VIRGIN ISLANDS RESOURCE MANAGEMENT COOPERATIVE

BIOSPHERE RESERVE
RESEARCH REPORT NO. 2

MARINE COMMUNITY DESCRIPTIONS AND MAPS OF BAYS WITHIN THE VIRGIN ISLANDS NATIONAL PARK / BIOSPHERE RESERVE

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U.S. MAN AND THE BIOSPHERE PROGRAM

NATIONAL PARK SERVICE
Department of the Interior

Virgin Islands National Park

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BEETS

The Virgin Islands Resource Management Cooperative (VIRMC) was formed in 1982. Signatories to the Memorandum of Understanding are: Virgin Islands National Park, the Department of Planning and Natural Resources of the U.S. Virgin Islands Government (Division of Fish and Wildlife and Division of Natural Resources Management), University of the Virgin Islands, West Indies Laboratory, Island Resources Foundation, Eastern Caribbean Natural Area Management Program, U.S. Geological Survey, U.S. Fish and Wildlife Service, Southern Forest Experiment Station, University of Puerto Rico (Sea Grant Program and the Center for Energy and Environment Research), Caribbean Fishery Management Council, the Ministry of Natural Resources and Labor of the British Virgin Islands Government, and the British Virgin Islands National Parks Trust.

The objectives of the cooperative are:

1. To establish a Virgin Islands Resource Management Cooperative for the purpose of providing coordinated research, extension, and educational support of programs to achieve full benefits of island forests, wildlife, water resources, the marine environment, and historic areas and their associated resources for their cultural, social, commercial, economic, and recreational utilization and enjoyment.

2. To provide for the direction and management of the Cooperative by forming an Executive Committee, comprised of one representative from each of the organizations who are parties to this agreement, which will a) elect annually a Chairman from the membership of the Executive Committee to serve for a term of one year, b) appoint an Executive Officer to a staff position to coordinate the work of the cooperative, c) appoint technical committees and project leaders, d) provide for the orderly process of development and implementation of policy, and e) foster cooperative activities and relationships among participating parties and with other agencies and institutions.

3. To coordinate and facilitate financial and other support for research on environmentally acceptable uses of forests, wildlife, the marine environment and historic areas, and their associated resources in order to provide for their better management.

4. To provide for the collective utilization of the unique attributes and resources (personnel, facilities, equipment, and other support services) of the parties as they may relate to objectives pursued under this agreement.

5. To plan for appropriate dissemination, publication, and application of research and information.

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BIOSPHERE RESERVE

RESEARCH

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Abstract

REPORT NO.2
Subtask 1.1

MARINE COMMUNITY DESCRIPTIONS AND MAPS OF BAYS WITHIN THE VIRGIN ISLANDS NATIONAL PARK/BIOSPHERE RESERVE

A series of benthic maps were prepared representing the marine habitats of the bays of St. John, U.S. Virgin Islands. The maps were drafted from National Oceanographic Service aerial photographs and enhanced using existing photographs, charts and publications. All bays within Virgin Islands National Park boundaries were groundtruthed and described using standard methods adopted by the Virgin Islands Resource Management Cooperative. The major zones were identified and designated based on dominant physical and/or biotic components. A detailed description of major marine zones within each bay was prepared. Relative abundance, condition and percent cover of major species were estimated along with substrate composition and complexity. A summary of the marine zones and their relative condition within each bay and a list of general observations are presented.

St. John and the surrounding small islands of the northern Virgin Islands are of volcanic origin with precipitous slopes ascending from the flat Puerto Rican platform. Typical of these steep, volcanic islands, St. John does not have an extensive bank barrier reef system. However, the complex topography of the island, cays and associated formations yield a great diversity of marine communities.

Sedimentation, visitor damage, vessel anchor damage, beach erosion and illegal harvesting were noted problems within the Biosphere Reserve. Special emphasis was given to bays designated as 'areas of particular concern.' These areas of impact or potential impact were noted and described in greater detail. Two areas, Hawksnest and Fish Bays, were chosen for establishment of long-term phototransect monitoring.

A review of methodologies used from mapping and characterizing marine communities was prepared. The emphasis was on efficient, cost-effective methods which would be of practical use throughout the Caribbean.

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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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* Note that profile number correlates to section number in text

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ACKNOWLEDGEMENTS

For assistance during our work, we thank the following persons: Ralf Boulon of the Division of Fish and Wildlife for invaluable assistance in the field and all facets of the subtasks; Bob Brander, Jim Riddle, Caroline Rogers and the rest of the staff of the Virgin Islands National Park for technical and logistic support; Betsy Gladfelter, Miles Anderson and Holly Lund of the West Indies Laboratory for advice and assistance in design and preparation; Arthur Dammann for advice and information on previous work and collections in the Virgin Island area and Bruce Coblentz of Oregon State University for information and assistance in fish collection.

Additionally, we would like to thank Superintendent Noel Pachta and the Virgin Islands National Park Service for making available the NOS aerial photographs, the park research boat for field work, laboratory space and supplies for collection curating and an endless amount of logistic support.

1. INTRODUCTION

The emphasis of Subtask 1.1 has been to prepare a series of ecological marine community maps as reference for scientists and resource managers in planning future investigations and management strategies. The maps have been prepared from existing information, aerial photographs, and subsequent field investigation. The maps produced for Subtask 1.1 include the entire shoreline of St. John although the field work was restricted to Virgin Islands National Park Service boundaries and immediately associated areas.

During the four month field work period, February - May, 1984, every bay within the Virgin Islands National Park on St. John was investigated and major zones characterized. Methods used during the investigation were derived by the Working Group of the Virgin Island Resource Management Cooperative (VIRMC). Descriptions of the bays within the park around St. John were produced and form the main body of the report.

General observations of the marine communities for the entire island are presented in Discussion, Section 4., so as to provide a brief review of information from descriptions. Specific observations of areas with observed and potential problems are discussed.

A brief discussion of the methodologies used during this investigation and alternate methods is presented in Section 4. The emphasis has been in the evaluation of cost effective and efficient methods for practical use throughout the Caribbean. Recommendations are presented for continued investigation and long-term monitoring methods.

2. METHODS

Prior to field work, investigators involved in separate subtasks but with similar data requirements derived and adopted field techniques for use. Zones and subzone definitions were derived and adopted for use in all subtasks. A comprehensive presentation of the methods used for groundtruthing and characterization during this phase of the Biosphere Projects are presented in Report 1.3 by West Indies Laboratory.

Fish surveys were accomplished simultaneous to the field work for this subtask. Refer to Report 2.2 by the Division of Fish and Wildlife for methods and results.

2.1 Map Drafting

Draft base maps of marine communities were produced from aerial photographs. The aerial photographs of St. John and vicinity were from National Ocean Survey (1983 Series) with a scale of 1:5300. The aerial photographs were taken during March, 1983. Resolution and water penetration were excellent due to calm and clear conditions during the photographic flights. Most marine communities were easily visible to depths of approximately 20 meters.

The initial base maps were drafted directly from the enlarged aerial photographs (76.2 x 76.2 cm.) at the scale of 1:5300. Drafting acetate was placed over the photographs on a light table and all distinguishing coastal and marine features were inked onto the acetate.

Definition of the various marine communities (zones and subzones) was completed by the Working Group of VIRMC prior to drafting. The following definitions were derived:

Major Zones:

1) Shore zone: The region between the highest waterline and the mean low tide level.

2) Subtidal bedrock: An extension of bedrock from the island, either flat or massive, or boulder and rock rubble talus from shore.

3) Lagoon: The relatively quiet shallow water area adjacent to 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.

Subzones:

1) Reef crest: The shallow portion of reef which extends to mean low tide and separates the fore and back reef areas.

2) Back reef: The portion of the reef shoreward of the reef crest.

3) Fore reef: The portion of the reef seaward of the reef crest.

4) Upper fore reef: Shallow fore reef normally dominated by branching coral (Acropora palmata) with high structural complexity.

5) Lower fore reef: Deeper fore reef dominated by head corals with normally a lower structural complexity than the upper fore reef.

6) Patch reef: A nonlinear reef complex separated from other reef complexes.

7) Bank reef: A large linear reef complex located offshore and separate from inshore reefs; not forming a shallow water barrier.

8) Pavement: Hard carbonate substrate of low relief with normally less than 20-25% cover of coral and other sessile invertebrates.

9) Gorgonian-dominated pavement: Hard carbonate substrate of low relief dominated by gorgonians with at least 20-25% cover.

10) Grass bed: Soft substrate dominated by spermatophytes (sea grasses).

11) Algal plain: A deep water substrate dominated by algae usually located on the bank.

Marine zones and subzones were differentiated, primarily, on the basis of community structure and composition with consideration to relief, depth, location and size. Visual analysis of aerial photographs was required to determine zone and subzone boundaries for the base maps. Although ability to differentiate zones and subzones improved with practice, knowledge of typical reef types, community structure and composition, experience with aerial photographs and, especially, knowledge of the area was extremely beneficial.

Following determination of each marine zone and subzone on the aerial photographs, the area was drafted onto the acetate. Mangrove areas lining the shoreline were drafted. Salt ponds were also drafted although not investigated. The inshore mangrove areas surrounding salt ponds were not drafted.

Smaller aerial photographs were used for reference due to loss of definition in the enlargements. The enlargements were darker with frequently obscured zones. Other available aerial photographs were reviewed for more complete assessment. Color photographs proved more useful in differentiating zones.

The base maps were photocopied onto Nalgene Polypaper for use in the field. Following groundtruthing, for verification of community types, the base maps were corrected.

2.2 Groundtruthing and Characterization

Prior to investigation of each area, investigators reviewed the base map copies and prepared a waterproof plastic data sheet for data recording in the water. Each zone was verified and described by snorkeling or using S.C.U.B.A. Within each bay or area, a representative section was chosen for a profile transect. A single transect was completed within most bays within the park boundaries unless complexity of marine communities within a bay required the completion of two or more transects.

Parameter estimates, such as percent cover, were accomplished visually by each investigator. Prior to investigation, field training was required to establish reliable estimates between investigators. This was accomplished by the placement of a one meter quadrat several times within various communities with varying density and determination of actual values.

The following data were recorded for each major zone:

1. Reefs and hard substrate
   a) total coral cover - percentage of substrate covered by gorgonians and scleractinian cover with each also recorded separately.
   b) percent cover - percentage of substrate covered by organisms of each major taxonomic group, recorded separately
   c) percent live vs dead - overall average percent cover of living tissue to non-tissue covered portions of the living scleractinian and hydrocoral colonies present within a zone. This provided an assessment of general health.
   d) substrate complexity - rating of habitat structural complexity with the following criteria:
      1) Flat sand zone or pavement
      2) Low profile reef - *Acropora prolifera* or *Porites porites* reefs

with small pore spaces

3) Partially consolidated rubble - dead or damaged reef with larger pore spaces

4) Medium profile active reef - Montastrea annularis reef or equivalent

5) Active vertical arboreal reef - Acropora palmata reef

e) species lists of all major organisms present with notes on relative abundance

2. Seagrass beds and algal flats

a) Seagrass species present with notes on relative abundance

b) Macroalgae present with relative abundance

Additionally, notes were taken on all unique and unusual features, formations and conditions. Particular emphasis was given to areas with suspected visitor damage, pollution and sediment damage. General observations and depth ranges for each zone were recorded.

Using the data, tables and profiles were constructed. The tables and profiles are located in Appedices 1 and 2, respectively. The zone and subzone designations used in profiles and tables are in Table 2.1. The acronyms for organisms used in the tables are in Table 2.2. The symbols for dominant organisms used in profiles are in Table 2.3.

Field investigation commenced the last week of January, 1984 and was terminated in May, 1984.

TABLE 2.1 Zone and Subzone Designations

Zone and Subzone Designations	Acronym
A) Shore Zone	S
1) Beach rock	Sb
2) Sand	Ss
3) Mangrove	Sm
4) Gravel/cobble	Sg
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
a) pavement	SBprp
5) Mud	SBm
6) Algae	SBa
7) Artificial reef	SBar
E) Reef (fringing and barrier)	R
1) Backreef	Rb
a) head coral/grotto	Rbh/Rbg
b) pavement	Rbp
2) Reef crest	Rc
3) Fore reef	Rf
a) upper (arborescent)	Rfu
b) lower (massive)	Rfl
c) pavement	Rfp
4) Sand	Rs
5) Gorgonian-dominated pavement	Rgo
6) Pavement	Rp
F) Bank	B
1) Gorgonian-dominated pavement	Bgo
2) Pavement	Bp
3) Sand	Bs
4) Seagrass bed	Bg
5) Patch reef	Bpr
a) crest	Bprc
b) fore reef upper/lower	Bpru/Bprl
c) pavement	Bprp
d) gorgonian-dominated pavment	Bprgo
6) Bank reef (linear aspect)	Br
a) crest	Brc
b) fore reef upper/lower	Brfu/Brfl
c) backreef	Brb
7) Algal plain	Ba
G) Shelf Edge Reef	SER

TABLE 2.2 Acronyms for Organisms

Hard Coral Taxa	Acronym
Acropora cervicornis	Acer
Acropora palmata	Apal
Acropora prolifera	Apro
Agaricia agaricites	Aga
Agaricia lamarcki	Agl
Cladocora arbuscula	Cla
Colpophyllia natans	Col
Dendrogyra cylindrus	Den
Dichocoenia stokesii	Dic
Diploria clivosa	Dcli
Diploria labyrinthyformis	Dlab
Diploria strigosa	Dstr
Eusmilia fastigiata	Eus
Favia fragum	Fav
Isophyllastrea rigida	Isas
Isophyllia sinuosa	Iso
Leptoseris (=Helioseris) cucullata	Lep
Madracis decactis	Mdec
Madracis mirabilis	Mmir
Manicina areolata	Mac
Meandrina meandrites	Mea
Millepora spp.	Mil
Montastrea annularis	Mann
Montastrea cavernosa	Mcav
Mussa angulosa	Mus
Mycetophyllia spp.	Myc
Oculina diffusa	Ocu
Porites asteroides	Past
Porites divaricata	Pdiv
Porites porites	Ppor
Scolymia spp.	Sco
Siderastrea radians	Srad
Siderastrea siderea	Ssid
Solenastrea bournoni	Sol
Stephanocoenia michelini	Ste
Tubastrea aurea	Tub

Other Taxa	
Acanthophora spicifera	Acan
Anemone	ane
Ascidians	asc
Briarium asbestinum	Bri
Chondrilla nucula	Chon
Condylactis gigantea	Con
Diadema antillarum	Dia
Dictyota spp.	Dict
Echinometra spp.	Eci

TABLE 2.2 Cond.

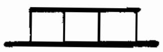
Other Taxa	Acronym
Halimeda incrassata	Hami
Halimeda opuntia	Hamo
Halodule wrightii	Hal
Halophila baillonis	Hap
Heteractis luridea	Het
Jania spp.	Jan
Gorgonia spp.	Gor
Gorgonians	gorg
Liagora spp.	Lia
Palythoa caribbea	Pal
Penicillus capitatus	Penc
Pinna carnea	Pca
Ricordea florida	Ric
Stoichactus helianthus	Sto
Sponges	spg
Syringodium filiforme	Syr
Thalassia testudinum	Tha
Udotea spp.	Udo
Zoanthus sociatus	Zoa

NOTE: Subsequent use of scientific names listed in this table will have the generic name abbreviated.

TABLE 2.3

Symbols for Dominant Organisms and Substrate

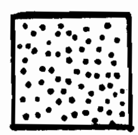
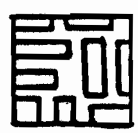
Hard Coral spp.

	*Acropora cervicornis*
	*A. palmata*
	*A. prolifera*
	*Diploria* spp.
	*Millepora*
	*Montastrea annularis*
	*M. cavernosa*
	*Porites divaricata*
	*P. porites*
	*P. astreoides*
	*Agaricia* spp.
	*Siderastrea siderea*
	*Colpophyllia natans*
	*Favia fragum*

Other Organisms

	Gorgonians
	*Echinometra*
	Zoanthids
	*Halimeda*
	*Penicillus*
	*Udotea*
	Sea Grass
	Mangrove

Substrate Types

	Sand
	Pavement/Coral Rubble/Turf
	Bedrock
	Beach Rock

3. RESULTS - MARINE COMMUNITY DESCRIPTIONS

A total of 16 maps were produced for the island of St. John. Groundtruthing and characterization were accomplished within Virgin Islands National Park Service boundaries only and including Otter Creek in Coral Bay. Areas outside National Park Service boundaries were drafted from zones apparent on the aerial photographs but were not groundtruthed. These areas are, therefore, subject to error and provide the base for future investigation.

The following sections are the marine community descriptions which were compiled from data and observations completed during the groundtruthing and characterization of the marine benthic communities within the boundaries of the Virgin Islands National Park. All major shoreline features are presented with prominent points, rocks, and cays labelled. Figure 1 lists the bays and locations of the areas groundtruthed during this investigation.

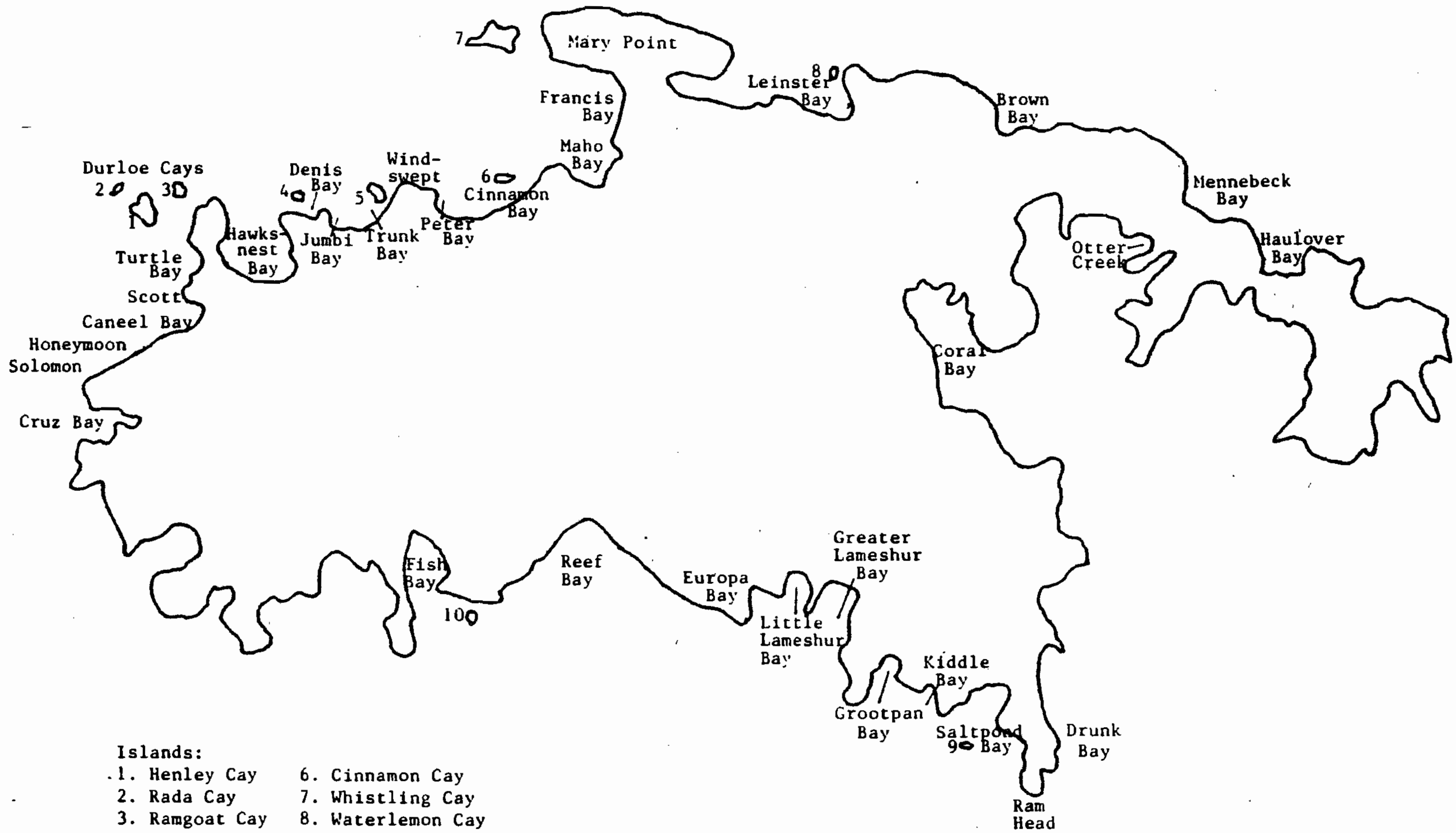
Information is presented in a format for easy map referral. The information for the north shore of St. John is presented first, followed by information for the south shore. All information is presented from west to east.

A map of each described area is provided for easy reference. Tables and profiles of each described area are located in Appendices 1 and 2, respectively. Species which were observed along the transects are presented in the tables. Additional species observed within each zone which were not observed along the transects are listed in the text. An attempt was made to list organisms by estimated relative abundance. Percent cover varied within a zone, sometimes considerably. The parameter estimates listed in the tables are an average for each zone. Notable variations are mentioned in the text.

3.1 Cruz Bay

Cruz Bay is the main harbor and port of entry for St. John (Fig. 2). The bay is well protected and is the most heavily utilized bay on the island. The largest township, Cruz Bay, is located along the bay and is the most developed area of the island. Only the northern and northeastern portions of the bay are within park boundaries. The Virgin Islands National Park Visitors' Center and the Caneel Bay Boat Yard occupy the northeastern portion of the bay. The Seaplane Shuttle maintains a seaplane ramp approximately halfway along the northern shore.

Red mangroves (Rhizophora mangle) occupy a portion of the northern



Islands:
1. Henley Cay
2. Rada Cay
3. Ramgoat Cay
4. Perkins Cay
5. Trunk Cay
6. Cinnamon Cay
7. Whistling Cay
8. Waterlemon Cay
9. Booby Rock
10. Coccoloba Cay

Figure 1. Areas groundtruthed within Virgin Islands National Park

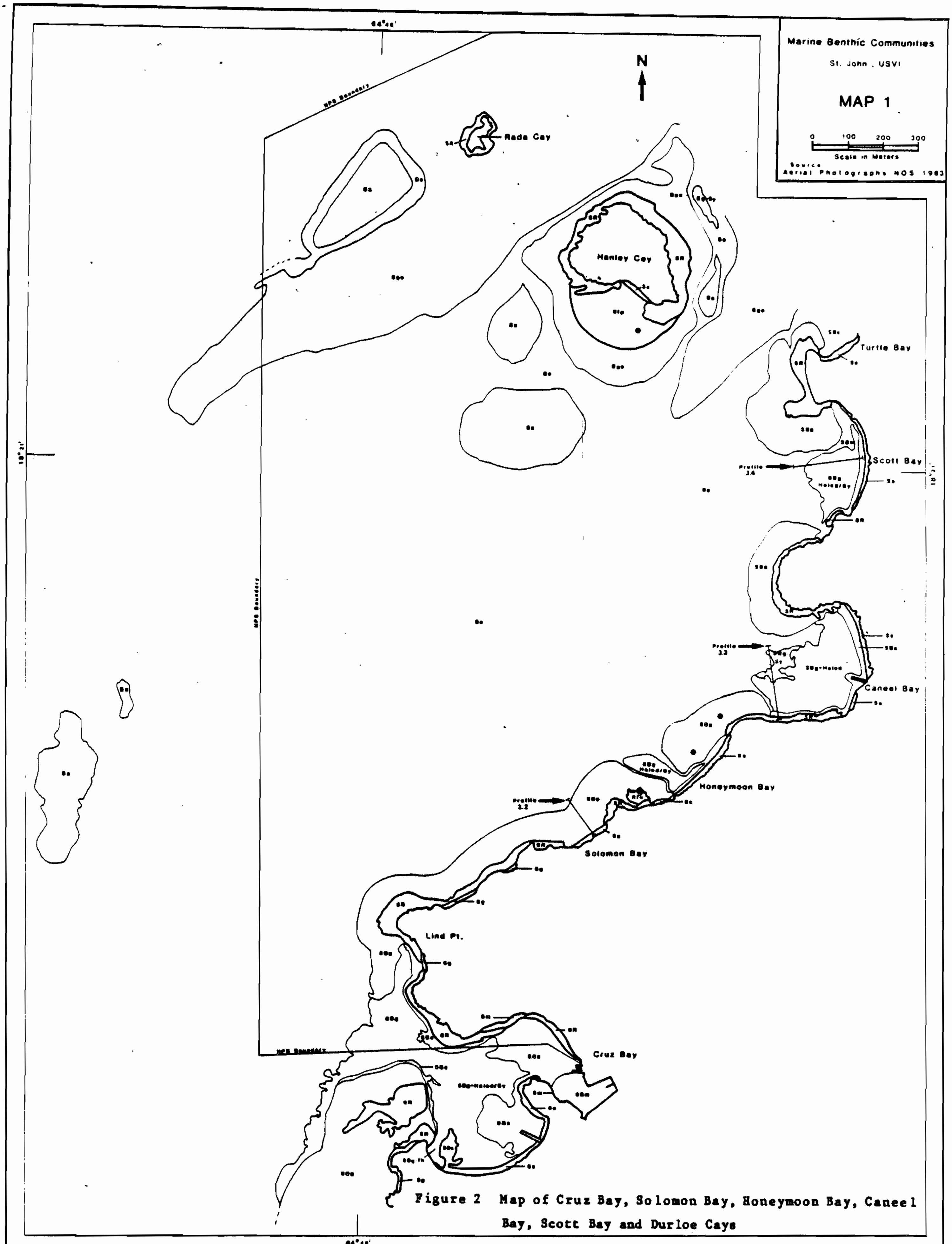


Figure 2 Map of Cruz Bay, Solomon Bay, Honeymoon Bay, Caneel Bay, Scott Bay and Durloe Cays

shore. The remaining portion is volcanic bedrock. Previous studies have documented the benthic communities and bottom types of the bay (Grigg, 1978; Brody et al., 1970).

3.1.1 Shallow Bay Mud

The inshore portion of Cruz Bay next to the Visitors' Center is dominated by mud bottom with very sparse living cover. This portion of the bay is enclosed by bulkheads which are colonized by a typical subtidal community of annelids, limpets, snails, mussels and barnacles. Mullets (Mugil sp.) are frequently observed in this area along with small schools of anchovies and herrings.

This area is marked by high turbidity due to prop wash and storm runoff which enters the bay from the 'gut', or drainage, on the extreme eastern portion of the bay.

3.1.2 Subtidal Bedrock

The small segment of subtidal bedrock along the nothern shore has sparse total coral cover (<5%). Millepora sp. dominates the shallow water area (0.5-1.0 m.) with cover increasing to the point. Typical subtidal community organisms occupy the zone. Other organisms present are P. asteroides, D. strigosa, D. labyrinthyformis, F. fragum, S. siderea, S. radians, M. annularis, gorgonians and sponges.

3.1.3 Shallow Bay Seagrass

Very sparse stands of H. wrightii and S. filiforme occupy most of the bay bottom. Occasional patches of T. testudinum are present and become dominant in the shallow southwestern portion of the bay. Anchor rake by vessels is very apparent throughout the bay.

3.2 Solomon and Honeymoon Bays

Solomon and Honeymoon Bays are well protected, shallow bays with sparse cover (Fig. 2). Most of the beach areas are sand with rock cobble. Sand and shallow sand over pavement dominate the bottom. Honeymoon Bay is a popular destination for day sailing charters from St. Thomas.

Additional information is presented in Table 3.2 and Profile 3.2.

3.2.1 Subtidal Bedrock

In Solomon Bay, rock cobble occupies the inshore area to a depth of approximately 1.0 m. The percent total coral cover is less than 5% here.

Bedrock dominates north and south of the beaches of both bays with 5-10% total coral cover. In addition to the organisms listed in Table 3.2, the following organisms occupy this zone: P. porites, A. palmata, A. cervicornis, S. radians, S. siderea, M. annularis, C. natans, D. clivosa, D. strigosa, P. caribbea. Gorgonians and sponges were extremely sparse.

Twenty-five individuals of D. antillarum were observed around the southern point of Solomon Bay.

3.2.2 Shallow Bay Seagrass

Syringodium filiforme with a patchy distribution covers a narrow zone in the southwestern third of Honeymoon Bay. Thalassia testudinum is present but sparse. Halodule wrightii occupies the shoreward area of this zone.

3.2.3 Shallow Bay Pavement

Very sparse total coral cover marks this zone (<5%) with very low percent live (10-20%). Gorgonian cover is low but increases slightly seaward. Sand covers much of this zone. Much of the area in Honeymoon Bay is covered by coral rubble, predominantly A. cervicornis.

A small patch of dead upper fore reef occupies the southern portion of Honeymoon Bay beside the point. A few small colonies of A. palmata survive among several dead colonies. Total coral cover is 20-25%. Other organisms observed were P. asteroides, M. annularis, A. agaricites, Millepora sp., P. porites, D. clivosa, D. strigosa, F. fragum, S. radians, D. labyrinthyformis, A. cervicornis, P. caribbea, and a few gorgonians. One D. antillarum was observed in this area.

The pavement increases in slope seaward to form a very sparse zone of coral cover (5-10%). Most of the colonies are eroded with low percent live cover. Total coral cover decreases to the north.

3.3 Caneel Bay

Caneel Bay is a well protected bay which has a white sand beach (Fig. 2). Caneel, Scott and Turtle Bays lie on Caneel Point which is the site of the RockResorts' Caneel Bay Plantation Resort. Caneel Bay is the largest and most developed bay. The resort maintains a dock and ferry service. Caneel Bay is a popular anchorage and frequently is occupied by over 15 vessels.

The bay has been the subject of previous surveys due to the effluent of desalination wastes (Robinson, 1972; Beets et al., 1985). Previous surveys have provided much physical, chemical, and biological data. An important finding was the disappearance of an extensive _T. testudinum_ bed described by Robinson (1972).

Additional information is presented in Table 3.3 and Profile 3.3.

3.3.1 Subtidal Bedrock

This is a narrow zone along both shores, 5-18 m., with low total coral cover (<5%). No large coral colonies exist except for one large, dead colony of _P. porites_ in the southeastern portion of the bay.

A storm water drain is present along the northern shore and the surrounding rock is colonized by dense algal turf.

3.3.2 Shallow Bay Seagrass

Halodule wrightii dominates the inshore area. Callianassid shrimp mounds are abundant here. _Syringodium filiforme_ dominates seaward with moderate to high density. _Thalassia testudinum_ is rare throughout the zone.

Anchor rake is evident within the seagrass bed. Long-term anchors and moorings have denuded the seagrass within areas of 4-6 m. diameter. No seagrass rhizomes were located within the denuded areas of those observed.

3.4 _Scott Bay_

Scott Bay is a well protected, shallow bay with a white sand beach (Fig. 2).

Additional information is presented in Table 3.4 and Profile 3.4.

3.4.1 Subtidal Bedrock

The inshore areas on both sides of the beach have a low percent coral cover (<5%) with _P. asteroides_ dominant. Along the southern shore, three large, dead colonies (2-3 m.) of _P. porites_ exist. Other organisms are _A. agaricites_, _A. palmata_ (few, small colonies), _Millepora_ sp., _A. cervicornis_, _D. strigosa_, _D. labyrinthyformis_, _F. fragum_, _S. radians_ and _S. bournoni_. Gorgonians and sponges are sparse.

The northern portion is more extensive. _Millepora_ sp. becomes dominant toward the point and the total coral cover increases (40-50%).

3.4.2 Shallow Bay Pavement

The pavement zone extends halfway across the bay to the sand zone. Total coral cover is <5% and decreases toward the center of the bay. A few large colonies of *M. annularis* and *S. siderea* exist in this zone. Other organisms are *P. asteroides*, *Millepora* sp., gorgonians and *P. caribbea*. A few *D. antillarum* and one holothurian were observed.

3.4.3 Shallow Bay Seagrass

Halodule wrightii sparsely covers the inshore portion of the zone. Filamentous algae and callianassid shrimp mounds are abundant. *Syringodium filiforme* dominates seaward with moderate density. The Queen conch, *Strombus gigas*, and garden eels are common in this area.

3.5 Turtle Bay

Turtle Bay is a well protected, shallow bay with a white sand beach (Fig. 3).

3.5.1 Subtidal Bedrock

Both sides of the beach have a large subtidal bedrock zone. The inshore areas have a low total coral cover (5-10%) which increases toward the points (20-30%) where *Millepora* sp. and *P. caribbea* dominate. Other organisms are *A. palmata*, *P. asteroides*, *M. annularis*, *A. agaricites*, *A. cervicornis*, *P. porites*, *F. fragum*, *M. cavernosa*, *S. siderea* and gorgonians. Several *D. antillarum* were observed around the southern point.

3.5.2 Shallow Bay Pavement

The total coral cover inshore is <5% but increases seaward to 15-20%. Several moderate sized colonies of the dominant coral, *M. annularis*, exist on the northern portion of the bay. *A. cervicornis* is dominant on the southern portion. Other organisms present are *D. strigosa*, *Millepora* sp., *P. asteroides*, *A. agaricites*, *D. clivosa*, *M. cavernosa*, gorgonians and sponges.

3.6 Durloe Cays (Henley, Ramgoat and Rada Cays)

The Durloe Cays are three small, uninhabited islands which include Henley, Ramgoat and Rada Cays (Fig. 2 & 3). Henley Cay is the largest of the cays,

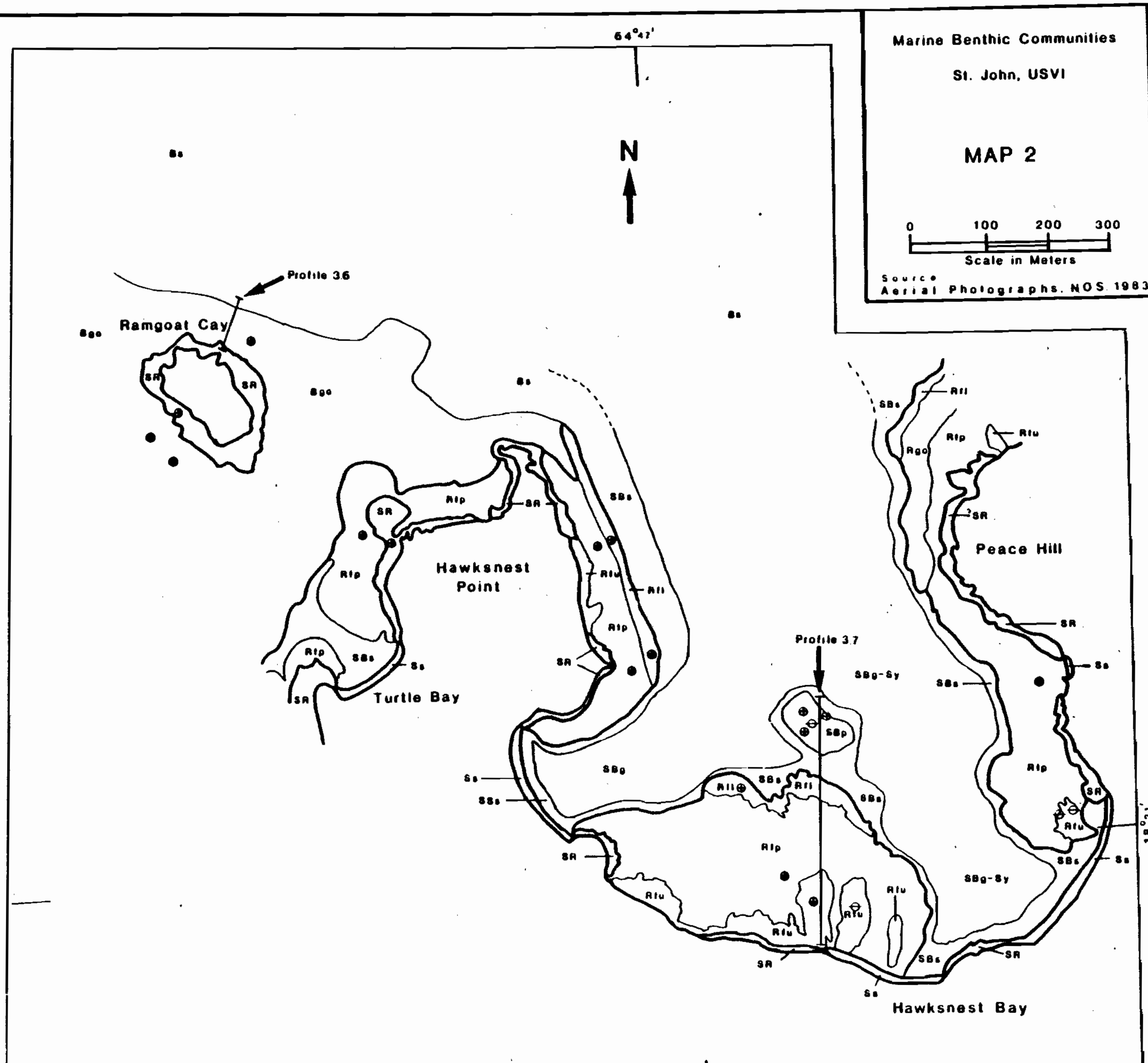


Figure 3 Map of Turtle Bay, Ramgoat Cay and Hawksnest Bay

Rada Cay, the smallest. The cays are located in the northeastern portion of Pillsbury Sound. The Durloe Cays, like most cays in the islands, are important shore bird nesting areas.

The physiography and current conditions yield an interesting community structure around the cays. Current velocity and direction are quite variable in this portion of the sound. The exposure to open water and moderately high energy yield a high coral cover with a very healthy condition around the cays. Very dense gorgonian-dominated pavement is the major zone represented in the channels and moderate to deep water areas surrounding the cays. Large sand mounds which rise 3-6 m. above the surrounding substrate are found in the lee (southwest) of Henley and Rada Cays. The surface of these sand mounds are dominated by patchy distribution of algae.

The Durloe Cays have shorelines which are entirely bedrock except for a small, white sand beach on the southern shore of Henley Cay. This is the only area which is utilized as a day anchorage for vessels.

Additional information is presented in Table 3.6 and Profile 3.6.

3.6.1 Subtidal Bedrock

Total coral cover around the cays varies considerably (20-60%). The exposed southeastern portions usually have a higher cover (40-60%) which decreases toward the southern shore. This is not as marked on the smallest cay, Rada Cay. All areas possess a high percent live vs. dead (40-60%).

Millepora spp. and *P. caribbea* usually dominate in the shallow wave exposed portions of the cays. *Acropora palmata* and other corals occupy the remaining areas. Several large colonies of *A. palmata* were observed but no dense stands exist. Gorgonians usually dominate below 2-5 m. *Dendrogyra cylindrus* was observed as unusually common around the cays. Additional organisms in the zone are *D. strigosa*, *D. labyrinthyformis*, *D. clivosa*, *C. natans* and *P. porites*.

3.6.2 Bank Pavement

A large portion of sparsely covered pavement lies to the south and southeast of Henley Cay. Seaward of the sand beach the pavement is covered by sand with dispersed, large colonies of *M. annularis* and *C. natans* and gorgonians. Several large, dead colonies of *P. porites* which have been recolonized by *P. asteroides* and *Millepora* sp. are located inshore. The total coral cover is low (5-10%).

The area to the southeast is marked by undercut ledges of carbonate which form platforms. The platforms rise approximately 1-1.5 m. above the substrate and extend from inshore to a depth of 4-5 m. The surrounding substrate has a low total coral cover (15-20%) but the surface of the platforms have a high total coral cover (60-80%). Millepora spp. dominates inshore (10-15%) while M. annularis is dominant in deeper water.

Other organisms in this zone include P. porites, P. asteroides, A. cervicornis, A. agaricites, S. siderea, D. strigosa and F. fragum. Sponges and gorgonians are sparse.

3.6.3 Bank Gorgonian-dominated Pavement

Gorgonian-dominated pavement is the major zone around the cays. Ledges exist on the northwestern portions of the cays where gorgonian cover decreases slightly but is normally high (30-60%). Occasionally, total cover reaches as high as 80%. Dendrogyra cylindrus is common over much of this zone in shallow water. Montastrea cavernosa and M. meandrites are commonly the dominant scleractinians in deeper water but always commanding <5% total coral cover. Scleractinian cover is normally <5%. Sponge cover reaches 5-10% in localized areas.

Gorgonians dominate across the channel from Ramgoat Cay to Hawknest Point. Maximum depth of the channel is 13 m. where cover decreases to 15-20%. Ircinia strobilina and Xestospongia muta are common in this area. A high diversity of sponges is present.

Additional organisms within the zone are D. strigosa, C. natans, A. cervicornis and P. asteroides. The ascidian, Clavelina sp. and the basket star, Astrophyton muricatum, are common thoughout the zone.

3.6.4 Bank Seagrass

A small patch of S. filiforme with low to moderate density exists between Henley and Ramgoat Cays. The calcareous green algae Udotea spinulosa and Penicillus capitatus are present in low abundance.

3.7 Hawksnest Bay

Hawksnest Bay is a semi-enclosed bay with a diversity of zones and three white sand beaches (Fig. 3). It is a popular beach with a picnic area landward of the middle beach. The bay is protected from the normal condition of easterly wave and swell, however, the northern swell, which is common during the winter months, yields much turbulence and wave action on the upper fore reef and beach zones.

The upper fore reef areas have experienced storm damage but the most disturbing observation is the reef damage caused by boats. The bay has become a popular day-sail destination with much vessel and dinghy travel near shore. On two dates during our investigations (2/6, 4/14/84), very recent damage to colonies of *A. palmata* was observed. On the second date the impact from a dinghy was observed. Bottom paint and damaged tissue marked the areas of damage. Several branches were broken in both incidences.

In the first incident (2/6/84), several entire colonies were broken and overturned indicating damage from a large vessel. Coral fragments were photographed for future reference. On 4/14/84, the same area was observed. Most of the broken fragments had lost their tissue. Tissue on most of the large stumps and many large fragments had begun to colonize the broken areas.

Photographs of both areas were taken and placed with the phototransect slides for future reference.

Hawksnest Bay is considered an Area of Particular Concern due to potential sedimentation damage. The upper portion of the watershed has been altered for construction of the new clinic. An enormous mound of dirt and rock was placed at the head of the drainage which was greatly eroded during the severe flooding on 4/18/83. Coral stress was noted in this area following the flooding.

This area was chosen for long-term monitoring phototransects (See Report 1.2).

Additional information is presented in Table 3.7 and Profile 3.7.

3.7.1 Subtidal Bedrock

Several segments of subtidal bedrock exist inshore as shown in Figure 3 and dominate the eastern and western shores. The inshore areas have a low total coral cover (5-10%) and lower percent live (40-50%). Algal cover is higher inshore especially on the southeastern shore where turf is abundant with *Halimeda opuntia*, *Caulerpa racemosa* and *Acanthophora spicifera* common. The southeastern shore has several colonies of dead *Acropora palmata* with very few living. The impact by sedimentation is suspected as a reason for the low percent cover and dead coral colonies.

Total coral cover increases toward both points (15-20%) with A. palmata dominant (10%). Other organisms are Millepora spp., P. asteroides, D. strigosa, D. clivosa, P. caribbea, A. agaricites, P. porites, F. fragum, S. siderea, Z. sociatus and gorgonians.

3.7.2 Upper Fore Reef

Four large patches of upper fore reef exist inshore which are dominated by A. palmata (10%). Indistinct subzones are evident on the patches with a narrow fore reef, large crest area, and back reef. Storm damage is evident with low cover on the fore and much A. palmata rubble present in the back reef area. The crest areas are extensive with dense stands of A. palmata but most colonies are dead. The fore usually has a low total coral cover (10-15%), the crest higher (15-25%) and the back reef lowest (<5%). P. asteroides is very common on the fore.

The two patches to the west extend shoreward in a pavement zone to the beach. The pavement is broken and is colonized by Turbinaria turbinata, Dictyota spp., Liagora sp. and Halimeda sp. E. lucunter is abundant in this area. D. clivosa and D. strigosa are common in the back reef especially to the west of the western patch.

Additional organisms within this zone include D. strigosa, D. clivosa, D. labyrinthyformis, A. agaricites, A. cervicornis, Z. sociatus, P. caribbea, sponges and gorgonians. Algal turf is present but less abundant than on the eastern patch.

A small section of upper fore reef exists along the western shore of the bay. Total coral cover is 25-30%. The colonies of A. palmata appear healthier than inshore and command 10-15% of the total coral cover. P. asteriodes is common with 5-10% of the cover. The scleractinian I. rigida and zoanthid P. caribbea are common in this area.

3.7.3 Shallow Bay Pavement

Most of the substrate within this zone has a low total coral cover (5-10%). In the western portion of the bay, much of the area is covered with a thin veneer of sand with a lower total coral cover.

Large colonies of M. annularis are sparsely distributed and increase in abundance toward the points. Other organisms within the zone include P.

asteroides, S. siderea, D. strigosa, P. porites, Millepora sp., A. agaricites, M. cavernosa, S. radians, P. caribbea, gorgonians and sponges. Colonies of D. cylindrus and A. cervicornis are found in the areas toward the points. Liagora sp. and Dictyota spp. are common inshore.

3.7.4 Lower Fore Reef

The lower fore reef zones are narrow areas which slope from the pavement areas at 5-6 m. to a depth of 10-12 m. The total coral cover is 25-30% which increases slightly toward the western point.

No species is dominant although M. annularis is usually more common. Additional species within the zone include M. cavernosa, M. lamarkiana, D. cylindrus, M. meandrites, S. michilli, E. fastigiata and I. sinuosa.

3.7.5 Gorgonian-dominated Pavement

The gorgonian cover increases toward the points on both sides of the bay to 30-60% total cover. Diversity of gorgonians and associated organisms becomes very high, especially north of Hawknest Point. Large stands of M. annularis and A. cervicornis occur within the zone to the end of the points. Scleractinian cover decreases toward the end of the points (<5%) where M. cavernosa becomes the most common scleractinian. The zoanthid P. caribbea is common.

On the western side of the bay the lower fore reef, which is characterized by a steeper slope, ends. The gorgonian-dominanted pavement slopes gradually to a depth of 15 m.

Other organisms located in the zone are C. natans, D. strigosa, D. labyrinthyformis, S. siderea and P. asteroides.
The ascidian, Clavelina sp., and the basket star, Astrophyton muricatum are common within most of the zone.

3.7.6 Shallow Bay Seagrass

Syringodium filiforme of low to moderate density occupies this zone. Halodule wrightii with low density surrounds the seagrass bed. Filamentous algae attached to seagrasses is abundant and the only algae present.

Seaward the seagrasses diminish and patches of Halophila baillonis and algae, predominantly Halimeda opuntia, Penicillus capitatus and Caulerpa mexicana, are present. A large aggregation of Strombus pugilus (>100) was observed in this area.

3.7.7 Shallow Bay Patch Reef

The patch reef has a low percent total coral cover (10-15%) with isolated areas of higher cover. Table 3.7 and phototransect data presented in Report 1.2, Table 3.2 list the species for this zone.

3.8 Dennis Bay and Perkins Cay

Dennis Bay is a small, open bay with a white sand beach (Fig 4). A small dock is located off the center of the beach. The shallow reef is storm damaged with low percent live cover. An old anchor is located in shallow water several meters off the dock.

Perkins Cay is a small cay with a good diversity of habitats in healthy condition.

Additional information is presented in Table 3.8 and Profile 3.8.

3.8.1 Subtidal Bedrock

Narrow zones of subtidal bedrock exist along the east and west shores. The total coral cover is low (5-10%) with a low percent live (20-30%) and decreases shoreward. Several large *A. palmata* colonies exist toward the points. Other organisms present include *P. asteroides*, *M. annularis*, *D. clivosa*, *D. strigosa*, *Gorgonia* sp. and sponges.

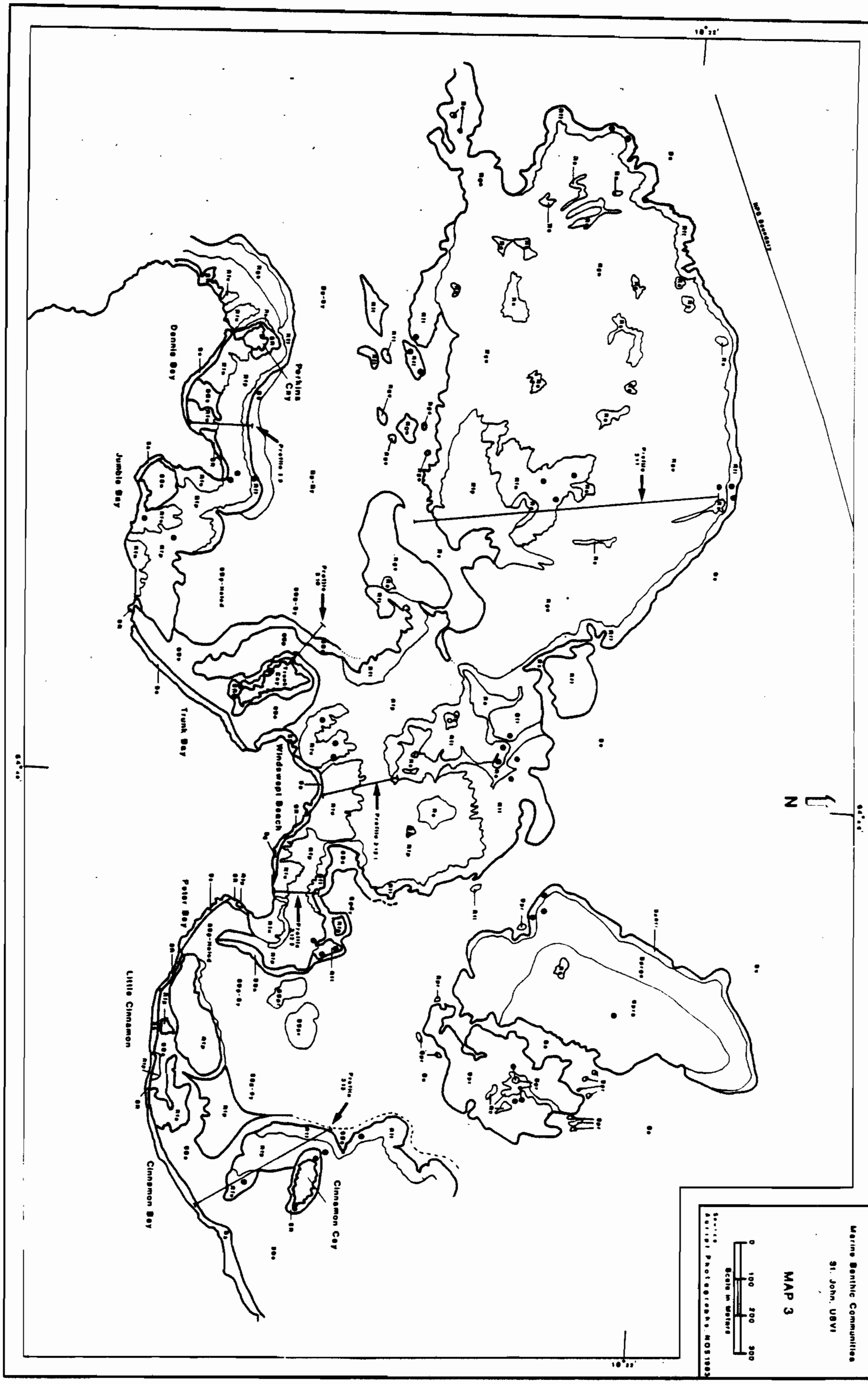
Most of Perkins Cay is bedrock with higher total coral cover (15-20%) and higher percent live (50-60%). *A. palmata* is dominant (5-10%) with *Millepora* spp. being nearly as common. Other organisms present are *A. agaricites*, *M. cavernosa*, *P. porites*, *A. cervicornis* and *P. caribbea*.

3.8.2 Upper Fore Reef

Large stands of *A. palmata* are located to the east and west separated by sand and pavement. Storm damage is quite evident with much of the back reef area covered by *A. palmata* rubble. Most of the *A. palmata* colonies are dead or with low percent live (10-15%). The total coral cover is low (5-10%) and decreases to the west where fewer colonies remain.

The patches of upper fore reef to the west of Perkins Cay and on the northeastern side of the cay have a higher total coral cover (15-20%) with a higher percent live (60-70%). *Porites asteroides* has a 5-10% coral cover

Figure 4 Map of Dennis Bay, Trunk Bay, Johnson's Reef, Windswept and Cinnamon Bay



with _A. palmata_ nearly as abundant. Additional organisms present are _A. agaricites_, _M. annularis_, _M. cavernosa_, _D. strigosa_, _D. labyrinthyformis_, _A. cervicornis_ and _P. caribbea_.

3.8.3 Fore Reef Pavement

The pavement zone has a low coral cover (<5%) which increases slightly seaward and toward the points. Sand covers much of the zone, especially inshore. _Montastrea annularis_ dominates with gorgonians increasing in abundance seaward. Much _A. cervicornis_ rubble covers the area.

Additional organisms in the area are _S. siderea_, _A. agaricites_, _P. asteroides_, _Millepora_ sp., _M. meandrites_, _P. caribbea_ and sponges.

3.8.4 Lower Fore Reef

The lower fore reef occupies a very narrow zone where the slope increases from 5-6 m. to 10-12 m. The total coral cover is 20-30% with 50-60% live. _Montastrea annularis_ and gorgonians are dominant.

Additional organisms present are _C. natans_, _E. fastigiata_, _M. mirabilis_, _P. caribbea_ and sponges.

3.9 _Jumbie Bay_

Jumbie Bay is a small, partially-protected bay with a small, white sand beach (Fig. 4). A moderate-sized patch of upper fore reef is located on the eastern portion of the bay. A smaller section of upper fore reef is located on the western portion.

A subzone of large colonies of head corals stretch between the upper fore reef areas. A sand zone is located shoreward of the head coral subzone.

3.9.1 Upper Fore Reef

Portions of upper fore reef are located on both sides of the bay which are dominated by stands of _A. palmata_. Storm damage is evident, especially on the western reef. _A. palmata_ rubble is abundant inshore. Of the extant colonies, the percent live is low (5-15%). The inner portion of the western reef is colonized by _Millepora_ sp. Total coral cover increases toward the point.

The eastern reef has many moderate-sized colonies with low percent live.

A few colonies have white band disease. White band disease may be the cause of the high mortality of A. palmata within the zone.

Other organisms present are P. asteroides, A. prolifera, D. clivosa, D. strigosa, P. caribbea, A. agaricites, C. natans, F. fragum, I. rigida, gorgonians and sponges.

3.9.2 Fore Reef Pavement

Most of the zone is of low total coral cover (5-10%). A band of head coral colonies, dominated by M. annularis, stretch between the upper fore reefs. Other corals in this subzone are P. asteroides, D. strigosa, and S. siderea.

Other organisms within the zone include gorgonians, D. labyrinthyformis, A. agaricites, A. cervicornis, Millepora sp, sponges and P. porites.

3.9.3 Lower Fore Reef

The lower fore reef is a continuation of the reef extending from Dennis Bay with the same organisms. The total coral cover decreases toward the east.

3.10 Trunk Bay and Trunk Cay

Trunk Bay is a shallow bay with a beautiful, white sand beach (Fig. 4). The Park Service maintains a picnic area landward of the beach. The bay's magnificent setting provides a very popular tourist attraction.

Trunk Cay is located in the eastern portion of the bay. Subtidal bedrock is the only zone represented around the shoreline of the cay. The Trunk Bay underwater trail is located on the western side of the cay. The trail is located in an area of sparse cover. Visitor damage is evident on colonies of A. palmata, gorgonians and sponges. Accidental breakage of coral colonies and occasional removal can be observed. A few large coral colonies have obviously been used as rest stops for snorkelers.

Additional information is presented in Table 3.10 and Profile 3.10.

3.10.1 Subtidal Bedrock

A small area of bedrock exists on either side of the beach with sparse coral cover. The zone is extensive around Trunk Cay. The total coral cover on the western side of the cay is 5-10% with 40-60% live. Colonies of M. annularis and A. palmata are of lower percent live to the southern end of the cay. This may be a result of visitor damage.

The eastern side of the cay has a lower total coral cover (<5%). *A. palmata* is dominant.

3.10.2 Upper Fore Reef

The western section of upper fore reef has a moderate total coral cover (10-20%) with high percent live (40-50%). *Acropora palmata* is dominant (5-10%) with many colonies in good condition.

The eastern section has a lower percent cover (5-10%) with few living colonies of *A. palmata*. Most of the area is dead *P. porites* reef. A few living colonies of the dominant coral *P. porites* exist.

Other organisms within the zone include *P. asteroides*, *A. agaricites*, *Millepora* sp., *A. cervicornis*, *D. strigosa*, *D. labyrinthyformis*, *P. caribbea*, *Z. sociatus*, *M. cavernosa*, *F. fragum*, *S. siderea*, *D. cylindrus*, *P. divaricata*, *Gorgonia* sp. and sponges.

3.10.3 Shallow Bay Pavement

Pavement is present on the western and eastern portions of the bay, much of which is covered by a thin veneer of sand. The pavement is represented by low total coral cover (5-10%) which is slightly higher around Trunk Cay. *Porites asteroides* is the dominant species. Occasional small colonies of *M. annularis* and *S. siderea* are scattered throughout the zone.

3.10.4 Shallow Bay Seagrass

Halodule wrightii dominates the inshore area of the bay. *Syringodium filiforme* dominates offshore. The distribution is patchy and density varies considerably throughout the zone. Algal density is quite low with *Penicillus capitatus*, *Halimeda opuntia* and *Acanthophora spicifera* present.

3.11 Johnson's Reef

Johnson's Reef is an extensive reef complex located north of Trunk Bay (Fig. 4). Most of the area is shallow (<10 m.) with the dominant zone being gorgonian-dominated pavement. An impressive, upper fore reef is located in the central portion of the reef. Although storm damage is evident, reef condition is good with many large, living colonies of *A. palmata* inhabiting the upper fore reef.

The lower fore reef is a very narrow band of coral cover which colonizes the margin of the reef. The margin is very precipitous and drops from approximately 10 m. to 25+ m. on the northern and eastern sides. Sedimentation is high over most of this zone resulting in high turbidity and poor visibility.

The pavement zone extends to the southeast and is continuous with the pavement off Windswept. This has made nomenclature difficult and arbitrary.

A separate complex of patches is located to the east of Johnson's Reef and north of Cinnamon Bay. Due to the similarity between these areas they will be discussed herein. The largest of these patches is similar to the Johnson's Reef complex but with a lower total coral cover on the surface pavement. No upper fore reef is present on the patch. The lower fore reef is quite similar to that of Johnson's Reef. A canyon with a depth of 20+ m. is formed between the two areas with a sand bottom which extends into Cinnamon Bay.

The patches to the southeast exhibit a higher total coral cover (20-25%). Gorgonians dominate on all excluding a few small patches which have a high scleractinian cover (40-60%).

Additional information is presented in Table 3.11 and Profile 3.11.

3.11.1 Reef Crest

The crest of Johnson's Reef is shallow (<1 m.) and dominated by *Millepora* sp. Much of the cover is on small, predominantly dead colonies of *A. palmata*. *Millepora* sp. occasionally forms dense stands on the substrate. The total coral cover is 30-40%.

3.11.2 Upper Fore Reef

Colonies of *A. palmata* dominate the zone (15-20%) with *Millepora* sp. being abundant (10-15%). Moderate to large colonies of *A. palmata* occasionally form dense stands, especially to the west. The area to the west is quite impressive with many, totally live colonies. White band disease was observed within the zone but not common. Within the zone, total coral cover (40-50%) decreases to the east. *Porites asteroides* is abundant in localized areas.

Scattered parts of boats attest to the fact that this reef sustains considerable damage from frequent vessel groundings.

3.11.3 Back Reef Pavement

The back reef portion of the upper fore reef, which lies south of the reef crest, is barren pavement. The substrate is predominantly coral rubble and rock cobble. Occasionally a coral colony with little live tissue is present to the south. The percent cover increases to the west and east where gorgonians begin to dominate.

Organisms present in this zone are *P. asteroides*, *D. strigosa*, *D. clivosa*, *M. annularis* and *A. palmata*.

3.11.4 Gorgonian-dominated Pavement

A high diversity of gorgonians dominate this zone. The total cover is 30-40% which locally reaches as high as 50-60%. Scleractinian cover is usually <10%. Sand patches are common over the zone with gooves trailing to the margin of the reef complex.

3.11.5 Lower Fore Reef

This zone consists of a very narrow band of scleractinian and sparse gorgonian growth. *Montastea annularis* is the dominant coral on the reef edge where the total coral cover is normally high (30-40%). The southern and western edge is usually gradually sloping to 20+ m. with gorgonians dominant and lower total coral cover. The northern and eastern portions are precipitous walls which drop from approximately 10 m. to 25+ m.

On the steep slopes the total coral cover is lower (20-30%). Many crevices and small grottos are present, especially to the east. Sedimentation and low visibility is evident on the eastern portion. Patches off the southeastern side of the complex have a higher total coral cover (30-40%) with many quite large colonies of *M. annularis*, *C. natans* and *A. agaricites*.

Additional organisms are *Stylaster roseus*, *Panulirus guttatus* and *P. argus*.

3.12 Windswept

Windswept is an exposed point with a white, sand beach which is protected by a large upper fore reef (Fig. 4). The point is protected from easterly currents by Mary's Point but the northern swell during winter months causes breaking waves on the reef.

The reef is dominated by *A. palmata* in fair condition. Storm damage is evident but less extreme than in surrounding areas. Damage due to vessels is evident and occurs frequently.

Additional information is presented in Tables 3.12.1 and 3.12.2 and Profiles 3.12.1 and 3.12.2.

3.12.1 Upper Fore Reef

The upper fore reef is a large section which is divided by a sand channel. The zone is dominated by *A. palmata* of varying condition. The seaward portion is dominated by large colonies with a high percent live (40-50%) which decreases to the east. Several small colonies are present throughout the zone suggesting recolonization. The eastern portion is marked by an abundance of broken coral which is the result of vessel damage.

The middle portion exhibits a high total coral cover (30-40%) which decreases in the back reef area (<5%). Large stands of *A. palmata* are present within this area. *Millepora* sp. is abundant in the middle portion. Percent live decreases inshore. *A. palmata* fragments are abundant inshore. Algal cover is high inshore (40-50%) with the following species occurring: *Jania* sp., *Halimeda opuntia*, *Dictyota* sp. and *Acanthophora spicifera*. (see Table and Profile 3.12.1)

White band disease was observed as uncommon in the western portion but increasing in abundance to the east.

The section to the west has a small stand of *A. palmata* (Table and Profile 3.12.2). The total coral cover within this area is lower (5-10%) with a lower percent live (15-20%).

3.12.2 Fore Reef Pavement

The pavement is of very low cover inshore (<5%). The total cover increases seaward (10-20%) to where it grades into the gorgonian-dominated pavement of Johnson's Reef.

3.12.3 Lower Fore Reef

The lower fore reef is a very narrow zone to the east. The total coral cover is 20-25% with *M. annularis* being dominant. (see Table and Profile 3.12.2.)

3.13 Cinnamon, Little Cinnamon and Peter Bays

Cinnamon Bay is a shallow, open bay with a large, white sand beach (Fig.4).

The bay is protected from the easterly currents by Mary's Point but receives high energy waves from the northern swell during the winter months. Patches of upper fore reef are located along the eastern shore.

Cinnamon Cay is a small cay in the center of the bay which is a popular snorkeling site. The cay's shoreline is bedrock with a low, but diverse, total coral cover.

The Park Service maintains a campground landward of the beach. Several permanent, concrete cabins and an access road were constructed at the base of the drainage on the western side of the beach. The drainage alteration and resulting destabilization has caused a loss of a portion of the white mangroves nearshore.

Several houses are located in the upper portion of the watershed and development continues.

Cinnamon Bay has been of great interest for several years due to the loss of a large portion of the beach on the western end. Several meters of beach has been eroded away which is evidenced by large trees falling seaward and dying. Hoffman et al (1974) and Hayden et al (1978) have studied the problem and concluded that the major contributing factor is storm wave energy. Present observations lead to the speculation that the resulting beach erosion is due to more complex processes.

Two patches of diminished upper fore reef are located several meters off the beach toward Cinnamon Cay. The western patch is essentially barren. The eastern patch has a few colonies of living *A. palmata* which are in fair condition. The same situation, in a more advanced stage, exists on the patch inshore of Little Cinnamon Bay. The patches of upper fore reef on the eastern shore of Cinnamon Bay are of low percent live cover and coral cover has declined within recent years according to the Park Service interpreters who have frequented the area.

Little Cinnamon and Peter Bays are are included in this discussion. Additional information is presented in Table 3.13 and Profile 3.13.

3.13.1 Subtidal Bedrock

Subtidal bedrock is the dominant zone around Cinnamon Cay. The total coral cover is low (5-10%) with good diversity but increases to the east (10-15%). The percent live is quite high (60-70%). *Porites asteroides* and *M. annularis* are dominant with *P. caribbea* and *Millepora* sp. locally very abundant.

Several small colonies of _A. palmata_ are present on the eastern end of the cay with a high percent live.

Consolidated rock and bedrock extend from the cay inshore. Total coral cover is extremely low (<5%) within this area. A few large colonies of _M. annularis_ are present and increase in abundance toward the cay. The colonies shoreward are of low percent live and are apparently declining. _Porites asteroides_ dominates this area. Other organisms located here are _Millepora_ sp., _P. porites_, _F. fragum_, _S. radians_, _C. nucula_ and other sponges. Algal cover by _Halimeda opuntia_, _Liagora_ sp. and _Dictyota_ sp.

3.13.2 Upper Fore Reef

The upper fore reef patches shoreward of Cinnamon Cay are apparently the declining remains of a zone of _A. palmata_. The total coral cover is extremely low (<5%) with _P. asteroides_ dominating. On the western patch, two totally living colonies of _A. palmata_ exist. A very few, small colonies exist with no recruitment evident. The eastern patch has several large colonies of _A. palmata_. Algal cover, by the following species, is very sparse: _Acanthophora spicifera_, _Caulerpa racemosa_, _Halimeda opuntia_ and _Liagora_ sp.

Three small patches are present along the eastern shore. Inshore the total coral cover is low (<5%) but increases toward the point (10-20%). Many moderate to large, dead colonies of _A. palmata_ are present with a few live colonies on the seaward margins. White band disease is present but not common. _Palythoa caribbea_ and _Millepora_ sp. dominate the area. A few, moderate sized colonies of _M. annularis_ and _D. strigosa_ are present with low percent cover. Algal turf is dense and dominating the substrate. Macroscopic algae present are _Acanthophora spicifera_, _Halimeda opuntia_ and _Jania_ sp.

Other organisms present include _F. fragum_, _A. agaricites_, _P. porites_, _S. radians_, _B. asbestinum_, _I. rigida_ and sponges.

A zone of upper fore reef occurs on the northern point of Peter Bay. Most of the area is of extremely low total coral cover (<5%) with very few colonies of _A. palmata_ but much rubble. The dotted portion of this zone on the map indicates a small but surprisingly healthy _A. palmata_ stand. The total coral cover is extremely high (70-80%) with a high percent live (70-80%).

3.13.3 Fore Reef Pavement

The pavement inshore has extremely low total coral cover (<5%) with a low percent live (10-20%). Gorgonians are dominant with scattered colonies of M. annularis and S. siderea.

Seaward the total coral cover increases slightly (5-10%) with a greater percent live (60-70%).

3.13.4 Lower Fore Reef

This zone is a narrow zone with a steep gradient. Montastrea annularis and S. siderea are dominant with the former increasing in abundance to the east. Colpophyllia natans is abundant and M. mirabilis is locally very abundant.

A single specimen of Antipathes sp. was observed on the eastern portion of the zone at approximately 12 m. The dimensions were in excess of 2x2 m. with a basal diameter of approximately 2 cm.

An large old anchor (>4 m.) was located on the eastern portion of this zone off the eastern point of Cinnamon Bay.

3.14 Maho and Francis Bays

Maho and Francis Bays are well protected bays with white, sand beaches (Fig. 3.5). Protected from the northern winter swells, these bays are popular vessel anchorages. As many as seventy vessels have been observed on a single day within the area during the winter. Fortunately, the central portion of the bays are dominated by sand bottom with very sparse cover.

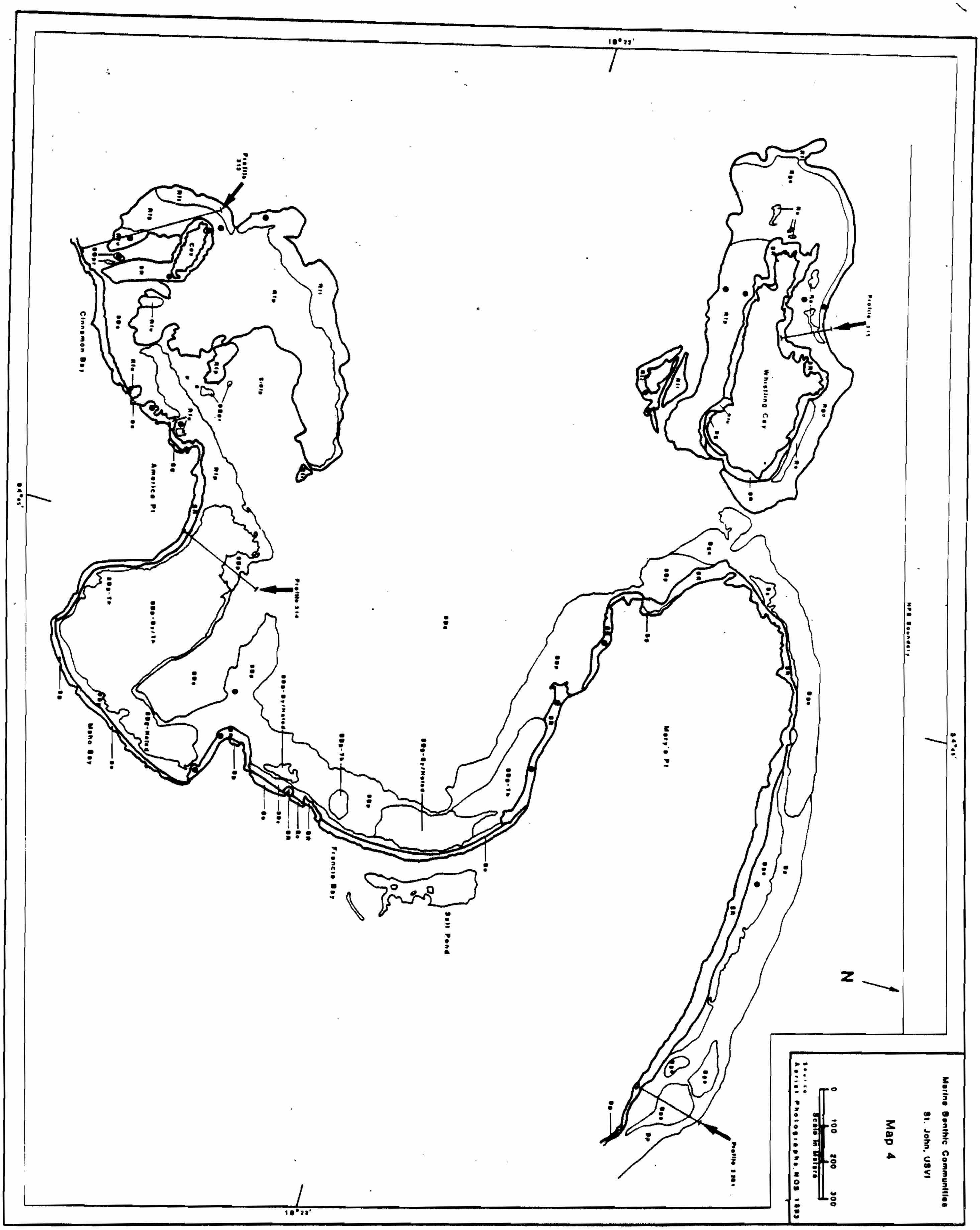
Although the seagrass beds are of low density and occupy narrow zones along the shores, the Green Turtle (Chelonia mydas), which grazes on seagrasses, is observed more commonly here than in any other bay on St. John.

Additional information is presented in Table 3.14 and Profile 3.14.

3.14.1 Subtidal Bedrock

Most of this zone in both bays is of low total coral cover (<5%). The portions seaward within Maho Bay have a higher total coral cover with a few small colonies of A. palmata and scattered moderate sized colonies of C. natans and D. strigosa. Most of the area is dominated by Millepora spp. and P. caribbea.

Figure 5 Map of Eastern Cinnamon Bay, Maho Bay, Francis Bay, Whistling Cay and Western Mary's Point



Rock cobble is present on the southern end of Maho Bay which extends several meters into the bay. This area has a lower total coral cover with *P. asteroides* dominating. Algal cover is high (70-80%) represented by *Halimeda opuntia*, *Dictyota* sp. and *Sargassum* sp.

Along the northern shore of Francis Bay, there is a high algal cover of the species listed above including *Padina santae-crucis*.

3.14.2 Shallow Bay Pavement

Pavement is located on the western and northeastern portions of Maho Bay. The zone is more extensive in Francis Bay. Total coral cover is extremely low throughout most of this zone (<5%) with occasional scleractinian colonies which are normally very eroded. Much of the zone is covered by sand. *Acropora cervicornis* rubble is abundant but no living colonies are present. In both bays the pavement drops rapidly from approximately 5 m. to 10+ m. where the bottom is dominated by sand with sparse cover of algae and invertebrates.

Along the northeastern shore of Francis Bay, the total coral cover increases toward the point with many moderate size colonies of *M. annularis*, *S. siderea* and *D. strigosa*.

Other organisms present in the zone include *P. porites*, *O. diffusa*, *D. labyrinthyformis*, gorgonians and sponges.

3.14.3 Shallow Bay Seagrass

In Maho Bay, the seagrass zone is extensive. *Thalassia testudinum* and *S. filiforme* dominate thoughout most of the zone with low density. *Thalassia testudinum* increases in density in the shallow portion along the southwestern shore. *Halodule wrightii* dominates inshore. Algal cover by *Halimeda incrassata* and *Acanthophora spicifera* is low. Grazing by the Green Turtle (*Chelonia mydas*) is evident thoughout the bay. Several large turtles were observed grazing in the bay. *Oreaster reticulatus* was uncommon within the zone and one holothurian was observed.

The seagrass zone in Francis Bay is smaller in size but grazing is quite evident. Several large turtles were observed feeding along the northeastern shore. A small patch of *S. filiforme* and *H. wrightii* exists in the southern portion. A small patch of sparse *T. testudinum* is located in the center of the inshore area.

The larger area of seagrass in the northeastern portion of Francis Bay is of higher density. The outer area is composed of patches of H. wrightii and S. filiforme with Avrainvillea nigricans and Halimeda incrassata. The inner area consists of sparse T. testudinum and H. wrightii with Halimeda incrassata and Penicillus capitatus. Several large Green turtles were observed grazing in this area.

3.15 Whistling Cay

Whistling Cay is an uninhabited cay located off the western end of Mary's Point (Fig. 5). An old customs house is located on the southeastern shore landward of the sand and cobble beach. The remaining portion of the cay is bedrock.

Additional information is presented in Table 3.15 and Profile 3.15.

3.15.1 Subtidal Bedrock

The subtidal bedrock zone has a low percent cover on the south side (5-10%) which increases on the north side (10-15%). Several moderate size colonies of A. palmata are present to a depth of three meters. Millepora spp. are dominant within the zone. Below three meters the cover increases with gorgonians dominating.

3.15.2 Upper Fore Reef

A stand of A. palmata exists off the sand and cobble beach on the southeastern shore of the cay. The moderate sized colonies of A. palmata become dense to the west. Many ledges are present thoughout the zone which harbor a large diversity of organisms. The total coral cover is 20-30% with A. palmata cover increasing from 5% to 20% to the west. White band disease is present but not common. Porites asteroides is abundant with a cover of 5-10%.

Other organisms present are D. strigosa, D. clivosa, P. caribbea, F. fragum, S. radians, A. agaricites, P. porites, M. annularis, D. labyrinthyformis, Millepora sp. and gorgonians.

3.15.3 Fore Reef Pavement

The pavement zone on the south side of the cay is represented by low total coral cover (<5%). Gorgonians are dominant and increase in abundance to the west. Consolidated rock rubble forms much of substrate.

Other organisms within the zone include M. annularis, P. asteroides, S. siderea, M. cavernosa, A. agaricites and sponges.

3.15.4 Gorgonian-dominated Pavement

The northern side of the cay has dense gorgonian cover (30-35%). Most of the pavement is of low relief with sparse scleractinian development.

3.15.5 Lower Fore Reef

The lower fore reef is a narrow zone which occupies the slope from ca. 10 m. to 18 m. on the northern and western side of the cay. Gorgonian cover is dominant (10%). The total coral cover is 15-20% with percent live 60-70%.

On the southeastern portion of the cay, the lower fore reef is heavily covered with sediment. The total coral cover is low (10-15%) and gorgonian cover is quite sparse.

3.16 Leinster Bay and Waterlemon Cay

Leinster Bay is a large, semi-enclosed bay which is well protected from the current and winter northern swell (Fig. 6). The central portion of the bay is deep with a sand bottom of sparse cover. Oreaster reticulatus is abundant within the sand zone.

Red mangroves (Rhizophora mangle) surround the western shore in Mary's Creek. Patches of upper fore reef are located in the western portion of the bay with dense seagrass beds occupying the shallow back reef zone. The upper fore reef area appears to have changed since the description by Stoeckle et al. (1968). This is probably the result of storm damage.

The eastern portion of the bay is protected with less reef development. This area is a popular anchorage. A sand and rubble beach is located along the southern shore.

Waterlemon Cay is located off the eastern point of the bay. The southern side has a white, sand beach.

A large platform of pavement is located seaward of Leinster Bay. The pavement is colonized by sparse gorgonian and algae with small colonies of encrusting M. meandrites, M. cavernosa, P. asteroides and D. stokesii.

3.16.1 Subtidal Bedrock

The subtidal bedrock zone along the eastern shore of Mary's Point has a low

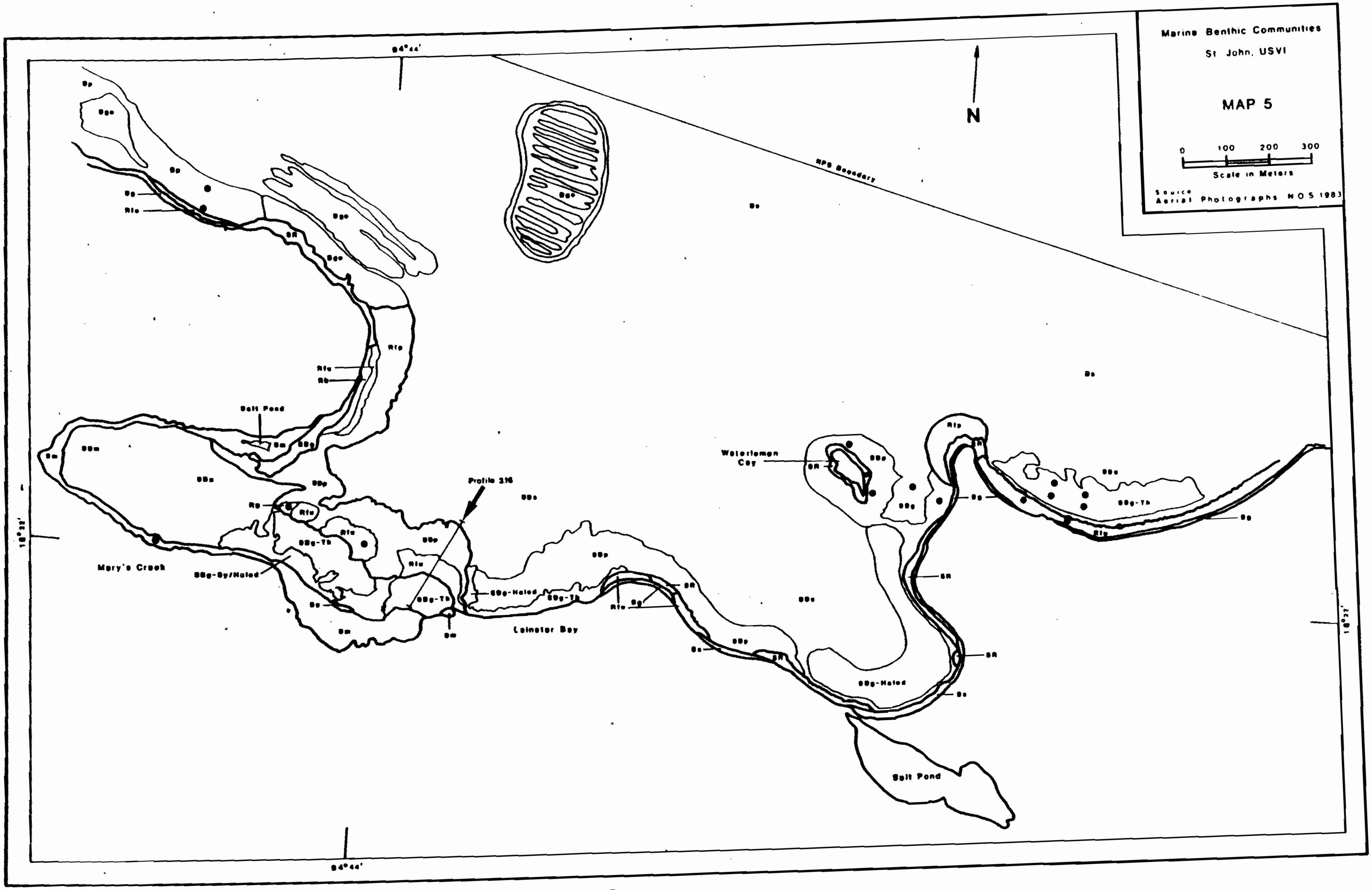


Figure 6 Map of Eastern Mary's Point, Mary's Creek and Leinster Bay.

total coral cover (5-10%) with *Millepora* spp. dominating. A few small colonies of *A. palmata* are present within this area. Algal turf is very sparse.

The bedrock area along the southeastern shore is of similar coral cover but without the colonies of *A. palmata*. The algal cover in this area is very high (70-80%) represented by *Padina sanctae-crucis*, *Acanthophora spicifera*, *Sargassum* sp., *Dictyota* sp. and dense turf species.

Along the western point *P. asteroides* is dominant with a few colonies of *A. palmata* present. Anemones are common is this area represented by *Phymanthus crucifer*, *C. gigantea* and *S. helianthus*. Seven *D. antillarum* were observed around the point.

Around Waterlemon Cay, the total coral cover is higher (10-20%) on the northwestern side and decreases to the south and east. Several large *A. palmata* and *P. porites* colonies in good condition exist on the northwestern side.

Other organisms present are *A. agaricites*, *Millepora* sp., *M. annularis*, *F. fragum*, *D. strigosa*, *D. clivosa*, *D. labyrinthyformis*, *S. siderea*, *P. caribbea*, *A. cervicornis*, *Z. sociatus*, gorgonians and sponges.

3.16.2 Shallow Bay Algae

Red mangroves (*Rhizophora mangle*) inhabit the shoreline surrounding the algal zone in Mary's Creek. A patchy distribution of algae exists throughout the zone with *Dictyota* spp. dominant. Common species include *Caulerpa cupressoides*, *Halimeda incrassata* and a fine unidentified red alga. Uncommon algal species are *Padina sanctae-crucis*, *Penicillus capitatus* and *Avrainvillea nigricans*.

A few sparse patches of the seagrasses *H. wrightii* and *H. baillonis* are present. *Thalassia testudinum* patches occupy a narrow area beside the mangroves.

Callianassid shrimp and *Oreaster reticulatus* are common throughout the zone.

3.16.3 Shallow Bay Seagrass

The seagrass beds in the western portion of the bay exhibit varied composition and density. The seagrass bed off the northwestern shore and the subzone shoreward of the upper fore reef off the southeastern shore are shallow

(<0.5 m.) and are dominated by Thalassia testudinum with the following algae common: Penicillus capitatus, Halimeda incrassata, Jania sp. and Dictyosphaeria cavernosa. A portion of this area is undercut around the margin where several juvenile lobster, Panulirus argus, were observed.

Inshore of the T. testudinum subzone is a sparse subzone of S. filiforme and H. wrightii. Algal abundance is low with Caulerpa cupressoides, Halimeda incrassata and Penicillus capitatus most common.

The seagrass bed to the east is dominated by dense H. wrightii with Udotea spinulosa. Composition shifts in the eastern portion of the zone to T. testudinum. Algal abundance is moderate with Halimeda incrassata, Amphiroa sp., Udotea spinulosa and Dictyota spp.

In the eastern portion of the bay, the seagrass bed consists of very sparse H. wrightii and S. filiforme. Halodule wrightii dominates inshore with increased density where Acanthophora spicifera and Padina sanctae-crucis are present in low abundance.

A small seagrass bed of moderate density of T. testudinum exists between Waterlemon Cay and the eastern point of the bay.

3.16.4 Upper Fore Reef

Several patches of upper fore reef are present in Leinster Bay. The western patches are dominated by stands of A. palmata. Most of the colonies are dead except for a few colonies in poor condition toward the fore. Storm damage is evident with A. palmata fragments abundant. Millepora sp. is dominant in the shallow areas. Large, dead colonies of P. porites are present. The fore has higher total coral cover with several large colonies of M. annularis and S. siderea. I. sinuosa is unusually common in this area. Liagora sp. is abundant. Total coral cover is 15-20%.

The small patches of upper fore reef along the southern shore have several large colonies of A. palmata with little living tissue. The dead portions of colonies are recolonized by Millepora sp., P. caribbea, P. asteroides and P. porites. Total coral cover is 5-10%. Dense algal turf covers the remaining substrate.

3.16.5 Shallow Bay Pavement

The pavement zone borders the inshore zones around the bay. The pavement slopes rapidly from approximately 5 m. to 10+ m. to sand around most of the bay. The sand bottom is sparsely covered but Oreaster reticulatus is abundant.

The pavement area off the northwestern shore has a high total coral cover (15-20%). Montastrea annularis is dominant with a cover of 10-15%. On the upper fore reef to the south the cover begins to diminish. Several large colonies of M. annularis, S. siderea and D. strigosa are present. I. sinuosa is common.

The total coral cover decreases to the east (<5%). Scattered colonies of M. annularis, gorgonians and sponges break the uniform substrate. A bank of higher cover is located on the slope to the sand zone along the southern shore. The cover is 5-10% which decreases to the east. The slope is dominated by gorgonians and includes colonies of M. annularis, M. cavernosa, S. siderea and sponges.

The pavement around Waterlemon Cay is of low total coral cover. Gorgonian cover increases to the north and west (15%).

3.16.6 Lower Fore Reef

A small zone of lower fore reef exists on the southeastern portion of the bay in shallow water (2-5 m.). The percent cover is 25-30% which increases to the west. The cover is dominated by M. annularis (25%). Many large, dead colonies of P. porites are present. The remaining colonies are in excellent condition.

Other organisms present include P. asteroides, Millepora sp., A. agaricites, A. cervicornis, C. natans and D. labyrinthyformis.

3.17 Brown Bay

Brown Bay is a partially protected bay which has a rock cobble beach with little sand (Fig. 7). A shallow, dense seagrass bed occupies most of the bay. Inshore many cleaned Queen conch (Strombus gigas) shells are present. Queen conch were extremely abundant within the bay during observation in 1983. Several fishermen have been known to frequent this bay for conch and have devastated the resource. During this investigation, no conch were observed within the inner bay.

Trash, which has been washed into the bay by currents, is abundant Additional information is presented in Table 3.17 and Profile 3.17.

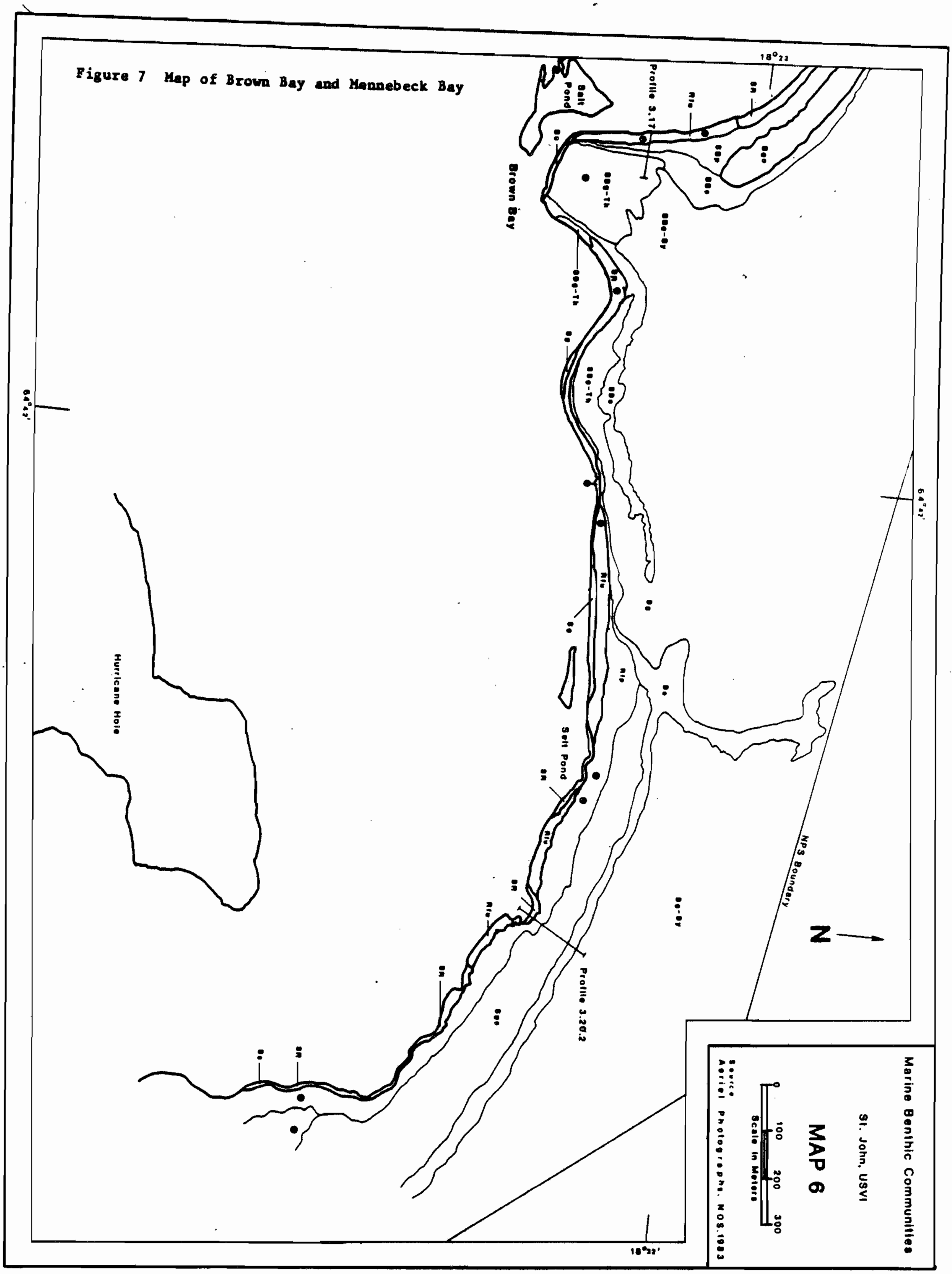


Figure 7 Map of Brown Bay and Mennebeck Bay

3.17.1 Subtidal Bedrock

The western portion of the bay has a higher total coral cover (15-25%). Several large, live colonies of A. palmata are present in this area and are dominant to 3.5 m. Below this depth, gorgonians dominate. Dense algal turf covers all available substrate.

The bedrock on the eastern portion of the bay is of low total coral cover (<5%). Millepora sp. is dominant. Inshore the bedrock is bordered by a large band of dead P. porites.

Other organisms present within the zone are P. asteroides, M. annularis, D. stoksii, F. fragum, S. siderea, A. agaricites, D. strigosa, D. labyrinthyformis, A. cervicornis, P. caribbea, D. cylindrus, P. porites, M. cavernosa, C. natans, I. sinuosa, gorgonians and sponges.

3.17.2 Upper Fore Reef

The upper fore reef located along the western shore is dominated by a stand of A. palmata. Most colonies are dead and broken. The total coral cover is low (10-15%) with the percent live of A. palmata low (10-15%). Storm damage is quite evident with most of the substrate dominated by A. palmata rubble. White band disease is present but not common.

A few large colonies of M. annularis and D. strigosa are present with several large, dead colonies of P. porites.

3.17.3 Shallow Bay Pavement

The pavement zone is of low total coral cover (10-15%) which decreases with depth. Gorgonians dominate the zone and increase in cover to the point (15-20%). The pavement is of little relief with very few large scleractinian colonies.

3.17.4 Shallow Bay Seagrass

The shoreward subzone of seagrass is dominated by T. testudinum of high density. A low density of S. filiforme is mixed throughout the subzone. Seaward the composition shifts to low density S. filiforme. Varying densities are apparent on the aerial photographs. Algal cover is sparse with Halimeda incrassata and Jania sp. Occasional free-living colonies of M. areolata and S. radians are present.

A narrow subzone of T. testudinum is present east of the eastern point.

Strombus gigas and *Oreaster reticulatus* are common seaward in the *S. filiforme* subzone.

3.18 Mennebeck Bay

Mennebeck Bay is a small, exposed bay with excellent cover and a good diversity of zones (Fig. 7). The upper fore reefs extend from both sides of the bay forming back reef areas and a semi-enclosed bay environment. This development is typical of the small exposed bays of the eastern portion of St. John. Much trash has accumulated inshore on the white sand beach.

Although similar bays are located to the east, Mennebeck Bay is the most impressive bay within park boundaries due to its diversity of zones and organisms and the general condition.

Additional information is presented in Table 3.18 and Profile 3.18.

3.18.1 Back Reef Pavement

The back reef pavement has very low total coral cover (<5%). No large coral colonies are present.

3.18.2 Reef Crest

The reef crest is a narrow zone which reaches to mean low water. The total coral cover is 25-30% and consists of *Millepora* spp., exclusively.

3.18.3 Upper Fore Reef

The upper fore reef is represented by high total coral cover (25-30%) which is highest on the fore and decreases to the reef crest. Coral are in excellent condition with a high percent live. Many living colonies of *A. palmata* are present. Storm damage is less severe within this bay. White band disease is present but rare.

3.18.4 Shallow Bay Pavement

The pavement zone has a low total coral cover (<5%). Occasional large colonies of *M. annularis* and *S. siderea* are present throughout the zone.

3.18.5 Lower Fore Reef

The lower fore reef is a very narrow, shallow zone with high total coral cover (35-40%). The reef is well developed and in excellent condition (70-

80% live). *Montastrea annularis* is dominant with many large colonies present. *Porites porites* is very abundant with many large complex stands which form small spurs. The western reef is more developed.

3.19 Haulover Bay

Haulover Bay is a large, partially exposed bay of uncommonly greater depth (Fig. 8). The largest beach is located on the southwestern shore and composed of rock cobble and sand. Much trash and tar cover the beach. Small, white sand beaches are located on the western and southeastern shore. A small patch of Red Mangroves (*Rhizophora mangle*) is located on the western shore and a larger stand is present on the eastern shore.

The western side of the bay is very impressive with a high diversity of zones. The reefs have excellent cover. The eastern portion is predominately subtidal bedrock.

The middle of the bay is deep (22+ m.) with a zone of patch reefs which extends across the bay. The patch reefs vary in size from a few meters to 30+ m. in length. The patches rise from the substrate 6-10 m. and possess a moderate total coral cover (20-40%). Diversity is high with no species dominant.

The most notable feature of the patch reefs is the high density of large colonies of antipatharians (black coral). Three species are present: 1) a large, dichotomously branching form, intermediate between *Antipathes pedata* and *A. dichotoma*, 2) *A. atlantica* and 3) *Stichopathes lutkeni* (pers. comm., Dr. Dennis Opresko). The latter two species are of low abundance.

The first unidentified species exhibits a high density. This species reaches a size of 3-4 m. in crown diameter with basal diameter as great as 80 mm. Large colonies are abundant. *A. atlantica* is normally less than 0.5 m. height and width.

Ridges and patches which exist seaward are predominantly pavement with patches of gorgonian and scleractinian cover. Antipatharians are common in this area.

Additional information is presented in Table 3.19 and Profile 3.19.

3.19.1 Subtidal Bedrock

A small segment of bedrock is present in the middle of the western shore. Along the eastern shore, subtidal bedrock is predominant. The bedrock is of

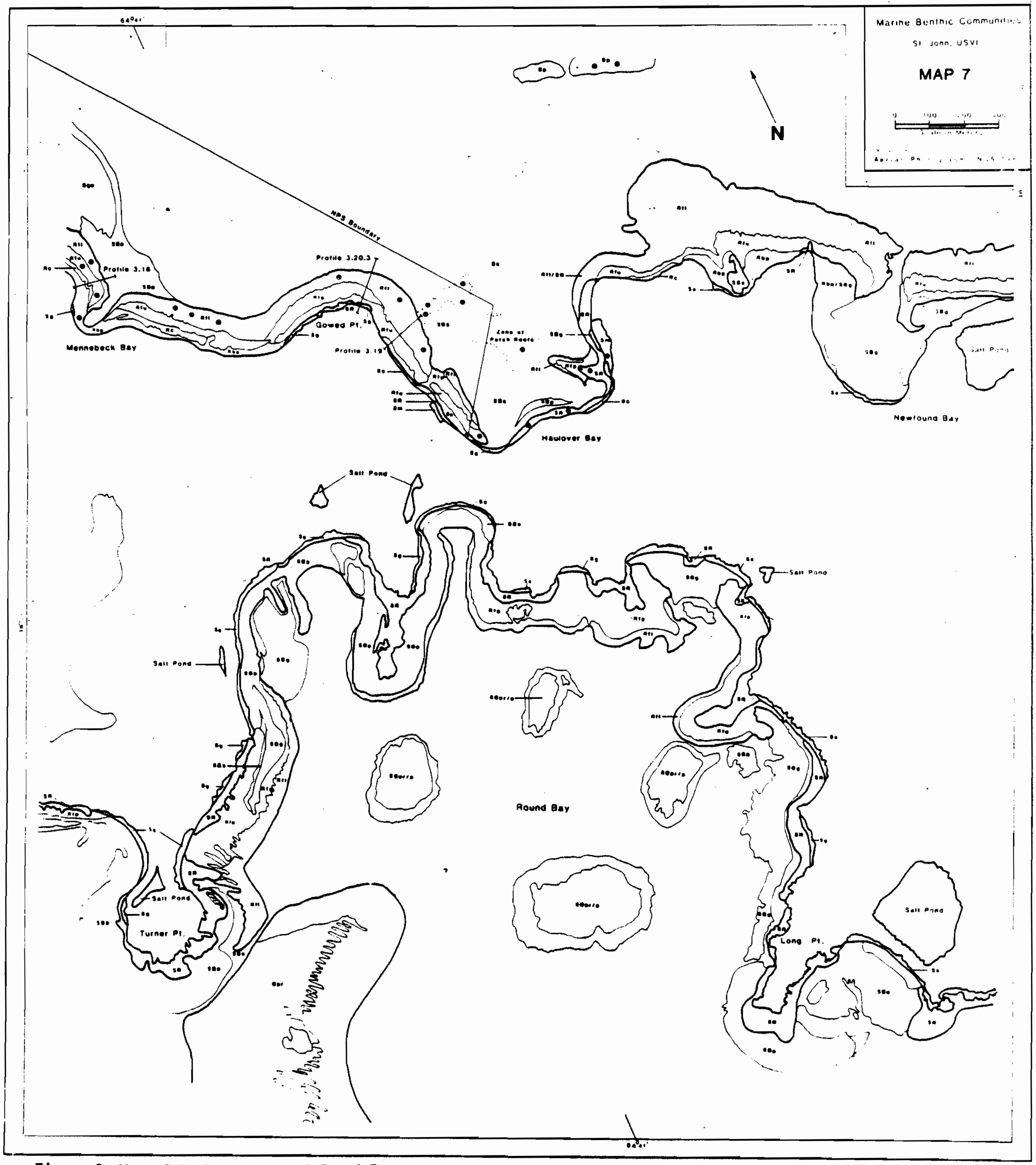


Figure 8 Map of Haulover Bay and Round Bay

low total coral cover (<5%) with *Millepora* sp. dominant.

Along the eastern shore, the total coral cover increases slightly to the point with gorgonians and sponges dominating. Algal turf is common inshore. A rubble zone is present seaward of the mangrove zone which slopes rapidly to the bay floor.

A subzone of lower fore reef organisms on boulder/bedrock substrate is present in deeper water in the northeastern portion of the bay. The zone slopes rapidly from 7-10 m. to 24+ m. The total coral cover is 15-20% with 70% live. *Montastrea annularis* is the dominant species. Other species include *D. labyrinthyformis*, *C. natans*, *M. cavernosa*, *S. siderea*, *A. cervicornis*, *P. porites*, *P. asteroides*, *D. strigosa*, *A. agaricites* gorgonians and sponges.

3.19.2 Back Reef Pavement

The back reef pavement shoreward of the upper fore reef on the eastern side is of low total coral cover. No large colonies are present. *D. strigosa* is dominant. Algae and *E. viridis* are common.

3.19.3 Upper Fore Reef

Two sections of *A. palmata* are located along the western shore. The total coral cover is high (40-60%) with colonies in good condition (30-35% live). Many large colonies of *A. palmata* are present with most in good condition. The indistinct crest has a lower percent live. Large colonies of *M. annularis* are present along the fore.

Storm damage is less evident than in bays to the west. No whiteband disease was observed. This zone contains the best existing *A. palmata* stands within park boundaries.

3.19.4 Fore Reef Pavement

The fore reef pavement is of low total coral cover (<5%). *Montastrea annularis* is dominant. Several large coral colonies are present thoughout the zone.

3.19.5 Lower Fore Reef

The southwestern portion of the lower fore reef occurs on the slope which drops rapidly from 5 to 12 m. The total coral cover is 30-40%.

In the northwestern portion, the lower fore reef is more extensive and quite impressive. The dense development of M. annularis extends from the upper fore reef to the slope edge at 8 m. This area is a garden of large M. annularis colonies with occasional stands of A. cervicornis. Few large stands of P. porites are present and have a low percent live (30%). The total coral cover is 60-80% with 50-70% cover of M. annularis.

The slope drops rapidly from 8 to 15 m. The diversity increases but total coral cover drops to 40-60%. No species is dominant. The large, unidentified species of black coral is present along the slope.

3.19.6 Patch Reefs

Patch reefs form a zone across the middle of the bay (Fig. 3.19). The percent cover is 20-40% with high diversity. No species is dominant. Three species of antipatharians (black coral) are located throughout the zone. The largest species is present in high density.

3.20 North Coast Rocky Shoreline

Several transects were accomplished along the extensive rocky shoreline along the north side of St. John between Mary's Creek and Haulover Bay. Occasional stands of upper fore reef are present (see Fig. 7 & 8). These stands are dominated by A. palmata but are storm damaged with low percent live.

An unusual zone of pavement is present off Mary's Point between 12 and 17 m. depth. This zone is dominated by sponge and large tunicates. Algae are very common. Other organisms are listed in Profile 3.20.1 and Table 3.20.1.

Additional information is presented in Tables and Profiles 3.20.2-3.20.3.

3.21 Fish Bay and Coccoloba Cay

Fish Bay is the westernmost bay within park boundaries on the southern coast of St. John (Fig. 9). Only the eastern half of the bay lies within park boundaries. The inner portion of the bay is well protected with Red Mangroves (Rhizophora mangle) lining the northern and eastern shores. The outer portion of the bay is exposed and has a well developed lower fore reef zone.

Storm damage within the upper fore reef and reef crest is very extensive. The reef crest on the eastern side of Fish Bay is a continuous rampart of A. palmata rubble which was established following the hurricanes

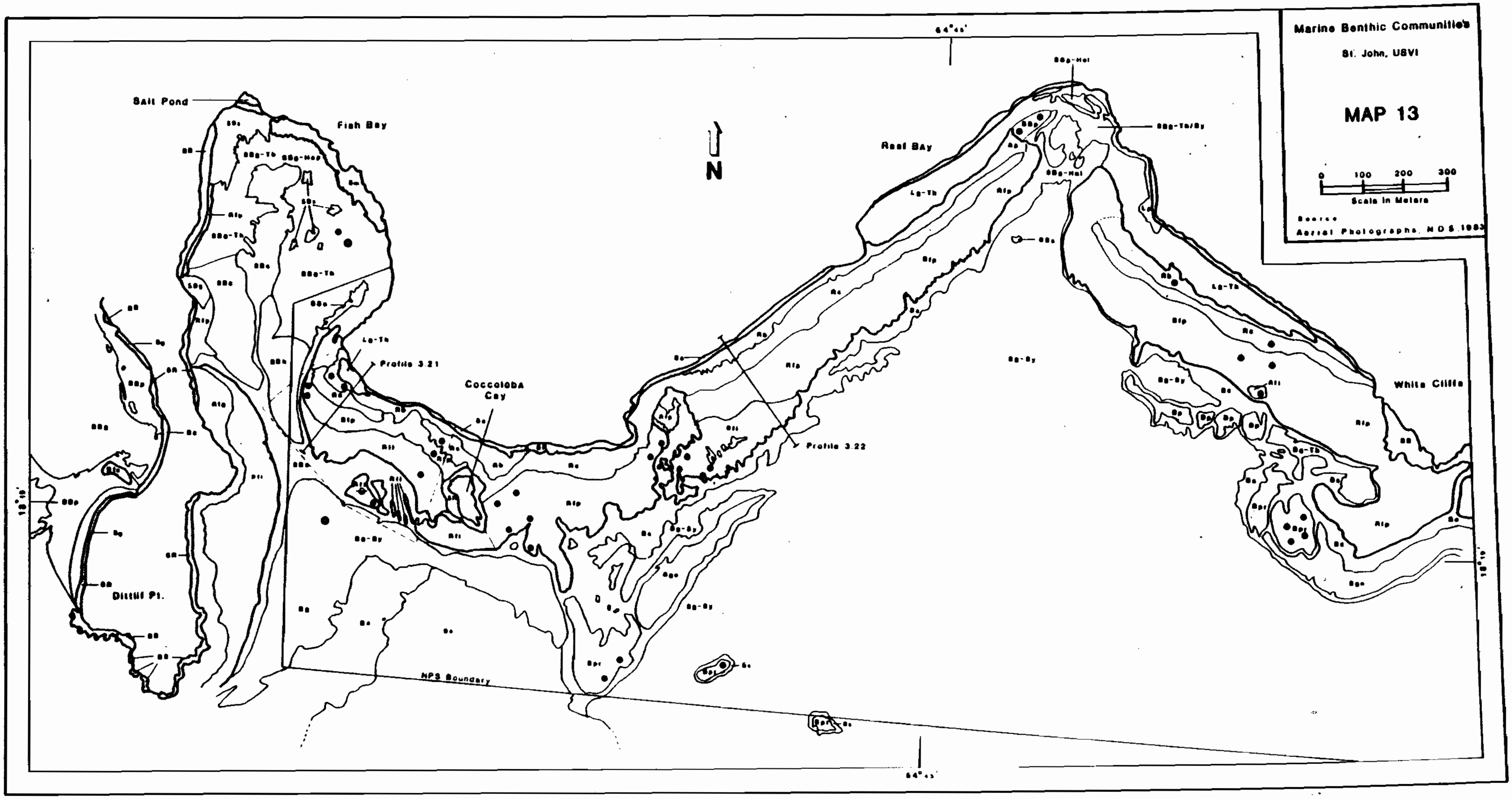


Figure 9 Map of Fish Bay and Reef Bay

of 1979, David and Frederic. The upper fore reef is barren pavement (labelled Rfp on Map) which has had the A. palmata colonies blasted away. A few large M. annularis colonies are present. Several dead colonies of A. palmata are located on the pavement northwest of Coccoloba Cay.

Sedimentation appears to be an increasing problem within Fish Bay. Most of the watershed is private land which is undergoing extensive development. Sedimentation from erosion of developed land is very obvious within the drainage.

On the days of investigation, heavy silt plumes were observed extending from the inner bay to the east. The dotted line in Fig. 3.21 indicates an area of lower total coral cover and percent live with heavy sedimentation.

Due to the conditions within the watershed, Fish Bay is listed as an Area of Particular Concern. This area was chosen for phototransects. (see also Tables 3.3 and 3.4 of Report 1.2)

Additional information is presented in Table 3.21 and Profile 3.21.

3.21.1 Subtidal Bedrock

The western shore has a low total coral cover (5-10%) with Millepora sp. dominating. The inner bay portion has a lower total coral cover with algal turf and Halimeda opuntia abundant. A small patch of dense coral cover, predominantly P. porites, is present on the northwestern shore.

The subtidal bedrock around Coccoloba Cay has a higher total coral cover (10-15%) with Millepora sp. and the zoanthid P. caribbea dominant. Several large colonies of A. palmata are present on the west side.

Other organisms present are D. stigosa, D. clivosa, A. cervicornis, P. asteroides, A. agaricites, A. prolifera and sponges.

3.21.2 Shallow Bay Seagrass

Seagrass beds dominate the inner bay. Thalassia testudinum dominates the inshore area with S. filiforme dominant offshore. Several large bare areas are present, some of which are colonized by H. wrightii. Halodule wrightii occurs around the periphery of the seagrass bed. Patches of H. baillonis are present in the northern, northeastern, and southern portions. The calcareous green algae Halimeda incrassata and Penicillus capitatus are common. A patch of unattached, filamentous algae occupies the area between the eastern and western reefs.

The outer portion of the bay is dominated by S. filiforme. Thalassia testudinum is rare. Algae are common with Udotea spinulosa, Caulerpa prolifera, C. mexicana and Acanthophora specifera dominating. Queen conch, Strombus gigas, are common.

3.21.3 Back Reef

The back reef zone on the eastern side of the bay is pavement covered with A. palmata fragments. A few patches of dead P. porites are present. Common algae are Liagora sp. and Dictyota spp. The portion to the east has higher algal cover (10-15%) including Penicillus capitatus, Padina sanctae-crucis, Halimeda opuntia, Avrainvillea nigricans and Acanthophora spicifera. Several D. antillarum were observed within this zone.

The western portion forms a shallow lagoonal environment (<5 m.). The inner portion is dominated by T. testudinum growing on dead P. porites with few colonies living.

3.21.4 Reef Crest

The reef crest on the eastern portion of the inner bay is a rampart of A. palmata fragments. The rampart rises approximately 0.5 m. above mean high water.

The crest on the north side of Coccoloba Cay has many A. palmata fragments scattered across the leeward (northwestern) portion. A few colonies of A. palmata are present with little living tissue. Several large carbonate mounds are present which are colonized by M. annularis, A. agaricites, S. siderea, P. asteroides, D. strigosa, A. prolifera, P. porites and P. caribbea. On the northeastern side, the crest is dead P. porites with few living colonies. On the seaward slope are several large, dead A. palmata colonies and few, small living colonies.

Other organisms present include S. radians, Millepora sp. and F. fragum.

3.21.5 Fore Reef Pavement

The pavement zone is barren over most of the area with a low total coral cover (<5%). Much of the upper portion was previously covered with stands of A. palmata. The remaining colonies are large mounds with sparse scleractinian cover. Few A. palmata colonies are present with low percent live. Most colonies of A. palmata are located northwest of Coccoloba Cay.

A. palmata rubble covers most of the upper portion. Few recolonizing colonies are present.

3.21.6 Lower Fore Reef

The lower fore reef is diverse and extensive with high total coral cover (30-40%). Along the western shore the reef is dominated by *A. agaricites* (10-15%). The western portion of the eastern reef is of lower total coral cover (10-15%). The sediment load is high within this area resulting in poor visibility. A silt plume was observed extending from the inner bay to the east. This area of impact is marked with a dotted line in Fig. 3.21. The area to the east has a higher total coral cover (20-30%) with lower sediment impact. Several large colonies of scleractinians are present with *M. annularis* dominant.

The deeper section of lower fore reef in the eastern section are spurs separated by sand. The spurs rise off the substrate 2-3 m. and have high coral cover (40-60%).

3.22 Reef Bay

Reef Bay is an open bay and the largest bay on the south side of St. John within park boundaries (Fig. 9). The inner bay is protected by the exposed reefs which form an incomplete barrier for the back reef zones. Several sections of white sand beaches are present.

The bay has a great diversity of zones and is certainly one of the most impressive within the park. The zones are in good condition except for the reef crests and upper fore reef zones which were annihilated during the 1979 hurricanes. The reef crests are ramparts of *A. palmata* fragments and the upper fore reef areas are sparsely covered pavement. The amount of *A. palmata* rubble indicates a previously extensive *A. palmata* zone.

Sedimentation is obvious on the western portion of the bay due to development. Recent improper construction methods near the shoreline has resulted in erosion of fill and resulting sedimentation of the inshore marine community. During this investigation, the turbidity within this area was high. The erosion has been photographically documented by the Park Service.

Additional information is presented in Table 3.22 and Profile 3.22.

3.22.1 Subtidal Bedrock

Most of the subtidal bedrock zone is narrow with small coral colonies. The total coral cover is <5%.

Below White Cliffs on the eastern shore, many large boulders are present with higher total coral cover (20-25%). Many large coral colonies are present which include A. palmata, M. annularis, D. cylindrus and Millepora sp.

3.22.2 Shallow Bay Seagrass

Thalassia testudinum dominates the inner bay with high density over most of the zone. Toward the middle of the inner bay the density of T. testudinum decreases and S. filiforme is present. Patches of low density H. wrightii occur throughout. Syringodium filiforme is dominant to the south. Grazing by the Green Turtle (Chelonia mydas) is apparent.

The shallow areas to the west and east are dominated by dense T. testudinum growing on dead P. porites flats with few remaining colonies.

Common algal species are Halimeda incrassata, Jania sp., Dictyosphaeria cavernosa and Penicillus capitatus.

3.22.3 Back Reef

On the western reef, the zone is barren except next to the crest. A few moderate size colonies (1-2 m. diameter) of living D. strigosa and several dead colonies are present. Toward the inner bay, total coral cover increases (10-15%) and is dominated by M. annularis. The narrow subzone shoreward of the crest consists of extensive stands of living P. porites and colonies of P. asteroides. This zone has a high total coral cover (30-40%) and extends only 2-3 m. shoreward.

On the eastern reef, the back reef zone is more extensive with large P. porites stands extending to the seagrass beds. Most of the P. porites stands are in good condition and have grown to low mean water. A few stands of A. palmata are present but most colonies are dead. Several large, living colonies of S. siderea, D. strigosa and D. labyrinthyformis are present. Algal cover is high on the substrate (50-60%) with Dictyota sp., Jania sp., Liagora sp. and Sargassum sp. Echinometra viridis is common and a few D. antillarum were observed. Total coral cover is 20-30%.

3.22.4 Reef Crest

Most of the reef crest along the western and eastern shore is rampart of A. palmata fragments.

To the southwest, the crest is quite unusual. Carbonate mounds rise 2-5 m. above the substrate to mean low water. The mounds are sparsely colonized on the sides, predominantly by the zoanthid P. caribbea, and on the surface by dense algal turf and Turbinaria turbinata. A few colonies of A. palmata are present with most of the larger colonies dead. A few large colonies of D. clivosa, D. strigosa and M. annularis are present. Total coral cover in this area is <5%.

3.22.5 Fore Reef Pavement

The pavement is composed of two subzones. The upper subzone (1.5-2.0 m.) is a flat barren area with extremely low total coral cover (<5%). An occasional colony of A. palmata is present with little living tissue. This area represents the devastated A. palmata zone. The deeper portion has many undercut ledges with few colonies of coral present.

To the southwest, east of Coccoloba Cay, the pavement becomes more complex. Steep ledges are abundant forming many large platforms. Massive colonies of coral, predominantly M. annularis, are present with numerous, small, recolonizing colonies of A. palmata.

The eastern reef pavement is similar. Several large carbonate mounds and colonies of M. annularis, D. strigosa and S. siderea are present. A. palmata rubble is abundant. A few small, recolonizing colonies of A. palmata are present but uncommon. Undercut ledges are abundant in the deeper portion. Small patches of typical lower fore reef organisms are present but uncommon.

The pavement which extends into the inner portion of the bay has a high coral cover (30-60%). Dictyota spp. and Liagora sp. dominate. Jania sp. and Sargassum sp. are common. Occasional coral colonies are present of which A. palmata, S. siderea, M. annularis, D. strigosa and D. labyrinthyformis are representative.

3.22.6 Bank Seagrass

The seagrass beds are dominated by moderate to high density of S. filiforme with sparse algal cover including Halimeda incrassata, Penicillus capitatus, *Avrainvillea nigricans*, *Udotea cyathiformis* and *Lobophora variegata*.

Along the eastern reef, a narrow subzone of *T. testudinum* is present. A dense *T. testudinum* bed is located off the southeastern portion of the reef.

3.22.7 Bank Pavement/ Bank Gorgonian-dominated Pavement

The bank pavement areas are patches of low gorgonian and scleractinian cover (<5%). The gorgonian-dominated pavement is of low relief that is dominated by a high diversity of gorgonians. Total cover is 20-30%.

3.22.8 Bank Patch Reefs

The northern portions of the large patch reefs are of gradual slope with low total coral cover (10-15%). Both large patch reefs have a zone of large boulders on the northern portion. The boulders rise 2-3 m. above the substrate with good cover (15-25%). This boulder zone is not present on the large patch reef southeast of White Cliffs.

The middle of the patch reefs are dominated by gorgonians with high cover (40-50%). This area grades into scleractinian-dominated reef to the south. The total coral cover is high in the southern portion (40-50%). Large colonies of *M. annularis* and *C. natans* are dominant. Sheet or plate morphology is predominant. The southern edge slopes rapidly from approximately 14 to 20 m.

The small patch reef off the southwestern shore is quite impressive with a high total coral cover (50-60%). The reef rises only two meters above the substrate at 23 m. *Agaricia agaricites* is the most common species but several large colonies of *M. annularis* and *C. natans* are present.

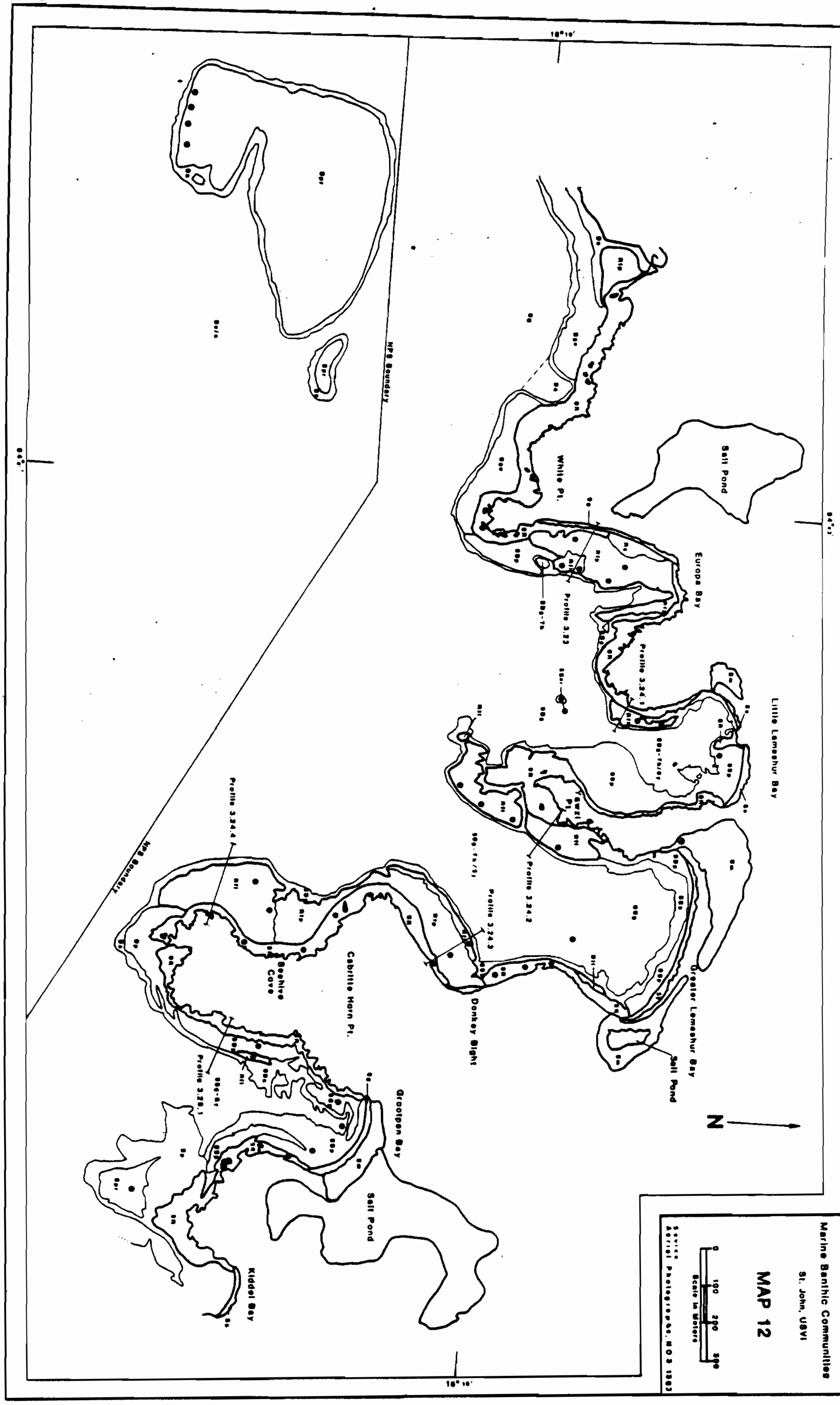
Other organisms present include *A. cervicornis*, *M. cavernosa*, *P. asteroides*, *M. meandrites*, *S. siderea*, *A. agaricites*, *D. strigosa*, *D. labyrinthyformis*, *D. cylindrus*, *M. decactis*, *M. mirabilis*, *D. stokesi*, *S. michelini*, *Millepora* sp., *M. lamarkiana*, *M. aliciae*, *E. fastigiata*, *P. porites*, *I. sinuosa* and sponges.

3.23 Europa Bay

Europa Bay is a shallow, exposed bay with a rock and coral cobble beach (Fig. 10). The benthic communities are heavily storm damaged and much *A. palmata* rubble is present throughout the bay.

Additional information is presented in Table 3.23 and Profile 3.23.

Figure 10 Map of Europa Bay, Little Lameshur Bay, Greater Lameshur Bay, Grootpan Bay and Kiddle Bay



3.23.1 Subtidal Bedrock

On the western shore the total coral cover is low (<5%). Small colonies of A. palmata are present. Millepora sp. is dominant. The protected portion north of White Point has a higher total coral cover (10-20%) with several large, living A. palmata colonies. Gorgonians dominate this area.

The northern portion has a higher total coral cover (20-30%) with M. annularis dominant (10%). Additional organisms within this area include A. agaricites, S. siderea, F. fragum, A. cervicornis, S. michelini, D. cylindrus and I. sinuosa.

3.23.2 Reef Crest

The reef crest is a narrow zone composed of heavily eroded corbonate mounds. The mounds rise 1-2 m. off the substrate to low mean water. The surface of the mounds are colonized by the zoanthid P. caribbea and the hydrocoral Millepora sp. The sides are colonized by D. strigosa, S. siderea, A. agaricites, C. nucula, Gorgonia sp., D. clivosa, M. annularis, P. porites, C. natans and F. fragum. The substrate is predominately A. palmata rubble with low total coral cover (<5%).

3.23.3 Fore Reef Pavement

The upper pavement is of sparse cover with few colonies of A. palmata, most of which are dead. Storm damage is evident with much A. palmata rubble present. Several recolonizing colonies of A. palmata are present which appear predominantly as asexual recruits (fragments).

The deeper portion is marked by elevated spurs on pavement substrate. The coral cover on the spurs is higher (10-15%) than on the surrounding substrate (<5%).

The total coral cover increases to the south (20-25%) where many undercut ledges are located. The pavement along the northern shore has a coral cover of 15-20% with M. annularis dominant (5-10%).

3.23.4 Lower Fore Reef

A patch of lower fore reef is present off the western shore. Montastrea annularis is dominant with several massive colonies. This area may typify the condition of the entire area prior to the hurricanes of 1979.

Other organisms present are _S. siderea_, _P. asteroides_, _D. strigosa_, _D. labyrinthyformis_, _P. porites_, _A. cervicornis_, _A. agaricites_, _C. natans_, _D. stokesii_, _M. meandrites_, gorgonians and sponges.

3.23.5 Shallow Bay Seagrass

Syringodium filiforme dominates the bay with moderate density. Algae are uncommon. A small patch of _T. testudinum_ with moderate density is present off the western shore.

3.24 _Little and Greater Lameshur Bays_

Little and Greater Lameshur Bays are partially protected bays with a diversity of zones (Fig.3.24). Little Lameshur Bay is a smaller bay with a white sand beach. This bay experiences periodic algal blooms due to an unstable beach berm on the northeastern shore. Following berm deterioration, nutrients enter the bay from the small mangrove lagoon which results in a great increase in algal biomass inshore. This is considered a natural, cyclic phenomenon.

Greater Lameshur Bay is a larger bay with a rock cobble beach inshore and a smaller, white sand beach along the eastern shore. A large mangrove stand is located in the northwestern portion of Greater Lameshur Bay which has a narrow channel connecting the inner swamp with the bay.

This area has been investigated by numerous reseachers since Randall initiated his work in 1958. A large artificial reef remains from his studies which is located off the western point of Little Lameshur Bay. Greater Lameshur Bay was the site for the Tektite I and II programs during 1969-1971.

In 1983, the School for Field Studies initiated baseline studies on the seagrass beds and reefs of Little and Greater Lameshur Bays. Reports with extensive data presentation are on file at the Virgin Islands National Park Service office.

The eastern portion of Greater Lameshur Bay is a popular vessel anchorage during the winter months.

Additional information is presented in Tables 3.24.1-3.24.4 and Profiles 3.24.1-3.24.4.

3.24.1 Subtidal Bedrock

The bedrock inshore is of low total coral cover (<5%) which increases toward the points. In Little Lameshur Bay, the total coral cover increases to 10-15%. In Greater Lameshur Bay, total coral cover increases to 15-20%. *Millepora* sp. and *P. caribbea* dominate on the points.

3.24.2 Shallow Bay Pavement

The pavement area in Little Lameshur Bay has a low total coral cover (<5%) with few colonies of *M. annularis* and *S. siderea* present.

In the northwestern portion of Greater Lameshur Bay, the pavement has a low total coral cover (5-10%). A few colonies of *M. annularis* and *S. siderea* are present. Dead colonies of *P. porites* are present. *Porites asteroides*, *F. fragum* and *S. radians* are common. *Diadema antillarum* were extremely abundant within this area prior to the die-off of December, 1983. *Acanthophora spicifera*, *Dictyota* spp. and *Liagora* sp. are presently abundant.

3.24.3 Fore Reef Pavement

The fore reef pavement on the eastern side of Greater Lameshur Bay has a high total coral cover (15-20%). *Montastrea annularis* is dominant and in healthy condition. The dense coral cover decreases to the south.

3.24.4 Lower Fore Reef

Several areas of lower fore reef are present within the bays. In Little Lameshur Bay, the lower fore reef on the western side has a total coral cover of 15-20% with *P. porites* and *M. annularis* dominant.

Off Yawzi Point, the reef has a total coral cover of 20-25% in the middle of the reef increasing to 30-40% on the edge. *Montastrea annularis* is dominant reaching a cover of 10-15%. On the east of Yawzi Point, the reef is a coral garden dominated by *M. annularis* (20-25% cover) with a total coral cover of 35-40%. The *M. annularis* colonies are large, often forming large continous complexes. Several large colonies of *C. natans* and *P. porites* are present.

The lower fore reef off Donkey Bight on the east side of Greater Lameshur Bay has a lower total coral cover (15-20%). Between this area and the reef in Beehive Cove, tiers of lower fore reef organisms which are separated by pavement extend around the point.

In the southeastern portion of Beehive Cove, the reef extends from the subtidal bedrock to the sand zone at 18 m. The diversity and total coral cover is high (25-30%). Montastrea annularis is dominant with 10-15% cover. The reef is typical spur and groove formation which is oriented northeast to southwest. This reef was the location of the of the Tektite underwater habitat and laboratory.

3.24.5 Shallow Bay Seagrass

The inner bay areas are dominated by a moderate density of T. testudinum and S. filiforme which grades into a uniform bed of S. filiforme to the south. Quantitative sampling has been completed by the School for Field Studies. A report with data supplement on densities of seagrasses and invertebrates are on file with the Virgin Islands National Park Service.

3.25 Grootpan and Kiddle Bays

Grootpan and Kiddle Bays are small, protected bays (Fig.10 & 11). Grootpan Bay has a rock and coral cobble beach which separates the bay from a large salt pond. Kiddle Bay has a predominantly white sand beach. Road construction is evident on the western shore of Kiddle Bay.

Additional information is presented in Tables 3.25.1-3.25.2 and Profiles 3.25.1-3.25.2.

3.25.1 Subtidal Bedrock

The subtidal bedrock has low total coral cover (5-10%) which increases to the point (10-15%). The eastern portion of Kiddle Bay has a lower total coral cover (<5%).

3.25.2 Shallow Bay Pavement

Along the western shore of Grootpan Bay, the pavement is complex with many ledges and several boulders present throughout the zone. Several large colonies of M. annularis, C. natans and D. cylindrus are present and form patches of lower fore reef. The total coral cover varies from <5% inshore to 20-25% within the dense patches.

Along the eastern shore of Grootpan Bay and both shores of Kiddle Bay, the pavement is of lower total coral cover (<5%).

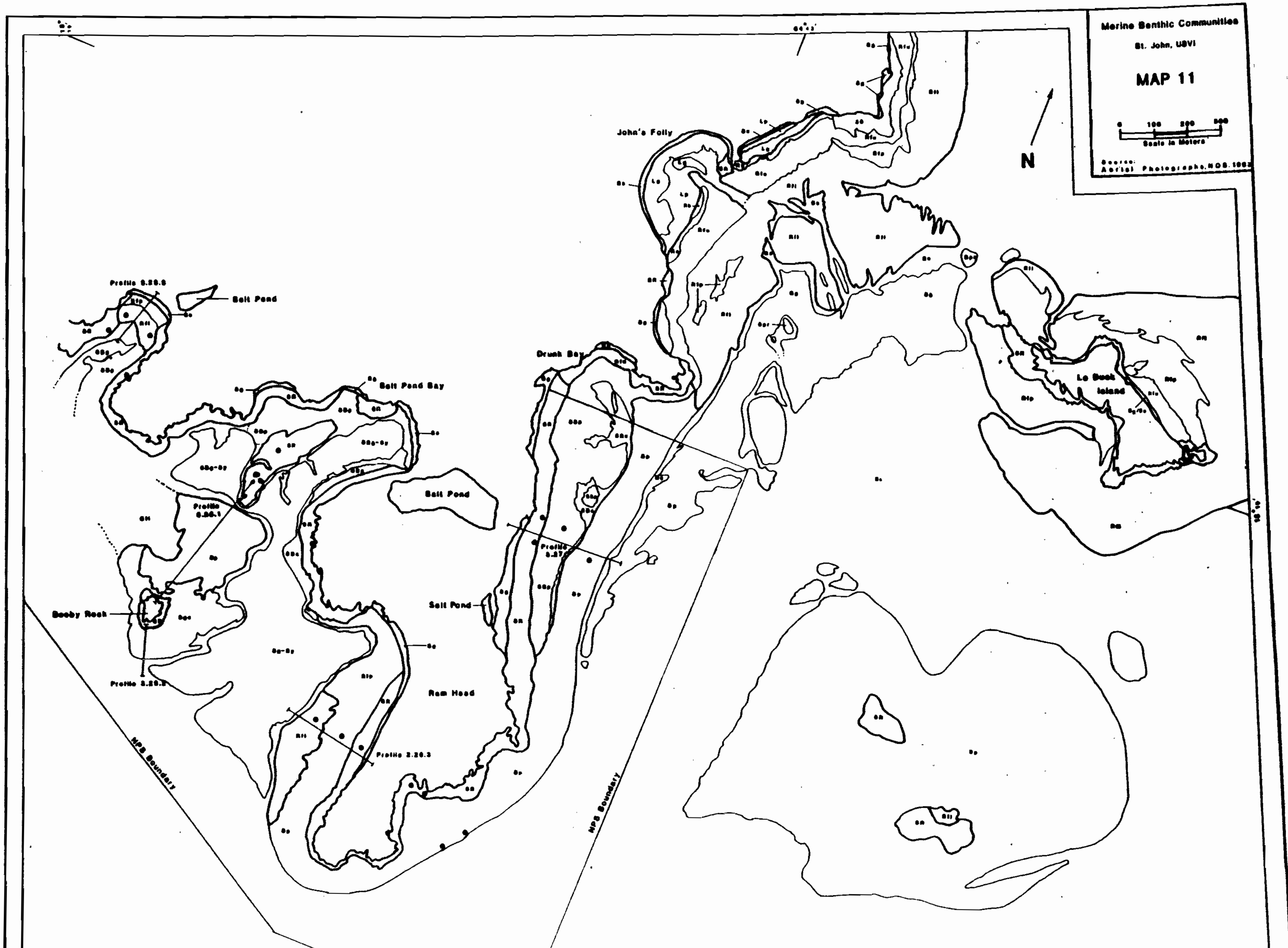


Figure 11 Map of Kiddle Bay, Salt Pond Bay, Ram Head, Drunk Bay and John's Folly Bay

3.25.3 Shallow Bay Seagrass

The seagrass beds within the Grootpan and Kiddle Bays are dominated by S. filiforme of moderate to high density. Algae are not common but include Penicillus capitatus, Lobophora variegata and Halimeda incrassata.

3.25.4 Lower Fore Reef

The lower fore reef in Kiddle Bay is shallow but with moderate coral cover (20-30%). An extensive stand of M. annularis dominates (20-25%) which extends across the inner bay.

3.25.5 Bank Patch Reef

The patch reef located south of the western point of Kiddle Bay is of low relief and low total coral cover (20-50%). Montastrea cavernosa is dominant with 5% cover. Gorgonians are common.

Other organisms present include M. annularis, S. siderea, M. meandrites, C. natans, Mycetophyllia sp., L. cuculata, A. agaricites, I. sinuosa, D. strigosa, D. labyrinthyformis, E. fastigiata, P. caribbea, M. decactis, P. porites, P. asteroides, D. stokesii, A. cervicornis, Scolymia sp. and sponges.

3.26 Salt Pond Bay, Booby Rock and Western Ram Head

Salt Pond Bay is a protected bay with a white sand beach (Fig. 11). Sparse cover dominates inshore. Salt Pond Bay is the most popular anchorage on the south shore of St. John within the park.

Booby Rock is a small cay south of Salt Pond Bay which is an important shore bird nesting area.

Ram Head is the southernmost point of St. John. It protects the bays to the northwest from the southeastern wave and swell.

Additional information is presented in Tables 3.26.1-3.26.3 and Profiles 3.26.1-3.26.3.

3.26.1 Subtidal Bedrock

The inshore area has a low total coral cover (<5%). The coral cover is higher around the rocks within Salt Pond Bay, predominantly Millepora spp. (30-35%), and around Booby Rock and Ram's Head (15-20%).

3.26.2 Shallow Bay Pavement/ Bank Pavement

The pavement zones have a low total coral cover (<5%) which increases slightly around Ram's Head (10-15%). Gorgonians dominate offshore.

3.26.3 Gorgonian-dominated Pavement

The pavement off the southeastern portion of Booby Rock is dominated by gorgonians. The total coral cover is 30-35%.

3.26.4 Shallow Bay Seagrass/ Bank Seagrass

Syringodium filiforme dominates the seagrass beds. Algal cover is low with *Udotea spinulosa*, *Avrainvillea nigricans* and *Halimeda incrassata*. Queen conch, *Strombus gigas*, are common offshore.

3.26.5 Lower Fore Reef

The lower fore reef is of low to moderate percent cover (20-30%). The area northwest of Booby Rock is extensive and forms tiers of reefs with high cover (30-40%). Many large colonies of *M. annularis* and *C. natans* are present.

The lower fore reef off the western portion of Ram Head demonstrates spur and groove formation oriented from northeast to southwest.

3.27 Drunk Bay and Eastern Ram Head

Drunk Bay is an exposed bay with a rock and coral cobble beach (Fig. 11). The bay has a large upper fore reef zone in the northern portion. Drunk Bay is the easternmost bay within park boundaries on the south side of St. John.

Several interesting and highly diverse areas lie to the east of Drunk Bay and outside the park. Eagle Shoal to the east is certainly one of the most impressive areas with numerous grottos and caves.

Additional information is presented in Table 3.27 and Profile 3.27.

3.27.1 Subtidal Bedrock

The bedrock zone is composed of consolidated boulders which form a shelf approximately 0.5 m. from mean low tide. This shelf is heavily undercut forming a continuous ledge alongshore. The total coral cover is 15-20%.

A large boulder area is present in the central portion with a high total coral cover. This area has several colonies of living *A. palmata*.

3.27.2 Upper Fore Reef

The upper fore reef is dominated by stands of A. palmata. Storm damage is evident with many broken colonies but most of the colonies are living. Total coral cover is 25-30% with A. palmata cover 10-15%. Patches of small colonies of A. palmata are abundant. Much recolonization is evident.

Carbonate mounds are present which are colonized by Millepora sp., P. caribbea, D. strigosa, M. annularis, P. asteroides, S. siderea, C. natans and gorgonians. Occasional stands of A. prolifera are present.

3.27.3 Shallow Bay Pavement/ Bank Pavement

The inshore pavement has a low total coral cover (<5%). Elevated pavement platforms are present with a low total coral cover (5-10%) and dominated by gorgonians and A. palmata.

The seaward pavement area is separated from the inshore area by a narrow sand channel. This zone has a higher total coral cover (10-15%) which is dominated by gorgonians.

Sparse pavement dominates the eastern side of Ram Head. The pavement slopes rapidly to the sand zone at 20-23 m.

3.27.4 Bank Seagrass

The seagrass bed is dominated by S. filiforme with low algal cover. Algae present include Udotea spinulosa, Avrainvillea nigricans, Halimeda incrassata and Caulerpa prolifera. Large Queen conch, Strombus gigas, are common.

3.28 Otter Creek - Coral Bay

Although Coral Bay is not within park boundaries, a single bay was groundtruthed to provide baseline information on a portion of this important area which borders the park. Coral Bay is undergoing rapid development which will result in the increase of sedimentation within the bay.

Otter Creek is a small bay on the eastern portion of Coral Bay (Fig. 12). As is true of a few bays within Coral Bay, the watershed of Otter Creek is within National Park Service boundaries and is protected. Otter Creek, like most of the northeastern bays of Coral Bay, is lined by a narrow zone of Red Mangroves (Rhizophora mangle). The bay is deep with sparsely covered sand and only a narrow zone of shallow habitat.

The northeastern bays of Coral Bay are popular 'hurricane holes' for vessels during severe storms.

3.28.1 Mangrove Zone

A narrow stand of Red Mangrove (Rhizophora mangle) borders the bay. A small stand of Black Mangrove (Avicennia germinans) occurs along the southwestern shore on a sand beach. A very narrow border of T. testudinum occurs beside much of the mangrove stands.

A community of dense algae and sponge dominate the Red Mangrove prop roots. Algal turf is dense with macroalgae abundant including Acanthopora spicifera, Padina sp., Dictyota spp., Laurencia sp. and Caulerpa racemosa. Echinometra viridis, Phymanthus crucifer, Condylactis gigantea, sabellids and hydroids are common.

3.28.2 Subtidal Bedrock

The bedrock zone is narrow with much rock rubble. Throughout most of the bay, the bedrock slopes rapidly to approximately 15 m. Sponges are dominant with 30-40% cover. Chondrilla nucula and Haliclona rubens are abundant. Total coral cover is <5% with D. labyrinthyformis, S. siderea, M. areolata, P. asteroides, P. porites, P. divaricata, F. fragum, S. bournoni and Millepora sp.

3.28.3 Shallow Bay Pavement

Portions of the bay, particularly toward the points, have pavement with very low total coral cover (<5%). The patch of pavement in the northeastern portion of the bay has a low total coral cover (<5%). Old, predominantly dead colonies of M. annularis and S. siderea are present. Chondrilla nucula is abundant.

*The remaining areas outside of park boundaries were mapped but were not groundtruthed nor described during this investigation.
Figure 13 includes Stevens Cay and Frank Bay on the western end of St. John.
Figure 14 includes Great Cruz Bay, Chocolate Hole and Rendezvous Bay.
Figure 15 includes Johnson Bay, Lagoon Point and Friis Bay.
Figure 16 includes East End of St. John and Flanagan Island.
Figure 17 includes Great Thatch Cay and Western End of Little Thatch Cay-BVI.
Figure 18 includes Western End of Tortola and Little Thatch Cay-BVI.

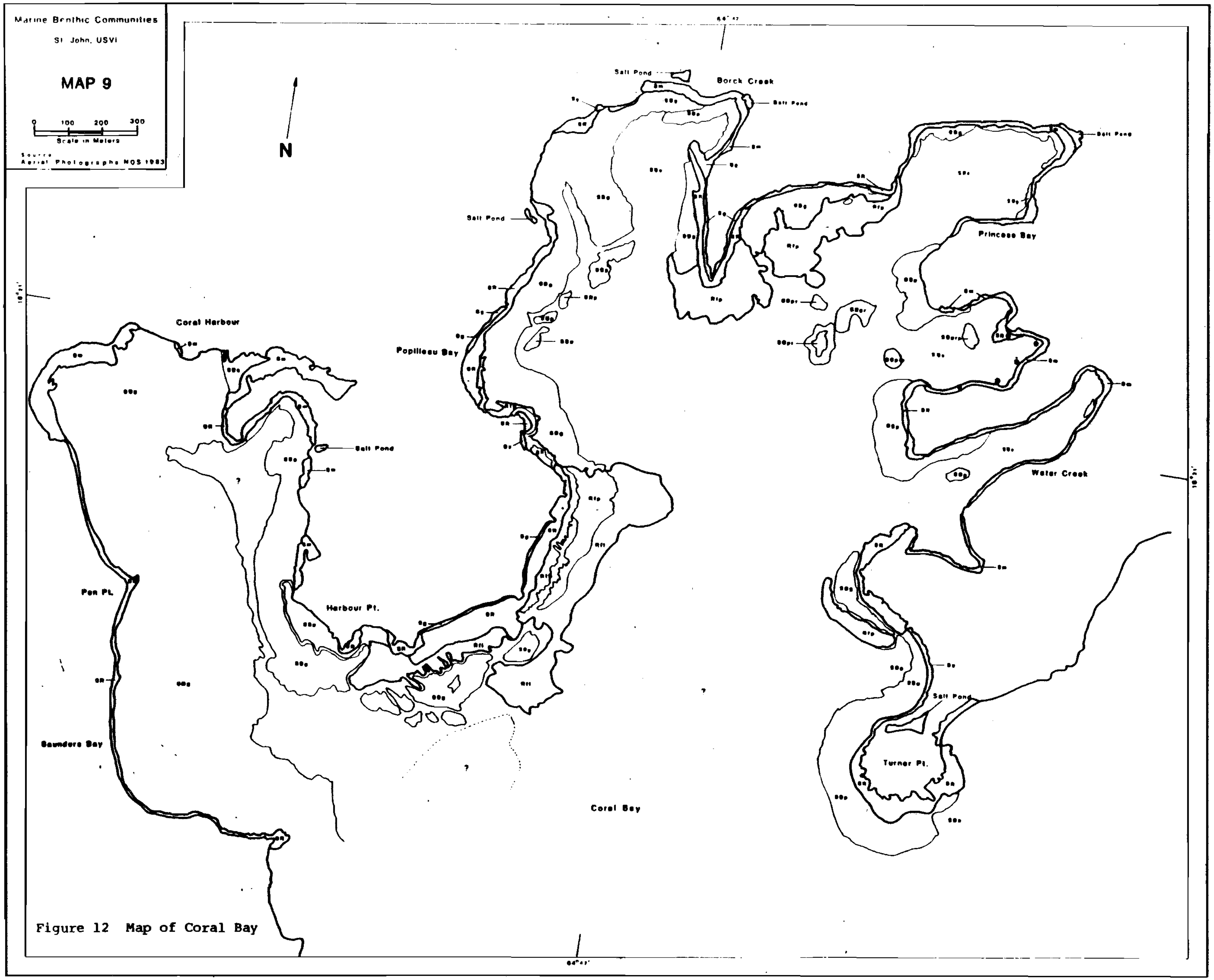


Figure 12 Map of Coral Bay

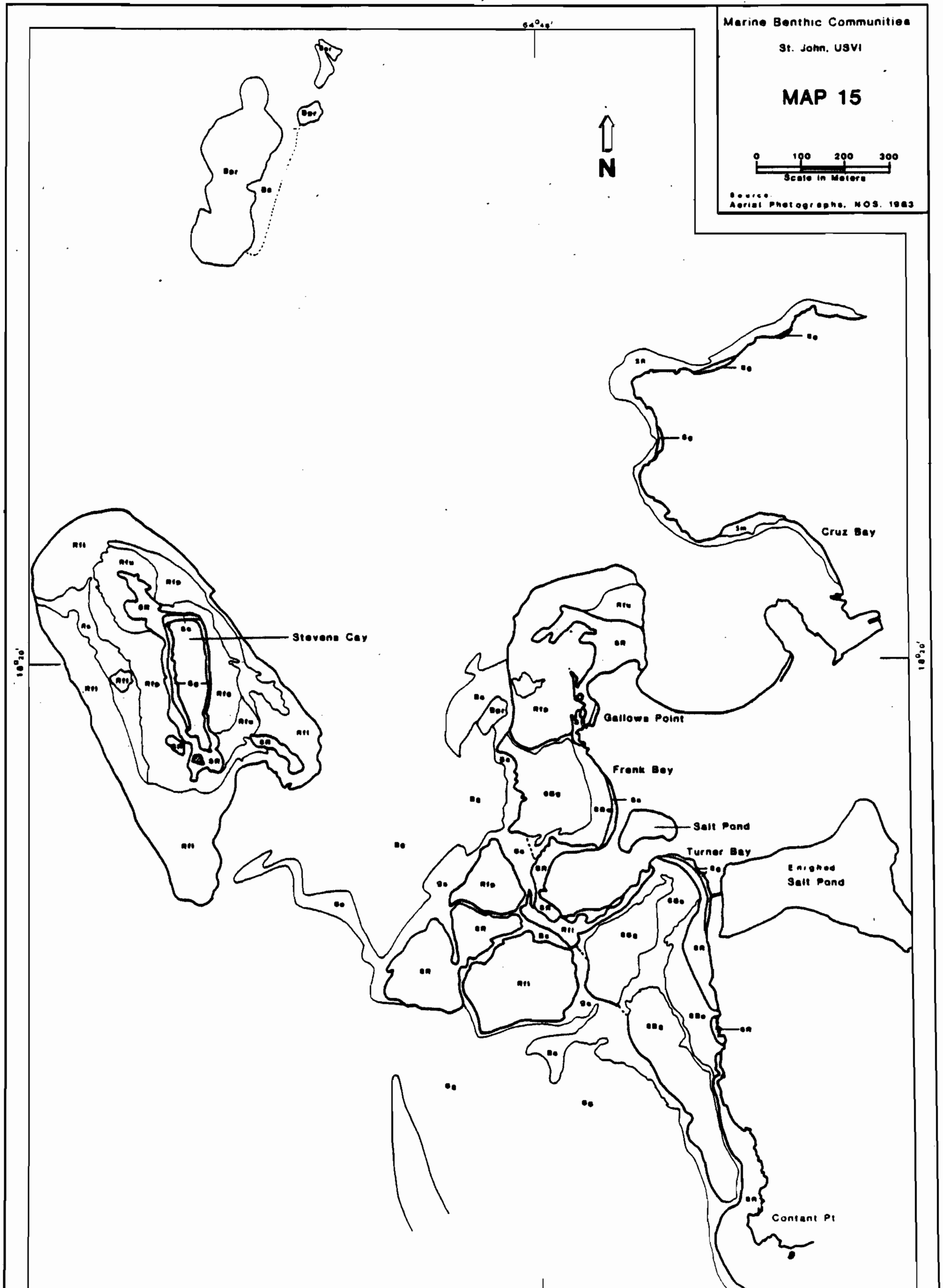


Figure 13 Map of Stevens Cay and Frank Bay.

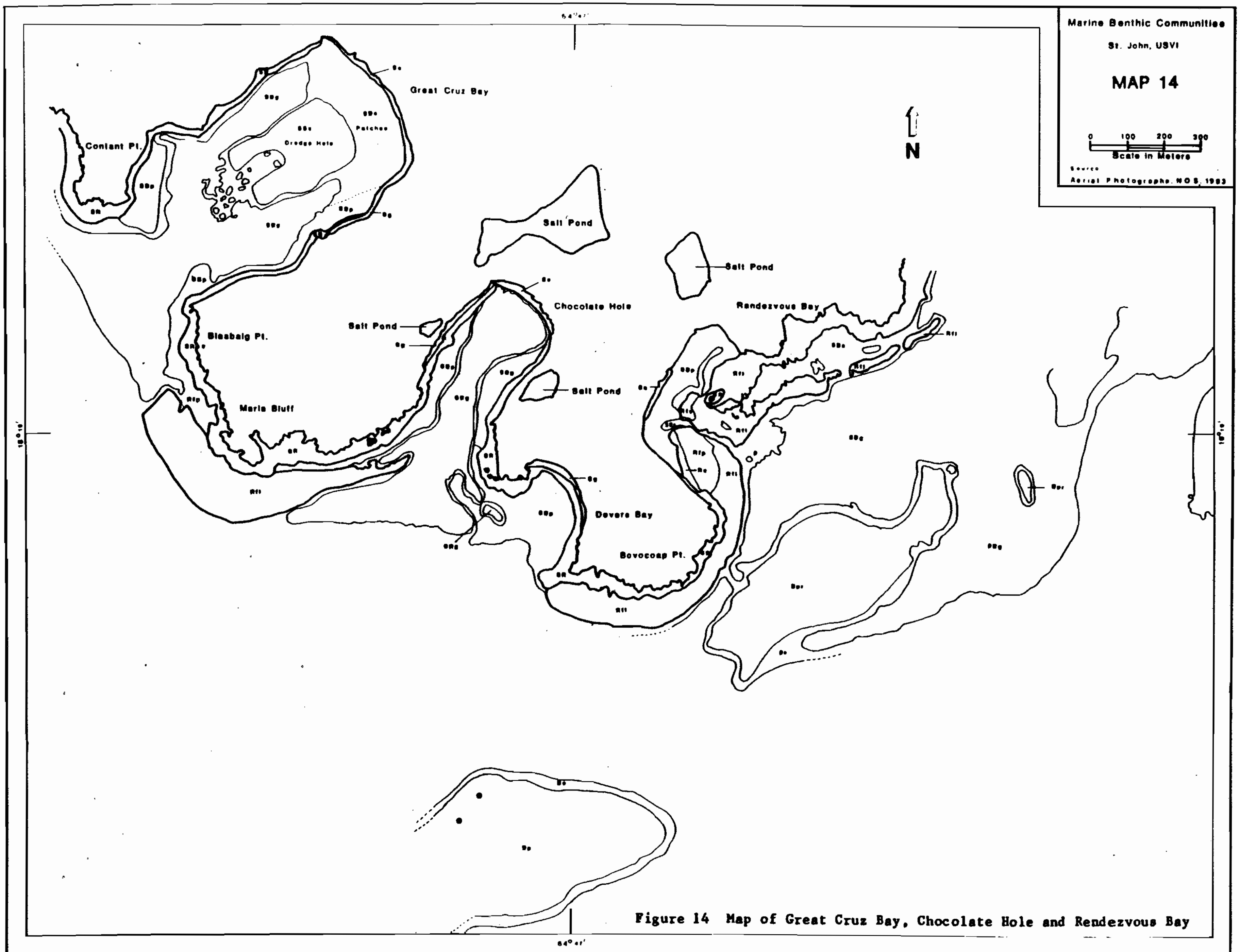


Figure 14 Map of Great Cruz Bay, Chocolate Hole and Rendezvous Bay

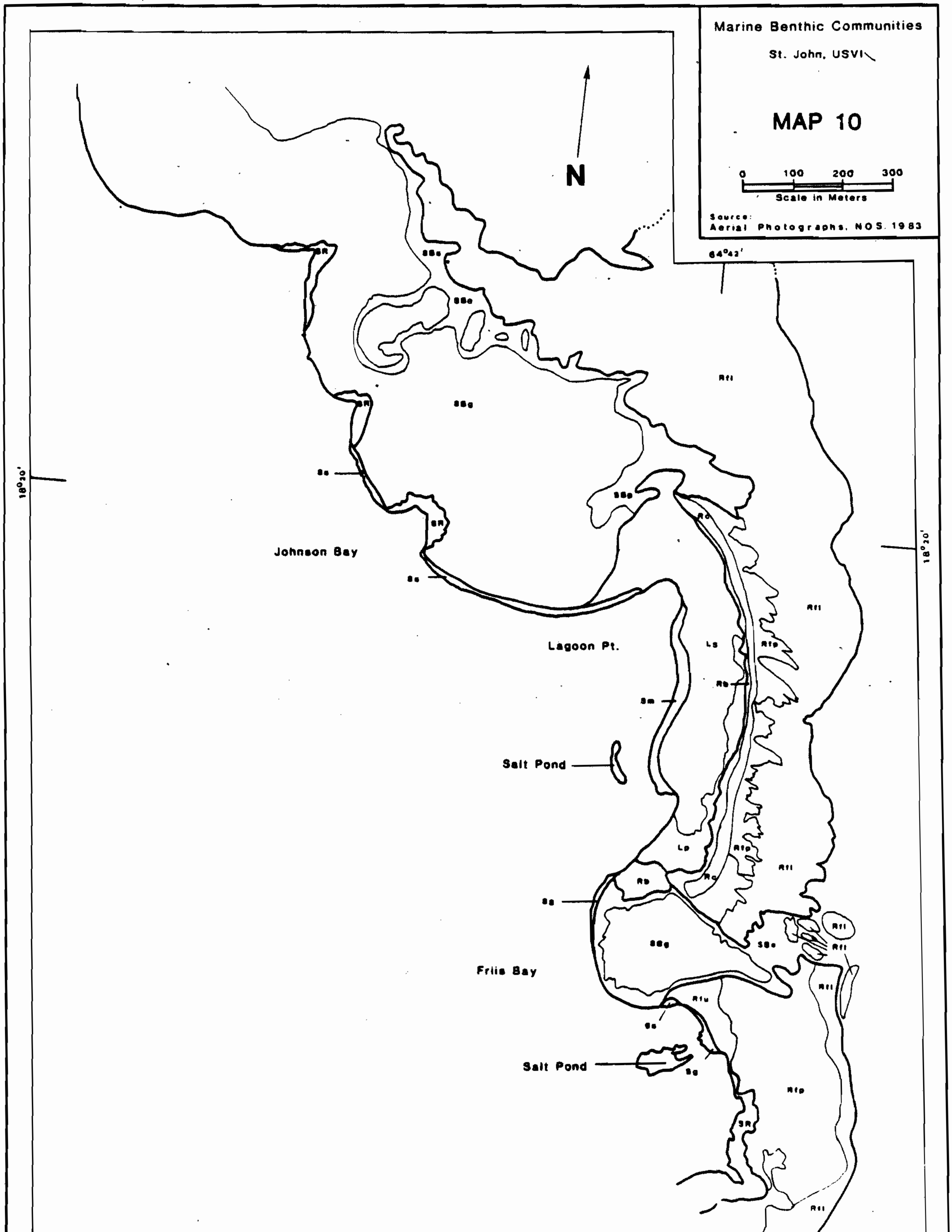


Figure 15 Map of Johnson Bay, Lagoon Point and Friis Bay - Coral Bay

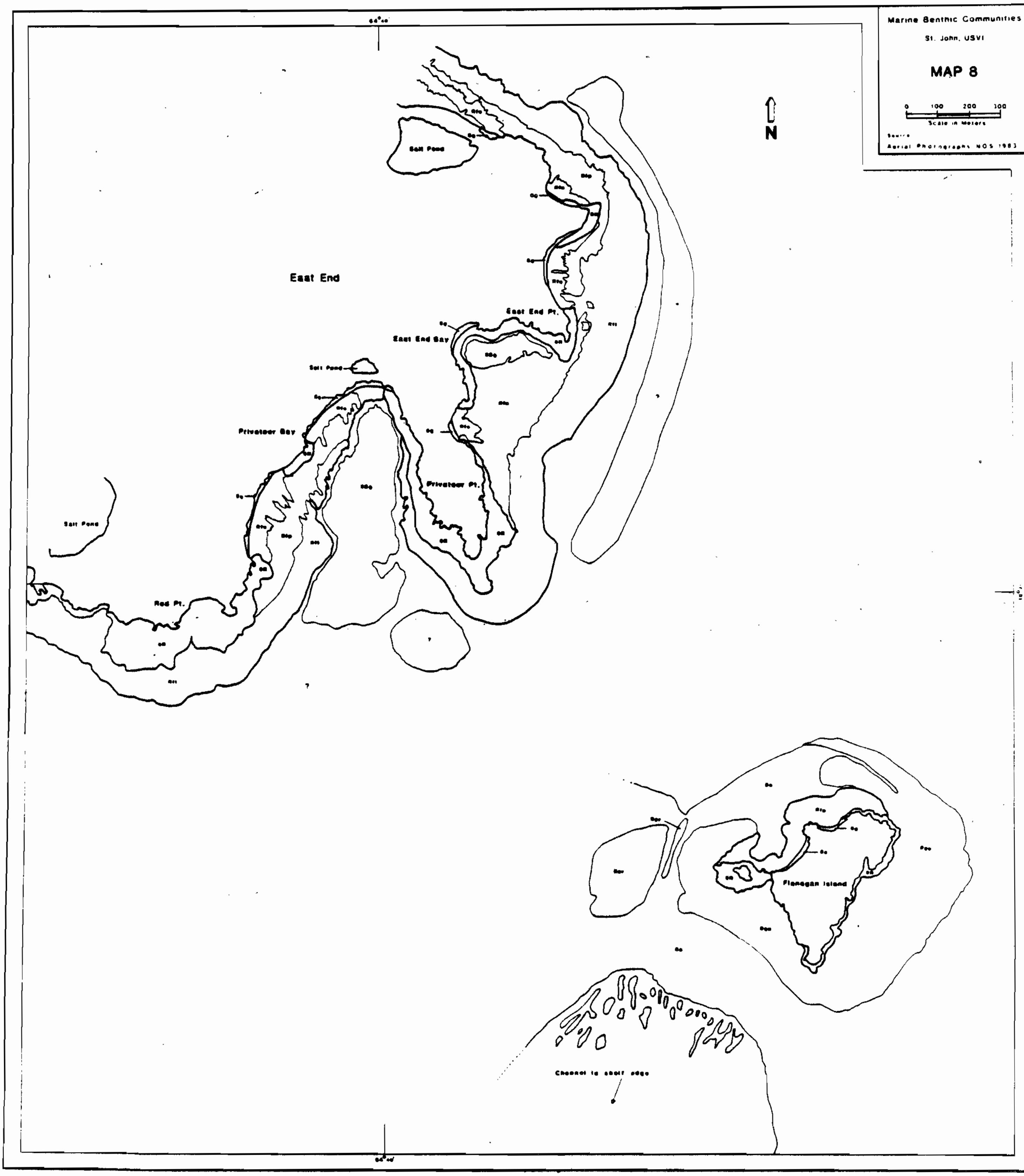


Figure 16 Map of Eastern End of St. John and Flanagan Island

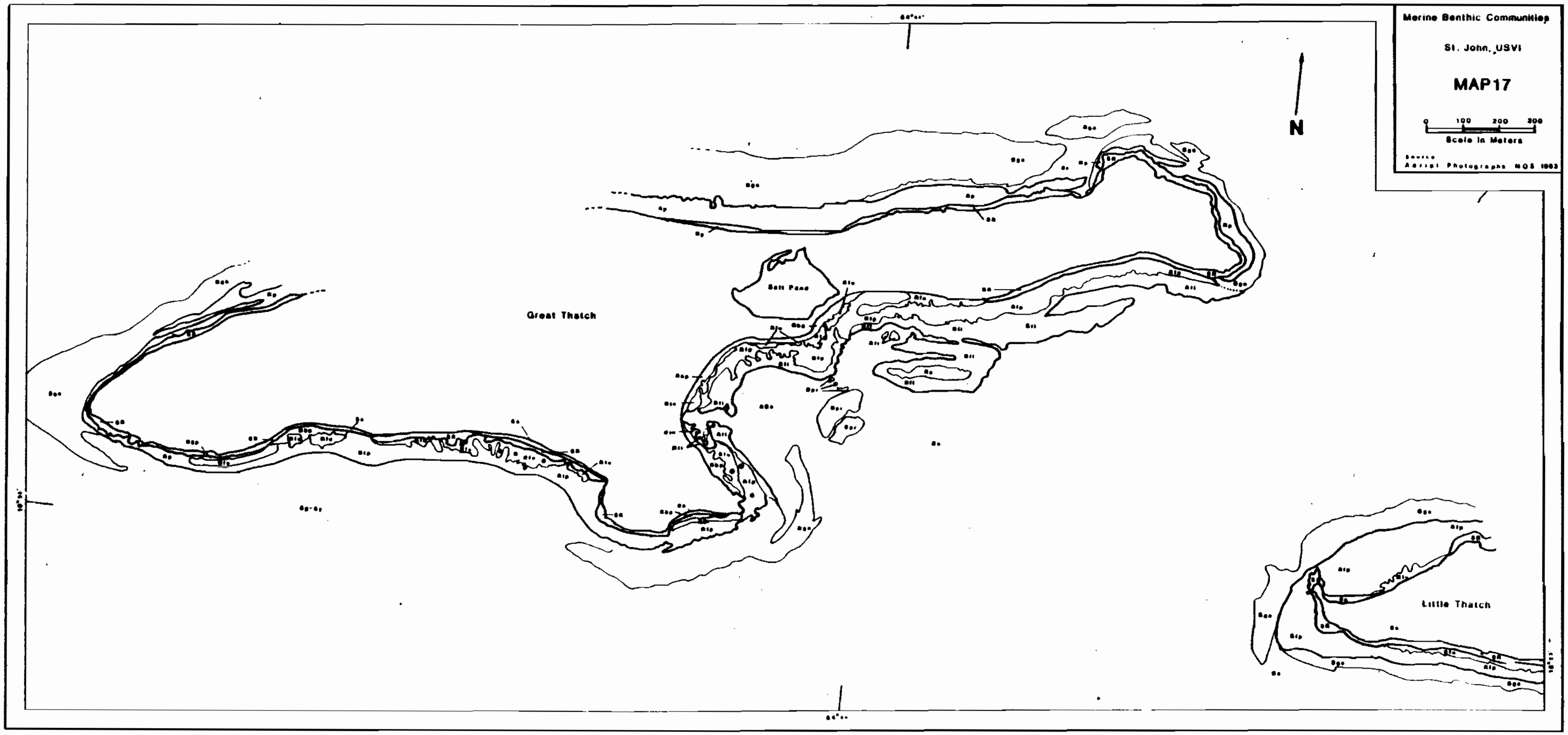


Figure 17 Map of Great Thatch Cay and Western End of Little Thatch - BVI

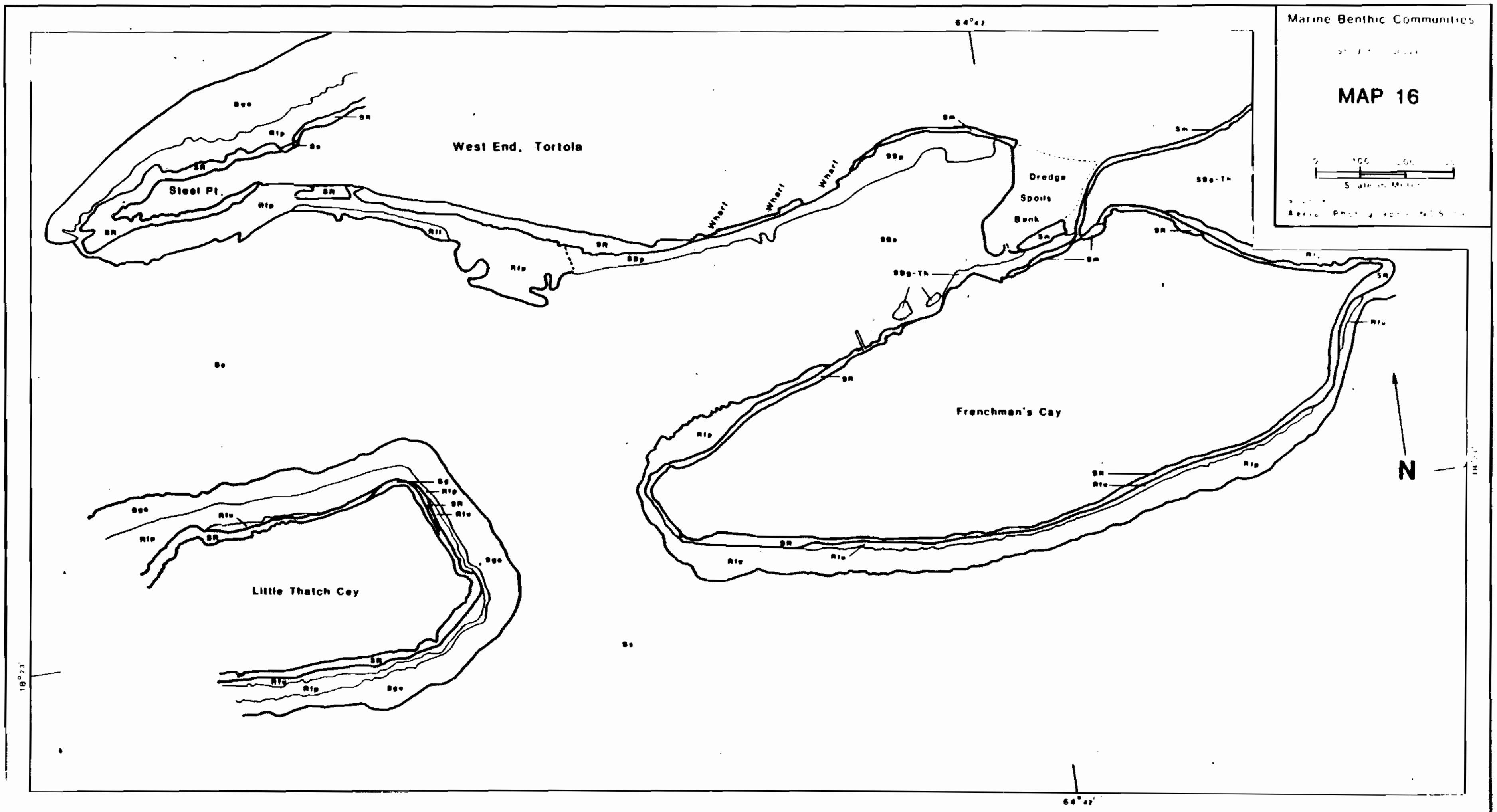


Figure 18 Map of Western End of Tortola and Little Thatch Cay - BVI

4. DISCUSSION

The general marine community mapping and inventory of the Virgin Islands National Park represents an initial phase for future investigation and resource management. Available information should provide for adequate planning of long-term monitoring and targeting resource management problems.

Several investigators have studied the marine communities of St. John. John Randall and associates from the University of Miami accomplished the first significant investigations from 1958 - 1961 which resulted in several publications as listed by Randall (1961). A small scale, marine community map was produced by Kumpf and Randall (1961), but detail and description of communities was lacking. These earlier investigations focused on fish taxonomy, fish ecology and fish abundance and stock on small and artificial reefs.

Many researchers contributed to the investigations during the Tektite I and Tektite II projects during 1969 - 1971. Most of the investigations were experimental and observational with few relevant baseline studies. These investigations were limited to Greater Lameshur Bay and vicinity. (see Fig. 19) The results of these investigations are found in Collette and Earle (1972) and Miller et al. (1971).

Virgin Islands National Park Service scientist, Allan Robinson, produced several file reports. Most are popular articles for general and interpretive information. An environmental survey by Robinson (1972) presented quantitative data on the soft bottom community within Caneel Bay. A report on turtle nesting within the Virgin Islands National Park was prepared by park technician, Vonnie Small (1982).

The School for Field Studies has initiated baseline studies on reef and seagrass beds within Greater and Lesser Lameshur Bays. Quantitative data on seagrass densities and coral transects are presented within their reports which were submitted to the Virgin Islands National Park Service.

A few relevant investigations have been conducted outside of park waters around St. John. Grigg et al. (1978) produced benthic maps and biological descriptions during an environmental assessment of Cruz Bay. Brody et al. (1970) studied the water quality, sediments and benthic communties of Chocolate Hole and Cruz Bay. Sigma Environmental Sciences (1977) produced similar information for Chocolate Hole during an environmental assessment.

Other studies conducted within the area have focused on water quality, oceanography, hydrology, geology and fishery assessment. Several years of

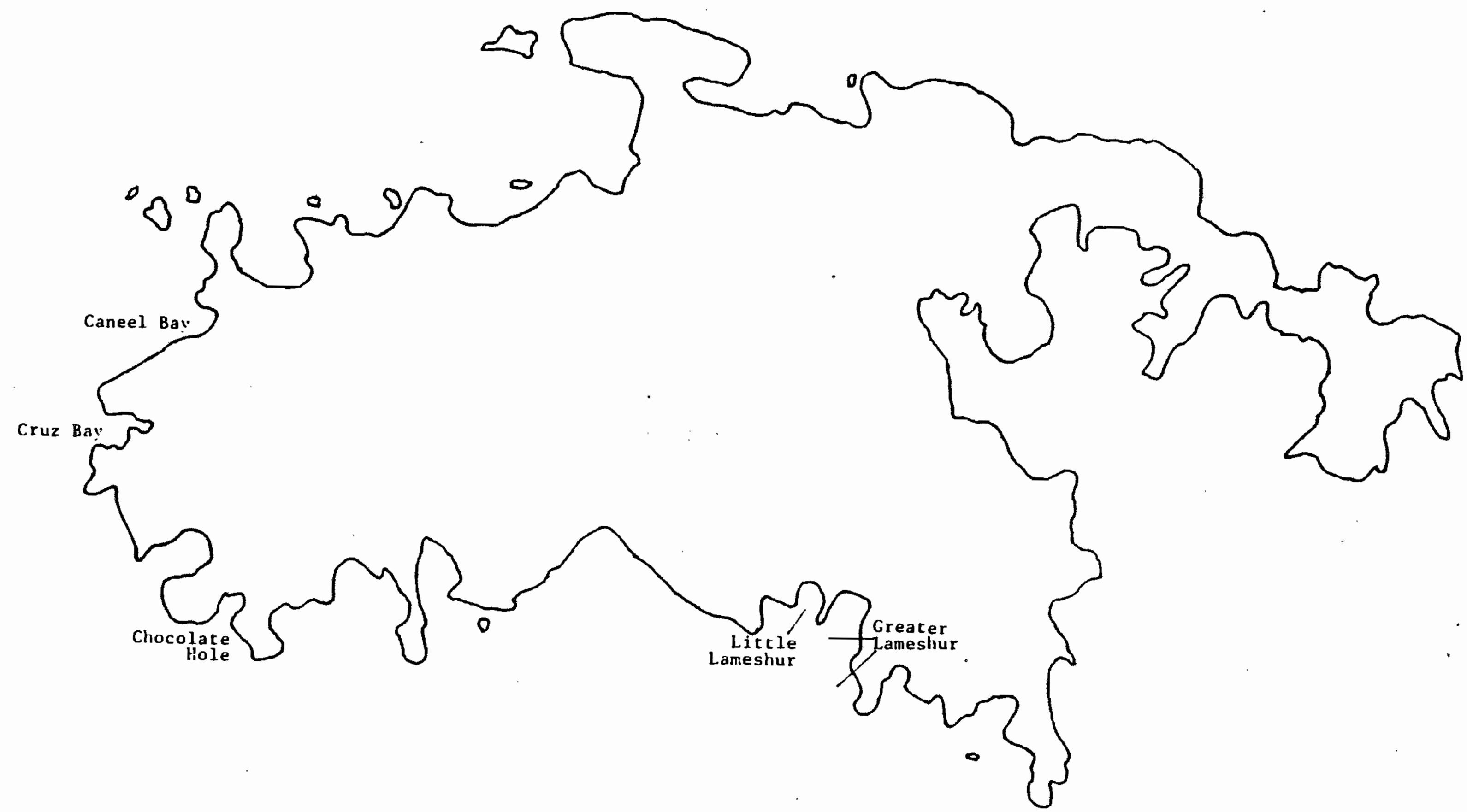


Figure 19. Previous benthic community surveys of St. John.

water quality data are available for park waters and surrounding U.S. waters from the Virgin Islands Territorial Government, Department of Conservation and Cultural Affairs, Division of Natural Resources Management.

4.1 Review of Descriptive Information

A summary of the marine communities present within the areas of investigation along with conditions is presented in Table 4. The following general observations were noted during this investigation and should assist in the interpretation of the community descriptions.

- Percent total cover generally increases seaward from inshore.
- Gorgonian cover increases seaward usually replacing the sparse pavement areas inshore.
- *Millepora* spp. and *Palythoa caribbea* increase in percent cover toward the higher energy areas in shallow subtidal bedrock zones.
- Shallow subtidal bedrock zones are normally colonized by a typical community of gastropods, bivalves, annelids and crustaceans as described in Glynn (1964; 1973).
- *Diadema antillarum* experienced a 'die-off' thoughout the Caribbean which began in 1983 and was first noted on St. John in December, 1983. Most of the mortality had occurred by the time field work began for this project in late January. Mortality was not total and varying abundance was observed. The number of juveniles appeared to increase during the course of the project.
- Coral cover, especially upper fore reef organisms, normally increases toward the windward (eastern) portion of the island.
- Storm damage resulting from the storm waves of the 1979 hurricanes, David and Frederic, greatly impacted the upper fore reef subzones, specifically the *Acropora palmata* stands, throughout the park. The greatest destruction occurred along the southeastern shore of St. John.
- Storm damage was usually associated with a higher incidence of White Band Disease and/or lower percent live cover of *Acropora palmata*.
- Several observations were made in the deeper offshore areas (20+ m.) which are occasionally visible on the NOS aerial photographs. Sand and carbonate nodules dominate most of the area with varying densities of *Halophila baillonis* and algae. The dominant algae are *Halimeda opuntia*, *H. incrassata*, *Penicillus capitatus*, *P. dumetosus*, *Lobophora variegata*, *Udotea flabellum*, *U. cyathiformis*, *Avrainvillea nigricans* and *Caulerpa* spp.

Table 4. Survey of marine communities and conditions within VINP. AD=anchor damage, ES=existing sediment damage, PS=potential sediment damage, BD=coral damaged by boat groundings, SD=storm damage, WB=white band disease, BE=beach erosion, IH=illegal harvest of marine resources. See also Table 2.1.

	Sb	Ss	Sm	Sg	SR	Lp	Lg	SBs	SBp	SBg	SBpr	SBprp	SBm	SBa	SBar	Rb	Pbp	Rc	Rfu	Rfl	Rfp	Rs	Rgo	Bgo	Bp	Bs	Bg	Bpr	Bpru Bpfl	Bpr-go	Ba	Conditions
Cruz Bay		x	x	x	x			x	x	x			x																			AD,ES,PS
Solomon + Honey Moon		x			x				x	x									x													
Caneel Bay		x			x			x	x	x																						AD
Scott Bay		x			x			x	x	x																x						
Turtle Bay		x			x			x													x											
Durloe Cays		x			x																x			x	x		x				x	
Hawksnest Bay	x	x			x			x	x	x	x							x	x	x	x		x									BD,SD,ES,PS
Dennis Bay + Perkins Cay		x			x			x											x	x	x					x						SD
Jumbie Bay		x						x											x	x	x											SD,WB
Trunk Bay + Trunk Cay		x			x			x	x	x									x		x											IH
Johnson's Reef																	x	x	x	x	x	x	x			x						SD,ES,BD
Windswept		x			x														x	x	x											SD,BD,WB
Cinnamon Bay		x			x			x	x	x	x								x	x	x	x				x		x				SD,SI,WB,BE, PS,AD
Maho + Francis Bay		x		x	x			x	x	x																						BE,PS,AD
Whistling Cay				x	x															x	x	x	x									
Leinster Bay + Watermelon Cay		x	x	x	x				x	x				x		x			x	x	x											SD
Brown Bay				x	x			x	x	x									x					x								SD,WB,IH
Mennebeck Bay		x							x								x	x	x	x												SD,WB
Haulover Bay		x	x	x	x			x	x		x					x	x		x	x	x											IH,SD
North Coast Rocky Shoreline				x	x														x	x	x			x	x	x						SD
Fish Bay + Cocoloba Cay			x	x	x		x	x		x				x		x		x		x	x					x	x				x	SD,BE,ES,PS IH
Reef Bay		x			x	x	x		x	x						x	x	x		x	x			x	x	x	x	x	x	x		SD,ES,IH
Europa Bay				x	x				x	x								x		x	x											SD
Lesser Lameshur		x			x			x	x	x					x					x												
Greater Lameshur		x	x	x	x			x	x	x										x	x											AD
Grootpan Bay				x	x			x	x	x										x					x			x				
Kiddle Bay		x			x				x	x																						PS
Salt Pond Bay		x			x				x	x																						
Booby Rock					x															x			x		x		x					AD
Ram Head				x	x															x	x				x		x					
Drunk Bay + Eastern Ram Head				x	x			x	x										x						x	x	x					SD
Otter Creek + Coral Bay			x		x				x			x																				

Occasionally solitary corals are present (i.e. *Manicina areolata*). Aggregations of *Strombus pugilus* and old individuals of *S. gigas* with eroding and heavily colonized shells are present.

An important task is the identification of areas with existing or potential problems within the Virgin Islands National Park. Several impacts, often working synergistically, have yielded changes within the marine communities of St. John. The following is a brief review of some of the largest problems.

1) Sedimentation causes the destruction of most tropical marine communities. Coral reefs are particularly vulnerable to sediment input.

Cruz Bay has a heavily developed watershed with much sediment input occurring during storm runoff.

Inshore marine communities of Hawksnest Bay may have been damaged during the major flooding on April 18, 1983. Potential impacts from sedimentation exist from erosion of the large amount of fill placed at the head of the watershed. The unstabilized fill was placed during construction of the new St. John Clinic. A significant portion of the fill was eroded during flooding last year.

Fish Bay watershed is being heavily developed for residential use. Sedimentation and increased turbidity is presently obvious, especially following storm runoff. Comparison of previous aerial photographs demonstrates the apparent impact to the seagrass beds. Potential damage is high.

The western portion of Reef Bay is the site of residential development. Inadequate construction methods have resulted in fill erosion and increased turbidity. (see Section 3.22)

Kiddle Bay has a road along the western shore. Potential impacts exist if development occurs.

Several areas outside the Virgin Islands National Park boundaries are experiencing rapid development. Coral Bay is a large bay with abundant marine resources. Development within this large watershed is increasing due to recent real estate development of private land. Potential impact of this large resource is great. Presently, no baseline investigations are pending.

2) Visitor damage by snorkelers is not a great problem in most bays of St. John. Hawksnest, Trunk and Cinnamon receive the greatest visitation and broken coral is present in all areas.

Trunk Bay is the site of the underwater trail and receives the greatest visitor pressure. Visitor damage to coral colonies, soft corals and sponges is obvious along the trail. Visitors can frequently be observed standing or inadvertantly contacting coral colonies. Occasional removal of organisms can be observed.

3) Anchor damage can be observed in selected bays. Existing and potential anchorages are presented in Figure 20.

Cruz Bay Harbor is a heavily used anchorage. Seagrass communities have altered due to anchor rake. This has resulted in a decline of marine organisms such as sea turtles.

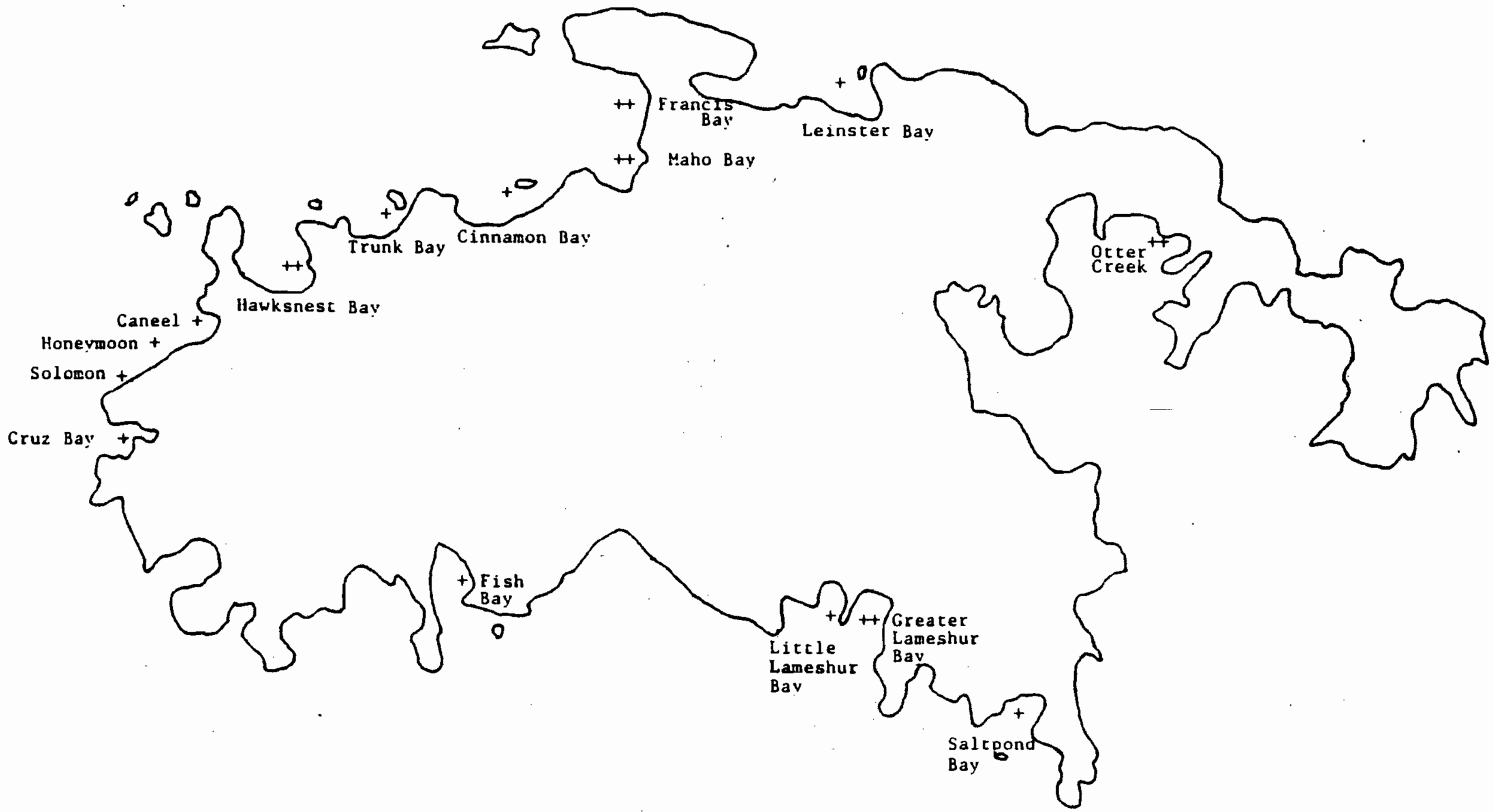
Caneel Bay is a popular anchorage with constant ferry and vessel traffic. Damage to the seagrass bed due to improper moorings was observed. Excessively long mooring chains have removed the surrounding seagrasses. Additionally, Caneel Bay receives a brine effluent from a reverse osmosis plant which is operated by Caneel Bay Plantation Resort. A _Thalassia testudinum_ bed described by Robinson (1972) has been extirpated.

Vessel anchoring in Maho and Francis Bays is fortunately predominant within the sparsely colonized, deeper portions of the bays. Increased anchoring within the bays can potentially damage the seagrass beds in the shallow portions of the beds. These areas are the most heavily used feeding grounds for the Green Sea Turtle (_Chelonia mydas_) within the park.

4) Inshore reef degradation and beach erosion is present in Cinnamon Bay. The upper fore reefs within Cinnamon Bay have apparently degraded resulting in low percent cover. This may be the result of several factors, i.e. alteration of drainage patterns within the lower portion of the watershed (specifically, the campground), development within the watershed, storm damage and beach erosion. Beach erosion is apparently due to wave and swell effects on the altered portion of the lower drainage. Degrading coral reefs may accelerate beach erosion.

5) Illegal havesting has impacted populations within several of the bays of St. John.

The antipatharians (Black Corals) within Haulover Bay are a small, restricted resource within the park. Living colonies are preferred jewelry specimens. Removal was realized by two observations of small, economically unimportant portions which covered the substrate below the site where the colony was detached. Illegal harvesting will result in the extirpation of these restricted, slow growing organisms.



\+ Existing anchorages within Virgin Islands National Park.
++ Potential problem areas if anchorages were to increase.

Figure 20. Existing and potential anchorages in Virgin Islands National Park

A few bays within the Park contain large populations of the Queen conch (*Strombus gigas*). Overharvesting, as was documented in Brown Bay in 1983, demonstrates the susceptibility of impact on a population and emphasizes the need for more adequate public awareness and resourse management policies.

4.2 Review of Survey Methods

Ecological surveys of coral reefs and associated environments are in a developmental period. Early surveys were restricted to intertidal and shallow water zones with a paucity of information from dredge samples. With the development of S.C.U.B.A., the investigation of tropical coral reef ecosystems rapidly expanded. Previously, throughout tropical and subtropical regions, coral reef systems were broadly discussed (Darwin, 1842) with subregions investigated in general descriptive terms. Few areas have been investigated in as much detail as portions of the Great Barrier Reef, Australia and western Caribbean subregions. Within these subregions, many small areas have been mapped and described in detail and quantitative methods developed for detailed investigation and description.

Many methods for coral reef description have been developed from modification of terrestrial techniques. Various methods have yielded different data which are usually difficult or impossible to relate. The obvious need for the development of comparative methods have resulted in at least one comprehensive review (Stoddart and Johannes, eds., 1978) and a standard method handbook for comparative descriptive surveys (Dahl, 1978).

The *Coral Reef Monitoring Handbook* (Dahl, 1978) presents an excellent approach for comparative descriptive surveys and is an important reference for any coral reef survey. The basic approach is similar to the methods used during the present project.

Dahl (1978) lists the following initial survey steps:

1. Initial expert advice
2. Aerial photographs (used in mapping)
3. Choice of priority areas for study
4. Mapping
5. Field checks of map (groundtruthing)
6. Training of survey personnel
7. Selection of study plots
8. Frequency of surveys

These steps are essential for any adequate survey and vary according to the intent of survey, size of area to be covered, time available and necessary degree of accuracy.

In any survey, aerial photographs are essential for adequate mapping. If adequate aerial photographs are not available, the preferred method is color photography with the use of a small airplane as described in Report 13 by West Indies Laboratory and by Hopley (1978). Other methods using a kite or balloon for aerial photography (Rutzler, 1978) may prove more convenient, practical and less expensive depending on the need.

Following acquisition of aerial photographs, base maps must be drafted prior to initiation of field work. Community types (zones and subzones) must be identified and defined. Careful analysis of the aerial photographs will provide differentiation between major zones and many subzones. The base maps are labelled with community type designations as determined by aerial photograph analysis. (see Section 2)

Adequate groundtruthing must be accomplished to provide reliable community maps. Each zone drafted should be investigated. Spot dives can be used to confirm base maps if time and/or support is restricted. Description requires complete or representative coverage of each area mapped. During this investigation, all subzones were investigated with detail characterization accomplished along transect located in representative locations. Parameters to be investigated must be carefully considered to provide adequate assessment within given restrictions, but should at least include those presented in Section 2.

After completion of final maps and description of marine communities, the following essential step is the establishment of long-term monitoring sites. Monitoring methods should be carefully designed to provide reliable quantitative information which is readily repeatable. Monitoring sites must be carefully chosen and well mapped, marked and described. Monitoring sites should be established within Areas of Particular Concern. These areas should be recognized as those with realized and potential damage from various sources, i.e. sedimentation, visitor damage, vessel anchorage. The descriptions of marine communities should provide information for the identification of Areas of Particular Concern.

The method presented by Dahl (1978) is visual assessment of circular plots (50 m^2). These plots are located in the different zones present within a given area of study. The number of plots per zone is determined by size, diversity, and complexity of each zone surveyed. Each plot is marked with a permanent marker for exact relocation. Parameters surveyed are those covered in the present project including fish counts which are addressed in Report 2.1. Other parameters such as temperature, turbidity and salinity may be of importance.

Errors with this method of monitoring are 1) inability or inaccuracy of plot relocation, 2) individual observer bias between plots and surveys, 3) inaccuracy of observations, 4) data transcription and 5) analysis of natural variation. Transects which were accomplished during the present project yielded similar data and are subject to the same errors. Kenchington (1978) discussed the various problems with visual surveys.

In the development of methods for long-term monitoring, several considerations are important. The method used for long-term monitoring during this initial phase was the establishment of permanent long-term phototransects (Laxton and Stablum, 1974; Ott, 1975; Bohnsack, 1979). The phototransect method used during this investigation is described in detail in Report 1.2.

Phototransects have many advantages: 1) individual observer bias is eliminated, 2) inaccuracy of observation is diminished, 3) data transcription errors are diminished, 4) using prescibed technique, personnel need not have extensive training and 5) a permanent, comparative record is established. Errors include 1) inability or inaccuracy in transect relocation, 2) inaccurate photographic technique, 3) analysis of natural variation and 4) potential loss or damage of photographic film.

Photographic film provides excellent comparative records. Analyses can be made between surveys by direct measurement of percent cover of each substrate type and each taxonomic group. Digitizing programs for small computers are now readily available and extremely useful for comparative analysis. An additional advantage is that detailed analysis may be completed by an expert away from the study site.

Phototransects were completed during this project in Areas of Particular Concern to provide an initial, permanant record and to provide information for future monitoring. Although the method provides an excellent comparative record, the analysis is two-dimensional and ignores certain characteristics, i.e. spatial heterogeneity, actual colony size, small and cryptic species.

Therefore, a comprehensive monitoring program should include the use of other methods which consider such parameters.

Comprehensive reviews of phytosociologic quadrat methods and related problems are discussed by Pichon (1978a,b) and Scheer (1978) with plotless and transect methods discussed by Loya (1978). Various methods have specific advantages and must be selected on study design. For comparative long-term monitoring, efficiency and comparative parameter results appear to favor the transect methods.

Loya (1978) states that 'transect sampling proved to be very efficient in information gained per unit time spent underwater and also in avoiding problems of bottom topography. Thus, a line may be put along depth contours, while quadrat sampling is much more complicated to interpret and handle underwater.' Furthermore, he adds that 'due to efficiency limitation of quadrat sampling a much smaller dimension of the reef can be covered when compared to line transect techniques in terms of results obtained per equal labour time.'

Weinberg (1981) presents a comparison of seven coral reef survey methods on a diverse shelf edge reef off the southern coast of Puerto Rico. Three criteria were used for evaluation: number of species observed, relative coverage and population densities. He concluded that point-intercept methods, linear and planar, yielded very poor results; random point method (point-centered quarter method) and linear transects yielded fair results; and in situ drawn maps of quadrats and photographic methods yielded good results. The best method tested was an individual counting and cover estimate method. In this method, every colony of each species was counted and the percent coverage was estimated. All the quadrat methods proved more efficient for the criteria used although more reef distance was covered by the linear transect method.

It appears that a combination of methods using phototransects and linear transects would provide the most comprehensive coverage for long-term monitoring. In this manner, the strengths of the quadrat and transect methods can be combined to yield a permanent, comparative method enhanced with data from three dimensions.

4.3 Recommendations

The following recommendations are provided for development of future investigations and resource management.

4.3.1 General Recommendations

1) Sediment impact due to development appears to be the largest existing and potential problem within the marine communities of the Biosphere Reserve. Investigations are needed to determine chronic effects of sedimentation.
2) Territorial coastal zone and water quality legislation requires adequate enforcement. Public education must be enhanced for support to be realized.
3) Long-term monitoring and intensive surveys of natural resources must be supported by the territorial government if legislation is to be effective. Virgin Island Resource Management Cooperative can provide technical assistance for the establishment of a regional survey and monitoring system.

4.3.2 Specific Recommendations for the Virgin Islands National Park

1) Areas of Particular Concern should be identified based on existing and potential environmental problems.
2) Long-term monitoring sites should be established within Areas of Particular Concern. Specific areas of concern with existing and potential sediment impact are the inshore communities within Hawksnest, Cinnamon, Maho, Francis, Fish and Reef Bays.
3) Long-term monitoring should be initiated within the area of the underwater trail in Trunk Bay to document visitor damage. A matrix of photoquadrats based on the method devised by Boulon (1980) may be a more practical method than the establishment of phototransects. Relocation of the underwater trail is not recommended presently. The present location within an area of low coverage seems to be the most reasonable so that intensive visitor use and resulting damage may be limited.
4) Investigation of the seagrass beds and their use as a preferred feeding ground for Green Sea Turtles (Chelonia mydas) within Maho and Francis Bays should be initiated to determine if vessel anchorage should be restricted. Limiting anchoring to deeper water areas and/or the establishment of permanent moorings which do not disturb the benthic communities may be an adequate alternative.

5) Intensive investigation of harvested species within the park is needed to determine adequate management policy. A reasonable policy could be the establishment of certain bays as 'no harvesting areas'. These would be reserve, source and control areas for future monitoring. Suggested intensive investigations are population dynamics on Spiny lobster (_Panulirus argus_), Queen conch (_Strombus gigas_) and West Indian Topshell, or whelk, (_Cittarium pica_) and the effect of fish traps on a small reef system.

6) Antipatharians (Black coral) are an endangered group and deserve recognition as a restricted and extremely limited resource within the park. The Virgin Islands National Park Management Plan does not mention this endangered group, therefore, inclusion is warranted.

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APPENDIX 1

TABLES OF TRANSECT DATA

ZONE	DEPTH (m)	HABITAT COMPLEXITY	TOTAL % CORAL COVER	% LIVE VS DEAD	CORAL TAXA	OTHER TAXA
TABLE 3.2 Solomon Bay						
SR	0-1.0	1-2	<5	50-60	*Fav Ppor *Past Aga Mil	spg gorg
SBp	7.0-12.0	1	<5	10-20	*Mann Acer *Ssid Col	
TABLE 3.3 Caneel Bay						
SR	0-2.5	1-2	5-10	60-70	*Past Ppor *Mil Dcli Aga Dlab Srad Ssid Fav	Dia spg
SBg	2.5-10.0	1			*Hal *Syr	
TABLE 3.4 Scott Bay						
Sand	0-1.5	1				
SBg	1.5-4.0	1			*Hal Syr	
TABLE 3.6 Ramgoat Cay						
SR	0-5.5	1-2	20-30	40-60	*Apal Past *Mil Mcav Mann Fav Acer Aga	*Pal gorg
Bgo	5.5-18.3	1	25-30	60-70	Mcav Ssid Mann Mea	*gorg

ZONE	DEPTH (m)	HABITAT COMPLEXITY	TOTAL % CORAL COVER	% LIVE VS DEAD	CORAL TAXA	OTHER TAXA
TABLE 3.7 Hawksnest Bay						
Rfu	0-2.0	5	10-20	30-50	*Apal Mil Past Dstr Ppor Fav Ssid	Dic Eci
Rfp	2.0-6.5	1	<5	40-50	*Mann Aga Ssid Mil Acer Mcav	*gorg spg
Rfl	6.5-9.0	3-4	25-30	60-65	*Mann Ppor *Dstr Ssid Acer Col Aga Past Dlab	*gorg spg
SBpr	9.0-6.7 -11.3	3-4	20-25	30-50	*Mann Dlab Ppor Dstr Ssid Col Aga Mea Past Ste Mcav	gorg spg
TABLE 3.8 Dennis Bay						
Rfu	0-1.5	3/5	5-10	10-15	*Apal Dstr Past Fav Dcli	Lia Gor
Rfp	1.5-6.5	1	<5	50-60	*Mann Ppor Acer Past	*gorg spg
Rfl	6.5-13.0	3-4	20-30	50-60	*Mann Ppor Dlab Mcav Dstr Mil Aga Ssid Acer Myc	*gorg spg

ZONE	DEPTH (m)	HABITAT COMPLEXITY	TOTAL % CORAL COVER	% LIVE VS DEAD	CORAL TAXA	OTHER TAXA

TABLE 3.10 Trunk Bay - Trunk Cay

ZONE	DEPTH (m)	HABITAT COMPLEXITY	TOTAL % CORAL COVER	% LIVE VS DEAD	CORAL TAXA	OTHER TAXA
SR	0-3.5	1-2	5-10	40-60	*Past Dstr *Apal Dlab Mann Fav	Pal gorg
Sand	3.5-6.5	1	0			
SBp	6.5-10.0	1	5-10	50-60	*Past Mcav *Mann Dlab Aga Dstr Ssid	spg gorg Pal
Sand	10.0	1	0			
SBg	10.0	1				*Hal Syr

TABLE 3.11 Johnson's Reef

ZONE	DEPTH (m)	HABITAT COMPLEXITY	TOTAL % CORAL COVER	% LIVE VS DEAD	CORAL TAXA	OTHER TAXA
Rc	1.0	3-4	30-40	40-50	*Mil	
Rfu	1.0-3.0	5	40-50	30-40	*Apal Fav *Mil Aga *Past Acer Dstr Den Dcli	Pal Bri
Rgo	3.0-10.5	1	30-40	60-70	*Mcav Mil *Ssid Mann Aga Mea	*gorg
Rfl	10.5-24.0	3-4	25-30	30-40	*Mann Tub Mcav Agl Aga Den Mdec Myc Past Mea Ssid Eus Hel Mil Ste Ocu Dstr Sco Dlab Mus Mmir Dic Acer	spg Pal Zoa

ZONE	DEPTH (m)	HABITAT COMPLEXITY	TOTAL % CORAL COVER	% LIVE VS DEAD	CORAL TAXA	OTHER TAXA

TABLE 3.12.1 Windswept - Profile 1

ZONE	DEPTH (m)	HABITAT COMPLEXITY	TOTAL % CORAL COVER	% LIVE VS DEAD	CORAL TAXA	OTHER TAXA
Rfu	0-2.0	5	25-30	40-50	*Apal Ppor *Mil Mann Past Acer Dstr Fav Dcli Srad	Pal
Rfp	2.0-12.0	1	5-10	60-70	*Mann Ppor *Mcav Ssid	*gorg

TABLE 3.12.2 Windswept - Profile 2

ZONE	DEPTH (m)	HABITAT COMPLEXITY	TOTAL % CORAL COVER	% LIVE VS DEAD	CORAL TAXA	OTHER TAXA
Rfu	0-2.0	3/5	5-10	20-25	*Apal Dstr *Mil Fav Past Srad	Pal
Rfp	2.0-5.0	1	<5	60-70	*Mann Ppor Mcav Ssid	gorg
Rfl	5.0-10.0	3-4	20-25	30-40	*Mann Col *Ssid Ppor Dlab Acer	

TABLE 3.13 Cinnamon Bay

ZONE	DEPTH (m)	HABITAT COMPLEXITY	TOTAL % CORAL COVER	% LIVE VS DEAD	CORAL TAXA	OTHER TAXA
Sand	0-1.5	1	0			
Rfu	1.5-2.5	1-2	<5	20-30	*Past Aga Mil Apal Fav	Pal spg
Rfp	2.5-7.0	1	5-10	60-70	*Ssid Dlab Mann Mil Past Acer Aga Den Ppor	*gorg spg
Rfl	7.0-11.0	3-4	15-20	50-60	*Mann Dstr *Ssid Dlab Col Eus Mmir Dic Past Sco Aga Mus Ppor Acer Mdec Myc Mil Den Hel Ocu Mea	gorg Pal Zoa

ZONE	DEPTH (m)	HABITAT COMPLEXITY	TOTAL % CORAL COVER	% LIVE VS DEAD	CORAL TAXA	OTHER TAXA
TABLE 3.14 Maho Bay						
SR	0-2.5	1-2	10-15	60-70	*Mil Mcav Apal Srad Dstr Ssid Col Dcli Ppor Mann Past Aga	*Pal *Chon gorg spg
SBp	2.5	1	<5	50-60	*Mann Acer *Past Dstr	
SBg	2.5-3.5	1				*Syr Tha
SBp	3.5-9.0	1	<5	40-50	*Mann Acer *Past Dstr	
TABLE 3.15 Whistling Cay						
SR	0-3.5	1-2	10-15	60-70	*Mil Dlab *Apal Dstr Past	Chon Pal Bri Lia
Rgo	3.5-7.5	1	30-35	70-80	Past Mil Ssid Iso Mcav Aga Ppor Mea Acer	*gorg spg
Sand	7.5	1	0			
Rfl	7.5-16.5	4	15-20	60-70	*Mcav Past Ssid Mea Col Eus Dlab Myc Mdec Acer Aga Mus	*gorg spg

TABLE 3.16 Leinster Bay

ZONE	DEPTH (m)	HABITAT COMPLEXITY	TOTAL % CORAL COVER	% LIVE VS DEAD	CORAL TAXA	OTHER TAXA
SBg	0-0.5	1				*Tha Hal
Rfu	0.5-2.0	5	15-20	15-20	*Mil Fav *Apal Aga Past Dlab Acer Ppor Mann Dstr Ssid Iso	Pal Lia Bri Chon gorg
SBp	2.0-9.0	1-2	5-10	50-60	*Mann Acer *Ssid Ppor *Dstr Past Aga	gorg Pal

TABLE 3.17 Brown Bay

ZONE	DEPTH (m)	HABITAT COMPLEXITY	TOTAL % CORAL COVER	% LIVE VS DEAD	CORAL TAXA	OTHER TAXA
Rfu	0-2.0	5	10-15	15-20	*Apal Ppor *Past Acer Mann Fav Col Mcav Ssid Dlab	gorg Bri Chon Zoa spg Lia
SBp	2.0-3.0	1	10-15	60-70	*Acer Dlab Dstr Ppor Ssid Den	*gorg spg
SBg	3.0-	1	0			*Tha *Syr

ZONE	DEPTH (m)	HABITAT COMPLEXITY	TOTAL % CORAL COVER	% LIVE VS DEAD	CORAL TAXA	OTHER TAXA
TABLE 3.18 Mennebeck Bay						
Rb	0-1.0 -0	1-2	<5	50-60	*Past Apal *Acer Dstr	
Rc	0-0.5	3-4	25-50	60-70	*Mil	
Rfu	0.5-2.0	5	25-30	20-25	*Apal Ppor *Mil Dcli Acer Fav Mann	Pal Zoa Sto Ric
Rfl	2.0-3.5	4	35-40	70-80	*Mann Ssid *Ppor Dlab Mil Apal Acer Iso Col Isas Past Den Dstr	Pal Zoa gorg spg Chon
SBp	3.5-	1	<5	60-70	*Mann Ssid Past Acer	gorg
TABLE 3.19 Haulover Bay						
Rp	0-0.5 -0.3	1-2	<5	70-80	*Dstr Mil *Dcli Ssid *Past Iso Apal	Zoa Pal Chon Eci Acan
Rfu	0.3-2.5	5	50-60	25-30	*Apal Fav Mil Dstr Mann Dcli Acer	Pal Zoa
Rfl	2.5-15.0	4	60-70	60-70	*Mann Ssid *Aga Myc Ppor Lep Acer Mea Mcav Mdec Dstr Past Dlab Eus Col Mus	gorg spg

ZONE	DEPTH (m)	HABITAT COMPLEXITY	TOTAL % CORAL COVER	% LIVE VS DEAD	CORAL TAXA	OTHER TAXA

TABLE 3.20 Mary's Point

ZONE	DEPTH (m)	HABITAT COMPLEXITY	TOTAL % CORAL COVER	% LIVE VS DEAD	CORAL TAXA	OTHER TAXA
SR	0-3.0	1-2	5-10	70-80	*Mil Dstr Past Dlab Aga Ssid Mann Acer Apal	*Pal gorg
Bp	3.0-4.5	1	20-30	60-70	*Past Dstr *Mann Ssid Mcav Dlab Aga Acer	gorg
Bgo	4.5-12.0	1-2	30-35	70-80	*Past Acer Mcav Ste Mann Mdec Aga Col Dstr Mea Ssid Dic Dlab Eus	*gorg spg
Bp	12.0-17.0	1	5-10	60-70		*Gor *spg asc

TABLE 3.20.2 Point west of Mennebeck Bay

ZONE	DEPTH (m)	HABITAT COMPLEXITY	TOTAL % CORAL COVER	% LIVE VS DEAD	CORAL TAXA	OTHER TAXA
SR	0-4.5	1-2	10-15	30-40	*Apal Mil *Mann Past	Pal
Bp	4.5-7.5	1	10-15	50-60	*Mann Mcav Dlab Ssid	*gorg
Bgo	7.5-15.0	1	20-25	70-75	*Acer Mea *Mann Aga Ssid Past Mcav Dstr Dlab Mdec Col Mil	*gorg
Bp	15.0-16.5	1	5-10	60-70	*Mann Mcav Mea	*gorg spg

TABLE 3.20.3 Gowed Point

ZONE	DEPTH (m)	HABITAT COMPLEXITY	TOTAL % CORAL COVER	% LIVE VS DEAD	CORAL TAXA	OTHER TAXA
SR	0-5.0	1-2	10-15	60-65	*Mann Mil Apal Past Dlab Ssid	gorg spg Pal
Rfp	5.0-10.5	1	5-10	60-65	*Mann Past Ssid	gorg
Rfl	10.5-17.5	3-4	20-25	65-70	*Mann Past *Acer Fav *Ssid Dic Col Eus Mea Aga Dstr Iso Dlab Den Ppor	*gorg spg

TABLE 3.21 Fish Bay

ZONE	DEPTH (m)	HABITAT COMPLEXITY	TOTAL % CORAL COVER	% LIVE VS DEAD	CORAL TAXA	OTHER TAXA
Lg	0-0.3	1	<5	<5	Ppor	*Tha
Rb	0.3-0.5	1	<5	25-30	*Apal Aga *Ppor	*Lia *Dict Dia
Rc	0.5-0+	3	0	0	rubble	
Rfp	0-3.0	1	<5	5-10	*Apal Dstr *Mann Dlab Ssid Col	Gor
Rfl	3.0-6.5	3-4	20-25	50-60	*Mann Aga Ssid Mil Dstr Acer Dlab Past Col Fav Ppor	gorg spg Pal

ZONE	DEPTH (m)	HABITAT COMPLEXITY	TOTAL % CORAL COVER	% LIVE VS DEAD	CORAL TAXA	OTHER TAXA
TABLE 3.22 Reef Bay						
Rb	0-0.5	1	<5	40-50	*Dstr Aga Mann Fav	Pal
Rc	0.5-0+	3	0	0	rubble	
Rfp	0-5.5	1-2	5-10	30-40	*Mcav Ssid Mil Past Dstr Apal	*gorg
Rfl	5.5-7.5	4	25-30	60-70	*Mann Mea *Mcav Ppor Ssid Aga Dlab Past Dstr Ste Col Den Mil Eus	spg gorg Pal
TABLE 3.23 Europa Bay						
SR	0-2.5	1-2	<5	60-70	*Mil Ppor Apal Mann Past	Bri Pal spg gorg
Rfp	2.5-4.5	1	<5	30-40	*Mann Col *Past Mil Ssid Apal Dcli Dlab Dstr Aga Acer	Pal spg Zoa gorg
Rfl	4.5-7.5	3	25-30	50-60	*Mann Ppor Ssid Acer	gorg spg
Sand	7.5	1	0	0		
SBg	7.5-	1	0	0		*Syr

TABLE 3.24.1 Little Lameshur Bay

ZONE	DEPTH (m)	HABITAT COMPLEXITY	TOTAL % CORAL COVER	% LIVE VS DEAD	CORAL TAXA	OTHER TAXA
SR	0-2.5	1-2	10-15	60-70	*Mann Dlab Aga Ste Past Den Ssid Iso Fav Eus Acer Dic Mann Ocu Dstr	gorg spg Pal
Rfl	2.5-4.5	4	20-25	70-75	*Ppor Dstr *Mann Dlab Past Ste Mil Den Aga Eus Acer Dic Ssid	gorg spg
Sand	4.5	1	0	0		
SBg	4.5-	1	0	0		*Tha *Syr

TABLE 3.24.2 Yawzi Point - Greater Lameshur Bay

ZONE	DEPTH (m)	HABITAT COMPLEXITY	TOTAL % CORAL COVER	% LIVE VS DEAD	CORAL TAXA	OTHER TAXA
SR	0-3.5	1-2	15-20	60-70	*Mil Ssid Mann Ppor Dstr Aga Dlab Past	Pal spg
Rfl	3.5-9.5	4	25-30	50-60	*Mann Eus *Col Acer Ssid Den Ppor Myc Aga Ste Mcav Lep Past Fav Dlab Dic Dstr Mil Mea Isas Mmir	gorg spg
Sand	9.5	1	0	0		
SBg	9.5-	1	0	0		*Tha *Syr

ZONE	DEPTH (m)	HABITAT COMPLEXITY	TOTAL % CORAL COVER	% LIVE VS DEAD	CORAL TAXA	OTHER TAXA

TABLE 3.24.3 Donkey Bight - Greater Lameshur Bay

ZONE	DEPTH (m)	HABITAT COMPLEXITY	TOTAL % CORAL COVER	% LIVE VS DEAD	CORAL TAXA	OTHER TAXA
SR	0-2.0	1	<5	40-50	Fav Past Ppor	spg
Rfp	2.0-5.0	1	15-20	60-70	*Mann Past Mcav Dstr Col Dlab Ppor Acer Aga Dic Ssid Mil	gorg spg Pal
Rfl	5.0-7.3	4	20-25	50-60	*Mann Past *Col Mea Aga Dstr Mcav Acer Ssid Dic Dlab Den Ppor Mil	gorg spg
Sand	7.3	1	0	0		
SBg	7.3-	1	0	0		*Syr

TABLE 3.24.4 Beehive Cove - Greater Lameshur Bay

ZONE	DEPTH (m)	HABITAT COMPLEXITY	TOTAL % CORAL COVER	% LIVE VS DEAD	CORAL TAXA	OTHER TAXA
SR	0-6.0	1-2	15-20	60-70	*Mann Dcli *Past Sol Aga Mdec Mil Mcav Ssid Fav Apal Dstr Ppor Dlab Acer Mea Eus Lep Den	gorg Pal spg Het
Rfl	6.0-19.0	4	25-30	60-70	*Mann Dstr *Col Acer Aga Sco Mcav Dic Ssid Den Mdec Mus Dlab Iso Ppor Mil Past Isas Mea Eus Myc Lep Mmir Fav	gorg spg

ZONE	DEPTH (m)	HABITAT COMPLEXITY	TOTAL % CORAL COVER	% LIVE VS DEAD	CORAL TAXA	OTHER TAXA
TABLE 3.25.1 Grootpan Bay						
SR	0-4.5	1-2	10-15	60-70	*Mil Col Past Mcav Apal Dcli Srad Den Ssid Ppor Mann Dstr	*Pal spg
SBp	4.5-8.5	15-20	15-20	60-70	*Mann Ste *Mcav Iso Past Mea Ssid Mdec Ppor Den Fav Acer Dlab Aga Dstr	*gorg
Sand	8.5	1	0	0		
SBg	8.5-	1	0	0		*Str
TABLE 3.25.2 Kiddle Bay						
Rfp	0-2.5	1	<5	40-50	*Past Ssid Mann	
Rfl	2.5-4.5	4	25-30	60-70	*Mann Past Ssid Acer	gorg
SBp	4.5-7.5	1	<5	40-50	*Mann Ssid Past	gorg
SBg	7.5-	1	0	0		*Syr

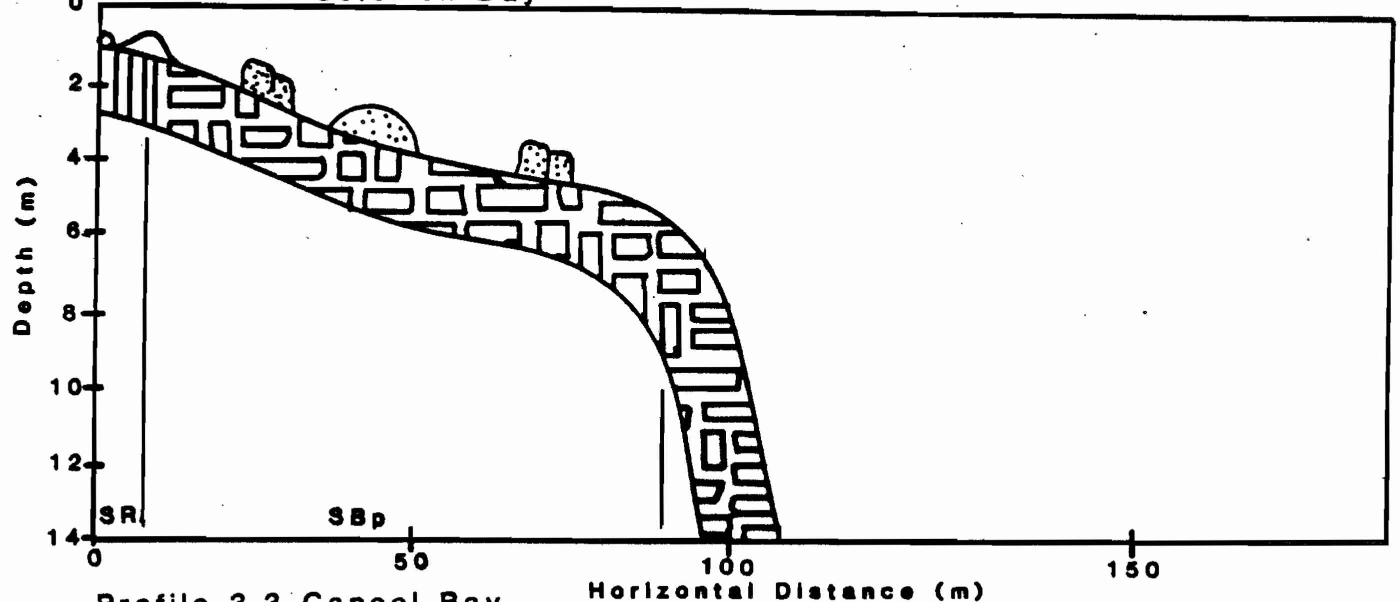
ZONE	DEPTH (m)	HABITAT COMPLEXITY	TOTAL % CORAL COVER	% LIVE VS DEAD	CORAL TAXA	OTHER TAXA
TABLE 3.26.1 Salt Pond Bay - Booby Rock						
SR	0-3.5	1-2	20-25	70-80	*Mil Fav *Past Aga Den Dstr Apal Dlab	*Pal spg
SBg	3.5-6.0	1	0	0		*Syr
Bp	6.0-10.5 - 7.5	1	<5	50-60	*Mcav Ssid Dic Sol	Udo
Bgo	7.5-4.5	1	20-25	70-80	*Mcav Dstr Ssid	*gorg
SR	4.5-0	1-2	30-35	70-80	*Mil Ssid *Past Dstr Mcav Pdiv	*gorg
TABLE 3.26.2 Booby Rock						
SR	0-12.0	1-2	35-40	70-80	*Mil Ssid *Past Dstr Mcav Pdiv Fav	*gorg
Bgo	12.0-21.3	1	30-35	70-80	*Mcav Dic Ssid Ste Dstr Iso Pdiv	*gorg Udo

ZONE	DEPTH (m)	HABITAT COMPLEXITY	TOTAL % CORAL COVER	% LIVE VS DEAD	CORAL TAXA	OTHER TAXA
TABLE 3.26.3 Western Ram Head						
SR	0-9.0	1-2	10-15	60-70	*Mil Dlab *Mann Acer Ssid Den Past Col Mea Ppor Dstr Ste	*gorg
Rfp	9.0-12.0	1	15-20	60-70	*Mann Ssid *Acer Dstr Aga Dlab Ppor Mea	*gorg
Rfl	12.0-15.3	4	20-30	50-60	*Mann Dlab *Mcav Mea Col Lep Aga Den Ppor Ste Dstr Past	gorg
TABLE 3.27 Drunk Bay						
SR	0-8.5	1/3	15-20	60-70	*Mil Fav Apal Acer Dstr Ppor Dlab Mann Past Ssid	*gorg *Pal spg
Bp	8.5-10.5	1	10-15	60-70	*Mcav Mann *Ssid Col Dlab Ppor Dstr Past Mdec Ste	*gorg spg
Sand	10.5	1	0	0		
Bp	10.5-9.0	1	5-10	60-70	*Mcav Col Ssid Ppor Dlab Past Mann Ste	*gorg spg
Sand	18.3	1	0	0		
Bg	18.3-	1	0	0		*Syr

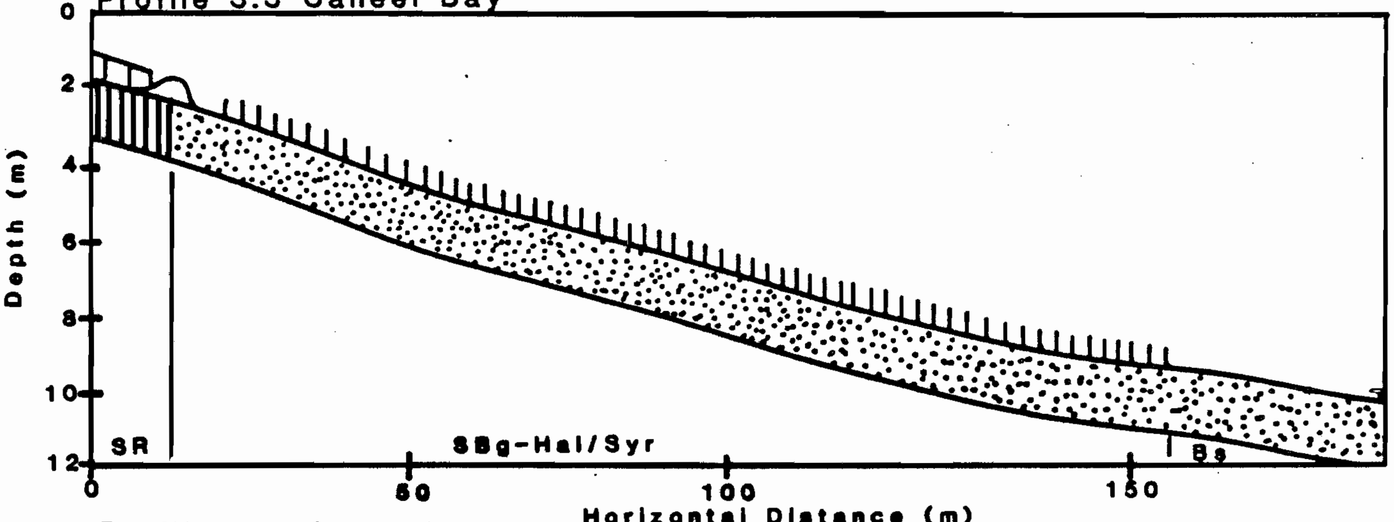
APPENDIX 2

PROFILES OF TRANSECT DATA

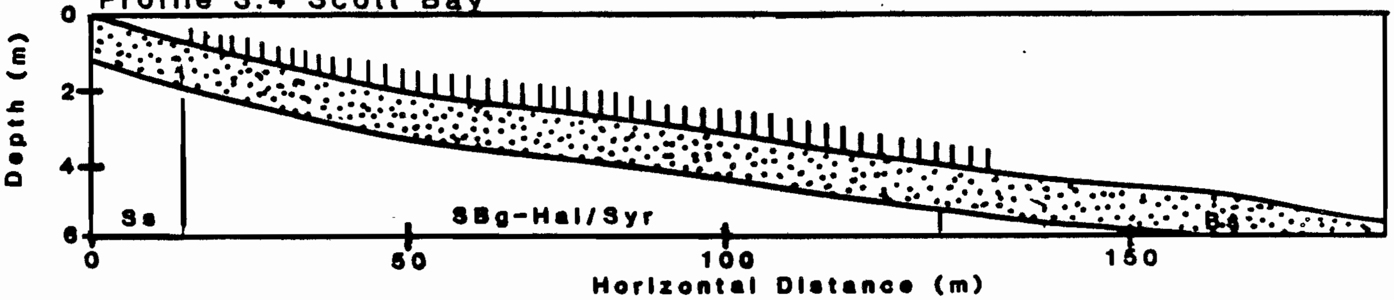
Profile 3.2 Solomon Bay

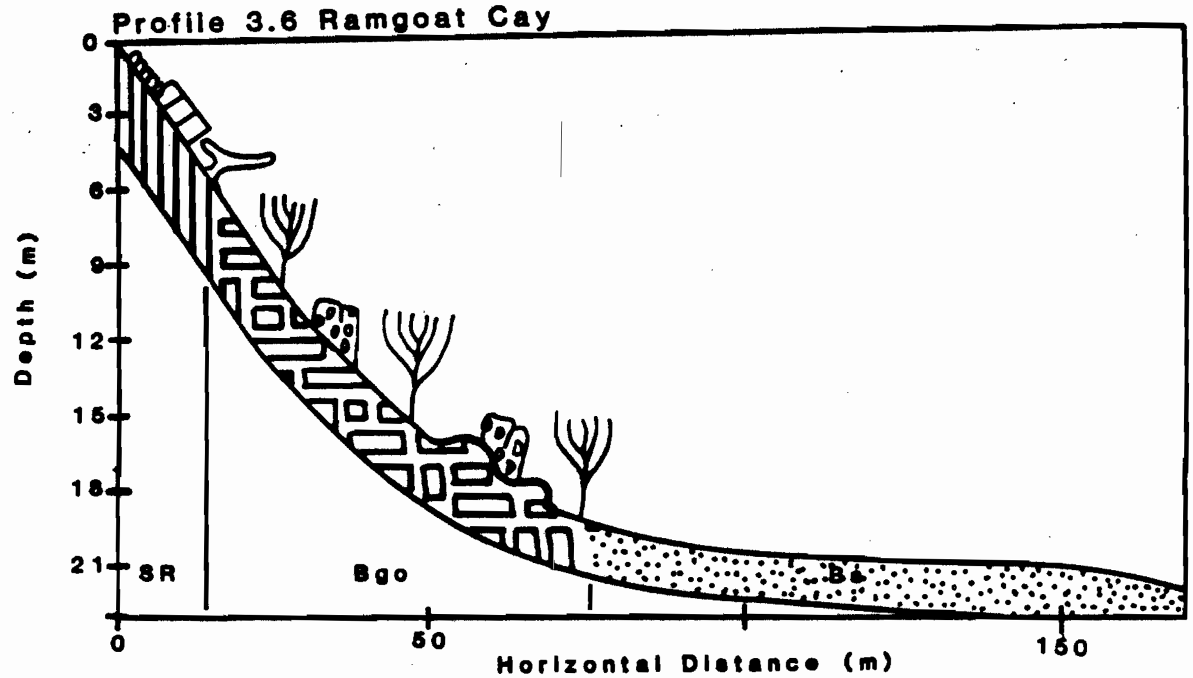


Profile 3.3 Caneel Bay

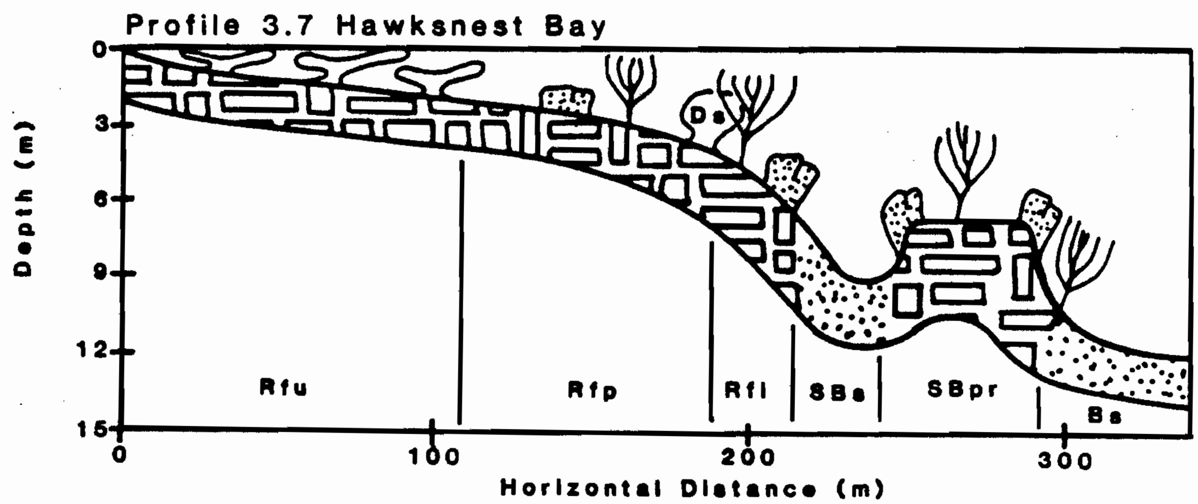


Profile 3.4 Scott Bay

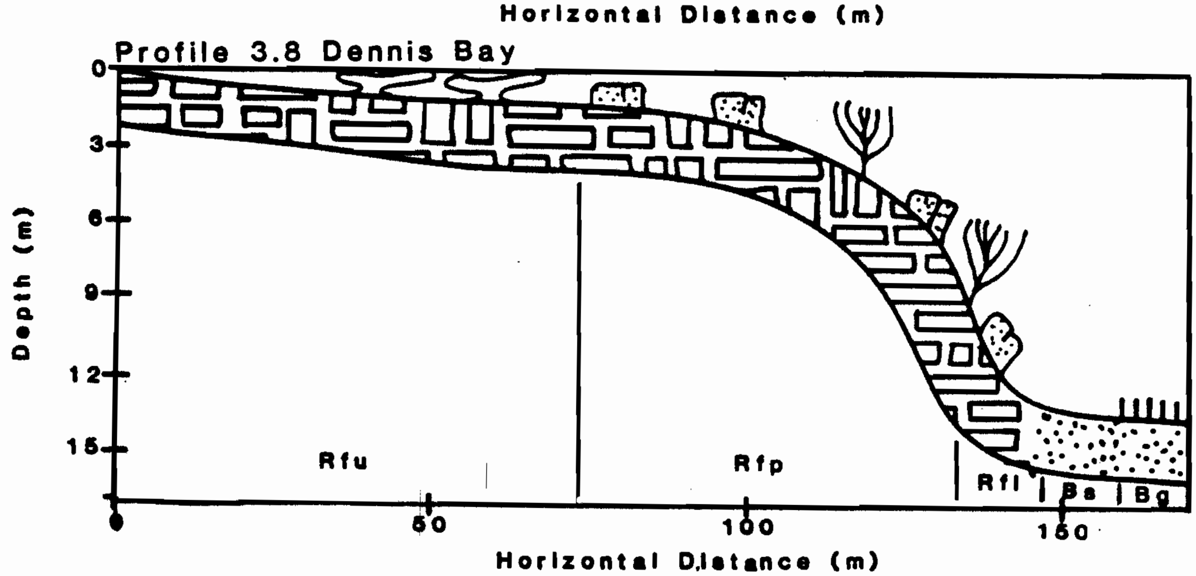




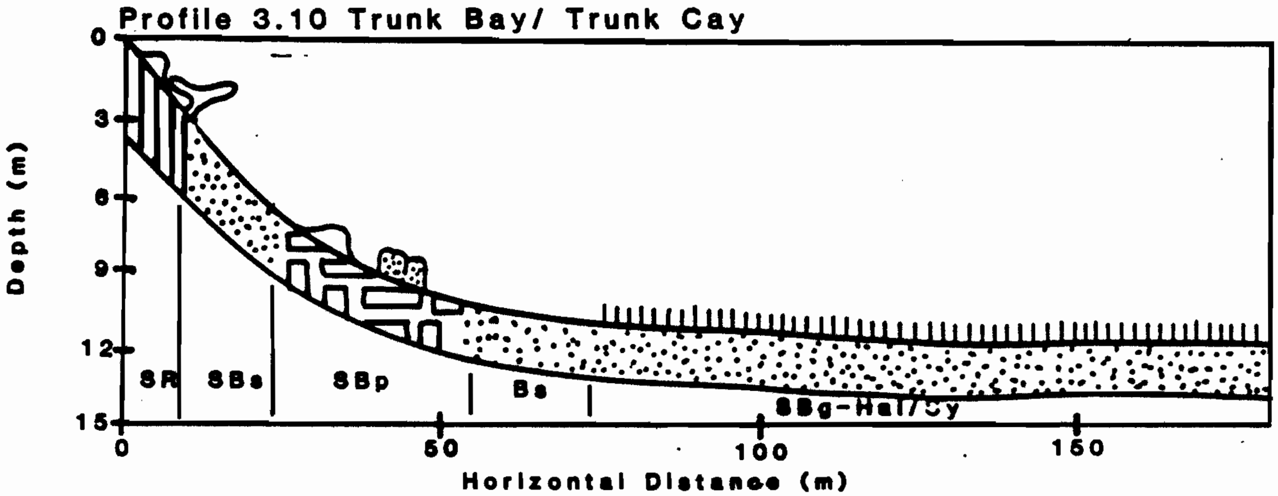
Profile 3.6 Ramgoat Cay
0
3
6
9
12
15
18
21
Depth (m)
SR
Bgo
Bs
0
50
150
Horizontal Distance (m)

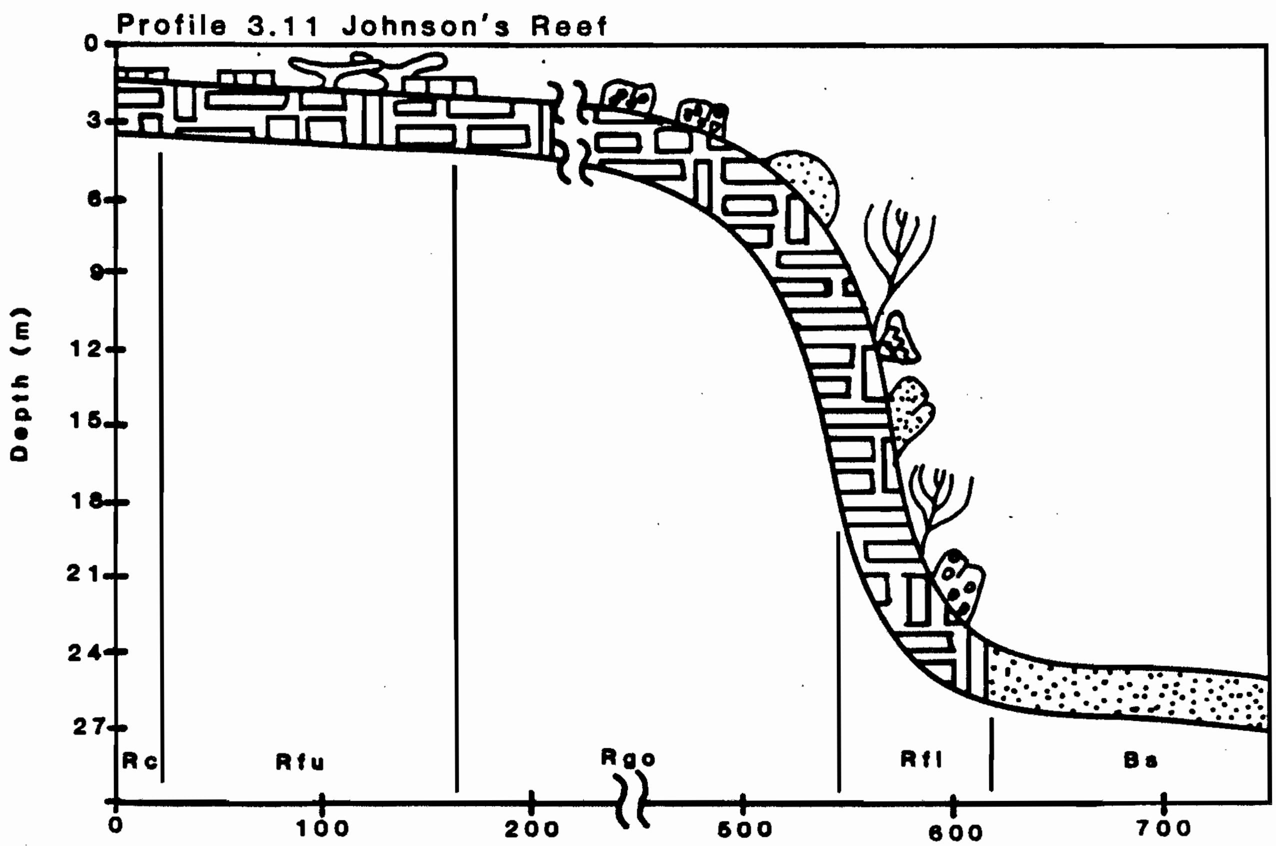


Profile 3.7 Hawksnest Bay
0
3
6
9
12
15
Depth (m)
Ds
Rfu
Rfp
Rfl
SBs
SBpr
Bs
0
100
200
300
Horizontal Distance (m)

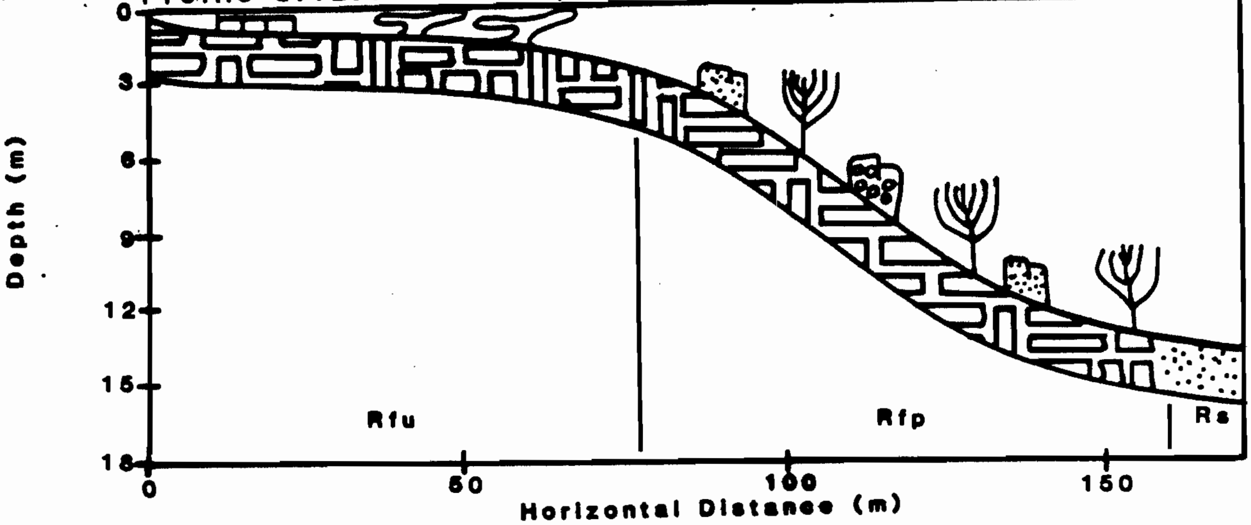


Profile 3.8 Dennis Bay
0
3
6
9
12
15
Depth (m)
Rfu
Rfp
Rfl
Bs
Bg
0
50
100
150
Horizontal Distance (m)

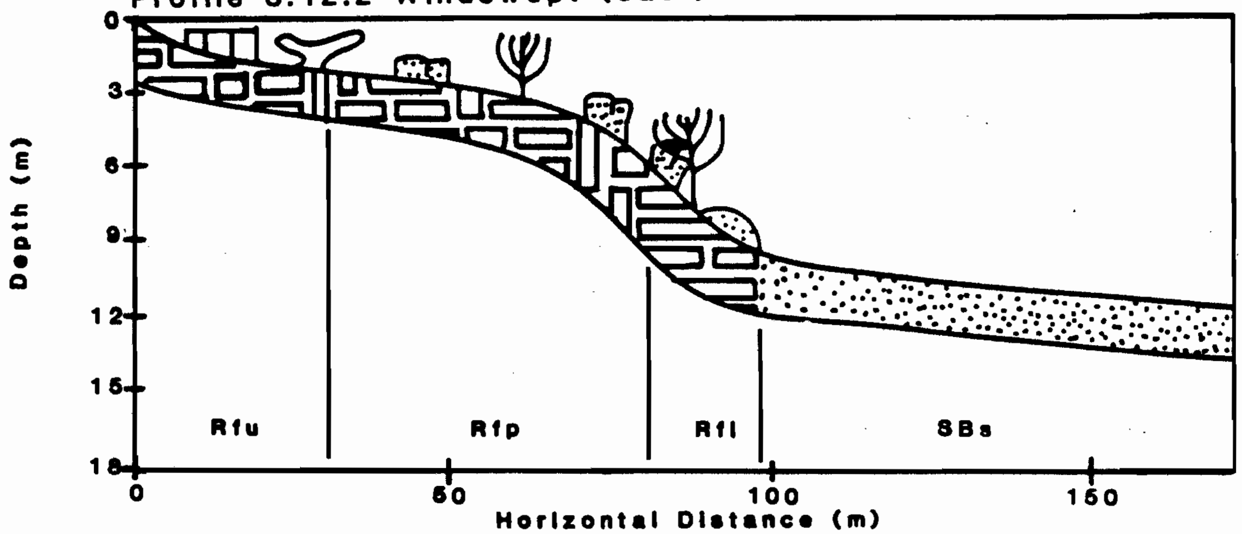

Profile 3.10 Trunk Bay/ Trunk Cay
Depth (m)
0
3
6
9
12
15
SR
SBs
SBp
Bs
SBg-Hal/Sy
0
50
100
150
Horizontal Distance (m)


Profile 3.11 Johnson's Reef
Depth (m)
0
3
6
9
12
15
18
21
24
27
Rc
Rfu
Rgo
Rfl
Bs
0
100
200
500
600
700
Horizontal Distance (m)

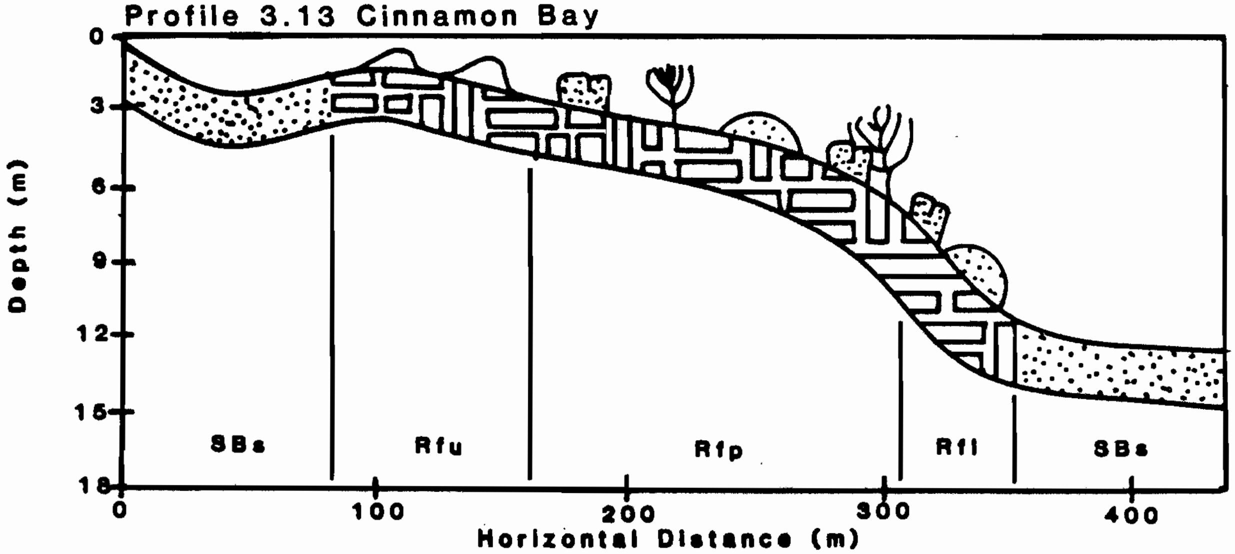
Profile 3.12.1 Windswept



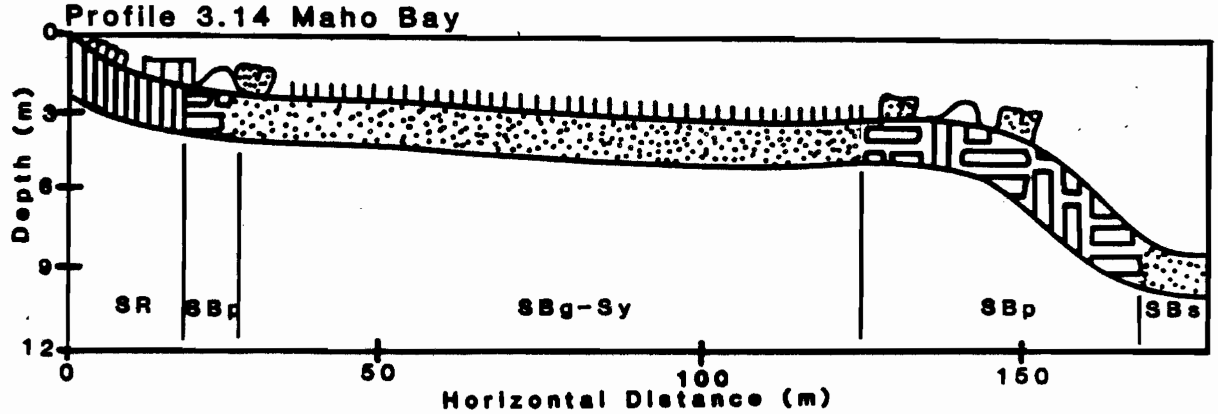
Profile 3.12.2 Windswept (east)



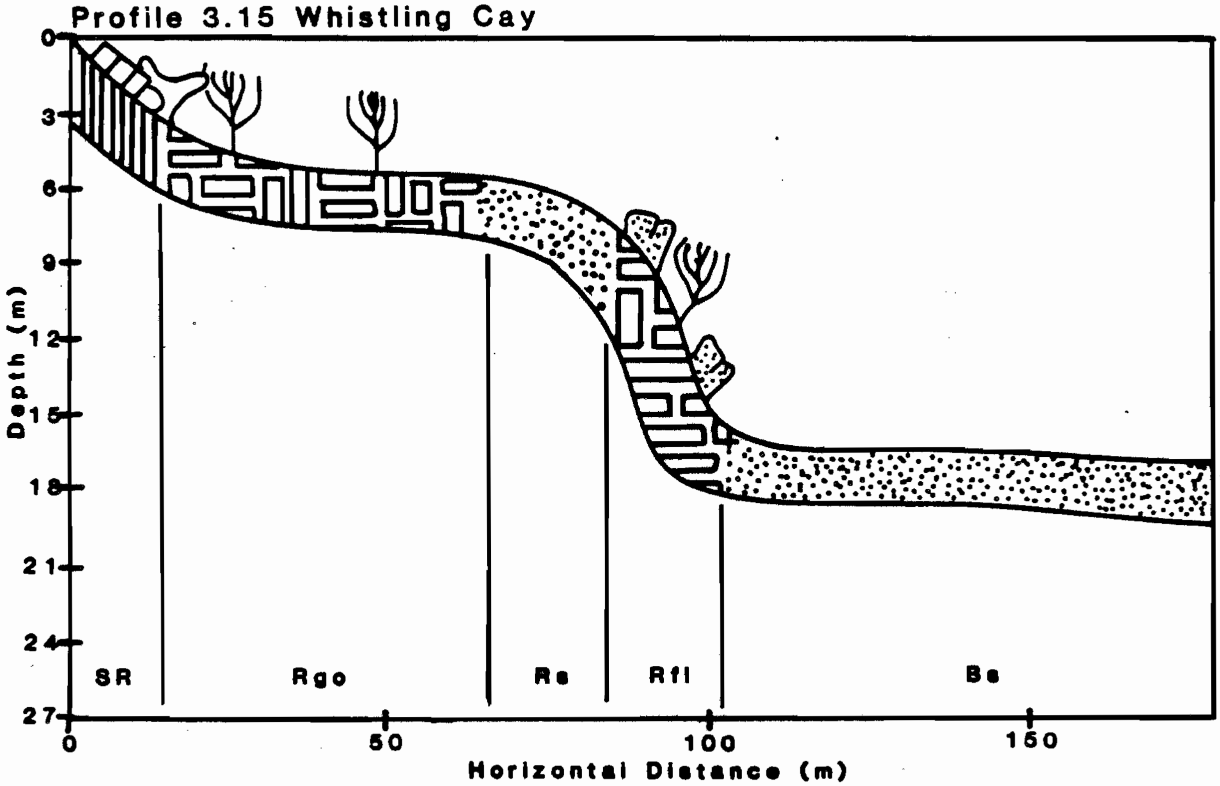
Profile 3.13 Cinnamon Bay



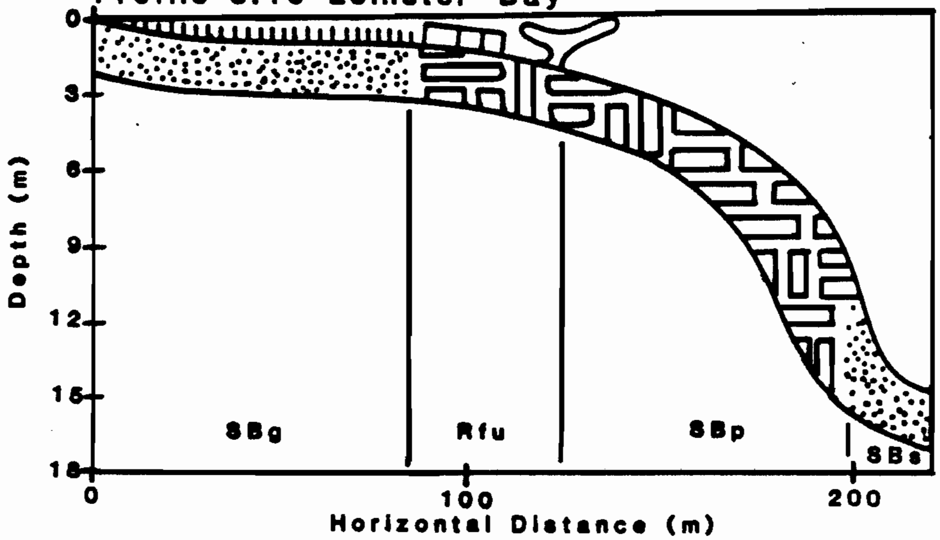
Profile 3.14 Maho Bay



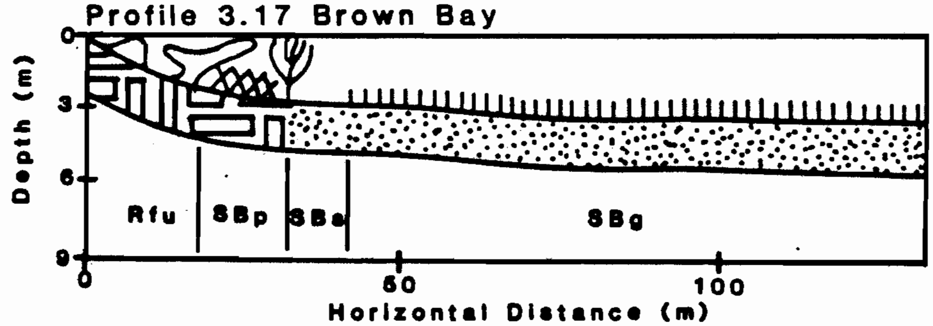
Profile 3.15 Whistling Cay



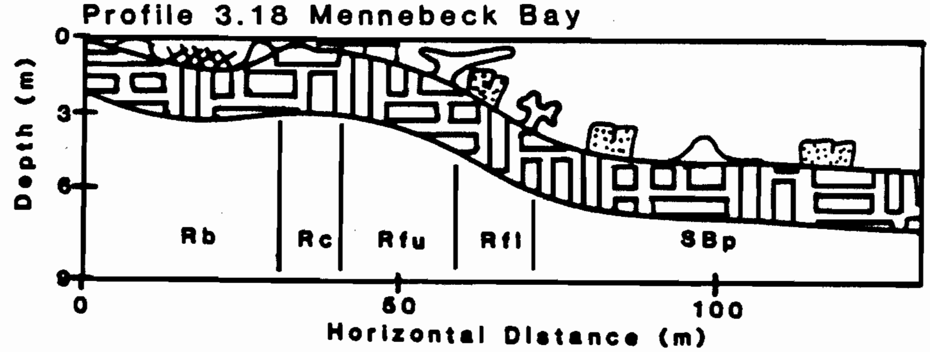
Profile 3.16 Leinster Bay



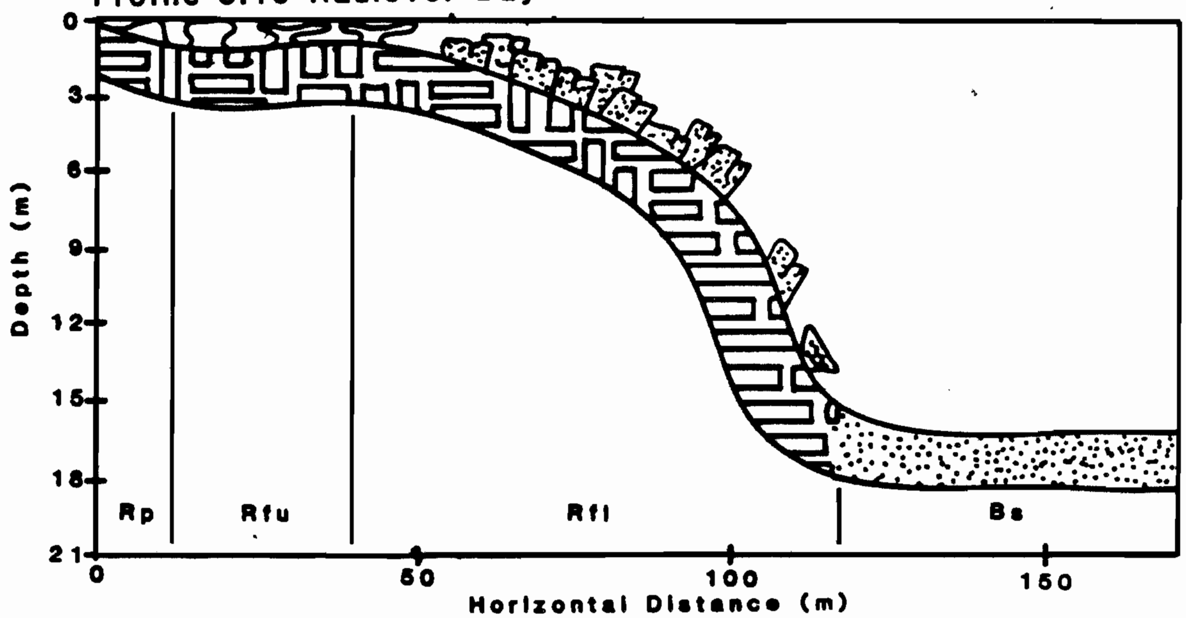
Profile 3.17 Brown Bay



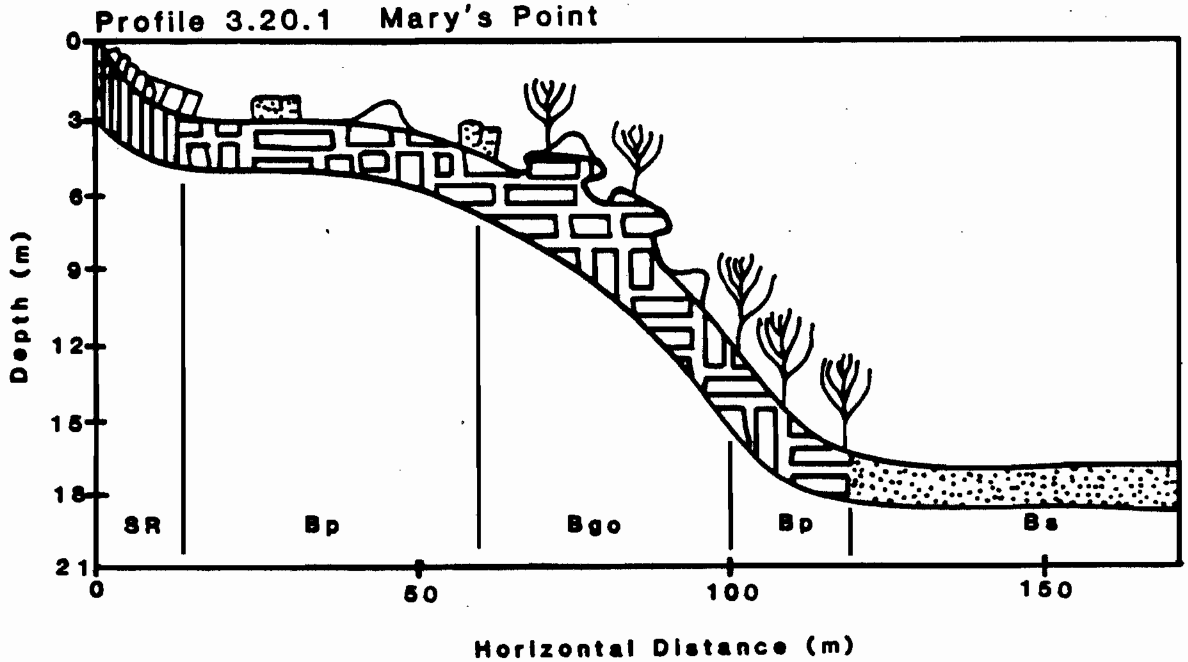
Profile 3.18 Mennebeck Bay

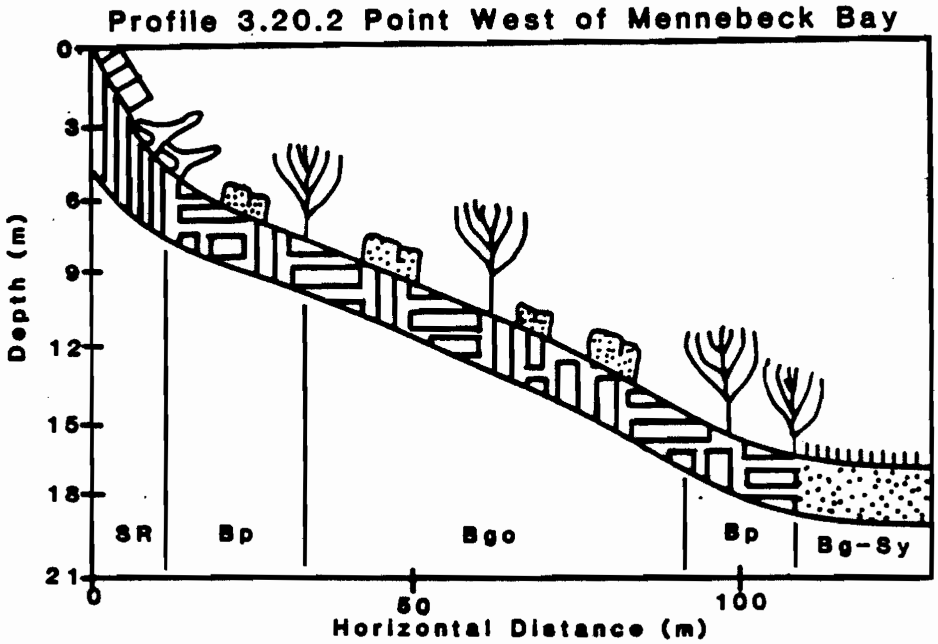


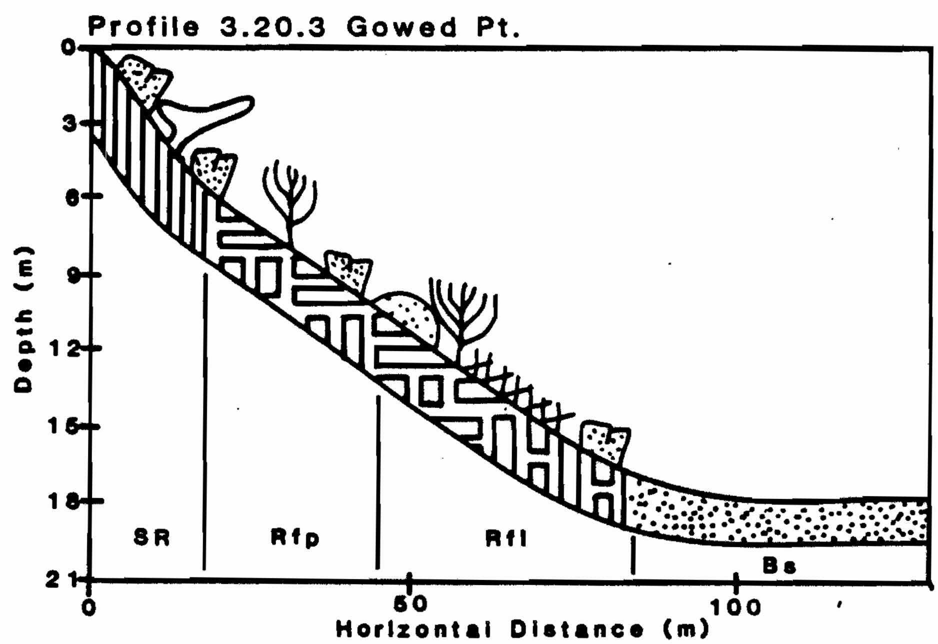
Profile 3.19 Haulover Bay



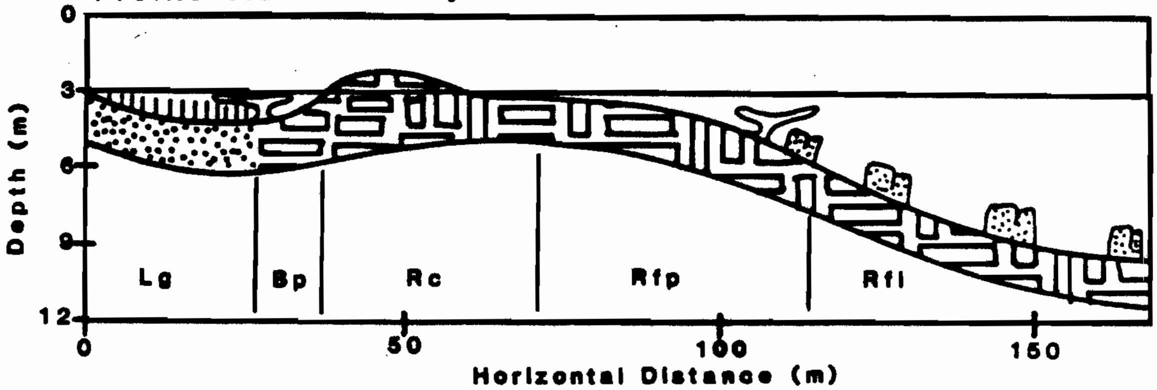
Profile 3.20.1 Mary's Point



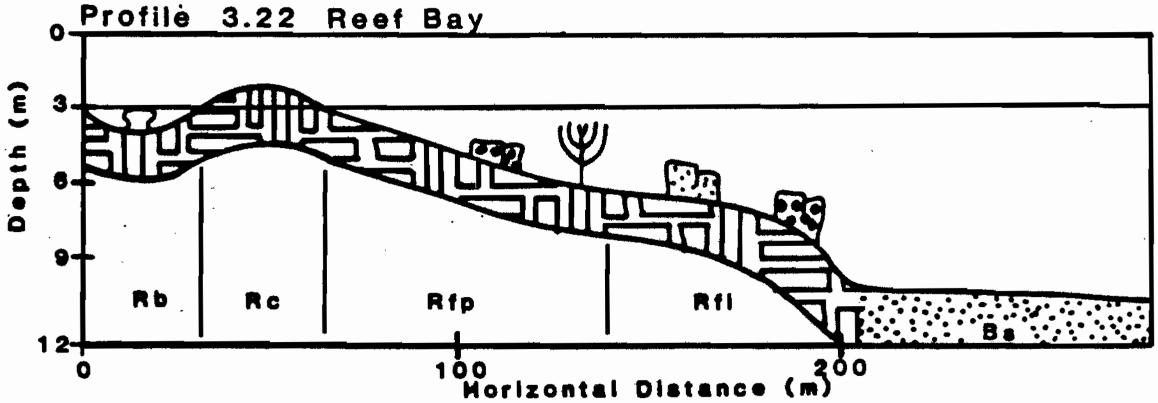

Profile 3.20.2 Point West of Mennebeck Bay
Depth (m)
0
3
6
9
12
15
18
21
SR
Bp
Bgo
Bp
Bg-Sy
0
50
100
Horizontal Distance (m)


Profile 3.20.3 Gowed Pt.
Depth (m)
0
3
6
9
12
15
18
21
SR
Rfp
Rfl
Bs
0
50
100
Horizontal Distance (m)

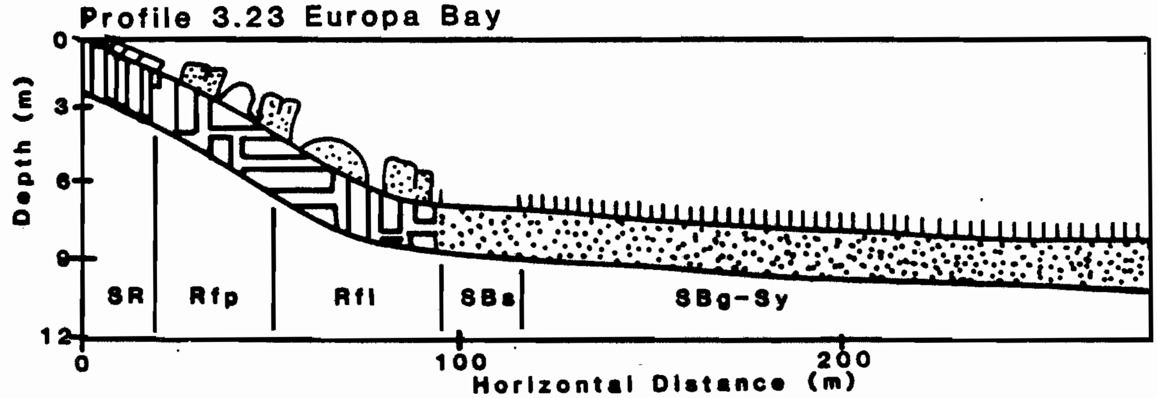
Profile 3.21 Fish Bay



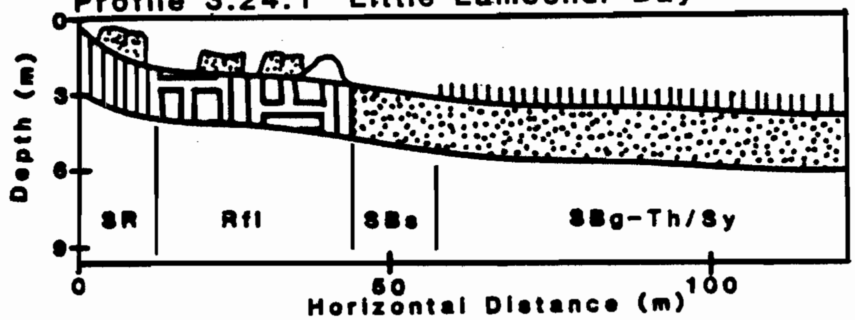
Profile 3.22 Reef Bay



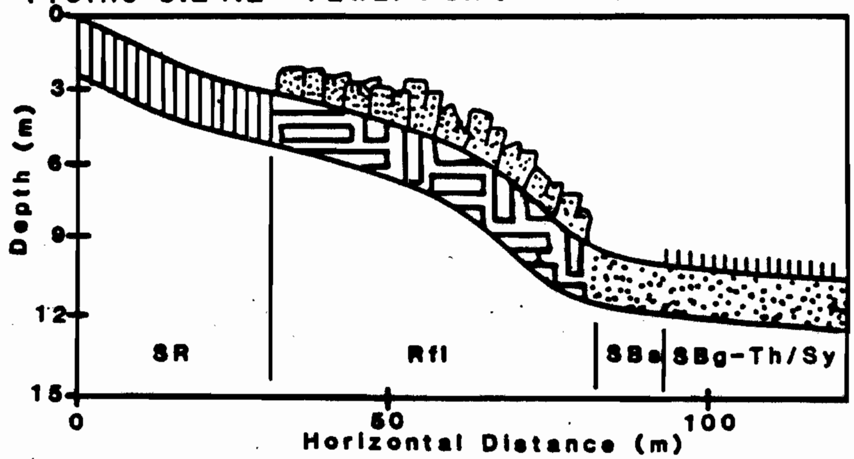
Profile 3.23 Europa Bay



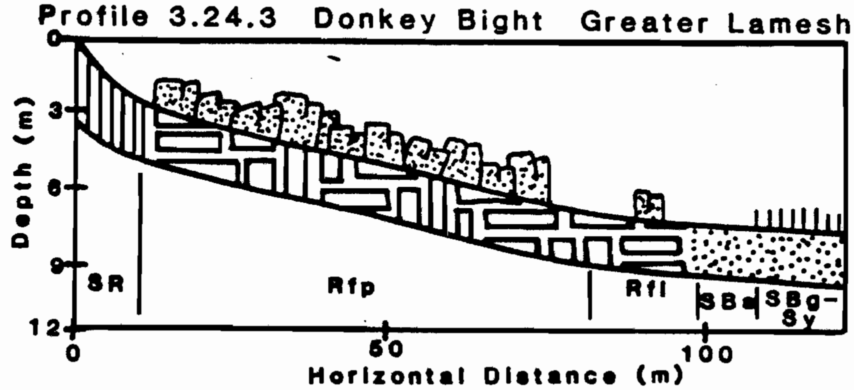
Profile 3.24.1 Little Lameshur Bay



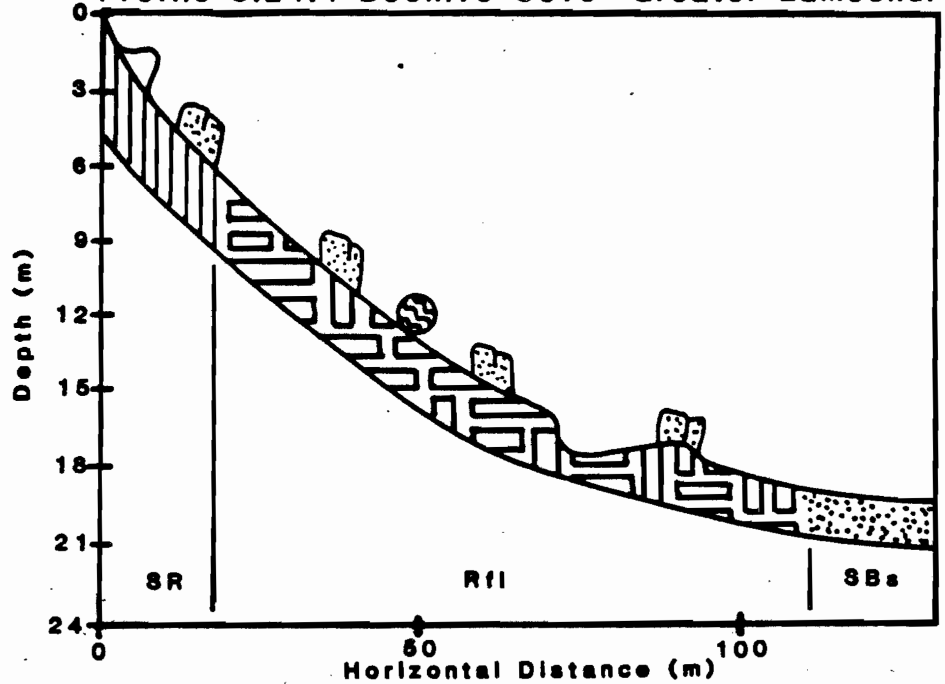
Profile 3.24.2 Yawzi Point Greater Lameshur Bay



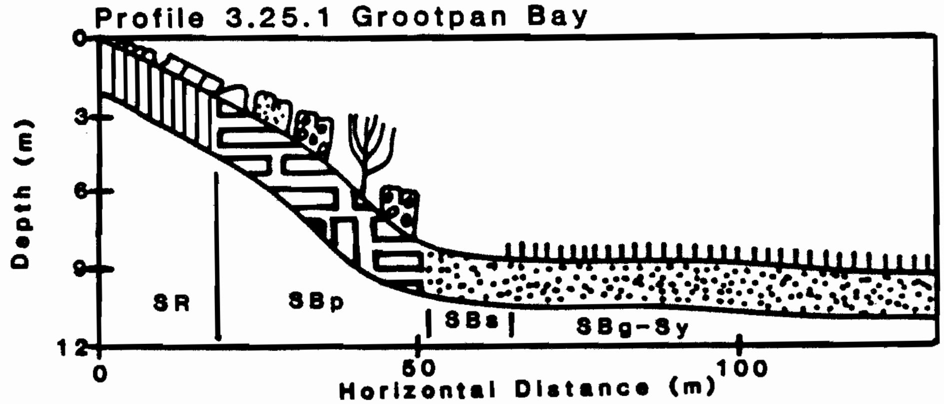
Profile 3.24.3 Donkey Bight Greater Lameshur

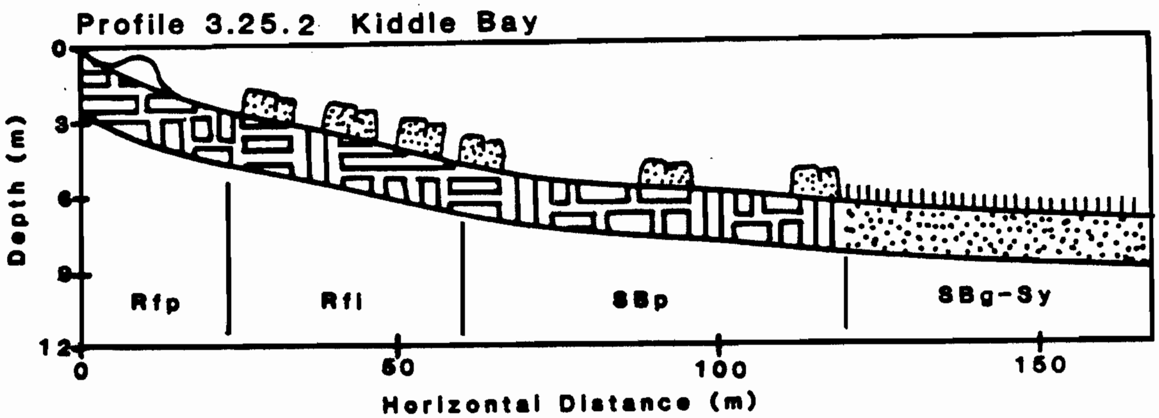


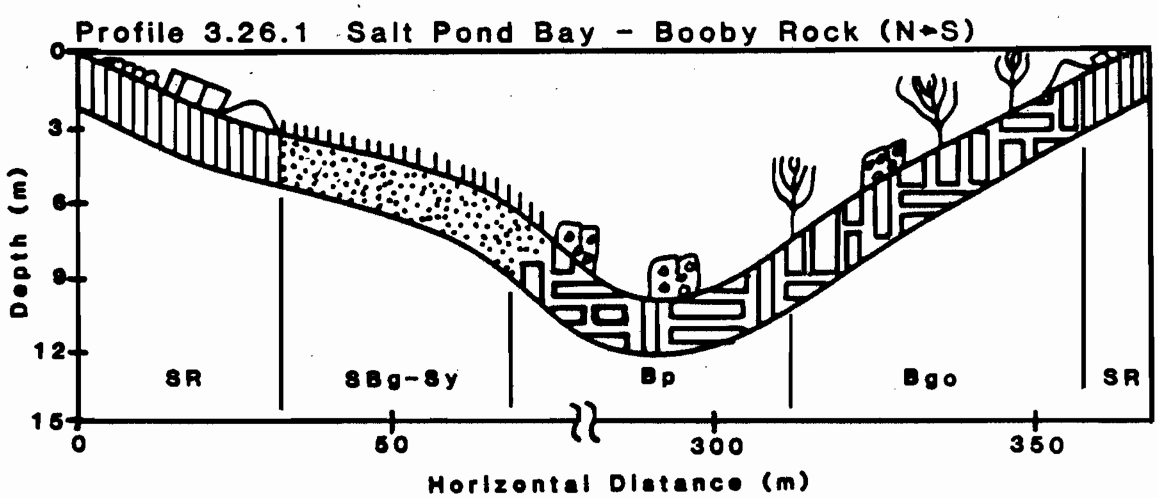
Profile 3.24.4 Beehive Cove Greater Lameshur



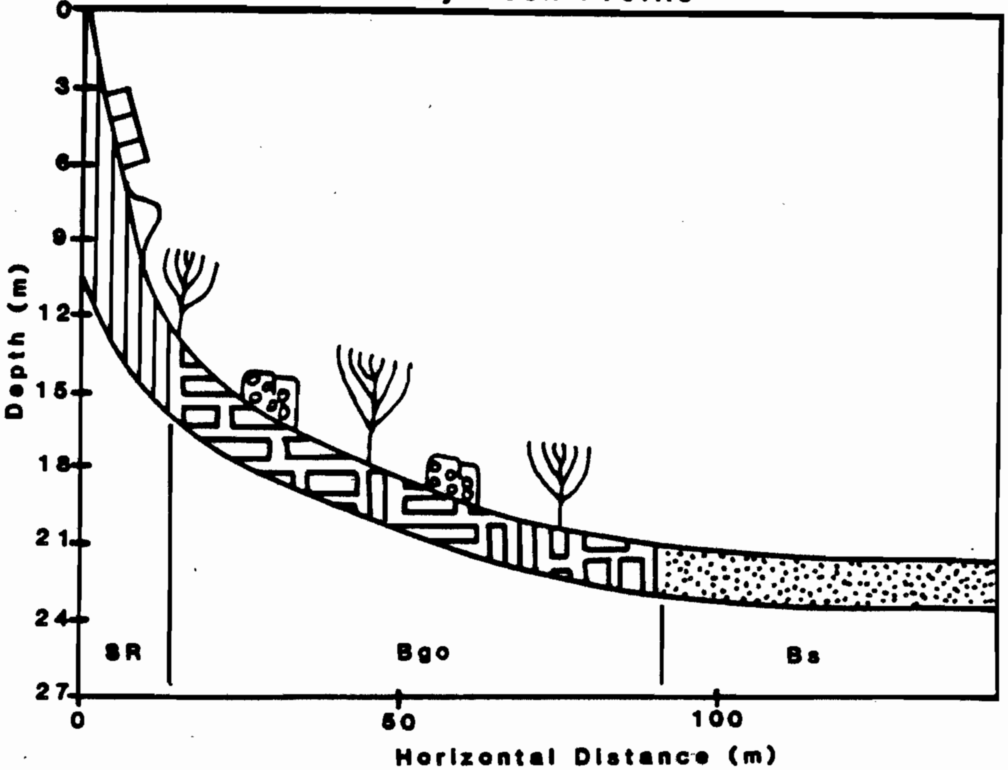
Profile 3.25.1 Grootpan Bay



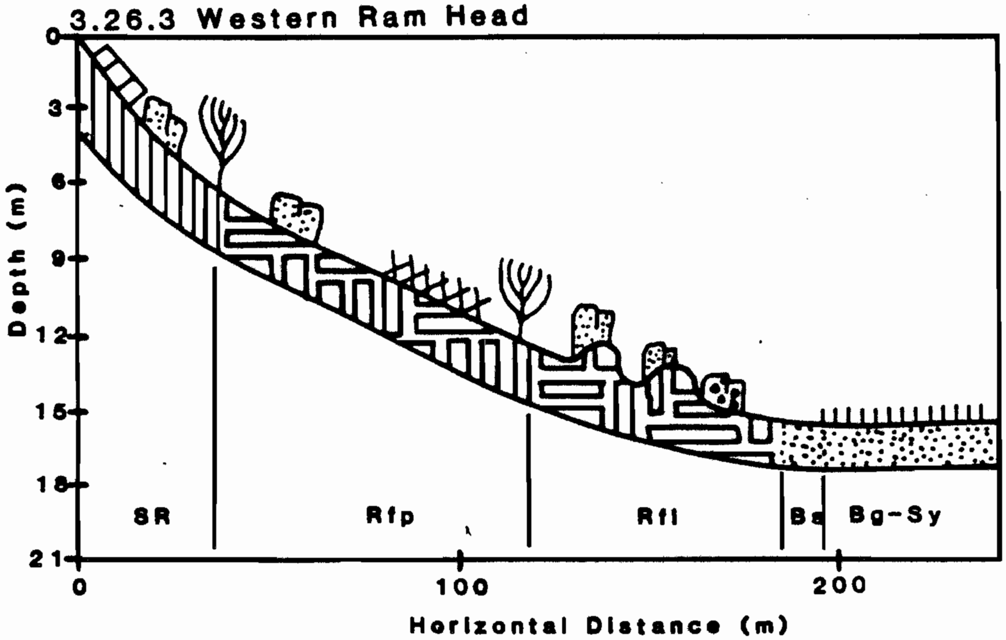

Profile 3.25.2 Kiddle Bay
Depth (m)
0
3
6
9
12
Rfp
Rfl
SBp
SBg-Sy
0
50
100
150
Horizontal Distance (m)


Profile 3.26.1 Salt Pond Bay - Booby Rock (N→S)
Depth (m)
0
3
6
9
12
15
SR
SBg-Sy
Bp
Bgo
SR
0
50
300
350
Horizontal Distance (m)

Profile 3.26.2 Booby Rock Profile



3.26.3 Western Ram Head



Profile 3.27 Drunk Bay