VIRGIN ISLANDS RESOURCE MANAGEMENT COOPERATIVE

BIOSPHERE RESERVE
RESEARCH REPORT NO. 26

BUCK ISLAND FISH AND SHELLFISH POPULATIONS

William Tobias
Department of Planning and Natural Resources
Division of Fish and Wildlife
St. Croix, U.S. Virgin Islands

Eric Telemaque
West Indies Laboratory
Fairleigh Dickinson University
St. Croix, U.S. Virgin Islands

Michael Davis
Virgin Islands National Park
St. Croix, U.S. Virgin Islands

U.S. MAN AND THE BIOSPHERE PROGRAM

Virgin Islands National Park

September, 1988

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

The objectives of the cooperative are:

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

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

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

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

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

BUCK ISLAND FISH AND SHELLFISH POPULATIONS

1988

BIOSPHERE RESERVE REPORT NO. 26

WILLIAM TOBIAS
DEPARTMENT OF PLANNING AND NATURAL RESOURCES
DIVISION OF FISH AND WILDLIFE
ST. CROIX, U.S. VIRGIN ISLANDS

ERIC TELEMAQUE
WEST INDIES LABORATORY
FAIRLEIGH DICKINSON UNIVERSITY
ST. CROIX, U.S. VIRGIN ISLANDS

MICHAEL DAVIS
VIRGIN ISLANDS NATIONAL PARK
ST. CROIX, 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

A fish and shellfish (conch and lobster) population study was conducted from November 1985 through June 1986 at Buck Island Reef National Monument (BUIS), St. Croix, U. S. Virgin Islands. The objectives of the project were: (1) to replicate fish census studies conducted by previous researchers in BUIS and compare their results to the present study; (2) to evaluate the impact of commercial trap fishing on BUIS reef fish and lobster populations; (3) to collect baseline data on conch and lobster populations at specific sites within BUIS; (4) to determine the effectiveness of the protective legislation at BUIS in sustaining or increasing fish and shellfish populations; and (5) to develop a long-term monitoring scheme for BUIS fish and shellfish populations.

Based on reef fish community census studies at BUIS, an area of limited fishing pressure, and Tague Bay, an area of unrestricted fishing pressure, BUIS reef fishes are decreasing at a rate equal to or greater than reef fishes at Tague Bay. The most abundant group of commercially important reef fish species present within BUIS are the herbivores, represented by the surgeonfishes (blue tang, and ocean surgeonfish) and parrotfishes (stoplight, princess, redtail and red band).

Mean conch density in the seagrass bed west of Buck Island for the six-month study period was 1 conch/7m^2. More than 98% of the conch censused were juveniles--those lacking a flared lip.

The average density of Caribbean spiny lobster for the six-month study period at the west patch reef (WPR), north patch reef (NPR) and south fringing reef (SFR) was 1.2 lobster/624 m^2, 1.5 lobster/165 m^2 and 1.3 lobster/1500 m^2, respectively.

Based on past sampling interviews with commercial fishermen and fish trap studies conducted in BUIS, estimates on commercial fishing effort with fish traps in BUIS indicate that 6,656 lbs. of reef fish and 1,996 lbs. of lobster may be removed from BUIS waters each year by 16 fish traps hauled twice/week. Additionally, an estimated 8,320 lbs. of fish are removed by 29 fish traps adjacent to BUIS waters. Although limited to two lobster and two conch/person/day from BUIS waters, the recreational harvest of these resources, unknown at present, may be substantial, based on 60,000 BUIS visitors/year.

Due to the small size of the protected area afforded by BUIS, reef fish and shellfish (conch and lobster) are adversely impacted by a relatively small but concentrated commercial and recreational fishing effort both in and adjacent to park waters. This impact may be exacerbated by the environmental degradation of the coral reef ecosystem due to natural and man-induced causes.

ACKNOWLEDGEMENTS

The authors wish to thank Hector Rivera, Theodore Skov and Willy Ventura of the Division of Fish and Wildlife for their assistance during various phases of the field work, and Jim Beets for his analysis of biostatistical reef fish data. This project could not have been accomplished without the logistical support and interest provided by the National Park Service, St. Croix, in particular, by Supervisory Ranger Felix Revello and Ranger Joel Tutein. Dr. William B. Gladfelter of West Indies Laboratory provided help with methods and statistical procedures, and Dr. John Ogden of West Indies Lab edited the final drafts of the manuscript. This is Contribution No. 173 of the West Indies Laboratory, Fairleigh Dickinson University, St. Croix, U. S. Virgin Islands.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Buck Island Reef National Monument (BUIS), located approximately 9.0 km (5.6 mi.) northeast of Christiansted, St. Croix, and 1.6 km (1.0 mi.) north of Tague Bay, St. Croix, consists of a land mass of 0.7 sq. km (180 ac) and surrounding marine environs of 3.0 sq. km (740 ac). Managed by the U. S. Department of the Interior, National Park Service, BUIS receives approximately 60,000 visitors each year.

In an effort to preserve the marine resources within the boundaries of BUIS without completely restricting traditional local commercial fishing, protective legislation was enacted during acquisition of Buck Island by the National Park Service in 1962. This was done to prohibit fishing of any type within the area designated as the "marine gardens" (the area within the eastern barrier reef system of Buck Island) and to allow fish trapping and line fishing in the remaining waters. Lobster and conch fishing were reduced to two spiny lobster and two conch per person per day outside the "marine gardens". The effects of this protective legislation within BUIS on commercial fisheries are not fully known. Despite this limited protection, concessionaires and park rangers report that they have observed a severe decline in BUIS fish populations over the years. Fish populations at BUIS are believed to be decreasing at nearly the same rate as adjacent St. Croix reef areas because of the impact from trap fishing, the principal commercial fishing method employed by artisanal fishermen.

The traditional Virgin Islands commercial fishery is a multi-species, multi-method fishery, due to both the limited availability of any one species for profitable commercial exploitation year-round and the artisanal nature of the fishery. This fishery has been and continues to be based upon fisheries resources associated with the narrow insular shelf around the U.S. and British Virgin Islands. Data presented by Olsen and LaPlace (1978), Olson et al. (1983) and Wood and Olsen (1983) show that these resources have been over-harvested in the past or are approaching the limits of their resource potential.

Fish community structure at BUIS was studied by Gladfelter et al. (1977) using visual census techniques. Their results indicate that the fish community at the eastern barrier reef system of Buck Island consisted of a high abundance of individuals (several species of parrotfish, damselfish and snappers); however, species diversity was low. Those individuals present were relatively large in size. Simpson (1979) studied the

changes in fish community structure at BUIS monthly over a one-year period by visual techniques and employed fish traps to study the effects of fishing pressure on the growth rate and size of fish in BUIS vs. Tague Bay. Fish abundance was found to be greater during the fall and winter months and diversity varied according to the type of habitat available. Based on fish trapping results, only two species of fish were found to be significantly larger within BUIS (low fishing pressure) than in Tague Bay (moderate fishing pressure). Differences in the rate of growth of fishes were not apparent with the methods used during the study period.

This report represents the results of a cooperative study, conducted by the Division of Fish and Wildlife (DFW), Fairleigh Dickinson's West Indies Laboratory (WIL), and the National Park Service (NPS), on the Buck Island fish and shellfish populations during the period November 1985 to June 1986. The objectives of the project were: (1) to replicate fish census studies conducted by previous researchers in BUIS and compare these results to the present study; (2) to evaluate the impact of commercial trap fishing on BUIS reef fish and lobster populations; (3) to collect baseline data on conch and lobster populations at specific sites within BUIS; (4) to determine the effectiveness of the protective legislation at BUIS in sustaining or increasing fish and shellfish populations; and (5) to develop a long-term monitoring scheme for BUIS fish and shellfish populations. Emphasis was placed on resurveying specific habitat areas studied by previous researchers and standardizing new methodologies for assessing previously unsurveyed marine resources. The DFW assumed overall project responsibility and conducted census surveys of commercially important fisheries resources including reef fish, conch and lobster. The WIL maintained administrative responsibility for the project and conducted reef fish census surveys. The NPS provided logistical support including boat transportation to the study site, diving assistance, establishment of study transects and a visual survey of the commercial trap fishing effort in and adjacent to BUIS waters.

METHODS

Reef Fish

The present fish community structure at BUIS was determined by employing visual census techniques, consisting of replicate 15-20 minute timed censuses with scuba equipment, at four sites (north patch reef - NPR, south patch reef - SPR, reef crest - RC, and deep fore reef/bank bottom - FR) (Figure 1). These sites were located in the "marine gardens", which is an area restricted to all fishing. Two sites in Tague Bay (Patch Reef #2 and Patch Reef #8) were also selected for comparative purposes (Figure 1 in Gladfelter and Gladfelter, 1978, reef fish census).

These patch reefs represent areas of heavy fishing pressure and were the subject of earlier studies. Censusing methods were identical to those used in previous studies to permit comparative data analysis. Each study site was circled by one or more divers and all species of fish were recorded. The number of replicate censuses varied between three and four depending on the number of divers available. The variability in diver data collection was reduced by employing the same divers throughout the study.

The NPR and SPR sites at Buck Island were identical to those areas surveyed by Gladfelter et al. (1977), Gladfelter and Gladfelter (1980) and by Simpson (1979). The NPR was located landward of the North Scuba Cut and consisted of a dense matrix of dead elkhorn coral (Acropora palmata) covered by a mixed algal turf. The patch reef rose from 3 m water depth to the surface and was surrounded by rocky bottom substrate on three sides and sand on the fourth side. The approximate size of the NPR is 165 m^2. The SPR was located northwest of the main channel entrance to the "marine gardens" and was approximately the same size as the NPR. The patch reef consists of an elevated open platform with loose coral rubble and some live Acropora palmata and Montastrea annularis. It was surrounded by a sandy bottom 3 m deep.

The RC and FR study sites were identical to those surveyed by Gladfelter et al. (1977). A 150-m long by 25-m wide transect, originating near the entrance of the snorkeling trail, was established over the reef crest in a northerly direction. The transect bisected the reef crest, sandy bank bottom, and two offshore patch reefs or "haystacks". The "haystacks" consisted of the elkhorn coral Acropora palmata growing from a bottom depth of 10 m to within 1 m of the surface.

The fish census sites in Tague Bay, Patch Reef #2 and Patch Reef #8, were identical to those surveyed by Gladfelter and Gladfelter (1978). Both patch reefs were located in the eastern portion of Tague Bay in 3-5 m water depth and consisted of carbonate pavement and dead Acropora palmata surrounded by turtle grass (Thalassia testudinum) and manatee grass (Syringodium filiforme). The areas of Patch Reef #2 and Patch Reef #8 were 2,500 m^2 and 850 m^2, respectively.

Diurnal fish censuses were conducted monthly from November through May for the Buck Island sites. The Tague Bay sites were censused diurnally in April and June 1986. Nocturnal censuses were conducted at the Buck Island sites in June 1986. The fish species censused were placed in the following abundance categories based on numbers present (Simpson, 1979):

Abundance Category	Number of Fish
1	1
2	2-5
3	6-10
4	11-24
5	25-50
6	51-100
7	> 100

The abundance of commercially important reef fish species was determined by employing a random point, visual census technique (Bohnsack and Bannerot 1983; Boulon et al. 1985) monthly for a period of six months at the four study sites previously designated for the fish community structure study within the BUIS. The selection of key fish species of commercial/artisanal importance was based upon (1) biostatistical (length/weight) measurements obtained from port sampling surveys of the catch of commercial fishermen fishing in or adjacent to BUIS, and (2) biostatistical measurements obtained from the catch of commercial trap fishermen from Lang Bank who participated in the Division of Fish and Wildlife biostatistical reef fish sampling program (Clavijo et al. 1986).

Four fish traps, one each at the four study sites used by Simpson (1979) (two in BUIS - NPR and SPR and two in Tague Bay - patch reef #18 (Gladfelter and Gladfelter 1978) and Tague Bay back reef northwest of patch reef #18), were deployed to obtain individual lengths and weights of commercial fish species. The fish traps deployed were typical single funnel West Indian "arrowhead" or "chevron" traps with a downward-opening funnel in the apex of the "V".

Dimensions of the traps were similar to those deployed by Simpson (1979), approximately 1.5 m wide, 1.25 m long and 0.5 m high. The traps were constructed with a wood frame and supports of locally cut "bunchberry" sticks over which is fastened 3.2 cm hexagonal mesh galvanized wire. Soak time for all traps was initially 7 days; however, injured fishes observed in Buck Island fish traps necessitated hauling these traps twice weekly. Munro (1974) has shown that total catch is relatively constant for a soak time of 6-7 days. The length/weight measurements of commercial fish species were compared to identical fish species caught by commercial fish trap fishermen in the immediate vicinity of Buck Island and on Lang Bank reefs to the east to determine if significant differences existed in the length and weight of fishes due to fishing pressure.

Conch

The abundance of queen conch (*Strombus gigas*) 10 m deep, in BUIS was censused along two 332 m long parallel strip transects, four meters in width extending due east from a point approximately 30 m east of "E" buoy, through a large seagrass bed comprised of *Thalassia testudinum* and *Syringodium filiforme* (Figure 1). Transect depth was 10 m. This seagrass bed, near the western park border, represents the only major conch habitat area at Buck Island. The seagrass bed is bordered to the north by coral reef, to the west by a steep dropoff at the shelf edge, to the south by a sandy algal plain 17 m deep, and to the east by Buck Island. Total seagrass bed area is approximately $16 \times 10^5 m^2$. The transect lines consisted of nylon line secured to steel stakes driven into the bottom substrate, thus supporting the line 30.5 - 45.7 cm above the bottom. This was necessary to allow free movement of the conch through the study area. Adult and juvenile conchs were counted in a two-meter wide strip on both sides of the transect line, following a technique used by Boulon (1985). Conch transects were conducted monthly for a period of six months to establish density.

Lobster

Lobster population censuses were made monthly for a period of six months at three study sites within BUIS: (1) the patch reef located due north of the west end of Buck Island behind the barrier reef designated as the west patch reef (WPR), (2) the NPR, and (3) south fringing reef (SFR), east of the "marine gardens" entrance (Figure 1). The three sites were selected because they represent typical reef communities within BUIS, were surveyable using diving or snorkeling techniques, and represent good lobster habitat. The census survey consisted of a 15-minute timed search for both spiny lobster (*Panulirus argus*) and spotted lobster (*Panulirus guttatus*). The numbers of lobsters observed and size class (spiny lobsters only): legal $\geq$ 3.5 in. carapace length or short: $<$3.5 in.) were recorded. Lobsters were censused visually and size classes were estimated to minimize lobster disturbance. Diver observations were compared to verify lobster counts.

Fishing Effort

Approximately 90% of all commercial fishing effort in BUIS is by trapping. A determination of trapping effort within and adjacent to BUIS waters was made by the NPS and DFW. At Buck Island, two park rangers conducted a visual survey, one ranger stationed on the Buck Island observation tower and another patrolling offshore in a

boat. The ranger on the observation tower was able to observe fishing activities throughout most of the northern and western waters of the Monument; Buck Island topography obscured the view of remaining waters. The ranger in the patrol boat observed fishing activities in the remaining southern and easternmost waters of the Monument. The "boat ranger" also obtained registration numbers of each fishing boat. Each ranger recorded trapping locations of each boat on a map. Radio contact between the rangers and later after-observation debriefings were used to compare and coordinate fish trap counts to obtain accurate information on trap locations and numbers. Rangers were deployed at observation locations prior to arrival of fishing boats from 0800-0900 hours over a period of four months on Wednesdays and Saturdays, traditional fishing days. Commercial artisanal fishermen have seldom been observed on other days when early morning patrols have been conducted.

DFW personnel conducted weekly port sampling interviews with commercial fish trap fishermen fishing adjacent to BUIS waters to obtain pertinent catch/effort information. Vessel registration numbers were compared with data obtained by the NPS to accurately access fishing effort.

RESULTS

Reef Fish

The relative abundance of reef fish species present at the BUIS and Tague Bay study sites, based on census surveys made from November 1985 - June 1986, are shown in Table I. This data was compared to similar reef fish census data collected by Simpson (1979) for BUIS NPR and SPR sites, Gladfelter and Gladfelter (1980) for the BUIS FR site, and Gladfelter and Gladfelter (1978) for Tague Bay Patch Reefs #2 and #3.

During this study, the Scaridae (parrotfishes) represented the most abundant family of fishes present at the NPR (27%), followed by the Pomacentridae (damselfishes) (19%), Labridae (wrasses) (14%), Acanthuridae (surgeonfishes) (12%) and Haemulidae (grunts) (11%) families. Similar relative abundance values were reported by Simpson (1979) for parrotfishes and damselfishes; however, more grunt species (15%) (particularly small mouth and French grunts) were recorded than labrids (13%).

The order of relative abundance for the reef fish families censused during this study, and that by Simpson (1979) at the SPR, were parrotfishes (21 and 22%,

respectively), damselfishes (17 and 18%, respectively), wrasses (13% each), grunts (11.0 and 12.5%, respectively) and surgeonfishes (11 and 12%, respectively). Differences in species abundance between the two censuses occurred with princess parrotfishes, threespot damselfishes, blackear wrasses and bluestriped grunts which were more abundant in Simpson's studies.

Differences in relative abundance values for reef fishes present at the FR study site were more apparent than either the NPR or SPR sites. Gladfelter and Gladfelter (1980) indicates that damselfishes (29%), parrotfishes (12%), surgeonfishes (10%) and wrasses (10%) represented the most abundant reef fishes. The present study indicates that the order of relative abundance has shifted to parrotfishes (31%), damselfishes (23%), wrasses (13%) and surgeonfishes (12%). Lutjanids (snappers) decreased in abundance from 9.0% to 2.9%.

Changes in relative abundance of reef fishes at Tague Bay Patch Reefs #2 and #8 are also apparent. Gladfelter and Gladfelter (1978) indicates that parrotfishes, damselfishes, wrasses and grunts dominated Patch Reef #2 (relative abundance = 23%, 13%, 12% and 10%, respectively). Our studies indicated that the order of relative abundance was parrotfishes (24%), grunts (18%), damselfish (14%) and surgeonfish (10%). Reef fish species increasing in abundance included redband parrotfish, French grunts and bluestriped grunts. Snappers increased from 2 to 9%.

At Patch Reef #8, grunts decreased in relative abundance from 17 to 11%, parrotfishes increased from 16 to 22%, damselfishes remained relatively stable at 12%, wrasses decreased from 9 to 1% and surgeonfishes increased from 4 to 12%.

Reef fishes of importance to commercial fish trap fishermen were censused at BUIS NPR, SPR, RC and FR study sites monthly from January through June 1986. A total of 42 species representing 17 families were censused.

Table 2 represents the six-month average of the number of individuals, relative abundance, and mean size of commercially important reef fish species observed at the four study sites within BUIS waters. Based on relative abundance, 19% of the fish observed at the NPR were ocean surgeonfish, 17% were blue tang, 15% were stoplight parrotfish and 9% were French grunt. Dominant fish species at the SPR were blue tang and French grunt (17% each), stoplight parrotfish (15%) and ocean surgeonfish (14%). The FR and RC were dominated by blue tang (29% and 45%,

respectively), ocean surgeonfish (24% and 17% respectively) and stoplight parrotfish (19% and 16% respectively). A greater number of commercially important fish species were recorded for the FR than for any other study site at BUIS; however, the monthly average for total number of fish present was greatest for the RC site.

The mean size of the most abundant commercially important reef fish species, such as the stoplight parrotfish, blue tang and ocean surgeonfish, was greater at the FR study site than at the other three Buck Island locations. The smallest individuals were recorded at the SPR.

Although habitat types of the study sites at BUIS and the Virgin Islands Biosphere Reserve in St. John were not identical, general comparisons of the reef fish community can be made between similar reef environs. Surgeonfish (ocean surgeonfish and blue tang) dominated the reef fish community present at the NPR and SPR (56% and 36% respectively) while accounting for only 12% of the fish community of the Hawksnest Bay patch reef site in St. John. Parrotfish represented 32% and 21%, respectively, at the NPR and SPR compared to 52% at the Hawksnest Bay patch reef. A total of 23% of the reef fish at the NPR and SPR were grunts versus only 3% at the Hawksnest Bay site. Snappers represented 10% and 1% of the fish community at the NPR and SPR, respectively; however, 28% of the reef fish at the Hawksnest Bay patch reef were snappers.

The FR at BUIS was comprised of 53% surgeonfish (29% blue tang and 24% ocean surgeonfish), 26% parrotfish, 3% snapper and 2% grunts. The Hawksnest Bay lower forereef was comprised of 30% surgeonfish (doctorfish), 23% parrotfish and 12% each snappers and grunts. A second area in St. John, Great Lameshur Bay lower forereef, consisted of 39% parrotfish, 17% snappers, 14% grunts and 10% surgeonfish (doctorfish).

Based on relative abundance, the RC site at BUIS was represented by 61% surgeonfish (45% blue tang and 16% ocean surgeonfish), 23% parrotfish and 7% snapper. The Hawksnest Bay upper fore reef, in comparison, had 69% grunts, 8% parrotfish, 8% doctorfish and 8% snapper.

Estimated sizes for commercial fishery reef fishes were generally larger for species censused at BUIS compared to the same species censused at the St. John Virgin Islands Biosphere Reserve.

A comparison of the lengths and weights of the 12 most common species of reef fish caught in the fish traps deployed at BUIS NPR and SPR and Tague Bay Patch Reef

#18 and back reef sites was made to fishes caught by commercial fish trap fishermen from waters adjacent to BUIS and Lang Bank (Table 3). During the month of June, a total of 14 species and 93 individual fishes were trapped in BUIS waters and 17 species and 156 individuals in Tague Bay. Significant differences were noted in the number of individuals and number of species trapped between Buck Island and Tague Bay. Statistical analysis of data (student's t-test) demonstrated that Buck Island had a consistently lower number of individuals trapped. Fish species trapped in Tague Bay and not appearing in BUIS traps included white spotted filefish, yellowtail snapper, queen parrotfish, Nassau grouper, doctorfish, dusky damselfish and redtail parrotfish. Fish species trapped in BUIS traps but not appearing in Tague Bay traps included bar jack, red hind, princess parrotfish, scrawled trunkfish, yellow goatfish and blue striped grunt.

Of the 12 most common species of reef fish caught in fish traps listed in Table 3, only three species, Sparisoma viride (stoplight parrotfish), Acanthurus coeruleus (blue tang) and Acanthurus bahianus (ocean surgeonfish), were caught in sufficient abundance from BUIS and Tague Bay traps to provide an adequate sample for statistical analysis between the four areas. Analysis of length and weight data (Student's t-test) indicates that for S. viride both lengths and weights of fishes caught at BUIS and Tague Bay were significantly less than S. viride caught in adjacent waters or on Lang Bank. No statistical difference was observed for lengths and weights of S. viride from BUIS and Tague Bay at the $p<.05$ level. No significant differences were observed for weights of A. coeruleus between any areas; however, fish lengths were significantly greater from Lang Bank. A. bahianus lengths were significantly greater at BUIS adjacent waters and Lang Bank compared to BUIS or Tague Bay. In turn, BUIS ocean surgeonfish were larger than those from Tague Bay. Significant differences existed at each area for A. bahianus weights.

Conch

Conch census data are shown in Table 4. The mean conch density along both Transects A and B was 1 conch/7 m^2 (0.14 conch/m^2) (S.D. = 0.025 and 0.013, respectively). Juvenile conch, those lacking a flared lip, outnumbered adults 41:1 on Transect A and 90:1 on Transect B. The average number of conch censused per month was 4 adults and 165 juveniles on Transect A and 2 adults and 179 juveniles on Transect B.

Conch transect lines were found broken in the fifth month of the study. Due to the presence of fish traps near the study area, it is believed that one or more fish traps may have become entangled in the transect lines during hauling and resulted in the broken lines. Transect lines were subsequently reestablished with a two-week delay of data collection.

Lobster

Monthly census data for spiny, lobster observed at the WPR, NPR and south fringing reef (SFR) from January through June 1986, is shown in Table 5. Lobster species censused included Panulirus argus, the Caribbean spiny lobster, and P. guttatus, the spotted lobster. The average density of Caribbean spiny lobster for the six-month study period at the WPR, NPR and SFR was 1.2 lobster/624 m^2, 1.5 lobster/165 m^2 and 1.3 lobster/1500 m^2, respectively. The average density of spotted lobster for the same period for the WPR, NPR and SFR was 1.4/624 m^2, 1.3/165 m^2 and 1.3/1500 m^2, respectively.

Fishing Effort

Commercial fishermen engaged in fish trapping were observed in three vessels both in and near BUIS each morning observations were made by the NPS. An additional four fishermen in two separate vessels, fishing adjacent to BUIS, were interviewed by DFW port sampling agents. Locations of fish traps deployed in, near and adjacent to BUIS are shown in Figure 1. A total of 12 fishermen in five different vessels fished 45 fish traps in or adjacent to BUIS waters (16 traps inside BUIS, 11 traps near BUIS and 18 traps in waters adjacent to BUIS) (Table 6). Two vessels were operating both inside and within 100 m of BUIS, two vessels operated only in waters adjacent to BUIS and one vessel operated solely in BUIS.

DISCUSSION

Fish Community Structure

When compared to fish community census studies conducted by Simpson (1979) for BUIS NPR and SPR sites, the present study indicates that an average of 38% of the fish species censused increased in number, 34% of the species decreased in number and 30% remained unchanged. Although shifts in the abundance of individual reef fishes censused were apparent, the relative abundance values for the reef fish families were quite similar using comparable census techniques. Appreciable changes were observed in the decrease of grunts and Bermuda chub presently observed

at the NPR, and grunts, snappers and surgeonfish at the SPR. Both study sites in addition to the FR site are in the protected waters of BUIS "marine gardens", where there is no fishing pressure.

Compared to Gladfelter et. al. (1977) studies at BUIS FR, the present fish census indicates that 24% of the fish species censused increased in abundance, 51% decreased and 25% remained unchanged. Most notable decreases in fish abundance occurred in the snapper, grouper and damselfish families. A 168% increase in parrotfishes was observed in the present study at the FR site.

Data collected by Gladfelter et. al. (1977) and Gladfelter and Gladfelter (1980) for BUIS indicated high abundances of urchin-eating fish species, including black margate, spanish grunt, caesar grunt and queen triggerfish. These species were not observed in the present study. The black sea urchin, Diadema antillarum, once abundant in waters of BUIS and Tague Bay, St. Croix, as well as throughout the Caribbean, suffered heavy mortality from January 1983 to January 1984 due to an unknown water-borne pathogen transported by ocean currents (Lessios et al., 1984). Because of Diadema's ability to affect algal and coral community diversity and compete with herbivorous fishes for available food (Ogden et al., 1973; Ogden and Lobel, 1978; Lessios et. al., 1984), a severe decline in Diadema population numbers would subsequently result in domination of the coral community by faster growing benthic algae, a reduction in overall benthic community diversity and an increase in food supply for herbivorous fishes. In time, a greater algal biomass would also be able to support a greater number of herbivorous fishes. The presence of greater numbers of herbivorous fishes, particularly parrotfish, on the FR may be a result of an increase in algal food supply and a decrease in predators (lutjanids and serranids).

The FR area censused lies adjacent to the Underwater Trail, which is visited by tens of thousands of snorkelers each year. The decrease in predator fishes in this area may be related to the increase in snorkelers on the coral reef, assuming zero mortality due to no fishing pressure.

Tague Bay fish census surveys, compared to similar work by Gladfelter and Gladfelter (1978), indicate that 47% of the reef fish species censused increased in abundance, 37% decreased in abundance and 16% remained unchanged. Depending upon area, those species increasing in abundance included snappers as well as grunts and parrotfishes.

Reef fishes at BUIS are decreasing at a rate equal to or greater than reef fishes at Tague Bay. It would be anticipated that an area subject to unlimited or heavy fishing pressure, such as Tague Bay, would show a significantly greater decrease in relative abundance of reef fishes than BUIS, where fishing pressure is limited. This discrepancy may be due to the ability of the large contiguous reef area of Tague Bay to better absorb fishing pressure. Due to the small size of the protected area afforded by BUIS, reef fish populations are adversely impacted by a relatively small but concentrated fishing effort.

The relative abundance of commercially important reef fishes at Buck Island is similar to that of Tague Bay and St. Croix in general. The most abundant reef fish species are the surgeonfishes, represented by the blue tang and ocean surgeonfish, followed by the parrotfishes (stoplight, princess, redtail, red band) and grunts (French grunt, smallmouth, white and bluestripe). By weight, the order of priority would be parrotfish, followed by grunt and/or surgeonfish depending upon seasonal abundance (Simpson, 1979; Gladfelter and Gladfelter, 1980). Herbivores dominate the fish fauna of BUIS with the larger fish occurring in the FR area. Similar reef fishes of commercial importance occur in the Virgin Islands Biosphere Reserve on St. John; however, their relative abundance differs from those fishes found at BUIS and St. Croix. In general, the relative abundance of herbivores, parrotfishes and surgeonfishes, is greater at BUIS and St. Croix.

Based on a comparison of lengths and weights of trap-caught stoplight parrotfish (S. viride), blue tang (A. coeruleus) and ocean surgeonfish (A. bahianus) from BUIS, Tague Bay, BUIS adjacent waters and Lang Bank, only ocean surgeonfish were significantly larger in BUIS waters where fishing effort is limited. Blue tang were significantly larger and stoplight parrotfish were both larger and weighed more in waters adjacent to BUIS and Lang Bank than within BUIS or Tague Bay. This further illustrates the ineffectiveness of the existing fishing regulations in BUIS to sustain or improve fish populations within park waters.

Conch

Census results at BUIS indicate the western grassbed is a natural conch nursery area. More than 98% of the conch censused were juveniles -- those lacking a flared lip. At no time were substantial numbers of adult conch observed.

Hesse (1979) found juvenile conch (<10 cm) to be sedentary with mobility increasing with size. Conch larger than 16 cm (up to 3 years in age) had ranges too large to be established (Berg, 1976).

Although not observed in BUIS waters, commercial conch divers with the aid of SCUBA equipment were observed harvesting conch adjacent to the western and southern park boundaries where water depth increases to 17 m. It is believed that as the conch mature in the BUIS western grassbed, they migrate to deeper water adjacent to the park and are harvested by commercial divers.

The western grassbed of BUIS has an area of approximately 1.6 x 10^5 sq. m. At a density 1 conch/7 m^2, a conch population of approximately 22,857 individuals is estimated to reside in this area. This represents a potential biomass of 7,300 kg that this predominantly juvenile cohort would produce if allowed to mature at an average of 320 g dressed meat wt/conch (Tobias, 1987).

Under the present park regulations, two conch/person/day may be removed from BUIS waters. With approximately 60,000 visitors each year at Buck Island, the removal of conch by recreational users has the potential to be significant. Under Federal or Virgin Islands law, there is no minimum size limit on conch. Removing juveniles from the population before they reach sexual maturity can have drastic effects on nearby adult populations which depend on the juveniles for recruitment (Boulon et al. 1985).

Lobster

The abundance of the Caribbean spiny lobster within BUIS is related to habitat availability, food supply and seasonal migrations inshore and offshore. Greatest abundance of spiny lobster was found at the NPR; however, this data may be biased since the structural complexity of this site afforded better observational access than the WPR or the SFR. Similar densities of the spotted lobster were also observed.

Park regulations also permit the removal of two lobster/person/day from waters outside the "marine gardens". Significant but unknown quantities of lobster are believed to be taken by recreational users each year.

Fishing Effort

Port sampling interviews with fishermen fishing adjacent to BUIS (N=15) indicate that an average of 7.5 fish (4.0 lbs.) per trap are taken back to port. Based on 16 fish

traps deployed in BUIS with an average take-home catch of 4.0 lbs./trap and hauled twice/week, approximately 6,656 lbs. of reef fish (13,312 fish at 0.5 lbs. each) would be removed per year. The 29 fish traps outside BUIS would account for another 8,320 lbs. of fish/year (11 traps hauled twice/week and 18 traps hauled once/week) (or 16,704 reef fish), assuming similar catch rates.

Port samples from commercial fish trap fishermen on Lang Bank from January through December 1986 (N=112) indicate that 1,593 lobster were caught from 2,051 fish trap hauls for a catch rate of 0.78 lobster/trap. BUIS and Lang Bank are adjacent to each other on the same insular shelf; however, available lobster habitat is different at BUIS and fish trapping is restricted to the western park area where lobster habitat may be less desirable. Based on fish traps set at BUIS NPR and SPR, a total of ten trap hauls resulted in the capture of six spotted lobster for a catch rate of 0.6 lobster/trap. Based on lobster census surveys, the abundance of spiny lobster was equal to the abundance of spotted lobster at the areas surveyed. It is assumed that spiny lobster and spotted lobster abundances are equal and the catch rates of lobster in fish traps outside of BUIS "marine gardens" are similar to those deployed at the NPR and SPR. Under these assumptions, 16 traps in BUIS waters would produce 998 lobster/year (16 traps hauled twice/week). At an average weight of 2.0 lbs./lobster, an annual harvest of 1,996 lbs. may be estimated.

CONCLUSIONS

Reef fish census studies, supported by statistical analysis of length/weight measurements of commercially important reef fish species, indicate that the protective regulations enacted by the National Park Service have been ineffective in maintaining or enhancing BUIS fishery resources. Due to the small area encompassed by BUIS, major adverse impacts may be incurred from a relatively small but concentrated commercial fishing effort in and adjacent to park waters. Although restricted by bag limits on conch and lobster for commercial harvest, recreational user groups, due to their great numbers, contribute to the decline of these limited resources.

In addition to adverse impact by commercial and recreational fishing pressure, fisheries resources at BUIS have also been affected by environmental changes resulting from coral mortality due to white-band disease, Diadema mass mortality, and the physical impact of 60,000 visitors/year on the reef ecosystem.

RECOMMENDATIONS

The following short-term and long-term recommendations have been made to more thoroughly define the impacts of continued limited fishing pressure on the fishery resources in BUIS.

(1) All fish traps deployed in BUIS waters should be properly marked with surface floats having the respective color pattern assigned to the commercial fisherman, as required under V.I. Code, ACT 3330. This will allow for an accurate count of both fish traps within BUIS and registered commercial fishermen.

(2) Commercial fish trap catches can be monitored visually, both in and adjacent to park waters by diver surveys conducted the day prior to traditional trap hauling days, to assess catch rates and catch composition of fish and lobster.

(3) Fish census studies can be repeated at NPR, SPR and RC/FR study sites and compared to previous work.

(4) Tag and recapture studies can be conducted on the more abundant commercially sought reef fishes (i.e. scarids, acanthurids, haemulids and lutjanids) to determine home range and immigration/emigration in park waters.

(5) Permanent conch transects should be established in the western grassbed to monitor conch population changes. This data can be compared to baseline data provided in this study.

(6) Permanent conch transects should be established for population assessment purposes in adjacent waters where the animals are commercially harvested.

(7) Subadult size conch in the BUIS western grassbed should be tagged to monitor migration patterns from the nursery area to offshore grounds.

(8) Commercial conch divers in waters adjacent to BUIS should be interviewed periodically to determine catch/effort data.

(9) Lobster census studies of the NPR, WPR and SFR sites should be repeated and compared to the baseline data from this study and to similar sites selected from Tague Bay.

(10) The impact by recreational fishermen on conch and lobster resources in BUIS should be monitored by contact interviews.

The marine ecosystems in an area as small as BUIS are dependent upon and affected by marine ecosystems in adjacent waters. The general decline in reef fish resources at BUIS is simply a reflection of the general condition of St. Croix reefs. Although it would be ideal to prohibit all fishing at BUIS and establish a marine sanctuary -- supplying larvae and juveniles of fish and shellfish to naturally propagate St. Croix reefs -- simply prohibiting the harvest of fish, conch and lobster within BUIS may not be sufficient to reverse or stabilize negative trends. Comprehensive management plans for all inshore resources by all user groups in the U. S. Virgin Islands are essential to maintain the integrity of fish and shellfish stocks for the present and to improve them for the benefit of future Virgin Islanders and visitors alike.

REFERENCES

Berg, C. J. 1976. Growth of the queen conch Strombus gigas, with a discussion of the practicality of its mariculture. Mar. Bio. 34: 191-199.

Bohnsack, J. A. and S. P. Bannerot. 1983. A random point census technique for visually assessing coral reef fishes. In: C. A. Barons and S. A. Bortone (eds.), 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.

Boulon, R. H., J. Beets and V. Small. 1985. Long-term monitoring of fisheries in the Virgin Islands Biosphere Reserve. Biosphere Reserve Research Report #13, 32 p.

Clavijo, I. E., W. Tobias and C. Jennings. 1986. State/ Federal Cooperative Statistics Program - U.S. Virgin Islands: Completion Report, April 1, 1983 - March 31, 1986. Department of Conservation and Cultural Affairs, State/Federal Cooperative Statistics Program Report: Project No. SF-22, Segments 1-3, 29 p.

Gladfelter, W. B., E.H. Gladfelter, R.K. Monahan, J.C. Ogden and R. F. Dill. 1977. Environmental studies of Buck Island Reef National Monument. U. S. National Park Service Report. 144 pp.

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

Gladfelter, W. B., D. K. Hubbard, R. C. Carpenter and G. S. Simpson. 1979. Environmental Studies of Buck Island Reef National Monument, St. Croix, U.S.V.I. II. U. S. National Park Service Report. 168 p.

Gladfelter, E. H. and W. B. Gladfelter. 1980. Environmental Studies of Buck Island Reef National Monument III. U. S. National Park Service Report. 116 p.

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

Lessios, H. A., D. R. Robertson and J. D. Cubit. 1984. Spread of Diadema mass mortality through the Caribbean. Science 226:335-337.

Munro, J. C. 1974. The mode of operation of Antillean fish traps and the relationships between ingress, escapement, catch and soak. J. Cons. Int. Explor. Mer. 35:337-350.

Ogden, J. C., R. A. Brown and N. Salesky. 1973. Grazing by the echinoid Diadema antillarum Philippi: formation of halos around West Indian patch reefs. Science 182:715-717.

Ogden, J. C. and P. S. Lobel. 1978. The role of herbivorous fishes and urchins in coral reef communities. Env. Biol. Fish. 3(1):49-63.

Olsen, D. A. and J. A. LaPlace. 1978. A study of a Virgin Islands grouper fishery based on breeding aggregation. Proc. Gulf & Carib. Fish. Inst. 31st. Ann. Sess. pp. 130-144.

Olsen, D. A., R. S. Wood and W. J. Tobias. 1983. A preliminary economic analysis of cost returns of commercial fishermen using fish traps along the insular shelf of the U. S. Virgin Islands. Dept. Cons. and Cultural Affairs, Div. Fish and Wildlife, NMFS Ann. Rept.

Simpson, G. S. 1979. Fish community dynamics, In. Environmental Studies of Buck Island Reef National Monument, St. Croix, U.S.V.I. II by E. H. Gladfelter, W. B. Gladfelter, D. K. Hubbard, R. C. Carpenter and G. S. Simpson. U. S. National Park Service Report, 168 p.

Tobias, W. 1987. Biostatistical data on commercially harvested queen conch, Strombus gigas, from the insular shelf around St. Croix, U.S. Virgin Islands. Caribbean Fisheries Management Council Tech. Rept. 19pp.

Wood, R. S. and D. A. Olsen. 1983. Application of biological knowledge to the management of the Virgin Islands conch fishery. Proc. Gulf and Carib. Fish. Inst. 35th Ann. Sess. pp 112-121.

TABLE 1. Relative abundance of reef fish species censused at BUIS North Patch Reef (Site 1), South Patch Reef (Site 2), Forereef (Site 3) and Tague Bay Patch Reefs #2 (Site 4) and #8 (Site 5), during VIRMC III Study (a) compared to data collection by Simpson (1979)(b), Gladfelter and Gladfelter (1980) (c), and Gladfelter and Gladfelter (1978)(d).

FAMILY SPECIES	N=6 Site 1 a	b	N=6 Site 2 a	b	N=5 Site 3 a	c	N=5 Site 4 a	d	N=2 Site 5 a	d
SYNONDONTIDAE										
Synodus intermedius (sand diver)	0.2	0.6	0.4	1.3	0.0	2.0	0.0	0.0	0.0	0.6
HOLOCENTRIDAE										
Holocentrus ascensionis (squirrelfish)	2.6	0.0	2.1	0.2	1.9	0.0	6.3	8.7	3.2	3.5
AULOSTOMIDAE										
Aulostomus maculatus (trumpetfish)	1.2	1.5	0.6	1.2	2.1	2.5	0.0	1.4	2.6	1.7
SERRANIDAE	(0.7)	(0.0)	(0.8)	(1.0)	(0.3)	(5.5)	(1.8)	(2.1)	(0.0)	(2.9)
Epinephelus fulvus (coney)	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0
Epinephelus guttatus (red hind)	0.0	0.0	0.4	0.5	0.0	2.0	0.6	1.4	0.0	1.2
Hypoplectrus unicolor (butter hamlet)	0.0	0.0	0.2	0.5	0.3	0.5	0.6	0.7	0.0	0.0
Serranus tigrinus (harlequin bass)	0.7	0.0	0.2	0.0	0.0	1.0	0.6	0.0	0.0	1.7
PRIACANTHIDAE										
Priacanthus cruentatus (glasseye snapper)	0.4	1.5	0.0	1.7	0.0	N/A	0.0	0.0	0.0	1.2
CARANGIDAE										
Caranx ruber (bar jack)	1.7	2.4	2.7	1.5	2.4	3.0	3.8	0.7	7.1	0.0
EMMELICHTHYIDAE										
Intermia vittata (boga)	0.0	0.0	0.4	0.0	0.3	2.0	0.0	0.0	0.0	0.0
LUTJANIDAE	(5.9)	(5.8)	(3.2)	(4.7)	(2.9)	(9.0)	(8.8)	(2.2)	(9.7)	(4.7)
Lutjanus apodus (schoolmaster snapper)	2.2	2.9	0.4	1.7	0.5	4.0	0.0	0.0	1.3	1.2
Lutjanus mahogani (mahogany snapper)	1.5	0.9	1.4	0.8	1.1	2.5	3.8	0.0	5.2	1.2
Ocyurus chrysurus (yellowtail snapper)	2.2	2.0	1.4	2.2	1.3	2.5	5.0	2.2	3.2	2.3
GERREIDAE										
Gerres cinereus (yellowfin mojarra)	1.8	0.7	2.4	2.0	0.3	N/A	1.3	0.0	0.0	1.7

TABLE 1. (continued)

FAMILY SPECIES	N=6 Site 1 a	 b	N=6 Site 2 a	 b	N=5 Site 3 a	 c	N=5 Site 4 a	 d	N=2 Site 5 a	 d
HAEMULIDAE	(10.8)	(15.3)	(11.0)	(12.5)	(3.0)	(5.5)	(18.2)	(10.0)	(10.5)	(16.8)
Haemulon aurolineatum (tomtate grunt)	0.0	0.2	0.2	0.2	0.0	0.5	0.0	0.0	0.0	0.0
Haemulon carbonarium (caesar grunt)	1.7	1.2	1.5	0.0	0.3	0.5	0.0	0.0	0.7	2.9
Haemulon chrysargyreum (smallmouth grunt)	2.3	4.8	0.8	0.0	0.5	0.0	0.0	0.0	1.3	3.5
Haemulon flavolineatum (French grunt)	4.0	5.7	6.1	7.0	1.9	2.5	8.8	4.3	2.0	4.0
Haemulon sciurus (bluestriped grunt)	1.5	1.2	0.0	2.8	0.0	1.0	8.8	1.4	6.5	2.9
Haemulon plumieri (white grunt)	1.3	2.5	2.4	2.5	0.3	1.0	0.6	4.3	0.0	3.5
MULLIDAE	(2.9)	(2.7)	(4.9)	(4.0)	(2.2)	(3.0)	(4.4)	(5.0)	(7.8)	(4.6)
Mulloidichthys martinicus (yellowtail goatfish)	1.7	2.3	3.5	2.3	1.1	2.5	1.3	1.4	2.6	1.7
Pseudupeneus maculatus (spotted goatfish)	1.2	0.4	1.4	1.7	1.1	0.5	3.1	3.6	5.2	2.9
KYPHOSIDAE										
Kyphosus sectatrix (Bermuda chub)	0.7	2.7	0.0	0.0	1.6	2.5	0.0	0.0	0.0	0.0
CHAETODONTIDAE										
Chaetodon capistratus (foureye butterflyfish)	0.3	1.1	2.4	2.0	1.3	2.0	2.5	2.9	1.9	1.7
POMACENTRIDAE	(18.7)	(17.5)	(17.3)	(18.0)	(22.8)	(29.0)	(13.8)	(12.9)	(11.7)	(13.3)
Abudefduf saxatilis (sergeant major)	2.3	3.1	1.2	0.0	1.6	3.0	1.9	1.4	0.0	1.7
Abudefduf taurus (night sergeant)	1.8	1.5	0.4	0.2	0.0	N/A	0.0	0.0	0.0	0.0
Chromis cyanea (blue chromis)	0.0	0.0	0.0	0.0	5.9	5.5	0.0	0.0	0.0	0.0
Chromis multilineatus (brown chromis)	0.0	0.0	0.0	0.0	3.8	4.0	0.0	0.0	0.0	0.0
Microspathodon chrysurus (yellowtail damselfish)	2.3	2.4	2.0	4.0	5.1	5.0	1.9	0.7	2.6	2.3
Eupomacentrus diencaeus (longfin damselfish)	0.3	0.0	0.8	N/A	0.5	N/A	0.0	0.0	0.0	0.0
Eupomacentrus fuscus (dusky damselfish)	5.3	5.0	4.1	4.0	2.4	4.5	0.0	3.6	0.0	2.9
Eupomacentrus leucostictus (beaugregory)	1.7	0.4	5.6	2.3	0.0	0.5	5.0	3.6	1.9	0.6
Eupomacentrus planifrons (threespot damselfish)	2.3	4.8	3.2	6.2	2.4	4.5	4.4	1.4	5.2	3.5
Eupomacentrus variabilis (cocoa damselfish)	2.7	0.3	0.0	1.3	1.1	2.0	0.6	2.2	2.0	2.3
LABRIDAE	(13.5)	(12.5)	(13.0)	(13.3)	(12.9)	(9.5)	(5.6)	(12.3)	(0.7)	(8.7)
Clepticus parrai (creole wrasse)	0.0	0.0	0.0	0.0	2.7	3.0	0.0	0.0	0.0	0.0
Halichoeres poeyi (blackear wrasse)	0.5	4.2	0.4	4.5	0.3	2.5	0.0	2.2	0.0	1.7
Halichoeres bivittatus (slippery dick)	4.0	1.6	3.8	0.7	0.8	1.0	0.0	3.6	0.0	2.9
Halichoeres radiatus (puddingwife)	2.2	0.6	2.1	1.3	1.1	1.0	0.0	2.2	0.7	1.2
Thalassoma bifasciatum (bluehead)	6.8	6.1	6.7	6.8	8.0	2.0	5.6	4.3	0.0	2.9

TABLE 1. (continued)

FAMILY SPECIES	N=6 Site 1 a	N=6 Site 1 b	N=6 Site 2 a	N=6 Site 2 b	N=5 Site 3 a	N=5 Site 3 c	N=5 Site 4 a	N=5 Site 4 d	N=2 Site 5 a	N=2 Site 5 d
SCARIDAE	(27.4)	(25.4)	(21.3)	(21.7)	(30.8)	(11.5)	(24.4)	(23.0)	(22.2)	15.7)
Scarus croicensis (striped parrotfish)	5.2	2.4	4.5	2.3	6.2	0.5	5.0	4.3	5.8	3.5
Scarus taeniopterus (princess parrotfish)	1.2	3.9	0.2	3.7	2.1	2.0	0.0	4.3	0.0	3.5
Scarus ventula (queen parrotfish)	3.8	3.9	0.6	1.2	4.6	N/A	0.0	0.0	2.6	0.0
Sparisoma aurofrenatum (redband parrotfish)	2.2	1.6	2.0	2.3	3.2	2.5	5.0	1.4	0.0	0.6
Sparisoma chrysopterum (redtail parrotfish)	1.3	1.6	1.8	2.0	1.9	0.5	2.5	1.4	0.0	0.6
Sparisoma radians (bucktooth parrotfish)	0.0	0.3	0.0	0.0	0.0	0.0	0.0	2.9	0.0	1.2
Sparisoma rubripinne (redfin parrotfish)	2.5	1.3	1.8	0.2	3.2	2.5	0.6	0.0	0.7	0.0
Sparisoma viride (stoplight parrotfish)	5.5	4.5	5.5	3.7	5.6	3.5	5.0	3.6	5.8	2.3
Scaridae (juvenile parrotfish)	5.7	5.9	4.9	6.3	4.0	N/A	6.3	5.1	7.3	4.0
BLENNIDAE										
Hemiemblemaria simulus (wrasse blenny)	0.5	N/A	0.9	N/A	0.0	N/A	0.0	0.0	0.0	0.0
Ophioblennius atlanticus (redlip blenny)	0.0	N/A	0.0	N/A	0.0	2.2	0.0	1.4	0.0	0.0
GOBIIDAE										
Gobiidae (gobies)	0.3	N/A	0.8	N/A	0.0	N/A	0.0	2.2	0.0	2.3
ACANTHURIDAE	(12.2)	(9.9)	(10.9)	(12.3)	(12.3)	(10.0)	(10.0)	(7.9)	(12.4)	(4.0)
Acanthurus bahianus (ocean surgeonfish)	5.5	4.3	4.5	6.2	4.8	5.0	5.0	4.3	6.5	2.3
Acanthurus chirurgus (doctorfish)	1.0	0.7	0.9	1.3	0.8	0.0	0.6	1.4	0.7	0.0
Acanthurus coeruleus (blue tang)	5.7	4.9	5.5	4.8	6.7	5.0	4.4	2.2	5.2	1.7
TETRAODONTIDAE										
Tetraodontidae (puffers)	0.0	N/A	0.4	N/A	0.3	N/A	1.3	0.7	0.7	1.2

TABLE 2. Number of individuals, relative abundance (percent) and mean size of commercially important reef fish species observed at the four study sites within the BUIS waters, January - June 1986. Fish size is expressed in millimeters.

Location: BUCK ISLAND REEF NATIONAL MONUMENT

Study Site:	NORTH PATCH REEF				SOUTH PATCH REEF				FORE REEF				REEF CREST			
No. Censuses:	SIX-MONTH AVERAGE				SIX-MONTH AVERAGE				SIX-MONTH AVERAGE				SIX-MONTH AVERAGE			
SPECIES	Tot.# Indiv.	Rel. Abund. (%)	Mean Size	Stand. Deviat.	Tot.# Indiv.	Rel. Abund. (%)	Mean Size	Stand. Deviat.	Tot.# Indiv.	Rel. Abund. (%)	Mean Size	Stand. Deviat.	Tot.# Indiv.	Rel. Abund. (%)	Mean Size	Stand. Deviat.
stoplight parrotfish	22	15.3	213.4	152.4	22	14.6	160.0	114.3	30	19.0	271.8	88.9	40	16.0	269.2	20.3
redtail parrotfish	3	2.1	320.0	22.9	6	4.0	261.6	88.9	5	3.2	246.4	43.2	4	1.6	248.9	45.7
queen parrotfish	5	3.5	307.3	68.6					1	0.6	246.4	50.8	10	4.0	108.2	48.3
red band parrotfish					< 1	0.3	152.4	-	5	3.2	172.7	20.3	2	0.8	154.9	7.6
princess parrotfish	2	1.4	259.1	22.9					2	1.3	218.4	17.8	1	0.4	68.9	30.5
redfin parrotfish	< 1	0.3	177.8	25.4	1	0.7	147.3	48.3					1	0.4	254.0	13.7
rainbow parrotfish					< 1	0.3	635.0	-								
white grunt	< 1	0.3	304.8	0	8	5.3	287.0	43.2	1	0.6	165.1	71.1				
bluestriped grunt	2	1.4	289.6	38.1	2	1.3	297.2	5.1	1	0.6	210.8	25.4	1	0.4	82.8	25.4
French grunt	13	9.1	134.6	27.9	27	17.9	88.9	33.0	2	1.3	142.2	5.1				
smallmouth grunt	8	5.6	127.0	20.3												
porkfish									< 1	0.3	304.8	-	< 1	0.2	254.0	0
margate	< 1	0.3	304.8	-												
mutton snapper	1	0.7	482.6	73.7												
schoolmaster snapper	6	4.2	299.7	50.8					1	0.6	243.8	50.8	13	5.2	314.9	38.1
mahogany snapper	2	1.4	241.3	40.6	1	0.7	241.3	12.7	1	0.6	210.8	25.4	5	2.0	205.7	50.8
yellowtail snapper	1	0.7	190.5	5.1	< 1	0.3	152.4	-	4	2.5	289.6	58.4				
gray snapper													< 1	0.2	254.0	-
lane snapper													< 1	0.2	203.2	-
black durgeon													1	0.4	304.8	0
scrawled filefish					< 1	0.3	457.2	-								
French angelfish	1	0.7	261.6	7.6									< 1	0.2	355.6	-
rock beauty									< 1	0.3	203.2	-				
red hind					< 1	0.3	254.0	-								
grasby									< 1	0.3	279.4	12.7				
tiger grouper									< 1	0.3	381.0	76.2	< 1	0.2	254.0	-
blue tang	25	17.4	162.6	72.2	27	17.9	129.5	66.0	46	29.2	167.6	43.2	113	45.1	144.8	43.2
doctorfish	4	2.8	154.9	35.6	8	5.3	63.5	22.9	1	0.6	182.9	38.1	1	0.4	50.8	-
surgeonfish	27	18.8	121.9	60.9	21	14.0	114.3	53.3	37	23.5	124.5	35.6	42	16.8	119.4	25.4
yellow goatfish	6	4.2	172.7	35.6	10	6.6	241.3	22.9	1	0.6	210.8	12.7	2	0.8	228.6	-
spotted goatfish	< 1	0.3	76.2	0	3	2.0	121.9	25.4	1	0.6	119.4	38.1				
bar jack	4	2.8	200.7	93.9	3	2.0	266.7	81.3								
horse-eye jack									10	6.3	226.1	114.3	4	1.6	246.4	6.8
Bermuda chub	3	2.1	177.8	17.8					2	1.3	134.6	40.6	2	0.8	222.0	71.1
squirrelfish	2	1.4	228.6	30.5	2	1.3	182.9	53.3					2	0.8	218.4	25.4
smooth trunkfish									1	0.6	139.7	15.2				
barracuda	< 1	0.3	1219.2	0	< 1	0.3	762.0	-	1	0.6	647.7	-	< 1	0.2	533.4	-
sennet													3	1.2	254.0	-
yellowfin mojarra	2	1.4	205.7	27.9	3	2.0	210.8	48.3	1	0.6	228.6	76.2				
jolthead porgy					< 1	0.3	304.8	50.8								
puddingwife wrasse	2	1.4	193.0	60.9	3	2.0	254.0	33.0	1	0.6	254.0	-	< 1	0.2	254.0	-
cero mackerel									< 1	0.3	609.6	-				
	—				—				—				—			
TOTAL # OF SPECIES:	24				23				27				25			

TABLE 3. Biostatistical comparison of the 12 most common species of reef fish caught in fish traps deployed in BUIS and adjacent waters, Tague Bay and Lang Bank. Data from waters adjacent to BUIS and Lang Bank were obtained from commercial fishermen. Fish size is expressed in millimeters and weight in grams.

	L O C A T I O N																			
FAMILY	BUIS TRAPS					TAGUE BAY TRAPS					BUIS ADJACENT WATERS					LANG BANK				
		LENGTH		WEIGHT			LENGTH		WEIGHT			LENGTH		WEIGHT			LENGTH		WEIGHT	
SPECIES	N	$\bar{x}$	Sx	$\bar{x}$	Sx	N	$\bar{x}$	Sx	$\bar{x}$	Sx	N	$\bar{x}$	Sx	$\bar{x}$	Sx	N	$\bar{x}$	Sx	$\bar{x}$	Sx
Holocentridae																				
Holocentrus ascensionis (squirrelfish)	4	209.5	11.3	326.8	53.1	28	204.7	12.8	216.7	41.2	0	-	-	-	-	21	214.2	19.9	239.3	74.4
Serranidae																				
Epinephelus guttatus (red hind)	4	313.4	65.1	686.2	325.0	0	-	-	-	-	0	-	-	-	-	16	301.3	60.5	595.3	489.7
Lutjandae																				
Lutjanus apodus (schoolmaster snapper)	2	351.0	29.7	1125.0	247.5	1	205.0	-	200.0	-	0	-	-	-	-	7	278.1	34.6	467.9	141.9
HAEMULIDAE																				
Haemulon plumieri (white grunt)	1	225.0	-	250.0	-	9	200.0	15.2	257.2	69.1	105	207.8	23.9	225.9	59.5	96	220.5	28.4	249.5	50.3
Haemulon sciurus (bluestriped grunt)	4	221.8	45.5	375.0	210.2	0	-	-	-	-	15	225.2	17.8	273.5	73.1	15	238.5	9.4	306.7	39.5
Mullidae																				
Mulloidichthys martinicus (yellow goatfish)	7	238.6	21.7	403.5	104.5	1	240.0	-	300.0	-	0	-	-	-	-	26	209.3	11.9	180.8	40.8
Scaridae																				
Sparisoma viride (stoplight parrotfish)	11	261.4	24.3	503.6	118.0	13	245.1	32.3	384.4	160.5	28	294.8	33.7	584.8	181.9	32	285.1	22.3	574.2	127.2
Sparisoma chrysopterium (redtail parrotfish)	3	226.7	23.1	316.7	104.1	5	237.9	21.2	327.1	137.3	41	246.0	20.9	317.1	76.5	48	227.0	7.2	392.1	60.5
Scarus taeniopterus (princess parrotfish)	4	292.2	43.3	556.3	214.5	0	-	-	-	-	0	-	-	-	-	10	255.0	15.8	390.0	52.9
Sparisoma aurofrenatum	3	204.3	24.0	241.7	52.0	4	217.5	17.6	237.5	47.9	0	_	_	_	_	17	211.5	6.3	247.1	26.3
Acanthuridae																				
Acanthurus coeruleus (blue tang)	23	165.3	16.1	194.8	60.5	54	177.8	19.4	217.0	74.1	29	172.8	24.2	206.0	57.7	54	186.1	40.8	212.3	64.6
Acanthurus bahianus (ocean surgeonfish)	29	171.7	32.0	192.2	94.8	15	150.4	21.3	115.7	38.7	21	197.4	10.5	244.0	37.8	30	189.7	16.8	204.2	66.9

TABLE 4 . Conch (Strombus gigas) census data for two permanent transect areas located east of "E" buoy within the boundaries of BUIS. Transect A (north transect) depth = 8.0m: Transect B (south transect) depth = 8.2m. Transect locations are shown in Figure 1.

	TRANSECT A						TRANSECT B					
DATE	Transect Length(m)	Transect Area(m^2)	Number Juveniles	Number Adults	Total Conch	Density (Conch/m^2)	Transect Length(m)	Transect Area(m^2)	Number Juveniles	Number Adults	Total Conch	Density (Conch/m^2)
1/24/86*	200	800	129	13	142	.18	-	-	-	-	-	-
2/21/86**	322	1288	139	3	142	.11	322	1288	168	5	173	.13
3/21/86	322	1288	185	2	187	.15	322	1288	165	4	169	.13
4/18/86	322	1288	154	3	157	.12	322	1288	187	1	188	.15
5/29/86	NO DATA - TRANSECT DISTURBED						NO DATA - TRANSECT DISTURBED					
6/12/86***	365	1460	188	2	129	.13	322	1288	179	0	179	.14
6/26/86	322	1288	193	0	193	.15	322	1288	198	2	200	.16

* preliminary transect run

** permanent transects established - 322m in length

*** transects re-established (Transect A - 365m - temporary)

TABLE 5. Lobster census data for three survey areas (West Patch Reef, North Patch Reef and South Fringing Reef) within the boundaries of BUIS. Survey areas are shown in Figure 1.

STUDY AREAS:	WEST PATCH REEF (624m²)				NORTH PATCH REEF (165m²)				SOUTH FRINGING REEF (1500m²)			
	P. argus	#/m²	*P. guttatus*	#/m²	*P. argus*	#/m²	*P. guttatus*	#/m²	*P. argus*	#/m²	*P. guttatus*	#/m
Date: 1/24/86	0	0	0	0	1+*	1/165	0	0	2(1+)	1/1000	0	0
2/21/86	4(3+)	1/167	1	1/500	2+	1/83	3	1/56	1+	1/1429	0	0
3/21/86	0	0	2	1/333	0	0	3	1/56	0	0	3	1/500
4/18/86	0	0	2	1/333	3(2+)	1/56	1	1/165	2+	1/1000	2	1/1000
5/29/86	1+	1/500	0	0	4(3+)	1/12	0	0	3(1+)	1/500	2	1/1000
6/26/86	0	0	3	1/200	1	1/165	1	1/165	0	0	1	1/1429

* (+) indicates *P. argus* of legal harvestable size (carapace length ≥ 3.5 inches)

TABLE 6. Data on fish trap effort in, near*, and adjacent** to Buck Island Reef National Monument.

			NUMBER OF TRAPS		
	Boat Number	Number Fishermen	Inside Monument	Near Monument	Adjacent Monument
	1	2	8	7	-
	2	3	3	4	-
	3	3	5	-	-
	4	2	-	-	8
	5	2	-	-	10
TOTALS:	5	12	16	11	18

* Near BUIS indicates within 100 m of boundary

** Adjacent BUIS indicates >100 m <300 m of boundary

BUCK ISLAND REEF NATIONAL MONUMENT

LEGEND

NPR - North Patch Reef
SPR - South Patch Reef
WPR - West Patch Reef
SFR - South Fringing Reef
RC - Reef Crest
FR - Fore Reef
⊗ - Ranger Observation Tower

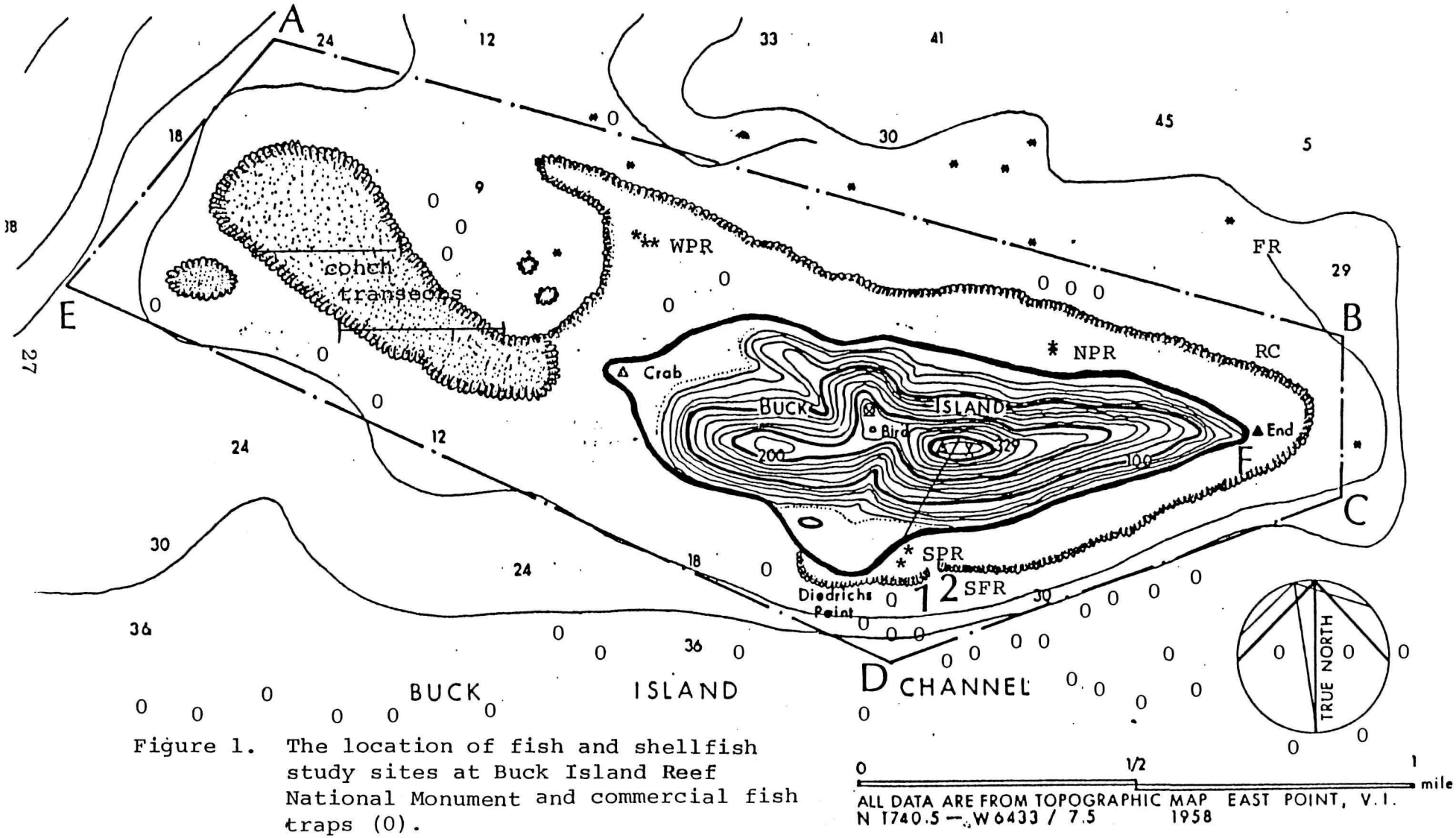

Figure 1. The location of fish and shellfish study sites at Buck Island Reef National Monument and commercial fish traps (0).