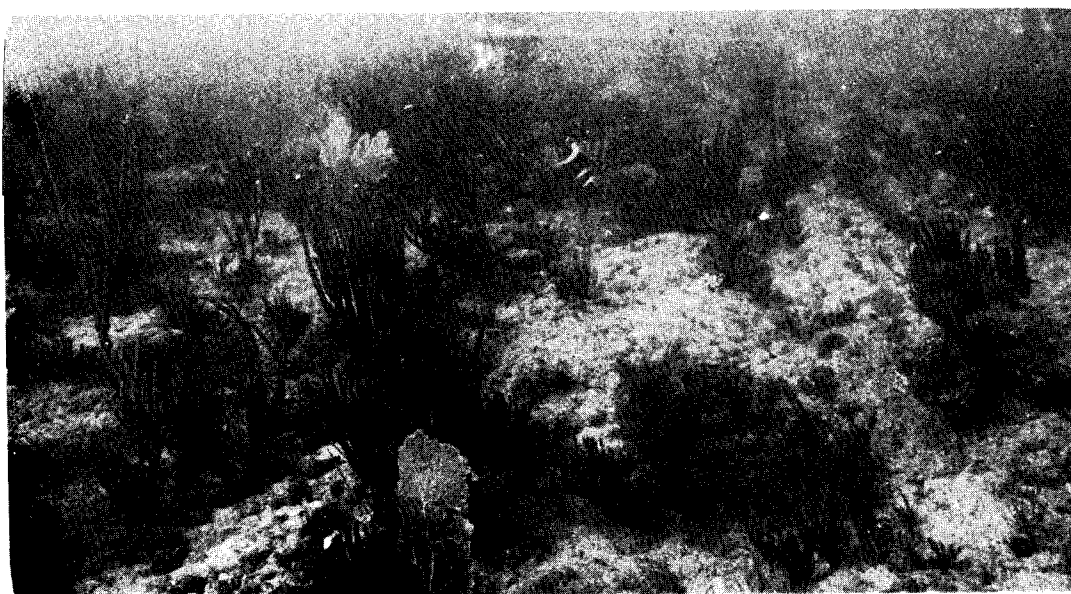


Table F

Site		Fl					
Zone		S	SBs	Rp	R	Rfl	Bs
Depth Range (m)		0	0- 4	4- 6	6- 7.5	7.5- 20	20+
H A R D C O R A L	Acer				+	+	
	Apal			+	+	+	
	Aga				+	+	
	Col					+	
	Den				+		
	Dcli			*			
	Dlab				*	*	
	Dstr			*	*	*	
	Eus					+	
	Fav			+			
	Hel					+	
	Isas					+	
	Iso					+	
	Mea					+	
	Mil			+	+	+	
	Mann			*	*	*	
	Mcav			*			
	Myc					+	
TOTAL # SPP.				9	10	16	
G O R G O N I A N S	Bri						
	Ery				+		
	Eun				+		
	Gor			+		+	
	Mur						
	Ple						
	Plxl				*		
	Ptg						
	Pst				*		
	Pal						
TOTAL # SPP.				1	4	1	
C O V E R	% HC	1	10	25	40		
	% Go	1	5	60	5		
	% Z		2				
	% DC	10				55	
	% T			83	15		
	% S	50	88				100
	% Sbr	50					
Habitat Complexity		1	1	3	4	5	1
O R G A N I S M S	Pal			+			
	spg					+	
	Zoa			+			



F1-a



F1-b

Plate F1-a,b Tobago

F1-a: Shallow bay sand, F1-b: Shallow bay pavement



F1-c



F1-d

Plate F1-c,d Tobago
F1-c: Reef, F1-d: Lower forereef

LITTLE JOST VAN DYKE

Introduction

The proposed marine park site at Little Jost Van Dyke includes the south shore of the island, Green Cay (located ca. 200 m to the east), and Sandy Cay (located ca. 2 km due south of Green Cay; Fig. G). Two transects at Little Jost Van Dyke proceed south; transect G1 is located on the southeast shore of the island, and transect G2 surveys the biological communities within a bay where there is a jetty on southwest Little Jost Van Dyke. Transect G3 heads southwest from the southwest shore of Green Cay. At Sandy Cay, transect G4 maintains a north-northwest heading from a reef fringing the northwest coast. Sandy Cay has previously been studied but relocatable transects were not established (Teytaud, 1983).

The site at southwest Little Jost Van Dyke (G2) serves as an overnight anchorage. Southeast Little Jost Van Dyke (G2) is rarely used as a day or night anchorage. Southwest Green Cay (G3) is subject to being used as a day anchorage, although an occasional boater will stay overnight. Visitors commonly anchor for day use off of the southwest shore of Sandy Cay, but the northwest coast (G4) is not normally used for this purpose.

LITTLE JOST VAN DYKE

Transect G1

Transect G1 is aligned with the cement building on shore and proceeds in a southerly direction, perpendicular to shore (Fig. G1). Three sand subzones occur along the transect line; one is

located immediately seaward of the beach, another separates two bank reef zones, and a third borders the seaward base of the seaward-most bank forereef. One strip of pavement lies seaward of the shallowest sand subzone (Profile G1; Table G).

Shore Zone

Eighty percent of the shore zone is composed of bedrock. A sand beach comprises the remaining 20%.

Bank Sand/Pavement

Sand (100% cover) occurs seaward of the shore zone and interfaces with bank pavement (2.5 m depth). Live coral (10% cover) and gorgonian density (10% cover) is greatest at the seaward edge of the pavement (4 m depth).

Bank Lower Forereef/Sand

A lower forereef begins a 45° slope seaward at 4 m depth. Montastrea annularis contributes significantly to the live coral cover of 40%. Gorgonians colonize 5% of the sea floor, sand accounts for 15% of the substrate, and the lower forereef terminates in sand at 8 - 9 m depth. The bank sand is colonized by filamentous algae.

Bank Reef/Sand

A backreef rises from the bank sand (9 m depth) to 5.5 m depth. The backreef supports a community composed of live corals (40% cover), gorgonians (10% cover), and sponges. The reef crest community composition is similar to that of the backreef (Table G). A relative decrease in live coral density occurs on the bank

forereef (to 30% cover), however, both gorgonians (15% cover) and sponges increase in abundance. Vase sponges are large. Platy M. annularis, and the black corals Stichopathes and Antipathes occur here.

The forereef interfaces with a flat sand bank at 17 m depth. The presence of infauna is indicated by burrows.

Transect G2

Transect G2 extends south from a sand and mangrove lined bay on the southwest coast of Little Jost Van Dyke (Fig. G1). It traverses seagrass, a fringing reef, and terminates over an algal plane which slopes to greater than 17 m depth (Profile G2; Table G). To the south and west of the transect, the substrate decreases in depth and a sandbar projects most of the way across the channel to Jost Van Dyke.

Shore Zone

Dense mangrove growth occurs in the intertidal mud. Halodule dominates the healthy seagrass bed which borders the mangroves. Beginning at ca. 0.3 m depth Thalassia becomes the dominant seagrass.

Fringing Reef

The Thalassia seagrass bed overlaps with the shoreward portion of the reef zone. Some sand has settled on the dead Porites porites reef (1 m depth) and Thalassia (10% cover) colonizes it. The density of the dead P. porites thicket increases and the Thalassia abundance decreases as the reef crest is approached (0.3 m depth). Less than 1% of the P.

porites here is living and, combined with an abundance of the hydrocoral Millepora and a relative increase in live P. porites cover on the forereef (to 5%), the total live coral cover for the fringing reef is 20%.

Shallow Bay Sand

A strip of clean sand (a grazing halo) occurs at the base of the reef (1 m depth).

Shallow Bay Algae/Seagrass

Predominantly filamentous algal growth begins at 3 m depth and is sparse. The penshells Pinna carnea are common and sponges are growing on the carbonate debris in the bay.

A healthy population of the seagrass Syringodium occurs on the west side of the bay, with areas at 2 m depth having 100% cover. Syringodium is present as patches between 3 m and 7 m depth.

GREEN CAY

Transect G3

Transect G3 proceeds southwest from the southwest shore of Green Cay, across a narrow fringing reef, bank pavement, and a gorgonian/coral flat (Profile G3; Table G). A larger fringing reef, adjacent to but not crossed by the transect, is also described (Fig. G2).

Shore Zone

The shore zone has three constituents. Cobble occupies the highest intertidal belt, beach rock occurs in the middle of the

zone (0.3 m depth) and consolidated Acropora palmata composes the seaward edge of the intertidal region (0.3 - 0.5 m depth).

Fringing Reef

A narrow (4 - 5 m width) fringing reef occurs between the shore zone (0.5 m depth) and the bank (2 m depth). Live corals (20% cover), gorgonians (3% cover), the zoanthid Palythoa (5% cover), algae, and sponges colonize the substrate. Acropora palmata, Diploria strigosa, and the hydrocoral Millepora are the dominant live corals here (Plate G3-a).

Bank Pavement

A bank pavement which is composed of sand (20% cover), and partially consolidated coral rubble colonized by algal turf (65% cover) begins at 2 m depth (Plate G3-b). The dominant corals contributing to the live coral cover of 10% are D. strigosa, A. palmata, A. prolifera, and A. cervicornis.

Gorgonian/Coral Flat

A gorgonian/coral flat begins at 3 m depth. The substrate is composed of live corals (15% cover), gorgonians (5% cover), algal turf (60% cover) and isolated patches of sand (20% cover). Dominant corals are Montastrea annularis and D. strigosa.

Fringing Reef

Transect G3 passes 2 m south of a fringing reef at the seaward edge of the pavement subzone. The fringing reef forms an arc; its northern end is adjacent to shore (Fig. G2). The backreef is primarily dead consolidated A. palmata colonized

by Lithothamnion (Plate G3-c). Habitat complexity is high. The reef crest (0.5 m depth) is composed of predominantly dead A. palmata colonized by the hydrocoral Millepora.^{*} A portion of the reef is separated into patches by channels ca. 2 m deep. The forereefs of the patches are composed of about 35% live coral, predominantly A. palmata (Plate G3-d). Some A. palmata exhibits gall formations and white band disease is evident (Davis et al., 1985; Plate G3-e). An advanced stage of fragmented A. palmata consolidation characterizes 65% of the forereef subzone.

SANDY CAY

Transect G4

Transect G4 proceeds north-northwest from the northwest shore of Sandy Cay (Fig. G3). It traverses a reef, bank pavement, and a gorgonian/coral flat (Profile G4; Table G).

Fringing Reef

Acropora palmata (some newly recruited) accounts for ca. 10% of the 15% total live coral cover of the fringing reef. A significant amount of coral rubble appears to be the result of storm damage. Large blocks of rubble are consolidated, and encrusted with the hydrocoral Millepora, coralline algae, and filamentous algae (75% cover). Live coral density decreases at the seaward edge of the reef however, species diversity is relatively high (Table G). A ledge drops to 5 m depth.

Bank Pavement

A significant amount of sand (40% cover) has accumulated on the bank pavement (5 m depth). Live corals (5% cover) and gorgonians (5% cover) increase in density at the seaward edge of the pavement (8 m depth).

Gorgonian/Coral Flat

A conspicuous decrease in live coral diversity, and increase in the number of gorgonian species present, occurs from 8 - 9 m depth (Table G). Live corals (10% cover) and gorgonians (20% cover) increase in abundance on the gorgonian/coral flat. Greater than 60% of the area is covered by consolidated coral rubble, encrusted with coralline and filamentous algae.

Summary

One of the more popular sites for cruising vessels in the British Virgin Islands, the proposed park site at Little Jost Van Dyke offers a variety of submarine tropical environments for enjoyment by the public. The sites surveyed were chosen as typical of those areas attracting visitors, as well as those including the entire spectrum of marine communities.

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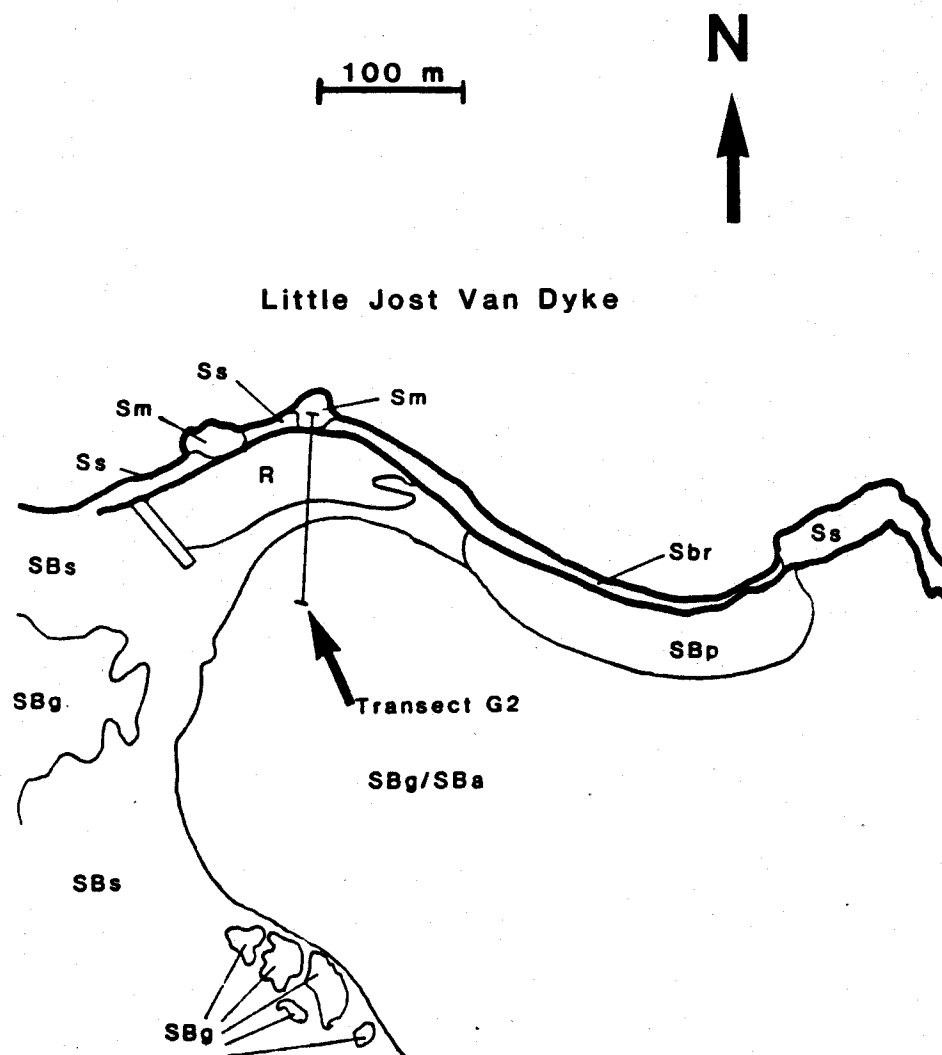


Figure G1

Location of transect G2 at Little Jost Van Dyke

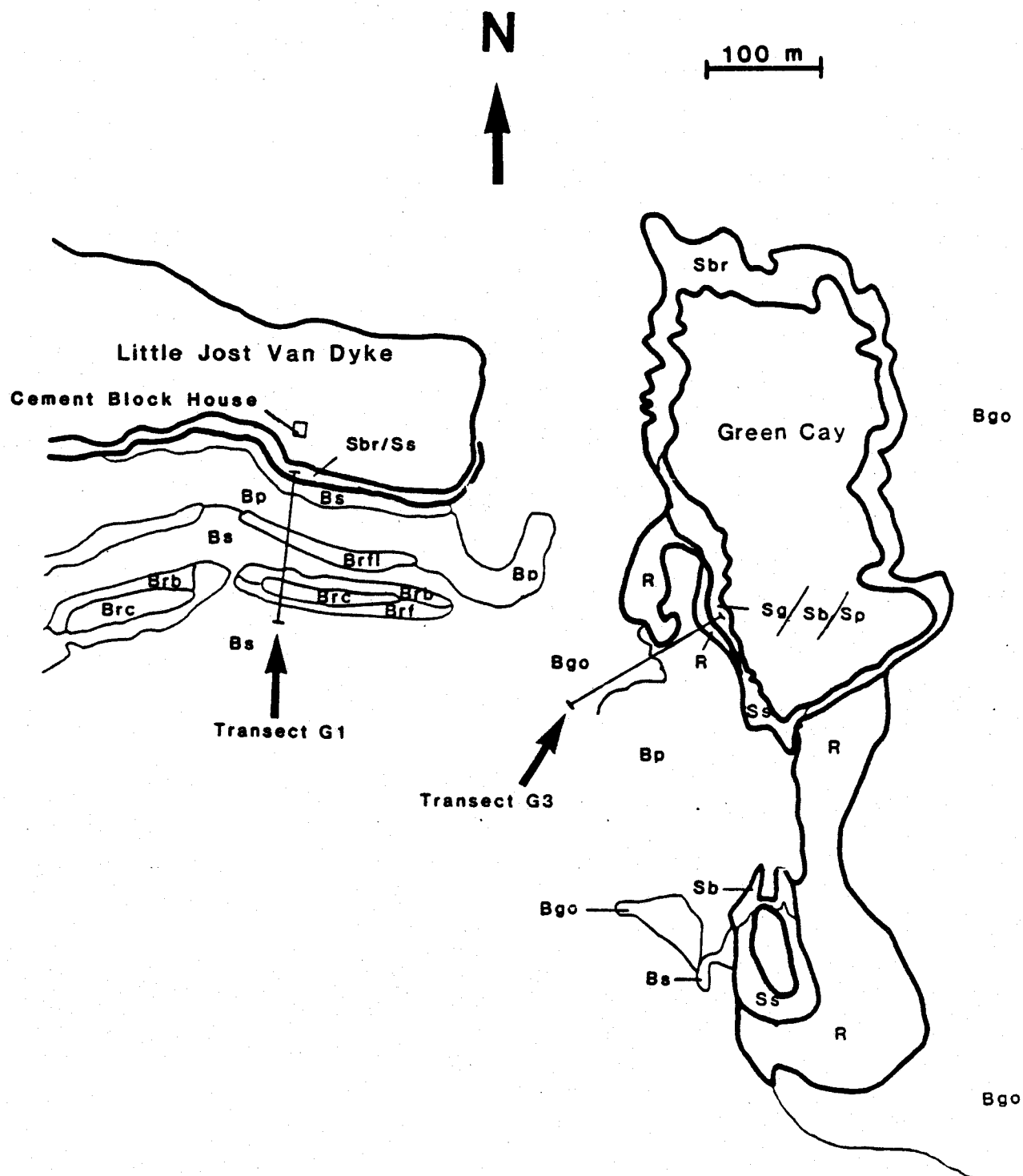


Figure G2

Location of transects G1 and G3 at Little Jost Van Dyke and Green Cay

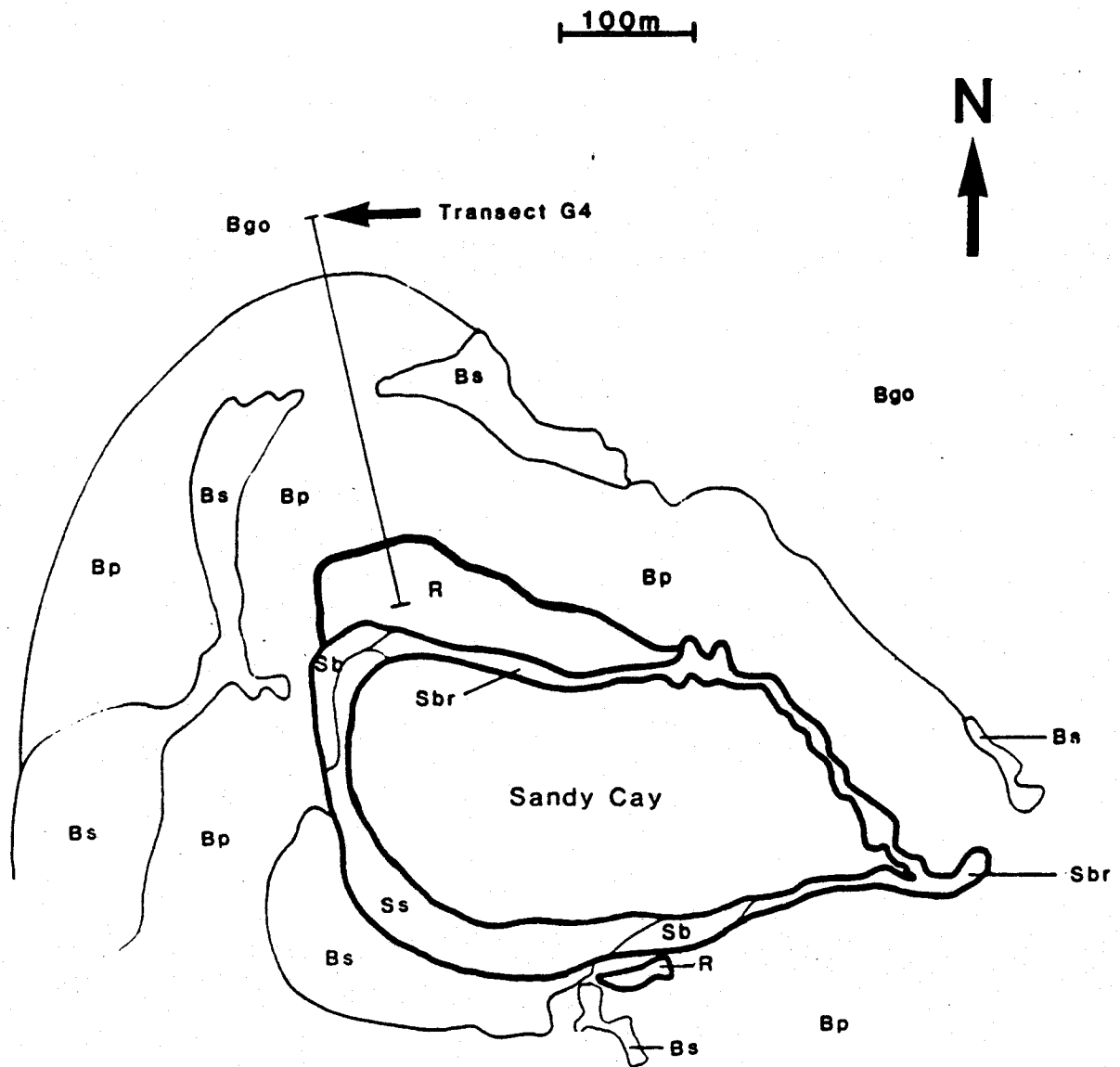
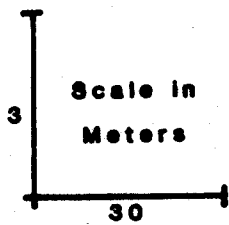
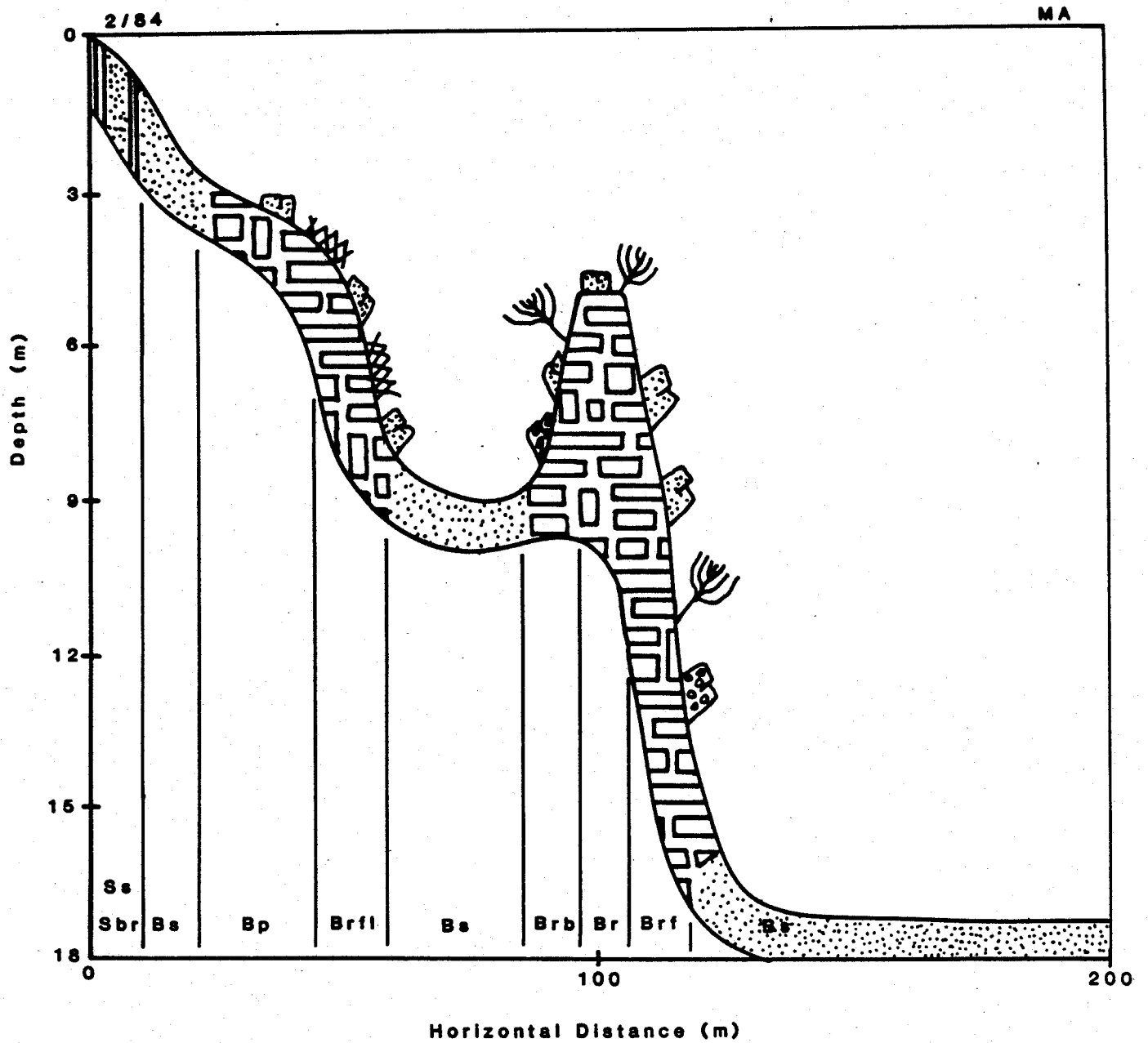


Figure G3

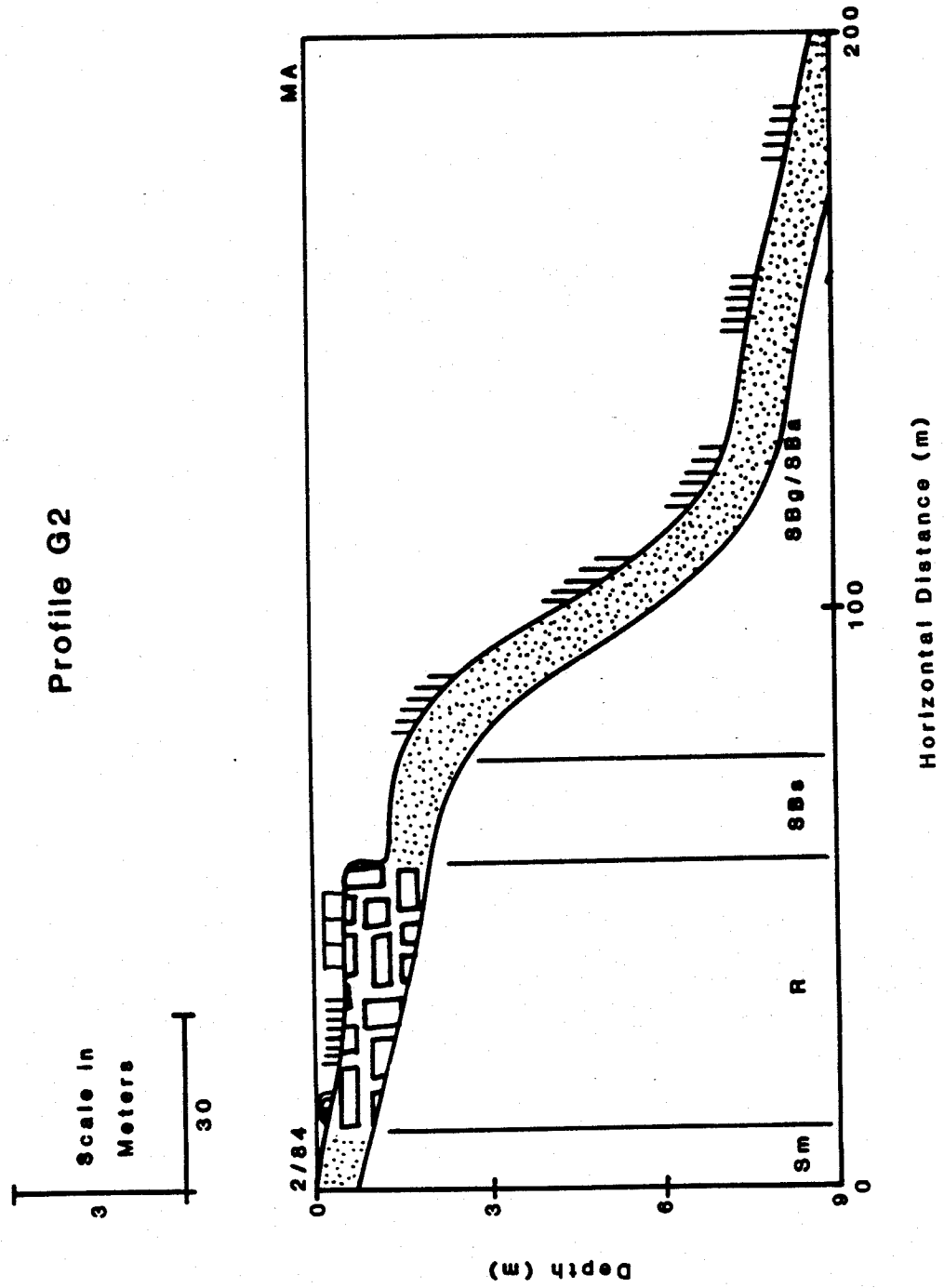
Location of transect D4 at Sandy Cay

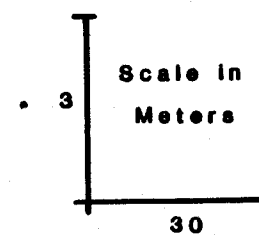
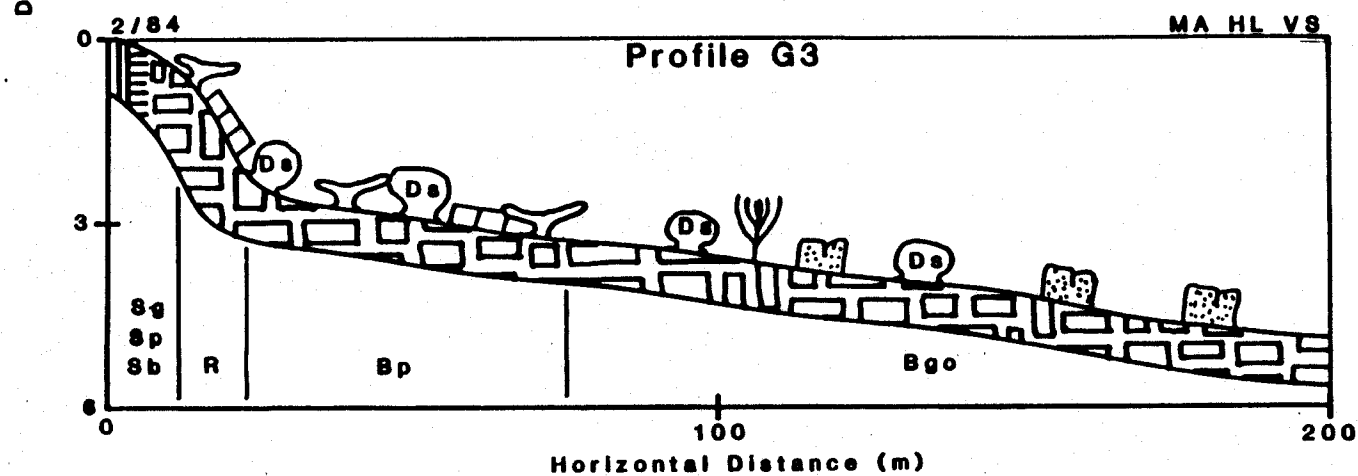
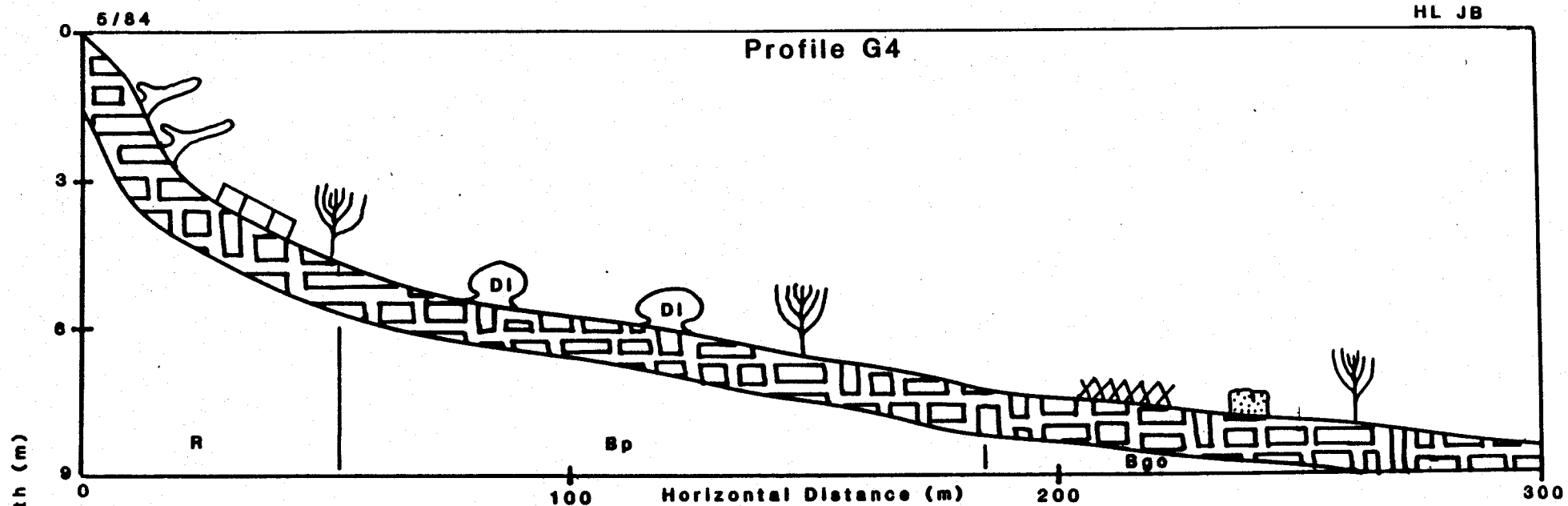


Profile G1



Profile G2

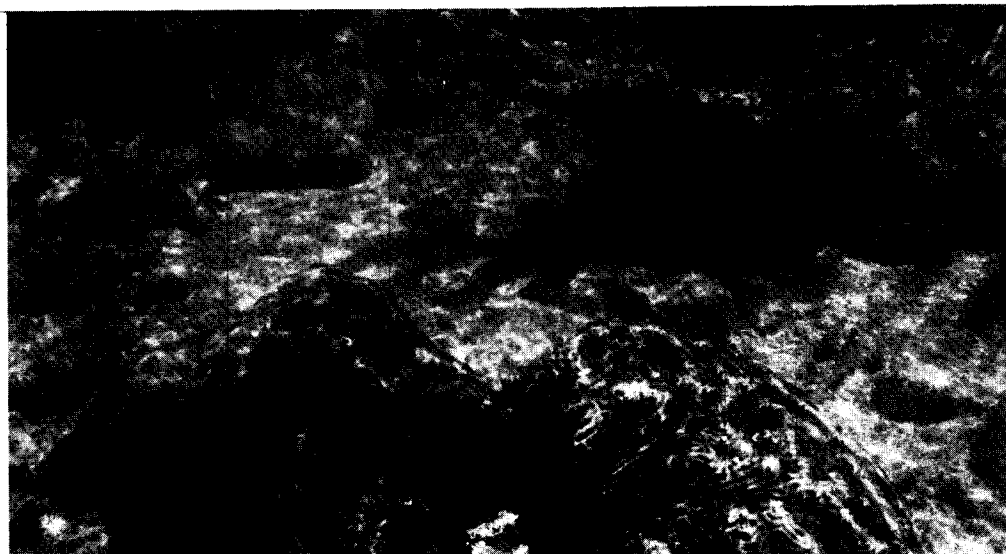




Data from transects G1 - G4

Table G

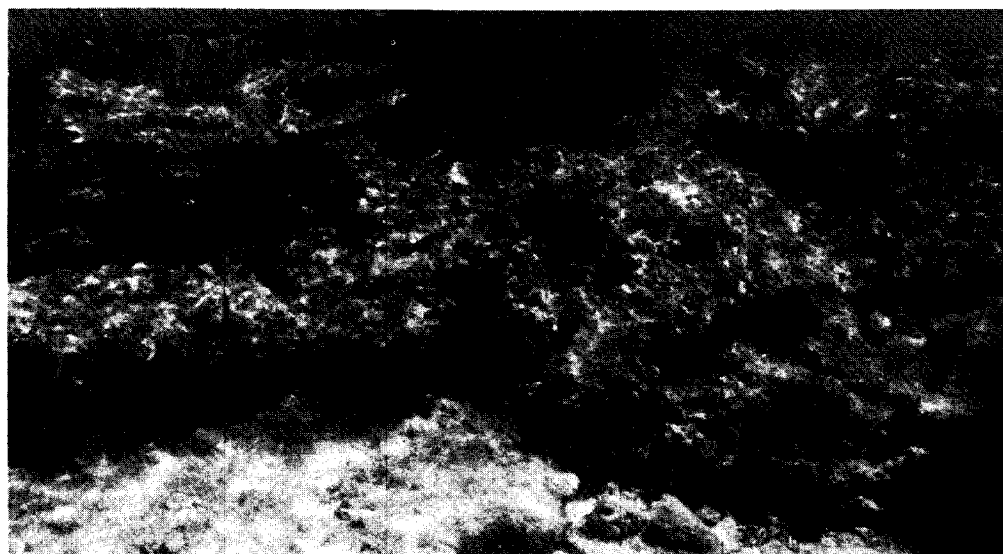
Site		G1										G2				G3				G4			
Zone		Sbr/Ss	Bs	Bp	Brfl	Bs	Brb	Brc	Brf	Bs	Sm	R	SBs	SBa/SBg	Sg/Sb/Sp	R	Bp	Bgo	R	Bp	Bgo		
Depth Range (m)		0-1	1-2.5	2.5-4	4-9	9-17	17-25	25-33	33-41	41-49	0-0.3	0.3-1	1-3	3-17	0-0.5	0.5-2	2-3	3-4	0-5	5-8	8-9		
HARD CORALL	Acer			+	+		+	+	+								*	+	+	*	+	+	
	Apal																*	*	+	*			
	Appro																*						
	Aga									+									+	+			
	Col							+	+	+													
	Den																	+					
	Dic																			+			
	Dcli																+						
	Dlab			+	+			+	+	+										+	+		
	Dstr			+	+			+	+	+							*	*	*	+			
	Fav																			+		+	
	Isas																			+			
	Mea																				+		
	Mil							+	+	+		*					*	+	+	*	+		
Mann			+	*			+	+	+									*		+	+		
Mcav							+	+	+										+		+		
Myc								+	+														
Past			+	+			+	+	+							+	+		+	+			
Ppor											+						+			+			
Srad									+											+			
Ssid									+								+						
TOTAL # SPP.				5	5		8	9	12		2					7	6	6	10	10	3		
GORGONIANS	Bri			+	+												+			+	+	+	
	Erv						+	+															
	Eun				+		+													+			
	Gor			+	+				+								+		+	+	+		
	Mur																	+			+		
	Ple						+	+	+										+	+	+		
	Plxl				+		+	+	+										+	+	+		
	Ptg			+	+												+		+		+		
Pst																			+				
Psl																							
TOTAL # SPP.				3	5		4	3	3							3		3	5	4	7		
COVER	% HC			10	40		40	40	30		20					19	10	15	15	5	10		
	% Go			10	5		10	10	15							3		5	5	5	20		
	% Z															5	2		2	2			
	% A													45									
	% Sm										50												
	% G										50	10		45									
	% DC							20	20														
	% T			80	40		30	30	55		70					40	73	68	60	78	48		
	% S	20	100		15	100				100			100	10				20	20		40	10	
% Sbr	80														30								
% Sb															30								
Habitat Complexity		1	1	3	4	1	4	4	4	1	2	2	1	2		1	4	3	3	4	3	2	
OTHER TAPHZERRIA	Ant								+														
	Hsm																+						
	Hal										*												
	Pal																						
	Pca																+	+		+	+		
	spg							+	+	+			+										
	Sti								+					+			+			+			
	Syr																						
Tha										*	*		*										
Udo																							
Zoa																	*	+		+			



G3-a



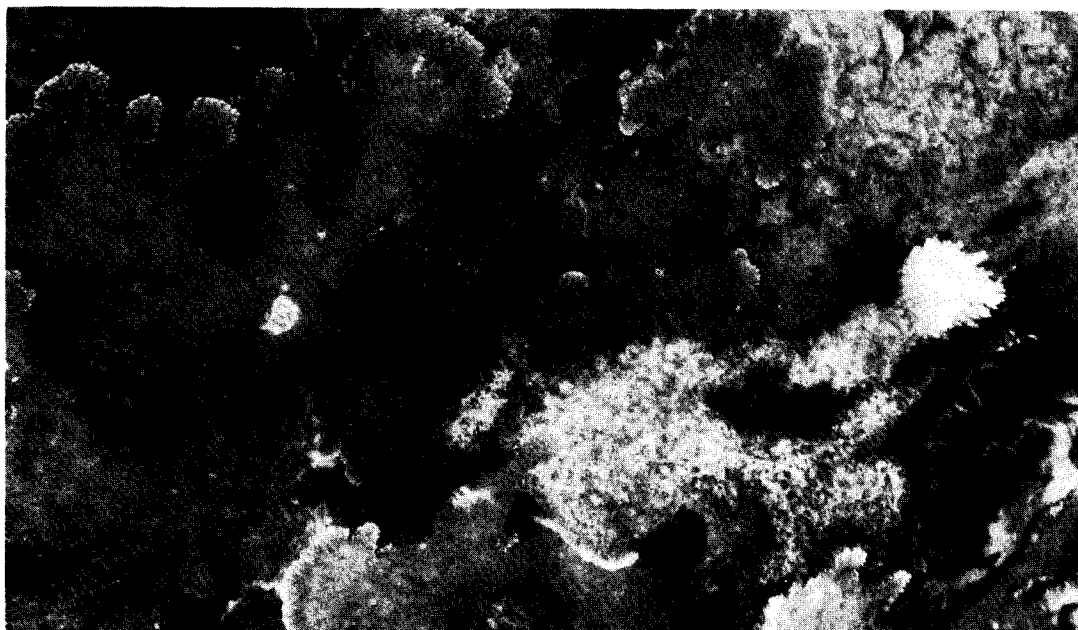
G3-b



G3-c

Plate G3 -a,b,c Green Cay

G3-a: Fringing reef, G3-b: Bank pavement, G3-c: Fringing reef



G3-d



G3-e

Plate G3-d,e Green Cay

G3-d,e: Fringing reef

CANE GARDEN BAY

Introduction

Two transects were established to survey the biological communities at Cane Garden Bay, on the northwest shore of Tortola (Fig. H). The entire length of the back of the bay is sand, except for one outcropping of rock north of Rhymer's Restaurant. Transect H1 traverses a fringing reef which connects to shore immediately south of the bedrock outcrop. Transect H2, established on the north side of Cane Garden Bay, proceeds from a cobble shore across a predominantly pavement area.

The fringing reef adjacent to the southern shore line extends across a major portion of the bay in a northerly direction. A channel beginning at the northern tip of the reef is marked by navigational buoys. The large area shoreward of the reef serves as a popular anchorage. Cane Garden Bay, sheltered by its position on Tortola and the fringing reef, has relatively low energy water movement.

Transect H1

Transect H1 begins at the outcropping of rock on the north side of Rhymer's Restaurant and proceeds southwest across the sand anchorage, shallow bay pavement, the fringing reef subzones, and bank sand (Fig. G1; Profile H1; Table H).

Shallow Bay Sand

A 100% sand substrate extends 300 - 400 m seaward of the shore. The sand is colonized by localized populations of nearly microscopic filamentous algae. Visiting boaters anchor in the

sand which reaches a maximum depth of 5 m.

Shallow Bay Pavement

A pavement area borders the sand on the south side of the bay. All solid substrate (i.e. boulders and coral rubble) is colonized by algal turf (75% cover). Sand accounts for the remaining 25% of the substrate. The pavement rises seaward from 5 m to 3 m depth.

Backreef

The backreef maintains an approximate 30' slope to the reef crest (1 m depth). The live corals (5% cover) present are predominantly small and widely spaced (Table H; Plate H1-a). Many of the larger colonies of Acropora palmata show evidence of white band disease (Davis et al. 1985). The hydrocoral Millepora is the primary contributor to the vertical relief. Gorgonians (5% cover), small sheets of Palythoa (2% cover), coralline algae, and Echinometra are present.

Reef Crest

A gradient of increasing coral cover is evident as the forereef is approached (Plate H1-b). The average live coral cover of 10% on the reef crest is dominated by A. palmata and the hydrocoral Millepora. A major portion of the A. palmata stands exhibit a knobby morphology. Algal turf accounts for 90% of the substrate cover. Encrusting sponges are common.

Upper Forereef

The reef crest (1 m depth) drops vertically to 3 m depth. A spur and groove system has developed across the forereef. Sand channels separate vertical walls colonized by live corals (20% cover) and gorgonians (5% cover; Plate H1-c). The hydrocoral Millepora and A. palmata are the dominant corals. White band disease is prevalent (Davis et al. 1985). Algal turf comprises 50% of the forereef substrate.

Forereef Pavement

A reef pavement (ca. 75 m width), bordering the base of the upper forereef (3 m depth), slopes to 7 m depth (Plate H1-d). Live corals (5% cover) and gorgonians (5% cover) are sparse and no organisms are noticeably dominant. Stands of A. palmata are present and few colonies are infected with white band disease. A gradient of increasing live coral cover and diversity is evident at the deeper edge of the pavement (6 - 7 m depth).

Lower Forereef

The local dominance of the corals M. cavernosa, M. annularis, A. cervicornis, Agaricia, Diploria species, and the hydrocoral Millepora generates cover in places as great as 90%. The average live coral cover on the lower forereef, however, is 30% (Plate H1-e). Gorgonians contribute 10% to the total substrate cover. Algal turf colonizes the portion of the substrate composed of coral rubble and pavement (60% cover). Sponges are large and diverse.

Bank Sand

The base of the lower forereef interfaces with bank sand (20 m depth). The sand supports a thin layer of algal turf.

Transect H2

Transect H2 proceeds southwest, from the cobble shore zone on the northern point of Cane Garden Bay (Fig. H1). It crosses shore pavement, bank pavement, and bank sand (Profile H2; Table H).

Shore Zone

Loose cobble composes the shore and interfaces with beach rock at the tide line. The shore zone constituents have been cemented together to form a shore pavement in the intertidal region.

Bank Pavement/Beach Rock

A subzone composed of cemented bedrock boulders begins at ca. 1 m depth. Live coral cover is 10% and zoanthids contribute 5% to the substrate cover. The pavement drops to 2 m depth at its seaward edge forming a precipice made of cemented boulders (up to 1 m across).

Bank Pavement

A sparse bank pavement begins at 2 m depth and supports live corals (10% cover), gorgonians (5% cover), and zoanthids (5% cover).

Bank Sand

The pavement interfaces with sand at the navigational buoy marking the boat channel at the entrance of Cane Garden Bay. The sand channel is barren except for patchy filamentous algal growth.

Summary

One of the more popular anchorages in the BVI is Cane Garden Bay. Its fringing reef combined with its sheltered position on Tortola makes it a particularly well suited area for overnight anchorage. The reef crest is convoluted with buttress canyons and grottos and, given good weather conditions, produces a particularly attractive area to snorkel. A lot of litter was seen in the central sandy area of the bay.

The palm tree lined white beach along the entire back of Cane Garden Bay, its spectacular sunsets, excellent anchoring conditions and overall friendliness lends to its rapidly growing popularity. However, extremely low live coral cover and an excessively littered sea floor maybe indicative of its already degraded condition.

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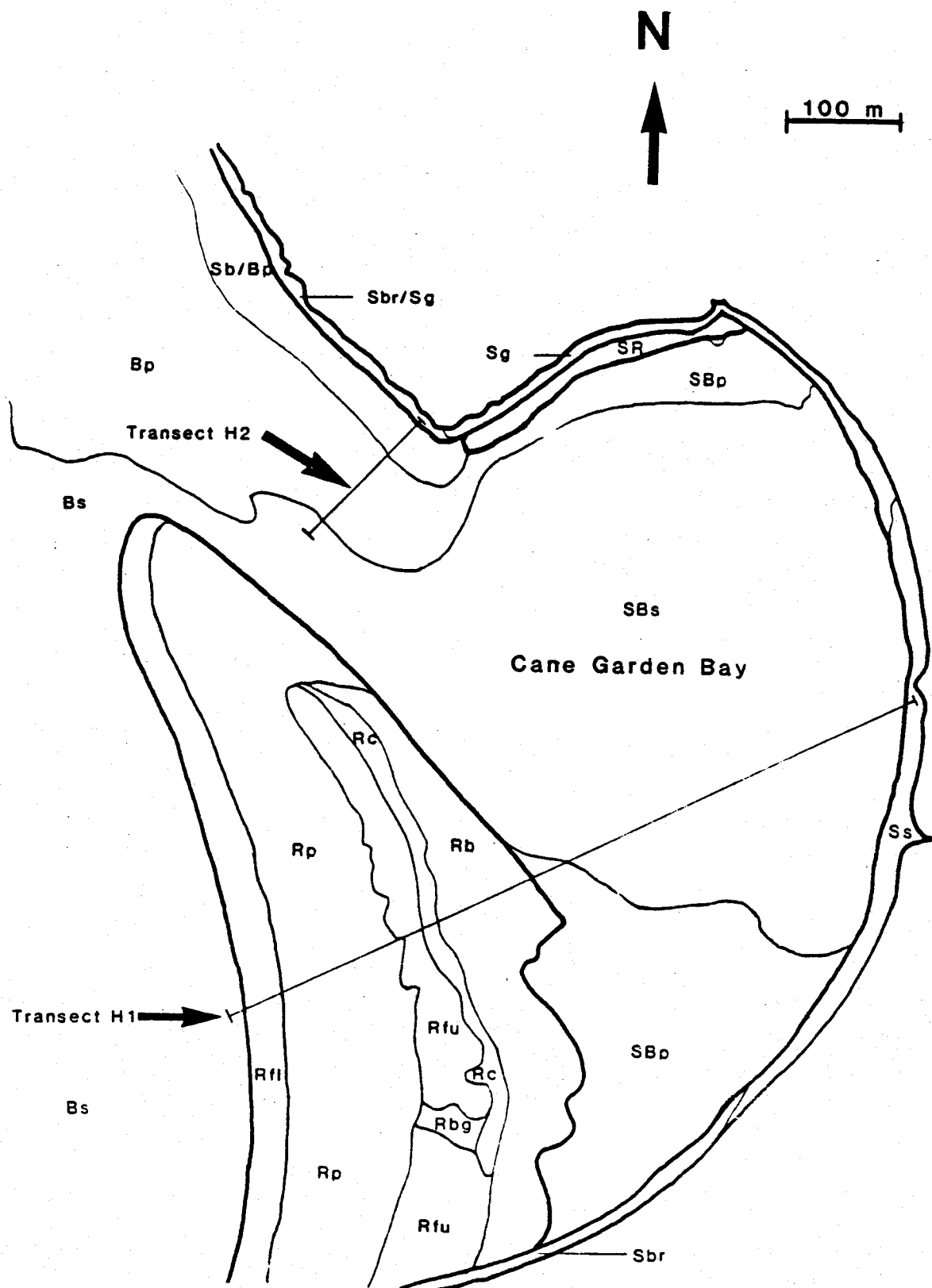
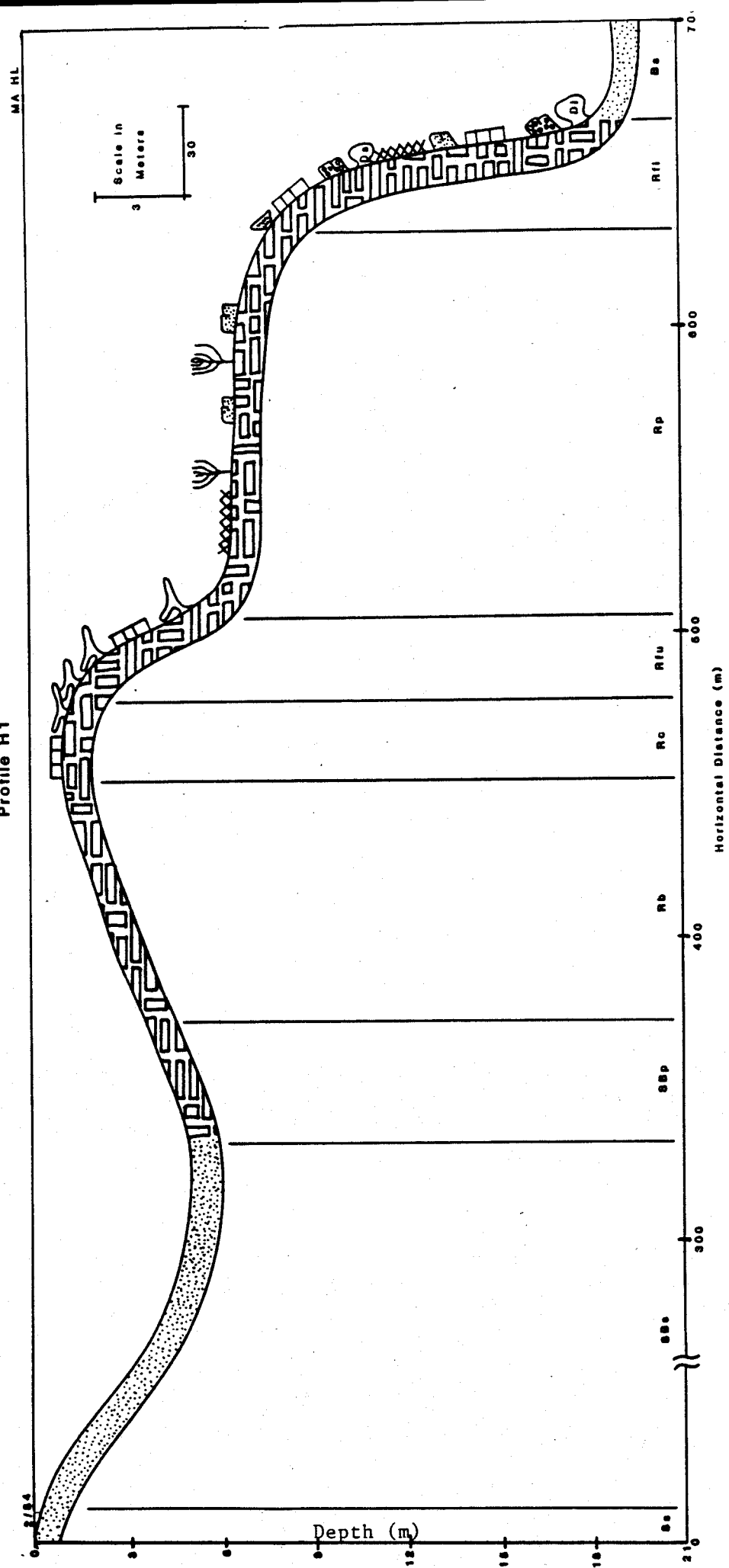


Figure H1

Location of transects H1 and H2 at Cane Garden Bay on Tortola

Profile H1



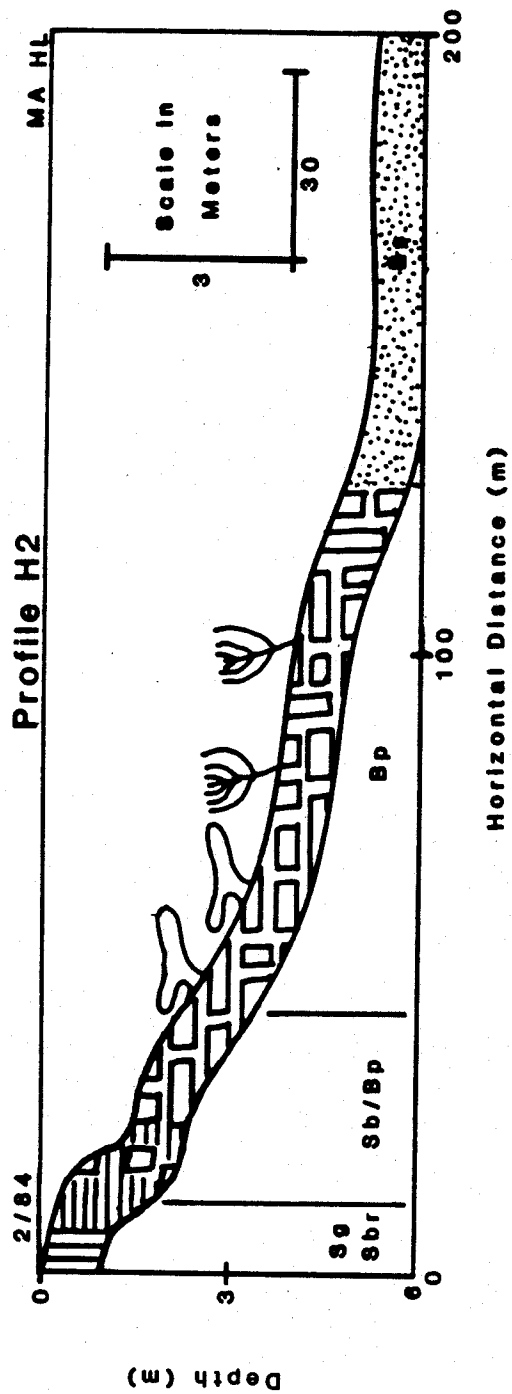
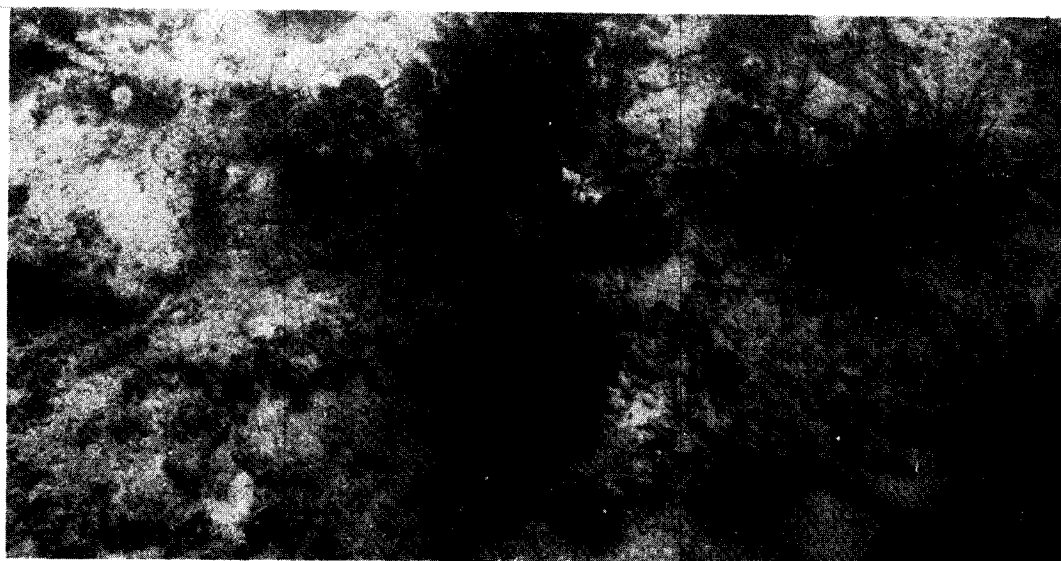


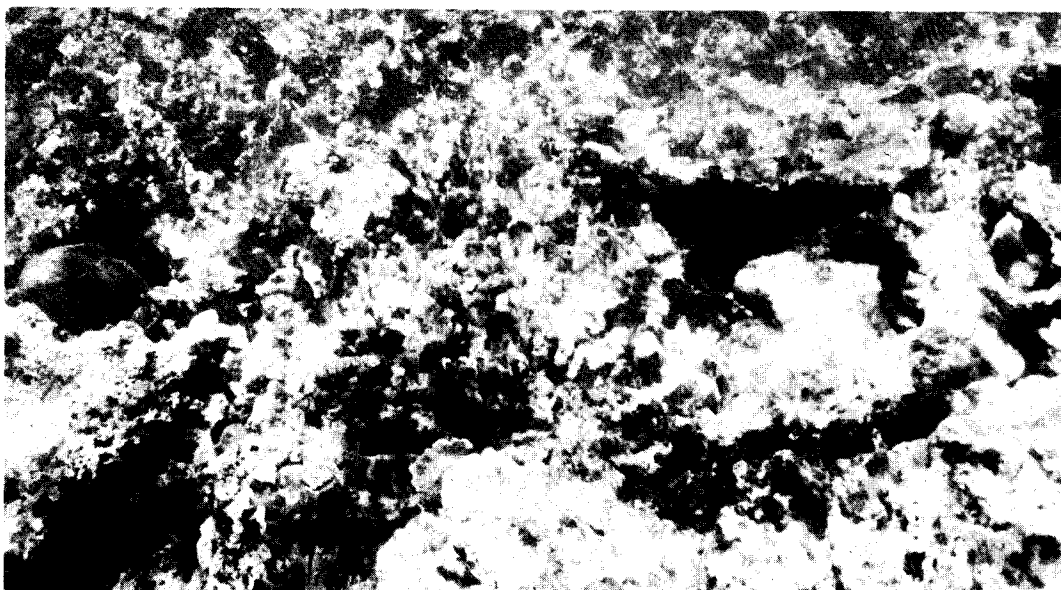
Table H

Data from transects H1 - H2

Site		H1								H2			
Zone		SBs	SBp	Rb	Rc	Rfu	Rp	Rfl	Bs	Sbr/Sg	Sp/Bp	Bp	Bs
Depth Range (m)		0-5	5-3	3-1	1-3	3-7	7-20			0-1	1-2	2-5	
H A R D C O R A L	Acer					+	*						
	Apal			+	*	*	+				+	*	
	Aga						+	*				+	
	Col							+					
	Den					+		+					
	Dic							+					
	Dcli						+	*			+	+	
	Dlab						+	*					
	Dstr			+	+		+	*				+	
	Egs							+					
	Fav			+	+								
	Hel							+					
	Iso							+					
	Mdec						+	+					
	Mea							+					
	Mil			+	*	*		*					
	Mann				+	+	+	*			+	*	
	Mcav						+	*					
	Mus							+					
	Past			+	+			+				+	
	Ppor			+	+			+					
	Srad			+	+		+						
	Ssid			+	+		+	+					
TOTAL # SPP.				8	9	4	11	20			3	6	
G O R G O N I A N S	Bri												
	Ery												
	Eun					+	+					+	
	Gor					+	+					+	
	Mur					+							
	Ple												
	Plxl						+						
	Ptg												
C O V E R	Pst					+							
	Psl												
TOTAL # SPP.						4	3					2	
C O V E R	% HC			5	10	20	5	30			10	10	
	% Go			5		5	5	10				5	
	% Z			2							5	5	
	% DC					25							
	% T		75	88	90	50	70	60			85	80	
	% S	100	25				20		100				100
% Sbr										100			
Habitat Complexity		1	1	1	1	3	1	3	1	1	1	1	1
O R G A N I S M	Eci			+									
	Ham			+									
	Pal			+	+	+					+	+	
	spg				+			+					
	Zoa			+							+	+	



H1-a



H1-b

Plate H1-a,b Cane Garden Bay

H1-a: Backreef, H1-b: Reef crest

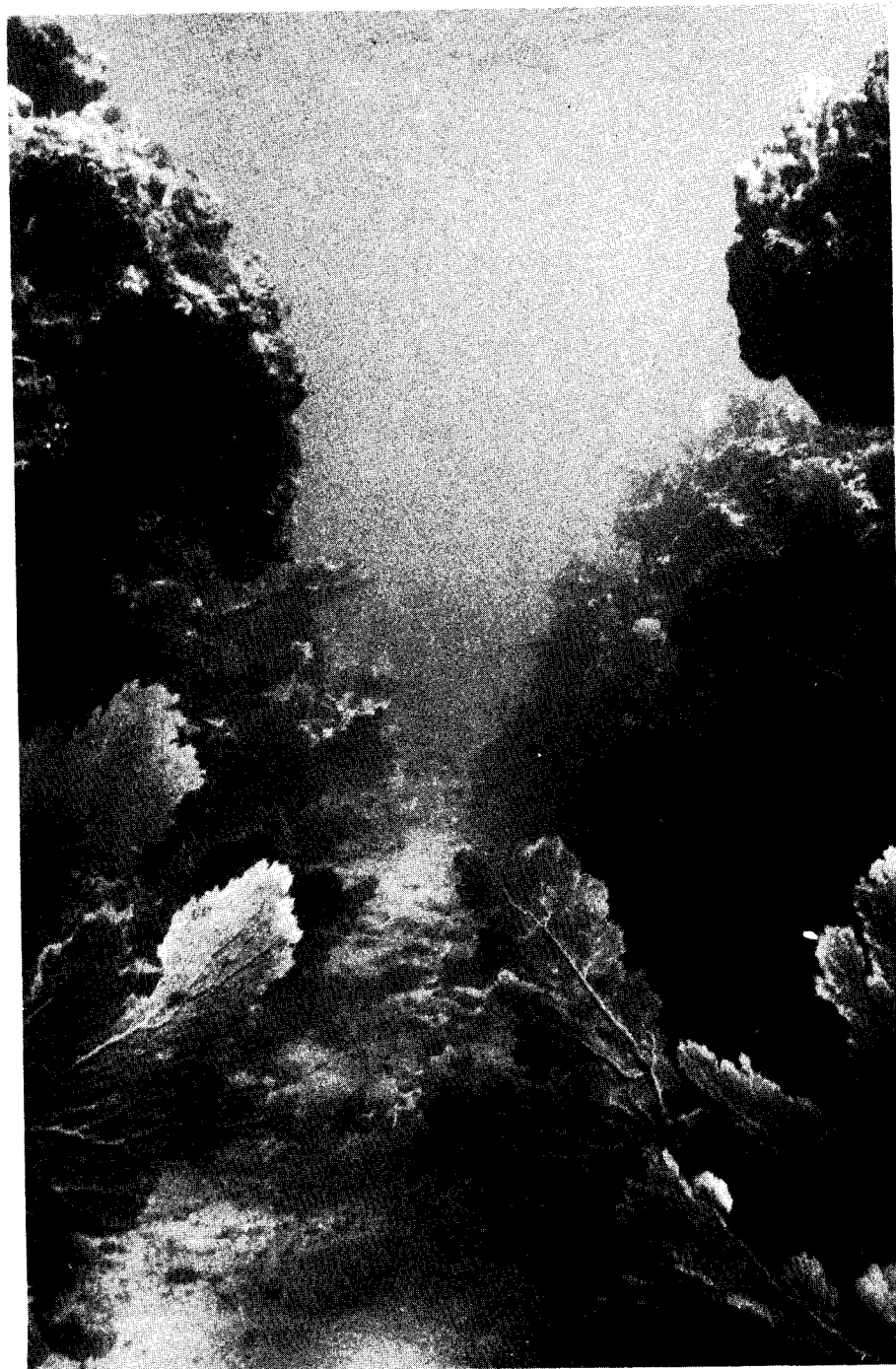


Plate H1-c Cane Garden Bay

H1-c: Upper Forereef



H1-d



H1-e

Plate H1-d,e Cane Garden Bay

H1-d: Forereef pavement, H1-e: Lower forereef

BEEF ISLAND

Introduction

The proposed marine park site at Beef Island is located in Hans Creek Lagoon, on the southern shore, between the point of land southeast of Well Bay and The Bluff (Fig. 1). The area is a delicate system of mangroves, fringing Porites reefs, and shallow bay/lagoons.

Access to Hans Creek Lagoon is limited. There is a dirt road to the westernmost point of land. A deviation from the standard linear transect format was made based on an attempt to ground truth representative shallow bay, lagoon, and reef communities here.

Transect 11 proceeds seaward (of the access point) across shallow bay sand, lagoon pavement, and a barrier reef, reenters the lagoon (ca. 0.325 km to the east), and terminates in the mangrove shore zone (Fig. 11).

Transect 11

Two profiles were prepared for transect 11. Profile 11a illustrates the biological communities colonizing the shallow bay sand and lagoon pavement on the west end of Hans Creek Lagoon. Profile 11b illustrates more clearly the occurrence of reefs on the lagoon's east end (Profile 11a, 11b; Table 1).

Shallow Bay

The shallow (up to 1.5 m depth), quiet water bay at the west end of Hans Creek Lagoon has a predominantly sand bottom and is bordered by dense mangrove growth. The alga Digenia simplex

with epiphytic filamentous algae (less than 5% cover) is present in localized patches (Plate 11-a). Local patches of Penicillus, Udotea, and filamentous algae also occur on the southern side of the bay. The frequency of shrimp burrowing activity is extremely high.

A particularly dense population of filamentous algae at the southern margin of the shallow bay colonizes a sand substrate to the west (Plate 11-b) which grades into Porites porites rubble to the east (Plate 11-c). The rubble is also colonized by corals (less than 5% cover), and seagrass (Table 1).

Bank Pavement

A channel (3 m depth) passes between a mangrove cay and the rocky point of land to the west. It interfaces with a broad sand plane, bordered on the seaward side by pavement (which extends the entire distance, in an east - west direction, of Hans Creek Lagoon). The channel is virtually completely covered with algal turf. On the pavement, a few small colonies of live coral are present (Table 1).

Reef Zone

A major portion of the east - west oriented barrier reef crest is emergent. It is apparent that coral rubble has been hurled onto the reef crest by storm seas. The backreef and forereef, composed of pavement, are colonized by coral (less than 5%) and algal turf (greater than 95%).

Lagoon Sand

The sand bordering the bank reef is stabilized by the rhizoidal growth of the seagrasses Syringodium, Halodule, and Thalassia (Plate 11-d). Seagrass density increases at the edges of the patches at which point the substrate drops vertically (10 - 15 cm) to a sandy region within the lagoon.

The sand in the lagoon is subject to heavy burrowing activity, rendering it loose and white. The effect is to give the lagoon a particularly rich turquoise color.

Lagoon Patch Reefs

Several patch reefs occur within the lagoon and are composed of dead, bleached white P. porites (Plate 11-e).

Fringing Reef

A fringing reef, composed of P. porites (ca. 0.5 km long and 15 - 25 m wide), borders the back of the lagoon and has 10% total live coral cover. The forereef has virtually 100% live cover and rises vertically from the lagoon sand (Plate 11-f). A major portion of the reef crest is dead and, as the mangrove shore line is approached, live coral cover becomes zero. Here Thalassia is dominant and recruits from the mangroves are locally abundant.

Shore Zone

The mangrove stands at Hans Creek are particularly dense and healthy. The fringing reef is apparently growing seaward while the reef crest is being successively colonized by seagrass and mangroves.

Summary

The study area at Beef Island would be ideal for a long term monitoring of mangrove growth. Human impact on the environment at this site, other than litter, is minimal at present. The lagoon at Hans Creek is a beautiful example of the delicate interdependence of ecological communities (mangrove cays and shore lines, fringing and barrier reefs, sandy and grassy lagoons), and preservation of this complex environment should rank as high priority.

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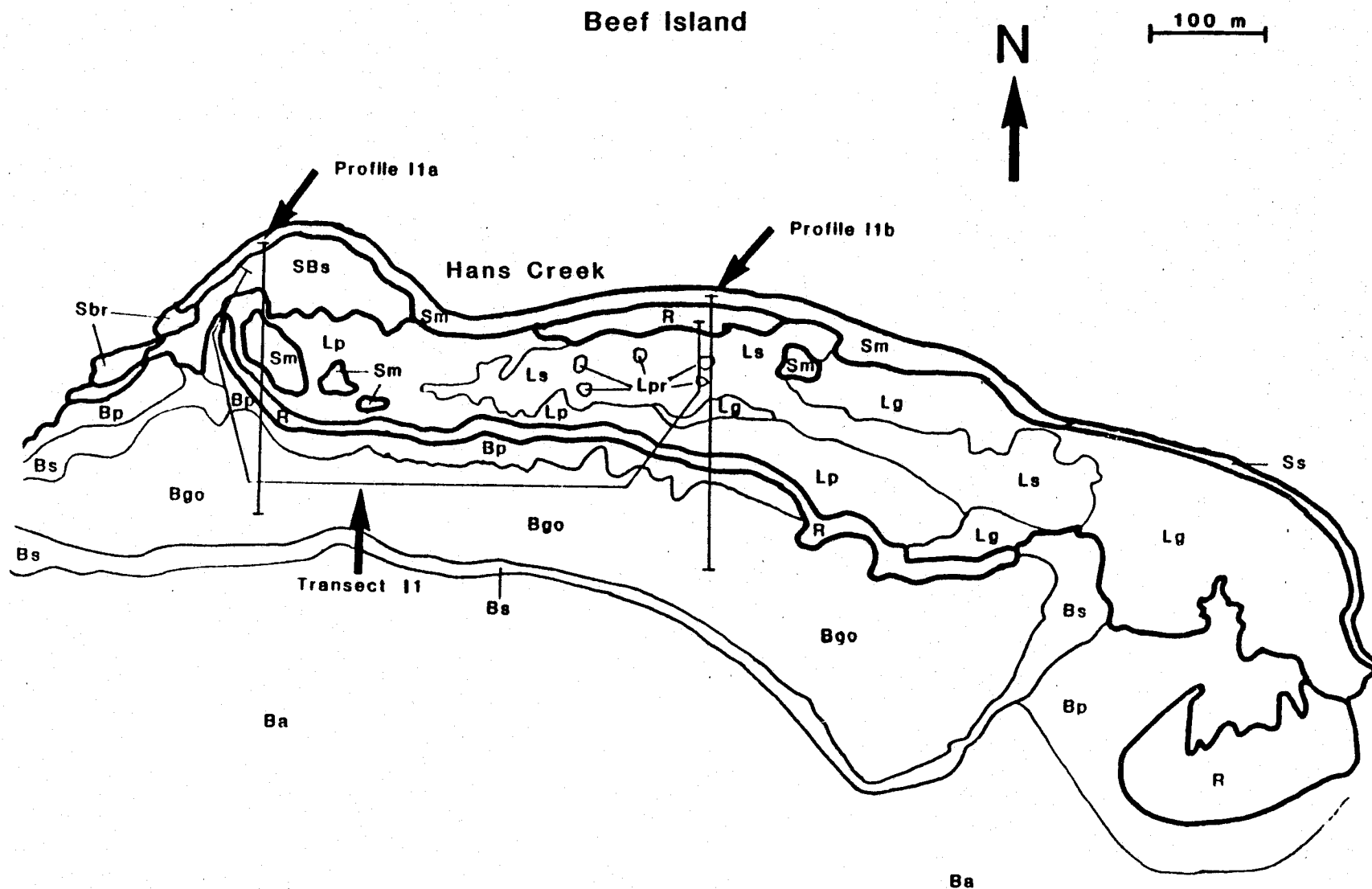


Figure 11

Location of transect 11 and profiles 11a and 11b at Beef Island

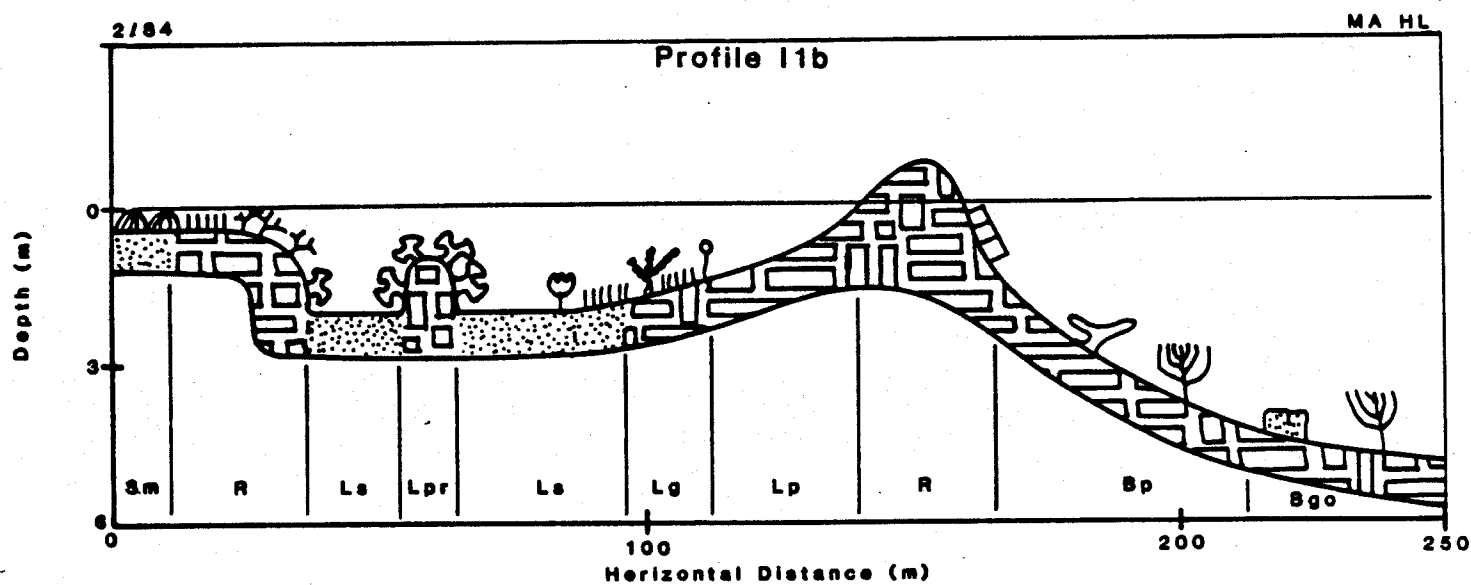
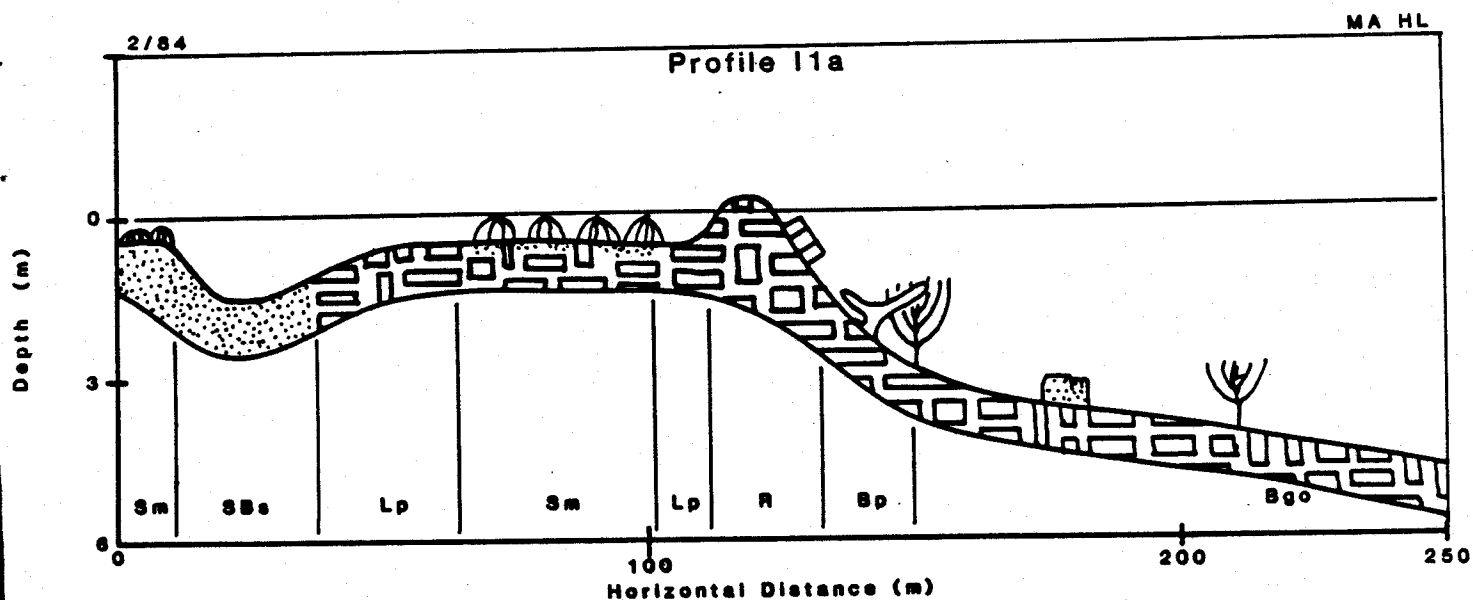
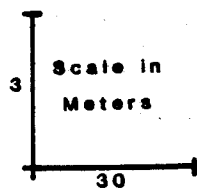
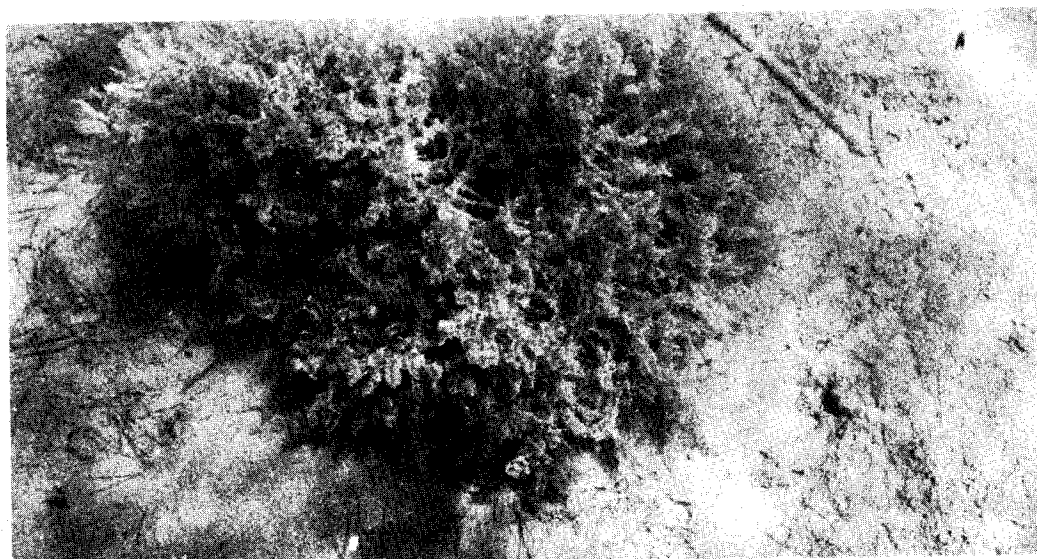


Table I

Data from transect II

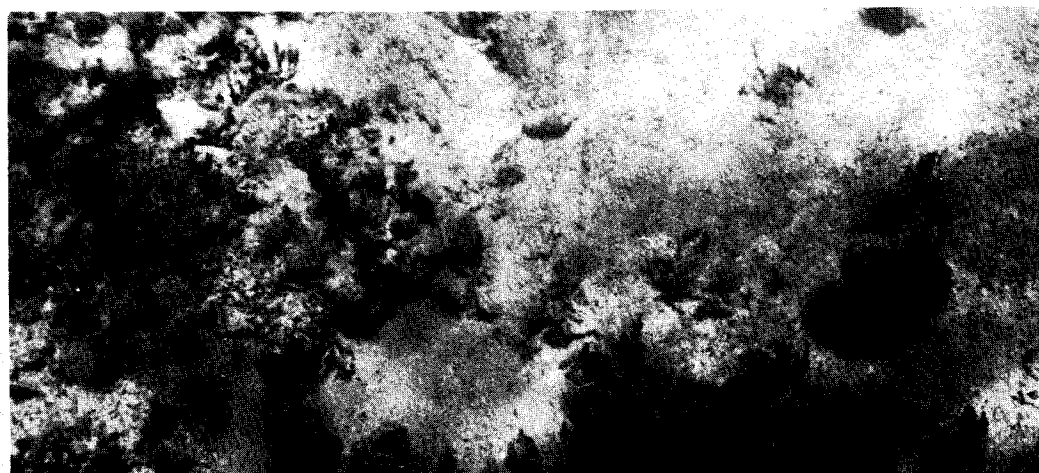
Site		II.							
Zone		SBs	Bp/Bgo	R	Lp	Ls	Lpr	R	Sm
Depth Range (m)		0-1.5	1.5-10	1.5-0	0-1	0-2	1-2	2-0.5	0.5-0
H A R D C O R A L	Acer		*						
	Apal		*	+					
	Apro	*							
	Aga		+						
	Dcli		*						
	Dlab		*						
	Dstr		*						
	Fav		+						
	Mil	*		+				+	
	Past		+						
L	Ppor	*	+				+	*	
	Ssid		+						
TOTAL # SPP.		3	10	2			1	2	
C O V E R	% HC	5	5	5				10	
	% Z								
	% A	10							
	% Sm								100
	% G	5				5		15	
	% DC		2				100	75	
	% T		93	95	100				
Habitat Complexity		1	2	2	1	1	2	2	3
O R G A N I S M S	Dsi	*							
	Gra	+							
	Ham	*							
	Hal					*			
	Pen	*							
	Svr					*			
	Tha	*				*		*	
S		*							
Udo		*							



I1-a



I1-b



I1-c

Plate I1-a,b,c Beef Island

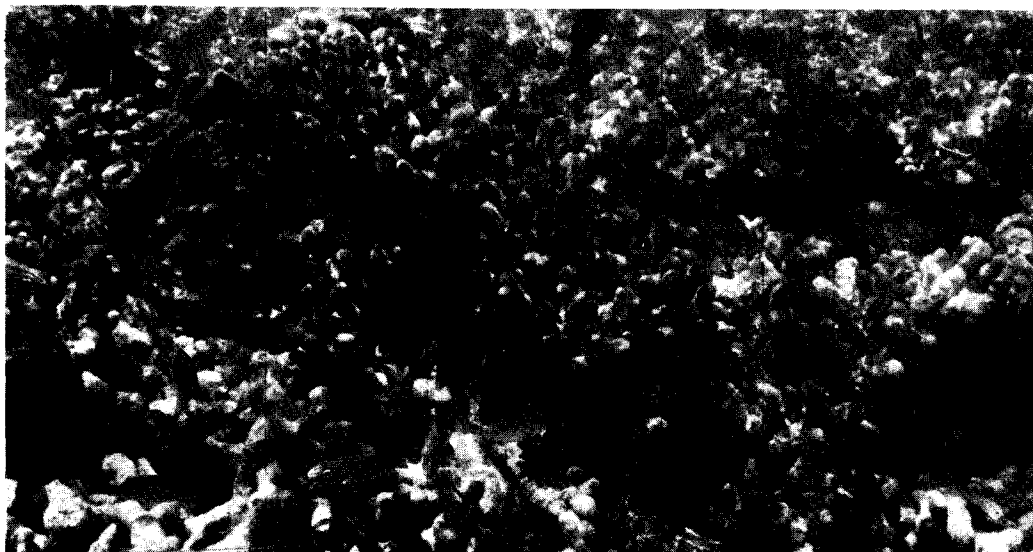
I1-a: Lagoon sand, I1-b: Lagoon algae, I1-c: Shallow bay sand



I1-d



I1-e



I1-f

Plate I1-d,e,f Beef Island

I1-d: Lagoon grass, I1-e: Lagoon patch reef, I1-f: Fringing reef

THE DOGS

Introduction

The proposed marine park site at The Dogs includes four islands that compose The Dogs (West Dog, Great Dog, George Dog, and Cockroach Island), two islands that form The Seal Dogs (West Seal Dog and East Seal Dog), and the passages between them (Fig. J). Anchorages provided by the islands are primarily suited for day use; an occasional boater will stay overnight.

Bedrock cliffs border most of each island's shore; sand beaches occur on the north of Great Dog, the south of George Dog, and southeast of East Seal Dog. These beach areas are subject to a major portion of the day use traffic here. Other areas within The Dogs are frequented by SCUBA diving tour operations.

Nine transects were established within this site. One (J1) crosses the subtidal bedrock and bank zones on eastern West Dog. A second (J2) and third (J3) traverse reef areas on south and north Great Dog respectively. Transects J4 and J5 survey communities on opposite sides (the northwest and southeast shores) of George Dog. The sixth (J6) and seventh (J7) transects are located off the southeast and north shores of Cockroach Island, respectively. The north side of West Seal Dog is the site of transect J8, and transect J9 proceeds north from the north shore of East Seal Dog.

WEST DOG

Transect J1

The transect proceeds north from the shore zone bordering an

east extending finger of bedrock on West Dog (Fig. J1). The subtidal bedrock zone interfaces with a gorgonian/coral flat at ca. 3 m depth (Profile J1; Table J).

Subtidal Bedrock

Crevices (1 m wide) are formed by the fractured structure of the island. The bedrock surfaces are relatively barren (33% uncovered), and yet the diversity and abundance of live corals (15% cover) and gorgonians (5% cover) increases with distance from shore (Table J). Palythoa (3% cover) and algal turf (44% cover) also colonize the substrate in this zone.

Gorgonian/Coral Flat

A shift to a zone with a conspicuous increase in live coral (30% cover) and gorgonian abundance (10% cover) begins at 3 m depth (Plate J1-a). Palythoa (5% cover) is present.

Acropora prolifera and A. cervicornis coral rubble colonized by algal turf (45% cover) borders patches of sand (10% cover) and increases in abundance with depth.

Acropora palmata colonies are dominant on the shallower portion of the bank. The branches of some stands are much more palmate, rather than branching in the classic elkhorn style (Plate J1-b). Many new recruits were noted (ca. 50% new and 50% rejuvenating). Montastrea annularis is the dominant live coral on the deeper portion of the bank (greater than 5 m depth).

GREAT DOG

Transect J2

South Great Dog has a relatively shallow (1.5 m depth)

near-shore insular shelf (Profile J2). Shallow bay pavement and sand occupying this region interface with a reef zone which extends seaward to more pavement (Fig. J2; Table J).

Shallow Bay Pavement

A thin veneer of sand (60% cover) has settled on the shallow bay pavement. Filamentous algae, Echinometra, and some Diadema are present on the sandy pavement cover close to shore. Consolidated coral rubble, colonized by algal turf (20% cover) and crustose coralline algae, creates an irregular pavement surface (Plate J2-a).

Shallow Bay Sand

Transect J2 proceeds from the pavement across a patch of sand (Fig. J2). Live corals (<5% cover), gorgonians (2% cover), zoanthids, and coral rubble colonized by algal turf contribute less to the total substrate cover here than in the pavement subzone..

Reef

A series of patch reefs occurring parallel to the shore have bases composed of predominantly dead Porites porites and Acropora palmata (Plate J2-b). The reef crests come to within 1 m of the surface and are composed of live A. palmata colonies (Plate J2-c). Sand channels (average 7 m width) lined by dead A. palmata and A. cervicornis, and a few live Montastrea annularis recruits separate the patch reefs.

Reef Pavement

Live coral and gorgonian density and diversity increase in the reef pavement subzone (Table J). Live corals cover 45% and gorgonians contribute 10% to the total substrate cover.

Transect J3

A sand beach bordered on each end by bedrock boulders lines a cove on the north side of Great Dog (Fig. J2; Profile J3). The diversity of the live coral in the bay is unusually high (equal in number of coral species only to transect A1; Table J). The transect begins in the middle of the beach and runs due north crossing a reef, sand, and a gorgonian/coral flat.

Shore Zone

The shore is 100% sand. The sand extends ca. 7 m offshore at 1 m depth.

Reef

A small dead reef fringes the beach beyond which the substrate (of an area approximately the size of a football field) is colonized by a diversity of corals (15 - 40% cover). The patch reefs are separated by sand channels (20% cover).

The reefs that occur here are predominantly composed of Montastrea annularis, capped by the hydrocoral Millepora, and are in close proximity (within 1 m) to Porites porites thickets (Plate J3-a,b). These coral species are particularly healthy and are among the dominant corals in this community (Table J). The sand that occurs between the patch

reefs is primarily colonized by Acropora cervicornis, P. divaricata, and small heads of Montastrea annularis.

The health of the A. cervicornis thickets present ranges from 90% alive to 90% dead. Some white band disease is evident and a station for the long term monitoring of the disease was established here (Davis et al. 1985). Several of the P. divaricata colonies present are bright blue. One colony collected for positive identification was confirmed to be P. divaricata.

Acropora palmata becomes the dominant coral in this zone as the distance from shore increases (Plate J3-c). Montastrea annularis and P. porites colonies are smaller in this area than in the near shore region (Plate J3-d). The reef edges are bioeroded and therefore porous. The relatively cryptic corals Tubastrea, Helioseris, and Scolymia are present here.

Montastrea annularis dominates the live corals on a narrow pavement area seaward of the patch reefs. Fragmented branches of A. palmata compose a major portion of the pavement. This coral rubble is colonized by some live corals.

Bank Sand

A strip of sand (25 - 30 m width) is located seaward of the pavement area (from 3 m to 5 m depth) and serves as an anchorage for visiting boaters.

Gorgonian/Coral Flat

A bank interfaces with the sand strip at ca. 5 m depth. Between 15 and 20% of the bank is colonized by live corals and an equal amount of the substrate is covered by gorgonians. This bank slopes gradually seaward.

GEORGE DOG

Transect J4

An isthmus of sand connects a rocky outcropping to the southern tip of George Dog. The sand forms a beach (ca. 100 m long) on the southeast shore of the island, which terminates on its eastern end at another outcropping of bedrock. Transect J4 begins here and heads southeast across a reef, a gorgonian/coral flat, bank sand, and a bank seagrass zone (Fig. J3; Profile J4; Table J).

Reef

The reef immediately adjacent to the shore zone is composed of predominantly live and healthy stands of Acropora palmata (Plate J4-a). A shift to live coral dominance by Montastrea annularis begins at 2 m depth (Plate J4-b). The M. annularis colonies are healthy; areas 17 m across exhibit 80% live cover. Live coral cover for the entire reef area averages to 50%.

Gorgonian/Coral Flat

A sparse gorgonian/coral flat begins at 3 m depth (Plate J4-c). Montastrea annularis dominates the live coral cover

of 15% on this pavement and Pseudopterogorgia contributes significantly to the gorgonian cover of 15%.

Bank Sand

A sand halo begins at 8 m depth and borders the seaward edge of the bank pavement. It is approximately 10 m wide.

Bank Seagrass

A particularly dense bed of Syringodium begins at 10 m depth and supports a population of large conchs and helmets. Several turtles were seen in this area, although no obvious grazing scars were evident in the seagrass.

Transect J5

The northwest tip of George Dog is a popular SCUBA diving location. Transect J5 begins in the subtidal bedrock zone here and follows a due north heading across a gorgonian/coral flat, and onto bank sand (Fig. J3; Profile J5; Table J).

Subtidal Bedrock

The bedrock shore maintains a nearly vertical slope to ca. 8 m depth. A crevice penetrates 30 m into the bedrock structure. The floor of it (at 7 m depth) is strewn with smooth bedrock fragments (averaging 15 cm dia.). Greater than 60% of the bedrock substrate (including the total amount of rock fragments forming the crevice floor) is barren. The live coral cover of 15% is dominated by the hydrocoral Millepora and the zoanthid Palythoa contributes 5% to the substrate cover.

Gorgonian/Coral Flat

A bank begins at 8 m depth and slopes 15° to 23 m depth. Blue, grey, and bright green colonies of Siderastrea siderea are among the dominant corals. Acropora cervicornis is also dominant and fragments of this coral account for 40% of the coral rubble occurring here. Some bedrock boulders lie on the pavement substrate.

Bank Sand

At 23 m depth an abrupt transition from bank pavement to bank sand occurs.

COCKROACH ISLAND

Transect J6

Transect J6 proceeds across bank pavement from the rocky southeast shore of Cockroach Island (Fig. J4; Profile J6; Table J).

Subtidal Bedrock

The bedrock cliffs of Cockroach Island plunge to 3 m depth. The hydrocoral Millepora is the dominant coral contributing to the low live coral cover of 5%. Palythoa, colonizing 100% of the substrate in places, contributes 5% to the total substrate cover. Some algal turf colonizes the otherwise barren bedrock (combined cover of 87%).

Bank Pavement

Less than 10% of the flat bank pavement is colonized by

live corals. No one coral is dominant, although an abundance of Acropora palmata recruits were noted.

Transect J7

Transect J7 heads due north from the northernmost point of Cockroach Island (Fig. J4). The shore zone extends to 20 m depth and is composed of jagged and massive bedrock blocks, caves, and overhangs. A division into two zones separates the biologically different communities that colonize the bedrock (Profile J7; Table J). At the base of the bedrock zones (20 m depth) is a gorgonian/coral flat.

Subtidal Bedrock Zone 1

The effects of a high water motion regime on the zone occurring between the ocean surface and 2 - 3 m depth is immediately apparent. Small solution notches have developed in the island and the zoanthid Palythoa is uncommonly abundant (35% cover; Plate J7-a). The live corals (less than 5% cover) and gorgonians (less than 5% cover) present are scarce and stunted. Colonies of Acropora palmata are small (up to 1 m across) and crustose, although a few have sprouted short upright branches. Other hard corals are also small and sturdy (Table J).

Branching, predominantly dead A. palmata colonies occur in relatively sheltered areas near the shore. These stands are encrusted by the hydrocoral Millepora (Plate J7-b).

Subtidal Bedrock Zone 2

The bedrock substrate in this zone (3 m to 20 m depth) is structurally impressive; crevices and overhangs convolute the

down sloping wall.

The biological community in this zone has a higher density of corals and gorgonians, but is fairly equal in species diversity to zone 1 (Table J). Montastrea cavernosa is the dominant coral contributing to the live coral cover of 20% (Plate J7-c). Gorgonians generate 15% cover. Several Stichopathes colonies were seen at the deepest level.

Gorgonian/Coral Flat

Beginning at 20 m depth, a gorgonian/coral flat slopes gradually seaward. The diversity of both live corals and gorgonians here is higher than on the bedrock substrate (Table J). Montastrea cavernosa is the dominant coral contributing to the live coral cover of 15%. Gorgonians account for greater than 35% of the substrate cover and are large; several Gorgonia 1.5 m in diameter and a Pseudoplexaura 2 m high were noted.

WEST SEAL DOG

Transect J8

The transect constructed at this site runs due north from the northeast tip of the island (Fig. J5). The bedrock shore zone extends to 16 m depth and the biological communities occurring here were divided into three zones. Each zone is also characterized by slope (Profile J8; Table J).

Subtidal Bedrock Zone 1

The substrate maintains a gentle slope from the intertidal area to 3 m depth. The community present is adapted to a high

water motion regime. Low relief crustose coralline algae are dominant and Palythoa is noticeably abundant (10% cover). An Acropora palmata fringing reef is located at the seaward edge of the shelf and contributes significantly to the live coral cover (5%). No gorgonians are present. An increase in the slope of the substrate to 45° (at 3 m depth) indicates the transition to zone 2 (Profile J8).

Subtidal Bedrock Zone 2

Beginning at 3 m depth the substrate maintains a relatively steep slope to 10 m depth. Live corals (5% cover) and gorgonians (20% cover) are present (Plate J8-a,b). The substrate in this zone to the west of transect J8 is nearly vertical.

Subtidal Bedrock Zone 3

The substrate maintains a more gradual slope at 10 m depth. Montastrea cavernosa dominates the live coral cover of 10% and gorgonians contribute 20 - 40% to the total substrate cover (Plate J8-c,d). The sea floor slopes gently to 16 m depth where an overhanging ledge creates a locally high habitat complexity and then resumes its gradual slope seaward.

EAST SEAL DOG

Transect J9

A transect proceeds north from the rocky north shore of East Seal Dog (Fig. 5). It crosses a subtidal bedrock zone which slopes seaward to a gorgonian/coral flat at 5 m depth (Profile J9; Table J).

Subtidal Bedrock

Fractures originating near the top of the bedrock cliff extend subtidally to form channels (up to 3 m depth) which have been filled by sand. Bedrock boulders lie in the shore zone and are colonized by algal turf (75% cover) and zoanthids (5% cover). Acropora palmata is the dominant coral contributing to the live coral cover of 15%. White band disease was present (Davis et al. 1985).

Gorgonian/Coral Flat

Beginning at 3 m depth, 27% of the substrate is composed of bedrock boulders. Relatively small heads of Diploria species are common, contributing to the live coral cover of 25%.

Gorgonians account for 20% of the substrate cover and have a diversity equal to that of transect A1 (Table J).

Summary

Two of the most striking features of The Dogs are the isolation of the locality and the ruggedness of the coastline, both of which at first glance make the site seem less appealing to the casual day sailor. In fact, the area supports examples of the most spectacular underwater communities in all the sites surveyed. Preservation of the innate beauty of the marine world at The Dogs warrants attention in the near future while the environment is still in its natural state, as compared to other less pristine areas in the British Virgin Islands which have been more frequented by man.

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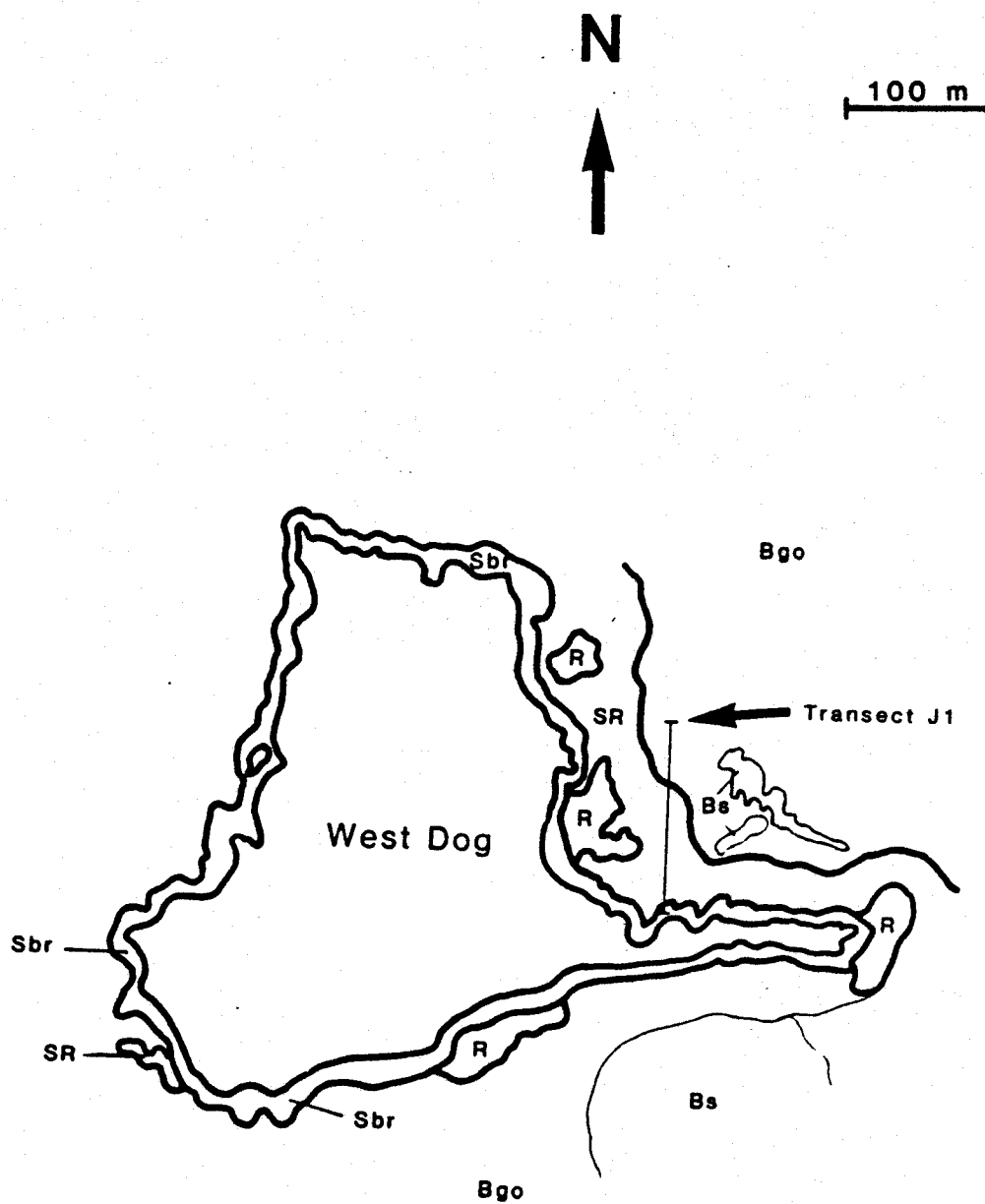


Figure J1

Location of transect J1 at West Dog

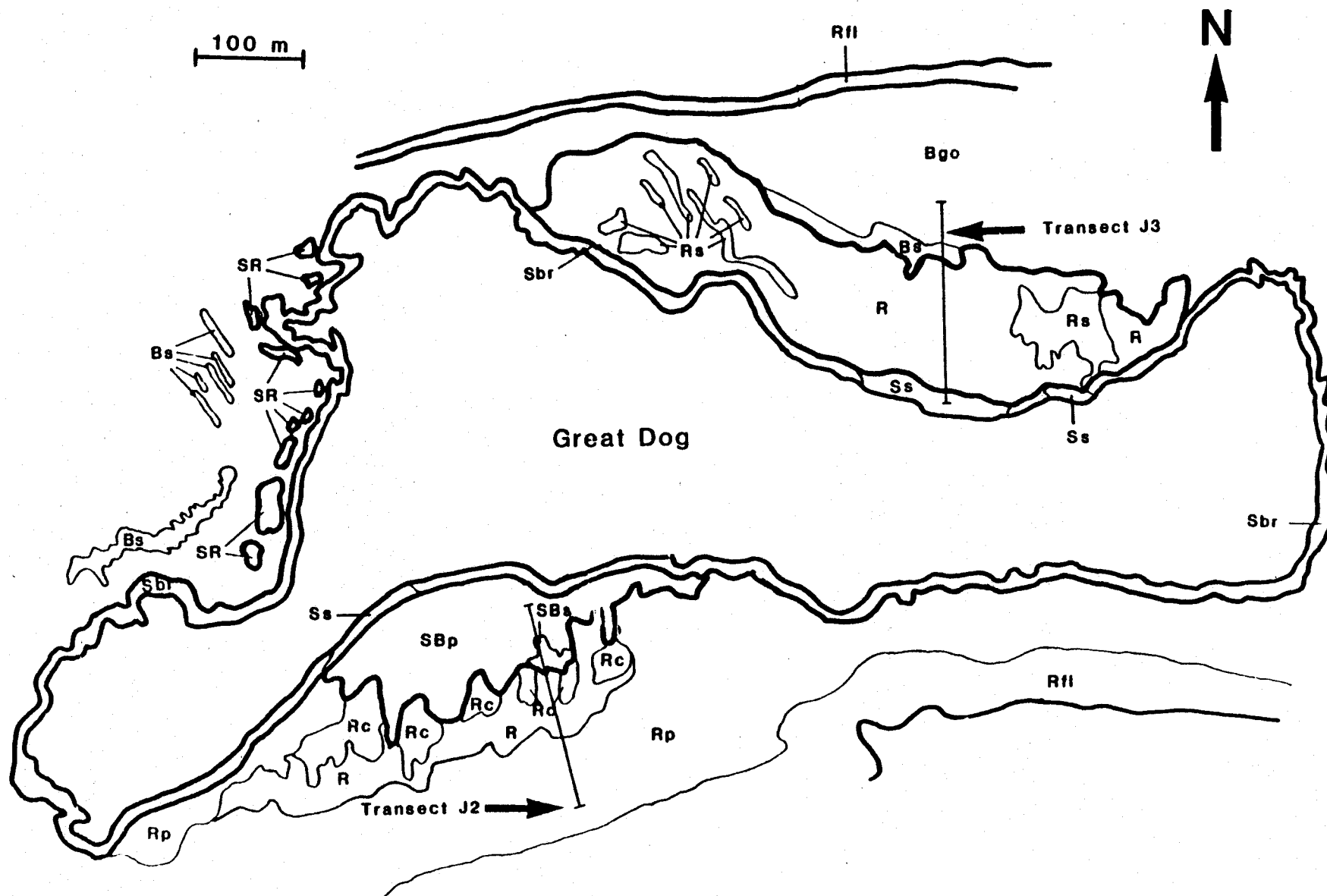


Figure J2

Location of transects J2 and J3 at Great Dog

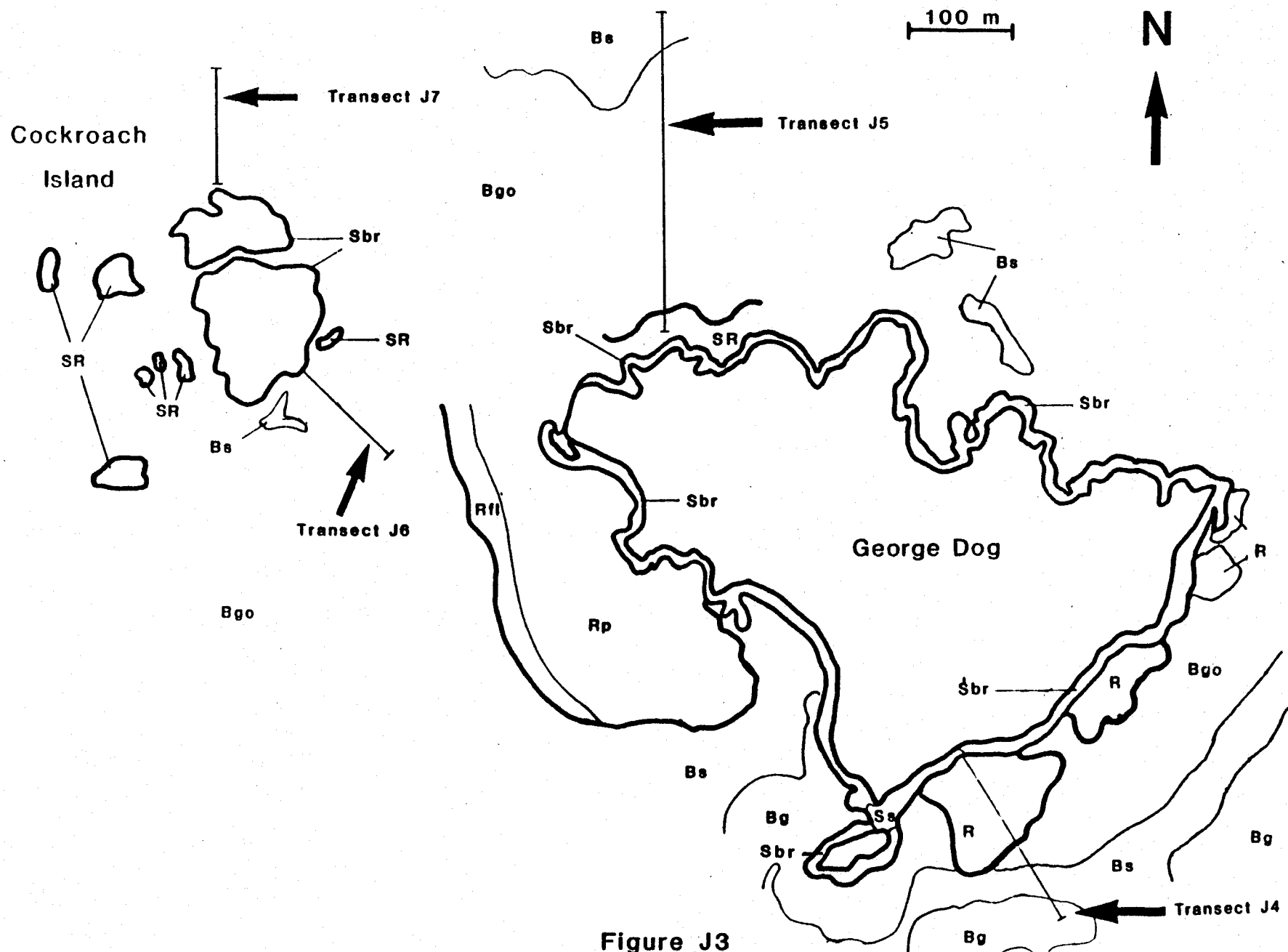


Figure J3
Location of transects J4 and J5 at George Dog and transects J6 and J7 at Cockroach Island

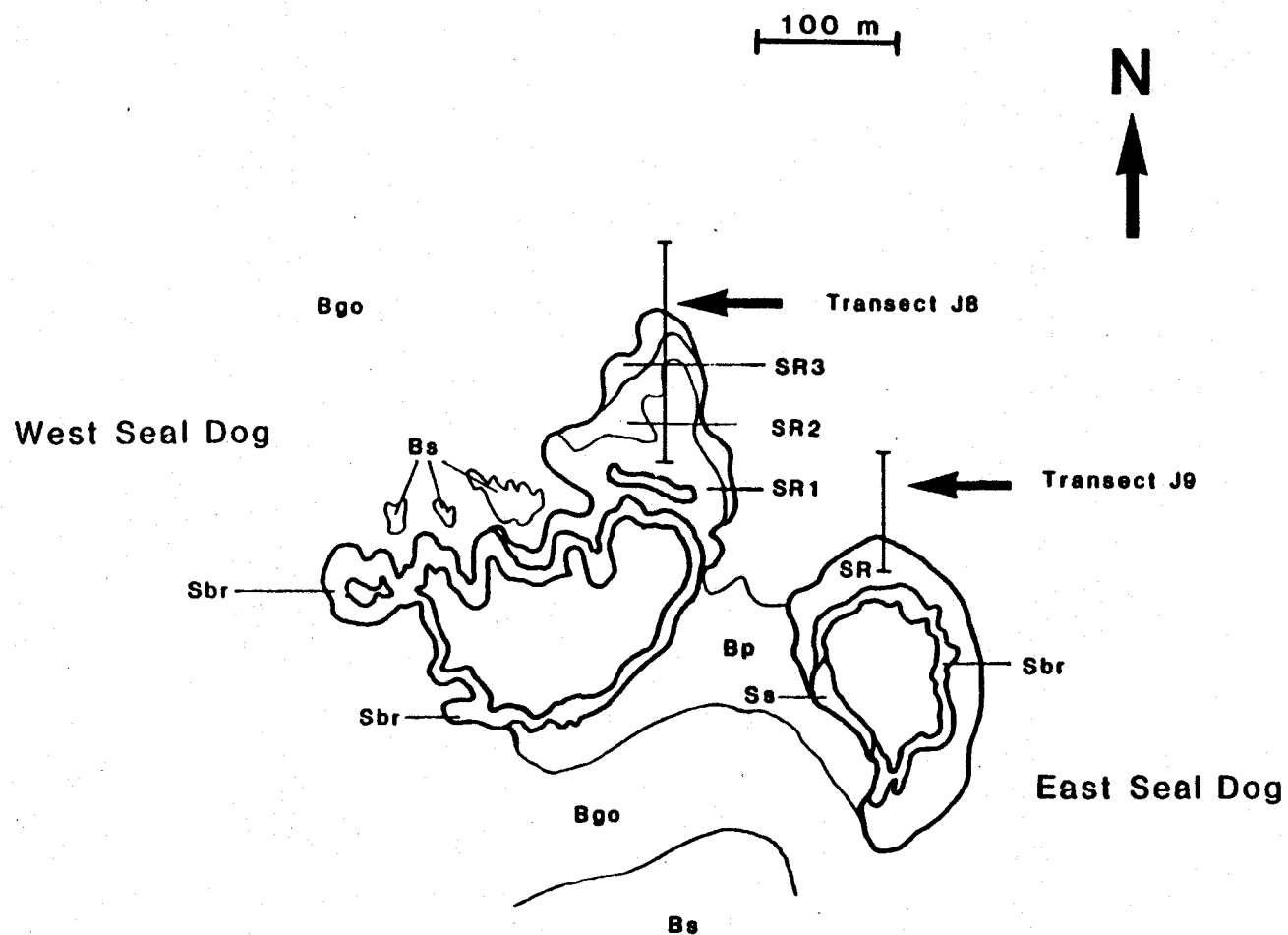
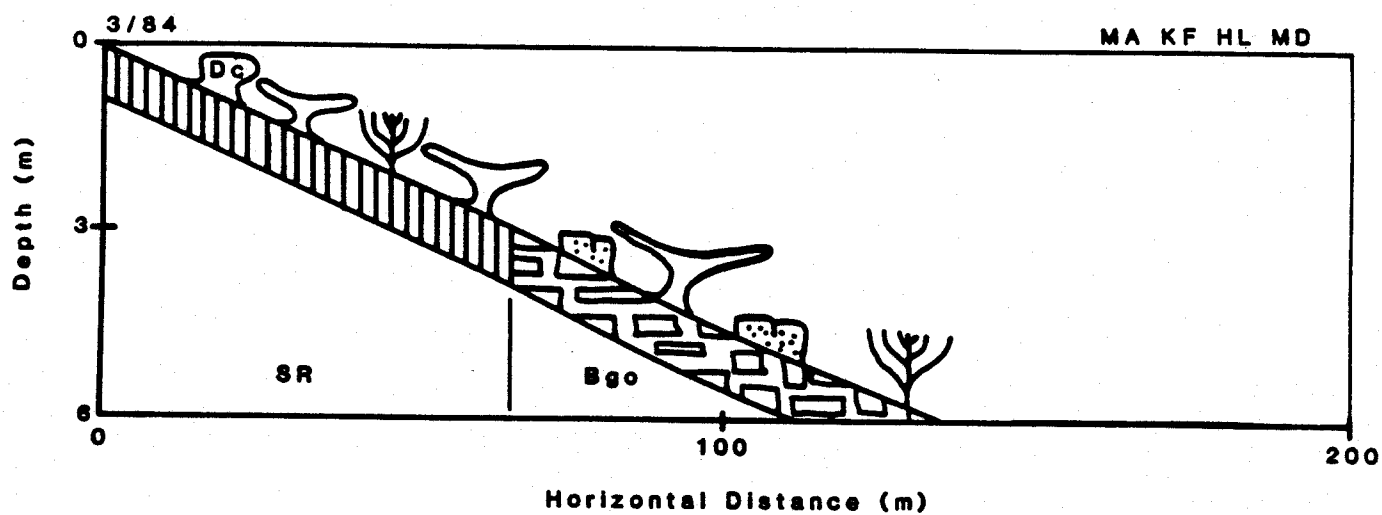


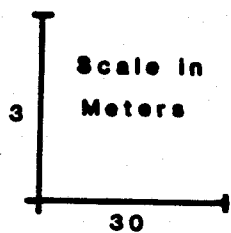
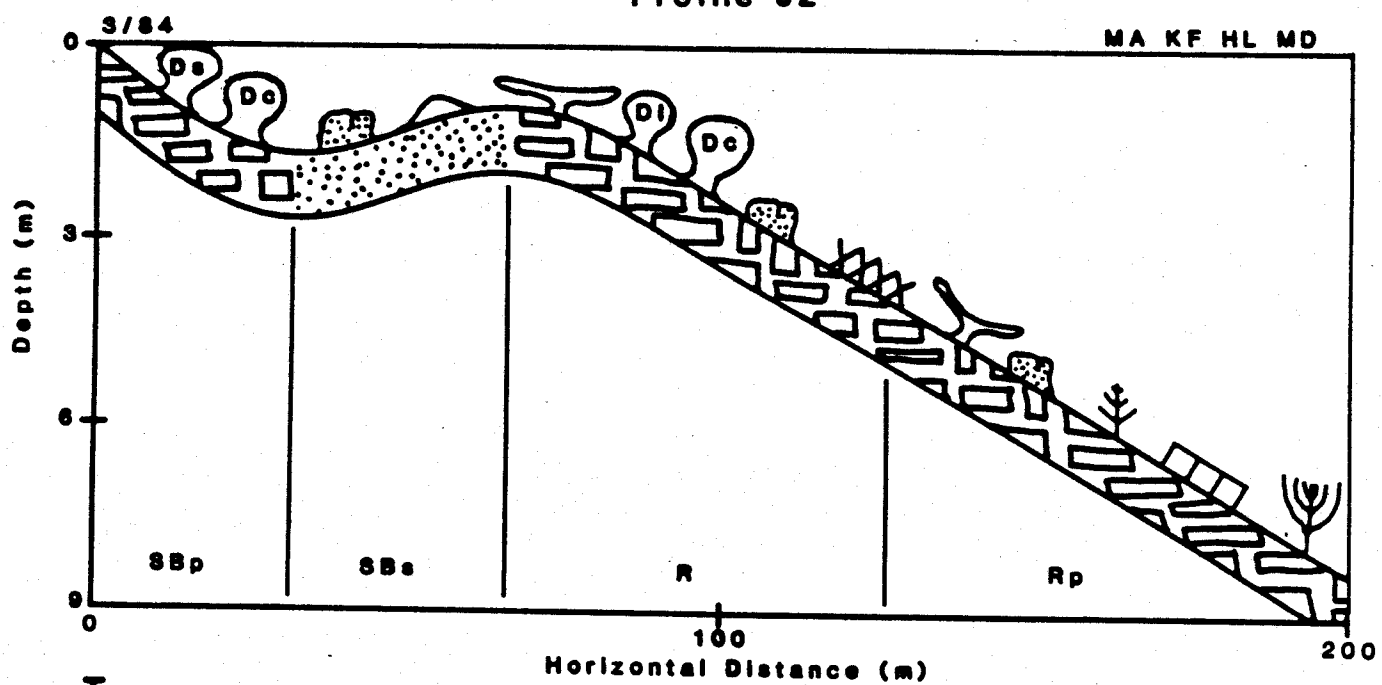
Figure J4

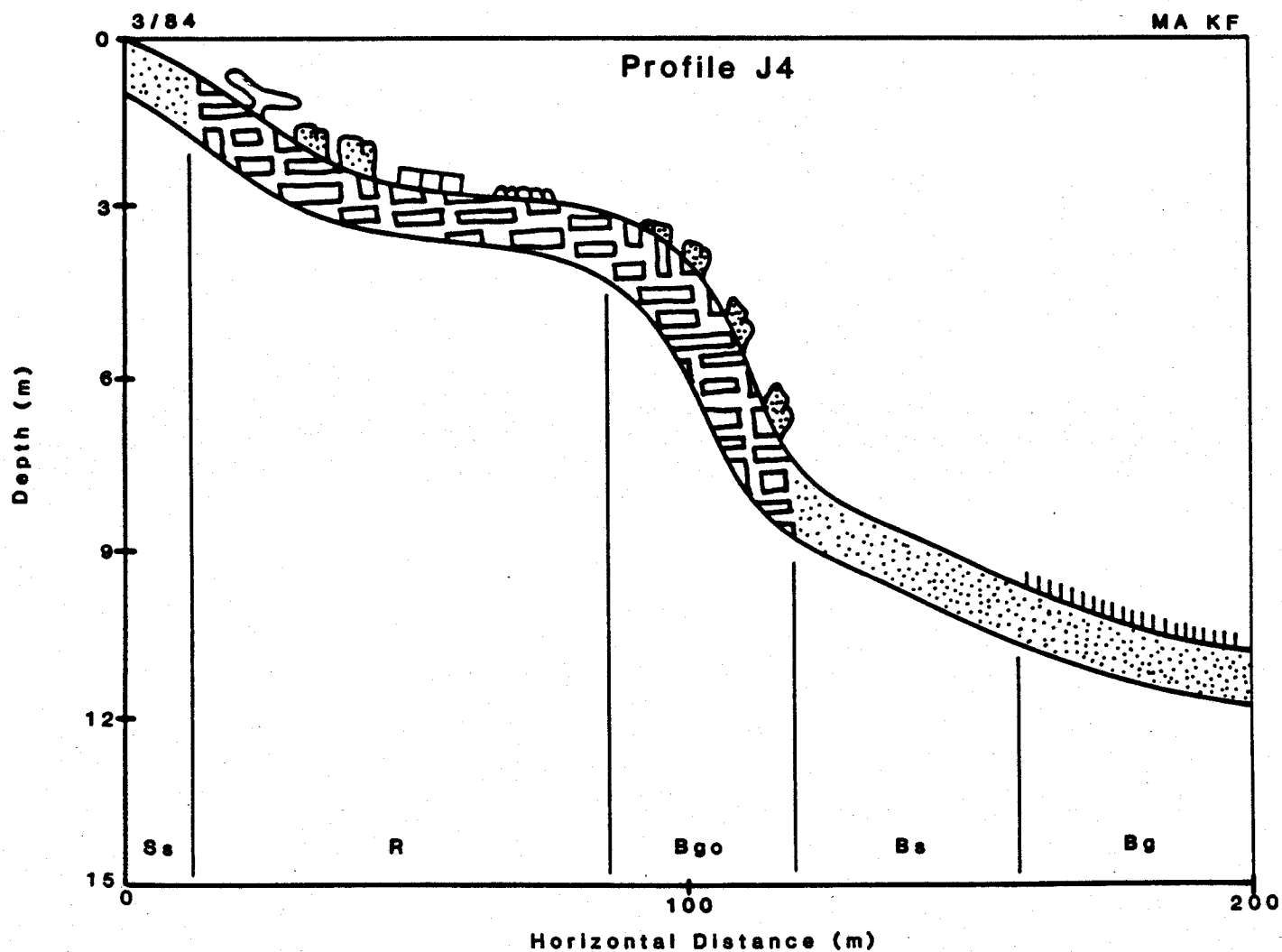
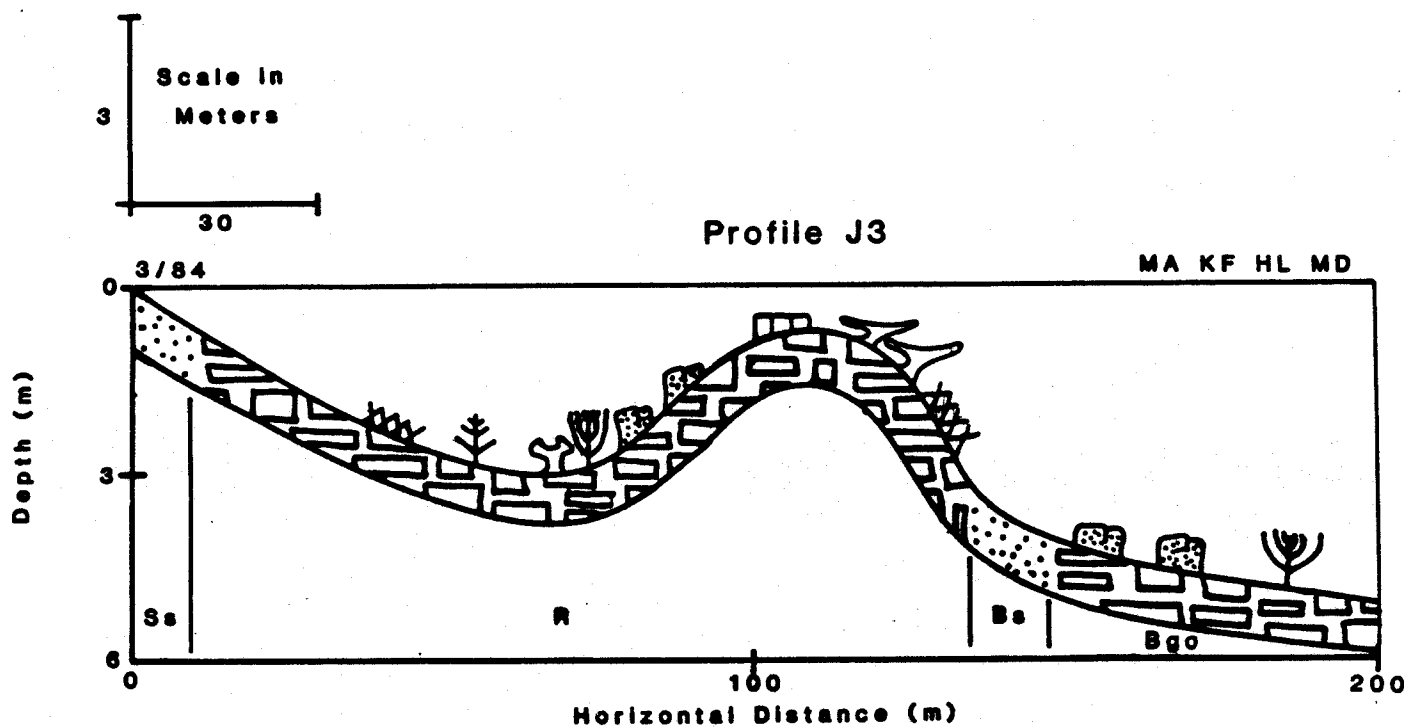
Location of transects J8 and J9 at the Seal Dogs

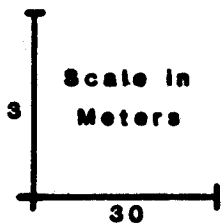
Profile J1



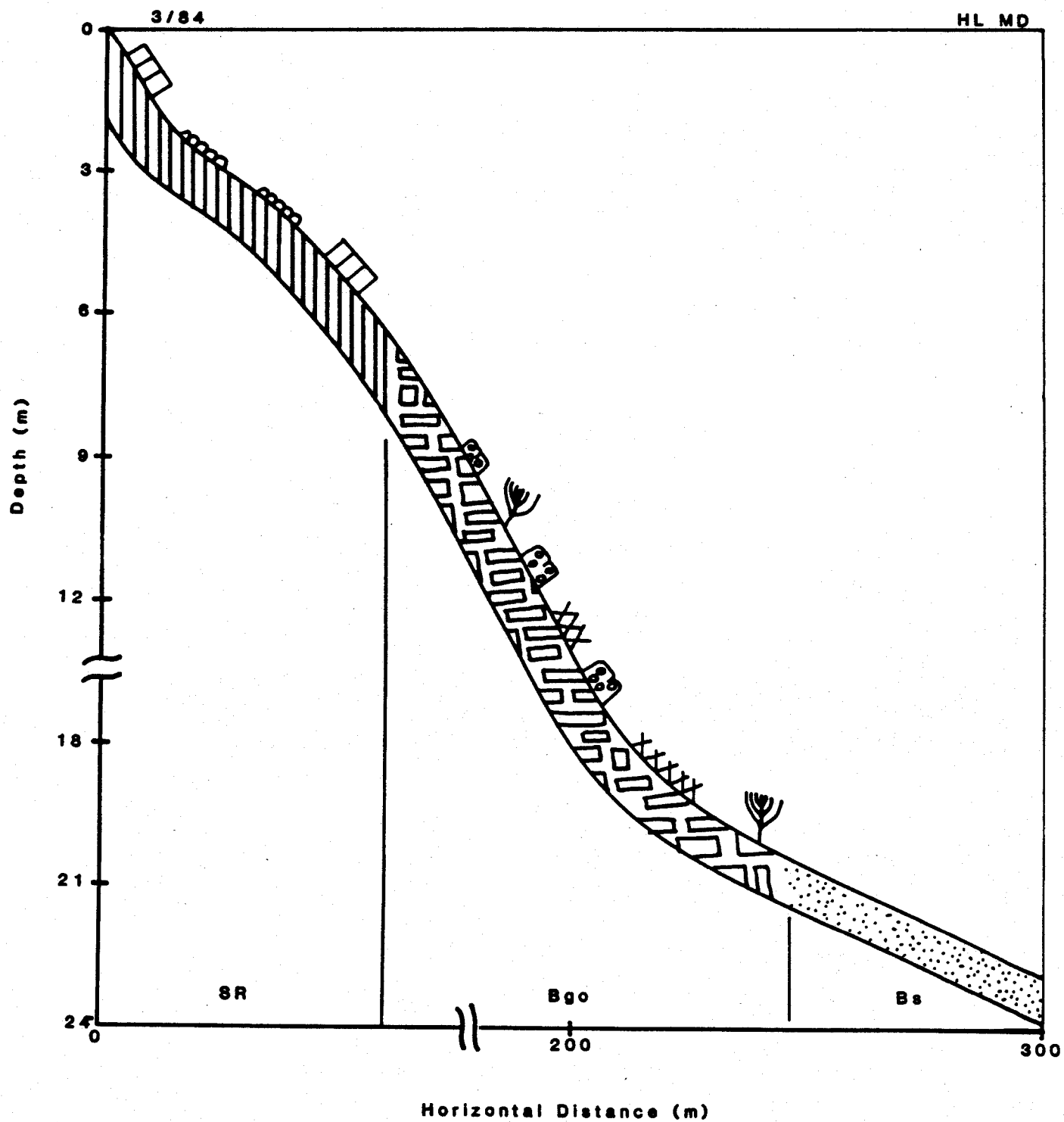
Profile J2

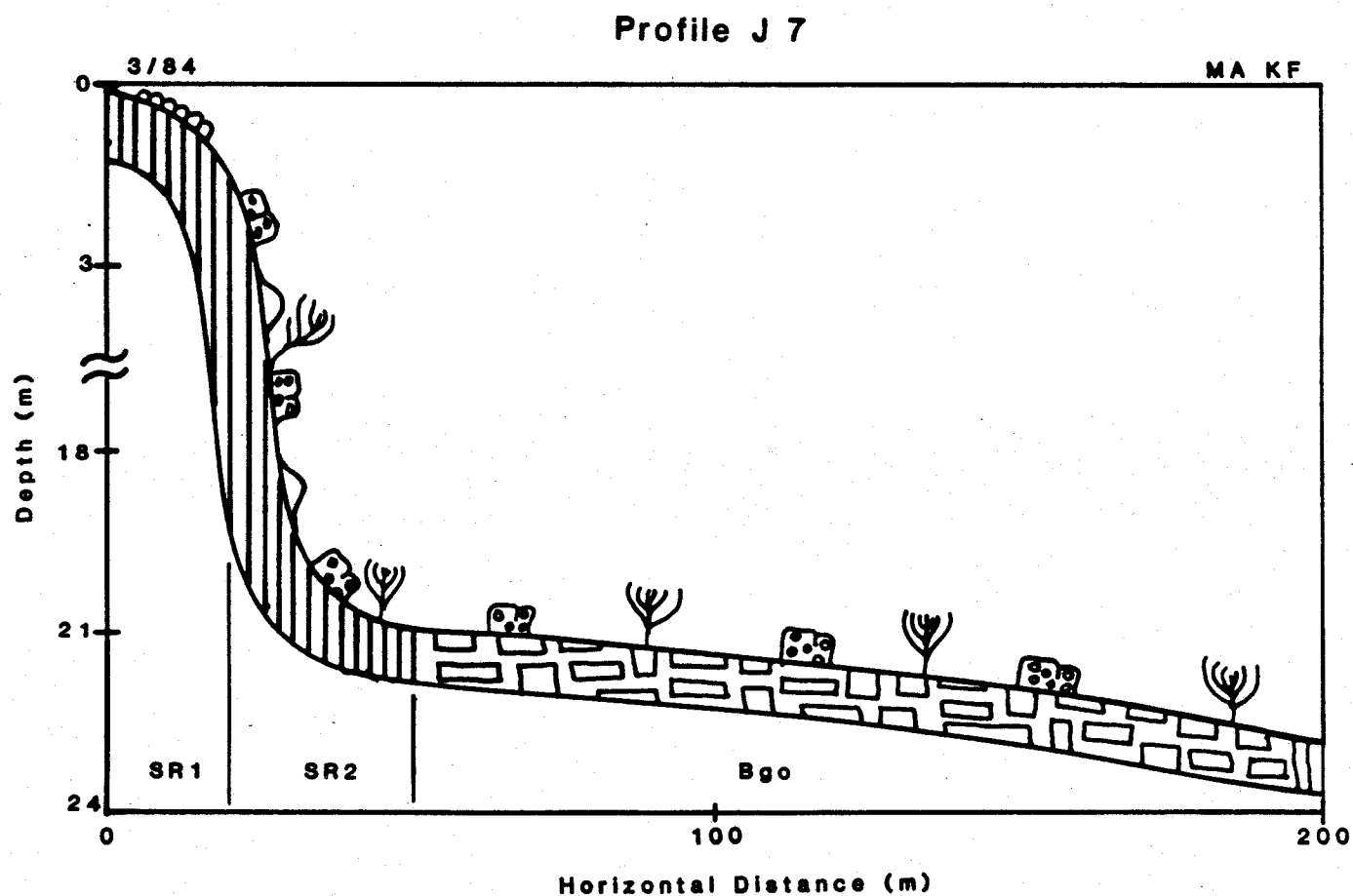
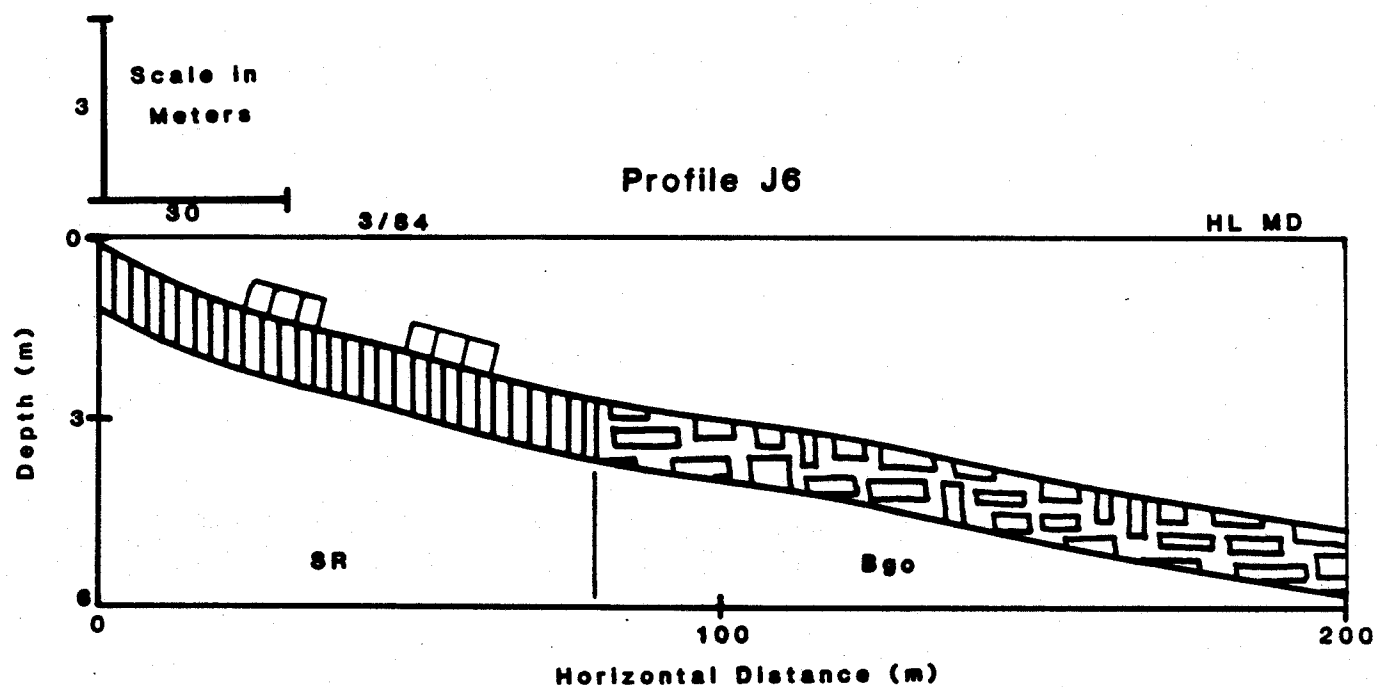


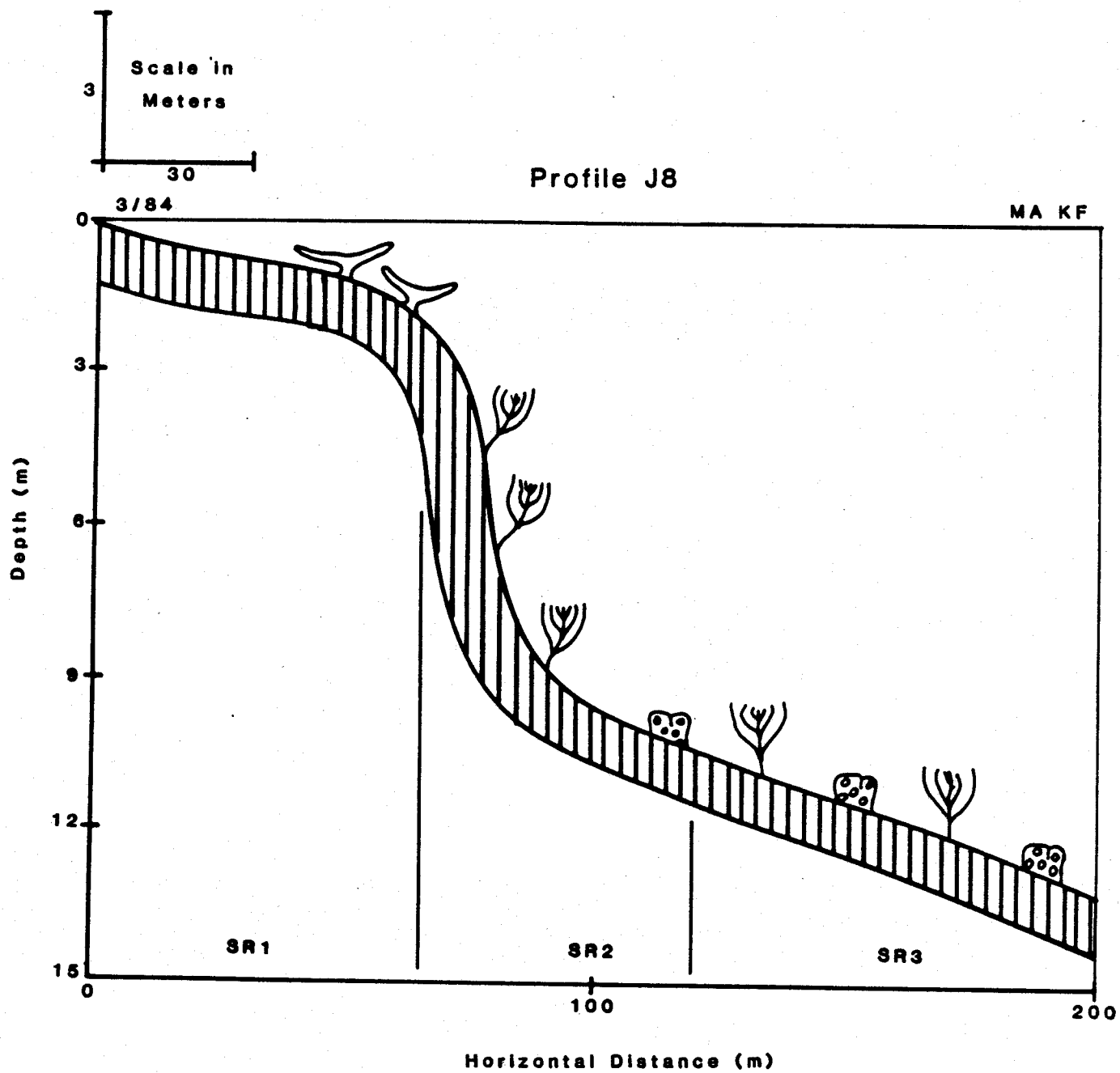


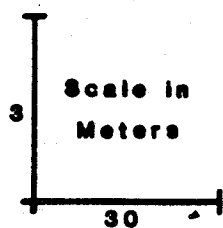


Profile J5









Profile J9

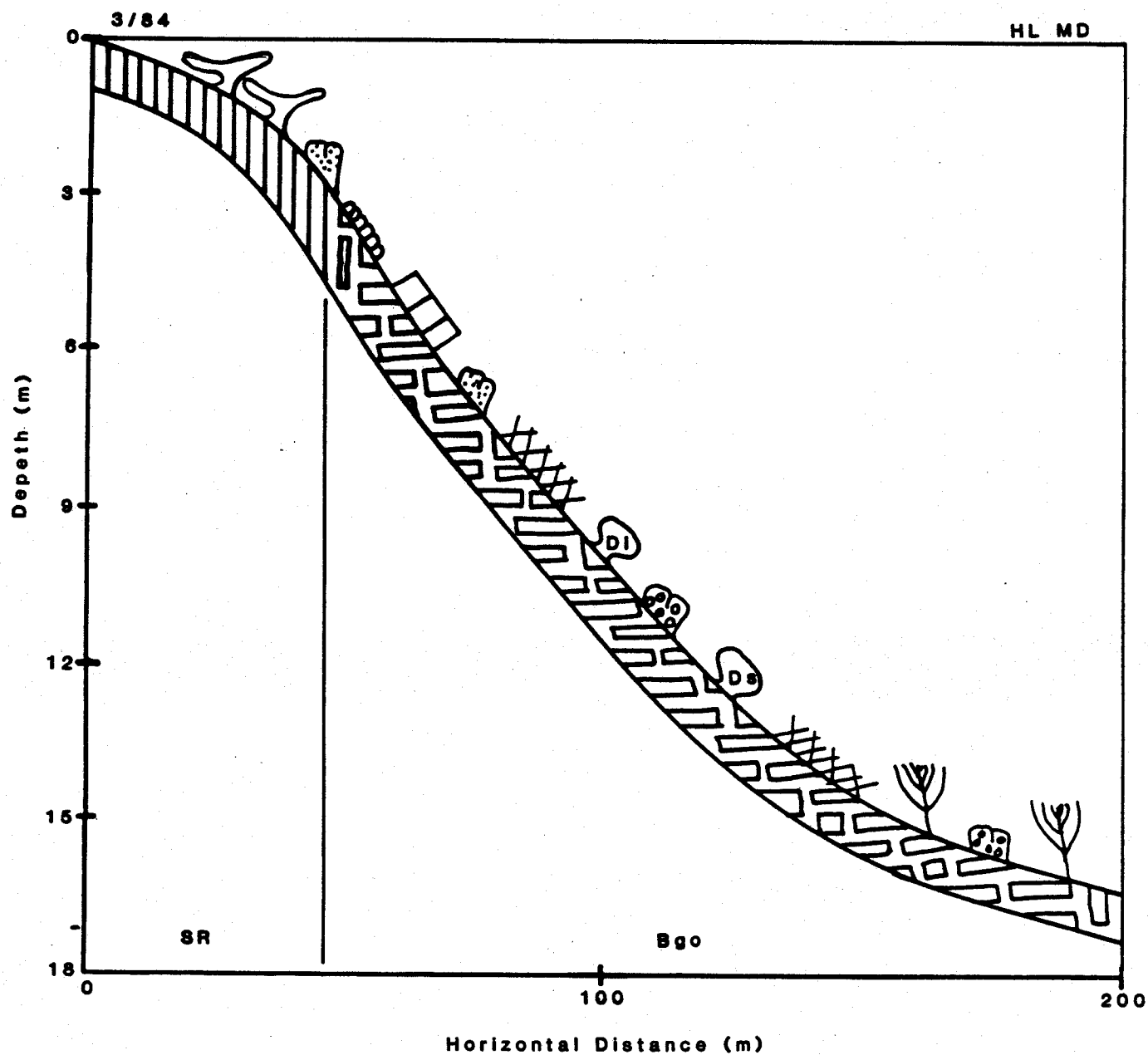
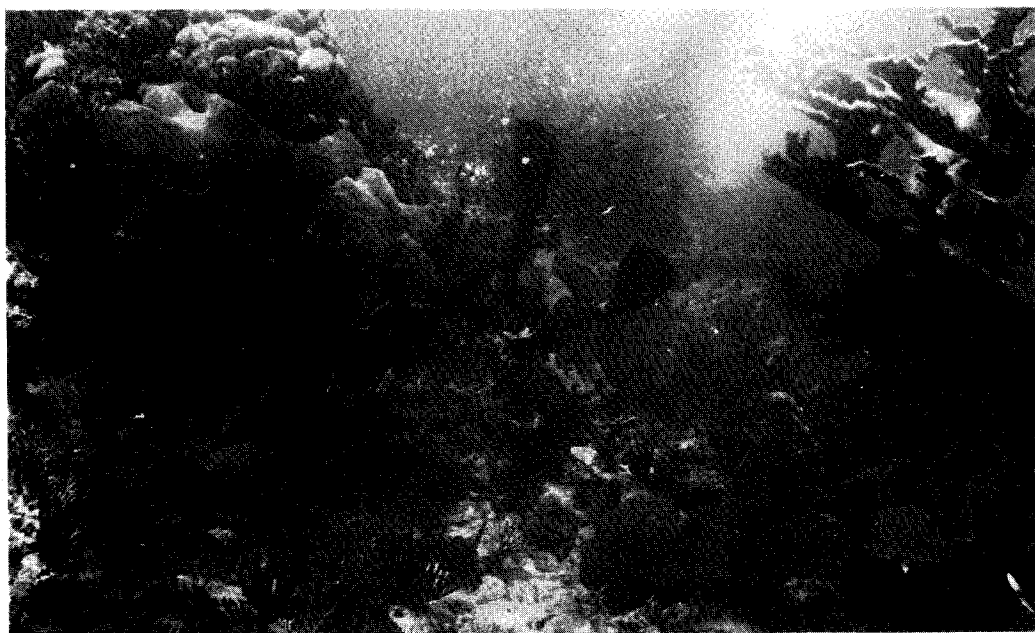


Table J

Data from transects J1 - J9

Site		J1	J2				J3	J4					J5	J6	J7			J8			J9							
Zone		SR Bgo	SBp	SBs	R	Rp	Ss	R	Bs	Bgo	S	R	Bgo	Bs	Bz	SR	Bgo	Bs	SR	Bp	SR1	SR2	Bgo	SR1	SR2	SR3	SR	Bgo
Depth Range (m)		0- 3+	0- 1.5	0- 1.5	1- 4	4- 7	0- 1	1- 3	3- 5+	1	3	8	10	15	8	23	0- 3+	0- 3	3	20	0- 3	3	10	16	0- 3	3	17	
HARD CORAL	Acer	+			+	+	+		+	+		+	+			+	+		+	+				+	+	+	+	
	Apal	+	+		+	+	+	+	+	+		+	+			+	+		+	+	+			+	+	+	+	
	Appro	+				+		+				+	+											+				
	Arg							+				+	+			+	+					+	+	+	+	+	+	
	Col							+		+		+	+														+	
	Den																			+								+
	Dic																+										+	
	Dcli	+		+		+		+				+	+			+	+			+	+						+	
	Dlab		+		+	+	+		+			+	+				+	+		+	+	+		+	+	+	+	+
	Dscr	+	+		+	+	+	+				+	+				+			+	+	+	+	+	+	+	+	+
	Eus		+					+																			+	
	Fav			+			+										+			+							+	
	Hel																					+						
	Ioss																											
	Iso		+			+		+				+				+											+	
	Mdec				+	+						+				+												
	Mac																											
	Msa				+					+							+								+		+	
	Mil	+	+	+		+	+	+	+	+		+	+			+	+	+	+	+	+	+	+			+	+	+
	Mann		+		+	+	+	+	+	+		+	+			+	+							+			+	+
Hcav		+														+			+		+	+	+	+	+	+	+	
Mus			+				+				+					+								+	+	+	+	
Nyc							+				+	+				+						+		+	+			
Pacr		+	+	+	+	+	+		+		+	+			+	+	+	+	+	+	+			+	+	+	+	
Pdiv											+																+	
Ppor		+	+	+	+	+	+	+	+		+	+																
Sco							+				+																	
Srad			+		+																			+				
Ssid		+			+										+	+						+		+			+	
Tub							+																					
TOTAL # SPP.		4 14	10 7	10 14			24	10			17 12			7 19	6 9	6 6	9	8 9	9	14 11								
GORGONIAN	Bri				+		+	+								+											+	
	Ery																											
	Eun						+									+	+		+	+	+	+	+	+	+	+		
	Gor	+	+	+		+	+	+			+	+			+	+	+	+	+	+	+	+	+	+	+	+		
	Mur					+										+										+		
	Ple	+	+			+	+	+							+	+			+	+	+	+	+	+	+	+		
	Plxl					+									+	+							+			+		
Ptg					+										+	+						+			+			
Pet	+	+									+				+	+		+	+	+	+	+	+	+	+	+		
Pal												+										+	+	+	+	+		
TOTAL # SPP.		3 3	1 1	6			4	3			1 2			4 6	3 2	1 2	5	5 5		3 7								
COVER	Z HC	15 30	10 5	35 45			15	20			50 15			15 15	5 10	5 20	15	5 5	10	15 25								
	Z Go	5 10	5 2	10			5	18			3 15			10 15	3 10	5 15	35	20 30	5 20	5 20								
	Z Z	3 5	2 2	4 2							4 2			5 2	5 3	35		10		5 10								
	Z G												100															
	Z DC				34		15	18			13 14			10				5 5	5	10								
	Z T	44 45	19 9	51			45	34			16 39			58	87 37	55 65	50	80 70	35	75								
Z S	10	64 82	10 9			99 20	98 10			50 14	15 100			10 100	40				20									
Z Sbr	33					1	2			50			60												8 27			
Habitat Complexity		1 5	2 1	5 4			1 4	1 4			1 5	3 1	2	1 3	1	2 2	1 2	3	3 3	4	4 3							
OTHER	O Dia		+																									
	O Eci		+																									
	O Ham		+																									
	O Pal	+	+		+	+					+			+	+	+	+	+	+	+	+	+	+	+	+	+		
	O Spg	+												+											+	+		
	O Sti																		+									
RHS	Syr																											
	Zoa		+								+	+														+		



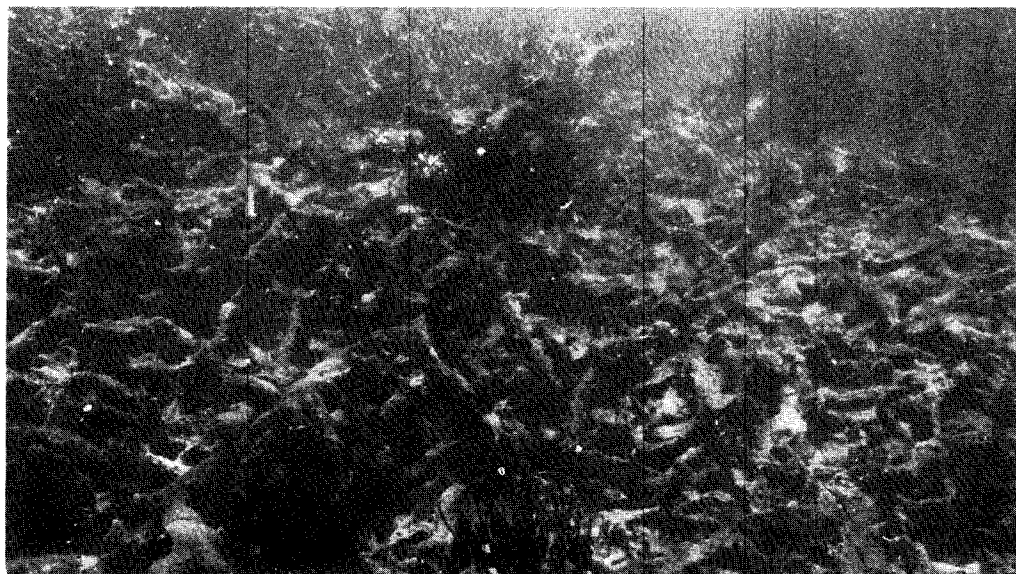
J1-a



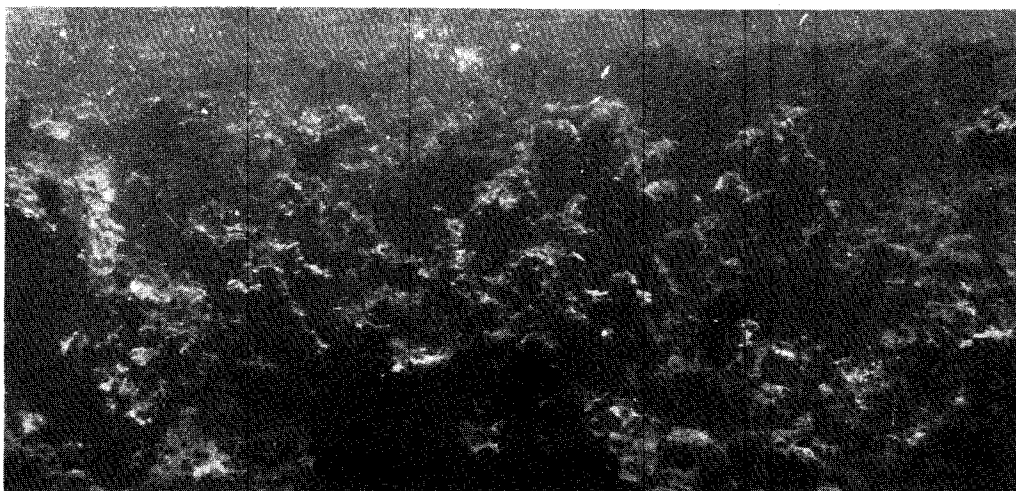
J1-b

Plate J1-a,b West Dog

J1-a,b: Subtidal bedrock



J2-a



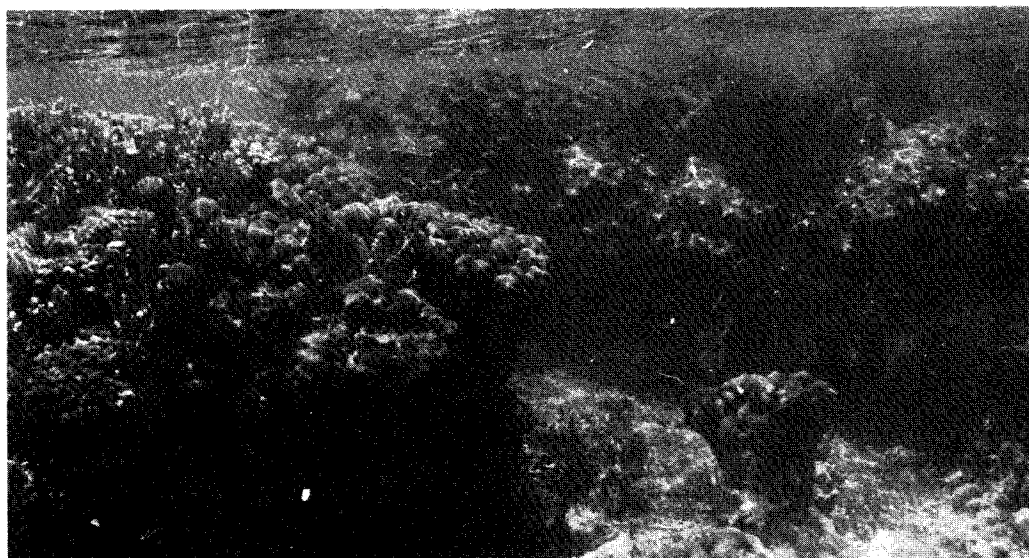
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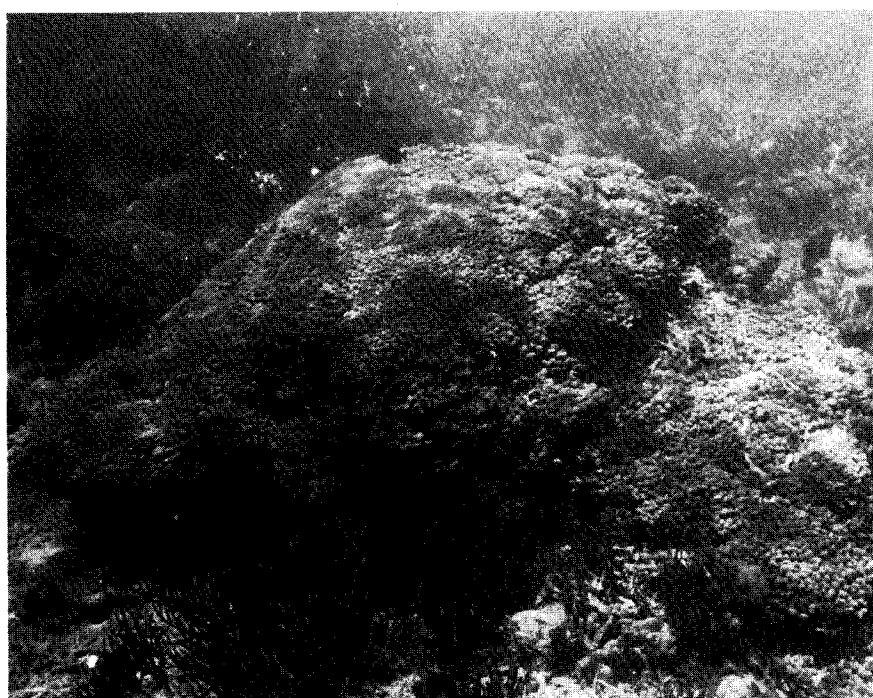
J2-c

Plate J2-a,b,c Great Dog (south)

J2-a: Pavement, J2-b,c: Reef



J3-a



J3-b

Plate J3-a,b Great Dog (north)

J3-a,b: Reef



J3-c



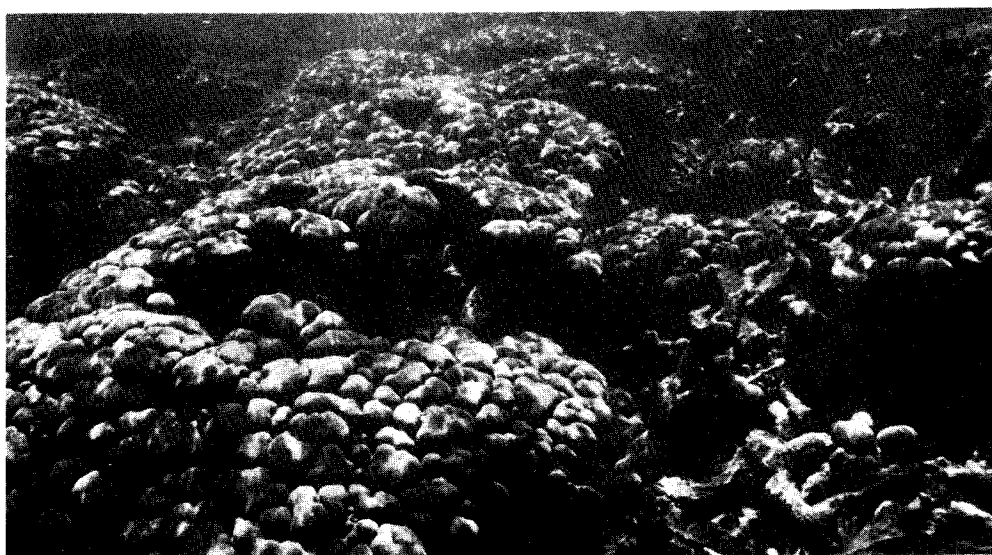
J3-d

Plate J3-c,d Great Dog (north)

J3-c,d: Reef



J4-a



J4-b



J4-c

Plate J4-a,b,c George Dog (south)

J4-a: Reef, J4-b: Reef, J4-c: Gorgonian coral flat



J7-a



J7-b



J7-c

Plate J7-a,b,c Cockroach Dog

J7-a: Subtidal bedrock 1, J7-b,c: Subtidal bedrock 2



J8-a



J8-b

Plate J8-a,b West Seal Dog

J8-a,b: Subtidal bedrock 2



J8-c



J8-d

Plate J8-c,d West Seal Dog

J8-c,d: Subtidal bedrock 3

BUCK ISLAND REEF NATIONAL MONUMENT

Introduction

Buck Island, located 2 km north of Teague Bay, St. Croix, became a national monument in 1961. The marine biological communities surrounding the island have since been studied and baseline data established (Gladfelter et. al., 1980). This section of this report is a continued effort to update the status of these communities.

A barrier reef is adjacent to shore at the point of land delineating Turtle Bay on the southernmost tip of Buck Island. Navigational buoys mark a channel (ca. 20 m width) in the southeast portion of the reef. The barrier reef forms an arc around the east end of the island; it roughly parallels the north shore, and grades into a contiguous series of patch reefs toward the northwest of Buck Island (Fig. K). The system of patch reefs extends ca. 2 km northwest of the west tip of Buck Island.

Acropora palmata is a major constituent of this reef system.

A manchineel forest borders the beach rock and sand shore on the northwest coast of the island. The southwest coast of Buck Island is a broad sand beach. Offshore is a vast seagrass bed in which many turtles (several ca. 150 - 200 kg) have been sighted.

North and east of the barrier reef system is a vast gorgonian/coral flat. Several massive A. palmata reefs are emergent at low tide. Although the reefs are composed of 100% A. palmata, less than 20% of the coral is alive.

A lagoon ca. 200 m wide occurs between the barrier reef

and the shore on Buck Island. Sand, in the center of the lagoon, separates patch reefs, head coral communities, and predominantly dead A. prolifera thickets. Two strips of pavement occur; one borders the shore zone, and another interfaces with the backreef (Profile K1). The east and northeast portion of the lagoon has been established as a SCUBA diving and snorkeling site. The National Park Service has placed permanent moorings in this area to identify the locations of two specific marine features; a reef grotto frequented by SCUBA divers, and a snorkeling trail. The moorings serve to reduce anchor damage to the marine communities here.

The SCUBA diving area was selected as the site of transect K1 (Fig. K1). The transect begins at shore and runs in a northeast direction under the SCUBA mooring, and through a grotto in the barrier reef. It then continues seaward across the gorgonian/coral flat.

Transect K1

Four biological community zones were identified at the site selected for transect K1 (Fig. K1). The transect crosses shore, lagoon, reef, and bank zones (Profile K1; Table K).

Shore Zone

The shore zone is composed of beach rock, sedimentary laminated rock, and small northeast-facing cobble beaches. Some coral fragments have mixed in with the cobble, however, the prevailing seas and wind conditions maintain sufficiently high water motion to scour away sand and most debris.

Lagoon Pavement

The pavement (ca. 50 m width) which occurs on the shoreward side of the lagoon borders nearly the entire north coast of the island. The inner edge of the pavement (1 m depth) is sparsely populated by corals (3% local cover) and gorgonians (3% total cover) (Plate K1-a). Diploria clivosa and Porites astreoides are the dominant live corals colonizing the inner pavement edge (Plate K1-b). Intermittent patches of sand (10% cover) are present on the lagoon pavement.

A gradient of increasing live coral density (to 15% cover) and diversity is evident near the outer pavement edge (Table K). Eroded Montastrea annularis heads contribute significantly to the habitat complexity here which is higher than in the shoreward area. The average live coral cover on the pavement strip is 10%. Palythoa and Zoanthus colonize ca. 5% of the substrate. The outer edge of the pavement (1.5 m depth) drops vertically to the lagoon sand.

Lagoon Sand

Lagoon sand begins at 3 m depth. The patch reefs and isolated head corals present are primarily composed of D. strigosa, D. clivosa and M. annularis (Plate K1-c). The patch reefs and coral heads have ca. 20% live coral cover but the reefs cover no more than 10% of the lagoon sand. Live coral cover for the entire region was estimated to be 3%. Gorgonians (3% cover) and Zoanthus (2% cover) were noted.

Patches of predominantly dead Acropora prolifera, which

appear dark on the aerial photographs, occur on the outer edge of the lagoon sand. Regenerating branches of this coral were noted to comprise no more than 1% of the total live cover on the patches. The dead branches are partially consolidated and colonized by algal turf (Plate K1-d).

Patches of calcareous algae located nearly directly under the SCUBA mooring are dominated by Halimeda and Udotea (Plate K1-e). The cover created within the patches themselves may be as high as 80% but, due to the small size of the patches (ca. 5 - 10 m across) and their low number, the algae covers no more than 5% of the total lagoon sand substrate. The lagoon sand interfaces with the outer lagoon pavement at 4 - 5 m depth.

Lagoon Pavement

This pavement is composed of consolidated coral heads and patch reefs (primarily A. palmata and M. annularis) (Plate K1-f). Patches of A. prolifera contribute to the live coral cover of 10% on this pavement.

Backreef

The backreef is comprised primarily of broken A. palmata branches colonized by Lithothamnion and Halimeda. Acropora palmata contributes significantly to the live coral cover of 5% (Plate K1-g,h). Gorgonians (5% cover) are present and Zoanthus (15% cover) seems heavily grazed.

Reef Crest

The hydrocoral Millepora and A. palmata are the dominant live corals comprising the reef crest (0.5 m depth).

They generate ca. 25% live coral cover in this subzone (Plate K1-l).

Reef Grotto

The reef grottos are structurally similar to the forereef, however, neither coral nor gorgonian diversity is as great (Table K). The live coral cover here (20%) is dominated by A. palmata. Gorgonians (5% cover) and Zoanthus (15% cover) are present.

Forereef

From the reef crest (0.5 m depth) the forereef drops almost vertically to the bank (10 m depth). Patches of healthy A. palmata colonies generate a local live coral cover of 80%, however, the majority of the forereef is composed of stands of this coral which are nearly 100% dead (Plate K1-j). The evidence of impact from white band disease on the barrier reef is strong (Davis et al. 1985). Coral diversity is high (Table K).

Gorgonian/Coral Flat

A vast gorgonian/coral flat extends seaward of the barrier reef and supports a diverse coral community of which Montastrea annularis is dominant (Table K; Plate K1-k). Patches of Acropora cervicornis are locally dominant and also contribute to the live coral cover of 25%. Gorgonians account for 20% of the substrate cover.

Bank Patch Reefs

Patch reefs, located on the bank, are structurally similar

to the coral communities on the upper forereef described above. The primary difference between the zones is in the level of consolidation of the dead A. palmata branches. They are less consolidated in the patch reefs than in the barrier reef (Plate K1-1,m). Live coral cover can, in an area, be as low as 10%, which combined with localized areas of 100% live coral cover produces an average value of 30%. Massive A. palmata stands are the primary contributor to the live coral cover, however, Millepora is dominant on the reef crests.

Summary

Buck Island Reef National Monument, established in 1961, is located 2 km north of the Island of St. Croix. Buck Island is bordered on its east end by a barrier reef which forms a lagoon. Although the types of communities surveyed in the present study have not changed since the initial descriptions in 1977 (Gladfelter et al. 1977), the condition of several of the communities is dramatically different. For instance, the lagoon area, with a rich, live Acropora prolifera population in 1977 is now consolidated A. prolifera rubble covered with Halimeda and the Acropora palmata dominated reef shows a reduction in live coral coverage from about 100% to only 20%. The cause or causes resulting in these changes are still not well understood.

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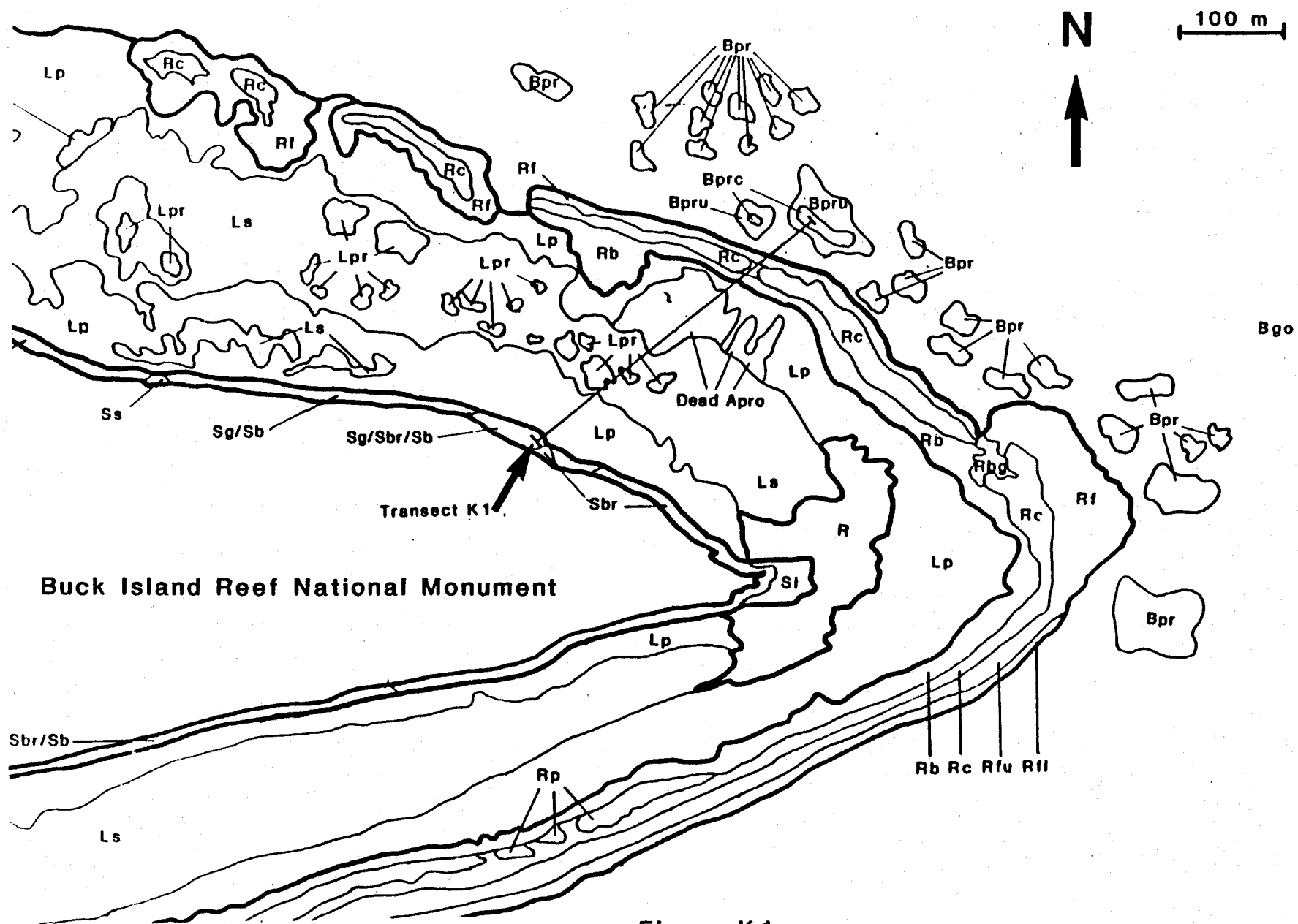


Figure K1

Location of transect K1 at Buck Island Reef National Monument

Profile K1

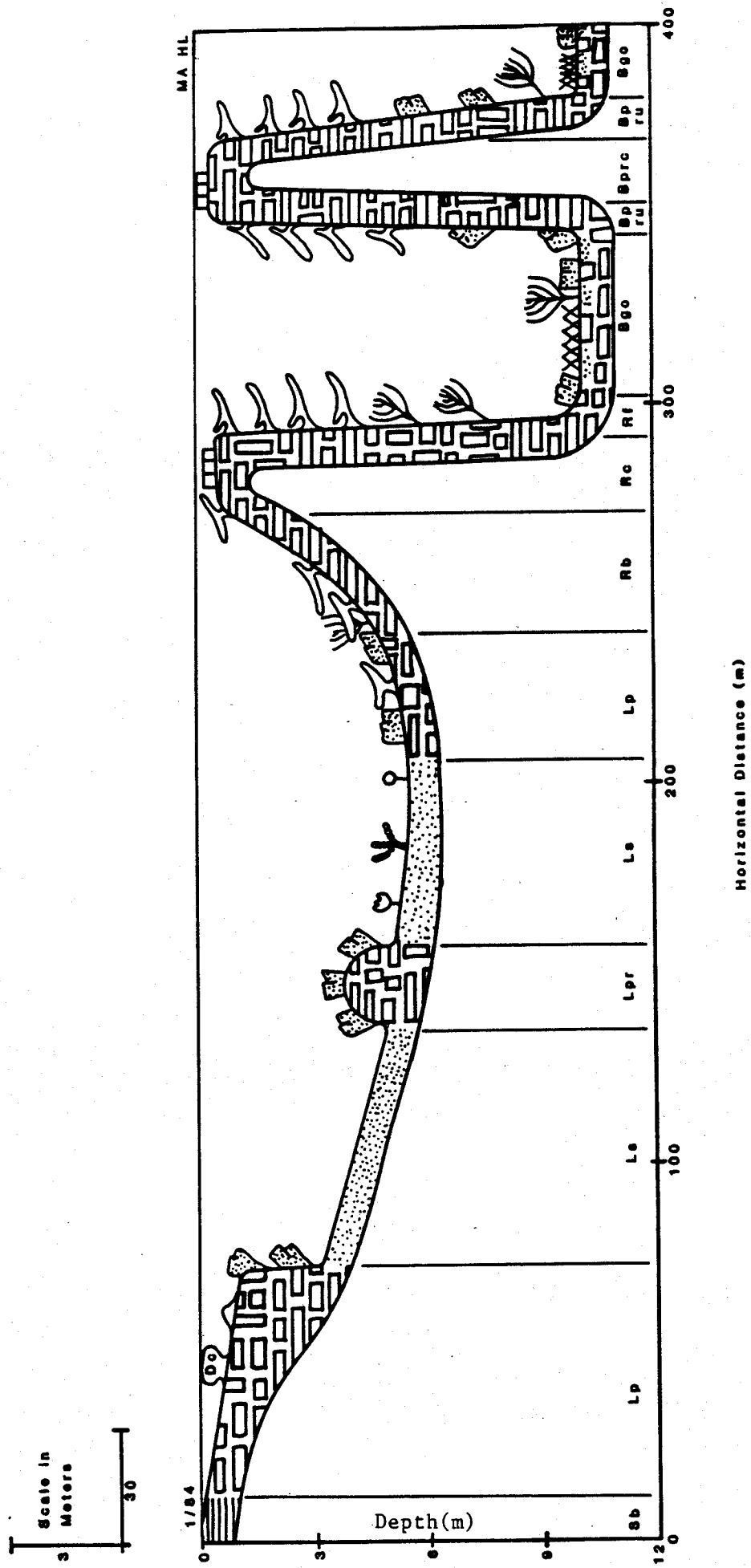


Table K

Data from Transect K1

Site		K1									
Zone		Sb	Lp	Ls	Lp	Rb	Rc	Rg	Rfu	Bgo	Bpr
Depth Range (m)		0-1	1-3	3-5	4	4-0.5	1-0.5	0.5-4	0.5-10	10	10-0.5
H A R D C O R A L	Acer									*	
	Apal		+	+	*	*	*	*	*	+	*
	Apro			+	+						
	Aga			+				+	+	+	
	Col				+				+	+	+
	Den								+	+	
	Dcli		*	+		+					
	Dlab				+				+	+	
	Dstr		+	+	+	+					
	Eus									+	+
	Fav							+	+		+
	Hel								+	+	+
	Isas							+	+	+	+
	Iso							+	+	+	+
	Mea								+		+
	Mil		+				*		+		*
	Mann		+	*	*	+		*	+	*	+
	Myc							+	+	+	+
	Past		*	+	+	+		+	+	+	+
	Ppor								+	+	+
	Sco							+	+	+	
	Srad				+						
	Ssid		+	+	+						
TOTAL # SPP.			7	8	9	5	2	9	17	14	13
G O R G O N I A N S	Bri		+	+	+	+			+		
	Ery										
	Eun		+		+			+	+	+	
	Gor				+	+		+	+	+	
	Mur								+		
	Plc			+	+						
	Plxl			+	+					+	
C O V E R	Ptg										
	Pst							+	+	+	
	Ps1										
TOTAL # SPP.			3	3	5	2		3	5	4	
C O V E R	% HC		10	3	10	5	25	20	20	25	30
	% Go		3	3	5	5		5	10	20	
	% Z		5	2	15	15	30	15			
	% A			5							
	% DC			10	15	30	30		70		70
	% T		72	5	55	45	15	60		45	
	% S			10	72					10	
Habitat Complexity	% Sbr		50								
	% Sb		50								
O G T H N E I R S M S	Ham		+	+		+					
	Pal		+		+						
	Pen			+							
	Udo			+	+						
	Zoa		*	+	*	*	*	*	+		



K1-a



K1-b

Plate K1-a,b Buck Island

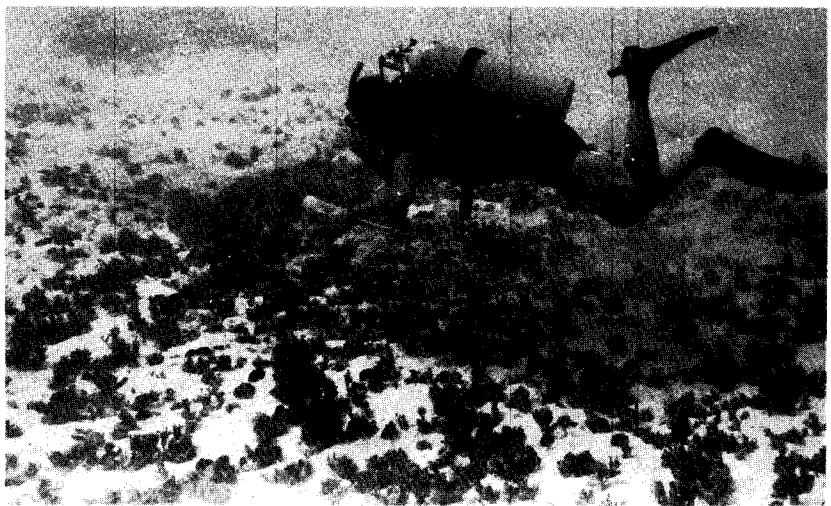
K1-a,b: Lagoon pavement



K1-c

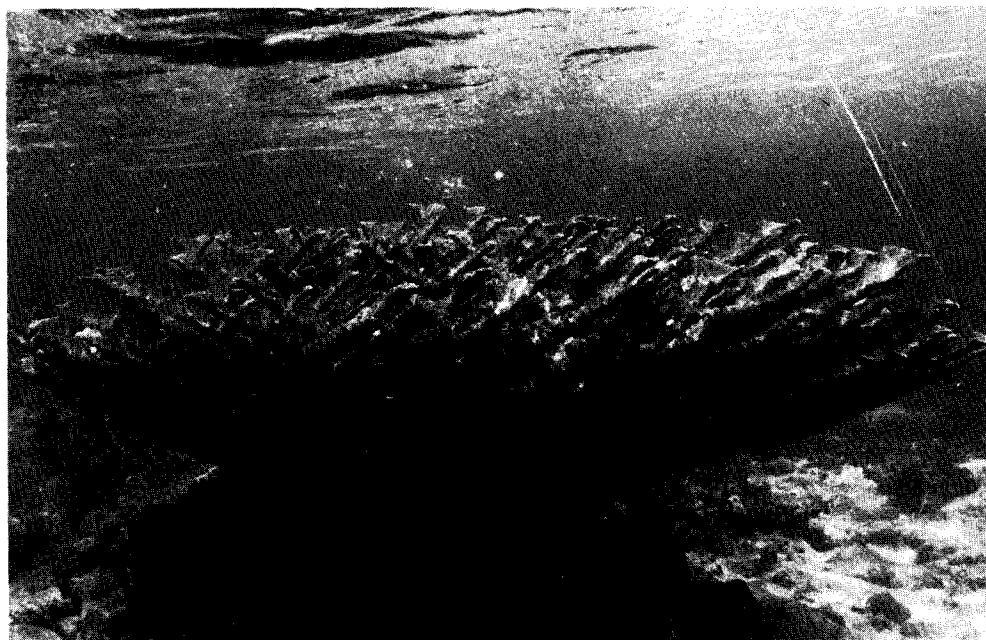


K1-d

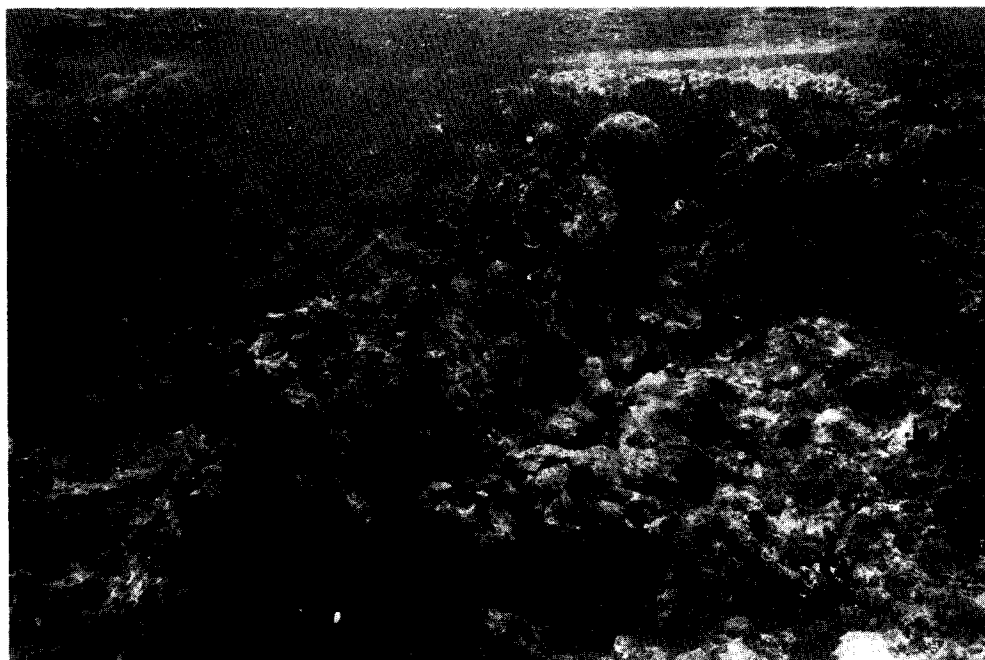


K1-e

Plate K1-c,d,e Buck Island
: Lagoon sand



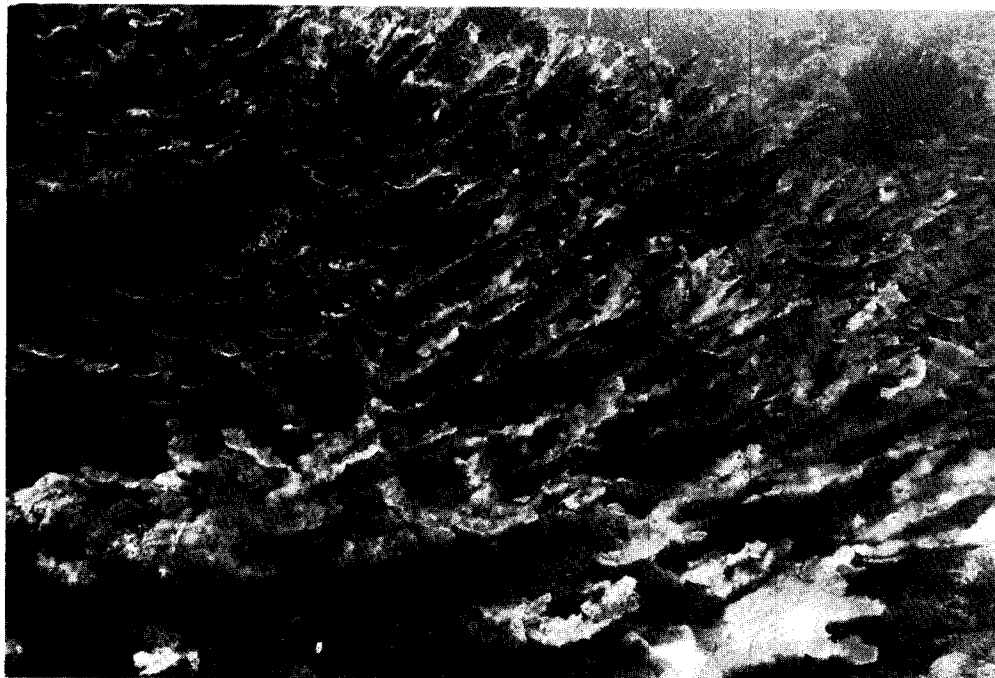
K1-g



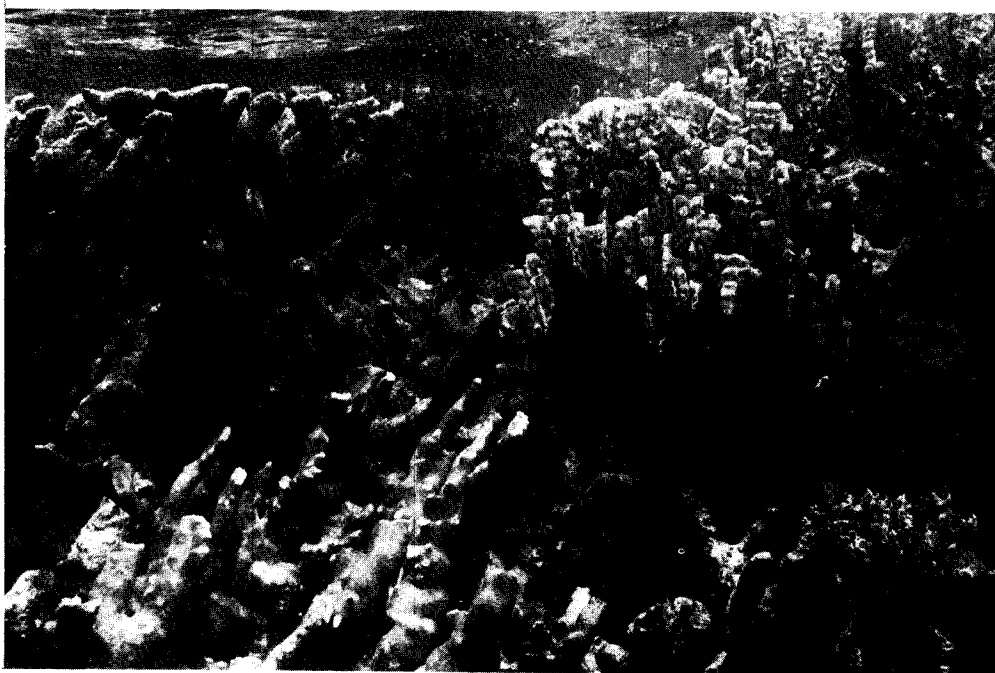
K1-f

Plate K1-f,g Buck Island

K1-f: Lagoon pavement, K1-g: Back reef



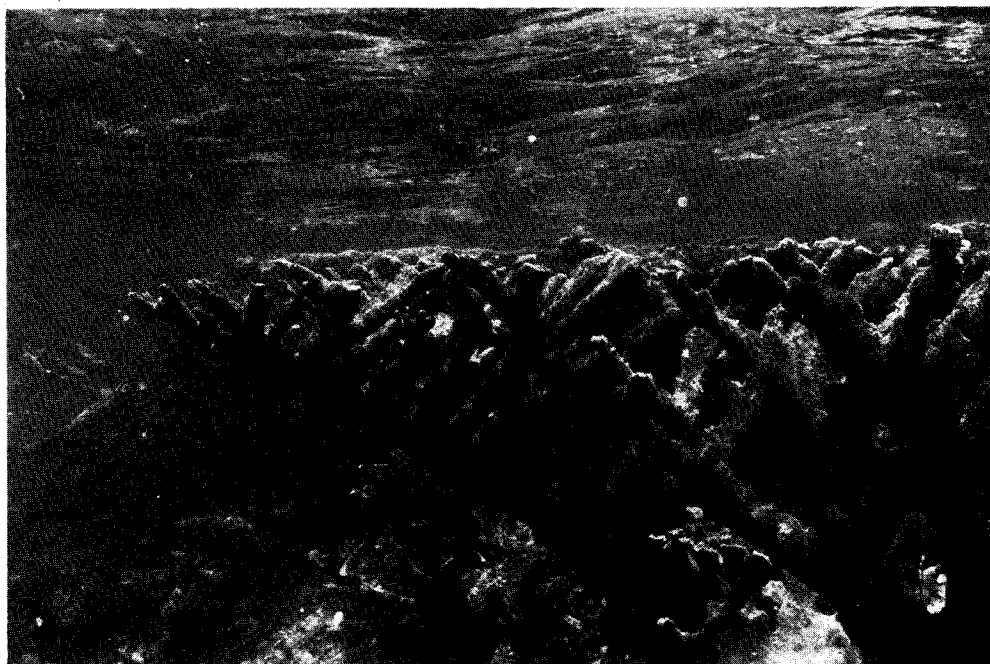
K1-h



K1-i

Plate K1-h,i Buck Island

K1-h: Back reef, K1-i: Reef crest



K1-j



K1-k

Plate K1-j,k Buck Island

K1-j: Upper foreereef, K1-k: Bank



K1-l



K1-m

Plate K1-l,m Buck Island

K1-l,m: Bank patch reef

DISCUSSION

The marine communities of the present and proposed park sites of the British Virgin Islands are (with a few exceptions to be noted) healthy, scenic and scientifically interesting examples of Caribbean coastal waters.

The Man and the Biosphere Program seeks to understand the interaction between natural ecosystems and man. We have therefore evaluated three aspects of each of these park sites: scientific interest, recreational potential, and observed human impact. Other potential human use, such as commercial activities of fishing or mariculture, were not assessed in the present study. As discussed in Gladfelter et al. (1985) knowledge of the structure of the marine communities (as is presented in the present report) can be used to predict potential fisheries or mariculture use of the area. Our evaluations range from a scale of 1 to 3; 1 is minimal, 2 average while 3 is maximal for each site. The results can be found in Table .

For scientific interest, we used criteria outlined in Gladfelter et al. (1985) for the tropical marine ecosystems of coral reefs, mangroves and seagrassbeds. The assigned values are relative to other sites in the USVI and BVI. A value of 3 indicates a site with particular scientific interest, usually a particularly rich and diverse area. A 2 ranking indicates an average site, while 1 indicates a rather poorly developed example of the particular ecosystem. If the ecosystem is not found within the park site, it is marked N.A. meaning not applicable.

It should be noted that most of the sites have at least one ecosystem with high scientific interest, while Anegada and The Dogs have two ecosystems ranked at that level.

To evaluate recreational potential we considered the following uses of the marine park sites: SCUBA, snorkeling, yachting, beaches and wreck exploring. A value of 3 for SCUBA indicates area with high aesthetic attributes including high coral cover and diversity and/or great vertical relief. A 3 for snorkeling indicates a rich and spectacular benthic community growing in shallow water with easy access either to an anchorage or by dinghy. For yachting, 3 indicates good anchorages and relatively easy access to support facilities such as stores for supplies. A 3 for beaches refers to easy and safe access, as well as an expanse of sandy beach (devoid of extensive beachrock or other obstructions). Finally, 3 for wreck exploring reflects access to wrecks.

We judged human impact based on our impressions of all the sites we visited. Lund et al. (1985) discusses specific information about the conditions of the biological communities at each of the major anchorages in the present or proposed park sites of the BVIs. We ranked half the park sites as 1, that is relatively pristine. Two sites were ranked 1-3, meaning most of the coastal area was relatively pristine, but one or more isolated areas were heavily impacted by human use. These sites are North Sound (with dredging near Bitter End) and The Baths (with a heavily used hard ground anchorage). Another site ranked 3 was Cane Bay, extensively used for both recreation and

industry. Salt Island, the site of the wreck of the Rhone is frequently visited by the diving public; the marine communities show extensive damage due to dragging anchors. The sites ranked as 2 were also impacted primarily at anchorages. These include Green and Sandy Cays near Little Jost Van Dyke and the Caves at Norman Island.

These evaluations are preliminary and based on our collective experiences in mapping the marine communities of these sites as well extensive diving and snorkeling in other areas of the USVI, the BVI and throughout the Lesser Antilles. It is hoped that this information will contribute to the evaluation of additional sites to complement the Virgin Islands National Park portion of a Lesser Antillean Biosphere Reserve.

Preliminary evaluation of Marine Communities of the Present
and proposed Park of the British Virgin Islands

PARK SITES

	Aneгада	No. Sound	The Baths	Salt Island	Dead Chest	Norman Island	Pelican	Tobago	LJVD	Cane Bay Garden	Beef Island	Dog Island	
SCIENTIFIC ¹ INTEREST	REEFS	3	3	1	1	3	2	3	3	2	2	2	3
	GRASS BEDS	3	1	NA	3	1	3	1	NA	2	1	2	3
	MANGROVES	2	2	NA	NA	NA	1	NA	NA	1	NA	3	NA
RECREATIONAL	SCUBA	3	3	2	2	3	2	2	3	2	2	1	3
	YACHTING	2	3	3	2	2	3	2	2	3	3	1	3
	BEACHES	2	1	3	2	1	1	1	1	3	3	1	2
	SNORKLE	2	3	3	2	2	1	3	2	2	3	3	3
	WRECKS	3	NA	NA	3	NA	NA	NA	NA	NA	NA	NA	NA
IMPACT ²	Observed Extent of Human Impact	1	1/3	1/3	3	1	2	1	1	2	3	1	1

1 refer to Gladfelter et al. (1985)

2 refer to Lund et al. (1985)

LITERATURE CITED

- Beets, J., Lewand, L., and V. Small. 1985.
- Brown, B. E. and R. P. Dunne. 1980. Environmental controls of patch reef growth and development. *Mar. Biol.* 56: 85-96.
- Davis, M., Gladfelter, E., Lund, H. and M. Anderson. 1985. Geographic range and research plan for monitoring White Band Disease. VIRMC Tech. Report # .
- Dunne, R. P. and B. E. Brown. 1975. Anegada Marine Biological Survey. Report of the Cambridge University Anegada Expedition.
- Gladfelter, E., Anderson, M., Lund, H. and M. Davis. 1985. Marine ecosystems of the Lesser Antilles-Identification of representative sites. VIRMC Tech. Report # 7 .
- Gladfelter, W.B., Gladfelter, E.H., Monahan, R.K., Ogden, J.C., and Dill, R.F. 1977. Environmental Studies of Buck Island Reef National Monument St. Croix, U.S.V.I. Report prepared by West Indies Laboratory, St. Croix, U.S.V.I., for the National Park Service, U.S. Department of the Interior.
- Lund, H., Anderson, M., Gladfelter, E. and M. Davis. 1985. Trends in recreational boating in the British Virgin Islands, A preliminary assessment of impact from human activities on anchorages and Development of a monitoring program for safe anchorages. VIRMC Tech. Report # 5 .
- Rogers, C. S., H. Carl Fitz and Marcia Gilnack. 1982. Coral Reefs, Mangroves, and Seagrass Beds of Northern Virgin Gorda, BVI. A report submitted to the ECNAMP and the Gov't of the BVI.
- Teytaud, A. R. 1983. Study of Management Alternatives for the Proposed Protected Areas at Sandy Cay and Norman Island, BVI. A report prepared for the Eastern Caribbean Natural Areas Management Program.
- West Indies Laboratory, Fairleigh Dickinson University. 1982. The Reef of Anegada Island, British Virgin Islands Survey of Potential Marine Park Sites. A report prepared for ECNAMP and the Gov't of the BVI.
- West Indies Laboratory, Fairleigh Dickinson University. 1983. The Bight at Norman Island: Survey of a Potential Park Site. A report submitted to ECNAMP and the Gov't of the BVI.

APPENDIX 1

Ecological Community Type Maps of the
Proposed Marine Park Sites in the British
Virgin Islands and Buck Island Reef
National Monument.

Note: Maps were reduced from originals
prepared at 1:5300 scale. Copies of
originals are available upon request.

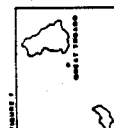
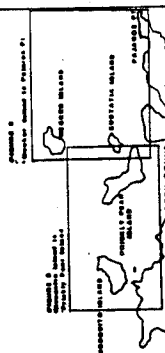
MAP 1

BRITISH
VIRGIN ISLANDS



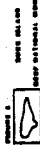
N

CARIBBEAN SEA



MAP 1

ST. CROIX



N

ST. CROIX

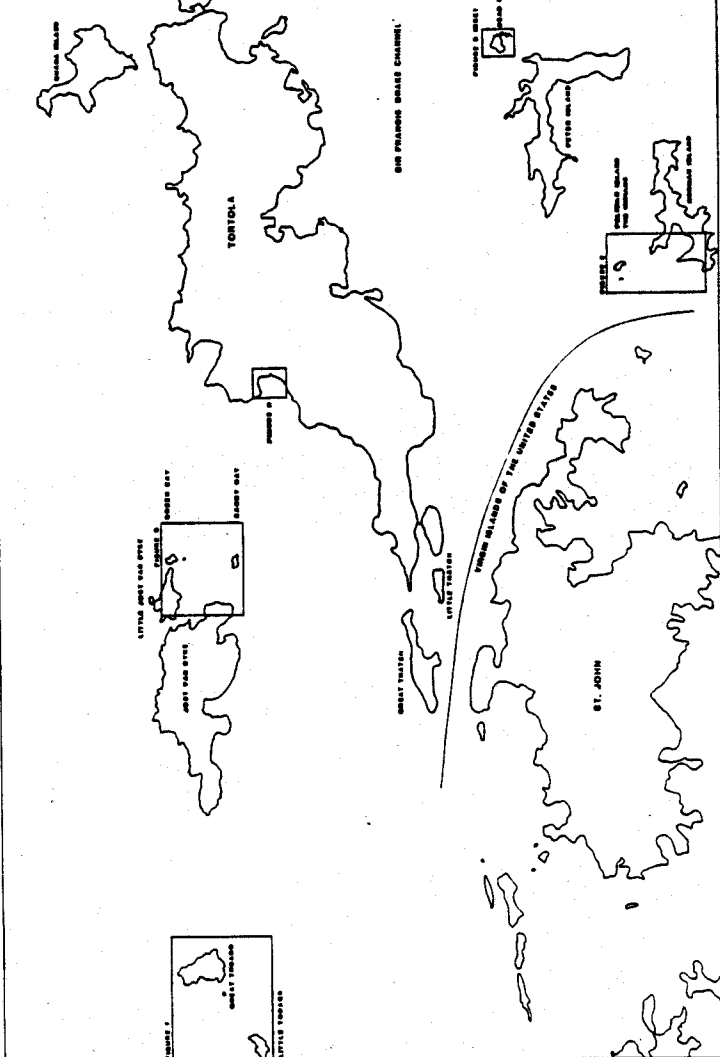
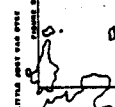


Figure B
NORTH SOUND

Recher Island to Palmer Point

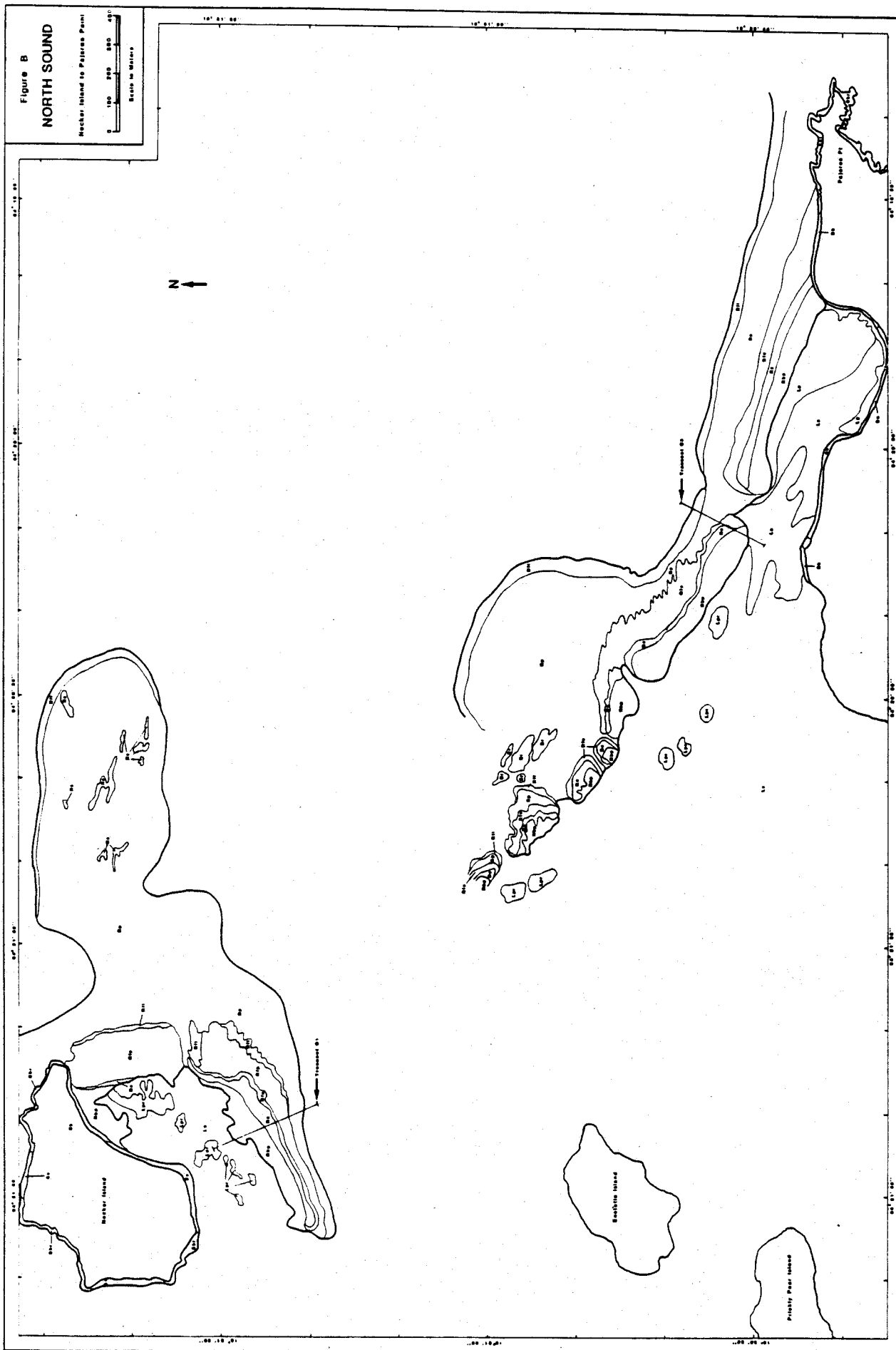
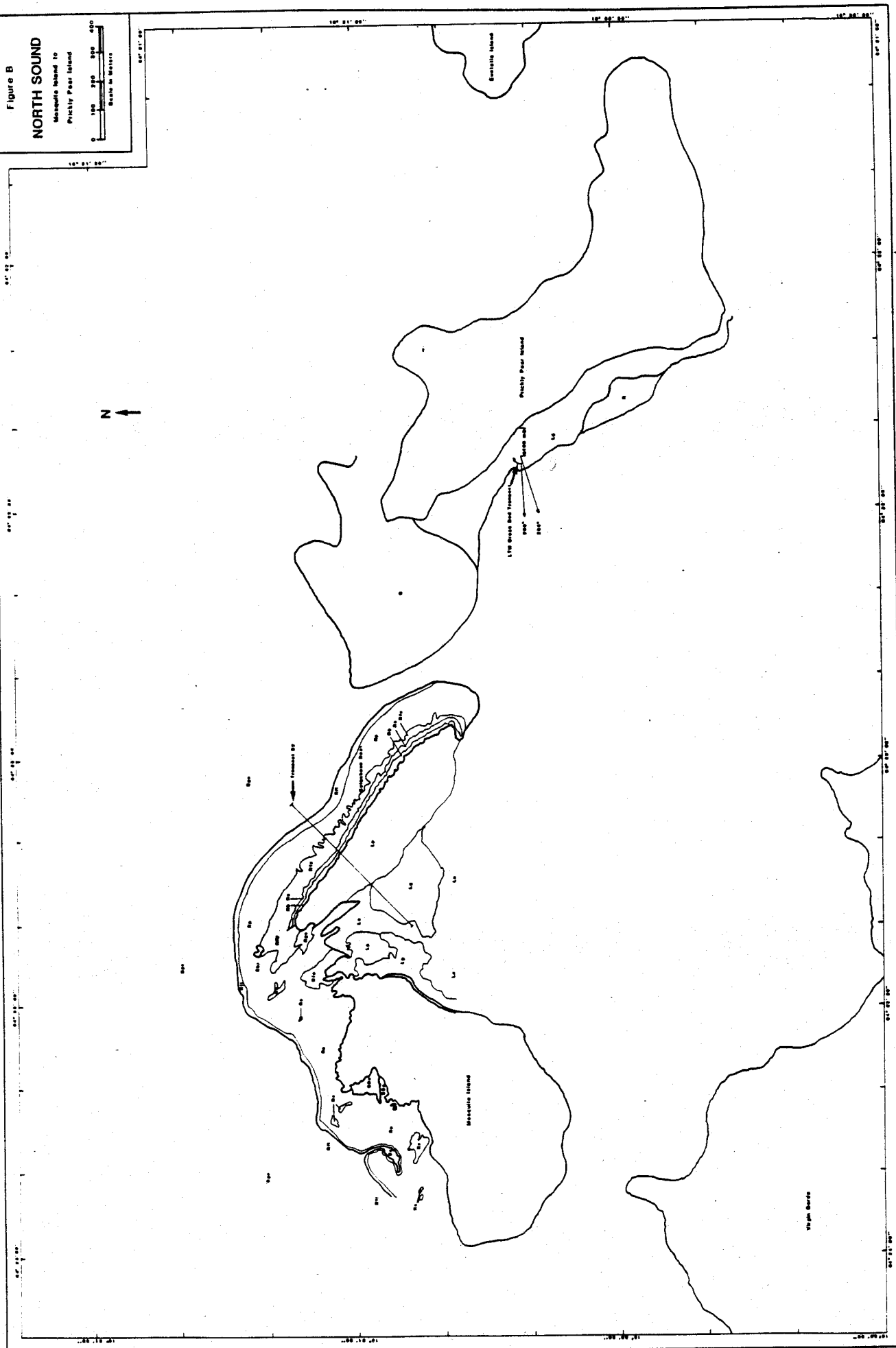


Figure B
NORTH SOUND

Mesquite Island to
Picky Peak Island



N



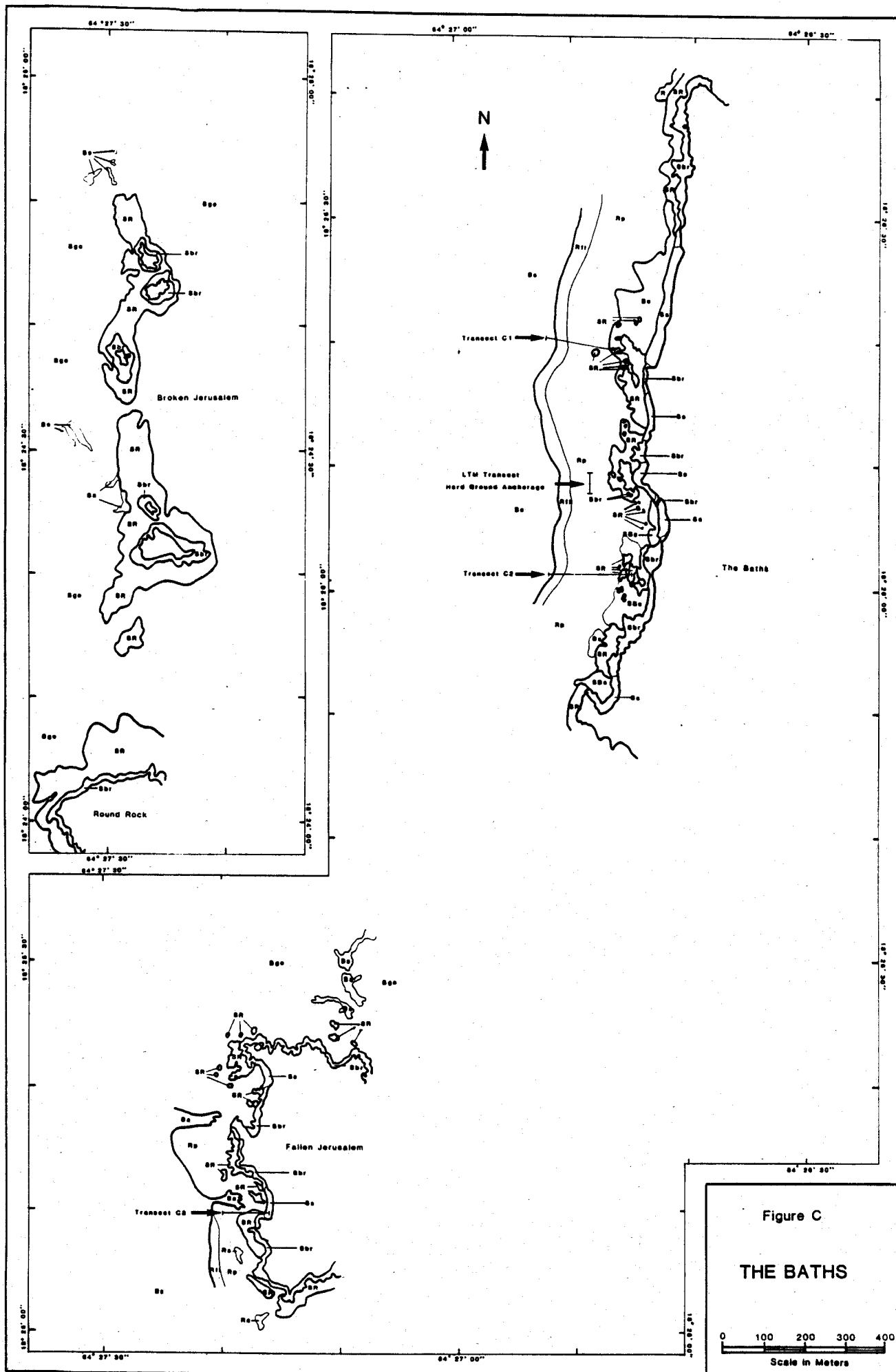


Figure C

THE BATHS

0 100 200 300 400
Scale in Meters

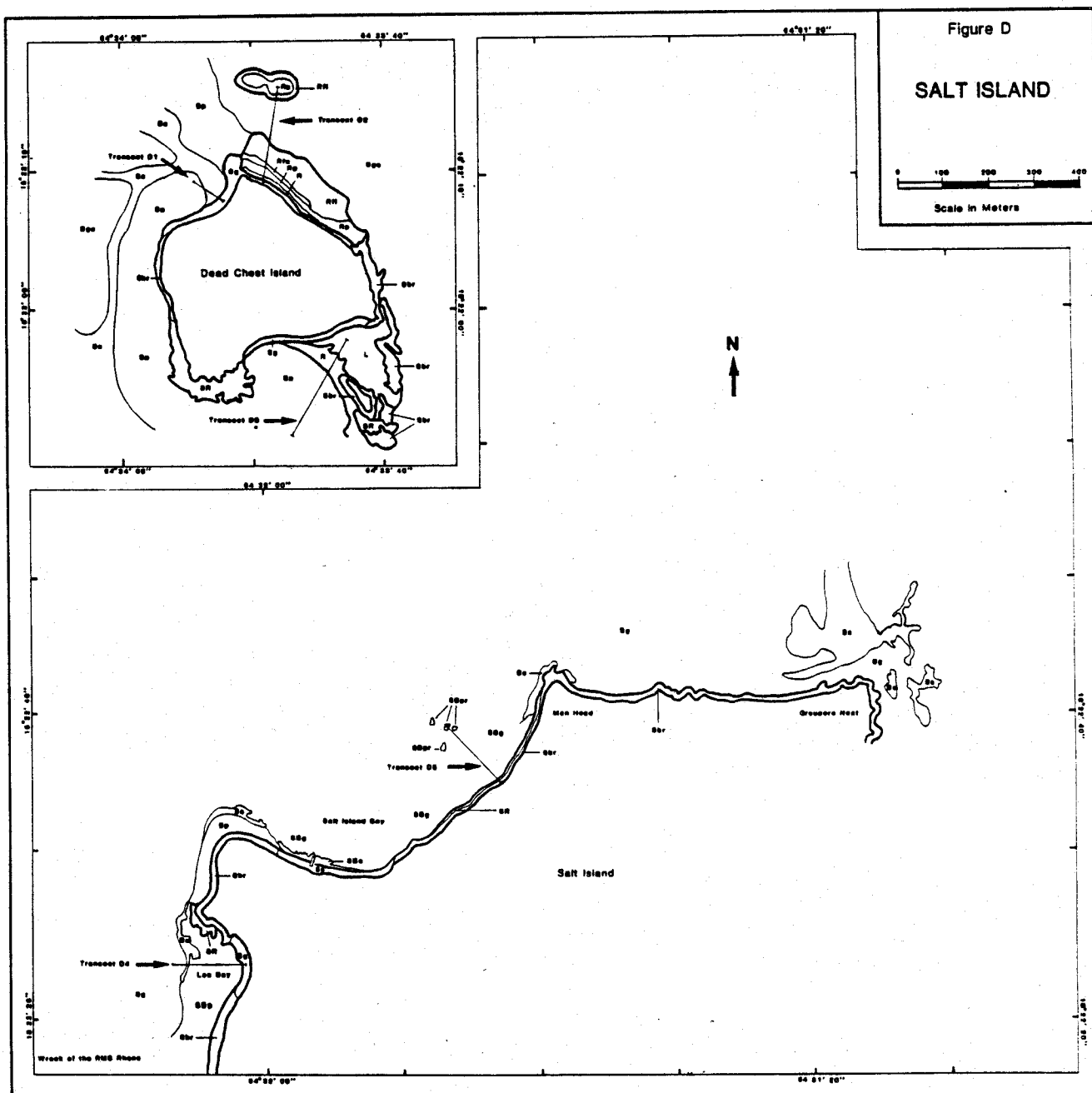


Figure E

NORMAN ISLAND

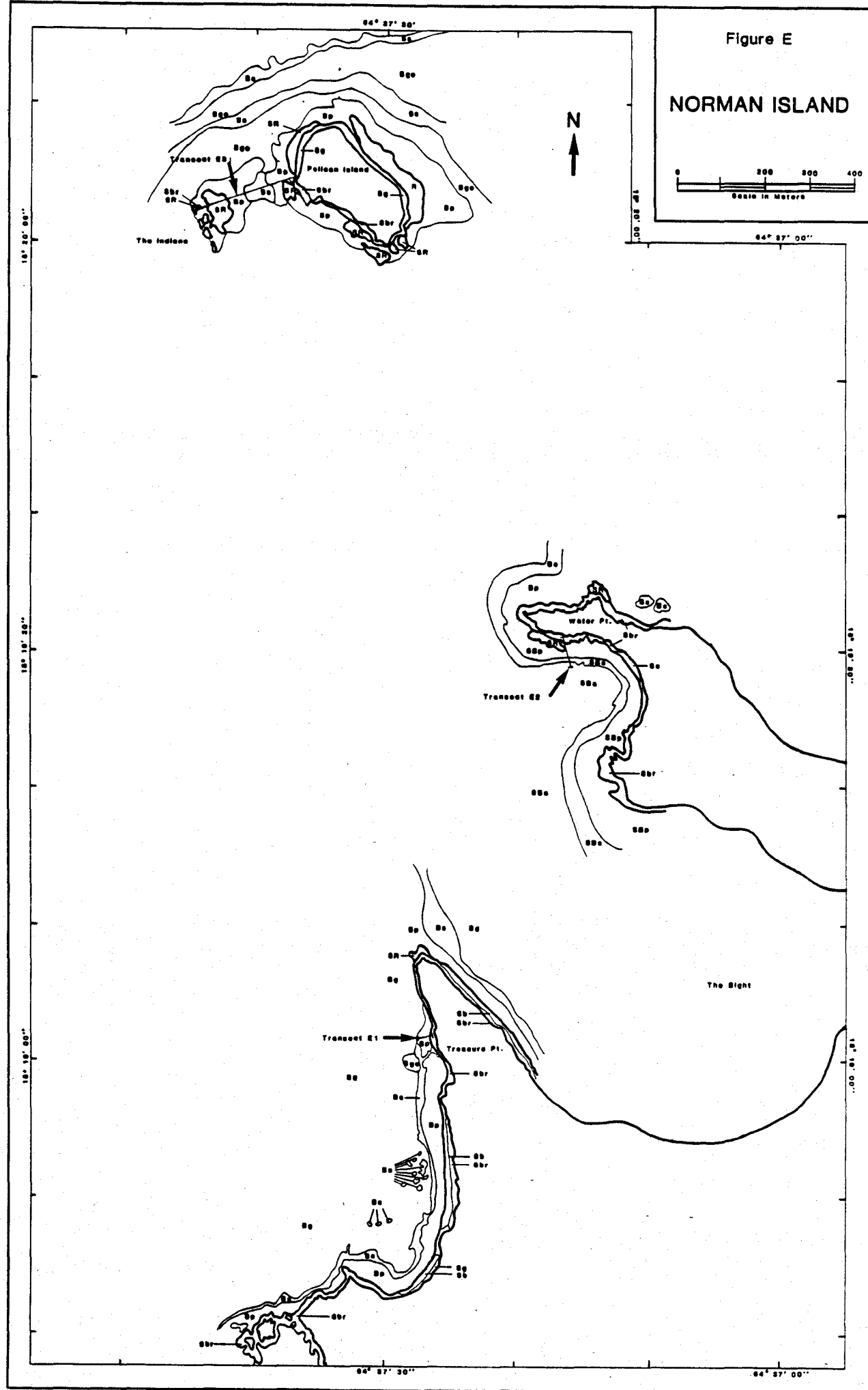
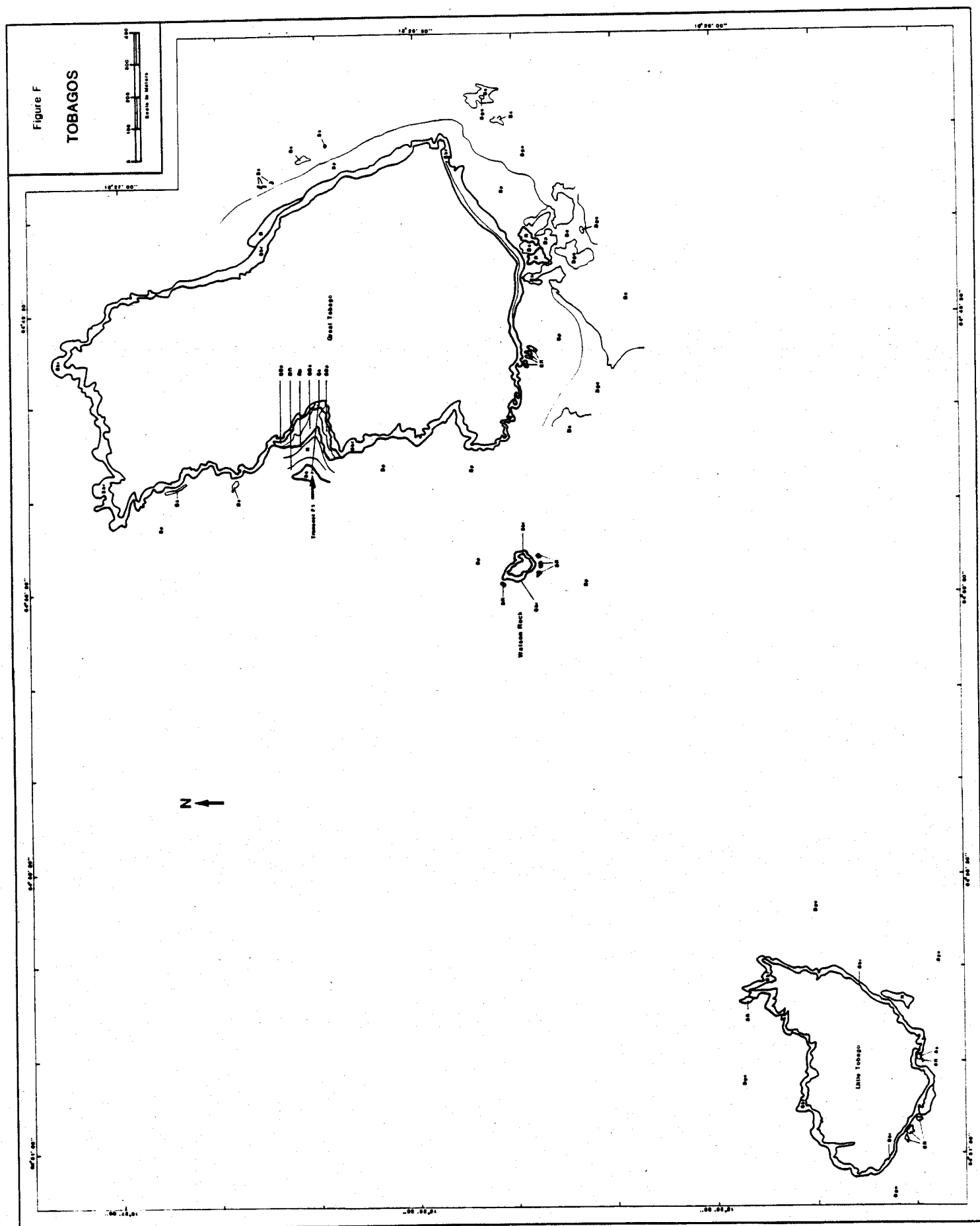
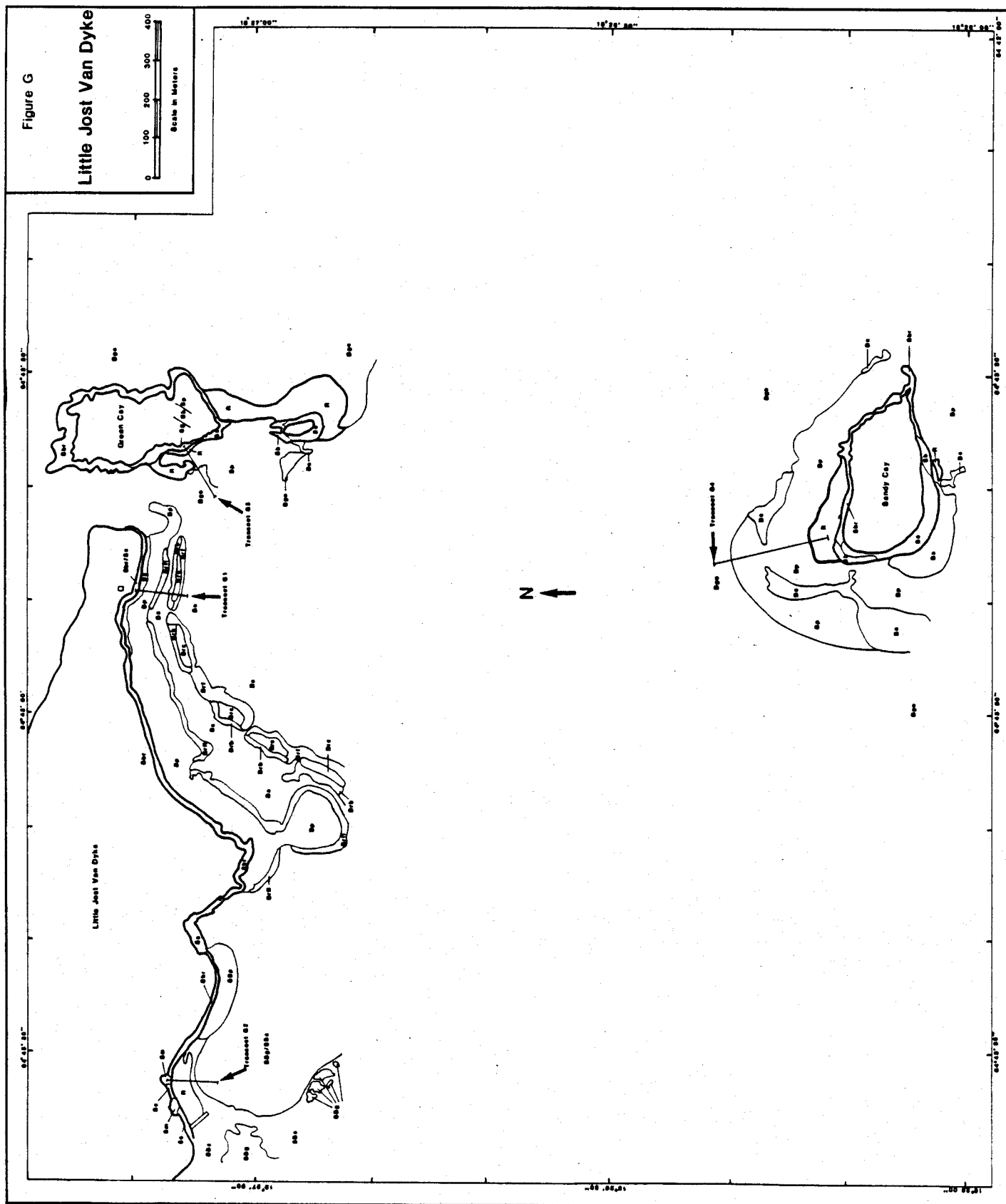


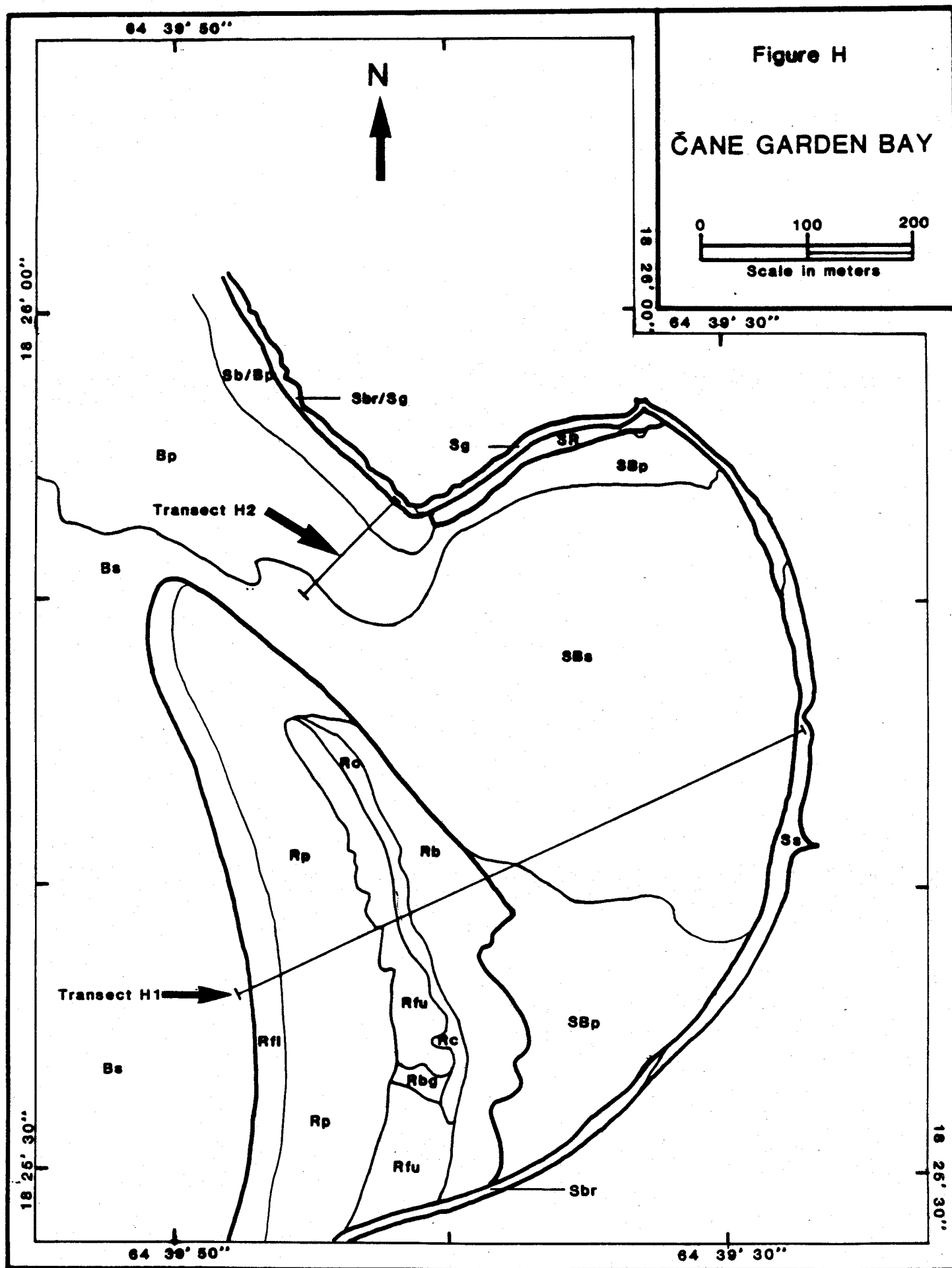
Figure F

TOBAGOS



Little Jost Van Dyke





BEEF ISLAND

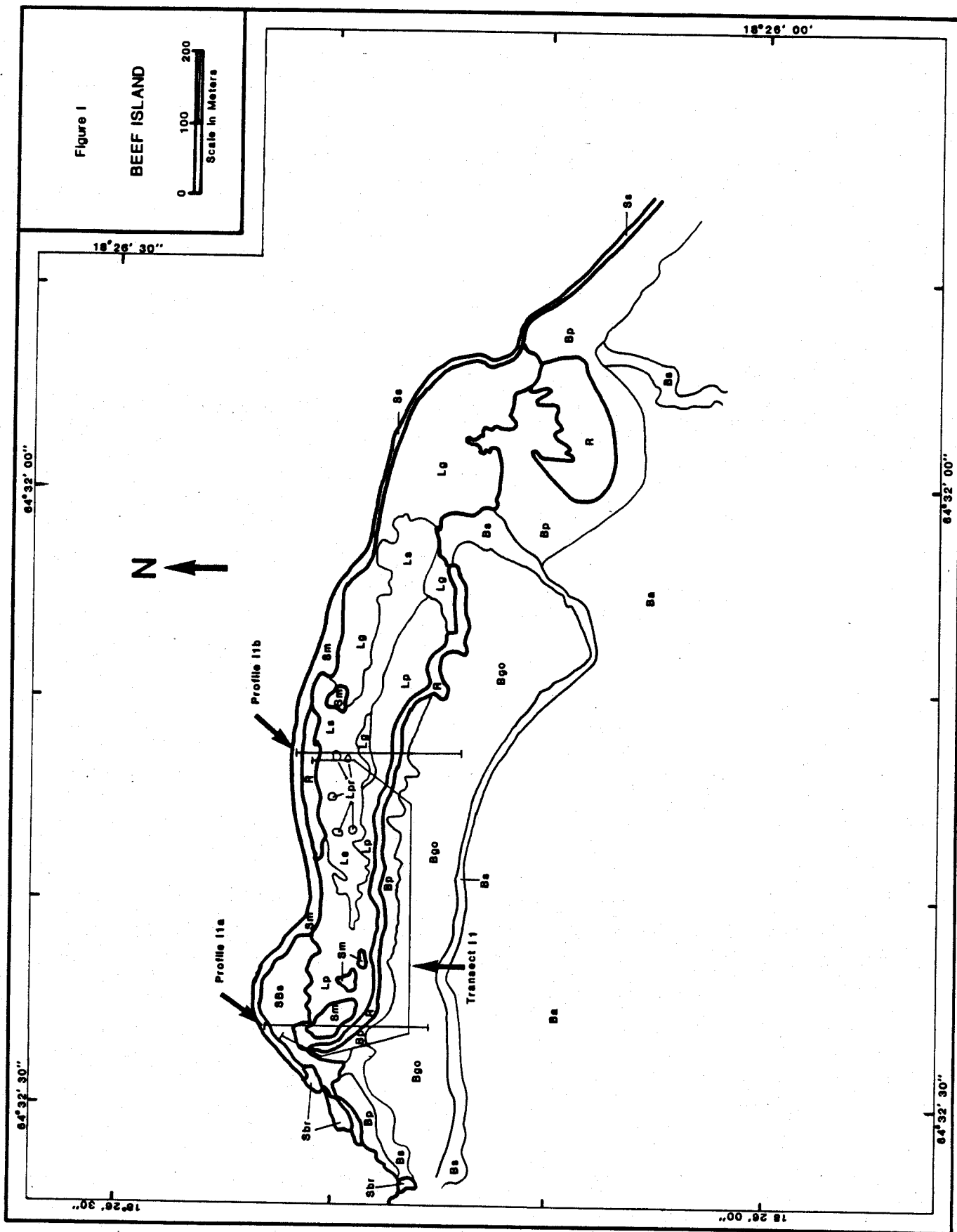


Figure J

THE DOGS



N

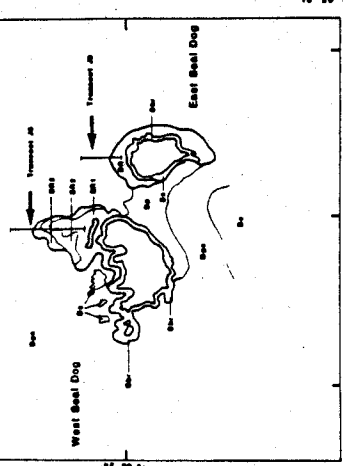
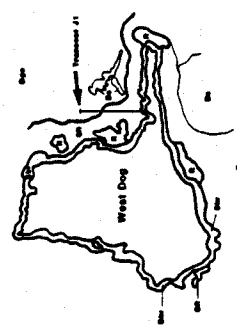
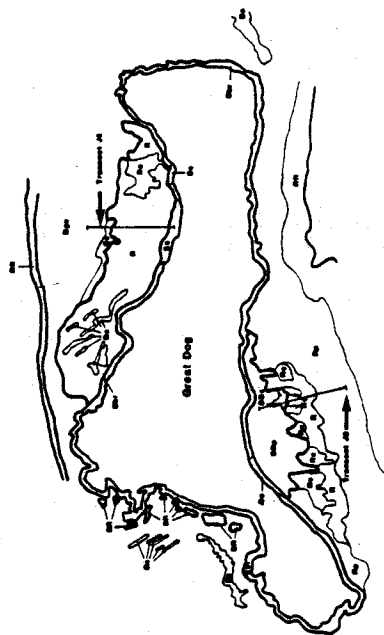
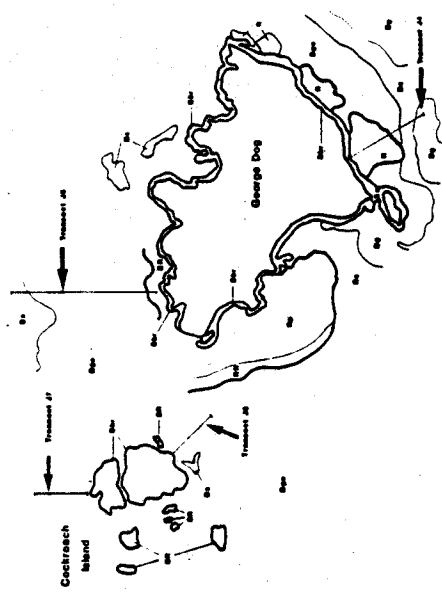


Figure K

BUCK ISLAND

