LONG-TERM MONITORING OF FISHERIES IN THE VIRGIN ISLANDS BIOSPHERE RESERVE

BIOSPHERE RESERVE

RESEARCH

REPORT NO. 13

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(NPS CONTRACT NO. CX-0001-3-0048)

Abstract

REPORT NO. 13
Subtask 2.6

LONG-TERM MONITORING METHODS FOR FISHERIES RESOURCES OF THE VIRGIN ISLANDS BIOSPHERE RESERVE

Long-term monitoring methods of species of demersal fin fish, conch, and whelk that are commercially important were developed and used at selected sites in the VIBR. The techniques used proved objective, repeatable, fast, easy and subject to a minimum of observer bias.

A random-point, visual-census technique was used at habitats with a high fish-species count of demersal fin fish. Of the four bays selected, three (Trunk, Hawksnest, and Fish) have potential for tourist or land-based-sedimentation impact. The fourth, Lameshur Bay, has low impact potential. Baseline data was collected for seven habitat types found in these bays.

A visual, swimming, strip-transect method was used at three sites in two bays (a shallow [inner] and deep [outer] grass bed in Fish Bay and a shallow grass bed in a small bay east of Leinster Bay) to estimate conch densities and population structure. Over a four-month period, the inner site at Fish Bay was composed of juvenile conch in densities ranging from .09-.28 conch/sq.m.; the outer of 99.9% mature conch in densities ranging from .08-.18 conch/sq.m. Sampled twice, the bay east of Leinster Bay was composed of 79% mature conch the first time, and 99% juvenile conch the second time. Densities ranged from .21-.26 conch/sq.m. The shift in population structure may be seasonal (migration).

A random-point, strip-transect method was used for estimating density and population structure of whelk along a rocky coastland between Peter Bay and Windswept Beach (selected due to known low harvest). All whelks within a one-meter-wide strip from dry land to a one-meter depth were collected. The largest population size class is whelks under 1 cm., with 82% of all whelks being less than 4 cm. (approximate average size for maturity). This may indicate that periodic harvesting does occur. The density of whelks is estimated to be 36.7 whelks/m. of shoreline.

Recommendations are made to monitor lobster using a systematic canvassing technique to ensure total coverage and no overlap of a selected, discrete lower fore-reef or bank pavement area. Data on sex (if female, whether berried or not) and size should be gathered. Handling lobster may effect the study and should be avoided.

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FOREWORD

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

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

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

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

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

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

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

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

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1. INTRODUCTION

Populations of finfish, shellfish (conch, whelk) and lobsters appear to be declining in the waters around St. John. Local fishermen are demonstrating this through reduced catches and smaller individual fish. It is important, therefore, to determine the status of the populations of these commercially important species. Baseline data on these populations are needed to establish resource management guidelines and evaluate the response of these populations to man-made or natural disturbances. Long-term monitoring of these populations using consistent methodology can provide the necessary baseline data.

To the present, few studies of a long-term nature have been carried out within the marine portions of the Virgin Islands Biosphere Reserve. The only long-term fin fish study took place on an artificial reef in Little Lameshur Bay (Randall, 1963; Ogden and Ebersole, 1981). This was a study of recruitment and community changes on a large, man-made reef and provides little information for resource management. As part of a fisheries survey of St. John, Randall (1962) carried out a tagging program to determine growth and movements of reef fishes. The study lasted 17 months, but also provided no information on population status or trends for the species studied.

Long-term monitoring of conch (*Strombus gigas*) populations in the Virgin Islands Biosphere Reserve to establish population trends has not been done. Randall (1964) carried out a two and one-half year study of conch on St. John. The study emphasized biological aspects of possible importance to regulation of the fishery such as growth, spawning season and predators. Wood and Olsen (1983) made assessments of stock abundance and estimate that harvest has approached or exceeded sustainable yield for at least three years. They additionally point out that total landings and catch-per-unit-effort have declined during the same period, necessitating some sort of regulatory managment.

The status of whelk (*Cittariuum pica*) populations is essentially unknown. Very little work has been done on this species. Randall, H.A. (1964) focused on the biology (feeding, habits, growth, movement, etc.) of the whelk and provides no information on densities or population trends.

Lobster (Panulirus argus) are an extremely important species in the local commercial fisheries. Data indicate that from 1978 to present reported lobster landings have declined, while number of licensed fishermen has generally increased (Clavijo, et al., 1984). Based on this and data on the minimum size for reproduction in females, an initial management measure of raising the carapace size limit in the Virgin Islands to 3.5 inches has been established (Act 4953, June 1 1984). With strict enforcement, this should enable the local lobster populations to begin to recover. The only major study on lobsters within the Virgin Islands Biosphere Reserve was carried out in Lameshur Bay during the Tektite Program (Olsen, et al., 1975). In 1970, when this project was carried out, there was little fishing pressure on this population. While determination of lobster population trends is of top priority, it was deemed to be a major project beyond the scope of this study. However, observations of lobster occurences from a concurrent study (Boulon, 1985) will be discussed.

The intent of this study is to select commercially important species of concern, select locations to study them, and develop methods to assess their population trends on a long-term basis.

2. LONG-TERM MONITORING

2.1 Fin Fish

2.1.1 Methods

Four locations (Figure 1) were selected to sample for commercially important fin fish species to obtain baseline data for long-term monitoring of their populations. 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. Nearly all species selected for this project are considered in the Fishery Management 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.

A. Fish Bay - Although the majority of the bay is just outside the National Park Service boundary, it is considered an area of particular concern due to the marine communities found there and the impending development of the surrounding lower watershed. With approximately 200 residential homesites planned for this watershed, a considerable amount of impact will be felt by the marine communities found in this bay. Primary impacts will be in the fom of land-based sedimentation, increased boat traffic, and increased fishing/diving/swimming pressures.

B. Lameshur Bay - Although subject to a certain amount of artisanal fishing pressure, this bay was selected as having relatively low or no impact from land-based development. Additionally, this bay has been the subject and site of much scientific research over the years, and thus, can provide an additional data base for long-term monitoring studies of fin fish.

C. Hawksnest Bay - This bay is considered an area of particular concern due to the potential for impact from the excation for the St. John Clinic and resultant mounds of unconsolidated fill material at the top of this watershed. Unless this fill material is stabilized through planting or retained with retaining walls or berms, it could raise the sediment load of Hawksnest Bay to a critical chronic level, affecting the marine communities in the bay.

D. Trunk Bay Cay Underwater Trail - This site was selected due to the visitor impact on the communities around Trunk Bay Cay. Every year tens of thousands of visitors snorkel this underwater trail and physically damage the marine communities on the trail. It is unfortunate that no data are available to determine exactly how much damage has occurred. It may be that further impact cannot degrade the situation significantly. If the National Park Service ever decides to remove the underwater trail from this location, a data base for fish communities in this location will provide an opportunity for studying recovery under reduced impact.

Fish communities of commercial importance dwelling in different habitat types (Table 1) within each of these bays were censused 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 particular direction and during a five-minute period, rotate clockwise 360°, sampling all fish within an eight meter radius cylinder surrounding the observer. Due to good water clarity, an 8m radius could be used in all censuses made in this study. As the observer rotated through the census the number of individuals observed for each species was recorded on a preprinted form (Appendix I). The preprinted form saves time in writing down the species' name. After using this form 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 lengths for each species were recorded. These lengths are 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 are counted as they appear in the sample radius and if large, are counted in 10's, 100's, or even 1000's.

Advantages of this method are numerous. It is simple, objective, repeatable,

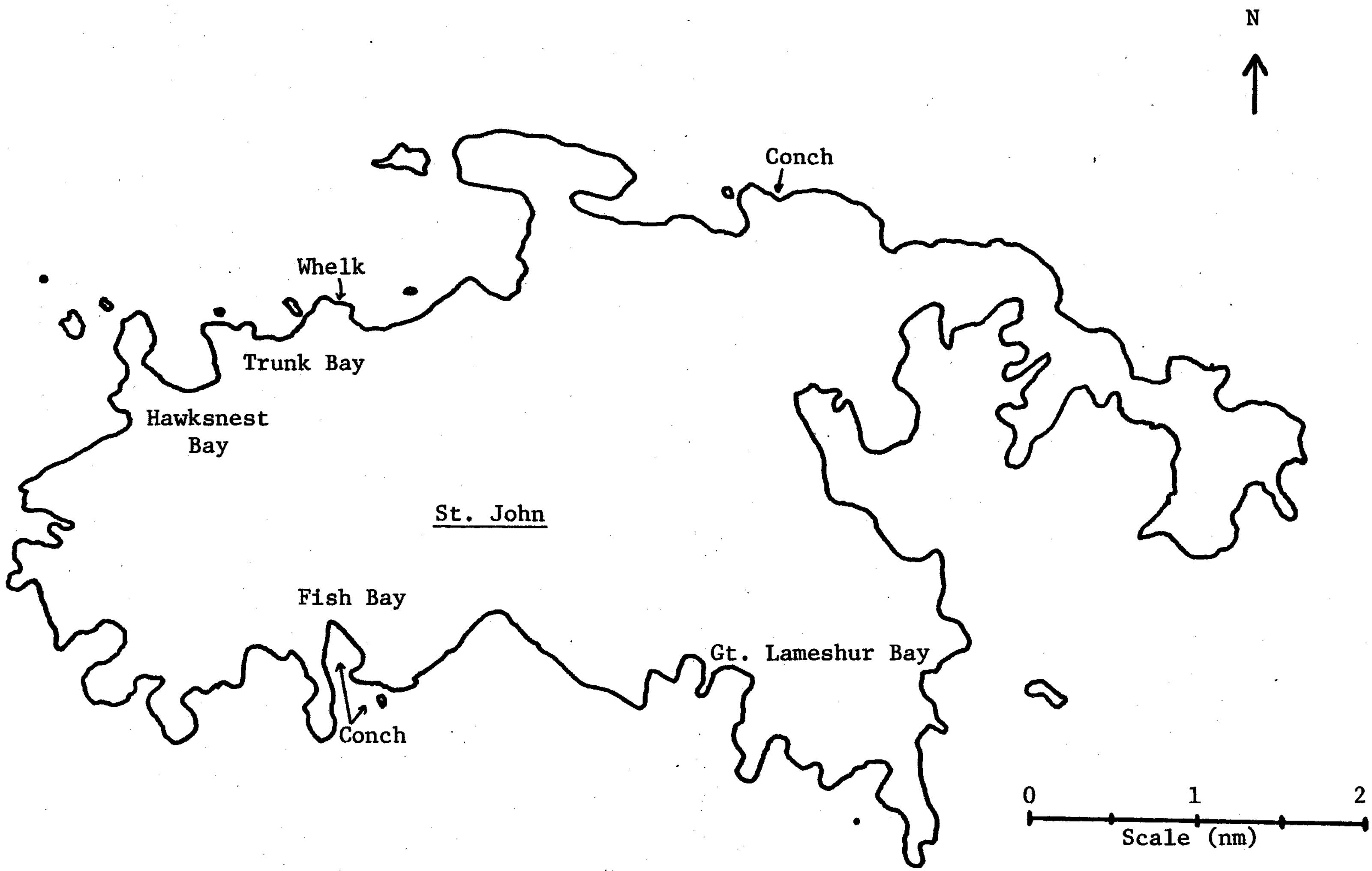


Figure 1. Bays used for baseline data collection for long-term monitoring of fin fish. Locations also shown for conch and whelk monitoring sites.

TABLE 1

Habitat-types censued for commercially important species of fish. Acronyms used in all succeeding tables. See report for Subtask 2.1 for description of habitat types.

HABITAT TYPES	ACRONYMS
1. Shore Mangroves	Sm
2. Subtidal Bedrock	SR
3. Back Reef	RB
4. Upper Fore-reef	Rfu
5. Fore-reef Pavement	Rfp
6. Lower Fore-reef	Rfl
7. Shallow Bay Patch Reef	SBpr

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 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. There are also species which are attracted to 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 disadvantages of this direct sampling method do exist but are generally considered outweighed by the advantages. Using this method, nocturnal and highly cryptic species tend to go undetected. Being a point census technique, the effects of schooling, territoriality or preference for certain substrates, all of which can cause uneven distribution of fish populations, can affect abundance estimates. However, ensuring that censuses are performed in habitat"core areas" (Boulon, 1985) will eliminate the significance of these problems.

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).

Habitat maps for the bays used in this study for fin fish monitoring are shown in Boulon (1985). These maps show the location and extent of marine benthic communities around St. John, U.S.V.I. and have the specific census locations marked on them.

2.1.2 Results

Baseline data for various habitat types in each of the bays selected for long-term monitoring are shown in Table 2. Habitat types chosen for each bay were those that were significant fisheries habitat and which would exhibit the greatest amount of impact from any environmental perturbation. A small number of censuses within a particular habitat type (e.g. Shoreline Mangroves in Gt. Lameshur Bay or Back Reef in Fish Bay) usually relates to the extent or quantity of this habitat type. Other habitat types with few censuses (e.g. Fore-reef Pavement in Fish Bay or Upper Fore-reef in Hawknest Bay) are due to an oversight on the author's part and were not realized to be low until analysis was started. These can be rectified during the first monthly sample if a long-term monitoring program is set up. The primary goal of this segment of the study is to provide recommendations on locations and methods to be utilized for long-term monitoring of

TABLE 2.

Number of individuals, relative abundance and average size of fin fish species of commercial importance observed in various habitat types in selected bays around St. John, U.S.V.I. See TABLE 1 for habitat type acronym explanations. Average size per species was calculated as Σ Avg. size per census (max. + min. /2) /No. censuses. Sizes are in cm.

Location / Habitat Type / No. Censuses	Fish Bay Rb 2			Fish Bay Rfp 1			Fish Bay Rfl 3			Gt. Lameshur Bay Sm 1			Gt. Lameshur Bay Rfl 7			Gt. Lameshur Bay SR 6		
Species	Tot. # Indiv.	Rel. Abun.	Avg. Size	Tot. # Indiv.	Rel. Abun.	Avg. Size	Tot. # Indiv.	Rel. Abun.	Avg. Size	Tot. # Indiv.	Rel. Abun.	Avg. Size	Tot. # Indiv.	Rel. Abun.	Avg. Size	Tot. # Indiv.	Rel. Abun.	Avg. Size
Mackerel							1		35.5				2	.006	33.0	3	.02	25.5
Carang							2		20.5				5	.02	25.5	36+	.19	20.5
Queen Triggerfish													1	.003	35.5	1	.005	25.5
Blue-striped Grunt							1		15.0				6	.02	15.0	11	.06	19.0
White Grunt							2		20.5				5	.02	12.5			
French Grunt	50	.34	9.0	1	.04	12.5	13		12.5				28	.08	12.5			
Tomtate	24	.16	10.0							1	.001	11.5						
Sailor's Choice													7	.02	15.0			
Mutton Snapper																		
Dog Snapper										506+	.64	5.0						
Grey Snapper										6	.007	20.5	6	.02	21.5	4	.02	18.0
Schoolmaster	14	.09	12.5				3		18.0	2	.003	12.5	13	.04	19.0			
Yellowtail	3	.02	12.5	2	.09	20.5	6		18.0	15	.02	6.5	38	.11	16.5	13	.07	18.0
Mahogany Snapper	5	.03	11.5							200+	.25					2	.01	20.5
Fr. & Queen Angelfish							3		25.5				1	.003	15.0			
Grey Angelfish													3	.009	21.5	6	.03	19.0
Red Hind							1		15.0				5	.02	18.0			
Coney							1		30.5				5	.02	18.0	4	.02	18.0
Nassau Grouper													1	.003	28.0	3	.015	26.5
Porgies																5	.03	16.5
Sea Bream										14	.02	7.5						
Doctorfish	13	.09	10.0	12	.52	9.0	14		14.0				32	.10	12.5	48	.25	12.5
Yellow Goatfish	6	.04	14.0							50+	.06	10.0	12	.04	14.0	11	.06	15.0
Spotted Goatfish				1	.04	15.0							5	.02	15.0			
Spanish Hogfish													1	.003	15.0	2	.01	16.5
Parrotfish	29	.20	9.0	7	.30	15.0	17		14.0				131	.39	12.5	32	.17	12.5
Trunkfish													1	.003	15.0	3	.015	11.5
Sea Chubs																		
Barracuda																		
Squirrelfish	2	.01	12.5				6		15.0				24	.07	15.0	4	.02	15.0
Mojarra																6	.015	21.5
Blue Fry	X																	
Snook										2	.003	30.5						
Total # Species	10			5			13			9			22			18		

TABLE 2 (CONT'D.)
Number of individuals, relative abundance and average size of fin fish species of commercial importance observed in various habitat types in selected bays around St. John U.S.V.I. See TABLE 1 for habitat type acronym explanations. Average size per species was calculated as $\sum$ Avg. size per census (max. + min./2)/No. censuses. Sizes are in cm.

Location Habitat Type No. Censuses	Hawksnest Bay SBpr 3			Hawksnest Bay Rfl 3			Hawksnest Bay Rfp 3			Hawksnest Bay Rfu 1			Trunk Bay Cay SR 5		
Species	Tot. # Indiv.	Rel. Abun.	Avg. Size	Tot. # Indiv.	Rel. Abun.	Avg. Size	Tot. # Indiv.	Rel. Abun.	Avg. Size	Tot. # Indiv.	Rel. Abun.	Avg. Size	Tot. # Indiv.	Rel. Abun.	Avg. Size
Mackerel															
Carang	2	.01	-	4	.03	25.5	3	.04	25.5				3	.03	23.0
Queen Triggerfish															
Blue-striped Grunt	5	.03	-	4	.03	18.0				3	.23	20.5	1	.01	20.5
White Grunt															
French Grunt				12	.09	12.5	1	.01	12.5	6	.46	12.7			
Tomtate															
Sailor's Choice															
Mutton Snapper	1	.01	38.0	2	.01	38.0									
Dog Snapper															
Grey Snapper															
Schoolmaster															
Yellowtail	7	.04	30.5	15	.11	19.0	9	.13	18.0	1	.08	7.5	5	.05	20.5
Mahogany Snapper	41	.22	20.5												
Fr. & Queen Angelfish															
Grey Angelfish	4	.02	-				2	.03	23.0						
Red Hind	2	.01	-	2	.01	14.0									
Coney	1	.01	-	1	.01	12.5									
Nassau Grouper													1	.01	20.5
Porgies	1	.01	-	1	.01	25.5	2	.03	15.0						
Sea Bream															
Doctorfish	22	.12	-	42	.30	12.5	26	.38	7.5	1	.08	10.0	40	.39	12.7
Yellow Goatfish	1	.01	-	10	.07	18.0							1	.01	20.5
Spotted Goatfish	1	.01	-	6	.04	15.0									
Spanish Hogfish															
Parrotfish	98	.52	18.5	32	.23	20.5	26	.38	11.5	1	.08	25.5	52	.50	19.0
Trunkfish	2	.01	12.5							1	.08	20.5	1	.01	15.0
Sea Chubs	1	.01	30.5												
Barracuda	1	.01	76.0												
Squirrelfish				6	.04	14.0									
Mojarra															
Blue Fry	X						X			X					
Snook															
Total # Species	17			13			8			7			8		

commercially important fin fish populations.

2.1.3 Discussion

The results of fish censuses serve as a baseline on which to expand as a long-term monitoring program. Comparisons between bays are somewhat difficult due to differing number of censuses, however, some obvious differences do exist. A good example is a comparison of Subtidal Bedrock (SR) between Gt. Lameshur Bay and Trunk Bay. The much lower numbers of species and individuals in Trunk Bay is probably due to visitor impact, i.e. people scaring away the fish and removing much of the organisms attached to the Subtidal Bedrock which provide food and refuge for fish. A point of similarity is found in comparing Lower Fore-reef (Rfl) in Fish Bay and Hawksnest Bay. A similar number of censuses detected the same number of species, although species composition varies slightly.

Although fish may move considerable distances during nocturnal or diurnal feeding migrations, it has been shown for grunts (Ogden, 1976), parrotfish (Bardach, 1958; Clavijo, 1982), copper sweepers (Gladfelter, 1979), and others (Hobson, 1975) that in general they return daily to the same reef location for refuge. Personal observations by the authors and others indicate that individuals of nonmigratory species (e.g. Nassau Grouper, squirrelfish, hinds) can remain in the same hole in the reef for many months. Additionally, Randall (1962) determined from tag recoveries that in general, reef-dwelling fish are nonmigratory. The predictability of residency for most fish species should mean that changes in fish assemblage composition or population structure will occur gradually over time in response to a gradually increasing environmental perturbation. A catastrophic event could result in a rapid change, but all other changes should be gradual.

For these reasons, it should not be necessary to sample a particular location more frequently than on a monthly basis. We suggest that a minimum of five censuses per habitat type per month should be made to ensure accuracy and comparability of data to detect any changes in predominant fish assemblage composition or structure. It may not be possible to obtain this number of monthly censuses in a limited habitat (e.g. Shoreline Mangroves in Gt. Lameshure Bay, where more than two censuses will overlap), but the same number of censuses per month for these habitat types should yield comparable data.

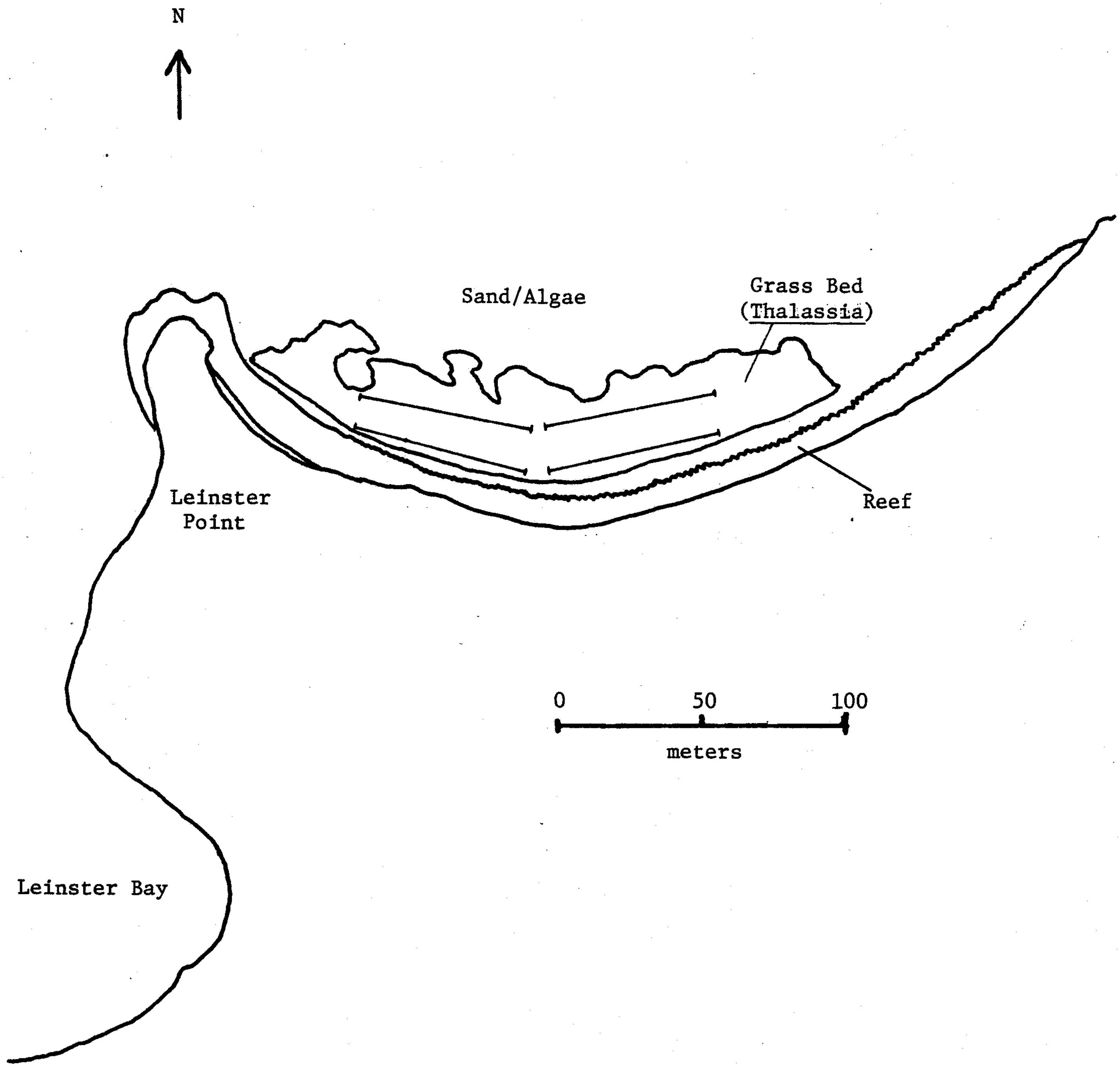
When monitoring, changes in composition, numbers and sizes due to fishing pressure should also be taken into account. Where possible, the owners of any fish traps in the immediate vicinity of the long-term monitoring site should be interviewed to determine catch composition numbers and sizes. This may give an indication of fishing impact and enable fishing influence to be differentiated from environmental influence on the community structure of reef fish populations.

2.2 Conch

2.2.1 Methods

Two locations were selected for baseline data collection on conch populations: Fish Bay on the south shore, and a small bay east of Leinster Bay on the north shore (Figure 1). The north shore site is a small indentation of the coastline with a narrow fringing reef (Figure 2). A narrow sand zone (~5m) lies between the reef and the sea grass bed, which is generally less than 100m wide. The sea grass bed is composed entirely of *Thalassia testudinum* and ranges from 2m to 6m in depth. The long axis of this seagrass bed is bounded by the two points of land which define the bay. Seaward of the seagrass bed the bottom slopes into deep water and is composed of sand and algal communities.

A visual swimming transect method was used to estimate conch densities at this site. A 61m fiberglass measuring tape was weighted at both ends and laid out on the bottom. Because of high current velocities, the transect was placed in line with the currrent (parallel to shore). No SCUBA was necessary at this site due to shallow depths. All conchs within 2m of either side of the transect line were counted as either adult or juvenile, based on the presence or absence



<u>Figure 2</u>. Location of conch census transects on the north shore of St. John, U.S.V.I.

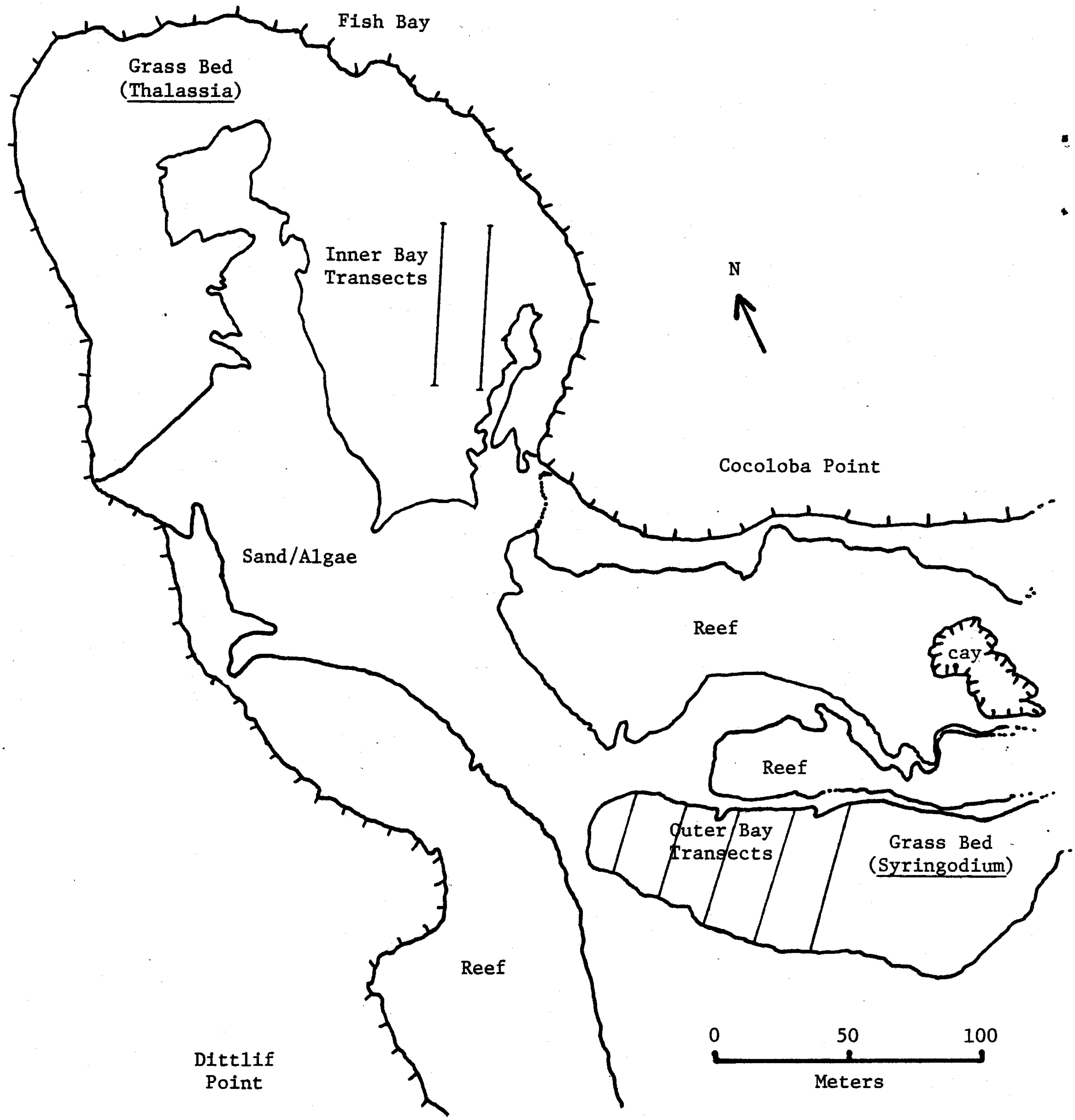


Figure 3. Location of conch census transects in Fish Bay, south shore, St. John, U.S.V.I.

respectively, of a flared lip.

The south shore site, Fish Bay, is a deeply indented mangrove embayment (Figure 3). The inner portion of the bay is bordered by Red Mangrove (*Rhizophora mangle*) and has relatively shallow (.5 to 2.5m) *Thalassia* covered bottom. Further outside the bay between the fringing reef on the east side and Ditliff Point on the west lies a *Syringodium filiforme* sea grass bed in 10m of water. This sea grass bed appears to be quite distinct from the surrounding sand and algal communities.

The inshore site at Fish Bay was sampled twice for juvenile conch. The first sample was simply a transect swum over an estimated distance with all conch counted within a 2m wide swath. The second sample was composed of two 61m transects. The outer bay site was sampled from N to S. From four to six different transects were swum per census in order that comparable quantities of transect over sea grass bed were obtained. All conchs within 2m of either side of the transect were counted as either adult or juvenile and conch densities were calculated.

2.2.2 Results

The north shore site was censused once in April and once in June (Table 3). Total numbers of conchs observed and densities in the two samples differ somewhat, but the most striking difference is in age distribution. The first census was composed of nearly 80 percent adult conchs with only a few juveniles observed. The second census 46 days later, was composed of 99 percent juveniles.

Inner Fish Bay on the south shore was sampled twice (Table 3). Comparison of these two samples is difficult; however, it does appear that the juvenile conchs were much more abundant in the area sampled in March than in the area sampled in April. Even if the transect length were underestimated by 50 percent (50m), the

TABLE 3

Conch census data for two bays on St. John, U.S.V.I. See Figure 1 for locations.

Location	Bay east of Leinster Bay Point, North Shore, St. John		Inner Bay, Fish Bay, South Shore, St. John		Outer Bay, Fish Bay, South Shore, St. John			
Date	4/27/84	6/12/84	3/6/84*	4/2/84	3/6/84	4/2/84	5/9/84	6/12/84
Depth	2.5 - 4m	2.5 - 4m	1.5m	1.5m	10m	10m	10m	10m
No. Transects	4	4	1	2	4	5	4	6
Total Length	244m	244m	100m	122m	227m	261m	241m	341m
Total Area	$976m^2$	$976m^2$	$200m^2$	$488m^2$	$908m^2$	$1044m^2$	$976m^2$	$1364m^2$
No. Adults	165	2	0	0	163	130	119	105
No. Juveniles	44	253	56	44	2	2	1	1
Total Conch	209	255	56	44	165	132	120	106
Density (conch/m^2)	.21	.26	.28	.09	.18	.13	.12	.08

*The accuracy of the total area surveyed on this date is not known. Data provided by L. Lewand.

resultant density would still be twice as high as the April census. Both samples were taken in the same approximate location.

The outer sea grass bed at Fish Bay was sampled four times at one month intervals from March to June (Table 3). Ratio of adults to juveniles remained essentially the same for all the censuses. During the course of this study, the numbers of conchs and the resultant densities decreased steadily from March to June.

2.2.3 Discussion

Conch populations within the Virgin Islands Biosphere Reserve are declining. It is increasingly difficult to find mature, adult conch in the shallow bays around St. John. Most adult populations are found in the deeper (> 10m) sea grass beds and offshore algal plains and are being taken by divers using SCUBA.

The north shore site had a surprisingly large population of adult conchs when observed in April. It is very unusual to find mature conch at that density in less than 4m of water less than 30m from shore. The size distribution observed on the second occasion, (mostly juveniles) is a more common one for this type of location (depth).

The shift in population structure at this site can probably best be explained by migration patterns. Hesse (1979) found juvenile conch (< 10cm) to be quite resident within a particular area. Mobility increased with size with conch larger than 16cm having ranges too large to be established. This size range would include conch up to nearly three years in age (Berg , 1976), although shell length is not considered an appropriate measurement for conch (Wood and Olsen, 1983). Randall (1964) showed that maximum shell length is obtained at or before maturity and Hesse (1977) found that shell lip thickness was related to growth for adult conch. It is unlikely that this shift in population structure is due to harvesting since fewer juveniles were present on the first occasion than on the second occasion and harvesting would not produce a nearly six-fold increase in juveniles.

The initial population structure observed is more commonly found in deeper (> 10m) conch habitats and less and less frequently in the shallow, more protected habitats where the second observed population structure (mostly juveniles) is more common. Much longer and more frequent monitoring of this site is needed before we can say which population structure is normal here.

The inner grass beds in Fish Bay on the south site are inhabited solely by juvenile conch, at least during the two sample days in this study. The distribution of juvenile conch at this site appears to be quite patchy. The difference in numbers between the first and second sample is undoubtedly due to sample bias. The first sample location was selected by the observer due to the noticeable abundance of conch. The second was located in the same area as the first; however, abundances as high as the first were never observed. This is probably due to general movements of the conch into and out of a particular area and chance clumping.

This juvenile population is unfortunately subjected to heavy harvesting (National Park Service, pers. comm.), as substantiated by large piles of empty juvenile conch shells on the adjacent shoreline. Unfortunately, this conch bed is just outside of the National Park Service boundary and, therefore, not subject to take limitations. Under Virgin Islands fishery law there is no minimum size limit on conch. This needs to be established. The taking of juveniles from this population in large numbers can have drastic effects on nearby adult populations which depend on the populations for recruitment. Not only does this reduce the number of conchs that reach a maximum yeld-per-recruit size, (most efficient size for harvest as growth crve drops off after this age), but by removing individuals before they reproduce at least once, there is no hope for ever stabilizing the population. It will be fished into extinction.

The outer Fish Bay population decreased in density during the course of this study. This may be due to harvesting or migration or both. Small fishing boats with SCUBA divers on board have been seen in this location on numerous occasions, presumably taking either conch or lobster from the adjacent reef. The primary source of recruitment for this population probably is the inner Fish Bay juvenile population. Continued harvest of these juveniles could lead to a gradual disappearance of this adult population.

To accurately assess population status, trends and effect of harvest, this study must be continued on a much more intensive level. The populations selected in this study must be monitored on a bi-weekly basis to detect harvesting, migration and any natural mortality. The surrounding areas need to be monitored for their potential effect on the population being studied (immigration/emigration). Coupled with this a port sampling scheme should be devised to determine harvest levels of conch both from the populations being studied and the other populations within the Virgin Islands Biosphere Reserve. Determination of population status and trends will lead to development of management options.

2.3 Whelk

2.3.1 Methods

The site selected for initial long-term monitoring of a whelk population within the Virgin Islands Biosphere Reserve is located along the coast between Windswept Beach and Peter Bay (Figure 1). This section of coastline is bordered on its landward side by private property. The site was selected due to accessibility and known low levels of fishing pressure. Europa Bay on the south shore was looked at as a possible site as Helen Randall (1964) did her work there; however, this site is generally rough and only marginally accessible by boat.

The site selected is composed of good whelk habitat varying from solid bedrock sheets extending down into the water to scattered boulders with occasional tide pools. Seaward of this site is a narrow fringing reef. Benthic filamentous algae appear to be plentiful as a food resource for the whelks. The study includes approximately 100m of coastline.

Along this strip of coastline 10 randomly selected sampling sites were chosen. At each sampling site a one-meter wide strip transect was run from above the high water mark to approximately one meter in depth or the furthest offshore emergent boulders along the transect. All whelks were collected within this strip transect. Underwater portions of the transect were surveyed using mask and snorkle. After collection, all whelks were measured from tip of spire to distal edge of the lip and released at the capture site.

2.3.2 Results

A single whelk census was performed to establish baseline data for a single location at a single point in time and to test the methods. Along the 100m of coastline 10 randomly performed strip transects yielded 367 whelk ranging in size from less than .5cm to 6.6cm. The size distribution within each sample and the totals are shown in Table 4. Totals within each sample ranged from 11 to 81 whelks per meter of coastline.

When all the whelks are distributed into one cm size classes, the population size distribution is represented by the histograph in Figure 4. The largest size class is composed of whelks under 1cm. This size class may be even larger as these whelks are extremely hard to detect with their good camouflage coloration. This size class can be considered the recruitment into the area. Using Randalls' (1964) estimated growth rate of 1.06mm per month for whelk ranging in size from 1.5mm to 8.2mm, we can say that all whelk in this size class are less than 9.5

TABLE 4

Sample size distribution of whelks collected west of Peter Bay, St. John, U.S.V.I. Shell measurement is from tip of spire to distal edge of shell.

Size Class (cm)

Sample	0-.9	1-1.9	2-2.9	3-3.9	4-4.9	5-5.9	6-6.9	Totals
1.	8	11	3	24	4	1	1	52
2.	2	1	3	2	7	5	-	20
3.	13	6	5	3	2	-	-	29
4.	3	1	5	2	-	-	-	11
5.	14	2	24	12	6	3	-	61
6.	3	3	1	4	3	-	-	14
7.	15	4	16	21	17	5	3	81
8.	7	10	24	6	6	-	-	53
9.	18	-	2	8	2	-	-	30
10.	7	4	3	2	-	-	-	16
Totals	90 (.25)	42 (.11)	86 (.23)	84 (.23)	47 (.13)	14 (.04)	4 (.01)	367

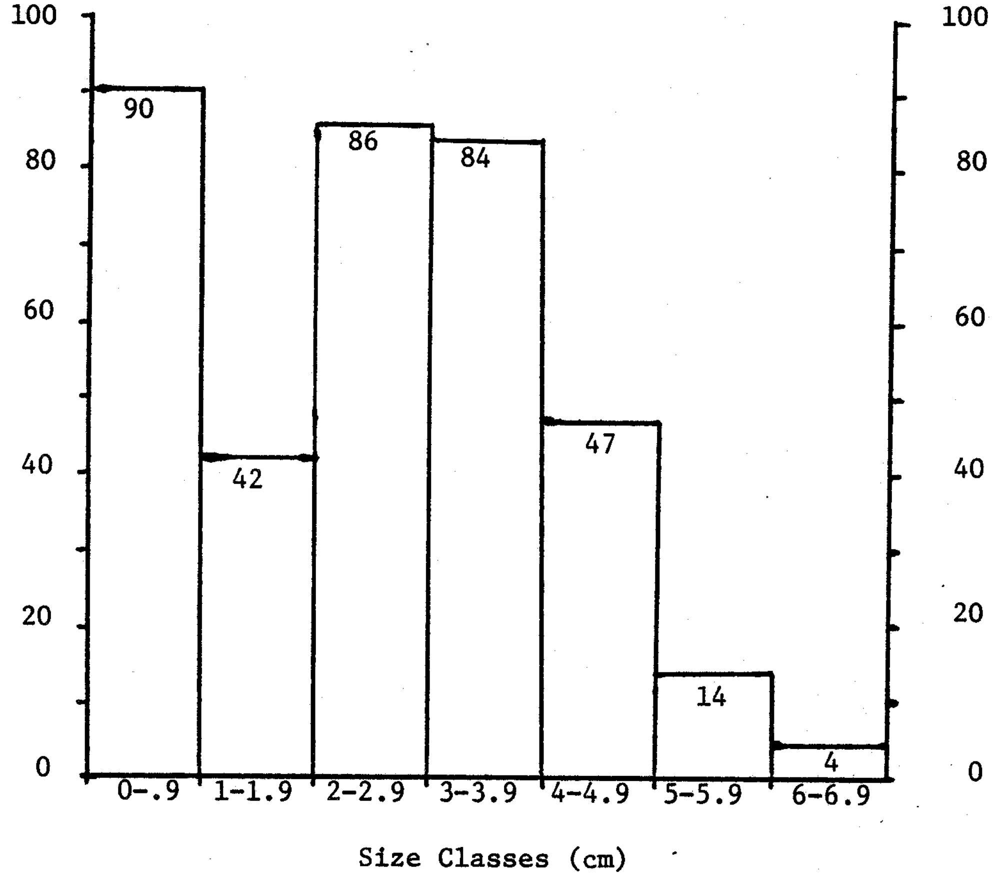


Figure 4. Histograph of size distribution of whelks collected west of Peter Bay, St. John, U.S.V.I. Shell measurement is from tip of spire to distal edge of shell.

months in age. It has been hypothesized that many species of gastropods have slow growth rates as juveniles due to less frequent feeding than adults. The juveniles tend to cluster in groups in cracks in the rocks at the upper limit of the intertidal zone where little algal food is present. Feeding may primarily be at night.

The initial recruitment size class is followed by a sharp drop in numbers in the next size class. This may be explained by high mortality or predation. Of the immature size classes the population peak appears to be in the 2 to 4 cm size classes. The larger size classes drop off in numbers essentially following they typical normal distribution curve for population structures.

2.3.3 Discussion

It appears that the population of whelks surveyed between Windswept Beach and Peter Bay has a relatively high level of recruitment. A high level of mortality or predation reduces the numbers reaching the larger size classes. The peak distribution lies in the immature size range. Randall (1964) found the smallest mature female in her samples to be 3.4cm and the smallest mature male to be 3.2cm. The conspicuous drop in numbers of larger individuals and the absence of individuals larger than 6.9cm indicates a high level of human harvest. Randall (1964) reported individuals up to 10cm at Europa Bay . Although this location is relatively isolated from areas of heavy human traffic, there must be harvesting of whelks that the authors are unaware of. Given a growth rate of approximately 1.45mm per month for the larger size classes (3 to 8cm) (Randall, 1964) it takes a whelk nearly seven months to move from one size class to another. At this rate, a harvest every six months of all individuals larger than 7cm and decreasing numbers to 4cm would maintain the present population structure as is. If we assume that all populations of whelks are in the same state, then we are going to see a gradual reduction towards elimination of the species, as harvests will include smaller and smaller whelk until no reproductive individuals are left.

It is impossible to determine at the present time the accuracy of this population census. In order to truly determine the status and size distribution of this population, we need to know if there is any movement of individuals relative to state of the tide, wave action, or solar radiation that might affect population distribution at any time. To assess population trends accurately, censuses must be carried out repeatedly at various states of the tide and times of the day. It would be extremely difficult to assess the affect of wave action on the population structure. Personal observations indicate, however, that during periods of greater wave action, the rocks are devoid of most whelks. It is assumed that they move into deeper water to avoid being washed off the rocks. Less energy spent holding on also means more time for feeding.

2.4 Lobster

2.4.1 Discussion

Although a study of lobster populations was determined to be beyond the scope of this project, incidental observations were compiled by location and habitat type (Table 5). While the data presented in Table 5 cannot be corrected for effort or area to allow good comparisons between locations, a few locations do stand out as areas where lobster appear to be very abundant. These include the lower fore-reef areas in Fish Bay and the offshore raised areas of bank pavement off the northeast coast of St. John. Both of these locations represent prime lobster habitat having many ledges and caves for shelter.

To adequately survey a given area for resident lobster populations, one must first clearly define the area. All portions of the area must then be systematically canvassed to ensure total coverage and no overlap. All lobsters observed should be classified as male or female. If female, they should be noted as being berried

Table 5. Incidental lobster (*Panulirus argus*) observations made during the course of the study within and immediately adjacent to Virgin Island Biosphere Reserve waters.

LOCATION	HABITAT TYPE	NO. DIVES*	NO. LOBSTER
South side St. John:			
S. of Bovocoap Pt.	Bank Pavement	2	2
Fish Bay	Lower Fore-reef	10	18 +
Reef Bay	Bank Patch Reef	4	2
Reef Bay	Fore-reef Pavement	3	4
Lt. Lameshur Bay	Lower Fore-reef	1	1
Gt. Lameshure Bay	Lower Fore-reef	4	1
Kiddle Bay	Bank Patch Reef	2	1
Booby Rock	Lower Fore-reef	2	1
W. side Ram Head	Lower Fore-reef	2	2
Otter Creek, Hurricane Hole	Shore Mangrove	1	1
North side St. John:			
Henley Cay	Fore-reef Pavement	2	1
Johnson's Reef	Lower Fore-reef	18	6
Whistling Cay	Lower Fore-reef	3	1
Mary's Point	Reef Gorgonian on Ledges	2	2
N. of Gowed Point	Bank Pavement	5	13

* This figure represents number of man-dives of effort (number of dives times number of divers looking for lobster). This figure is approximate.

(having eggs), tarred (attached sperm packet), or unberried. Size (carapace length) should either be measured or estimated. This is best done by capturing the lobster using an antenna snare, however, released lobsters tend to vacate their shelter and this may affect subsequent population estimates. Therefore, we recommend using an underwater flashlight and taking the time to carefully inspect the lobster without capturing it. Where this is not possible it may be best to simply determine densities (#lobsters/square meter).

3. DISCUSSION

Clearly, management strategies must be developed for fishery resources of the Virgin Islands. Antecedent to this, however, is a need to establish population trends for the species involved. The Virgin Islands Biosphere Reserve could serve as a discrete fisheries model to integrate into the Caribbean Fishery Management Council Draft Fishery Management Plan for the Shallow-Water Reeffish Fishery of Puerto Rico and the U. S. Virgin Islands (1984). The FMP relies on monitoring of the entire system by incorporating presently available and continually accruing data into a systems model which eventually will help determine the effectiveness of the management measures on the biological and socio-economical components of the fishery ecosystem.

Methodologies developed in this report to monitor fish and shellfish populations on a long-term basis were chosen for their effectiveness in estimating densities and relative abundances. Secondarily, they were chosen for their ease of use which enables different researchers in different locations to study the target species with a minimum of observer bias and with a minimum of hi-tech equipment. This should always be taken into account when setting up a long-term monitoring study, as a great potential exists for changes in personnel. A minimum of observer bias potential and equipment familiarization produces the greatest amount of consistency throughout the study.

The methods use in this study are recommended for continuation of a long-term monitoring program. A lobster long-term monitoring program would require a complete canvass of several discrete reef areas to monitor population levels. By doing this on a twice monthly basis one should be able to detect migrations and determine harvest levels. Good locations for this would be the lower fore-reef areas in Fish Bay and Western Reef Bay (see habitat maps in Boulon, 1985). Both are areas with known good lobster habitat and the ability to define a relatively discrete area for study.

Both juvenile and adult populations of conch should be monitored at Fish Bay. This should be done once monthly to detect seasonal population fluctuations. Whelk should be continued to be monitored at the Peter Bay location on a monthly basis as should fish populations. Peter Bay is recommended due to the present pristine nature of the bay and the potential for 15 or more residential homes to be build in the not so distant future. Long-shore transport of sediments from any development in this bay could affect reef and fish communities westward along the coast including Trunk Bay. Baseline data for this bay could be used to formulate mitigation measures should development threaten nearshore marine communities.

Fish should be monitored on a monthly basis in areas of particular concern (Fish Bay, Trunk Bay, Hawksnest Bay), in areas subject to potential development (Peter Bay), and in areas that are protected from development due to National Park Service ownership (Lameshur Bay or Haulover Bay). Areas to be monitored in all cases should be selected on the basis of the presence of a land-based natural drainage system (watershed) which could be studied to obtain much needed data on the interrelationships of terrestrial and marine ecosystems.

While coastal migratory pelagics are not included in this study due to obvious difficulties in monitoring them, they are a group that deserve special concern.

The fact that so little is known about their life histories and stocks could lead the fisheries unit into a critical state before we learn enough to manage it. The diffuse and wide-ranging nature of this group would make a direct sampling method unreliable to use. Additionally, any management measures formulated for this group will have to be implemented on a large scale (i.e. Caribbean and North Atlantic) for them to be biologically effective.

One thing to bear in mind when interpreting any data collected on a partial basis (i.e. only a few bays around a whole island) is that any trends observed in the population within those bays may be very localized and not related to large-scale trends. Studies on the related watersheds will provide possible explanation for observed trends.

The need exists for marine fishery resource management. The first step is to establish population status and trends. This can be accomplished through long-term monitoring programs for the various fishery elements. "Long-term" should include a minimum of one year's monitoring data and preferably two years. Once established, observed trends can be used to justify formulation of management measures for the species involved. Coupled with this, an analysis of fishery landings (lengths, weights and numbers) will provide an alternate source of information documenting population trends of commercially important species.

4. ACKNOWLEDGMENTS

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. Kathy Brown and Ms. Charlene Vaughan had to struggle through my handwriting to type this.

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Dive Times:

APPENDIX I

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)			