MAP OF FISHERY HABITATS WITHIN THE VIRGIN ISLANDS BIOSPHERE RESERVE

BIOSPHERE RESERVE

RESEARCH

REPORT NO. 8

RALF H. BOULON, JR.
DIVISION OF FISH AND WILDLIFE
DEPARTMENT OF CONSERVATION AND CULTURAL AFFAIRS
GOVERNMENT OF THE U.S. VIRGIN ISLANDS

U.S. DEPARTMENT OF THE INTERIOR
NATIONAL PARK SERVICE

AND

VIRGIN ISLANDS RESOURCE MANAGEMENT COOPERATIVE
VIRGIN ISLANDS NATIONAL PARK
P.O. BOX 7789, ST. THOMAS
U.S. VIRGIN ISLANDS 00801

LOCAL CONTRACTING AGENT
ISLAND RESOURCES FOUNDATION
RED HOOK BOX 33, ST. THOMAS
U.S. VIRGIN ISLANDS 00802
(NPS CONTRACT NO. CX-0001-3-0048)

Abstract

REPORT NO.8
Subtask 2.1

MAP OF FISHERY HABITATS WITHIN THE VIRGIN ISLANDS BIOSPHERE RESERVE

Nineteen naturally occurring and one man-made benthic community habitat types are described in terms of the commercially important fish species assemblages found occurring there. Marine habitat types were mapped for all of St. John from NOS (National Oceanographic Survey) aerial photographs and groundtruthed by divers from January to May 1984 to determine accuracy of mapping and to describe each habitat in detail. Fish species assemblages are determined using a random point, visual census technique which appears to be quite accurate, is easy, fast, and repeatable by anyone with minimal instruction.

Results indicate that each benthic habitat type can be distinctly described in terms of its unique fish species assemblage and life history function. The life history function is viewed as a continuum primarily related to distance from shore and depth with habitats like mangrove shoreline and back reefs being juvenile refuges and deeper offshore habitats like lower fore-reefs and bank patch reefs being mature fish habitats where most reproductive activities take place. Habitat types similar to each other in species assemblage generally share similar structural complexity or structural components. Habitats with greater structural complexity tend to contain a greater number of species.

In addition to demersal fin fish, lobster, conch and whelk are other heavily exploited fishery resources. Lobster populations appear to be quite low and appear to be highest in the deeper, more structurally complex habitats. Conch are less common in shallower habitats, possibly due to overfishing, but are frequently found in the deeper grassbeds seaward of coastal reef systems. With a limited, narrow habitat, which is very accessible to fishermen, whelk populations are extremely low with few large, mature individuals found.

Both migratory pelagic fish species and baitfish require substantial work before enough is known to even attempt to draft management guidelines.

TABLE OF CONTENTS

FOREWORD i

LIST OF TABLES iii

1. INTRODUCTION 1

2. METHODS 4
   2.1 Commercially Important Fish Species 4
   2.2 Habitat Types Sampled 7
   2.3 Census Technique 8

3. HABITAT DESCRIPTIONS 11
   3.1 Subtidal Bedrock - SR 11
      3.1.1 General Description 11
      3.1.2 Fishery Description 11
   3.2 Mangrove Shoreline - Sm 16
      3.2.1 General Description 16
      3.2.2 Fishery Description 16
   3.3 Shallow Bay Grass - Sbg 17
      3.3.1 General Description 17
      3.3.2 Fishery Description 22
   3.4 Shallow Bay Pavement - SBp 22
      3.4.1 General Description 22
      3.4.2 Fishery Description 23
   3.5 Back Reef - Rb 23
      3.5.1 General Description 23
      3.5.2 Fishery Description 24
   3.6 Upper Fore-reef - Rfu I 25
      3.6.1 General Description 25
      3.6.2 Fishery Description 25
   3.7 Upper Fore-reef on Subtidal Bedrock - Rfu II 26
      3.7.1 General Description 26
      3.7.2 Fishery Description 26
   3.8 Upper Fore-reef/Fore-reef Pavement Ecotone - Rfu/Rfp 27
      3.8.1 General Description 27
      3.8.2 Fishery Description 27
   3.9 Fore-reef Pavement - Rfp I 28
      3.9.1 General Description 28
      3.9.2 Fishery Description 29
   3.10 Fore-reef Pavement With Ledges - Rfp II 29
      3.10.1 General Description 30
      3.10.2 Fishery Description 30
   3.11 Lower Fore-reef - Rfl 31
      3.11.1 General Description 31
      3.11.2 Fishery Description 32
   3.12 Lower Fore-reef on Fore-reef Pavement - Rfl II 33
      3.12.1 General Description 33
      3.12.2 Fishery Description 33
   3.13 Lower Fore-reef on Subtidal Bedrock - Rfl III 34
      3.13.1 General Description 34
      3.13.2 Fishery Description 34
   3.14 Reef Gorgonian Flats - Rgo I 35
      3.14.1 General Description 35
      3.14.2 Fishery Description 35

CONTENTS (Continued)

3.15 Reef Gorgonian Flats on Ledges - Rgo II 36
3.15.1 General Description 36
3.5.2 Fishery Description 36
3.16 Shallow Bay Patch Reef - SBpr 36
3.16.1 General Description 36
3.16.2 Fishery Description 36
3.17 Bank Pavement - Bp 37
3.17.1 General Description 37
3.17.2 Fishery Description 38
3.18 Bank Gorgonian Flats - Bgo 39
3.18.1 General Description 39
3.18.2 Fishery Description 40
3.19 Bank Patch Reef - Bpr 40
3.19.1 General Description 40
3.19.2 Fishery Description 41
3.20 Shallow Bay Artificial Reef - SBar 42
3.20.1 General Description 42
3.20.2 Fishery Description 42

4. DISCUSSION 44

5. ACKNOWLEDGEMENTS 49

REFERENCES 50

APPENDIX I - Habitat Maps (No. 1 through No. 17) 53

APPENDIX II- Sample Data Sheet 70

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.

LIST OF TABLES

		PAGE
Table 1.	Fish and invertebrates of commercial importance in the Virgin Islands Biosphere Reserve.....	5
Table 2.	Habitat types censused for commercially important species of fish.....	9
Table 3.	Number of individuals per commercially important species censused within each habitat type and their percent occurrence.....	12
Table 4.	Average fish size per species per habitat type.....	18

1. INTRODUCTION

The insular shelf around St. John, U.S. Virgin Islands has representative examples of nearly every tropical marine environment from mangrove embayment to shelf edge reef. This diversity of habitats in turn supports a high diversity of fish species assemblages.

This report attempts to define the marine benthic habitats in the Virgin Islands Biosphere Reserve on the basis of their utilization by commercially important species of fish, molluscs and crustaceans. Each habitat type is described separately and characterized in terms of significant species found there and the type of utilization being made of the habitat.

It is generally accepted that marine habitat differences are due primarily to variations in substrate and that the difference in structural complexity results in differential use of these habitats by demersal fin fish species (Luckhurst and Luckhurst, 1978; Gladfelter and Gladfelter, 1978). Utilization ranges from mangrove lagoons as nursery grounds (Austin, 1971; Olsen, 1972) to offshore, deep reef reproductive or spawning grounds (Randall and Randall, 1963; Colin, 1978; Colin and Clavijo, 1978; Clavijo, 1983). Colin and Clavijo (1978) suggest that locations chosen for reproduction by reef fishes producing planktonic eggs may not be arbitrary. Rather, a selection process seems to take place where the most seaward extension of reefs may be chosen which allows the best opportunity for planktonic eggs to escape benthic egg predators and reach offshore circulation systems. The presence of a reef system provides shelter for the individuals engaged in reproductive activities.

Coastal migratory pelagic fish species are found from shallow water reefs and even mangrove embayments to oceanic conditions (Centaur, 1982). There does not appear to be any species-specific benthic habitat preferences. Specific habitat description is further complicated by the fact that the specific location of larval development is unknown and little scientific information is

available on specific migration patterns other than the hypothesis that general current patterns in the Atlantic may greatly affect the migration of pelagics. Although pelagic species are found throughout the shelf habitats, they do tend to appear more frequently and in greater abundances in the deeper water along the outer edges of these habitats.

Little is known about the population dynamics or habitat requirements of bait fish in the Caribbean. These species are very important in the marine food web. Not only do many fish species depend on them for food, but all species of seabirds depend on them for sustenance. The timing of migratory seabird arrivals may depend on coincident population peaks in the baitfish (Norton, R.L., pers. comm.).

Habitat descriptions for the queen conch, Strombus gigas, have been published for a number of locations in the Caribbean (Randall, J.E., 1964; Percharde, 1968; Berg, 1975, Hesse, 1979). Adult conchs are found from grass and mud-bottom mangrove embayments out to deep (10m +) algal plains. They are most often found in beds of seagrass (Thalassia testudinum, Syringodium filiforme, or a mixture of both), but are also commonly found on sand flats. Their occurrence on sand may be related to a need to bury themselves partially for shell deposition and for egg laying (Randall, J.E., 1964). Juvenile conchs are generally found in shallower water and in areas of less dense seagr-ass. Young conchs may be restricted in their movement in thick beds of seagrass.

The whelk or West Indian topshell, Cittarium pica, is primarily found in rocky, coastal habitats from slightly above the water level to several feet below (Randall, H.A., 1964). They appear to prefer coasts that are subject to at least some wave action. This may be due to the presence of cooler, well-oxygenated water. The smaller individuals tend to be found higher up in the habitat range of this species with larger, mature individuals being found in deeper (1-2m) subtidal bedrock or upper fore-reef zones.

The spiny lobster, Panulirus argus is found in a variety of habitats. Olsen et al. (1975) found that mature lobsters appeared to be most abundant

near reef-grassflat boundaries. Juvenile populations were found in mangrove and Thalassia habitats. In the reef habitat, lobsters are primarily found in dens where they spend the daylight hours. At night, they forage for food either on the reef or on adjacent sand-algal plains (Herrnkind, et al, 1975).

It is well known that the spiny lobster engages in periodic migrations from the normal habitats where it is found to deep water areas. Primary work on this phenomenon has been done in the Bahamas (Herrnkind and Cummings, 1964; Kanciruk and Herrnkind, 1978) although the migrations occur throught the range of the species. Reports from local divers indicate that the phenomenon may occur in the U.S. Virgin Islands (R. Nose, personal communication). To date, there is no good explanation as to the biological significance of this event.

In this report, the presence and abundance of commercially important species of fish will be used to characterize the marine benthic habitats in the Virgin Islands Biosphere Reserve. The different habitats will be described in terms of significant species found there and how the habitat is being used.

2. METHODS

2.1 Commercially Important Fish Species

Species of fish were selected for study on the basis of their importance in the local commercial fisheries. Basically, any species taken as a food fish by any means was considered. Table 1 lists the species selected for this study. They include six (6) pelagic species, forty-three (43) species of demersal fin fish, two (2) species of baitfish, two (2) species of molluscs and one (1) crustacean. For the purposes of this study, the molluscs were noted on a presence/absence basis, and the crustacean is noted as total numbers observed per habitat type. All crustacean observations were incidental as a survey for this species was of a magnitude beyond the scope of this project.

Nearly all species selected for this project are considered in the Fishery Mnanagement Plan for the Shallow-Water Reeffish Fishery of Puerto Rico and the U.S. Virgin Islands (CFMC, 1984). The species considered in the Fishery Management Plan were selected out of approximately one hundred eighty (180) which are landed and used in quantity throughout the Caribbean.

TABLE 1. Fish and invertebrates of commercial importance in the Virgin Islands Biosphere Reserve.

COMMON NAME	LATIN NAME
cero mackerel	Scomberomorus maculatus
king mackerel - kingfish/longmouth	S. cavalla
blue runner - hardnose	Caranx fusus
bar jack - carang	C. ruber
black jack	C. lugubris
greater amberjack	Seriola dumerili
DEMERSAL FIN FISH:	
queen triggerfish - ole wife	Balistes vetula
blue-striped grunt	Haemulon sciurus
white grunt	H. plumieri
french grunt	H. flavolineatum
tomate	H. aurolineatum
small-mouth grunt	H. chrysargyreum
spanish grunt	H. macrostomum
caesar grunt	H. carbonarium
sailor's choice	H. parra
juvenile grunts	H. spp.
Margate	H. album
mutton snapper - virgin snapper	Lutjanus analis
dog snapper	L. jocu
grey snapper	L. griseus
schoolmaster - mango snapper	L. apodus
yellowtail snapper	Ocyurus chrysurus
mahogany snapper - burn tail	L. mahogoni
queen & french angelfish - flatfish	Pomacanthus spp.
grey angelfish - flatfish	P. arcuatus
rock beauty	Holocanthus tricolor
red hind - hind	Epinephelus guttatus
graysby - butter socks	Petrometopon cruentatum
coney - butter fish	Cephalopholis fulva
mutton hamlet	Alphestes afer
Nassau grouper	Epinephelus striatus
black grouper	Myctoperca bonaci
tiger grouper	M. tigris
porgies	Sparidae
sea bream	Archosargus rhomboidalis
doctorfish and tang	Acanthurus spp.
yellow goatfish - queen mullet	Mulloidichthys martinicus
spotted goatfish	Pseudupeneus maculatus
spanish hogfish - spanish piper	Bodianus rufus
parrotfish - goutou	Scaridae
trunkfish - shellfish	Ostraciontadae
porkfish	Anisotremus virginicus
sea chubs	Kyphosus spp.
spadefish	Chaetodipterus faber
barracuda	Sphyraena barracuda
snook	Centropomus undecimalis
white mullet - cramo	Mugil curema

TABLE 1. (Continued) Fish and invertebrates of commercial importance in the Virgin Islands Biosphere Reserve

COMMON NAME	LATIN NAME
DEMERSAL FIN FISH:	
squirrel fish	Holocentridae
mojarra - sand diggers	Gerreidae
BAITFISH:	
blue fry - sweethead fry	Jenkinsia lamprotaenia
red ear sardine - yellow bill	Harengula humeralis
MOLLUSCS:	
queen conch	Strombus gigas
whelk	Cittarium pica
CRUSTACEANS:	
spiny lobster	Panulirus argus

2.2 Habitat Types Sampled

In collaboration with investigators on another project (Beets and Lewand, 1985) a series of maps were prepared for the marine benthic communities around St. John, U.S. Virgin Islands (Appendix I) with emphasis on those within V.I. National Park waters.

The maps were prepared by drafting directly from National Ocean Survey aerial photographs shot in March, 1983. The photographs were enlarged to 76.2 cm by 76.2cm with a scale of 1:5300. Drafting acetate was placed over the photographs on a light table, and all coastal and marine features were inked onto the acetate. These maps indicate the boundaries of all distinct benthic communities from the shoreline out to extensive offshore homogeneous habitat or the deepest discernible benthic feature on the aerial photographs.

Once all benthic communities had been established on the maps, a field sampling schedule was set up to determine the species of commercially important fish found in each type of benthic community (hereinafter referred to as habitat type). Initially, all habitat types were inspected to determine which were significant to the fishery resources within the Virgin Islands National Park boundaries. It readily became apparent that a number of habitat types (e.g., Bank sand, Bank algae and others) either had no species utilizing them or so few and in such low numbers that the value of these habitats to the fishery resources was insignificant. These habitats were not sampled. Of those that appear to be significantly utilized by the fishery resources within the National Park, twenty habitat types were selected for study (Table 2). Of these, thirteen are distinct habitat types. Four are areas made up of mixed habitat types where this mixture alters the species assemblage found in either of the two parent habitats. Two are habitat types with increased structural complexity due to the presence of ledges which alter the species assemblage found in the pure parent habitats. One is an artificial reef habitat and is included for

comparative purposes with similar natural habitats.

2.3 Census Technique

Habitats were sampled for commercially important fish species assemblages using a random point, visual census technique (Bohnsack and Bannerot, 1983). Census locations were selected on a haphazard basis within a habitat by attempting to locate oneself where only the desired habitat was present within the census radius. At each census location, the observer would begin by facing in one direction and during a five-minute period, rotate clockwise 360° , sampling all fish within an eight meter radius surrounding the observer. Due to good water clarity, we were able to use an 8m radius in all censuses made in this study. As the observer rotated, the number of individuals observed for each species was recorded on a preprinted form (Appendix II). The preprinted form saves time in writing down the species name. After using this form for a few times, the location of species' name is easily remembered. The chance of counting an individual twice was greatly reduced by strictly adhering to the 360° census with no overlap.

At the end of a sample period, the minimum and maximum length for each species was recorded. These lengths were estimates based on a pre-study test in which estimates were made of objects at various distances from the observer and then measured to determine accuracy.

Most species of fish occurred in low numbers during a census. Schools of fish were counted as they appeared in the sample radius and if large, were counted in the 10's, 100's or even 1000's.

Advantages of this method are numerous. It is simple, objective, repeatable, fast and easy to use. It is easily performed by anyone with a minimum of instruction and practice. It requires no complicated accessories such as cameras, transect lines, compasses, etc. As such, it is very applicable to developing third-world countries where technology is not available for higher-tech methods

TABLE 2.

Habitat types censused for commercially important species of fish. Acronyms used in all succeeding Tables. See text for description of habitat types. See also Beets and Lewand, 1985.

Habitat Types			* - Mixed habitat types + - Habitat types with increased structural complexity due to ledges
1.	SR	-	Subtidal Bedrock
2.	Sm	-	Mangrove Shore Zone
3.	SBg	-	Shallow Bay Grass Bed
4.	SBp	-	Shallow Bay Pavement
5.	Rb	-	Back-reef
6.	Rfu I	-	Upper Fore-reef
*7.	Rfu II	-	Upper Fore-reef on Subtidal Bedrock
*8.	Rfu/Rfp	-	Upper Fore-reef/Fore-reef Pavement Ecotone
9.	Rfp I	-	Fore-reef Pavement
+10.	Rfp II	-	Fore-reef Pavement with ledges
11.	Rfl I	-	Lower Fore-reef
*12.	Rfl II	-	Lower Fore-reef on Fore-reef Pavement
*13.	Rfl III	-	Lower Fore-reef on Subtidal Bedrock
14.	Rgo I	-	Reef Gorgonian Flats
+15.	Rgo II	-	Reef Gorgonian Flats on Ledges
16.	SBpr	-	Shallow Bay Patch Reef
17.	Bp	-	Bank Pavement
18.	Bgo	-	Bank Gorgonian Flats
19.	Bpr	-	Bank Patch Reef
20.	SBar	-	Shallow Bay Artificial Reef

requiring many accessories. It is easily performed either snorkeling or using SCUBA (for depths greater than 4m). A stationary observer has a better chance of observing more cryptic or wary species which would otherwise be scared away by a moving diver, thus biasing the data. Additionally, due to the small area actually sampled in one census, the chances of crossing habitats within a census are greatly reduced. The only requirement of this method is an underwater watch and an ability to identify fish species using external morphological or visual characteristics. This is easily accomplished after review of a good identification guide (Randall, 1968; Chaplin, 1972; Stokes, 1980).

Several other methods were reviewed but not selected for this study due to complexity or due to sample area problems. Visual census methods for assessing fish assemblages began with a transect method (Brock, 1954), but this method is time consuming as the researcher is required to lay a line of appropriate length underwater. Jones and Thompson (1978) proposed a species-time method (Rapid Visual Technique) which does not require a line. Time is used in place of area and assumes that given more time, a diver can census a greater area and is thus exposed to more species. However, this method has been recently criticized (Sanderson and Solonsky, 1980; and others) and results from it should be carefully interpreted.

Other methods of this nature such as the Visual Fast Count (Kimmel, in Press) were deemed unsuitable for the purposes of this present study as this study attempts to correlate fish assemblages with particular benthic marine habitats. As most habitats are fairly narrow in areal distribution, methods involving moving divers will easily carry the observer across discrete habitat boundaries or expose him to edge effects from adjacent habitats. Extremely hi-tech methods such as emplacement of time-lapse underwater movie cameras to record species within a particular area were not considered for practical reasons. While data from this method are excellent, the problems associated with the method make it impractical for general use (P.L. Colin, personal communication).

3. HABITAT DESCRIPTIONS

3.1 Subtidal Bedrock - SR

3.1.1 General Description

Significant portions of the coastline of St. John are fringed by this habitat. It is primarily composed of exposed, eroded bedrock which underlies the adjacent island coastlands. This zone generally ranges in depth from zero to 3 meters but in some cases may be found deeper. The rock surfaces are usually covered with an algal turf and low invertebrate cover. The most abundant invertebrates present include: Millepora spp. Palythoa caribbea, Porites asteroides, Acropora palmata, Montastrea annularis, Diploria clivosa, D. strigosa, Dendrogyra cylindrus, and Siderastrea siderea. Gorgonians and sponges are generally also present. Live coral cover in this zone generally is around five to ten percent.

3.1.2 Fishery Description

Although this habitat is found from shallow, protected bays to exposed rock points, the fish community supported by it remains relatively the same. A comparison of the extremes in location would undoubtedly show the presence of certain species which are more commonly associated with one extreme or the other (e.g., blue runner on rocky points and trunkfish in protected bays).

Twenty fish censuses in this habitat detected twenty-nine species of commercially important fish (Table 3). Of these, only four species occur frequently enough to be species of significance (most abundant in this habitat). These include yellowtail snapper, coney, doctorfish and parrot fish. Other species of potential significance (moderately abundant) include porgies, yellow goatfish and squirrelfish. Blue fry are fairly common in this habitat and attract individuals or schools of blue runner, mackerel and carang.

The average size per fish of the significant species here is smaller than in more seaward habitats (Table 4). This habitat may be transitional between the nearshore nursery habitats and the more offshore adult habitats.

Table 3. Total numbers of individuals per commercially important species censused within each habitat type and their percent occurrence (Number of censuses within that habitat type in which the species occurred/Total number of censuses within that habitat type). Total number of censuses per habitat type is listed below the habitat type acronym (see Table 2 for acronym explanations).

FISH SPECIES / Number of Censusses per Habitat Type / HABITAT TYPE	SR	Sm	SBg	SBp	Rb	Rfu I	Rfu II	Rfu/ Rfp	Rfp I	Rfp II	Rfl I	Rfl II	Rfl III	Rgo I	Rgo II	SBpr	Bp	Bgo	Bpr	SBar
	20	7	5	7	6	12	2	3	25	2	52	2	2	9	1	5	7	1	10	1
MACKEREL	5 / .15								6 / .12	1 / .50	8 / .15		2 / .50	1 / .11			1 / .14	4 / --	2 / .20	
KINGFISH				1 / .14													2 / .14		1 / .10	
BLUE RUNNER	3 / .05									1 / .02										
CARANG	62+ / .20	26+ / .29	5 / .40	8 / .71		34+ / .25	55+ / .50	5 / .67	67+ / .36		87 / .52	1 / .50	5 / .50			3 / .40	15 / .29		71+ / .70	
BLACK JACK											1 / .02									
AMBERJACK											2 / .04									
QUEEN TRIGGERFISH						1 / .08			4 / .08		5 / .08	1 / .50					8 / .57		15 / .50	1 / --
BLUE-STRIPED GRUNT	8 / .15	3 / .29		3 / .43	26+ / .33	8 / .25		6 / 1.00	9 / .12	4 / .50	47 / .31	2 / .50	1 / .50			5 / .60	13 / .57		15 / .50	
WHITE GRUNT	1 / .05	1 / .14			50+ / .17	31+ / .25					79 / .23		27 / .50				10 / .14		16 / .40	509+ / --
FRENCH GRUNT	84+ / .20	186+ / .86		1 / .14	375+ / .50	497+ / .67	503+ / 1.00	302+ / 1.00	1019+ / .40	7 / 1.00	587+ / .67	1 / .50	6 / .50	1 / .11	100+ / --	1025+ / .40	255+ / .29	2 / --	37 / .70	
TOMTATE		305+ / .71			33+ / .50	27+ / .17	100+ / .50				200+ / .02				2 / --	25+ / .20	1 / .14		75+ / .10	2000+ / --
SMALL-MOUTH GRUNT					100+ / .17			50+ / .33			25+ / .02									
SPANISH GRUNT					6 / .17		1 / .50													

Table 3. (Cont.)

HABITAT TYPE	SR	Sm	SBg	SBp	Rb	Rfu I	Rfu II	Rfu/ Rfp	Rfp I	Rfp II	Rfl I	Rfl II	Rfl III	Rgo I	Rgo II	SBpr	Bp	Bgo	Bpr	SBar
CAESAR GRUNT					31+ / .17											1 / .20				
SAILOR'S CHOICE											7 / .02								30+ / .10	
JUVENILE GRUNTS		1200+ / .29														200+ / .20				
MARGATE	2 / .05								1 / .04		2 / .04				2 / --					
MUTTON SNAPPER								1 / .33			5 / .08					1 / .20				
DOG SNAPPER		509+ / .57			5 / .17						4 / .08									
GREY SNAPPER		10 / .29						31 / .67			14 / .12						13 / .43		562+ / .30	
SCHOOLMASTER	1 / .05	20 / 1.00			209+ / .83	3 / .25		2 / .33	1 / .04	35+ / 1.00	121+ / .19	24 / .50	1 / .50				2 / .14		3 / .10	
YELLOWTAIL SNAPPER	33 / .35	58 / 1.00		5 / .43	9 / .67	28 / .67		8 / 1.00	25 / .32	7 / 1.00	162 / .71	1 / .50	30+ / .50		1 / --	7 / .20	69 / .43	1 / --	15 / .60	
MAHOGONY SNAPPER	8 / .10	249+ / .57	1 / .20		16+ / .50	50+ / .08		1 / .33		8 / .50	12 / .08					46 / .60	1 / .14		1056+ / .30	7 / --
FRENCH AND QUEEN ANGELFISH	1 / .05	1 / .14				1 / .08			2 / .08	1 / .50	12 / .13									1 / --
GREY ANGELFISH	2 / .10					2 / .17		1 / .33	13 / .20	2 / .50	35 / .40	1 / .50		3 / .33	2 / --	4 / .40	8 / .57		14 / .70	
ROCK BEAUTY									2 / .04	1 / .50										
RED HIND	3 / .10			3 / .43		1 / .08			10 / .24		24 / .44		1 / .50	10 / .33		2 / .20	2 / .29		6 / .60	1 / --
GRAYSBY	1 / .05										3 / .06									

Table 3. (Cont.)

HABITAT TYPE	SR	Sm	SBg	SBp	Rb	Rfu I	Rfu II	Rfu/ Rfp	Rfp I	Rfp II	Rfl I	Rfl II	Rfl III	Rgo I	Rgo II	SBpr	Bp	Bgo	Bpr	SBar
CONEY	10 / .30			4 / .29		3 / .17	1 / .50		4 / .16	1 / .50	13 / .17					1 / .20	8 / .57		10 / .50	1 / --
MUTTON HAMLET																				25+ / --
NASSAU GROUPER	2 / .10			2 / .29					1 / .04		5 / .10								1 / .10	
BLACK GROUPER	1 / .05								1 / .04		1 / .02		2 / .50		2 / --		1 / .14		2 / .20	
TIGER GROUPER	2 / .10										5 / .08	1 / .50			1 / --					
PORGIES	6 / .25	X		2 / .29					5 / .16		9 / .17			1 / .11		1 / .20			6 / .30	
SEA BREAM		14 / .14																		
DOCTORFISH	196 / .95	14 / .57		134 / 1.00	25 / .83	461+ / .92	126+ / 1.00	116+ / 1.00	461+ / 1.00	19 / 1.00	699+ / .96	25 / 1.00	36+ / 1.00	81 / 1.00		24 / 1.00	113+ / .86	11 / --	43 / 1.00	15 / --
YELLOW GOATFISH	38 / .25	62+ / .86		5 / .14	43+ / .67	81 / .25	2 / .50	34+ / 1.00	10 / .04	2 / .50	64 / .25	4 / .50	41+ / 1.00		9 / --	1 / .20	6 / .14	4 / --	69+ / .40	
SPOTTED GOATFISH	7 / .20	3 / .14		6 / .43		1 / .08		1 / .33	4 / .16		21 / .27		16+ / .50	2 / .22		2 / .40	2 / .29		1 / .10	
SPANISH HOGFISH	1 / .05						1 / .50			2 / .50	9 / .17						2 / .29		3 / .10	
PARROTFISH	177 / 1.00	37 / .86	2 / .20	79+ / 1.00	41 / .83	123 / 1.00	41 / 1.00	29 / 1.00	312 / 1.00	20 / 1.00	596 / 1.00	15 / 1.00	29 / 1.00	154 / 1.00	12 / --	96+ / 1.00	24 / .86	33 / --	125 / 1.00	1 / --
TRUNKFISH	3 / .15	X	5 / .60	2 / .29	1 / .17	3 / .25			2 / .08		7 / .10					2 / .20	1 / .14		1 / .10	
PORKFISH								2 / .33			2 / .04						2 / .14			
SEA CHUBS								14 / .67	12 / .12	2 / .50	6 / .04					1 / .20	8 / .14			

Table 3. (Cont.)

HABITAT TYPE	SR	Sm	SBg	SBp	Rb	Rfu I	Rfu II	Rfu/ Rfp	Rfp I	Rfp II	Rfl I	Rfl II	Rfl III	Rgo I	RgoII	SBpr	Bp	Bgo	Bpr	SBar
SPADEFISH											19 / .02						5 / .14			
BARRACUDA	2 / .10	1 / .14	1 / .20			2 / .17		1 / .33	2 / .08		5 / .08					1 / .20			2 / .20	1 / --
SNOOK		2 / .14																		
MULLET					6 / .17															
SQUIRRELFISH	10 / .25	1 / .14		4 / .57	9 / .50	24 / .33	1 / .50		7 / .20	7 / 1.00	186 / .67	3 / 1.00		1 / .11			8 / .43	1 / --	16 / .70	100+ / --
MOJARRA	4 / .15	30+ / .57		4 / .29	1 / .17	5 / .17		9 / .33	2 / .04		8 / .06	3 / .50							1 / .10	
BLUE FRY	-- / .25	-- / .71		-- / .43	-- / .17	-- / .33			-- / .12											
RED-EARED SARDINE		15+ / .14																		
CONCH		X	X																	
WHELK	X					X			X											
LOBSTER		1 / --							5 / --	1 / --	32+ / --				2 / --		15 / --		2 / --	
TOTAL NUMBER SPECIES OF FISH	29	25	5	17	19	22	10	18	26	16	40	13	13	9	9	20	26	7	28	12

NOTES:

1. A dash above the slanted line indicates that the individuals were too numerous to count.
2. A dash below the slanted line indicates that either the individuals were not seen during a census but noted for interest (i.e., lobsters) or percent occurrence is meaningless because only one census was made (e.g., Bgo).
3. An X indicates that the species was noted in a species list for the habitat type but not during a census.

The West Indian topshell or whelk (Cittarium pica was observed occasionally in this habitat. Individuals observed here were generally larger (greater than 10cm) than those observed in the intertidal zone.

3.2 Mangrove Shoreline - Sm

3.2.1 General Description

This habitat type occurs in several of the deeper, more protected embayments around St. John. These include Fish Bay, Great Lameshur, Coral Bay, Hurricane Hole and Mary's Creek. Small stands of mangroves also occur in Haulover Bay, Little Lameshur and Brown Bay. This habitat generally represents an area of low energy where wave action is baffled by the prop roots of Rhizophora mangle. These prop roots serve as substrate for communities of encrusting organisms such as sponges, tunicates, tree oysters and algae. The bottom under and near these prop roots is usually sand or mud with leaf litter on the top, but may also include some sub-tidal bedrock. The complexity produced by the prop roots additionally provides shelter from predators for juvenile fish.

3.2.2 Fishery Description

The very protected, low energy nature of this habitat makes it ideal as a nursery habitat for many species of commercially important fish. Seven censuses and three species list compilations produced a list of twenty-five species of commercially important fish (Table 3). Many of these were very abundant and can thus be considered species for which this habitat is significant as a nursery or juvenile development area. These include french grunt, tomtate, dog snapper, schoolmaster, yellowtail snapper, mahogany snapper, doctorfish, yellow goatfish, parrotfish and mojarra. The presence of many blue fry, generally of quite small size (1cm) indicates that this is an important habitat for them as well. The large numbers

of unidentifiable juvenile grunt supports the nursery habitat hypothesis.

The average size of fish per species in this habitat gives the greatest evidence for the theory that the mangrove habitat is a nursery habitat. Except for species unique to this habitat, all species present had an average size less than the average size per species for all habitats (Table 4).

Several species were observed here that were not observed in any of the other habitats. These include sea bream, snook and red-eared sardine. These species undoubtedly exist in other habitats but were not observed during a census. Juvenile conch (Strombus gigas) were also observed in this habitat in Hurricane Hole. One young lobster with a carapace length of less than 3 inches was observed.

3.3 Shallow Bay Grass - SBg

3.3.1 General Description

Many of the shallow bays around St. John have sand bottoms which are colonized by communities of sea grass. In general the communities consist of mixed stands of Thalassia testudinum and Syringodium filiforme with occasional patches of Halodule wrightii. Many species of algae may also be present including Halimeda spp., Penicillusspp., and others. The low structural complexity provides little shelter for fish. The infaunal and epifaunal communities present (molluscs, echinoderms) provide a food resource for several species of fish. It is not uncommon to see large eagle and other rays foraging on the bottom of these grass beds often accompanied by one or more trunkfish picking through the detritus for smaller food items missed by the ray. These grass beds have also been shown to be important in the nocturnal foraging of many species found on the reefs during the day (eg. grunts and snappers forage for food in the grassbeds at night (Hobson, 1973)).

TABLE 4.

Average fish size per species per habitat type. Number below the diagonal slash indicates number of fish used to estimate average size. Number of censuses used in estimate indicated below habitat type acronym. Total average size = Σ average size per habitat divided by number of habitats in which species occurred. All lengths in centimeters. See Table 2 for acronym explanations.

NUMBER OF CENSUSSES PER HABITAT TYPE / FISH SPECIES HABITAT TYPE	SR	Sm	SBg	SBp	Rb	Rfu I	Rfu II	Rfu/ Rfp	Rfp I	Rfp II	Rfl I	Rfl II	Rfl III	Rgo I	Rgo II	SBpr	Bp	Bgo	Bpr	SBar	AVERAGE SIZE TOTAL
	19	7	5	7	6	12	2	3	25	2	52	2	2	9	1	2 *	7	1	10	1	
MACKEREL	45.7 / 5								39.7 / 6	30.4 / 1	36.8 / 8		35.5 / 2	40.6 / 1			35.5 / 1	40.6 / 4	40.6 / 2		38.1
KINGFISH				76.2 / 1													60.9 / 2		106.6 / 1		81.2
BLUE RUNNER	30.4 / 3										25.4 / 1										27.9
CARANG	34.1 / 62	27.9 / 26	20.3 / 5	21.9 / 8		21.5 / 34	25.4 / 55	22.8 / 5	22.8 / 67		24.1 / 87	15.2 / 1	22.8 / 5			20.3 / 1	24.1 / 15		19.0 / 71		22.8
BLACK JACK											25.4 / 1										25.4
AMBERJACK											53.3 / 2										53.3
QUEEN TRIGGERFISH						25.4 / 1			31.7 / 4		35.5 / 5	30.4 / 1					31.7 / 8		31.7 / 15	20.3 / 1	27.9
BLUE-STRIPED GRUNT	20.3 / 8	12.7 / 3		16.5 / 3	20.3 / 26	16.5 / 8		20.3 / 6	17.7 / 9	17.7 / 4	17.7 / 47	16.5 / 11	12.7 / 1				21.5 / 13		16.5 / 15		17.7
WHITE GRUNT	15.2 / 1	10.1 / 1			15.2 / 50	12.7 / 31					13.9 / 79		12.7 / 27				25.4 / 10		19.0 / 16	7.6 / 50	15.2
FRENCH GRUNT	12.7 / 84	7.6 / 186		12.7 / 1	12.7 / 375	7.6 / 497	7.6 / 503	11.4 / 302	5.0 / 1019	15.2 / 7	12.7 / 587	12.7 / 1	11.4 / 6	12.7 / 1	12.7 / 100	6.3 / 1025	17.7 / 255	12.7 / 2	12.7 / 37		11.4
TOMTATE		6.3 / 305			11.4 / 33	13.9 / 27	6.3 / 100				13.9 / 200				15.2 / 2	8.8 / 25	12.7 / 1		12.7 / 75	3.8 / 20	101.6
SMALL-MOUTH GRUNT					10.1 / 100			11.4 / 50			12.7 / 25										11.4
SPANISH GRUNT					16.5 / 6		12.7 / 1														13.9

Table 4. (Cont.)

HABITAT TYPE	SR	Sm	SBg	SBp	Rb	Rfu I	Rfu II	Rfu/ Rfp	Rfp I	Rfp II	Rfl I	Rfl II	Rfl III	Rgo I	Rgo II	SBpr	Bp	Bgo	Bpr	SBar	
CAESAR GRUNT					12.7 / 31																12.7
SAILOR'S CHOICE											15.2 / 7								22.8 / 30		19.0
JUVENILE GRUNTS		3.8 / 1200														3.8 / 200					3.8
MARGATE	12.7 / 2								40.6 / 1		25.4 / 2				25.4 / 2						25.4
MUTTON SNAPPER								76.2 / 1			36.8 / 5										55.8
DOG SNAPPER		5.0 / 509			17.7 / 5						38.1 / 4										20.3
GREY SNAPPER		20.3 / 10						38.1 / 31			25.4 / 14						29.5 / 13		17.7 / 562		26.6
SCHOOLMASTER	15.2 / 1	12.7 / 20			15.2 / 209	22.8 / 3		22.8 / 2	20.3 / 1	20.3 / 35	20.3 / 121	17.7 / 24	15.2 / 1				20.3 / 2		20.3 / 3		19.0
YELLOWTAIL	10.1 / 33	8.8 / 58		15.2 / 5	15.2 / 9	16.5 / 28		22.8 / 8	20.3 / 25	21.5 / 7	17.7 / 162	17.7 / 1	17.7 / 30		12.7 / 1		27.9 / 69	20.3 / 1	22.8 / 15		17.7
MAHOGANY SNAPPER	8.8 / 8	6.3 / 249	7.6 / 1		12.7 / 16	16.5 / 50		20.3 / 1		25.4 / 8	16.5 / 12					8.8 / 5	20.3 / 1		20.3 / 1056	12.7 / 7	15.2
FRENCH & QUEEN ANGELFISH	25.4 / 1	10.1 / 1				5.0 / 1			25.4 / 2	27.9 / 1	25.4 / 12									20.3 / 1	20.3
GREY ANGELFISH	30.4 / 2					25.4 / 2		30.4 / 1	24.1 / 13	27.9 / 2	24.1 / 35	12.7 / 1		21.5 / 3	25.4 / 2		26.6 / 8		27.9 / 14		27.9
ROCK BEAUTY									17.7 / 2	12.7 / 1											15.2
RED HIND	17.7 / 3			17.1 / 3		12.7 / 1			16.5 / 10		17.7 / 24		20.3 / 1	15.2 / 10			17.7 / 2		19.0 / 6	25.4 / 1	17.7
GRAYSBY	17.7 / 1										21.5 / 3										19.0

Table 4. (Cont.)

HABITAT TYPE	SR	Sm	SBg	SBp	Rb	Rfu I	Rfu II	Rfu/ Rfp	Rfp I	Rfp II	Rfl I	Rfl II	Rfl III	Rgo I	Rgo II	SBpr	Bp	Bgo	Bpr	SBar	
CONEY	16.5 / 10			21.5 / 4		15.2 / 3	20.3 / 1		16.5 / 4	20.3 / 1	20.3 / 13						19.9 / 8		19.0 / 10	20.3 / 1	19.0
MUTTON HAMLET																				17.7 / 25	17.7
NASSAU GROUPER	29.2 / 2			25.4 / 2					30.4 / 1		35.5 / 5								35.5 / 1		31.7
BLACK GROUPER	20.3 / 1								30.4 / 1		35.5 / 1		38.1 / 2		30.4 / 2		25.4 / 1		22.8 / 2		29.2
TIGER GROUPER	45.7 / 2										22.8 / 5	25.4 / 1			30.4 / 1						30.4
PORGIES	17.7 / 6			12.7 / 2					19.0 / 5		22.8 / 9			15.2 / 1					20.3 / 6		17.7
SEA BREAM		7.6 / 14																			7.6
DOCTOR FISH	10.1 / 196	5.0 / 14		10.1 / 134	8.8 / 25	11.4 / 461	12.7 / 126	12.7 / 116	11.4 / 461	15.2 / 19	12.7 / 699	13.9 / 25	12.7 / 36	10.1 / 81		3.8 / 2	17.7 / 113	10.1 / 11	13.9 / 43	11.4 / 15	11.4
YELLOW GOATFISH	15.2 / 38	10.1 / 62		15.2 / 5	17.7 / 43	15.2 / 2	25.4 / 2	15.2 / 34	17.7 / 10	25.4 / 2	19.0 / 64	20.3 / 4	15.2 / 41		17.7 / 9	8.8 / 5	17.7 / 6	16.5 / 4	16.5 / 69		16.5
SPOTTED GOATFISH	8.8 / 7	8.8 / 3		16.5 / 6		15.2 / 1		10.1 / 1	13.9 / 4		15.2 / 21		20.3 / 16	13.9 / 2		7.6 / 1	11.4 / 2		20.3 / 1		13.7
SPANISH HOGFISH	15.2 / 1						25.4 / 1			22.8 / 2	22.8 / 9						20.3 / 2		16.5 / 3		20.3
PARROTFISH	12.7 / 177	7.6 / 37	5.0 / 2	8.8 / 79	8.8 / 41	16.5 / 123	20.3 / 41	20.3 / 29	13.9 / 312	12.7 / 20	13.9 / 596	19.0 / 15	12.7 / 29	13.9 / 154	16.5 / 12	7.6 / 1	17.7 / 24	16.5 / 33	13.9 / 125	10.1 / 1	13.7
TRUNKFISH	12.7 / 3		20.3 / 5	16.1 / 2	30.4 / 1	12.7 / 3			16.1 / 2		19.0 / 7						20.3 / 1		12.7 / 1		17.7
PORKFISH								16.5 / 2			17.7 / 2						20.3 / 2				17.7
SEA CHUBS								24.1 / 14	19.0 / 12	27.9 / 2	29.2 / 6						27.9 / 8				25.4

Table 4. (Cont.)

HABITAT TYPE	SR	Sm	SBg	SBp	Rb	Rfu I	Rfu II	Rfu/ Rfp	Rfp I	Rfp II	Rfl I	Rfl II	Rfl III	Rgo I	Rgo II	SBpr	Bp	Bgo	Bpr	SBar	
SPADEFISH											27.9 / 19						17.7 / 5				22.8
BARRACUDA	53.5 / 2	7.6 / 1	91.4 / 1			83.8 / 2		121.9 / 1	68.5 / 2		100.3 / 5								83.8 / 5	76.2 / 1	76.2
SNOOK		30.4 / 2																			30.4
MULLET					25.4 / 6																25.4
SQUIRRELFISH	13.9 / 10	10.1 / 1		13.9 / 4	12.7 / 9	15.2 / 24	12.7 / 1		15.2 / 7	15.2 / 7	15.2 / 186	16.5 / 3		12.7 / 1			15.2 / 8	15.2 / 1	15.2 / 16	15.2 / 100	13.7
MOJARRA	21.5 / 4	5.0 / 30		21.5 / 4	20.3 / 1	25.4 / 5		30.9 / 9	20.3 / 2		20.3 / 8	22.8 / 8							10.1 / 1		20.3
BLUE FRY																					
RED-EARED SARDINE		10.1 / 15																			10.1
CONCH																					
LOBSTER																					

NOTES

* - Only two of the five censusses made in SBpr had length estimates made for individuals by species.

3.3.2 Fishery Description

Five censuses in this habitat type revealed the paucity of fish present during the day (Table 3). Five species of commercial importance were observed. The most common family observed was the trunkfish family, generally browsing on the bottom for molluscs and other infaunal invertebrates. The trunkfish censused and observed in the Shallow Bay Grass tend to be of a larger size than in other habitats. It is not uncommon to see 12 inch trunkfish in this habitat. Other commercially important fish species observed occurred infrequently and are probably transients rather than residents. The only fish observed consistently in these grass beds is the bucktooth parrotfish, Sparisoma radians, although this species does not generally attain a size or abundance to make it commercially important.

Conchs were also observed occasionally in this habitat, primarily as juveniles. Some of these locations were Fish Bay, Brown Bay, a small bay east of Leinster Bay, Mary's Creek, Great Lameshur Bay and Huricane Hole.

3.4 Shallow Bay Pavement - SBp

3.4.1 General Description

Many of the shallow bays around St. John have pavement areas within them not associated with any adjacent reef systems. These are fairly flat, featureless bottoms of hard carbonate substrate sometimes covered by a thin sand veneer. Occasional coral heads, sponges and gorgonians may be present. Upraised portions of the carbonate substrate may be colonized by algal turf. Common coral species found here include M. annularis, S. siderea, A. agaricites and P. porites. Some of the bays in which this habitat type occurs include Reef Bay, Grootpan Bay, Hawksnest Bay, Honeymoon Bay and Maho Bay.

3.4.2 Fishery Description

Low structural complexity results in low numbers of fish found in this habitat. In general, fish observed in Shallow Bay Pavement were found associated with coral outcroppings or other areas having some vertical relief. Seven censuses in this habitat detected a total of seventeen commercially important species of fish (Table 3). Species having a high percent occurrence in this habitat include carang, doctorfish, parrotfish and squirrelfish. Less abundant species include blue-striped grunt, yellowtail snapper, red hind and spotted goatfish. Blue fry were fairly common in the Shallow Bay pavement and could account for high percent occurrence of carang. Nassau grouper, while not occurring frequently here, are more abundant in Shallow Bay Pavement than in any other habitat sampled.

In general, species occurrring in Shallow Bay Pavement are smaller than the total average fish size for all habitats sampled (Table 4). This habitat, like Subtidal Bedrock, may be a transitional habitat between the inshore nursery areas and the offshore habitats. Coneys here are larger and Nassau grouper are smaller than in any other habitat.

3.5 Back Reef - Rb

3.5.1 General Description

This habitat is principally located behind fringing reefs which are separated from shore by a shallow (1.5m maximum) lagoonal area. Generally this is a very protected area behind an emergent or nearly emergent reef crest. In many cases, the back reef slope to the bottom of the back reef lagoon is very steep and composed of large interlocking pieces of dead Acropora palmata which provide good shelter for the many species of fish found here. The floor of the lagoon is usually colonized by extensive stands of Porites furcata, P. porites and

P. divaricata. Also occurring here are M. annularis, P. asteroides and Millepora spp. Good examples of this habitat type occur in Fish Bay, Reef Bay Mennebeck Bay and to a lesser extent in Mary's Creek..

3.5.2 Fishery Description

The protected nature of a back reef makes it an ideal resting site for large daytime schools of fish. Nineteen species of fish were detected in six censuses (Table 3). Species with high percent occurrences in this habitat include french grunt, tomtate, schoolmaster, yellowtail snapper, mahogony snapper, doctor-fish, yellow goatfish, parrotfish and squirrelfish. Blue-striped grunt also were present in moderately high numbers. Relative to most other habitats sampled, there was a noticeable lack of the predatory species. The constricted nature of most back reefs may preclude their presence. The one exception to this was a 1.7m blacktip shark that was seen behind the reef at Reef Bay in 1.2m of water. The shark was obviously there due to the presence of large quantitites of prey fish. Several species of grunts were observed in this habitat that were present in few or no other habitats sampled. These include small-mouth grunt, spanish grunt and caesar grunt. Additionally, this is the only habitat in which mullet were observed although it is known that they also frequent mangrove areas and shallow bays.

The nearly even distribution between fish greater than or equal to the average size per species for all habitats (10) and those less than the average size per species for all habitats (8) (Table 4) would support the hypothesis that this habitat is a daytime resting area rather than a nursery area. The primary species of fish utilizing this habitat are species that leave the reef at night to feed in adjacent sand and grass flats. The single very large individual trunkfish observed in this habitat was seen in Reef Bay and may have been more closely associated with the extensive grass beds in the inshore portion of the back reef lagoon.

3.6 Upper Fore-reef - Rfu I

3.6.1 General Description

This habitat is found near shore in many localities around St. John, usually in the seaward, shallow (less than 3m) portions of fringing or barrier-type reefs. It is primarily composed of the highly branching coral A. palmata, but may have other species present including, P. porites, P. asteroides, A. agaricites, Diploria spp., and Millepora spp. The predominance of A. palmata produces a structurally complex habitat with good refuge capacity. Because of this complexity, this habitat (like the Back Reef habitat) serves as a principal daytime refuge for many species of fish that forage away from the reef at night in the adjacent grass beds and pavement areas.

The best developed examples of this habitat type occur on the north shore at Johnson's Reef, Windswept Beach, Mennebeck Bay and along the shoreline in various locations as narrow fringing reefs. The south side appears to have been well-developed examples of this habitat in Fish Bay and Reef Bay. At present, these areas show evidence of storm damage, probably from Hurricanes David and Frederic in 1979 and Allen in 1980, but are showing some evidence of recolonization.

3.6.2 Fishery Description

Twelve censuses in the Upper Fore-reef I detected twenty-two species of commercially important fish (Table 3). The primary species utilizing this habitat are four species of grunts (french grunt being predominant), three species of snapper (yellowtail snapper being predominant) and the usual doctorfish and parrotfish in high numbers. Most other species detected were present in fairly low numbers. There were no unique species noted for this habitat. Blue fry were present in relatively high numbers. Whelk were occasionally seen here, usually as large,

older individuals (greater than 9cm in diameter).

The species assemblage in this habitat is somewhat similar to that found in the back reef habitat. Fourteen species are shared between these habitats, including many that forage away from the reef at night and seek refuge in the reef during the day. Several more oceanic-type fish (carang, queen triggerfish, coney, angelfish) occur in the Upper Fore-reef while several of the less common grunt species and lagoonal species such as the mullet are absent.

The majority of species in this habitat have an average size smaller than or equal to the total average size per species for all habitats (Table 4). This could suggest the transitional nature of this habitat for many species from the inshore nursery grounds to the offshore reproductive areas. Schoolmaster snapper are the only species occurring in this habitat which is of a size larger than or equal to the size in all other habitats.

3.7 Upper Fore-reef on Subtidal Bedrock - Rfu II

3.7.1 General Description

This habitat is a mixed zone composed of an upper fore-reef type habitat growing on a basement of subtidal bedrock. When present, it occurs immediately adjacent to a rocky coastline. The combination of these two zones produces a habitat with physical characteristics of both (high structural complexity on top and rock surfaces below having high algal cover and low numbers of invertebrates). The predominant coral in the upper portion is A. palmata with Millepora, P. caribbea, A. agaricites, D. strigosa and others present.

3.7.2 Fishery Description

From the union of these two habitats, one would expect to see a fish species

assemblage representative of both habitats. Due to the rarity of this mixture, few censuses were made (Table 3). With two censuses we can only detect the most common species (ten observed). With the exception of spanish grunt, all species observed in the Upper Fore-reef II were present in either Upper Fore-reef I or Sub-tidal Bedrock or both. There is nothing notable about fish sizes in this mixed zone habitat (Table 4).

3.8 Upper Fore-reef/Fore-reef Pavement Ecotone - Rfu/Rfp

3.8.1 General Description

This habitat represents a transition between an upper fore-reef habitat and a fore-reef pavement habitat. It is dealt with as a separate zone due to the unique features of the fish species assemblage observed here. The primary example of this ecotone is found at the eastern end of Cinnamon Bay. Right adjacent to shore are found several large patches of A. palmata which appear to have produced large colonies extending from approximately 3.5m in depth to .3m in depth. Only the upper surface of these mounds are living. Tunnels extend several meters back into the mounds. The sides may be colonized by Millepora, Palythoa caribbea, A. agaricites and other corals.

3.8.2 Fishery Description

The habitat complexity resulting from this particular combination of features provides a unique form of shelter uncommon to either habitat type. As a consequence, a high number of commercially important fish species (18) apparently use this habitat (Table 3). Species with high percent occurrence for this habitat include carang, blue-striped grunt, french grunt, grey snapper, yellowtail snapper, doctorfish, yellow goatfish, parrotfish and sea chubs. A number of species

were observed here that were not detected in either of the two contributing zones. These include small-mouth grunt, mutton snapper, grey snapper and porkfish. Those species present in the contributing zones but not observed in the ecotone may show up with more censuses.

Nearly all the species present in this ecotone were of a larger average size than the total average size of the species for all habitats (Table 4). In particular, these include mutton snapper, grey snapper, parrotfish, barracuda and mojarra. Schoolmaster had an average size equal to the largest size found for any habitat. Location may be a factor here in that low or no fishing pressure may allow individuals to grow large at this site.

3.9 Fore-reef Pavement - Rfp I

3.9.1 General Description

This habitat occupies more area around St. John than any other nearshore, hard-bottomed habitat. In general, Fore-Reef Pavement I can be described as any relatively flat, hard, carbonate bottom having low percent live cover of corals and other sessile invertebrates. This pavement must be associated with a reef system are defined as either shallow-bay pavement or bank pavement (see Section 3.17).

Fore-reef pavement generally has a very low degree of structural complexity which provides little shelter for fish. Sessile organisms characteristic of this habitat include M. annularis, P. asteroides, S. siderea, Diploria spp., many gorgonian species and others. Overall gorgonian cover is below 25 percent. Portions of this habitat type may be covered by a thin sand veneer and appear to be a sand bottom with occasional coral or gorgonian outcroppings.

3.9.2 Fishery Description

Twenty-five censuses in this habitat detected twenty-six species of fish (Table 3). Although this appears to be a high number of species for a habitat with low structural complexity, it can be noted that very few species had high percent occurrences or numbers of indiviudals. Only five species occurred in greater than 30 percent of all censuses done in this habitat. They include carang, french grunt, yellowtail snapper, doctorfish and parrotfish. And of these, only doctorfish and parrotfish had percent occurrences over 40 percent and they were both 100 percent. Numbers of individuals were also very low for the less abundant species (percent occurrences less than 30 percent).

These statistics would indicate that while many species of commercially important fish can be found in this habitat, it is only an important habitat for a very few species. Other species may use it as an avenue between other adjacent habitat types or may be present there only when space or food is limiting elsewhere. Some species may utilize it for foraging but reside elsewhere.

Blue fry were found here occasionally, mostly in shallower areas. Large, mature whelk were observed occasionally on the sides of algal covered dead coral mounds, primarily in shallow water (less than 3m). During this study, five lobsters were observed in crevices or sand bottom caves under coral mounds in this habitat.

The majority of fish in this habitat (17) had a size equal to or larger than the total average size of the species for all habitats (Table 4). These size data suggest that this habitat is less of a transitional habitat than some of the nearer shore habitats. More of the individuals found here are mature.

3.10 Fore-reef Pavement with Ledges - Rfp II

3.10.1 General Description

This habitat has nearly the same general description as that for fore-reef Pavement I. Fore-reef Pavement II has areas where ledges have been formed either through uplifting of the carbonate substrate or erosion and undercutting. This anomaly is treated as a separate habitat even though it occupies very little of the total area of Fore-reef Pavement I, because the structural complexity created by the existence of ledges produces an unusual abundance and presence of some fish species which does not occur in Fore-reef Pavement I. Examples of this are on the west side of Ram Head or on the north side of Mary's Point.

3.10.2 Fishery Description

Only two censuses were made in this habitat type. While not enough to quantify differences from Fore-reef I, they do point out that differences do exist. Sixteen species of fish were detected (Table 3) of which fourteen were also found in Fore-Reef Pavement I. The two species which occurred here but not in Fore-Reef Pavement I were the mahogany snapper and spanish hogfish, both of which seem to prefer habitats with high structural complexity. The most abundant fish were schoolmaster, doctorfish and parotfish. The latter two were the most abundant fish in Fore-Reef I. The schoolmaster possibly is more abundant here due to the increased shelter available. The ledges additionally provide habitat for lobsters which were observed in both locations.

As with Fore-Reef Pavement I, this habitat appears to be less of a transitional habitat than those previously described. Thirteen of the species observed had average sizes larger than or equal to the total average size for the species for all habiitats (Table 4). The mahogany snapper here had the largest average size for all habitats sampled. Yellow goatfish had an average size equal to the

largest average size found in any of the habitats.

3.11 Lower Fore-reef - Rf1 I

3.11.1 General Description

This habitat type is very common around St. John. It forms the seaward border of most reef systems where they drop off into deeper water. However, because the Lower Fore-reef is defined more in terms of coral cover and composition than location or profile (Beets and Lewand, 1985), considerable variation exists. It can be found as an extremely dense, well-developed patch of Montastrea annularis in a shallow bay (Kiddle Bay) to a near vertical drop-off with high coral cover on the offshore edge of an extensive reef system (Johnson's Reef).

This habitat can be described as that portion of a reef having high percent live coral cover (greater than 20 percent), decreased gorgonian presence and sometimes steep slopes to deeper shelf sand, grass or algal plains. The most common coral species in this habitat include M. annularis, M. cavernosa, Colpophyllia natans, S. siderea, A. agaricites, Diploria spp. and Mycetophyllia spp.

In shallow areas where light penetration is good, the head corals can form large domed colonies with overhangs that produce good shelter for fish and lobster. In deeper areas, colonies tend to be flattened to maximize light capture. The steeper slopes in the deeper portions of this habitat are generally more eroded and have numerous crevices and overhangs which provide good shelter for many species of fish.

3.11.2 Fishery Description

Fifty-two censuses in this habitat detected forty species of commercially important fish (Table 3). We chose to do more censuses here because of this being a fairly common and very interesting habitat. The high number of species detected may be partly a function of the high number of censuses, although the data suggest that this may only be the case for a few species.

A number of species have a high percent occurrence. These include carang, blue-striped grunt, french grunt, yellowtail snapper, grey angelfish, red hind, doctorfish, parrotfish and squirrelfish. Moderately abundant species include white grunt, schoolmaster, yellow goatfish, spotted goatfish and spanish hogfish.

As would be expected, the number of pelagic species observed was higher than any other habitat. These include mackerel, blue runner, carang, black jack, and amberjack. Black jack and amberjack were only observed in Lower Fore-reef. This habitat also supports a large number of lobsters in the many crevices and caves present.

Of the forty species of fish detected in this habitat, 32 species had an average size larger than or equal to the total average size per species for all habitats (Table 4). This would suggest that this habitat supports mature, reproductive individuals with few juveniles and sub-adults. Further supporting this hypothesis is the number of species found here with larger individuals than in any other habitat. These include queen triggerfish, small-mouth grunt, dog snapper graysby, porgies, sea chubs and spadefish. Nassau grouper had a size equal to the largest found in all other habitats.

3.12 Lower Fore-reef on Fore-reef Pavement - Rf1 II

3.12.1 General Description

Where this habitat is found it can be described as large M. annularis or C. natans mounds up to 8 m in diameter located on fore-reef pavement. This is treated as a separate habitat due to the possibility of both Lower Fore-reef and Fore-reef Pavement I influencing fish species composition. The structural complexity found in the Lower Fore-reef portion of this habitat would attract abundances of fish not attracted to the Fore-reef Pavement I. The Lower Fore-reef acts as a patch reef in the midst of a less productive area.

3.12.2 Fishery Description

Having only two censuses in this habitat makes it difficult to draw conclusions about the similarity or dissimilarity between this habitat and either of the two contributing habitats. From Table 3 we can see that all species detected in this habitat were also detected in Lower Fore-reef I. All species but one (tiger grouper) were also detected in Fore-reef Pavement I. Without more data it is questionable as to whether this should be treated as a distinctly different habitat, however, the possibility exists that these areas are concentrating fish from the surrounding Fore-reef Pavement.

From size data (Table 4) no clear conclusion can be drawn concerning similarity of Lower Fore-reef II to either Fore-reef Pavement I or Lower Fore-reef I. Eight of the species in Lower Fore-reef II have an average size larger than or equal to the total average size per species for all habitats which may indicate that fish in this type of habitat tend to be larger, more mature individuals, as found in Lower Fore-reef.

3.13 Lower Fore-reef on Subtidal bedrock - Rf1 III

3.13.1 General Description

This atypical habitat generally occurs in shallow water (less than 3m) along a rocky coastline such as the east side of inner Great Lameshur Bay or at the north end of Waterlemon Cay in Leinster Bay. It is composed of well-developed coral stands producing a Lower Fore-reef environment on Subtidal Bedrock. The presence of these dense stands of coral alters the structure of the Subtidal Bedrock significantly. This modification of structural complexity should have an effect on the composition and abundance of the fish assemblage normally found in Subtidal Bedrock.

3.13.2 Fishery Description

Few censuses were made in this uncommon habitat. A low number of censuses makes comparative analysis with the two contributing habitats difficult. Two censuses in Lower Fore-reef III detected thirteen species of commercially important fish (Table 3). All species observed in this habitat were also observed in Lower Fore-reef I and Subtidal Bedrock. Some species such as red hind and black grouper were detected in few other habitats than the three mentioned above. This may demonstrate some relationship between these three habitats.

Of the thirteen species detected in this habitat, seven have an average size greater than or equal to the total average size per species for all habitats (Table 4). This may suggest a mix between the transition habitat (Subtidal Bedrock) and the habitat used for reproduction (Lower Fore-reef I). When comparing this habitat to the two contributing habitats, we find that ten of the species present have average sizes smaller than or equal to the species' average size in Subtidal Bedrock. This indicates that this habitat is a mixed habitat influenced by both contributing habitats and that possibly the Subtidal Bedrock has a slightly

higher level of influence, perhaps due to depth range (less than 4m).

3.14 Reef Gorgonian Flats - Rgo I

3.14.1 General Description

This habitat is very similar to and occurs in the same position on the reef as fore-reef pavement and is distinguished by having high percent gorgonian cover (greater than 25%) and reduced coral cover. It generally occurs in areas of high current such as Hawksnest Point, Whistling Cay and in portions of the Narrows, presumably because the high transport of particulate matter provides a rich nutrient source for the filter-feeding gorgonians.

The low structural complexity provides little shelter for fish. Additionally, the dense canopy formed by the gorgonian "forest" allows less light to reach the sandy substrate for algal growth and thus reduces food resources for herbivores. This in turn may reduce food resources for some of the more carnivorous species of fish.

3.14.2 Fishery Description

Nine censuses in this habitat only detected nine species of commercially important fish (Table 3). This demonstrates the depauperate nature of the fish fauna in this habitat. Only two species occurred here in relatively high abundance and these are doctorfish and parrotfish. Red hind was moderately abundant.

Of the nine species occurring here, seven species had an average size smaller than or equal to the total average size per species for all habitats (Table 4). This would suggest that this habitat is either a transitional or sub-optimal habitat which supports fish during life stages between juvenile and mature or is composed of individuals attempting to locate a suitable habitat.

3.15 Reef Gorgonian Flats on Ledges - Rgo II

3.15.1 General Description

This habitat is generally the same as Reef Gorgonian Flats I with the exception of numerous ledges created by uplifted substrate or erosion and undercutting. This increases the structural complexity of the Reef Gorgonian Flats I and provides shelter for fish species that are more cryptic.

3.15.2 Fishery Description

One census is insufficient to characterize the fish community in this habitat but it does indicate the presence of certain species that are most likely present due to the increase in structural complexity. Of the nine species detected in this habitat, six were not detected in the Reef Gorgonian Flats I (Table 3). Most of these species are species that are usually found in crevices and under overhangs. These include tomtate, margate, black grouper and tiger grouper. The sand bottoms under the ledges may account for the presence of yellow goatfish as they feed in sand. Lobsters were also observed utilizing these ledges for shelter.

As opposed to Reef Gorgonian Flats I, the majority of species found in Reef Gorgonian Flats II were larger than or equal to the total average size per species for all habitats (Table 4). These species were primarily the ones not found in Reef Gorgonian Flats I. It would seem then that the ledges provide habitat suitable for mature individuals of certain species. Those species also found in Reef Gorgonian Flats I may be utilizing this habitat for the same reasons as hypothesized for Reef Gorgonian Flats I.

3.16 Shallow Bay Patch Reef - SBpr

3.16.1 General Description

A shallow bay patch reef is generally a small reef occurring within the confines

of a shallow bay and isolated from shore and other reef systems by sand or seagrass. They can range from an actively growing shallow (less than 3 m) reef 4 m in diameter (Cinnamon Bay) to a storm damaged, sparsely colonized reef (Cinnamon Bay) to a larger (approximately 40 m in diameter) deeper (10 m) actively growing reef (Hawksnest Bay). What they all share in common is that they are an island of structural complexity in the middle of an area of flat featureless bottom. Thus, fish are attracted to them for shelter and daytime refuge.

3.16.2 Fishery Description

Five censuses in this habitat detected twenty species of commercially important fish (Table 3). Species for which this habitat appears to be important include carang, blue-striped grunt, french grunt, mahogany snapper, grey angelfish, doctorfish and parrotfish. Carang were primarily present in the deeper patch reef censused. Four species of grunts plus many unidentifiable juvenile grunts were observed in this habitat. They are undoubtedly utilizing this habitat as a daytime refuge near the sand and grass beds where they forage at night. Likewise, the mahogany snapper are utilizing these patch reefs as a daytime refuge. Grey angelfish and spotted goatfish were primarily observed in the deeper patch reef censused.

Due to the fact that three of the earlier censuses (deeper patch reef) for this habitat had no length data recorded, the average size for each species may not be truly reflective of this habitat as a whole (Table 4). It can be noted however, that the average size for the main species found in the shallower patch reef is smaller than the total average size per species for all habitats. This would suggest that these shallow-water protected patch reefs may be somewhat of a nursery or early transition habitat for some species.

3.17 Bank Pavement - Bp

3.17.1 General Description

Bank pavement habitats were defined as areas of hard, carbonate bottom seaward of

any near shore reef systems. In most Bank Pavement observed this bottom type has many raised ridge areas on it which are undercut to form ledges. This undercutting provides a fair amount of shelter for fish and lobsters. Living cover on Bank Pavement is generally quite low (5-10%). Coral species found here include M. annularis, S. siderea, A. agaricites and M. cavernosa.. Many gorgonians, sponges and black corals may be present. Depths are generally quite deep (greater than 20m). This habitat extends over much of the insular shelf region outside of the National Park Service boundaries.

3.17.2 Fishery Description

Seven censuses in this habitat type detected twenty-six species of commercially important fish (Table 3). Species having high numbers or high percent occurrence in this habitat include queen triggerfish, blue-striped grunt, french grunt, grey snapper, yellowtail, grey angelfish, coney, doctorfish, parrotfish and squirrelfish. Species which are more common in this habitat than in any other habitat include queen triggerfish and coney. In fact, through personal observations and reports from knowledgeable divers, it appears that this may be the principal habitat for the queen triggerfish which may be the most important commercially caught trap fish. A complete examination of the contents of twenty-two randomly selected fish traps in St. Thomas showed that 22 percent of the total catch was made up of queen triggerfish (Clavijo, et al. 1984), higher than for any other species. These abundances are in spite of relatively high fishing pressure as fishermen move offshore from the overfished inshore areas.

As with other deeper water habitats a higher number of pelagic species are present such as mackerel, kingfish and carang. The presence here of four species of grunts and four species of snappers indicates that this may be an important daytime refuge for species foraging at night in the nearby sand flats and algal plains.

The numerous ledges present on the ridges of Bank Pavement provide substantial habitat for lobsters and the currents present in many of these areas provide a mechanism for larval dispersal. Many of the areas fished commercially for lobster north, south and west of St. Thomas are areas of raised bottom possibly composed of Bank Pavement.

Twenty of the species found in this habitat had average sizes greater than or equal to the total average size per species for all habitats (Table 4). This supports the hypothesis that the deeper habitats support populations of larger mature fish and that these habitats may be the reproductive habitats where many of these species spawn and the pelagic eggs have a good chance of dispersal by the currents. A number of species found in this habitat had a larger average size than in any other habitat in which they were observed. These include blue-striped grunt, white grunt, french grunt, yellowtail, doctorfish and porkfish. For these species, this habitat may be an important source of larvae for the shallower water, more near shore habitats. This may also be the case for the lobster population present there. A male lobster weighing approximately 4800 grams was taken from this habitat during the study. This was the largest lobster seen in a long time by any of the investigators involved in this study.

3.18 Bank Gorgonian Flats - Bgo

3.18.1 General Description

This habitat is very similar to Reef Gorgonian Flats I except that it is not bounded on its seaward side by a reef system. It generally is a relatively flat, hard bottom area with high (greater than 25%) gorgonian cover and low structural complexity. This habitat appears to be rather patchy in distribution and appears to occupy areas with good current. As with Reef Gorgonian Flats I, this may be due to the filter-feeding nature of gorgonians and their need for water transport of nutrients. Examples of this habitat are on the north side of Mary's Point, around

the Durloe Cays and a large patch northeast of the eastern tip of Mary's Point.

3.18.2 Fishery Description

Only one census was made in this habitat which makes it difficult to compare the results with other habitats or to draw strong conclusions about the fishery composition. However, when comparing the species present in Bank Gorgonian Flats with the species observed in Reef Gorgonian Flats I, a strong similarity can be seen (Table 3). Five of the seven species detected in Bank Gorgonian Flats are also found in Reef Gorgonian Flats I. Of these, the most abundant species detected in Bank Gorgonian are also found in Reef Gorgonian Flats I. Of these, the most abundant species were doctorfish and parrotfish with all other species occurring only occasionally. With more censuses Bank Gorgonian Flats would probably exhibit even greater similarity to Reef Gorgonian Flats I.

In general, most fish in this habitat appear to have an average size larger than the total average size per species for all habitats (Table 4). This must be treated cautiously as the low number of censuses can produce misleading information.

3.19 Bank Patch Reef - Bpr

3.19.1 General Description

A bank patch reef in general is a discrete reef system, usually circular in shape, separated from shore and other reef systems by sand, grass or algal plain. They may have significant vertical relief (up to 10 m or more in elevation from the surrounding bank) and range in size from several meters to nearly 300 m in diameter. Examples of these variations can be found south of St. John off Reef Bay. Larger bank patch reefs usually have a flat upper surface which may be sparsely colonized compared to the nearly vertical sides. The sessile invertebrate communities in Bank Patch Reef are generally of a deeper water composition similar to Lower Fore-reef I. Dominant species of corals include *M. annularis*,

M. cavernosa, C. natans, A. agaricites, S. siderea, Diploria spp. and Madracis spp.. Percent living cover can be quite high (60 to 70 %) with few gorgonians.

Bank patch reefs appear to serve as islands of refuge on an otherwise featureless bottom. They may harbor many thousands of fish that seek vertical struc-ture to provide shelter primarily from predators. Many of these fish species may venture off the reef at night to forage in the surrounding sand, grass or algal flats. This foraging by fish and feeding by invertebrates maintain a sand zone around patch reefs that are situated in a grass bed or algal plain. This feature is very distinctive and aids in identification of patch reefs from aerial photographs.

3.19.2 Fishery Description

While not a very common habitat, particularly within the boundaries of the National Park, these patch reefs appear to be a very important habitat on the shelf regions around St. John. They provide shelter for many species of fish in an area where shelter is not otherwise available. Ten censuses in this habitat detected twenty-eight species of fish (Table 3). Many of these species had high numbers of individuals or high percent occurrences. It is these species in particular for which this habitat appears to have great significance as a refuge. These species include queen triggerfish, blue-striped grunt, white grunt, french grunt, grey snapper, yellowtail, mahogany snapper, grey angelfish, red hind, coney, doctorfish, yellow goatfish, parrotfish and squirrelfish. This habitat also attracts some pelagic species such as carang, mackerel and kingfish.

The presence of five species of grunts and four species of snappers provides evidence that this is an important daytime refuge for nocturnal foragers. Several species have a higher number of individuals and percent occurrence in this habitat than in any other habitat sampled. These include carang, grey angelfish and red hind. Queen triggerfish are nearly as common and abundant here as in Bank Pavement.

Lobsters are also found in this habitat. The complexity here is similar to Lower Fore-reef I and provides adequate shelter for lobsters.

Of the twenty-eight species of commercially important fish detected in this habitat, twenty-one have an average size greater than or equal to the total average size per species for all habitats (Table 4). This suggests that this habitat supports mature, reproductive fish similar to most of the other deeper water, offshore habitats. Only kingfish and sailor's choice have larger average size in this habitat than in any other of the other habitats sampled.

3.20 Shallow Bay Artificial Reef - SBar

3.20.1 General Description

This habitat is unique in that there is only one shallow bay artificial reef known in National Park waters. It is included here for comparative purposes with natural shallow bay patch reefs, although all sampled are situated in slightly different environmental settings.

This reef was set in place by John Randall in 1960, as a study of recruitment onto an artificial patch reef (Randall, 1963), and later studied by Ogden and Ebersole (1981). It is situated in Little Lameshur Bay in the middle of a dense seagrass bed. The reef is composed of standard concrete building blocks which have since become scattered over an area approximately 15 m in diameter. The greatest vertical relief is nearly .5 m. The blocks provide shelter in their core holes for a variety of fish and invertebrate species.

3.20.2 Fishery Description

One census in this artificial reef detected twelve species of commercially important fish (Table 2). The most abundant species observed were white grunt, tomtate and squirrelfish. Mutton hamlet were observed here in significant numbers. This species was not observed in any other habitat during this project.

Size comparisons with other habitats (Table 4) are not possible due to the single census and the occurrence of only single individuals for several species.

4. DISCUSSION

The only mapping project of any magnitude around St. John prior to this one and the one reported by other workers in this project series (Beets and Lewand, 1985) was carried out by Kumpf and Randall (1961). Their product was a map showing the major marine environments of St. John to the 10-fathom curve. While their map has served as a valuable aid to researchers for many years, we feel that the maps produced in this project series provide a level of detail far greater and should serve as a valuable aid for researches desiring to locate a particular habitat type.

Definition of a pure habitat type is in many cases quite difficult, particular-ly when dealing with motile species such as fish. Most habitats appear as part of a continuum of habitats where a pure habitat only exists if it is large enough to have a core area free from edge effects caused by adjacent habitats. Adjacent habitats may have chance occurrence of some species as a result of the proximity to a habitat where it is more common. It is for this reason that species of significance in a particular habitat are defined as those species which have a percent occurrence of greater than 30 percent. If a species occurs in one or more than one census out of three, then this species is probably commonly found in this habitat.

When each benthic habitat type is considered in terms of its significant fish species, we see a relatively distinct species assemblage for each major habitat type. While some major habitat types may appar somewhat similar in species composition (e.g., Reef Gorgonian Flats I and Bank Gorgonian Flats), we find that this is because the two habitats share similar structural complexity or structural components. We also see that habitats with greater structural complex-ity tend to contain a greater number of species. This is most likely due to the increased amount of available shelter. Additionally, the occurrence of within zone variations of species assemblage (presence of "exotic" species) many times are due to variations in structural complexity. Examples of this are ledges or an area of high relief in a habitat that by description has low relief and little

structural complexity (e.g., Reef Gorgonian Flats II).

The matter of uniform sample size may have some affect on the number of species observed in each habitat type. We can assume that, given enough censuses any habitat may eventually have had present it it at one time or another, all of the species of fish listed in Table 1. However, the censuses range from one to fifty-two for the different habitats.

A subsequent study by the author where ten consecutive censuses were made in the same location indicated that 80 percent of all species detected during 10 censuses were detected after four censuses. Ninety percent were detected after eight censuses. Therefore, we can say that fish assemblage descriptions for habitats with less than four censuses are representative of the most common species in the habitat but not necessarily good descriptions of the entire commercially important species assemblage using the habitat. Species occurring in greater than 30 percent of all the censuses in a particular habitat can be said to be species of significance and used to describe that habitat in fishery terms.

If we look at the various habitat types in terms of their utilization by the fish species assemblage present, we can note three major categories: nursery habitat, transition habitat and habitat used by reproductive individuals. Size data give a basis for the definition of these habitat categories. Nursery habitats (e.g., Shore Mangroves) are low energy, protected areas where juvenile fish can aggregate in a location relatively free from predation. Juvenile fish move into the areas as they settle out of the larval phase. As they reach some critical size or state of physiological development, they move out into the transition habitats (e.g., Upper Fore-reef, Fore-reef Pavement) where they may spend the majority of their sub-adult like. While some fish reach maturity and may reproduce in these transition habitats, most fish seem to be of a larger size in the deeper, offshore reproductive habitats (e.g., Bank Patch Reef, Lower Fore-reef, Bank Pavement). It is in these habitats where most fish having pelagic eggs apparently carry out reproductive activities. None of these habitats are absolute

in terms of providing a species with all of its daily requirements with the possible exception of the nursery habitat. There may exist daily migrations for certain species or individuals to deeper habitats for reproductive purposes while the rest of the time is spent feeding in shallower habitats (Randall and Randall, 1963).

Although differences in fishing pressure between habitats may influence sizes of individuals observed, it is felt that this may not be very important as most fishing methods (traps or line) are not very selective by size. Although some fishermen do throw back the small fish caught, few may survive due to the trauma of the capture and subsequent handling.

Coastal migratory pelagic species were detected in many of the habitats sampled. It was noted that a greater number of pelagics (mackerel, kingfish, blue runner, carang) were observed in the deeper, offshore habitats than the inshore habitats. This is as would be expected from our scant knowledge of pelagics. The carang is the only pelagic species which appears ubiquitous.

The coastal migratory pelagics deserve special attention. The fact that we know so little about their life histories and stocks could lead the fisheries unit into a critical state before we learn enough to manage it. Habitat areas of particular concern for this fisheries unit include: offshore areas of peak spawning activities, all habitats along migration routes that support populations of bait fish, and reef complexes which support high levels of primary marine productiv -ity (Centaur, 1982).

Bait fish were primarily observed in the shallower, more protected habitats. One factor that may bias this observed habitat preference is that bait fish tend to occur near the surface. When sampling deeper habitats, the surface is further away and is outside the census. In shallow areas, the surface is visible from the diver's census location and the bait fish are visible.

Lobster populations appear to be higher in the deeper, more structurally complex habitats. A juvenile lobster was seen in the mangroves in Hurricane Hole supporting the fact that lobsters utilize mangrove habitats as nurseries. During

the time period of this study, we had reports from local divers that the lobsters were migrating away. These observations were based on a sudden large decrease in numbers and not on observation of an actual migration. This may have resulted in a lower number of lobsters seen during the course of this study than are normally present.

Conch populations appear to be larger than expected. Juvenile abundances were quite high in several locations. Adult populations were observed in many deeper areas seaward of reef systems, on grass, sand or algal covered bottoms.

Whelk definitely require immediate management attention if any are to be around for the future. Very few were observed during this study. Of those seen very few were large, mature individuals.

Cursory examination of the data collected in this study indicates some difference in species abundance between bays on the same coast. These questions require further analysis of the data already acquired and possibly collection of additional data.

The methods utilized in this study for the mapping of fishery habitat appear to be quite reliable and cost efficient. The use of color aerial photographs for initial mapping of benthic marine habitats is extremely easy and effective. Through groundtruthing, one develops the capability of defining benthic habitats from the aerials on the basis of color, location and texture. The census method utilized appears to be quite accurate, is easy, fast and repeatable by anyone with a minimum of instruction. Additionally, it requires no major equipment other than SCUBA for deeper (greater than 4m) work and an underwater watch. Unless some other census method is developed which provides statistically better data with little or no extra disadvantages over this method, I would recommend this method for surveys of the larger, commercially important species as they tend to be less cryptic and not affected by a stationary diver. Additionally, a stationary observer will detect those species which are initially cryptic but become visible

after a short period of time (coney, hind). Some practice with objects of known size at different distances is necessary to be able to estimate fish size with some degree of accuracy.

5. ACKNOWLEDGEMENTS

This project was funded by the National Park Service, Contract No. CX-001-2-0048 (Work Order No. PX-0001-3-0885) and administered by Island Resources Foundation in conjunction with the Virgin Islands Resource Management Cooperative (VIRMAC). In addition to direct funding, the National Park Service provided immeasurable assistance in the form of a field technician, Ms. Vonnie Small, use of a Park Service boat for all field work, SCUBA tanks for all underwater work, and use of Park Service facilities as temporary office space. This assistance made the project possible. Special thanks also are due to Mr. James Beets and Mr. Lance Lewand who assisted in portions of the field work and with whom many discussions have led to ideas presented in this report. Dr. Arthur Dammann also provided much appreciated advice and technical support. Dr. Robert Brander made possible these projects in the first place and to him go thanks for all his effort. Ms. Sandra Tate and Ms. Charlene Vaughan had to struggle through my handwriting to type this.

REFERENCES

Austin, H. M., 1971. A survey of the ichthyofauna of the mangroves of western Puerto Rico during December 1967 to August 1968. Carib. J. Sci., 11 (1-2): 27-39.

Beets, J. and L. Lewand. 1985. Marine Community descriptions and maps of bays within the Virgin Islands National Park/Biosphere Reserve, St. John, USVI.

Bert, C. J. Jr., 1975. Behavior and ecology of conch (Superfamily Strombacea) on a deep subtidal algal plain. Bull. Mar. Sci., 25:307-317.

Bohnsack, J. A., And Bannerot, S. P., 1983. A random point census technique for visually assessing coral reef fishes. In: C.A. Barons and S.A. Bortone (Editors), The Visual Assessment of Fish Populations in the Southeastern United States: 1982 Workshop South Carolina Sea Grant Consortium Tech. Report 1, SC-SG-TR-01-83, pp. 14-17.

Brock, V. W., 1954. A preliminary report on a method of estimating reef fish populations. J. Wildl. Mgmt., 18:297-308.

Caribbean Fishery Management Council, 1984. Draft Fishery Management Plan, Regulatory Impact Review, and Environmental Impact Statement for the Shallow-Water Reeffish Fishery of Puerto Rico and the U.S. Virgin Islands. N.M.F.S., NOAA, DOC, 67 pp.

Centaur Associates, Inc. 1982. Draft Fishery Management Plan, Draft Environmental Impact Statement and Regulatory Analysis for the Coastal Migratory Pelagic Resources. Prepared for the Caribbean Fishery Management Council, 201 pp.

Chaplin, C.C.G., 1972. Fishwatchers Guide to West Atlantic Coral Reefs. Harrowood Books, Penn., 65 pp.

Clavijo, I. E., 1983. Pair spawning and formation of a lek-like mating system in the parrotfish Scarus vetula. Copeia, No. 1:253-256.

_____, Brandon, M., Tobias, W., 1984. Fisheries Statistics for the Virgin Islands (Preliminary Completion Report, Segments 1 to 5), N.M.F.S., PL 88-309, 2-335-R-5, Commercial Fisheries Research and Development, 55 pp.

Colin, P.L., 1978. Daily and summer-winter variation in mass spawning of the striped parrotfish, Scarus croicensis Bloch. Fishery Bull., 76(1):117-124.

_____, and Clavijo, I.E., 1978. Mass Spawning by the spotted goatfish, Pseudopeneus maculatus Bloch (Pisces: Mullidae). Bull. Mar. Sci., 28(4):780-782.

Gladfelter, W.V. and Gladfelter, E.H., 1978. Fish Community structures as a function of habitat structure on West Indian patch reefs. Rev. Biol. Trop., 26(Suppl.1):65-84.

Herrnkind, W.F. and Cummings, W.C., 1964. Single file migrations of the spiny lobster, Panulirus argus (latreille). Bull. Mar. Sci. Gulf. Carib., 14(1):123-125.

Herrnkind, W.F., VanDerWalken, J.A. and Barr, L., 1975. Population dynamics, ecology and behavior of spiny lobster, Panulirus argus, of St. John, U.S.V.I. :(IV) Habitation, patterns of movement and general behavior, result of the Tektite Program, Vol. 2, Bull. Nat. Hist. Mus. L.A. County, No. 20:31-45.

Hesse, K.O., 1979. Movement and migration of the queen conch, Strombus gigas, in the Turks and Caicos Islands. Bull. Mar. Sci., 29(3):303-311.

Hobson, E.S., 1973. Diel feeding migrations in tropical reef fishes. Helgolander wiss. Meeresunters, 24:361-370.

Jones, R.S. and Thompson, M.J., 1978. Comparison of Florida reef fish assemblages using a rapid visual technique. Bull. Mar. Sci., 28:159-172.

Kanciruk, P. and Herrnkind, W., 1978. Mass migration of spiny lobster, Panulirus argus: Behavior and environmental correlates. Bull. Mar. Sci., 28(4):601-623.

Kimmel, J.J., in press. A new species-time method for visual assessment of fishes and its comparison with established methods. Environ. Biol. Fish.

Kumpf, H.E. and Randall, H.A., 1971. Charting the marine environments of St. John, U.S. Virgin Islands. Bull. Mar. Sci. Gulf. Carib., 11(4):543-55.

Luckhurst, B.E. and Lockhurst, K., 1978. Analysis of influence of substrate variables on coral reef fish communities. Mar. Biol., 49:317-324.

Ogden, J.C. and Ebersole, J.P., 1981. Scale and community structure of coral reef fishes: A long-term study of a large artificial reef. Mar. Ecol. Prog. Ser., 4:97-103.

Olsen, D.A., 1972. A survey of the fishes of the St. Thomas Mangrove Lagoon area. Part A. Unpublished Preliminary Report.

_____, Herrnkind, W.F., and Cooper, R.A., 1975. Population dynamics, ecology and behavior of spiny lobster, Panulirus argus, of St. John, U.S.V.I.:(1) Introduction and general population characteristics. Results of the Tektite Program, Vol. 2, Bull. Nat. Hist. Mus. L.A. County, No. 20:11-16.

Percharde, P.L., 1968. Notes on distribution and underwater observations of the molluscan genus Strombus as found in the waters of Trinidad and Tobago. Carib. J. Sci., 8:47-53.

Randall, H.A., 1964. A study of the growth and other aspects of the biology of the West Inidan Topshell, Cittarium pica (Linnaeus). Bull. Mar. Sci. Gulf. Carib., 14(3):424-443.

Randall, J.E., 1962. Tagging reef fishes in the Virgin Islands. Proc., G.C.F.I., 14:201-241.

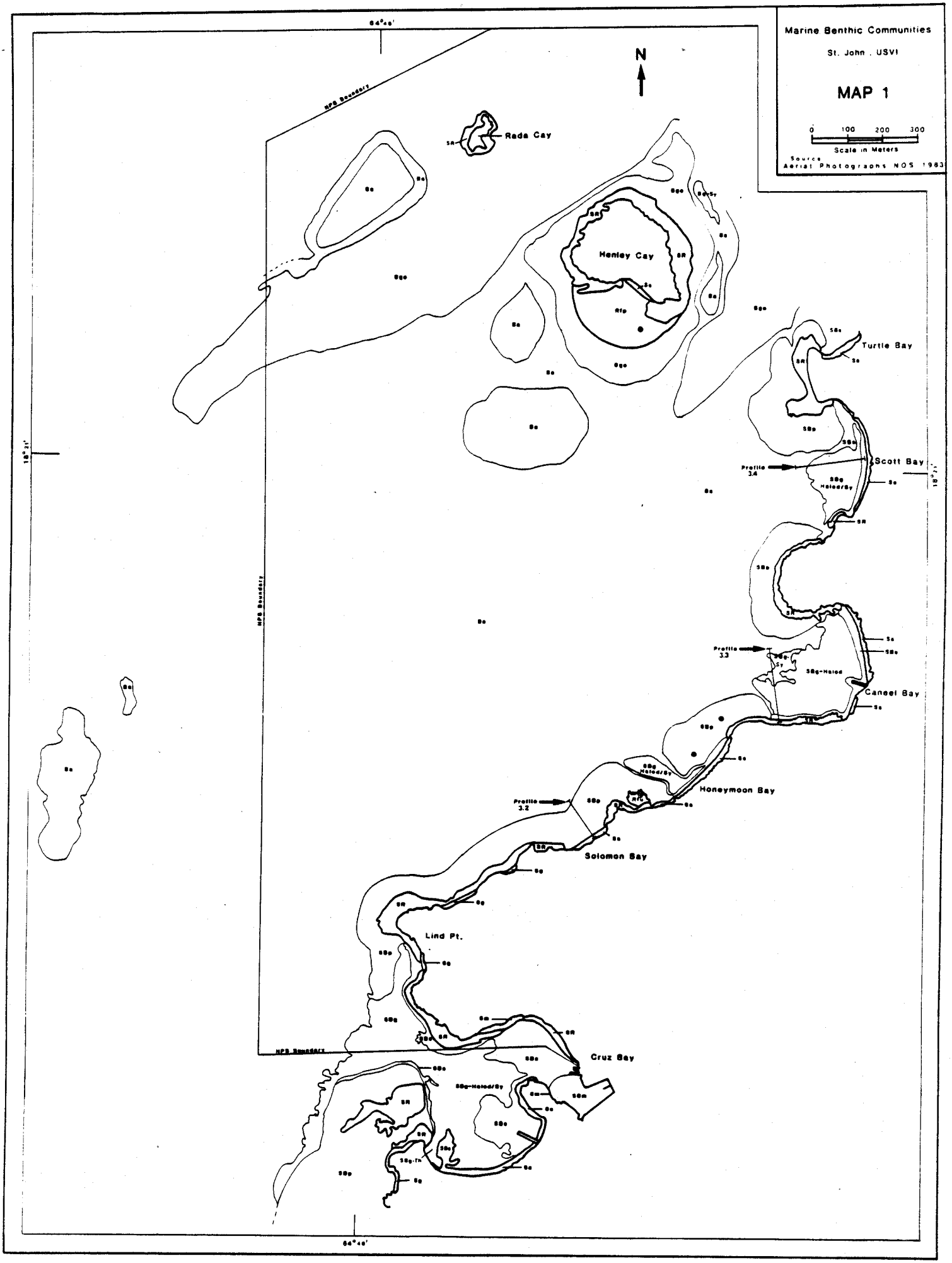
_____, 1964. Contributions to the biology of the queen conch, Strombus gigas. Bull. Mar. Sci. Gulf. Carib., 14:246-295.

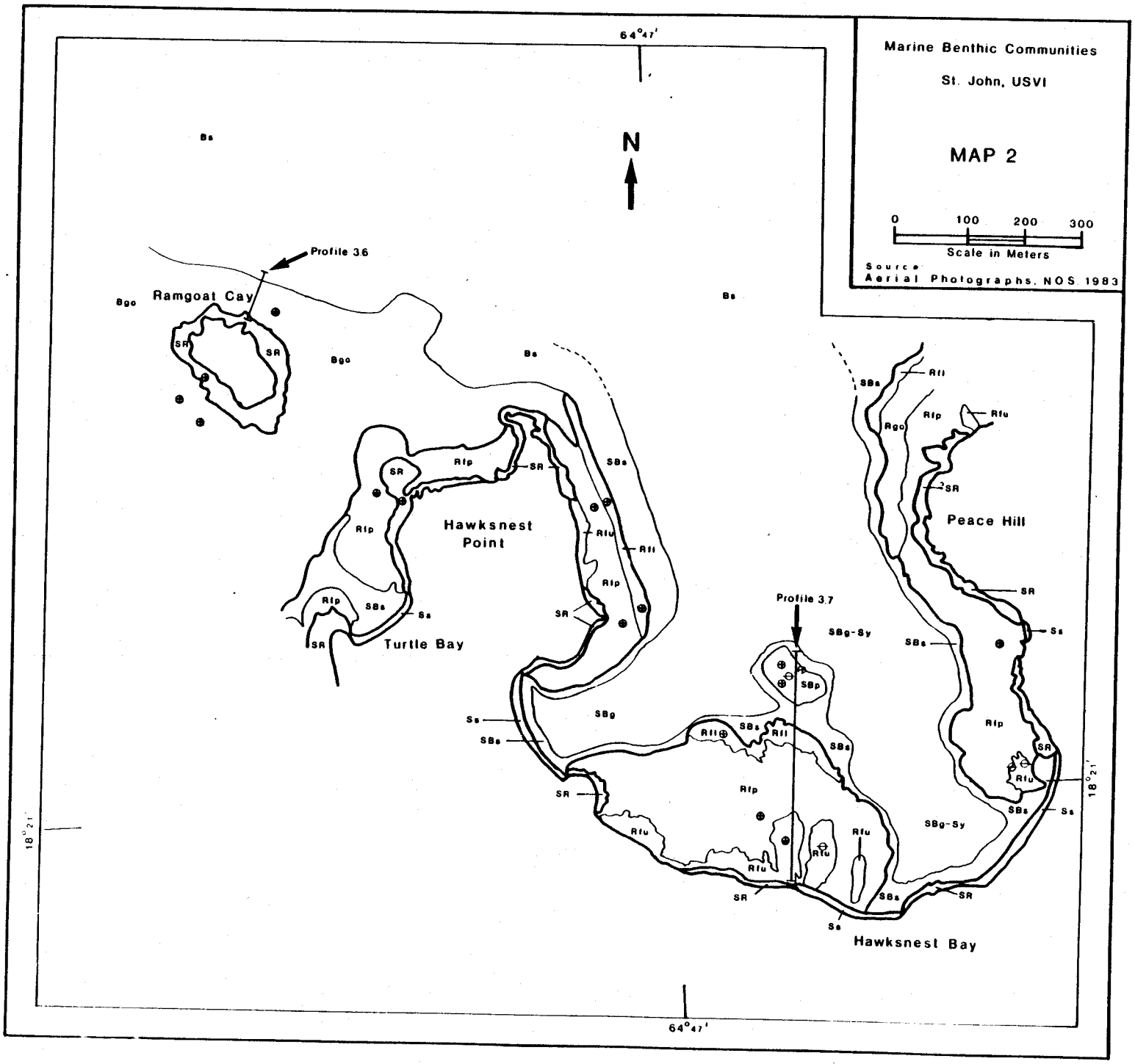
_____, 1968. Caribbean Reef Fishes. T.F.H. Publications, Hong Kong, 318 pp.

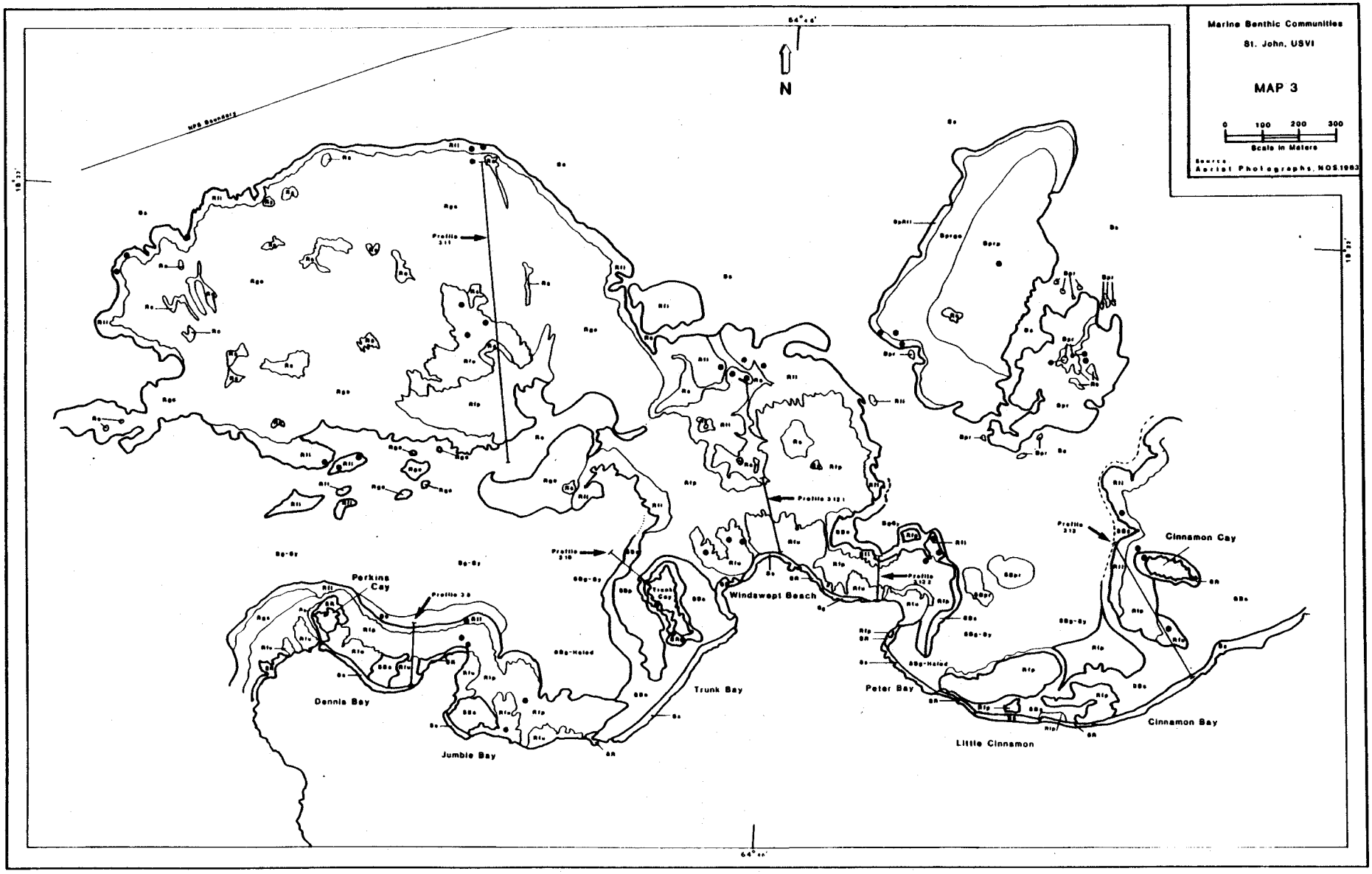
Randall, J.E., and Randall, H.A., 1963. The spawning and early development of the Atlantic parrot fish, Sparisoma rubripinne, with notes on other scarid and labrid fishes. Zoologica 48:49-60.

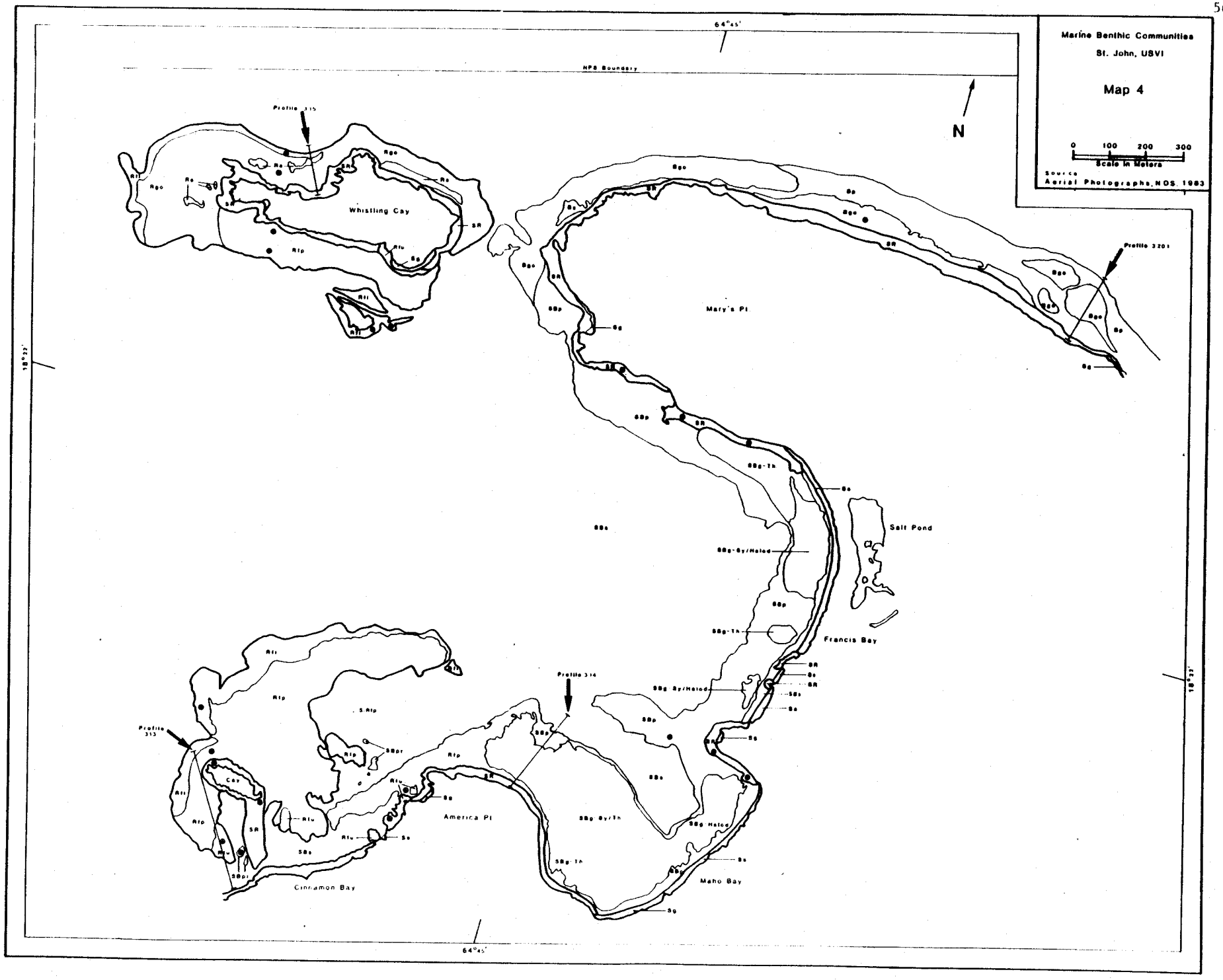
Sanderson, S.L. and Solonsky, A.C., 1980. A comparison of two visual survey techniques for fish populations. Pacif. Sci., 34:237.

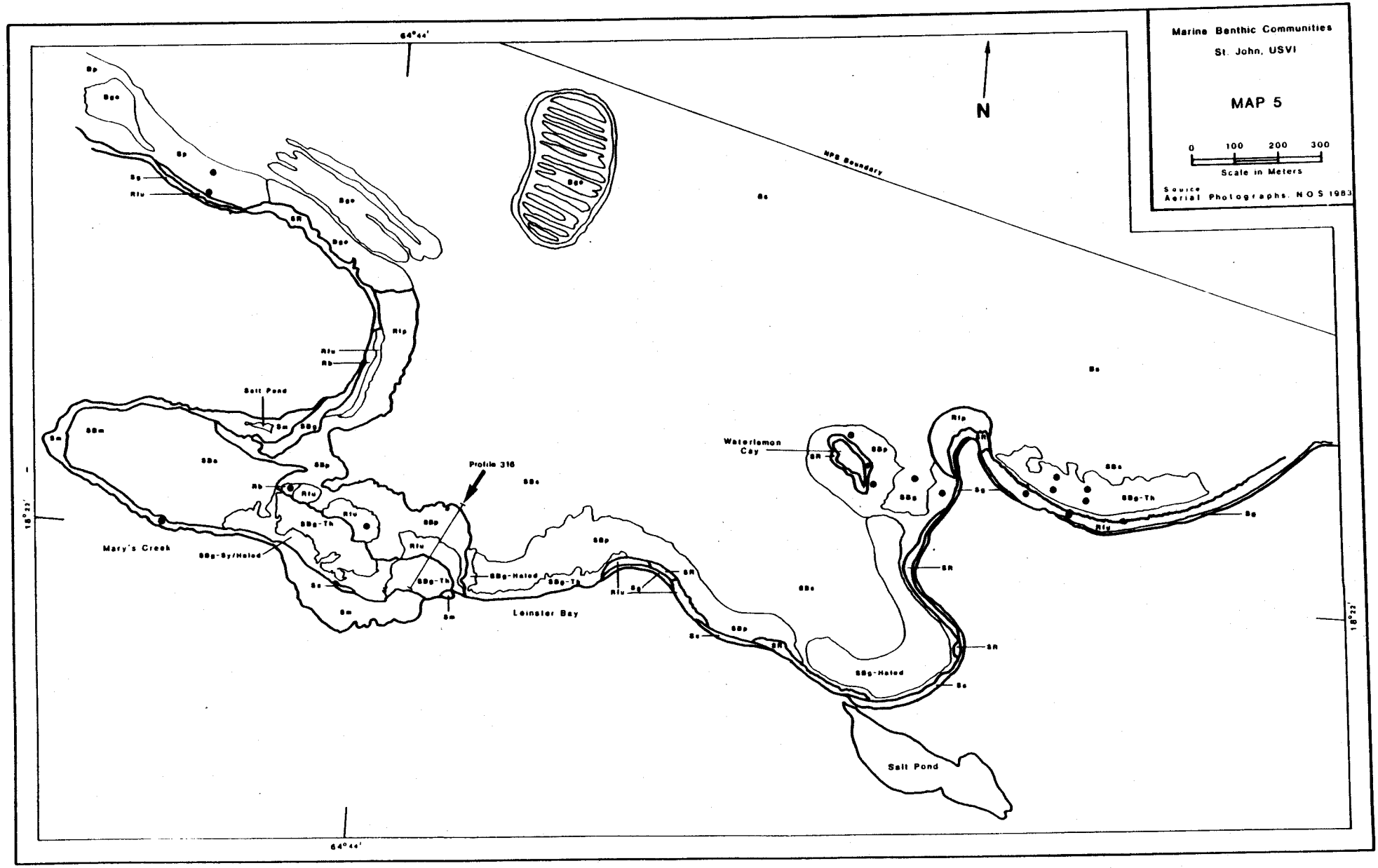
Stokes, F.J., 1980. Handguide to the Coral Feef Fishes of the Caribbean. Lippincott and Crowell, New York, 160 pp.

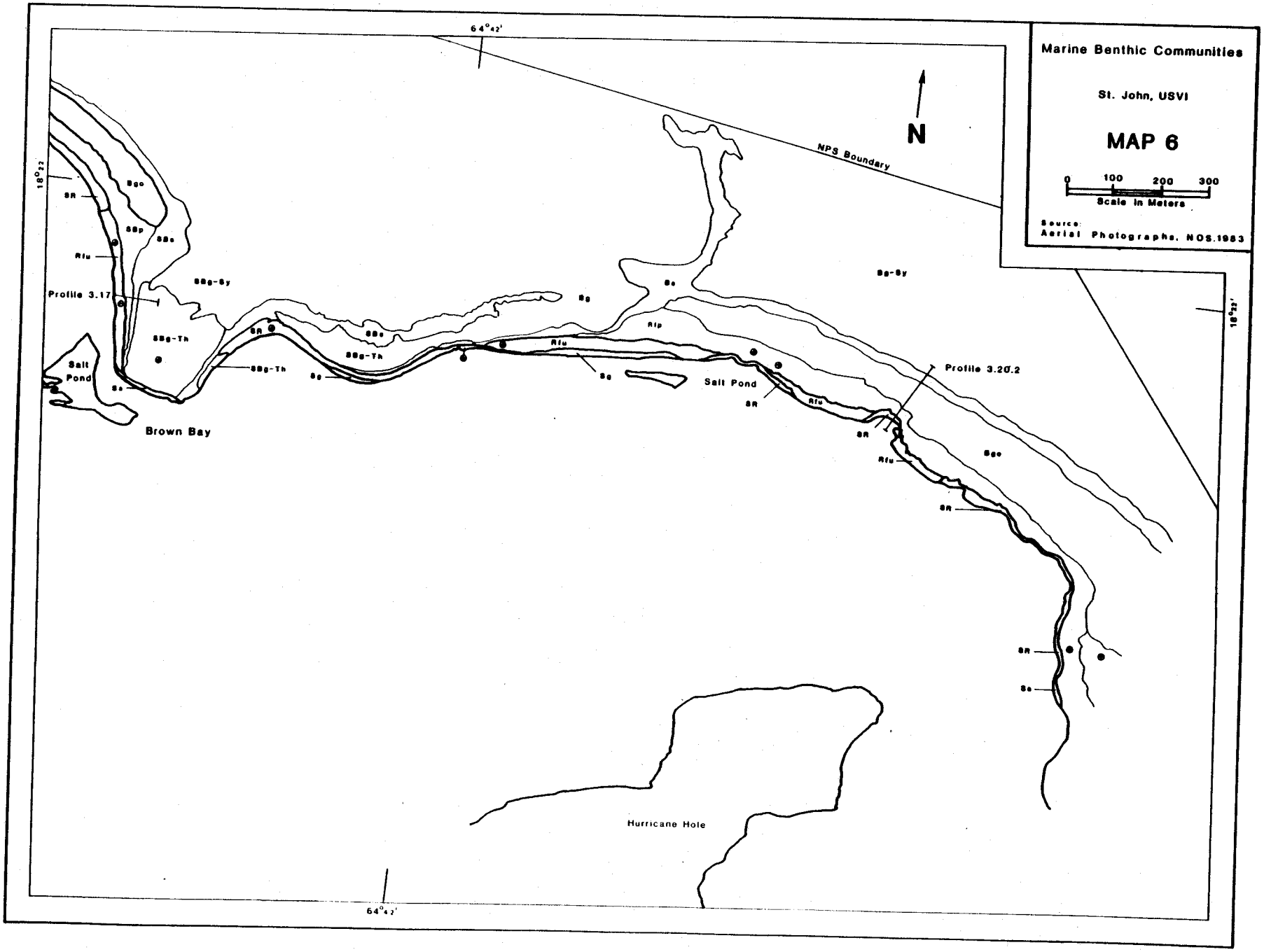

Marine Benthic Communities
St. John , USVI
MAP 1
0 100 200 300
Scale in Meters
Source
Aerial Photograaons NOS 1983
N
Reda Cay
Henley Cay
Turtle Bay
Scott Bay
Profile 3.4
Profile 3.3
Caneel Bay
Honeymoon Bay
Profile 3.2
Solomon Bay
Lind Pt.
Cruz Bay
NPS Boundary
64°46'
18°21'

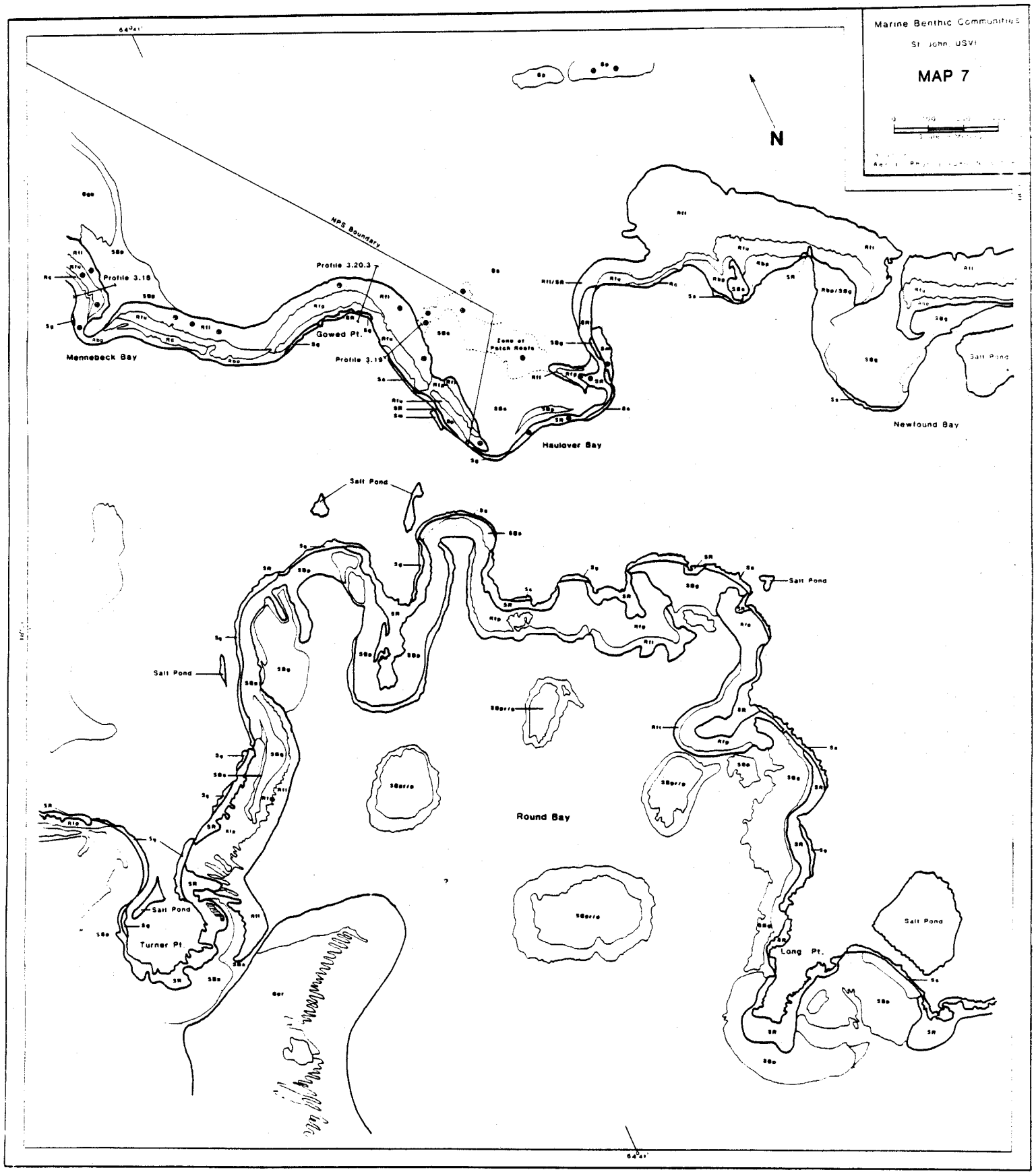

Marine Benthic Communities
St. John, USVI
MAP 2
0 100 200 300
Scale in Meters
Source
Aerial Photographs, NOS 1983
N
64°47'
18°21'
Profile 3.6
Profile 3.7
Ramgoat Cay
Hawksnest Point
Turtle Bay
Peace Hill
Hawksnest Bay
Bs
Bgo
SR
Rfp
Rfu
Rfl
SBs
SBg-Sy
SBg
SBp
Ss

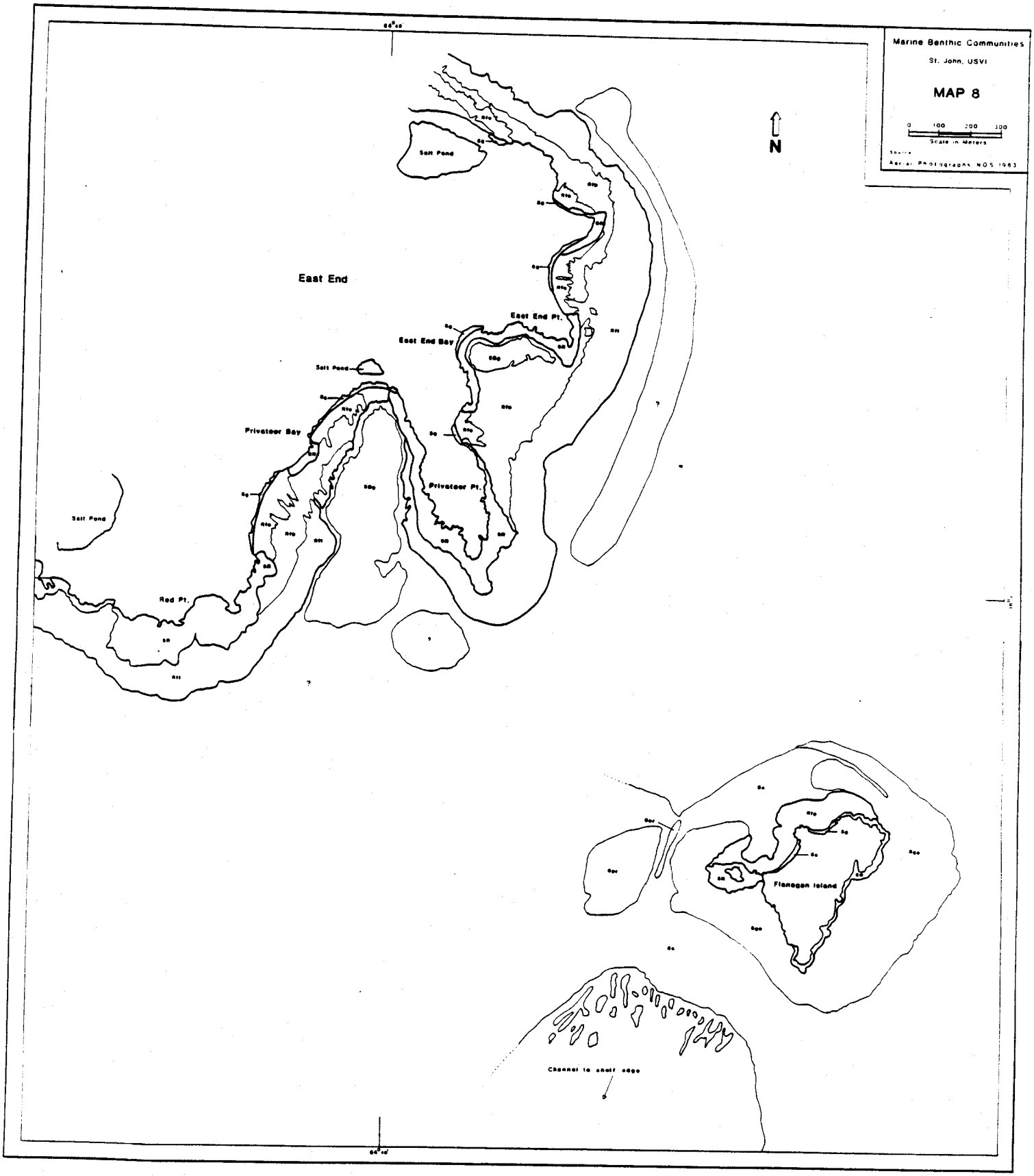

Marine Benthic Communities
St. John, USVI
MAP 3
0 100 200 300
Scale in Meters
Source:
Aerial Photographs, NOS 1983
N
NPS Boundary
Perkins Cay
Dennis Bay
Jumble Bay
Trunk Bay
Windswept Beach
Peter Bay
Little Cinnamon
Cinnamon Bay
Cinnamon Cay

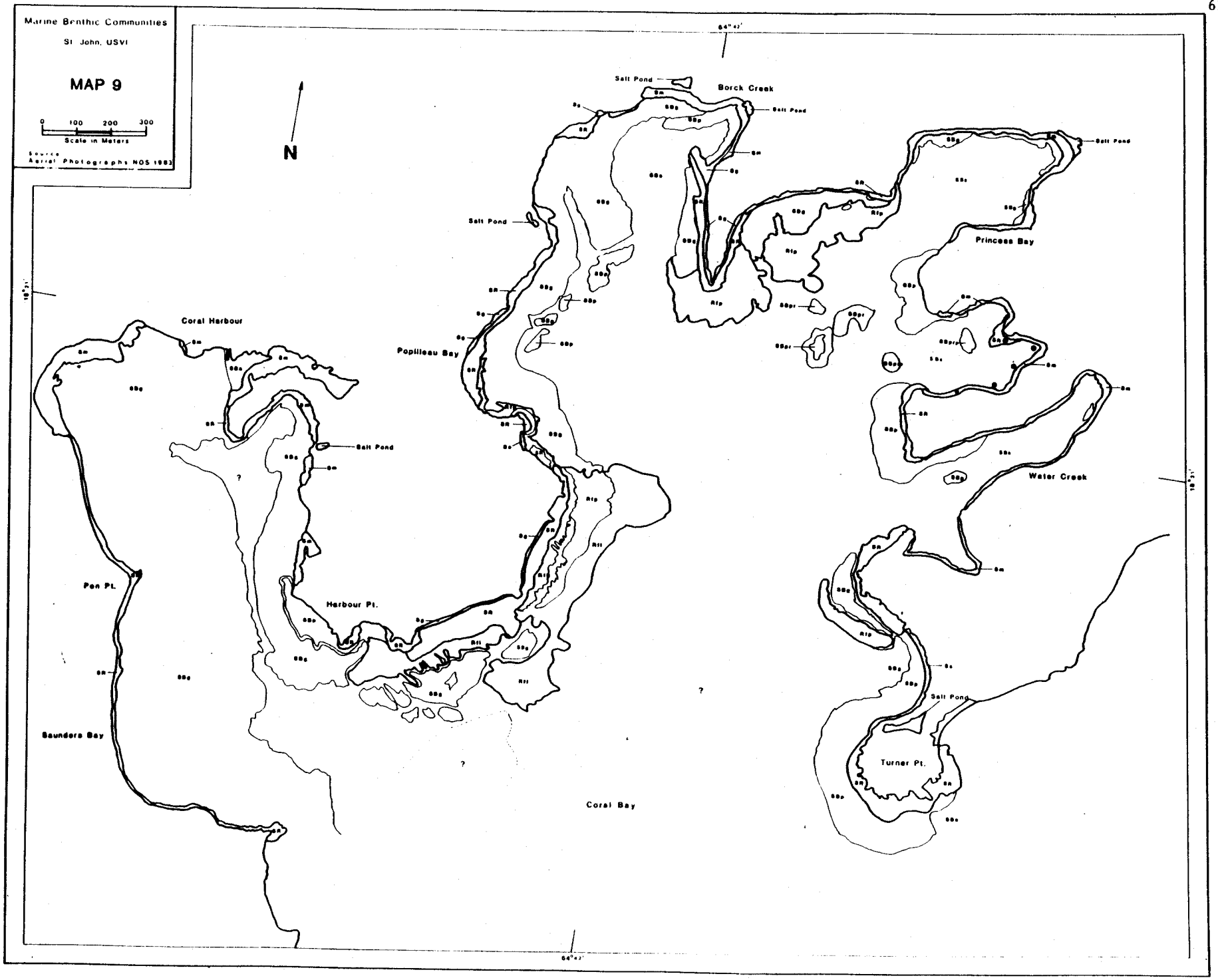

Marine Benthic Communities
St. John, USVI
Map 4
0 100 200 300
Scale in Meters
Source
Aerial Photographs, NOS, 1983
N
64°45'
18°22'
NPS Boundary
Profile 315
Profile 3201
Profile 314
Profile 313
Whistling Cay
Mary's Pt.
Salt Pond
Francis Bay
America Pt.
Cinnamon Bay
Maho Bay
Cay

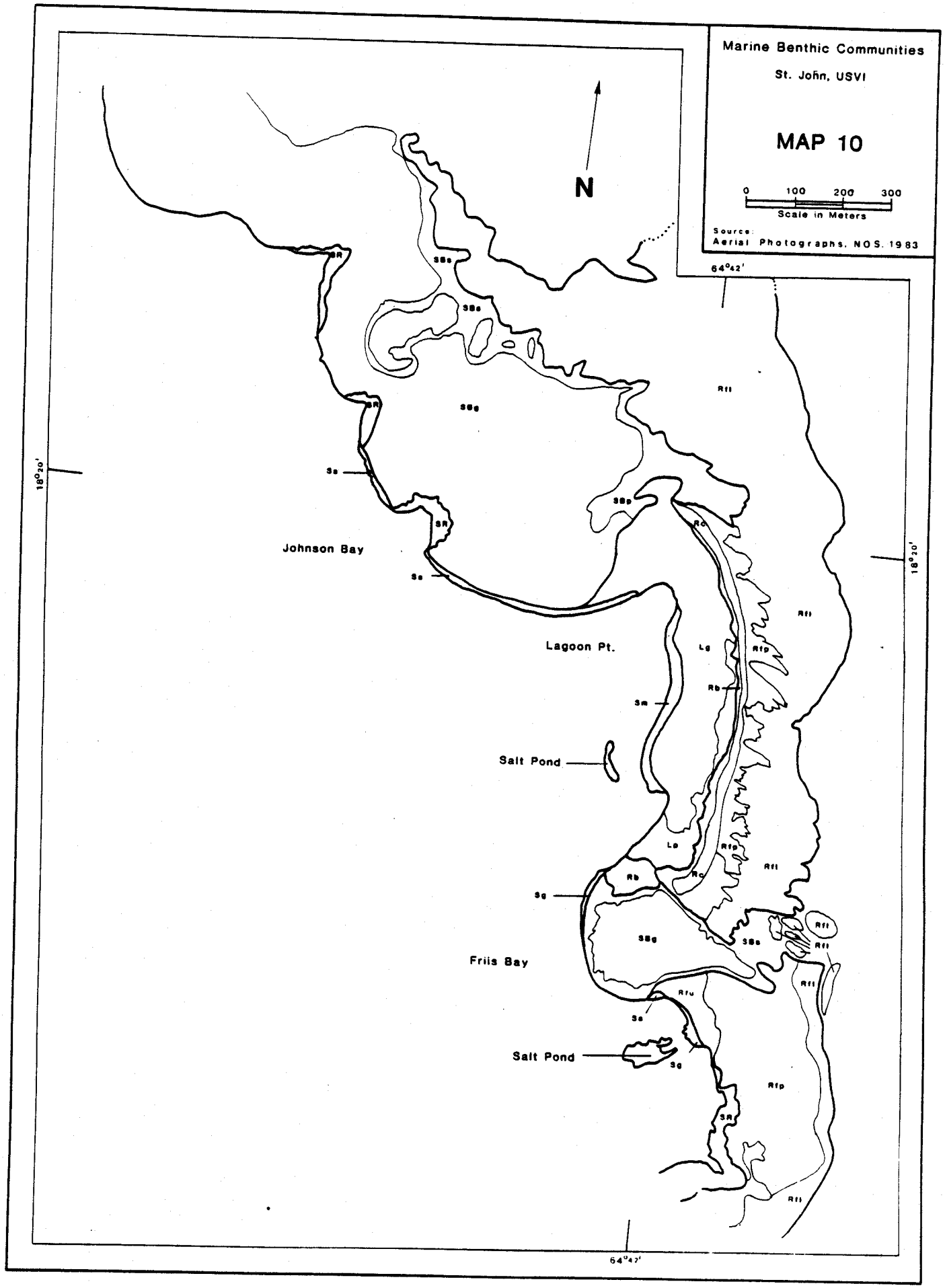

Marine Benthic Communities
St. John, USVI
MAP 5
0 100 200 300
Scale in Meters
Source
Aerial Photographs. N O S 1983
N
NPS Boundary
64°44'
18°22'
Salt Pond
Rb
Rlu
Rlp
Rs
Rm
SR
Sp
Sm
Ss
SBm
SBs
SBp
SBg
SBg-Th
SBg-Halod
SBg-Sy/Halod
Profile 316
Mary's Creek
Leinster Bay
Waterlemon Cay
Salt Pond

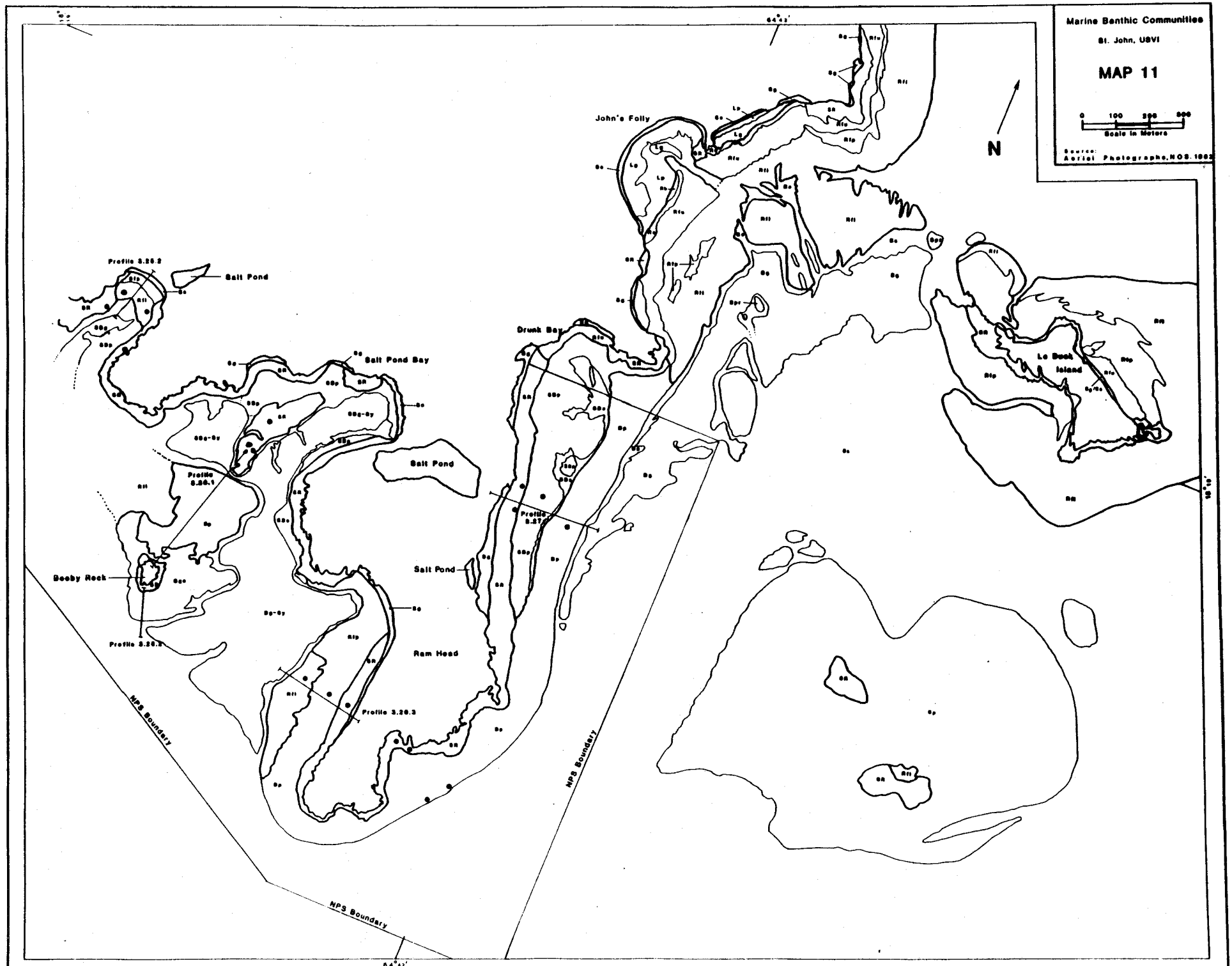

Marine Benthic Communities
St. John, USVI
MAP 6
0 100 200 300
Scale in Meters
Source:
Aerial Photographs, NOS.1983
N
NPS Boundary
64°42'
18°22'
Profile 3.17
Profile 3.20.2
Salt Pond
Salt Pond
Brown Bay
Hurricane Hole
SR
Rfu
Rlp
Sg
Se
Sgo
Sgp
SBe
SBg-Sy
SBg-Th
Sa-Sy

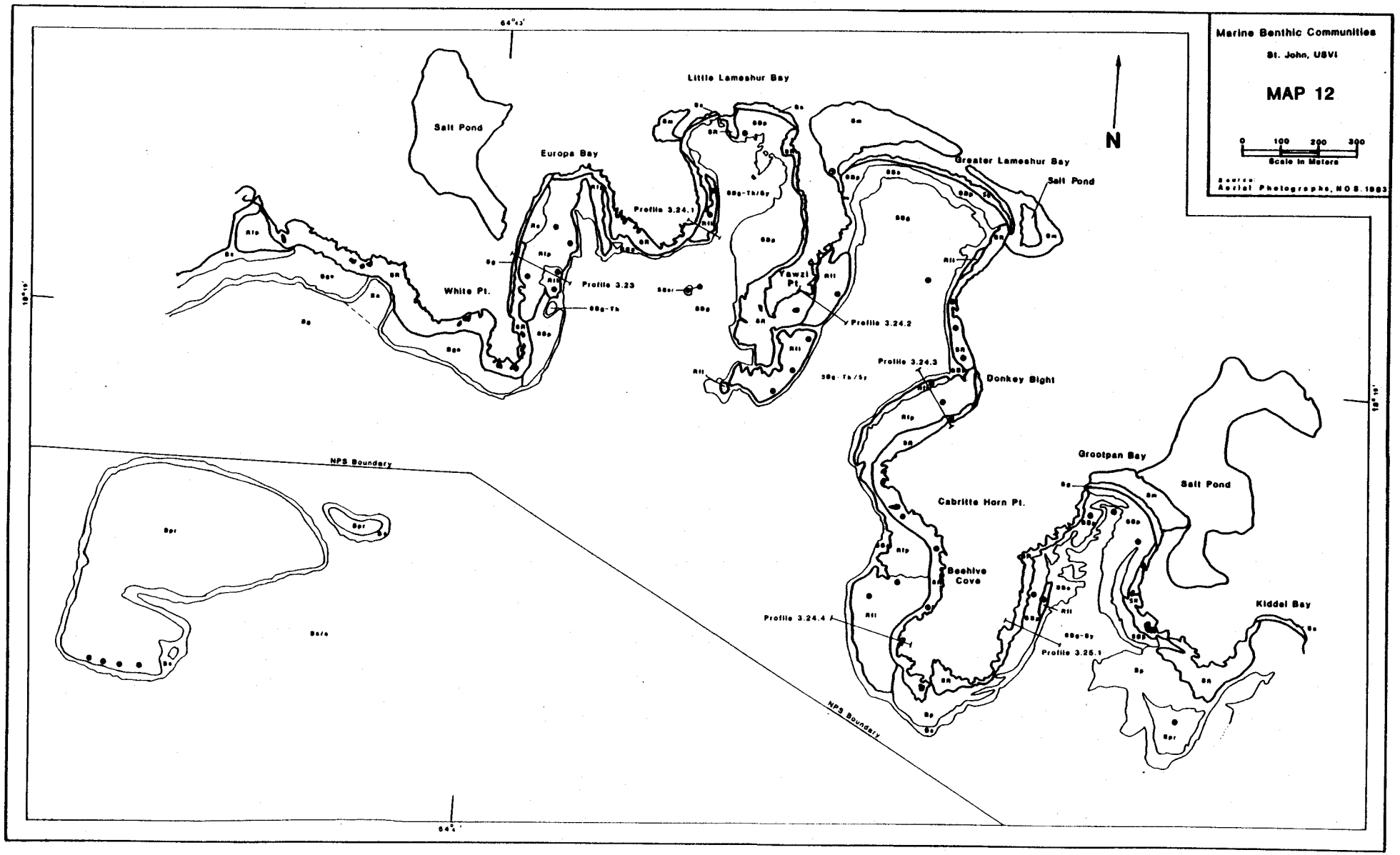

Marine Benthic Communities
St. John, USVI
MAP 7
N
NPS Boundary
Profile 3.18
Profile 3.20.3
Profile 3.19
Gowed Pt.
Zone of Patch Reefs
Mennebeck Bay
Haulover Bay
Newfound Bay
Salt Pond
Round Bay
Turner Pt.
Long Pt.
64°41'

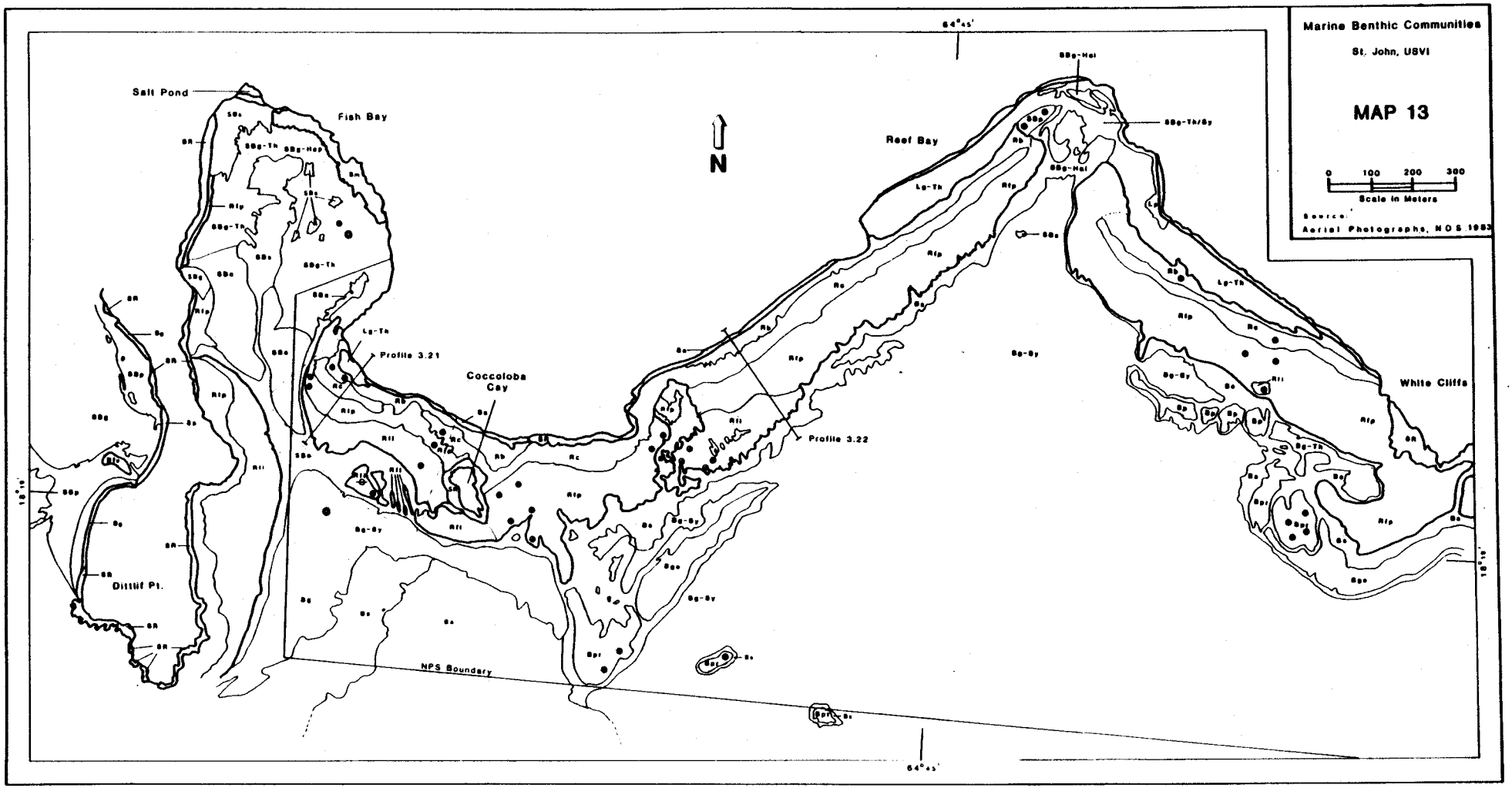

Marine Benthic Communities
St. John, USVI
MAP 8
0 100 200 300
Scale in Meters
Source
Aerial Photographs NOS 1983
N
East End
East End Pt.
East End Bay
Salt Pond
Privateer Bay
Privateer Pt.
Salt Pond
Red Pt.
Flanagan Island
Channel to small cays

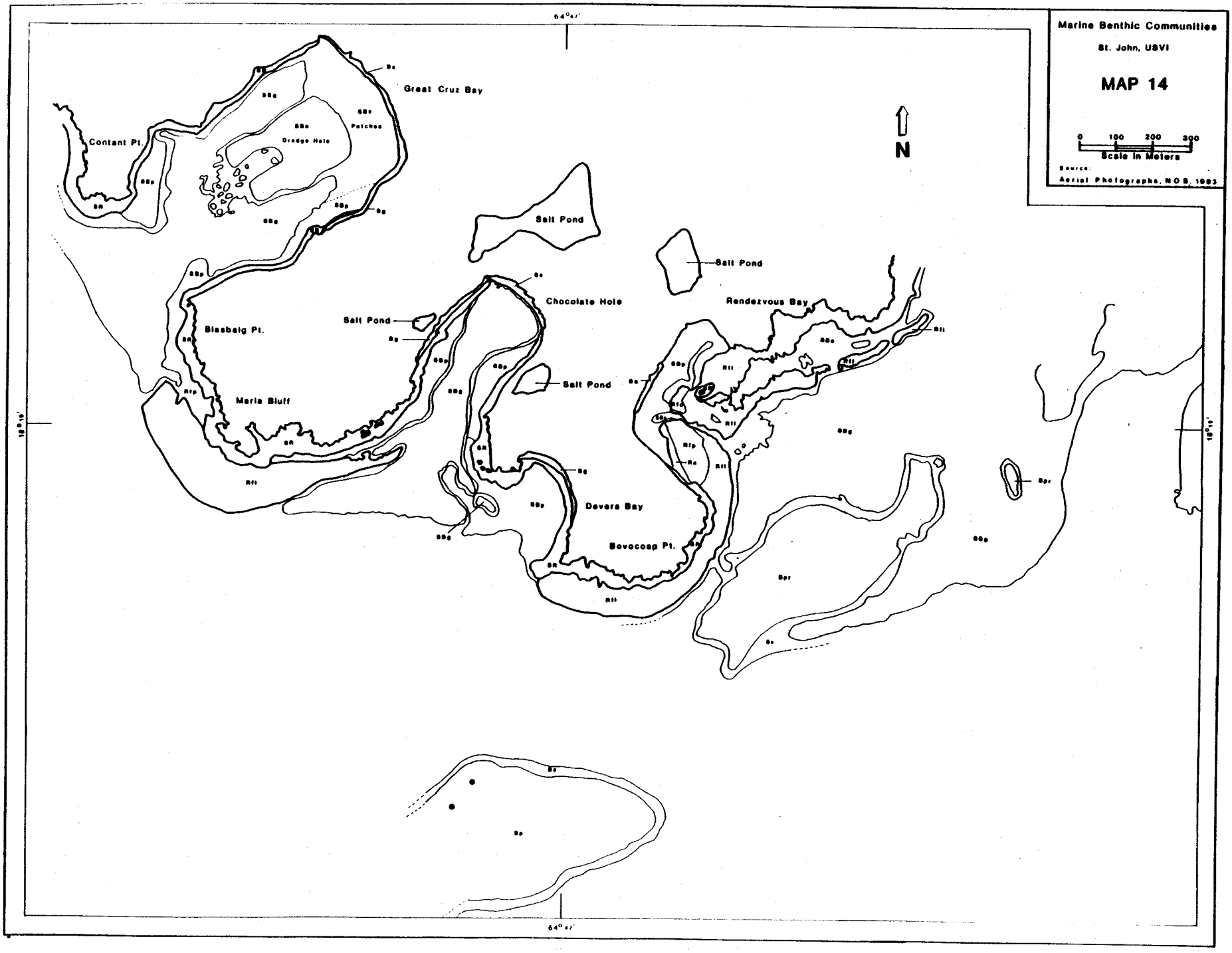

Marine Benthic Communities
St. John, USVI
MAP 9
0 100 200 300
Scale in Meters
Source
Aerial Photographs NOS 1983
N
64°42'
18°21'
Salt Pond
Borck Creek
Princess Bay
Coral Harbour
Popilleau Bay
Water Creek
Pen Pt.
Harbour Pt.
Saunders Bay
Coral Bay
Turner Pt.

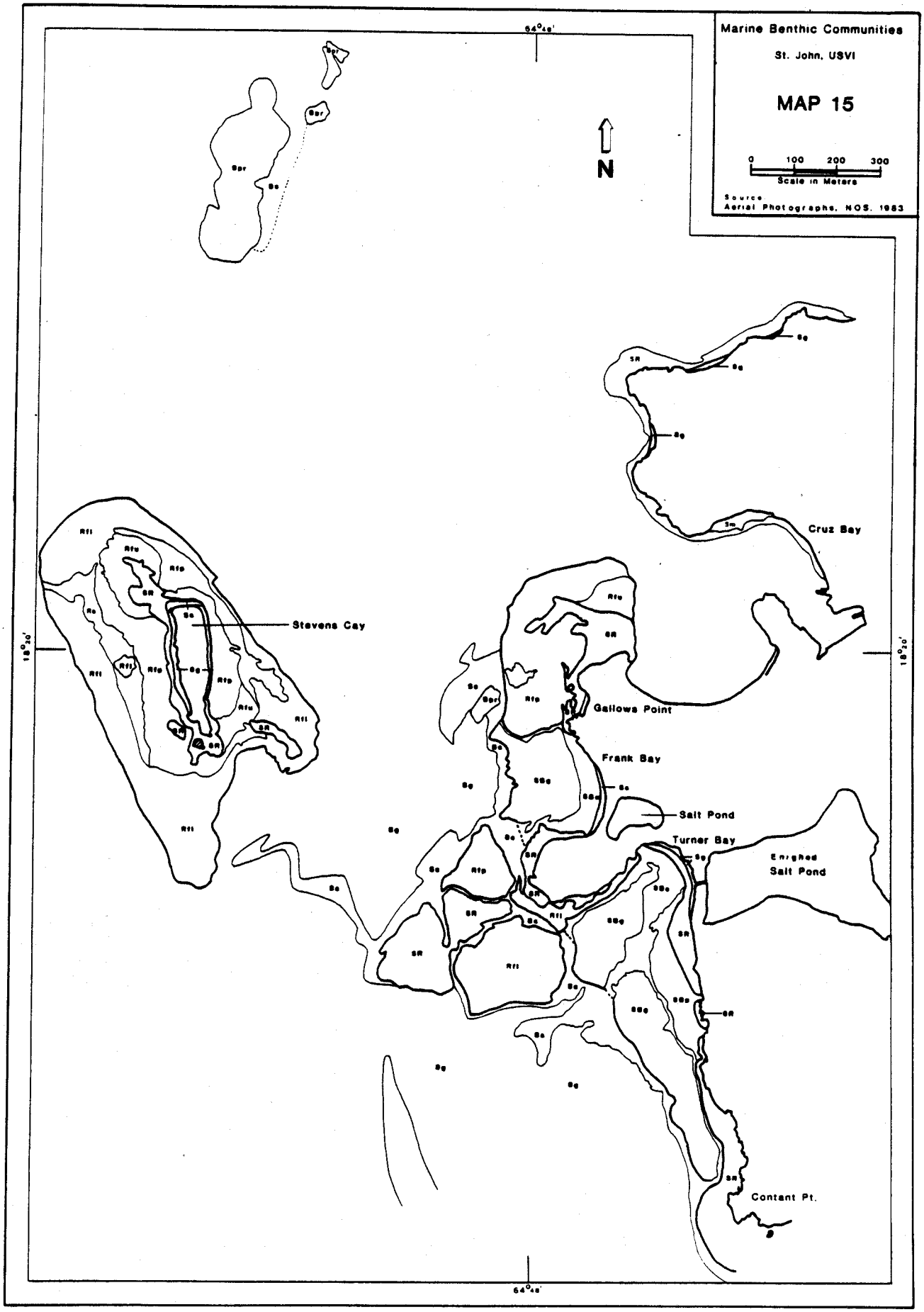

Marine Benthic Communities
St. John, USVI
MAP 10
0 100 200 300
Scale in Meters
Source:
Aerial Photographs, NOS. 1983
N
64°42'
18°20'
Johnson Bay
Lagoon Pt.
Salt Pond
Salt Pond
Friis Bay
SR
SBs
SBg
Se
SBp
Rc
Rfl
Lg
Rfp
Rb
Sm
Lo
Sg
Rfu

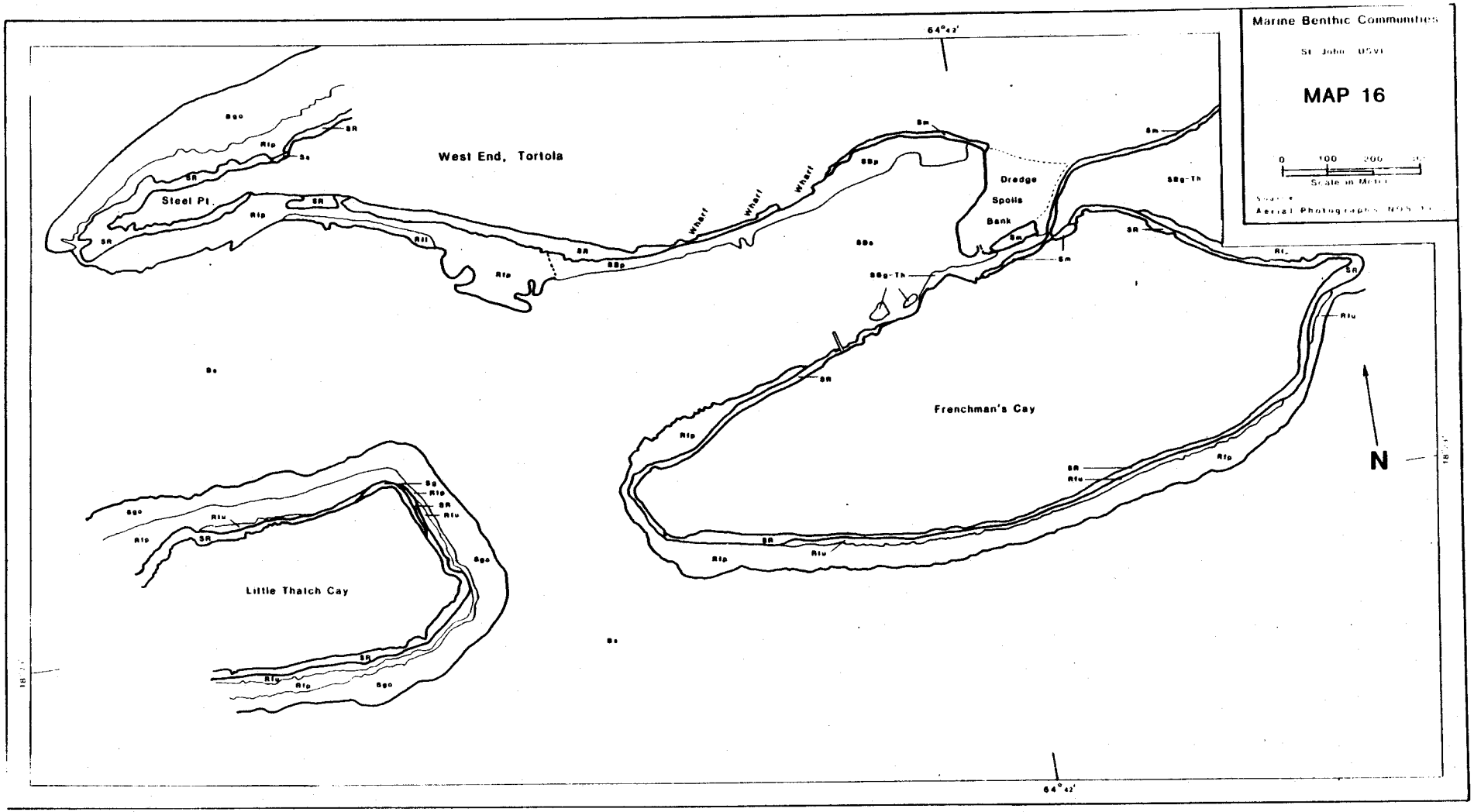

Marine Benthic Communities
St. John, USVI
MAP 11
0 100 200 300
Scale in Meters
Source: Aerial Photographs, NOS, 1983
N
John's Folly
Drunk Bay
Salt Pond
Salt Pond Bay
Salt Pond
Salt Pond
Booby Rock
Ram Head
Le Boeuf Island
Profile S.26.1
Profile S.26.2
Profile S.26.3
Profile S.27
NPS Boundary
NPS Boundary
NPS Boundary
64°42'
64°42'

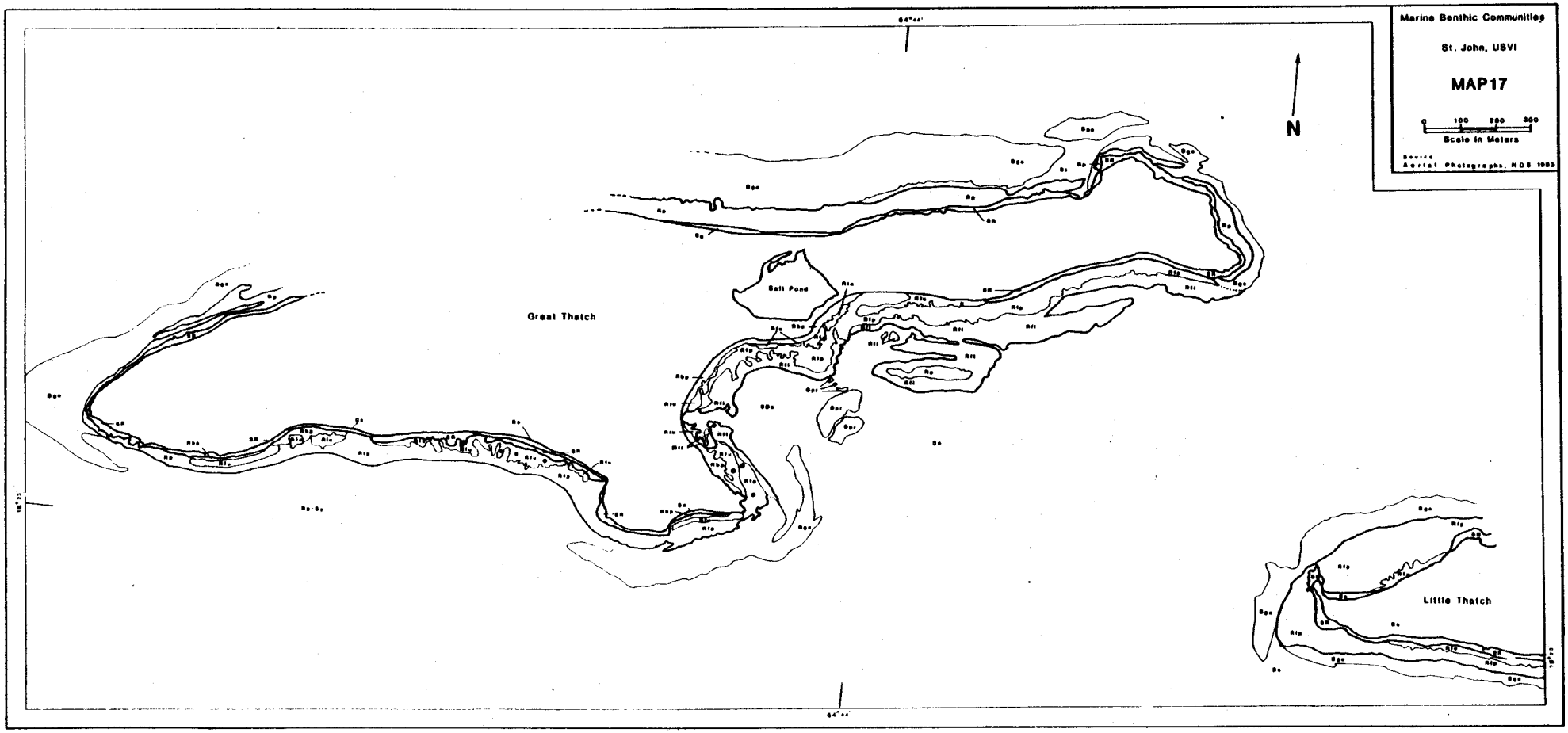

Marine Benthic Communities
St. John, USVI
MAP 12
0 100 200 300
Scale in Meters
Source: Aerial Photographs, NOS 1983
N
Little Lameshur Bay
Salt Pond
Europa Bay
Greater Lameshur Bay
Salt Pond
White Pt.
Bawzi Pt.
Profile 3.24.1
Profile 3.23
Profile 3.24.2
Profile 3.24.3
Donkey Bight
Grootpan Bay
Salt Pond
Cabritte Horn Pt.
Beehive Cove
Kiddel Bay
Profile 3.24.4
Profile 3.25.1
NPS Boundary
NPS Boundary


Marine Benthic Communities
St. John, USVI
MAP 13
0 100 200 300
Scale in Meters
Source:
Aerial Photographs, NOS 1983
N
Salt Pond
Fish Bay
Reef Bay
White Cliffs
Coccoloba Cay
Profile 3.21
Profile 3.22
Ditliff Pt.
NPS Boundary
64°45'
18°19'


Marine Benthic Communities
St. John, USVI
MAP 14
0 100 200 300
Scale in Meters
Source:
Aerial Photographs, NOS, 1983
N
64°47'
18°19'
Great Cruz Bay
Contant Pt.
Patches
Dredge Hole
Salt Pond
Salt Pond
Chocolate Hole
Rendezvous Bay
Blasbalg Pt.
Salt Pond
Salt Pond
Maria Bluff
Devers Bay
Bovocoap Pt.


Marine Benthic Communities
St. John, USVI
MAP 15
0 100 200 300
Scale in Meters
Source:
Aerial Photographs, NOS, 1983
N
64°46'
18°20'
Stevens Cay
Cruz Bay
Gallows Point
Frank Bay
Salt Pond
Turner Bay
Enrghed
Salt Pond
Contant Pt.


Marine Benthic Communities
St John USVI
MAP 16
0 100 200
Scale in Meters
Aerial Photographs NOS
64°42'
West End, Tortola
Steel Pt.
Dredge
Spoils
Bank
Wharf
Wharf
Wharf
Frenchman's Cay
Little Thatch Cay
N
64°42'


Marine Benthic Communities
St. John, USVI
MAP17
0 100 200 300
Scale in Meters
Source
Aerial Photographs, NOS 1983
N
Great Thatch
Salt Pond
Little Thatch

Dive Times:

APPENDIX II

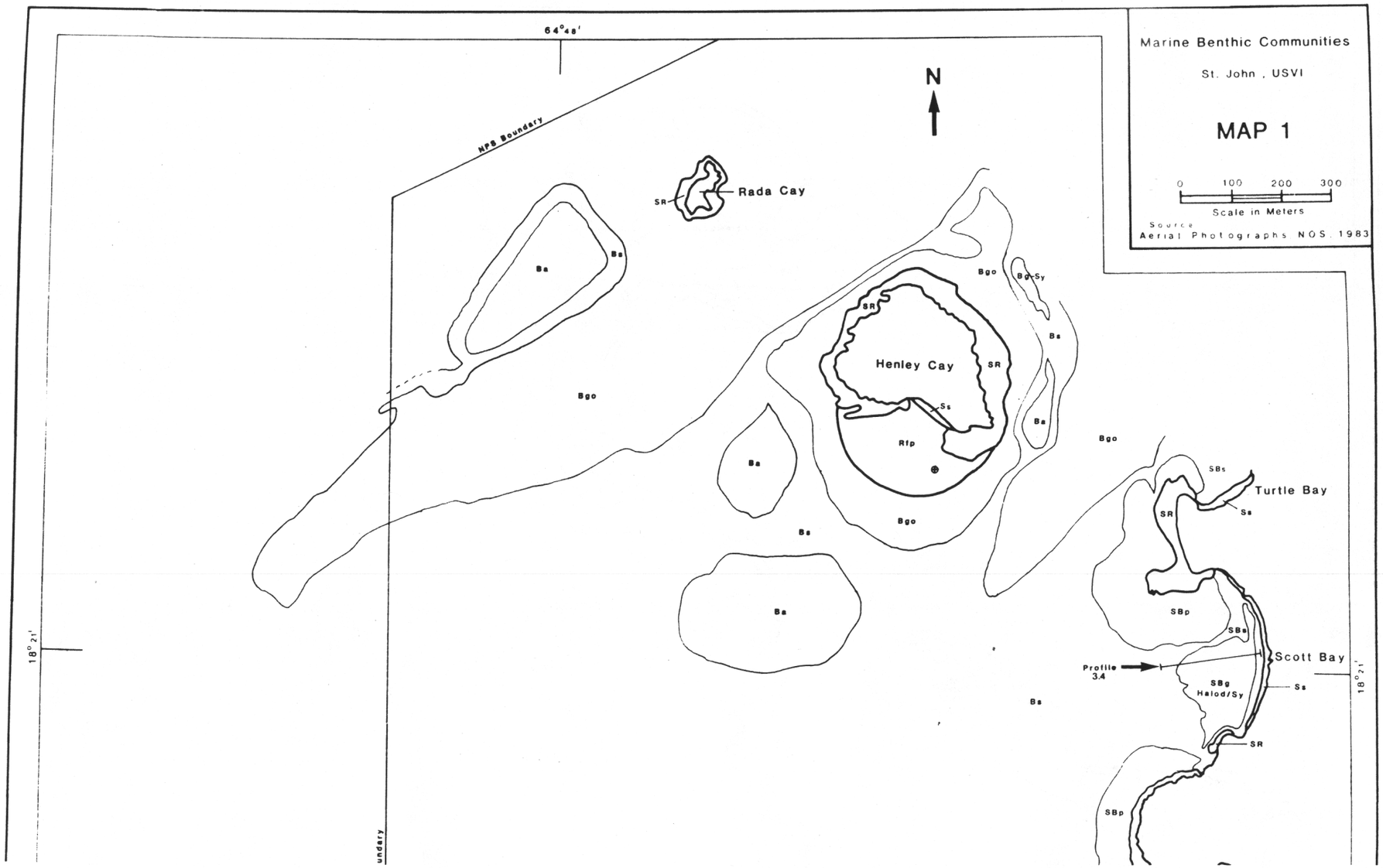
SAMPLE DATA SHEET

Location:

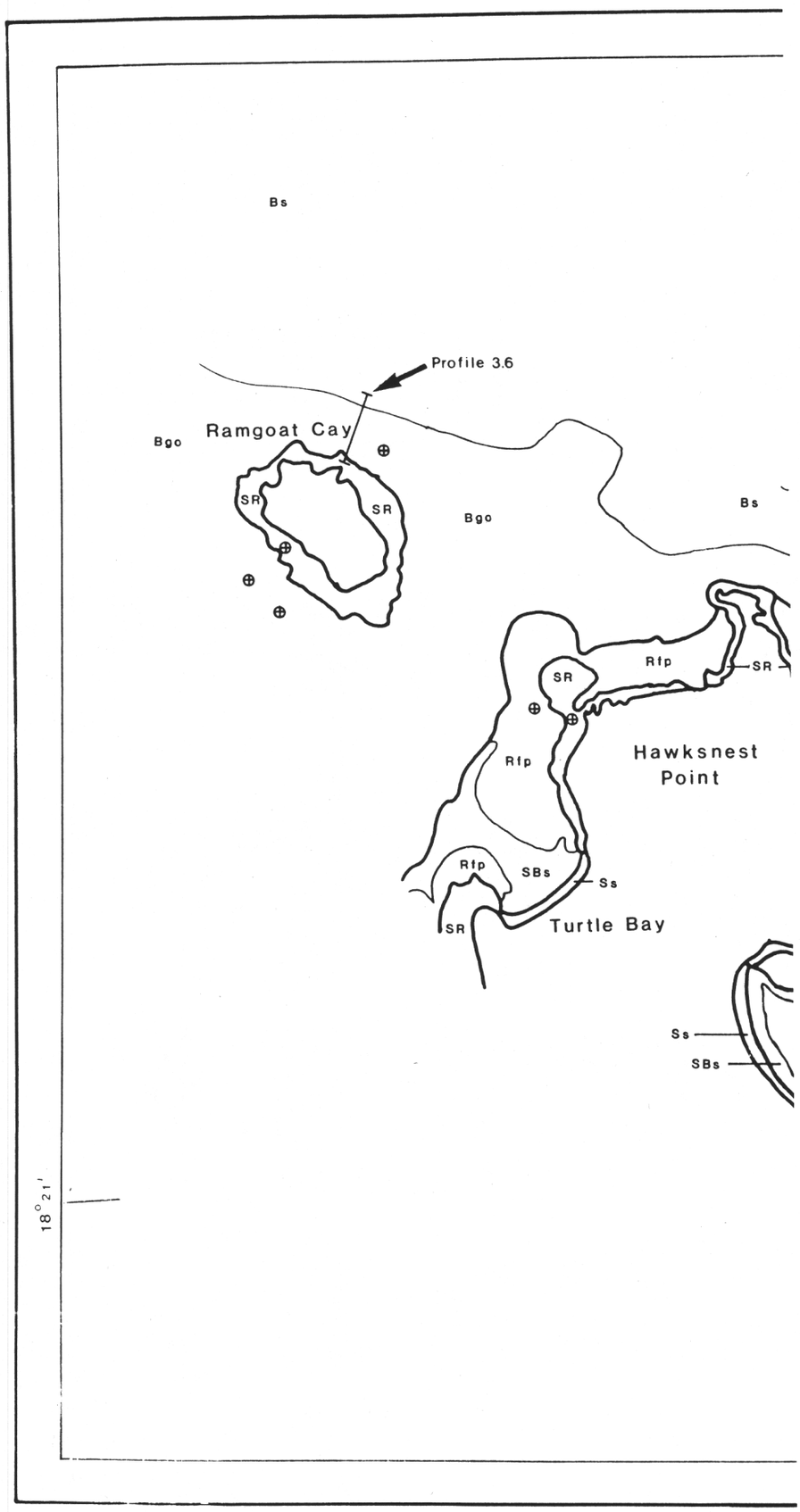
Radius Scanned:

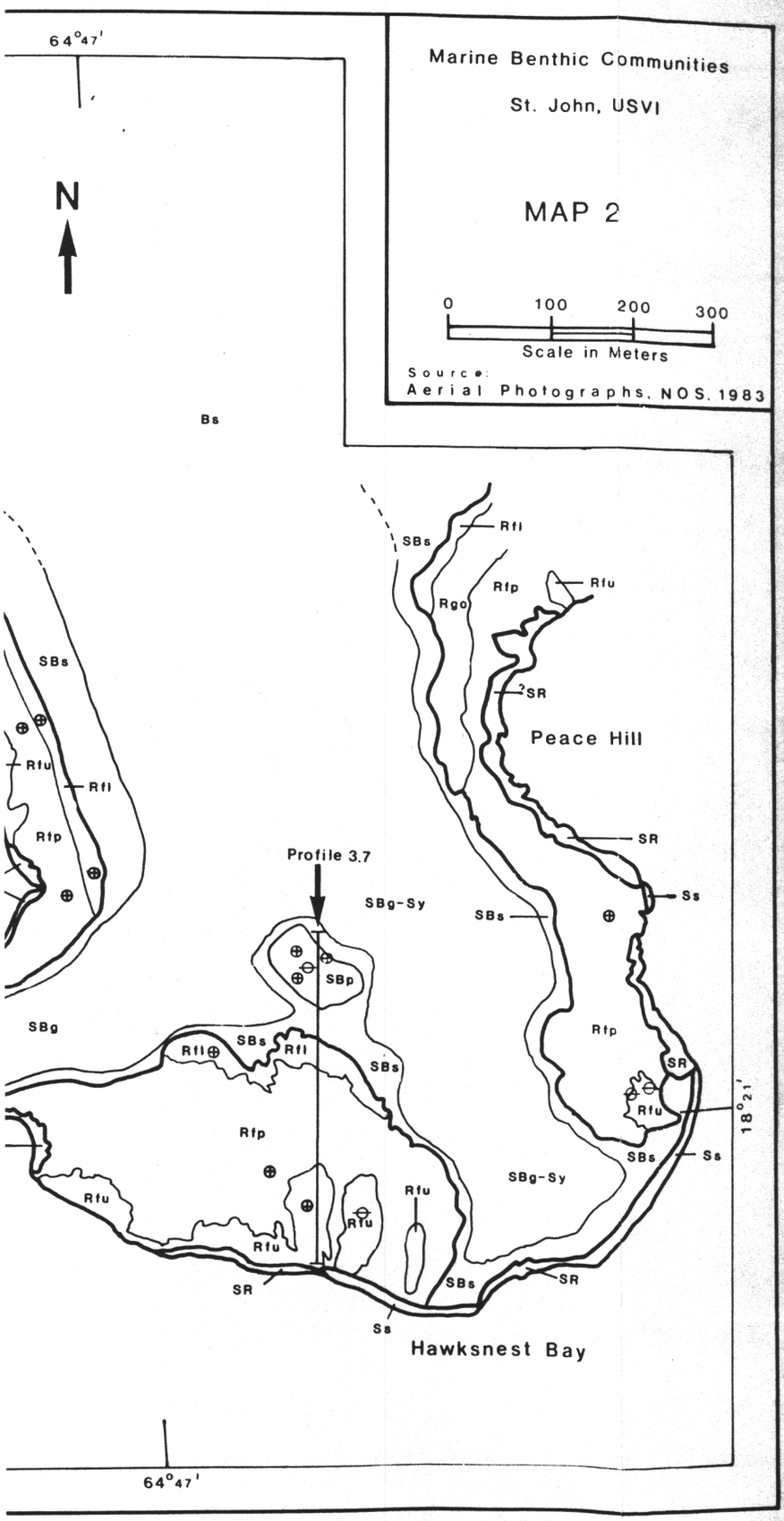
NUMBER OF INDIVIDUALS
(Including maximum/minimum size)

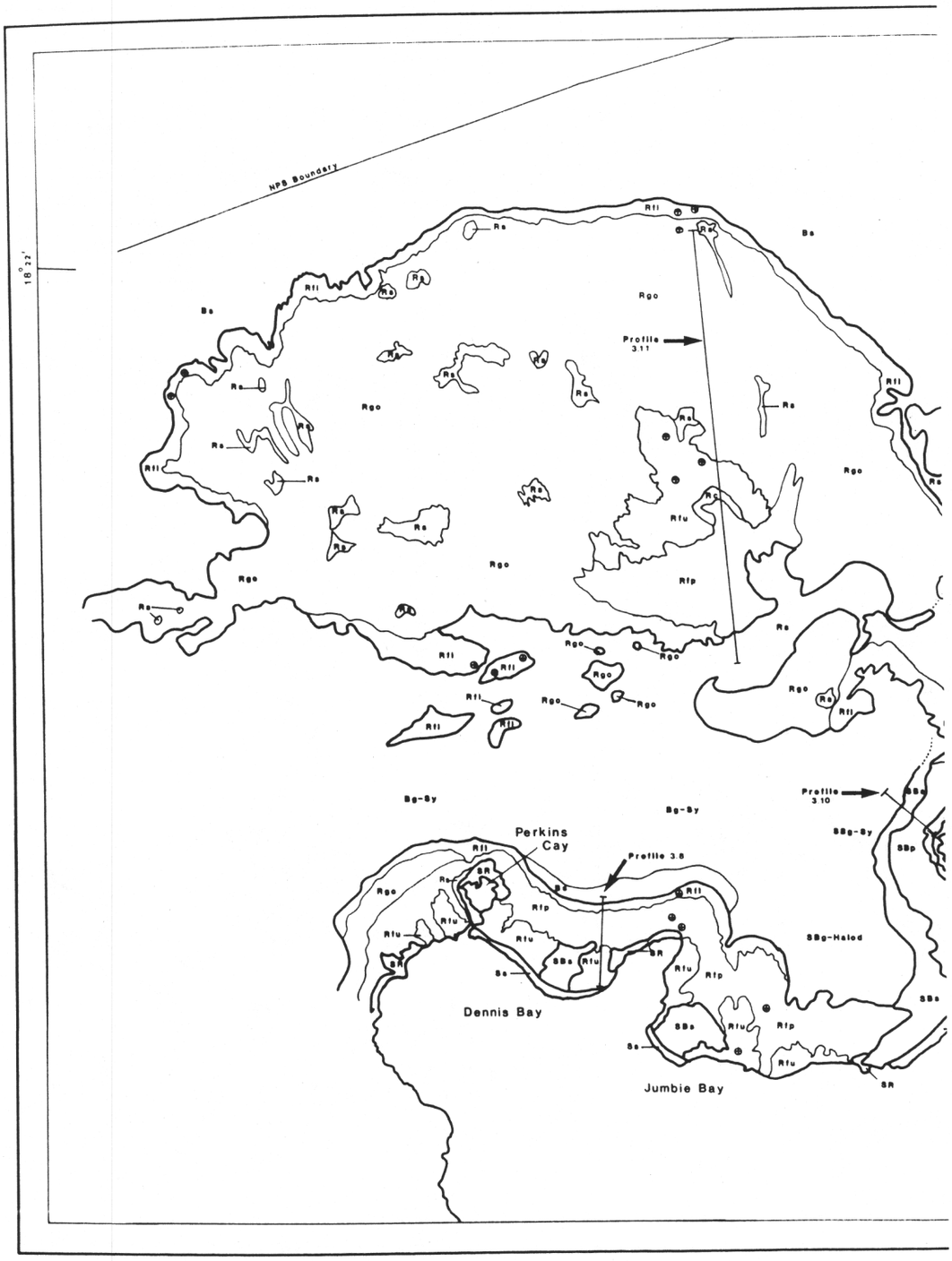
	Description of habitat with list of dominant invertebrates. Record depth, time of census and percent live coral cover		
Queen Triggerfish Blue striped Grunt White Grunt French Grunt			
Mutton Snapper Dog Snapper Grey Snapper Lane Snapper			
Schoolmaster Yellowtail Snapper Mahogany Snapper Angel fish			
Red Hind Graysby Coney Nassau Grouper			
Yellowfin Grouper Porgies Blue-Tang Doctor/Surgeon Fish			
Yellow Goatfish Spotted Goatfish Hogfish Spanish Hogfish			
Parrotfish Trunkfish Black Margate			
Carang Blue Runner Squirrelfish Barracuda			
Others (List)			

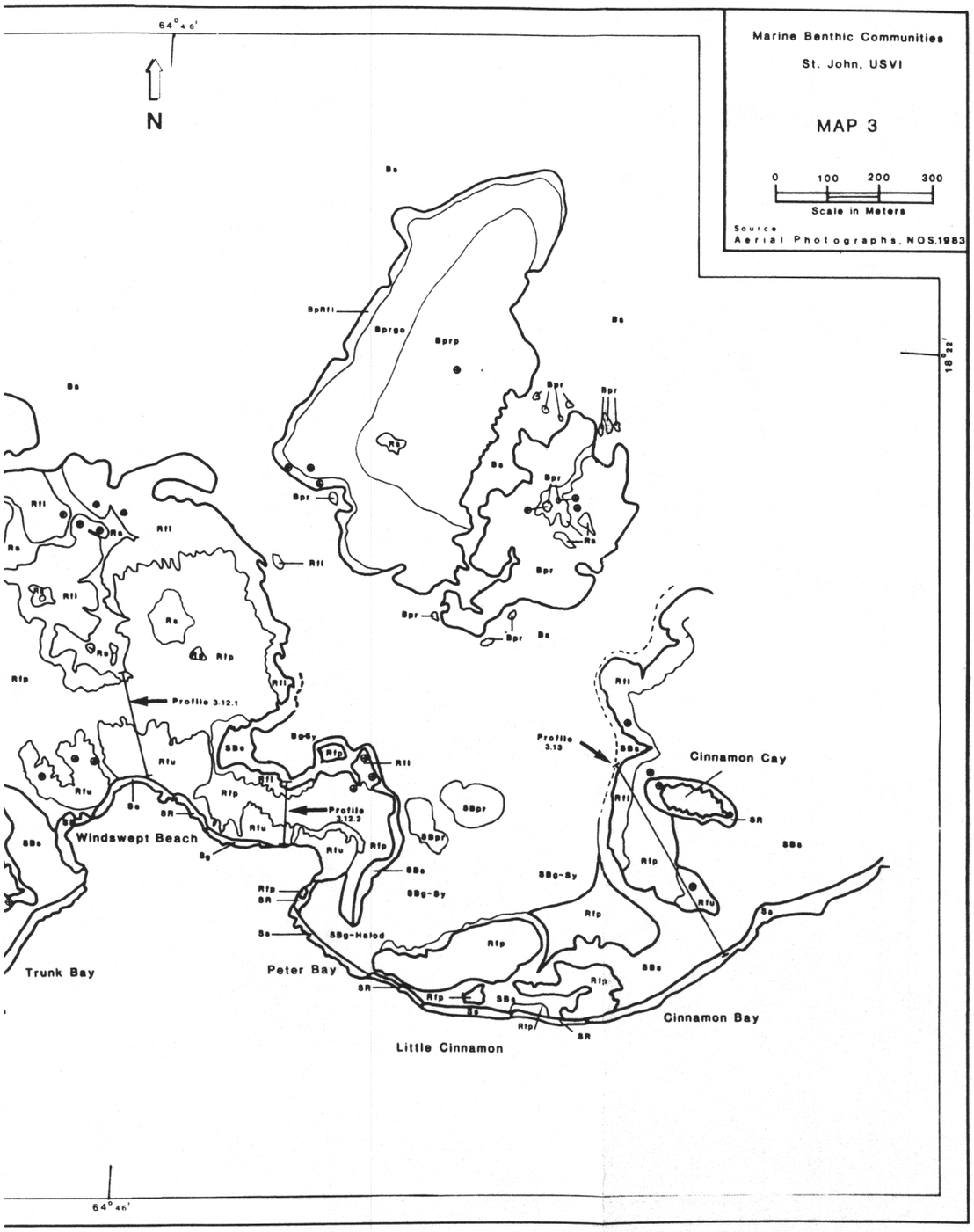

Marine Benthic Communities
St. John , USVI
MAP 1
0 100 200 300
Scale in Meters
Source
Aerial Photographs NOS 1983
N
64°48'
18°21'
NPS Boundary
Rada Cay
Henley Cay
Turtle Bay
Scott Bay
Profile 3.4
SR
Ba
Bgo
Bg-Sy
Ss
Rfp
SBs
SBp
SBg
Halod/Sy

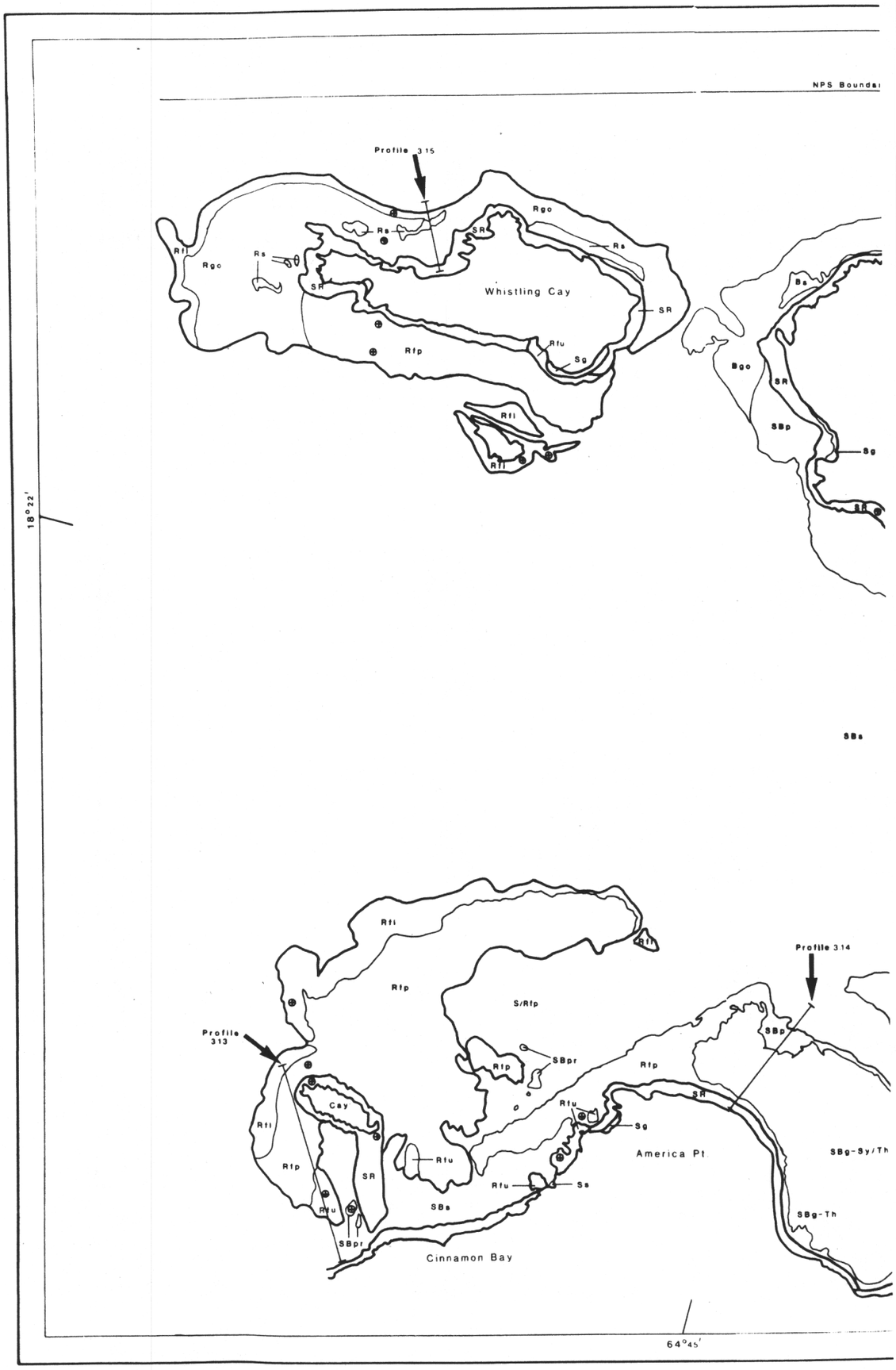
N
Ba
Ba
Profile 3.3
SBg-Sy
SBg-Halod
Caneel Bay
Ss
SBs
SBp
SR
Ss
SBg Halod/Sy
Honeymoon Bay
Profile 3.2
SBp
Rfg
SR
Ss
Ss
SR
Solomon Bay
Sg
SR
Sg
Lind Pt.
SBp
Sg
SBs
Sm
SR
SBs
SR
NPS Boundary
Cruz Bay
SBs
SBs
SBg-Halod/Sy
Sm
SBm
SR
Ss
SBs
SR
SR
SBs
SBg-Th
Ss
SBp
Sg
64°48'

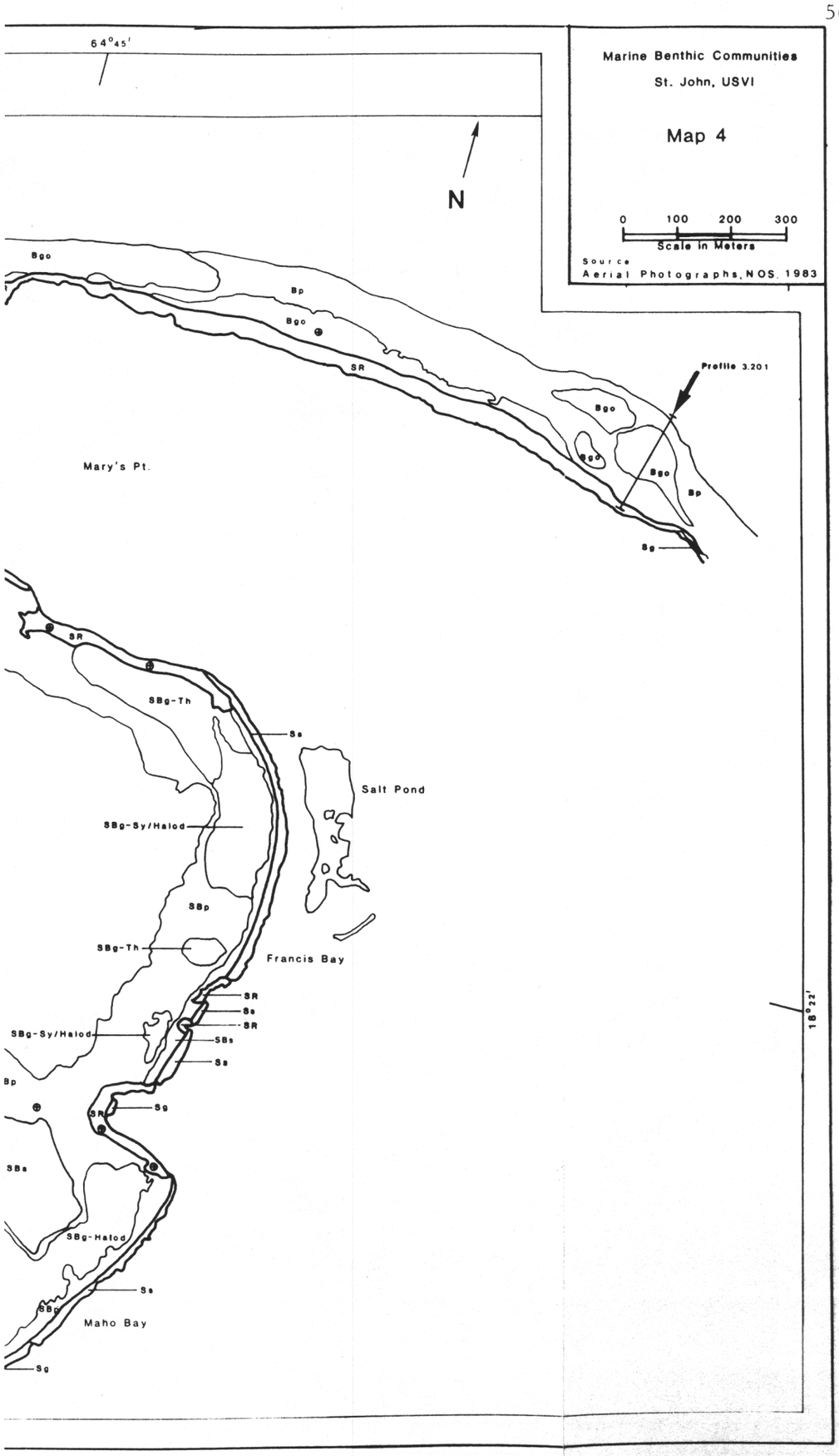

Bs
Profile 3.6
Ramgoat Cay
Bgo
SR
SR
Bgo
Bs
Rfp
SR
SR
Hawksnest
Point
Rfp
Rfp
SBs
Ss
SR
Turtle Bay
Ss
SBs
18°21'

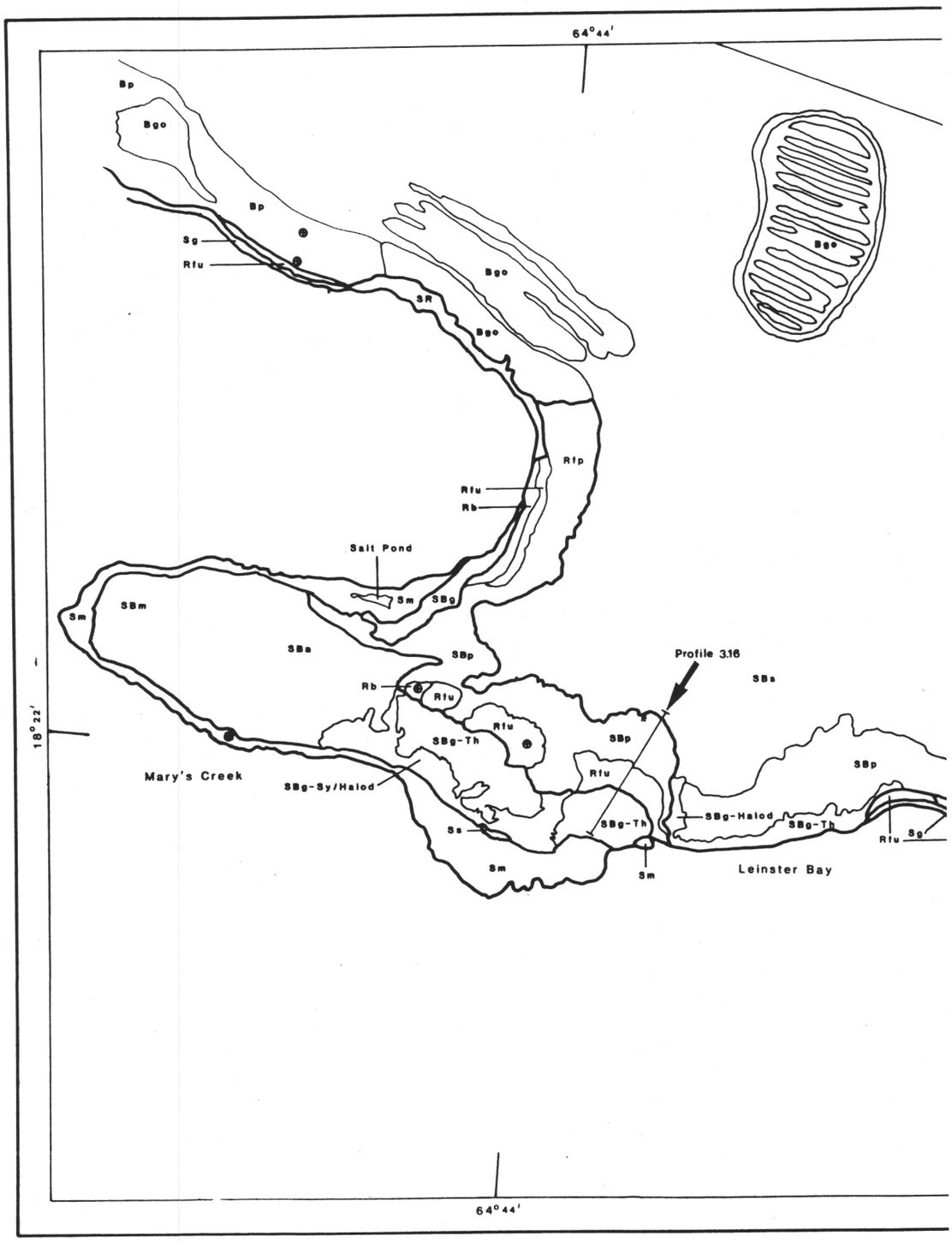

Marine Benthic Communities
St. John, USVI
MAP 2
0 100 200 300
Scale in Meters
Source:
Aerial Photographs, NOS. 1983
64°47'
N
Bs
SBs
Rfl
Rfp
Rfu
Rgo
SR
Peace Hill
Ss
Profile 3.7
SBg-Sy
SBp
SBg
Rfl
Hawksnest Bay
18°21'
64°47'

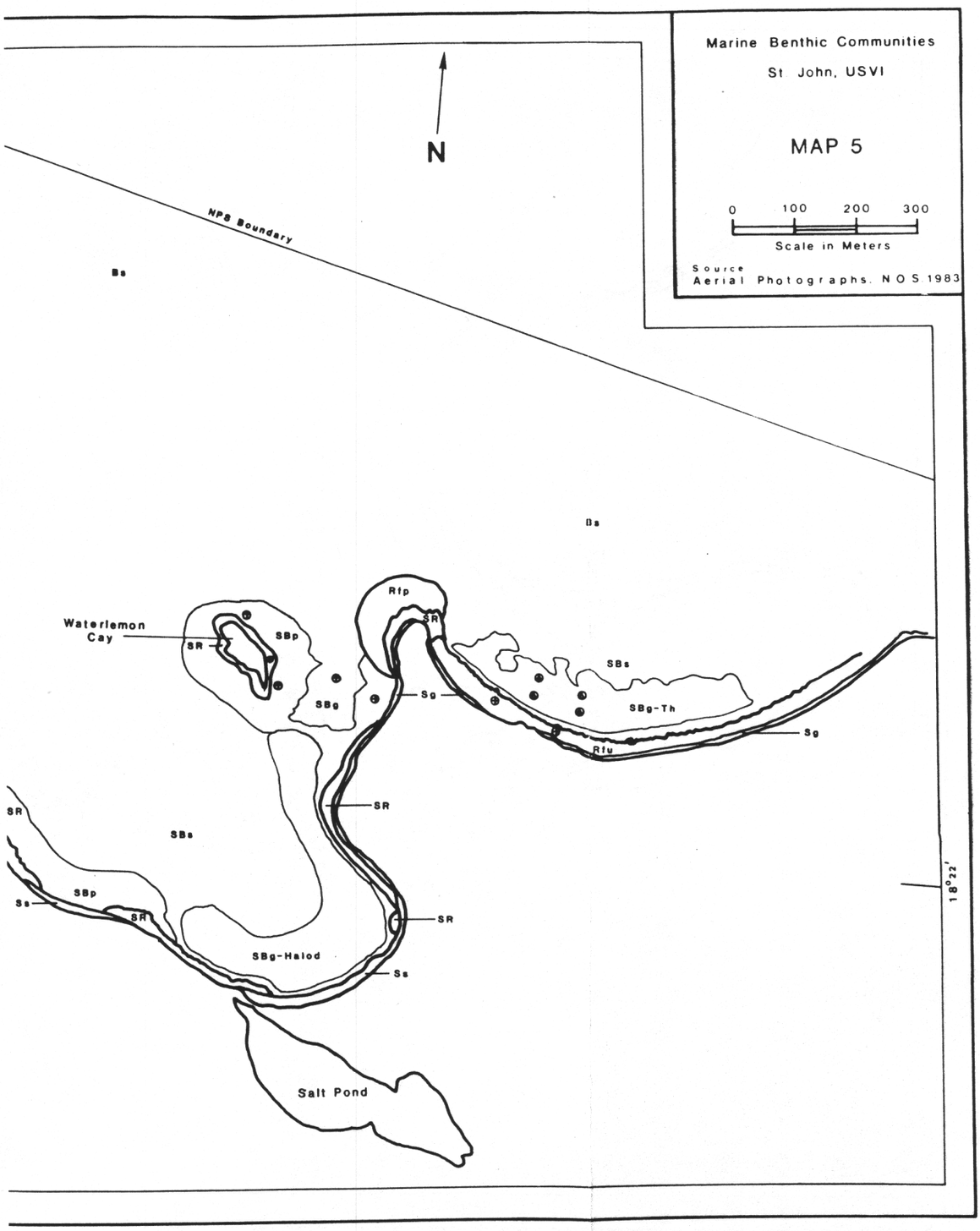

NPS Boundary
18° 22'
Rfl
Rs
Rgo
Rfu
Rfp
Profile 3.11
Profile 3.10
Profile 3.8
Bg-By
SBg-By
SBg-Halod
SBp
SBs
SR
Perkins Cay
Dennis Bay
Jumbie Bay

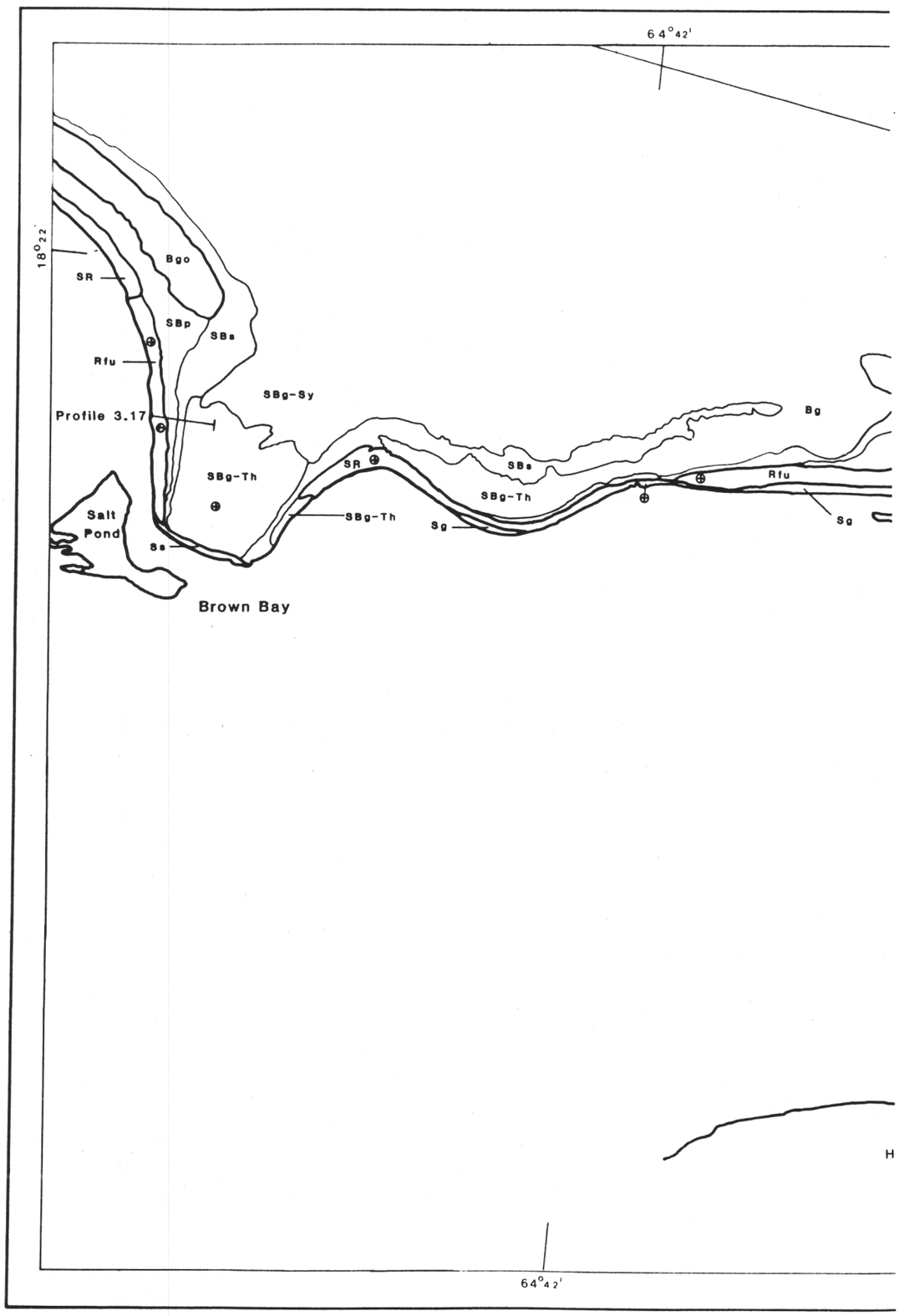

Marine Benthic Communities
St. John, USVI
MAP 3
0 100 200 300
Scale in Meters
Source
Aerial Photographs, NOS.1983
64°46'
18°22'
N
Profile 3.12.1
Profile 3.12.2
Profile 3.13
Windswept Beach
Trunk Bay
Peter Bay
Little Cinnamon
Cinnamon Cay
Cinnamon Bay
Rfp
Rfu
Rfl
Rs
Bpr
Bprgo
BpRfl
Bprp
Be
SBe
SBg-By
SBg-Haled
SBpr
SR
Sg

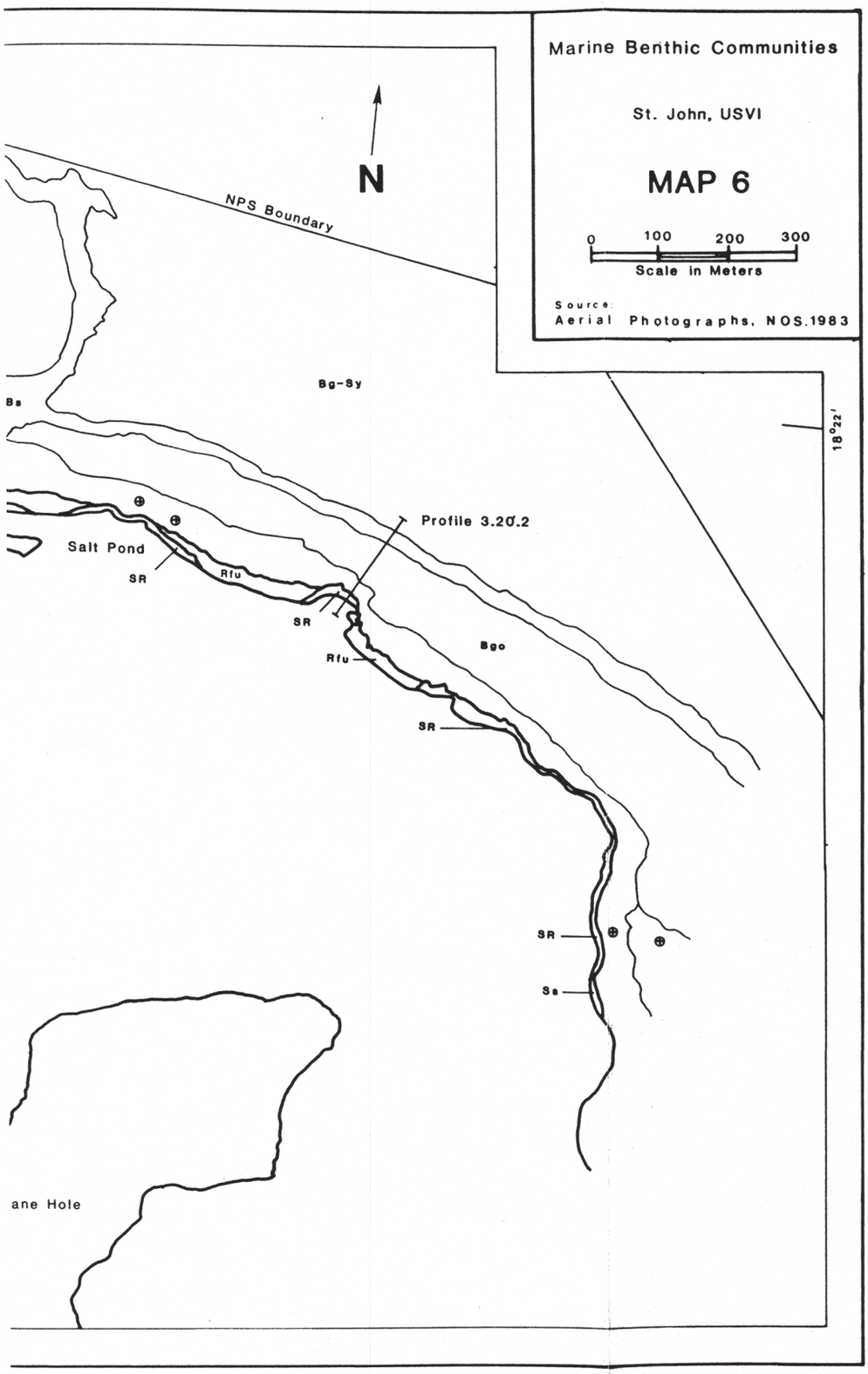

NPS Boundar
Profile 315
Rgo
Rs
SR
Rfl
Rgo
Rs
SR
Whistling Cay
Rs
SR
Rfp
Rfu
Sg
Rfl
Rfl
Bs
Bgo
SR
SBp
Sg
SR
18°22'
SBs
Rfl
Rfl
Profile 314
Rfp
S/Rfp
Profile 313
SBp
Rfp
SBpr
Rfp
Cay
Rfu
SR
Sg
Rfl
Rfp
SR
Rfu
America Pt
SBg-Sy/Th
Rfu
Ss
Rfu
SBs
SBg-Th
SBpr
Cinnamon Bay
64°45'

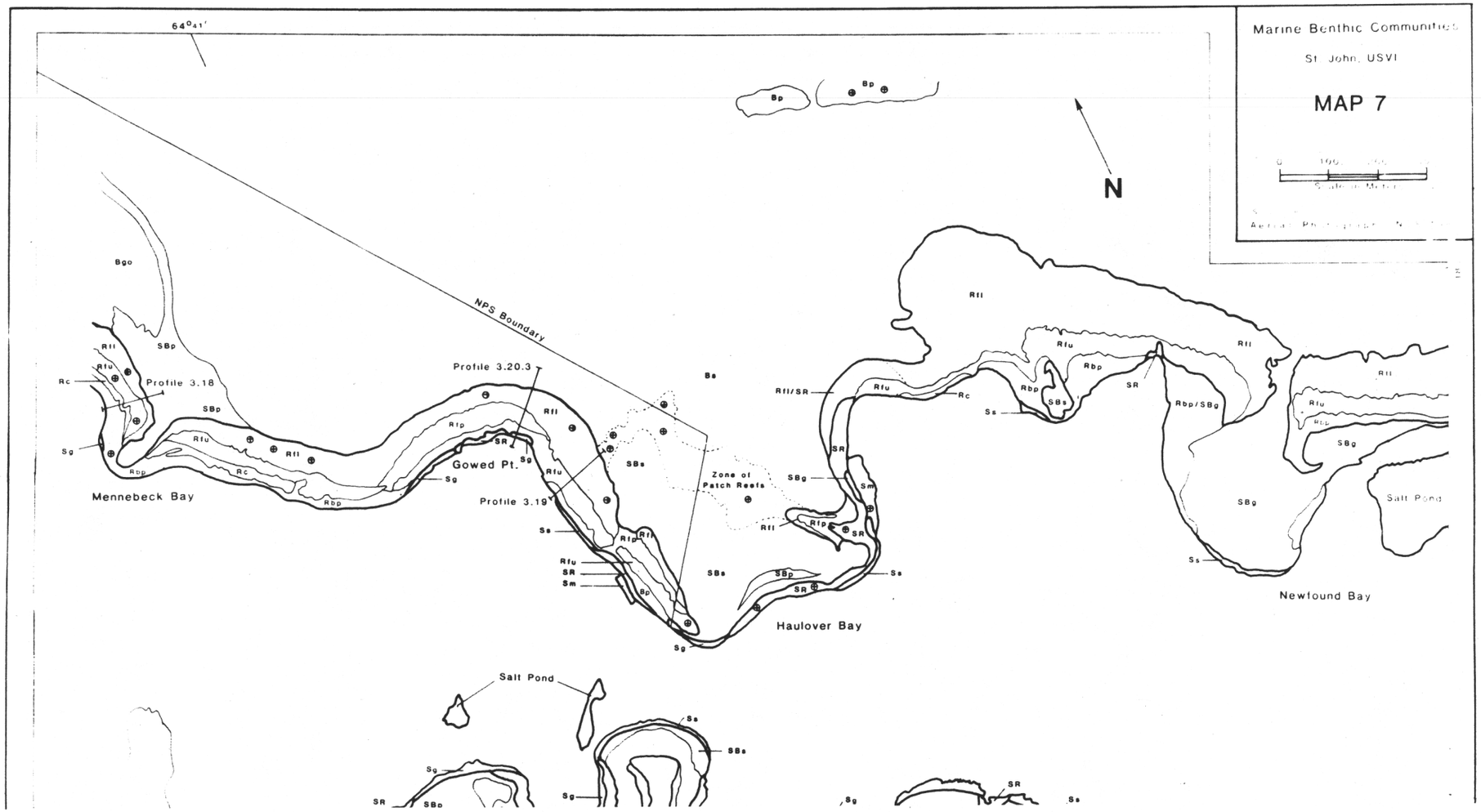

64°45'
N
Marine Benthic Communities
St. John, USVI
Map 4
0 100 200 300
Scale in Meters
Source
Aerial Photographs, NOS, 1983
Bgo
Bp
Bgo
SR
Profile 3.201
Bgo
Bgo
Bgo
Bp
Sg
Mary's Pt.
SR
SBg-Th
Se
Salt Pond
SBg-Sy/Halod
SBp
SBg-Th
Francis Bay
SR
Se
SR
SBg-Sy/Halod
SBs
Se
Bp
SR
Sg
SBs
SBg-Halod
Se
SBg
Maho Bay
Sg
18°22'

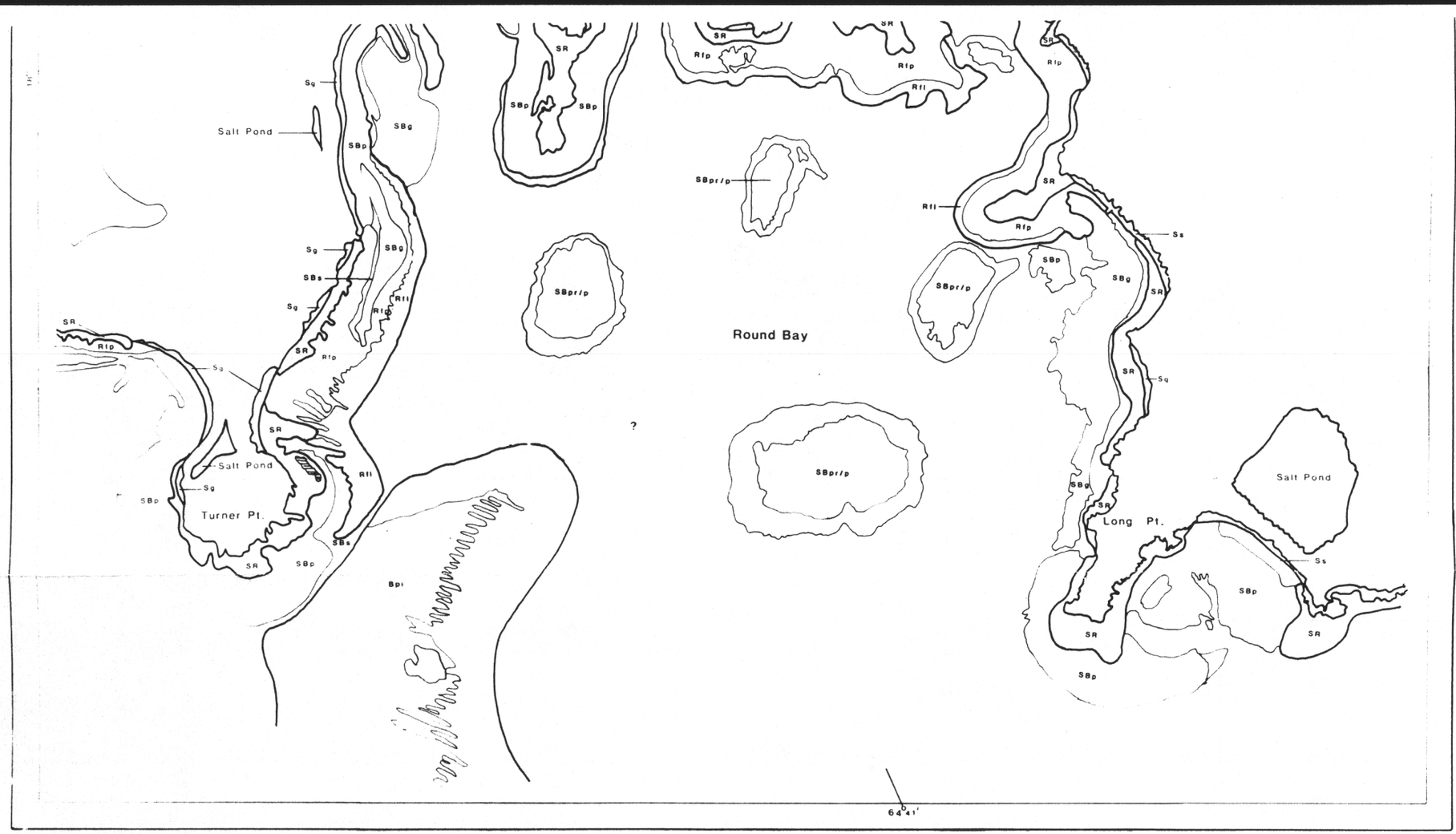

64°44'
18°22'
Bp
Bgo
Sg
Rfu
SR
Rfp
Rb
Salt Pond
Sm
SBg
SBm
SBs
SBp
Profile 3.16
Rfu
SBg-Th
Mary's Creek
SBg-Sy/Halod
Ss
SBg-Halod
Leinster Bay

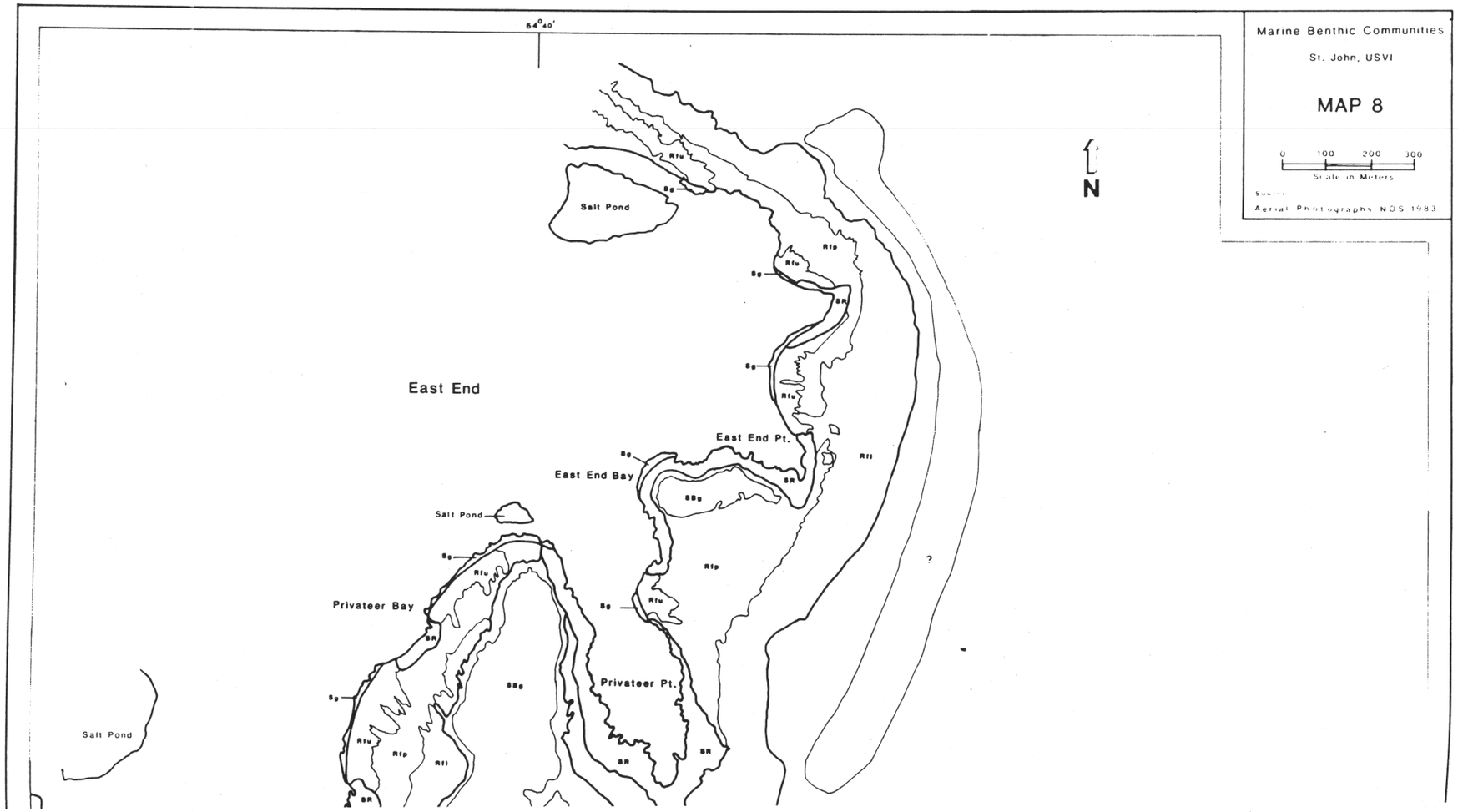

Marine Benthic Communities
St. John, USVI
MAP 5
0 100 200 300
Scale in Meters
Source
Aerial Photographs. N O S 1983
N
NPS Boundary
Bs
Ds
Waterlemon Cay
SR
SBp
SBg
Sg
Rfp
SR
SBs
SBg-Th
Sg
Rfu
SR
SR
SBs
SBp
Ss
SR
SR
SBg-Halod
Ss
Salt Pond
18°22'


64°42'
18°22'
Bgo
SR
SBp
SBs
Rfu
SBg-Sy
Profile 3.17
Bg
SR
SBs
Rfu
SBg-Th
SBg-Th
Salt
Pond
SBg-Th
Sg
Sg
Ss
Brown Bay
H
64°42'


Marine Benthic Communities
St. John, USVI
MAP 6
0 100 200 300
Scale in Meters
Source:
Aerial Photographs, NOS.1983
N
NPS Boundary
Bs
Bg-Sy
18°22'
Profile 3.20.2
Salt Pond
SR
Rfu
SR
Rfu
Bgo
SR
SR
Ss
ane Hole

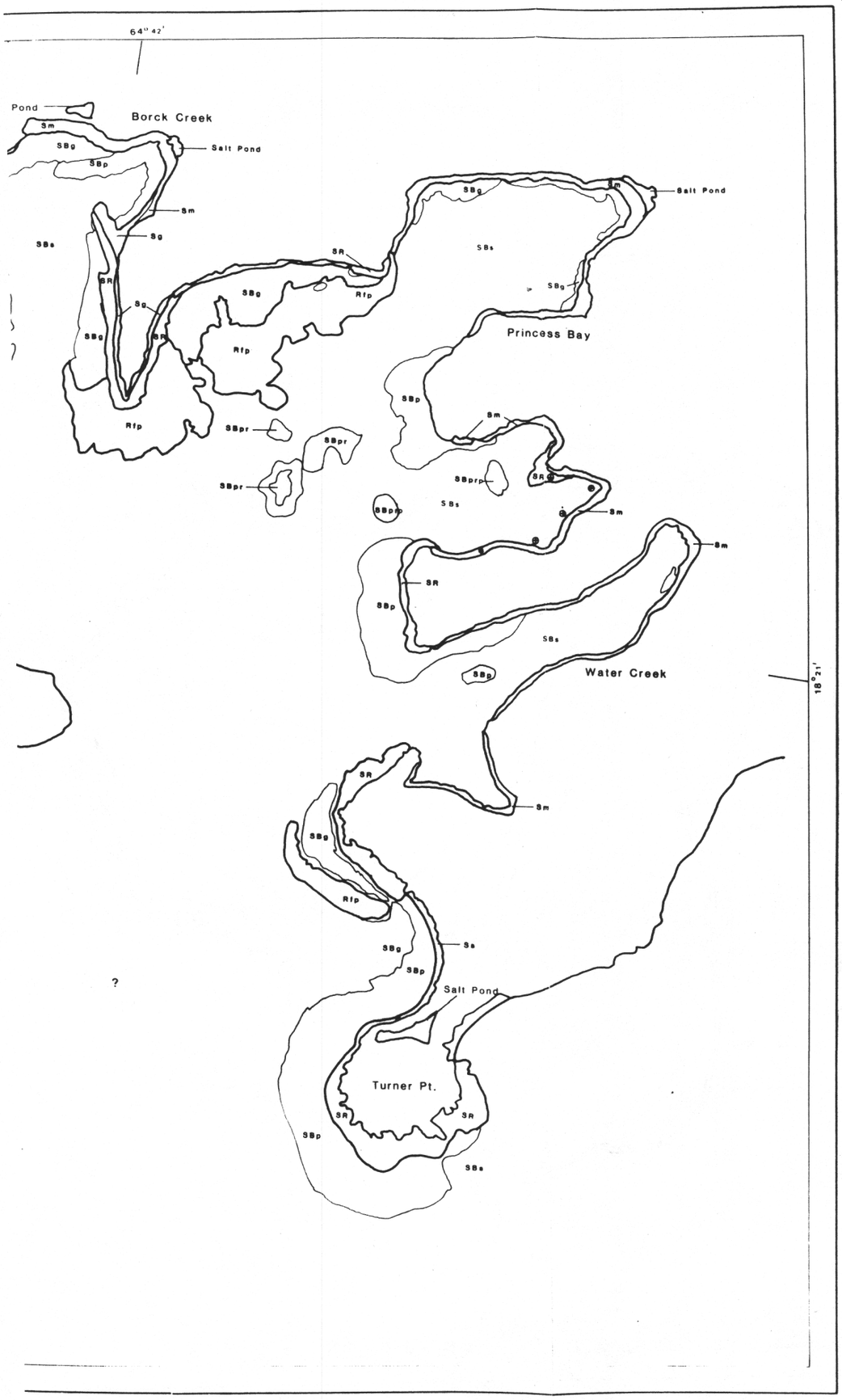

Marine Benthic Communities
St. John, USVI
MAP 7
64°41'
N
NPS Boundary
Profile 3.18
Profile 3.20.3
Profile 3.19
Gowed Pt.
Mennebeck Bay
Haulover Bay
Newfound Bay
Salt Pond
Zone of Patch Reefs
Bgo
SBp
Rfl
Rfu
Rc
Sg
Rbp
Rfp
SR
Sm
Bp
Se
SBs
Rfl/SR
Rbp/SBg
SBg
Ss

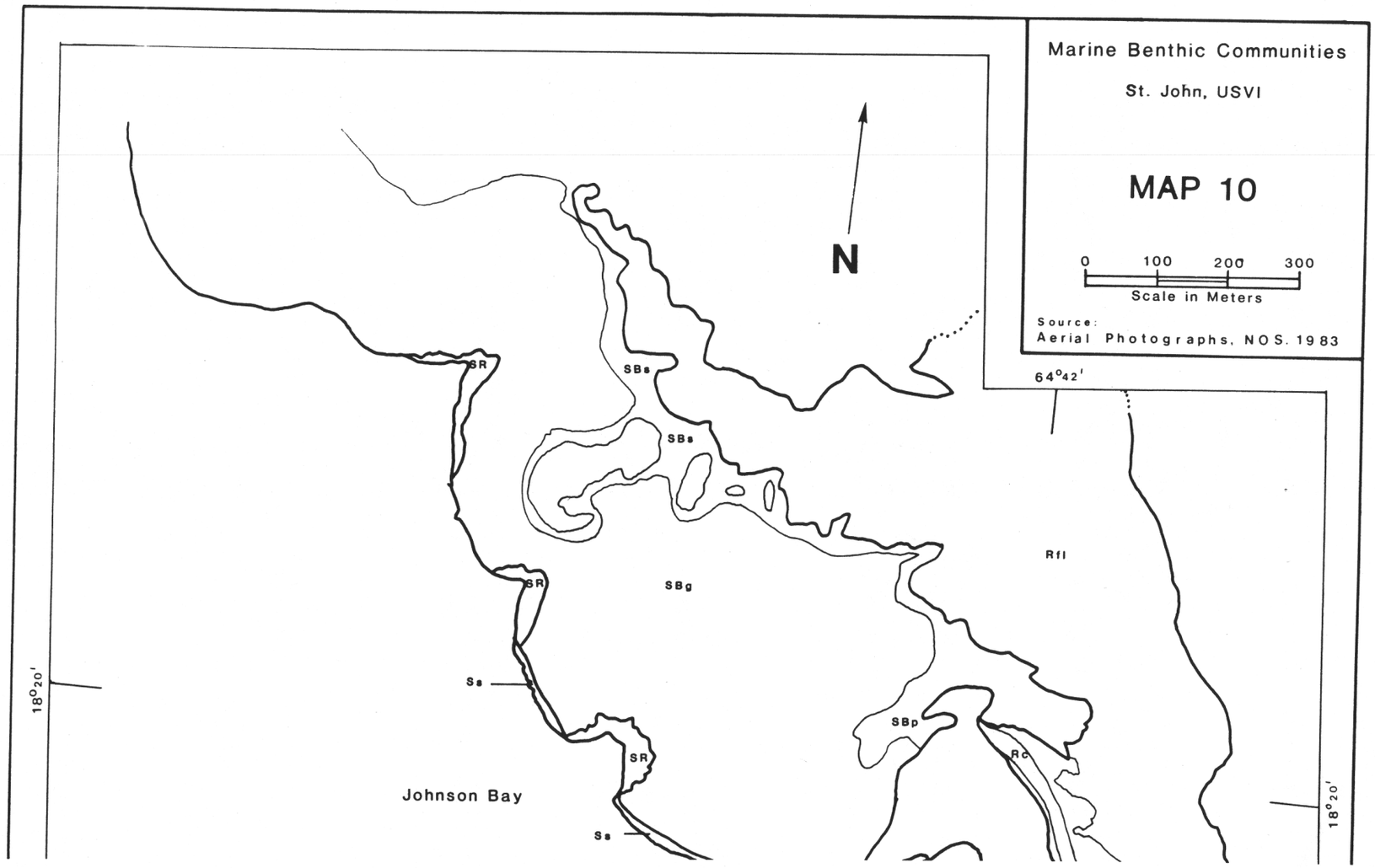

Salt Pond
Round Bay
Turner Pt.
Long Pt.
Salt Pond
Salt Pond
64°41'
Sg
SBg
SBp
SBs
SBpr/p
Rfp
Rfl
SR
Ss
Bpl

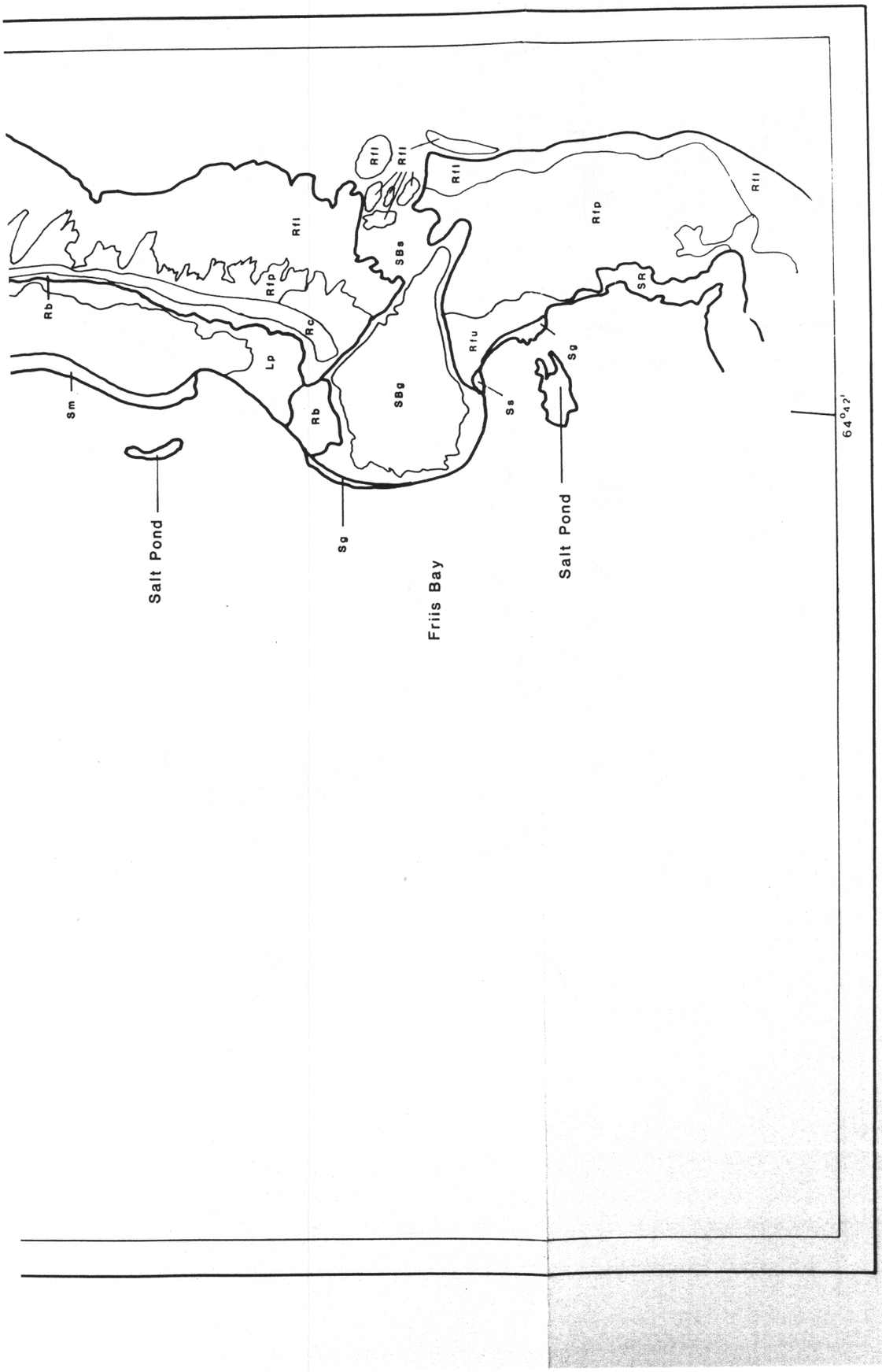

64°40'
Marine Benthic Communities
St. John, USVI
MAP 8
0 100 200 300
Scale in Meters
Source:
Aerial Photographs NOS 1983
N
Salt Pond
East End
East End Pt.
East End Bay
Salt Pond
Privateer Bay
Privateer Pt.
Salt Pond
Rfu
Rfp
Rfl
Sg
SR
SSg

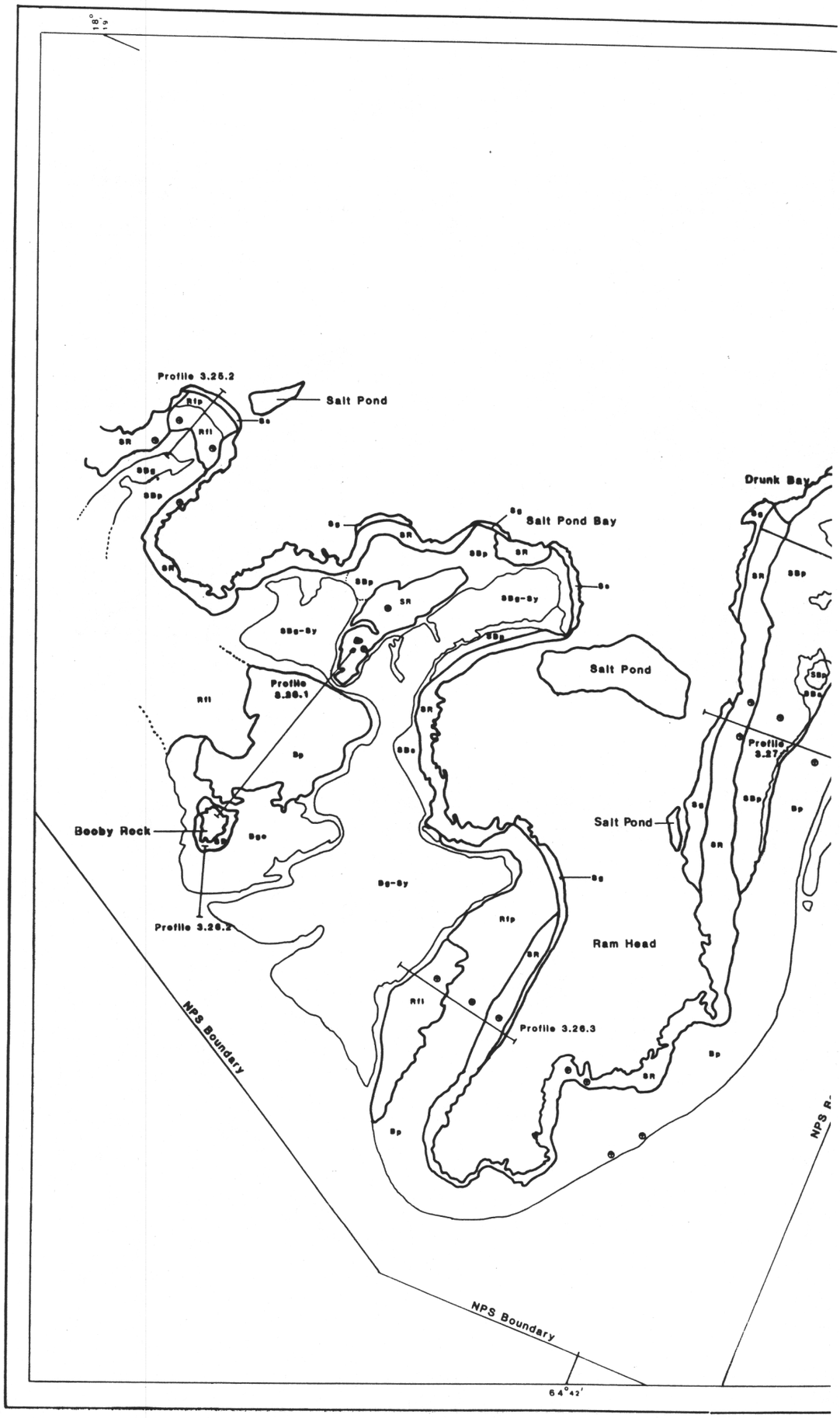

SR
Rfl
?
Bs
Rfp
Bpr
Sg
Bgc
Ss
Bpr
SR
SR
Flanagan Island
Bgc
Bs
Channel to shelf edge
64°40'

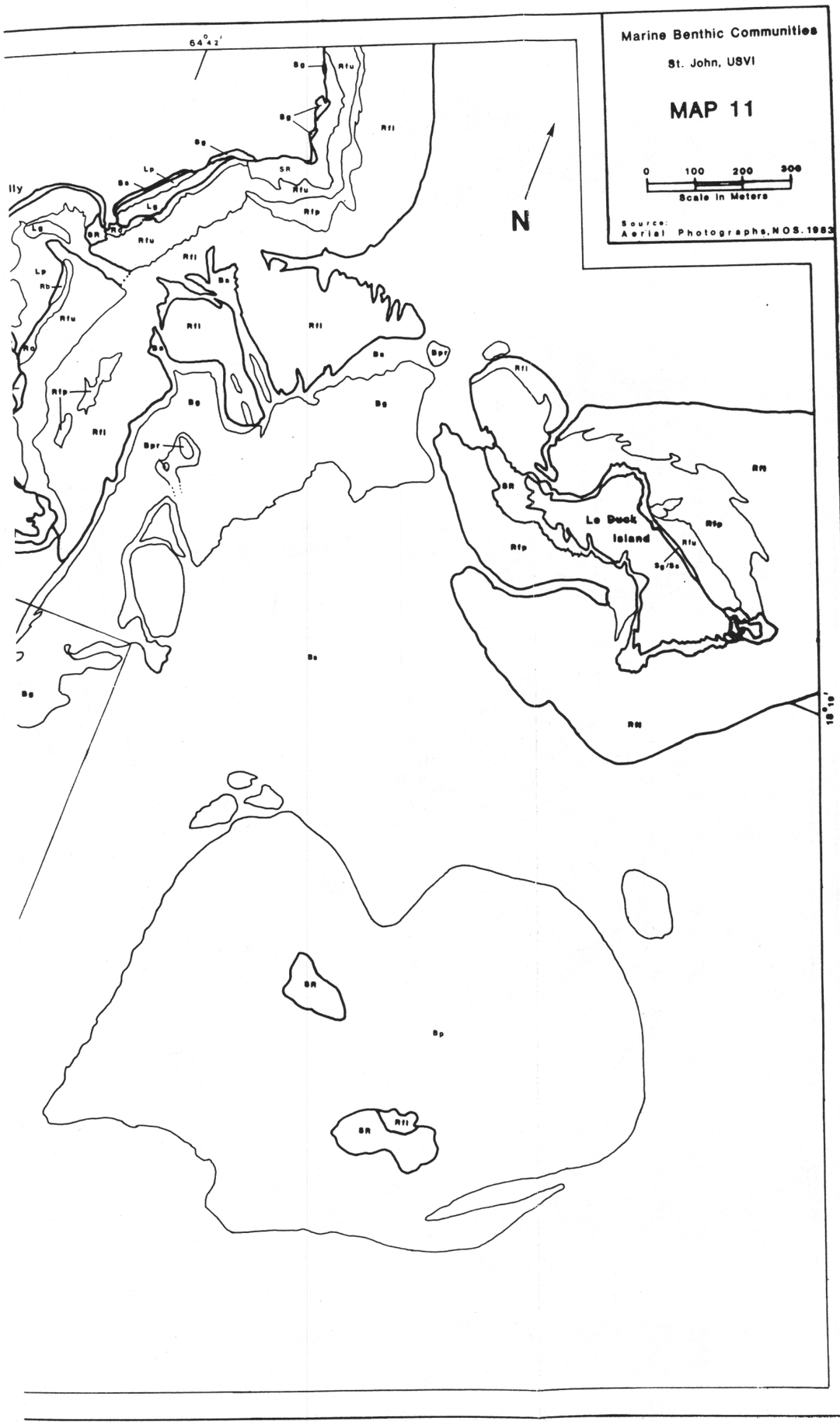

Marine Benthic Communities
St John, USVI
MAP 9
0 100 200 300
Scale in Meters
Source
Aerial Photographs, NOS 1983
N
18°21'
Salt Pond
Coral Harbour
Popilleau Bay
Salt Pond
Pen Pt.
Harbour Pt.
Saunders Bay
64°

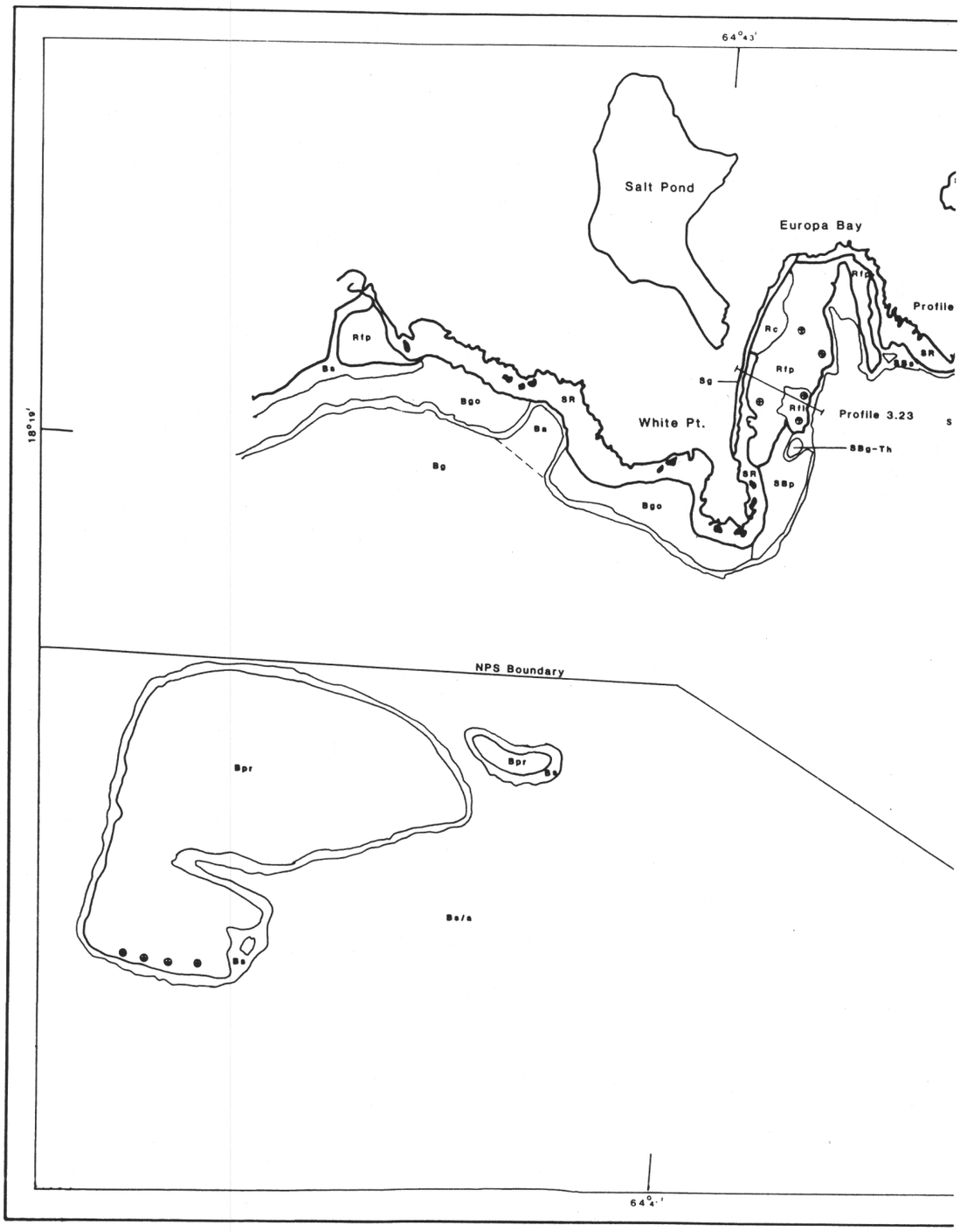

64° 42'
Pond
Sm
Borck Creek
SBg
Salt Pond
SBp
Sm
Sg
SBs
SR
SR
Sg
SBg
Rfp
SBg
SR
Rfp
Rfp
SBpr
SBpr
SBpr
SBg
Salt Pond
Sm
SBs
Princess Bay
SBp
Sm
SBprp
SR
SBprp
SBs
Sm
Sm
SR
SBp
SBs
SBg
Water Creek
18° 21'
SR
Sm
SBg
Rfp
Ss
SBg
SBp
Salt Pond
Turner Pt.
SR
SR
SBp
SBs
?

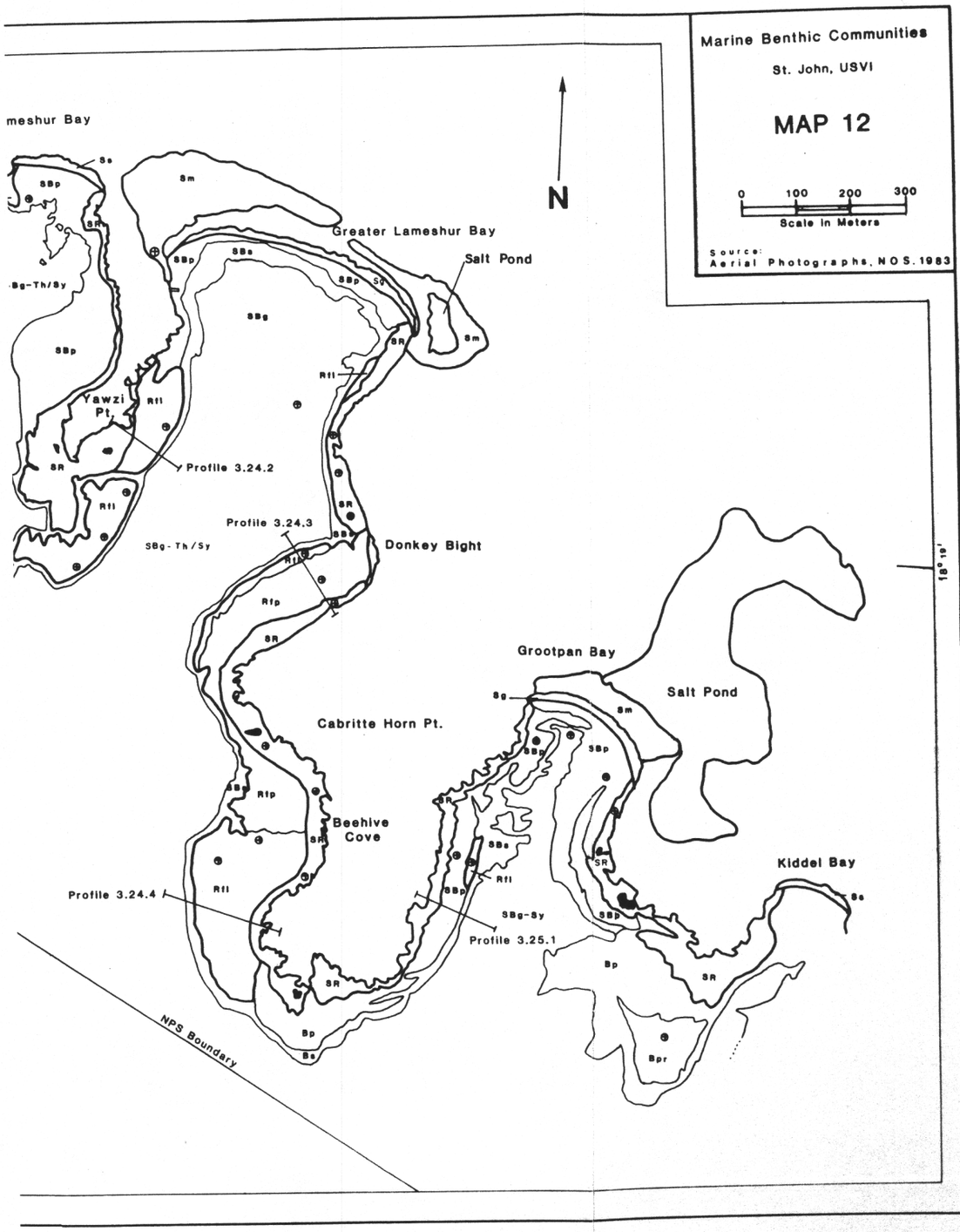

Marine Benthic Communities
St. John, USVI
MAP 10
0 100 200 300
Scale in Meters
Source:
Aerial Photographs, NOS. 1983
N
64°42'
18°20'
SR
SBs
SBs
SBg
Rfl
SR
Ss
SBp
SR
Rc
Johnson Bay
Ss
18°20'

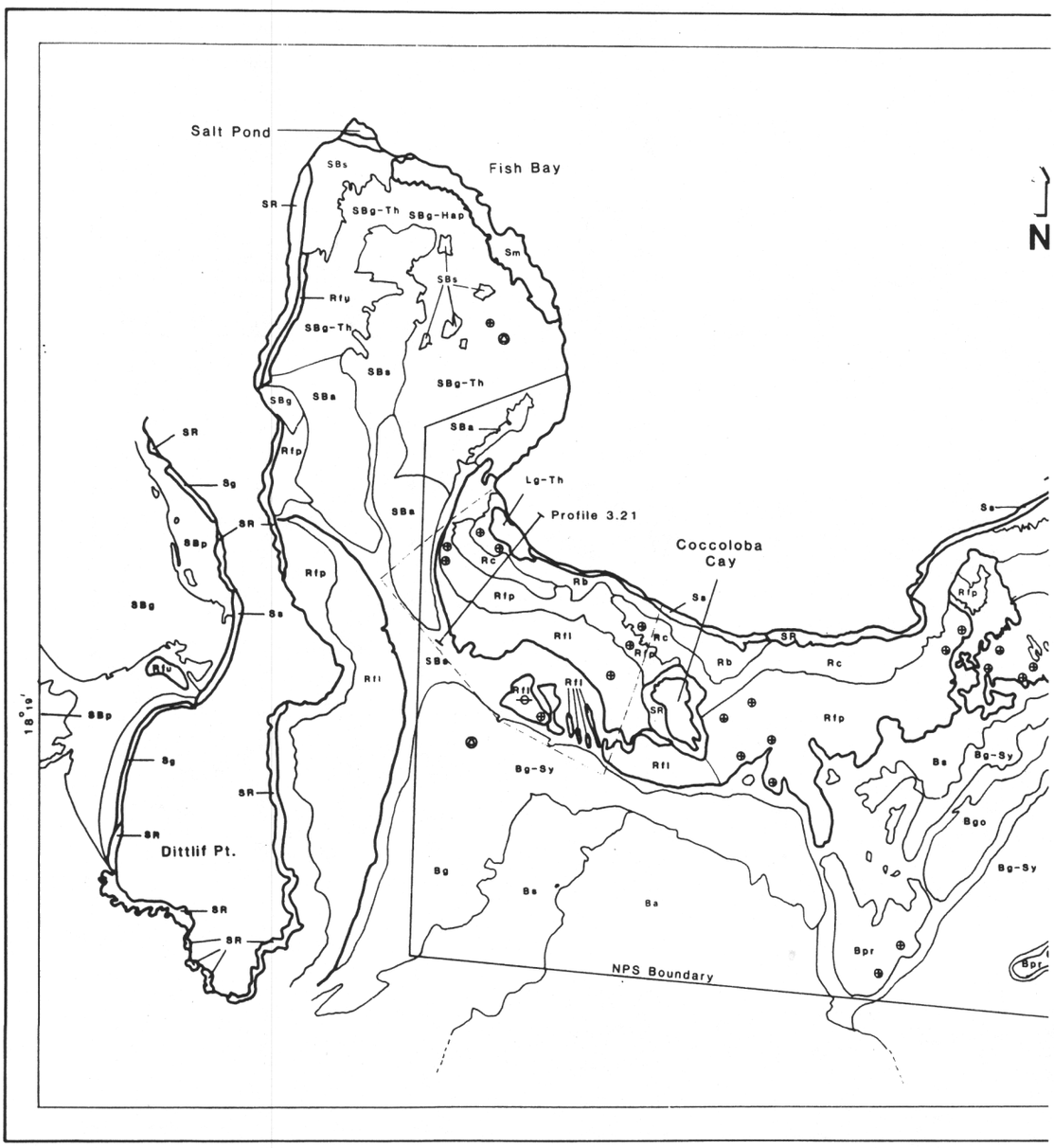

Rfl
Rfl
Rfl
Rfl
Rfp
Rfp
SBs
SR
Rb
Rc
Lp
Rfu
Sg
Sm
Rb
SBg
Ss
64°42'
Salt Pond
Sg
Friis Bay
Salt Pond

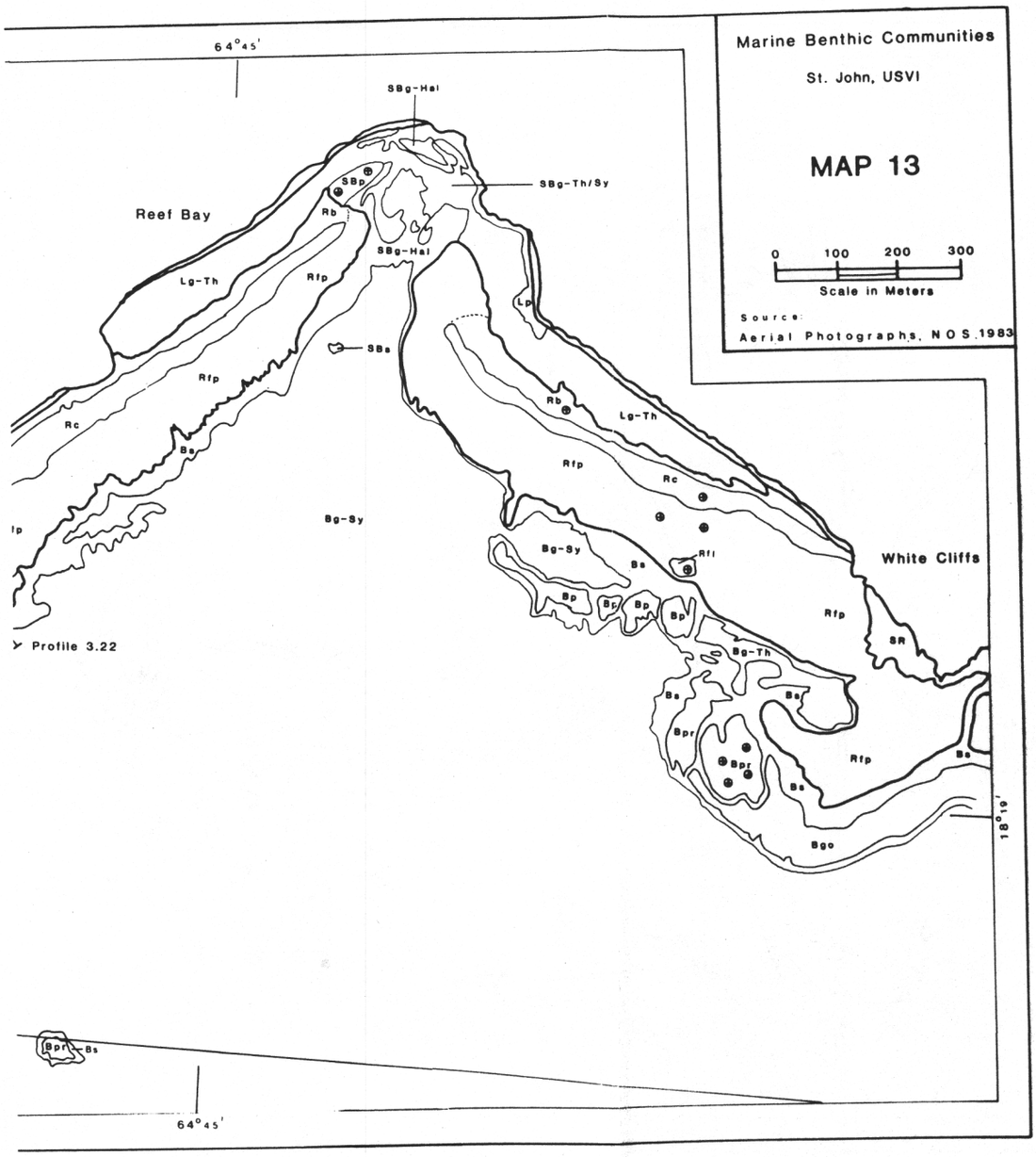

18° 19'
Profile 3.25.2
Salt Pond
Drunk Bay
Salt Pond Bay
Salt Pond
Profile 3.26.1
Booby Rock
Profile 3.26.2
Salt Pond
Ram Head
Profile 3.26.3
NPS Boundary
NPS Boundary
64° 42'

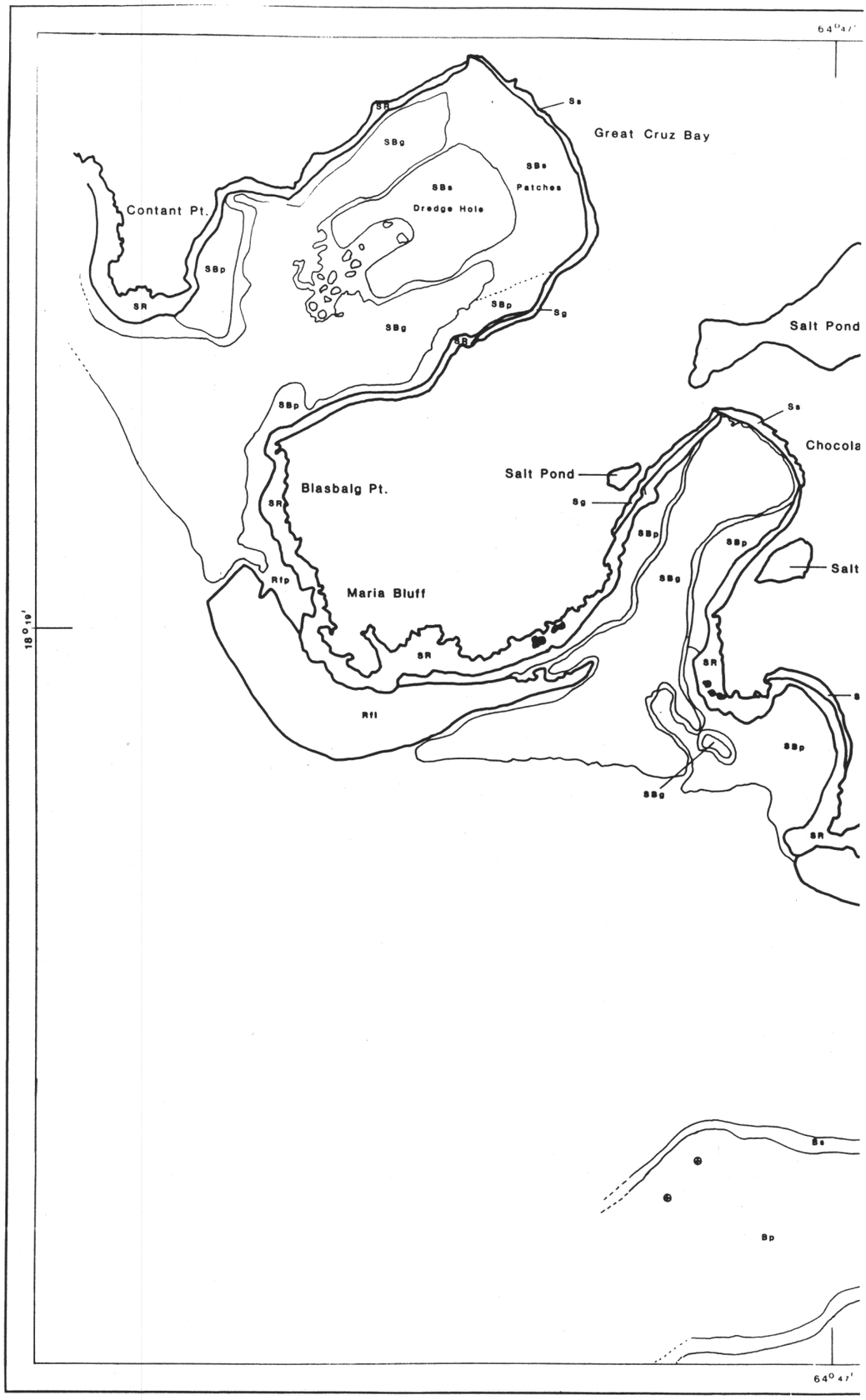

Marine Benthic Communities
St. John, USVI
MAP 11
0 100 200 300
Scale in Meters
Source:
Aerial Photographs, NOS. 1983
N
64°42'
18°19'
Le Duck Island
Rfu
Rfl
Rfp
Rm
Bs
Bp
Bpr
SR
Lp
Lg
Rb
Sg/Bs

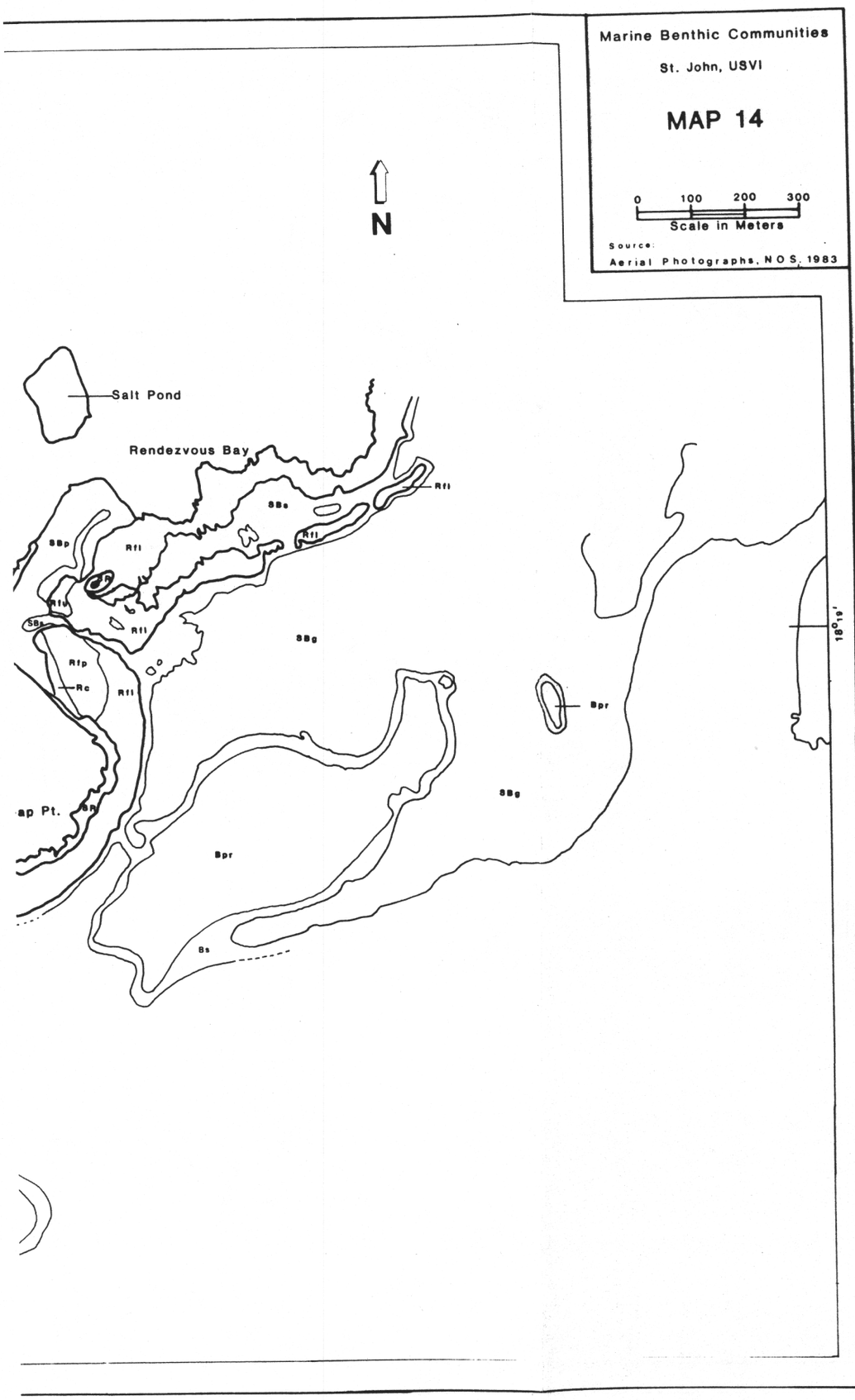

64°43'
Salt Pond
Europa Bay
Profile
Rfp
Rc
Rfp
Sg
Rfp
Profile 3.23
SBg-Th
SBp
SR
Bgo
Ba
Bg
White Pt.
18°19'
NPS Boundary
Bpr
Bpr
Ba/a
Ba
64°4'

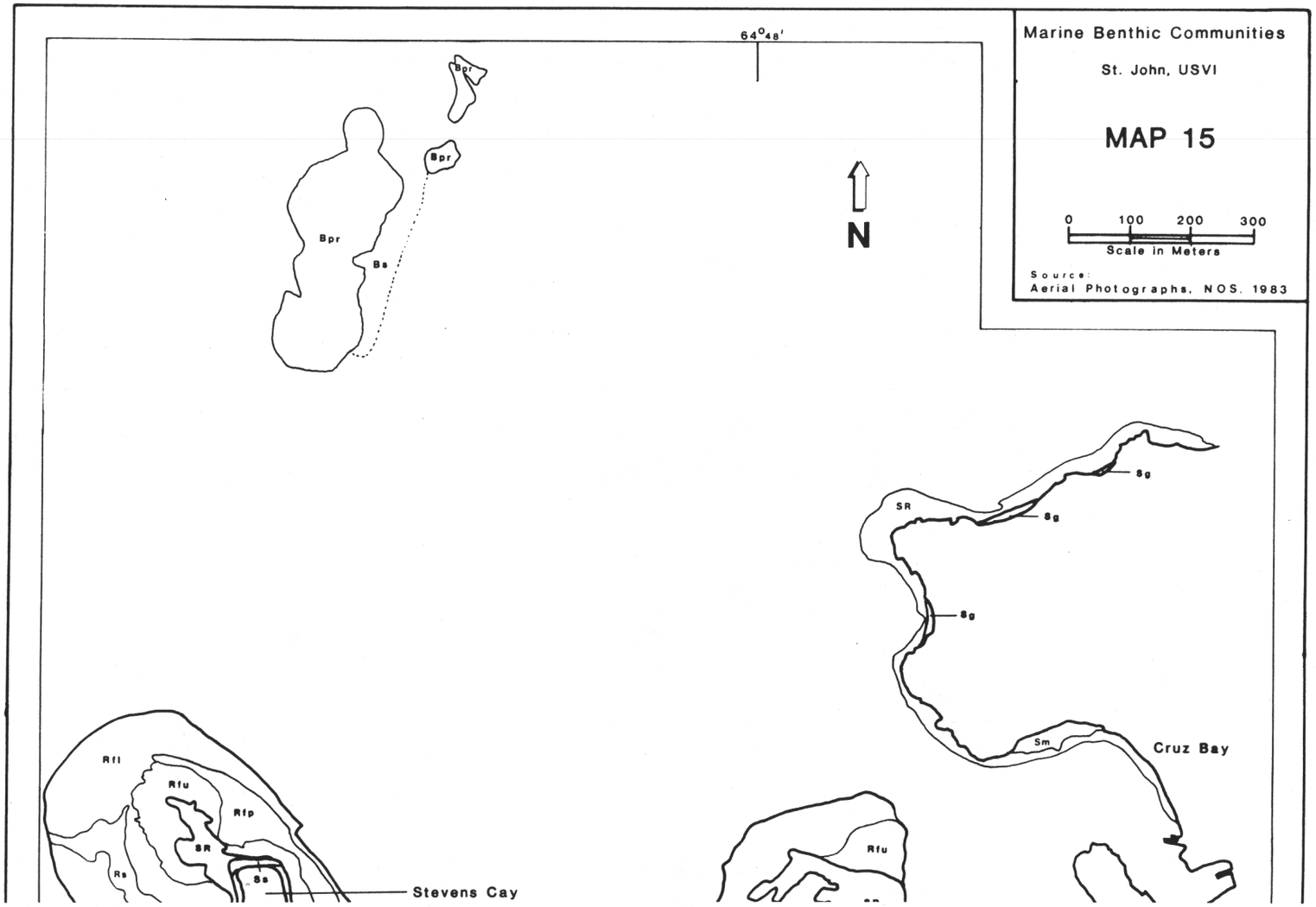

Marine Benthic Communities
St. John, USVI
MAP 12
0 100 200 300
Scale in Meters
Source:
Aerial Photographs, NOS. 1983
N
meshur Bay
Greater Lameshur Bay
Salt Pond
Yawzi Pt.
Profile 3.24.2
Profile 3.24.3
Donkey Bight
Grootpan Bay
Salt Pond
Cabritte Horn Pt.
Beehive Cove
Kiddel Bay
Profile 3.24.4
Profile 3.25.1
NPS Boundary
18° 19'

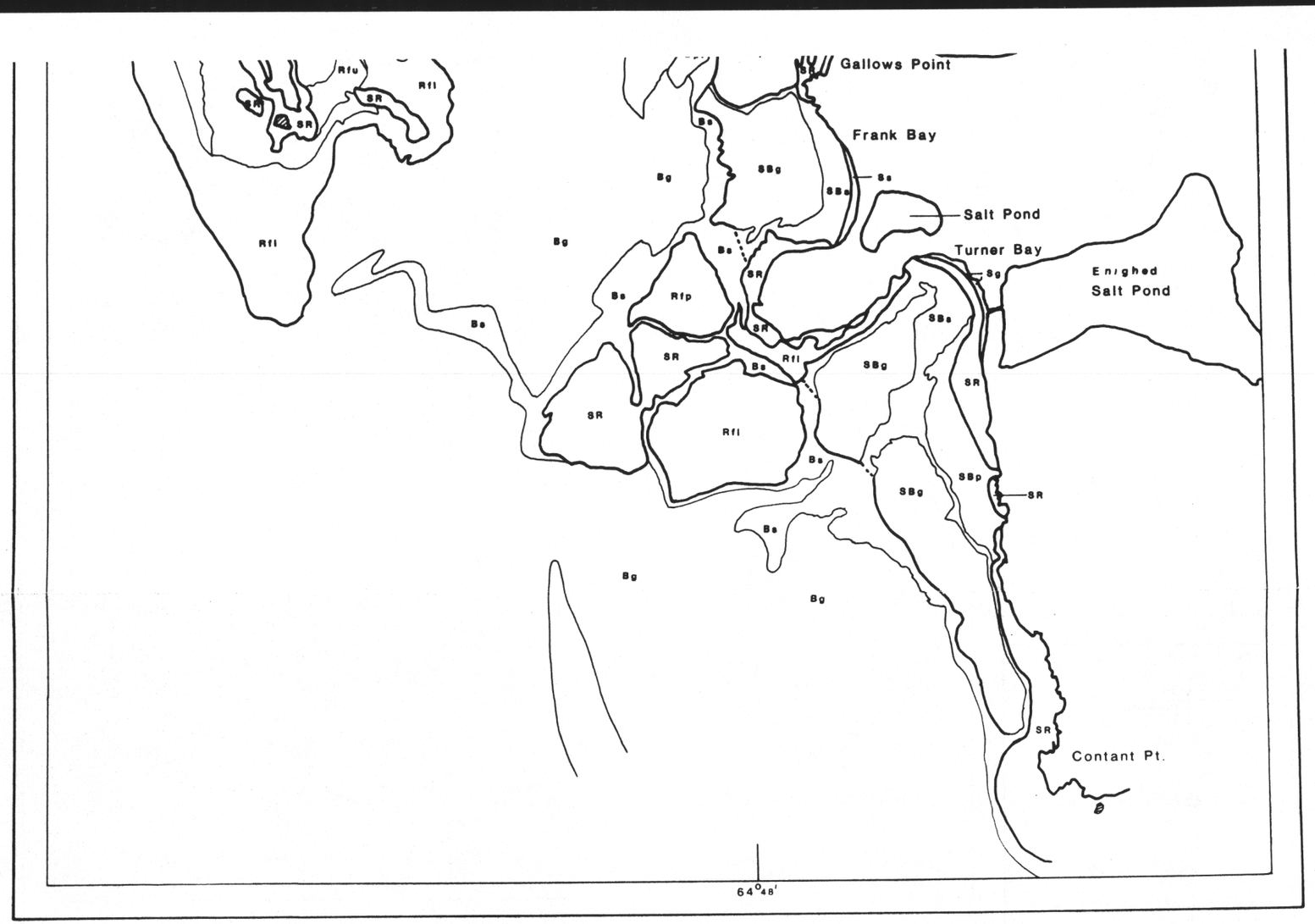

Salt Pond
Fish Bay
N
SBs
SR
SBg-Th
SBg-Hap
Sm
Rfu
SBg
SBa
Rfp
Sg
SBp
Ss
Rfl
Lg-Th
Profile 3.21
Coccoloba
Cay
Rc
Rb
Bg-Sy
Bs
Bgo
Bg
Ba
Bpr
Dittlif Pt.
NPS Boundary
18°18'

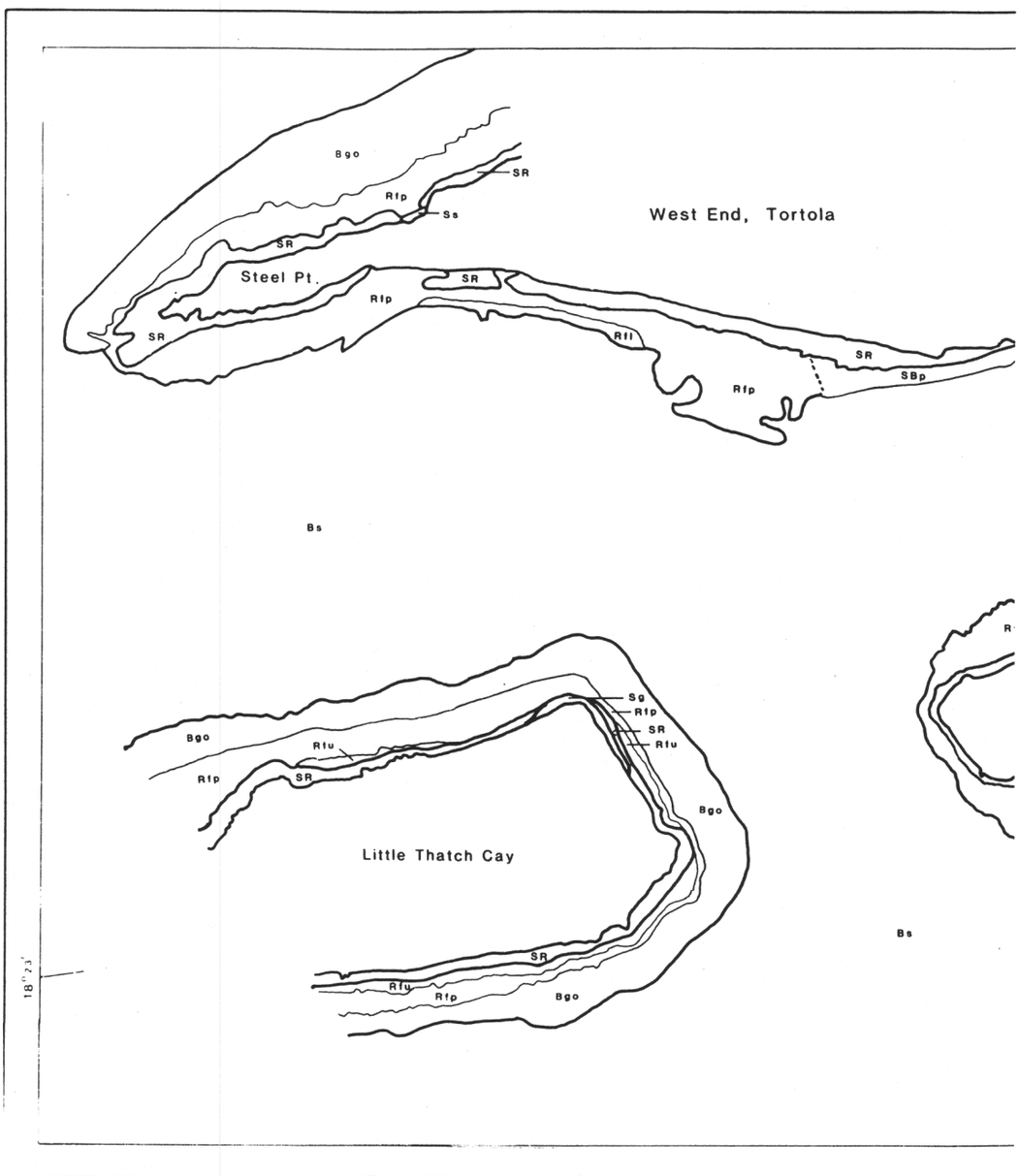

Marine Benthic Communities
St. John, USVI
MAP 13
0 100 200 300
Scale in Meters
Source:
Aerial Photographs, NOS.1983
64°45'
SBg-Hal
SBp
SBg-Th/Sy
Reef Bay
Rb
Lg-Th
Rfp
SBg-Hal
Lp
SBs
Rfp
Rc
Bs
Rb
Lg-Th
Rfp
Rc
Bg-Sy
Bg-Sy
Bs
Rfl
White Cliffs
Bp
Bp
Bp
Bp
Rfp
SR
Bg-Th
Bs
Bs
Bpr
Rfp
Bpr
Bs
Bs
Bgo
18°19'
Profile 3.22
Bpr
Bs
64°45'

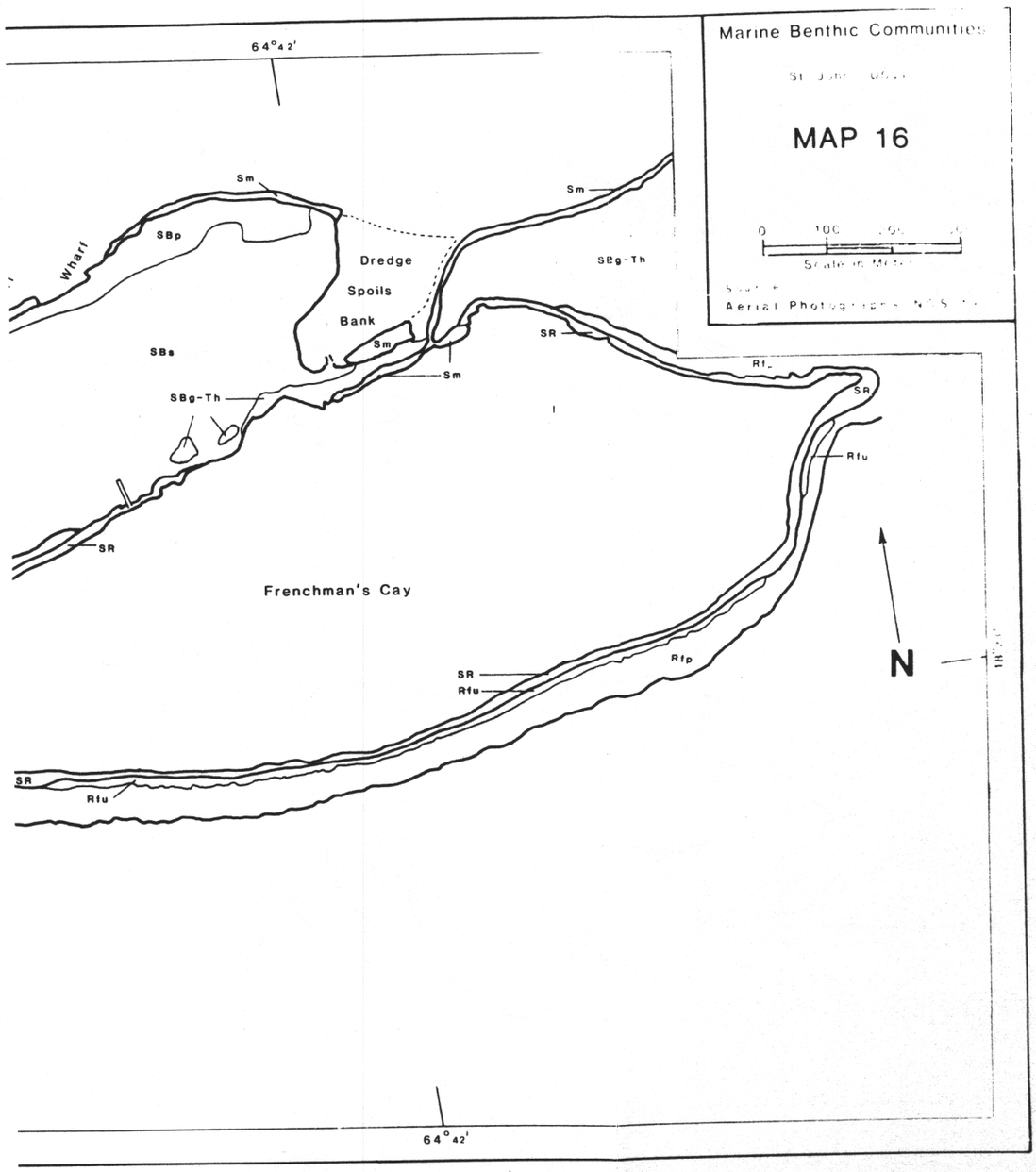

64°47'
Great Cruz Bay
Contant Pt.
Dredge Hole
Patches
Salt Pond
Blasbalg Pt.
Maria Bluff
Chocola
Salt
18°19'
SR
Se
SBg
SBs
SBp
Sg
Rfp
Rfl
Bp


Marine Benthic Communities
St. John, USVI
MAP 14
0 100 200 300
Scale in Meters
Source:
Aerial Photographs, NOS, 1983
N
Salt Pond
Rendezvous Bay
Rfl
SBs
SBp
Rfl
Rfl
Rfl
SBs
Rfl
SBg
Rfp
Rc
Rfl
Bpr
SBg
Bpr
Bs
18°19'

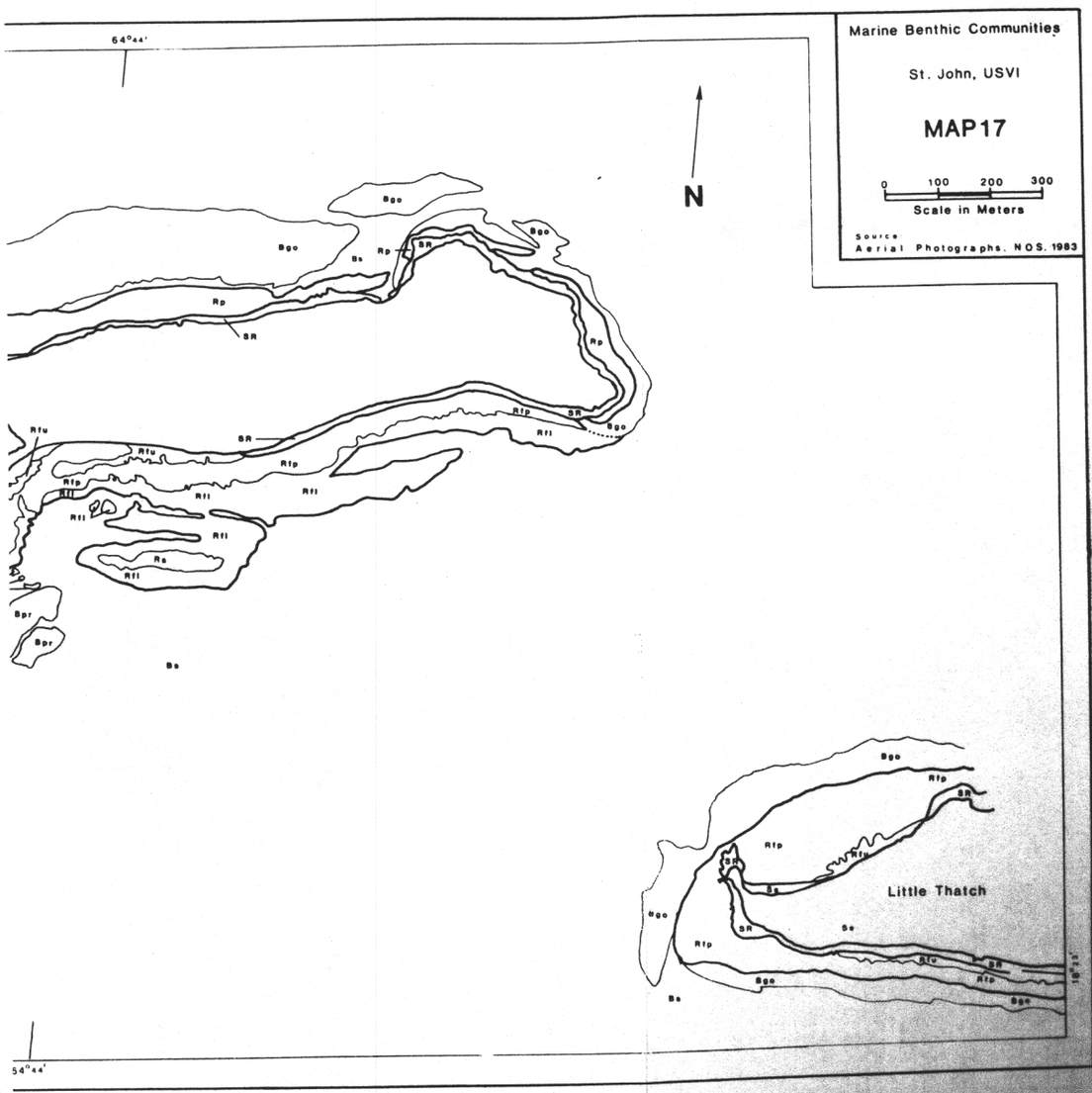

Marine Benthic Communities
St. John, USVI
MAP 15
0 100 200 300
Scale in Meters
Source:
Aerial Photographs, NOS, 1983
64°48'
N
Bpr
Bpr
Bpr
Bs
Sg
SR
Sg
Sg
Sm
Cruz Bay
Rfl
Rfu
Rfp
SR
Rs
Ss
Stevens Cay
Rfu


Gallows Point
Frank Bay
Salt Pond
Turner Bay
Enrighed
Salt Pond
Contant Pt.
Rfu
Rfl
Rfp
SR
Bg
Bs
SBg
SBs
SBp
64°48'


Bgo
SR
Rfp
Ss
SR
West End, Tortola
Steel Pt.
SR
Rfp
SR
Rfl
SR
SBp
Rfp
Bs
Sg
Rfp
SR
Rfu
Bgo
Rfu
Bgo
Rfp
SR
Little Thatch Cay
SR
Rfu
Rfp
Bgo
Bs
18°23'


Marine Benthic Communities
MAP 16
64°42'
Wharf
Sm
SBp
Dredge
Spoils
Bank
SBs
SBg-Th
SR
Rfu
Rfp
Frenchman's Cay
N
64°42'

18°23'
Great Thatch


Marine Benthic Communities
St. John, USVI
MAP17
0 100 200 300
Scale in Meters
Source
Aerial Photographs. NOS. 1983
64°44'
N
Little Thatch
Bgo
Rp
SR
Bs
Rfu
Rfp
Rfl
Rs
Bpr
Be
Se
54°44'