PRESERVATION, EXPLOITATION, OR CONSERVATION: EFFECTS OF A TRAP FISHERY IN VIRGIN ISLANDS NATIONAL PARK

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ABSTRACT

As resources continue to decline throughout the Caribbean due to numerous factors, such as exploitation and development, scientists and managers have looked for more successful management strategies to maintain and/or improve resources. One strategy which has become increasingly popular is the establishment of marine parks and reserves. This strategy has great potential for sustaining or improving the condition of resources in terms of abundance of exploited resources, species composition, and biodiversity. Proper design, statement of goals, and management are critical for success. Several problems and difficulties have been identified during evaluation of resources in Virgin Islands National Park, U.S. Virgin Islands. We have documented declines of resources due to regulated exploitation, investigated effects of trap fishing on resources of a reef, and identified some factors which are critical for consideration in design of marine park and reserves.

INTRODUCTION

Resources throughout the Caribbean, like most of the world, have continued to decline in response to the growing human pressure for space and food (Sadovy 1989, Richards and Bohnsack 1990). Fishery resources have particularly been targeted in the Caribbean to meet increasing demands for protein. Although many nations have attempted various management strategies to maintain supply and conserve reserves, there are few examples of success. While obviously the ultimate goal is to adopt strategies which will allow for human population control, scientists and managers continue to develop management strategies which will conserve resources and maintain biodiversity. Although few marine extinctions have been documented, there is growing concern for several exploited species, with some species becoming very scarce in fishery landings (Sadovy 1993), but also for marine biodiversity (Norse 1993, Culotta 1994).

In recent years, growing support has been for development of marine parks and reserves as a conservation strategy. Scientific support of the benefits of marine parks and reserves has greatly increased (Russ and Alcala 1989, Plan Development Team 1990, Roberts and Polunin 1991, 1994, Polunin and Roberts 1993, Russ et al.. 1994). However, some investigators have stressed the limitations of marine parks and reserves (DeMartini 1993, Russ et al. 1994). The immediate potential benefits, such providing a preserve for a portion of fish populations and closing spawning aggregations to avoid recruitment overfishing, are obvious and easily understood by resources users. However, other potential benefits, such as fisheries enhancement to adjacent areas due to larval dispersal and adult emigration, have not been demonstrated and may not be realized for several species (DeMartini 1993).

The potential benefits of marine parks and reserves must be thoughtfully considered by scientists and managers and carefully presented to resources users in order to ensure success. Numerous factors influence community structure and productivity, especially in coral reefs systems, which must be identified and evaluated while plans and goals for marine parks and reserves are derived.

Our recent investigations of the status of marine resources around the island of St. John, U.S. Virgin Islands, and specifically within the park boundaries around that island have yielded several valuable insights and lessons related to establishment and management of marine parks and reserves. Although the Virgin Islands National Park was established as a terrestrial and marine park in 1956, no adequate evaluation of success of the original resources management strategies has been conducted. Several long-term monitoring projects were established and can only provide a brief view of natural variation, however, some results have demonstrated alarming trends and provided important information of factors for consideration.

History of scientific investigation and marine resource management in Virgin Islands National Park. Information on the marine resources and resource users in and around Virgin Islands National Park/Biosphere Reserve has grown steadily during the past two decades. Most early work conducted within the Virgin Islands National Park focused on description of resources and basic systematics and ecology of marine organisms. This included the work of John Randall and staff from University of Miami during the early 1960s (numerous publications) and investigations conducted during the Tektite Program in the 1970s Collette and Earle 1972).

From 1983 to 1987, numerous investigations, funded by the US National Park Service, were conducted to map and characterize the marine and terrestrial communities of St. John and surrounding areas, to evaluate the status of known resources, and document the use of marine resources, primarily by fishermen. Most relevant studies have been synthesized in a comprehensive National Park Service report (Rogers and Teytaud 1988).

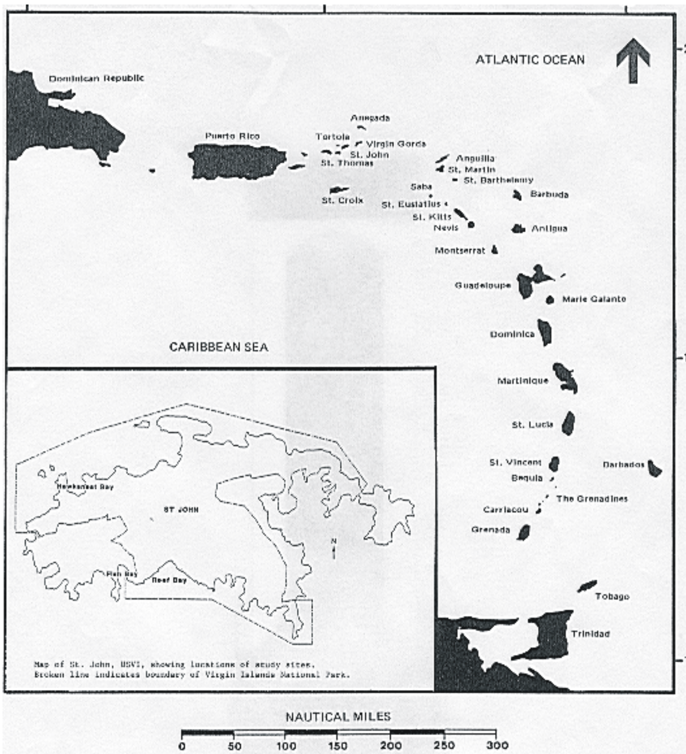


Fig. 1. Location of St. John, U.S. Virgin Islands.
From: Putney (1982).

Figure 1. Location of St. John U.S. Virgen Island. From Putney (1982).

An excellent description of historic and existing fishing around St. John is found in Rogers and Teytaud (1988). The earliest documentation of fishing around St. John has come from archeological investigation of middens produced by native Americans prior to European colonization. These early colonists were primarily gatherers who did not appear to have well developed fishing skills. Fishing was probably limited to gleaning in wading depths. Following European colonization, small scale fishing was conducted by plantations workers, which was described by in writings of a few colonists but formal records do not exist. Fishing was conducted using a few woven traps and handlines. Following decline of the plantation era and slave emancipation, island people increased their sustenance fishing which was limited to nearshore waters using woven traps and handlines from small rowboats and sailboats.

The first comprehensive documentation of the fishing industry was conducted in 1932. Fishing was extremely important to island people at this time and still conducted using traditional gear. Following World War II, the fishing sector began to use available technology which allowed for improved catches. When the tourism industry began to expand during 1950-1960, the population of the U.S. Virgin Islands greatly increased along with the demand for fisheries resources. Improved technology allowed fishermen to meet the increased demand. Older fishermen describe fish catches of this period as dominated by large groupers and snappers (deGraaf and Moore 1987). Although fishermen actively debate when fishery resources began to decline in the US Virgin Islands, nearly everyone agrees that fishery resources are in decline with most catches dominated by the herbivorous parrotfishes and surgeonfishes (Beets 1987). The decline of the preferred Nassau grouper, Epinephelus striatus, was documented in 1976 (Olsen and LaPlace 1978) and the spawning aggregation was subsequently fished to extirpation (Beets and Friedlander 1992). Additional fishery resources, including other groupers, snappers, and conch, have declined in proportion of landings or in long-term landing trends (USVI DFW annual reports).

Although investigations have been conducted to document the number of resource users and the status of fishery resources around St. John (Fiedler and Jarvis 1932, Idyll and Randall 1959, Dammann 1969, 1986, Boulon 1986a,b, 1987, Boulon and Clavijo 1986, Boulon et al. 1986, Koester 1986), trends in fishery resources and the impact of park regulations have not been adequately assessed. The purpose of this investigation was to assess the trends in the fishery around St. John, to obtain information on resource users and their impact on fishery resources, and to evaluate the impact of park regulations and their effectiveness in the conservation of the natural resources of Virgin Islands National Park/Biosphere Reserve.

The existing regulations covering marine resources in the Virgin Islands National Park were issued in the Federal Register in 1964 (Code of Federal Regulations Title 36, Section 7.74). These regulations only include resources within U.S. National Park Service (NPS) boundaries around the island of St. John, U.S. Virgin Islands (Figure 1). Regulations on fish species are limited to 1) no spearfishing and 2) fishing only with rod or handline except that fish traps of Òconventional Virgin Islands designÓ may be used and that bait fishes may be harvested with nets no greater than 20 ft and 1 in mesh (stretch). Three species of invertebrates are regulated as follows: 1) spiny lobster (Panulirus argus) harvest is limited to two per person per day and no harvest of females with eggs, 2) conch (no species named, but reference is obviously to Strombus species) harvest is limited to two per person per day, 3) whelk (no species named, but reference is obviously to Cittarium pica) harvest is limited to one gallon per person per day. All other species are given full protection and all species, included those previously mentioned, are fully protected in Trunk Bay and other waters containing underwater signs and markers. The lack of definition of 'conventional Virgin Islands design' of fish traps and the lack of emphasis on enforcement of fishing regulations has resulted in extensive resource decline and increase in commercial fishing within park boundaries. Additionally, there has been no legal opinion on the meaning of 'any limitation on customary uses of or access to such areas ... for ... fishing' which was stated in the enabling legislation for the park in 1956 (70 Stat. 940). When this legislation was established, fishing in the Virgin Islands, especially around St. John, was primarily artisanal, effort was low, traps were constructed of hoop vine or chicken wire, and landings were abundant with large grouper and snappers (deGraaf and Moore 1987).

Recently, an opinion was made by the US Department of Interior Regional Solicitor (memorandum dated June 30, 1974) supporting concurrent jurisdiction between the Virgin Islands National Park and the Government of the US Virgin Islands. The opinion concluded that territorial regulations should be enforced within park boundaries. Territorial legislation imposes gear restrictions on fish traps (mandatory biodegradable panel and mesh size greater than 1.25 in) and seines (mesh size greater than 1.5 in excluding bait nets), bans the use of explosives, and restricts harvest of spiny lobster (no harvest of females with eggs and minimum carapace length of 3.5 in). Recent regulations restrict the harvest of conch and whelk and the export of bait fishes.

Some results of current investigations of marine resources in Virgin Islands National Park

Several methods were employed during the present investigation in order to assess the fisheries, fisheries resources, and fish assemblages around St. John. These methods included:

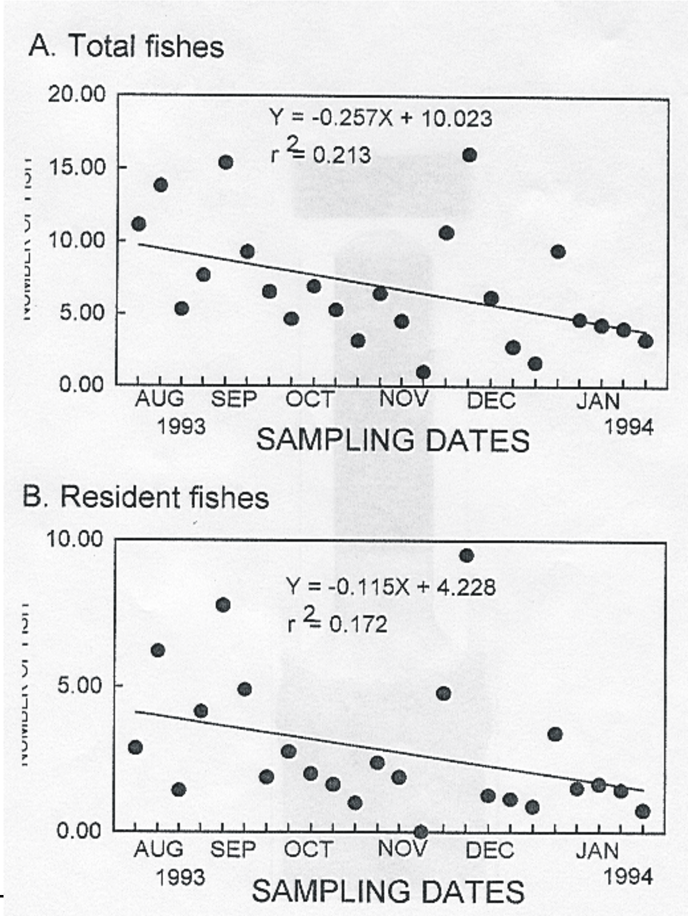
1. visual census sampling of fish assemblages
2. visual census sampling of groupers and snappers
3. visual census sampling of fishermen traps
4. fishermen landings sampling
5. resource monitoring using fish traps and handlines
6. experimental evaluation of the effect of fish traps on Yawzi Point reef.

Detailed information on methods and results were presented in Beets (1994).

One purpose of this paper was to present results of the current fisheries investigations in Virgin Islands National Park relevant to the topic and not a comprehensive summary of results. One advantage of using several methods of investigation has been comparison of results. We have noted, for instance, important biases among data obtained from fishermen landing, visual inspection of fishermen traps, resource monitoring using fish traps, and visual censes techniques (see Beets 1994). It is important to recognize and evaluate such biases prior to the establishment of a monitoring program designed to evaluate success of marine parks and reserves.

Visual Census Sampling Of Fishermen Traps

This sampling was conducted in order to evaluate the number of illegal traps operating within Virgin Islands National Park and to estimate trap catch and species composition. A total of 218 traps were inspected during 2 diving surveys (Table 1). The same number of traps were counted and observed within park boundaries in both surveys (n = 41). The results are for only buoyed traps and the number of traps set without buoys is unknown. A large percentage of traps observed during both surveys were illegal (Table 1). U.S. Virgin Islands legislation requires that all fish traps have biodegradable panels and mesh size greater than or equal to 1.5 inches (3.8 cm) in smallest dimension. All fish trap buoys must be marked with fishermen assigned colors. In November, 1992, 27 traps (73%) within park boundaries had no biodegradable panels and 4 traps (11%) had mesh size less than 1.4 inches. (1.4 inches was used for analysis to allow for measurement error.) Two fish trap buoys had no colors (designated as ‘white buoys’). When fish traps are set in strings (more than one trap per buoy line), traps on opposing ends of the



Figur
e 2. Results of regression analysis of experimental fish trapping conducted for six months during 1993-94 around Yawzi Point, St. John. A) Significative negative regression for all fish sampled B) Significative negative regression for resident fishes excluding jacks, porgies, and mojarras.

string are usually buoyed and frequently buoy colors appear on only one set of buoys. Our counts listed traps, or strings of traps, as 'with colors' if any buoy attached to the trap or string had colored buoys present.

Fewer illegal traps were observed in park boundaries during our second survey in July, 1993. Only 10 traps (24%) had no biodegradable panel and all traps observed had legal mesh size. Also, no traps with rectangular mesh ('rect'), which is usually an illegal mesh size of 2 x 1 in (5.1 x 2.5 cm), were observed during the second survey. However, the number of buoys without colors had increased ('white buoys' = 8). Based on buoy colors, there appears to be at least 20 fishermen setting traps within park boundaries.

There has been a shift in the fishery from fish traps constructed with hexagonal mesh ("hex") and antillean (arrow-head: 'arrow') design to square, vinyl-clad mesh ("square") and square design ("square"), which was apparent between surveys (Table 1). This shift to different materials and design is due to availability of wire, ease of trap construction, and supposed improvement in catch efficiency. Although approximately half of the traps within park boundaries are set individually, most traps are set in strings of 2 to 6 outside of park boundaries (Table 1). Therefore, buoy counts are of limited use in estimating trap number.

The number of fish observed per trap was quite variable as expected since soak times (days since hauled) were unknown. The average number of fish observed per trap ranged from 4.7 to 6.5 within park boundaries and from 4.3 to 4.4 outside of park boundaries (Table 1). These preliminary data would allow a minimum estimate of 10,020 fish caught by fish traps per year within park boundaries (assuming average trap soak time of 7 days). The rank abundances of numerically dominant species and families of fishes observed in fishermen traps were very similar to data obtained from port sampling, both being primarily dominated by surgeonfishes, angelfishes, grunts, porgies, and parrotfishes.

Visual Census Sampling Of Groupers And Snappers

The purpose of this sampling was to obtain abundance and density data on groupers and snappers, which were historically very important species in fishermen landings. In this method a large section (plot) of fringing reef (5000 m2) was selected for repeated sampling. Two sites were selected on the north side of St. John (Haulover and Newfound Bays) and two sites on the south side (Fish and Lameshur Bays). One site on each side is outside of park boundaries. The two sites on the south side are adjacent to seagrass beds. Grouper and snapper densities were recorded by conducting adjacent transects throughout each plot in January 1994 (the Fish Bay plot was not sampled this month). Groupers and snappers were significantly more abundant ($p<0.05$) on Yawzi Point reef (between Greater and Lesser Lameshur Bays) than in Newfound and Haulover Bays (Table 2). All reefs are similar in reef structure and coral composition. Newfound and Haulover Bays have little associated seagrass and, therefore, lower food availability for these fishes.

Experimental Evaluation Of The Effect Of Fish Traps On Yawzi Point Reef

Yawzi Point reef between Greater and Little Lameshur Bay on the south side of St. John was selected for intensive fish trapping within Virgin Islands National Park. The reasons for selecting this reef were: 1) historic trap data exist for comparison (1982-83, 1989-91); 2) several years of visual census data had been collected on this reef (1989-92); 3) Yawzi Point reef is relatively isolated with an abundance of commercially important species; 4) fishing pressure around the reef has been relatively low for several years with little trapping activity.

The trap data for 1982-83 were collected from a fishermen who set 5-10 traps (usually 8) in the Lameshur Bays (primarily around Yawzi Point) for over ten years. Eight traps were hauled weekly for six months during the 1993-4 investigation. Large changes were noted in the rank abundance of numerically dominant species and families from trap catches between the 1982-3 and 1993-4 samples (Tables 3-5). Several important species captured in abundance during 1982-3 were in very low abundance in 1993-4 (e.g., Epinephelus striatus, Haemulon sciurus) or not captured at all (e.g., E. adscencionis, E. afer, E. morio). Mean length of most species declined greatly between the two periods (Tables 3 and 4). Grunts, groupers, and snappers greatly declined in abundance, whereas, surgeonfishes, parrotfishes, and squirrelfishes increased (Table 5).

Regression analyses of the fish trap data collected during the 1993-4 investigation demonstrated that several species groups incurred significant declines in abundance during the period of trapping. Although abundance generally declined for all major groups, significant negative regressions existed for total fishes ($p<0.001$), resident fishes ($p<0.001$), squirrelfishes ($p<0.001$), and snappers ($p=0.001$)(Figures 2 & 3).

For comparison to the trap data, visual sampling was conducted near the reef edge where traps were set using a random point visual census technique (Bohnsack and Bannerot 1986), with 16-20 censuses taken per sampling period (usually bi-monthly). Additionally, belt transects for predators were conducting using ten 50 m transects along the reef edge near the trap sites.

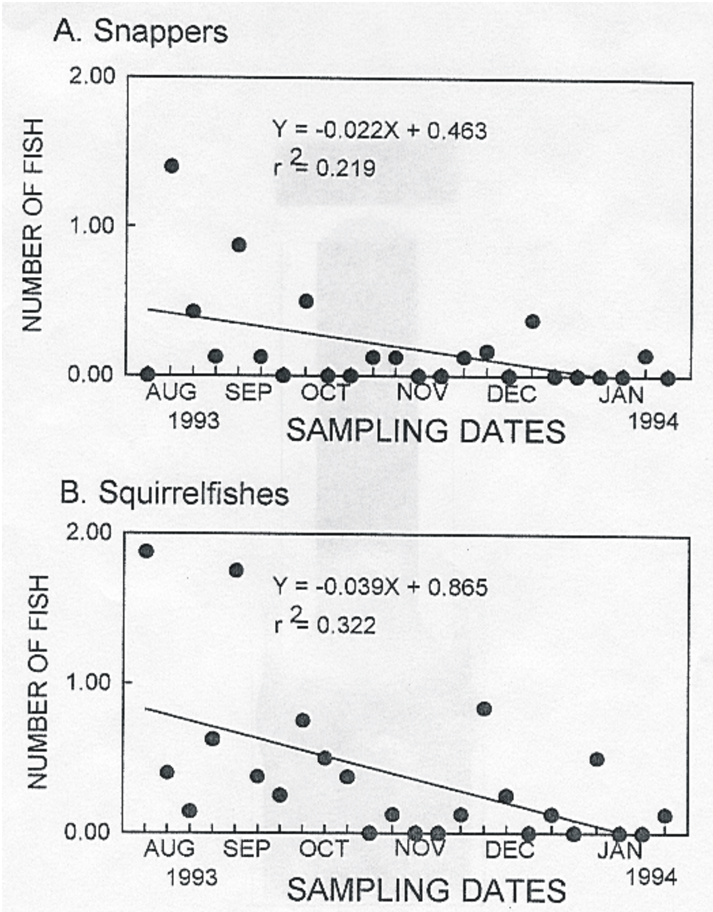


Figure 3. Results of regression analysis of experimental fish trapping conducted for six months during 1993-94 around Yawzi Point, St. John. A) Significative negative regression of snappers B) Significative negative regression for squirrelfishes.

Visual census data for both methods (point counts and belt transects) showed the same trend for declines in abundances of major fish groups (Tables 6 & 7). Point counts yielded significant differences in abundance for total fishes

(Mann-Whitney U: p=0.028), predators (p=0.023), and snappers (p=0.012) on Yawzi Point reef between the month before trapping began and the last month of sampling. Cocoloba reef, which was monitored as a control, yielded no significant differences in abundances between the same periods. Although belt transect data from Yawzi Point reef demonstrated the declines in abundances of all groups examined, no significant difference was noted in analysis.

DISCUSSION

From historical information, we know that fisheries in the Virgin Islands have declined in the face of increasing fishing pressure (CFMC 1985; Bohnsack et al. 1986; deGraaf and Moore 1987; Appeldoorn et al. 1992). This is especially true for a few species, such as groupers (Olsen and LaPlace 1978; Beets and Friedlander 1992; Beets et al. 1994). Beets (in press) provided an analysis of fisheries-independent data which demonstrated differences in species composition and catch per unit effort in an area south of St. John, which had a higher fishing effort, compared to an area north of St. Thomas-St. John, with lower fishing effort.

Fisheries landings data for the U.S. Virgin Islands have never allowed critical analysis by species group or by effort. It has also been difficult to separate fishery trends for St. John from St. Thomas since fisheries data are reported collectively. Fishermen landings data collection has always been lower on St. John due to the lack of funding for data collection projects, remote location of landing sites from St. Thomas, and lower landings compared to St. Thomas.

U.S. Virgin Islands legislation classifies fish traps as commercial gear and requires that fishermen using traps have a commercial fishing license. The use of commercial gear within Virgin Islands National Park is under review with an opinion pending. Based on our visual inspection of fishermen traps, there appears to be at least 20 fishermen who set traps within park boundaries. Many fish traps within park boundaries are illegal under USVI legislation although the trend appears to be changing. Compliance outside of park boundaries was low during both surveys.

One of the most important observations which visual census monitoring for the park project has provided was the great variation in fish abundance and assemblage structure among reefs. This large variation among reefs was apparent even among reefs of similar physical structure, coral composition, and other physical factors (e.g., depth, exposure). Intensive sampling at three sites around St. John (Beets 1993) and around Buck Island, St. Croix (Gladfelter et al. 1993) have provided information on differences among sites and ecological zones, trends in fish assemblages, and the impact of large-scale disturbance (hurricane Hugo in 1989). Small scale variation in fish abundance and assemblage structure and exposure of sites to large scale disturbance are factors which are important to consider for marine parks and reserves.

The results of visual sampling of large plots for groupers and snappers around St. John have provided useful density data and yielded interesting differences among reefs. The large abundances of groupers and snappers on Yawzi Point reef compared to other reefs were surprising considering that the trapping experiment had been conducted at that site for five months prior to the first large plot sample. We hypothesize that the abundance differences were due to the close association of seagrass beds to Yawzi Point reef, which enhanced food availability and fish production. The importance of interactions among ecosystems, such as coral reefs and seagrass beds, have long been recognized (Ogden and Zieman 1977, Zieman 1982). We recommend that habitats for inclusion in a marine park or reserve be evaluated for the interactive effects and enhanced production.

The experimental trapping study at Yawzi Point reef in the Lameshur Bays has provided documentation of the impact of fish traps on reef fisheries. The trapping effort, which was based on the known level of effort previously used by a fishermen on that reef, demonstrated large changes in species composition and declines in average size of species between the 1982-3 survey and the 1993-4 investigation. Significant declines in abundances of several species groups was observed over the six-month sampling period in 1993-4. Historically, fishermen rarely fished a single reef this intensively. Fishermen moved traps to different reefs or reef sections so as not to deplete an area and to improve catches. Unfortunately, the present level of fishing effort in the US Virgin Islands is very high, which frequently resulting in trap theft or loss. Since the entire insular shelf within the US Virgin Islands is fished, there is little ability to move traps into areas of less fishing pressure or to move traps among areas as occurred historically. The level of effort has resulted in near complete loss of some species within the fishery, general decline in catch per unit effort, general decline in size of species captured, and species composition shifts.

During 1994, two marine reserves of limited size have been established in the U.S. Virgin Islands. One south of St. John in federal waters three nm from shore. The other site is located on the southeastern end of St. Thomas, approximately four nm from St. John. This should provide impetus for the U.S. National Park Service to establish areas of total protection within the boundaries of Virgin Islands National Park. This has been proposed for the southern boundary of the park on St. John. Such an action would provide an excellent opportunity for evaluation of complete protection on reef resources within park boundaries and adjacent areas.

In conclusion, I would like to emphasize the importance of clear statement of goals and careful design of marine parks and reserves. Factors mentioned in the present paper should be carefully considered along with those of other authors. Loss and exploitation of resources are inevitable under the present constraints of human population growth. We must carefully consider the proper and best use of preservation practices, keeping in mind that these represent a single type of conservation measure in global resource management.

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Table1. Results of observations of fishermen fish traps around St. John. T = NUMBER TRAPS, WB = white buoys, BP = biodegradable panels (W= with, WO=without), MS = mesh size <1.4 inches, MT= mesh type (SQ=square, HEX= hexagonal,RECT=rectangular) , TT = trap type (AR= arrow, SQ= square), NT= number of traps, NO = umber of observations, NF = number of fish, PT= number of fish per trap. WNPS=within NPS boundaries, ONPS=outside NPS boundaries

Census 1. November 1992									
	T	WB	BP	MS	MT	TT	NT	NO	NF
WNPS	41	2	W=10 WO=27	4	HEX:31 RECT:2 SQ:7	AR:30 SQ:10	20 2:3 4;1	6:1 7:1	265 PT:6.5 SD:6.95
ONPS	29	6	W=7 WO=22 7	11	HEX:21 RECT:7 SQ:1	AR:19 SQ:10	17 2:2 4:2	>7	126 PT:4.3 SD:6.75
Census 2. July 1993									
	T	WB	BP	MS	MT	TT	NT	NO	NF
WNPS	41	8	W=10 WO=27	0	HEX:12 RECT:0 SQ:29	AR:7 SQ:34	16 4:2 5:2	7:1 >7	198 PT:4.7 SD:5.66
ONPS	102	9	W=7 WO=22 7	3	HEX:41 RECT:1 SQ:60	AR:42 SQ:60	1:9 2:4 3:1	4:1 5:2 6:5	448 PT:4.4 SD:5.62

Table 2. Results of large area transects for groupers and snappers conducted January 1994. Total area covered per reef was 100 x 50 meters.

	NEWFOUND BAY	HAULOVER BAY	LAMESHUR BAY
GROUPERS			
Epinephelus adscencionis	1		3
E. cruentatus	21	18	36
E. fulvus	2		17
E. guttatus	14	11	8
E. morio			1
E. striatus	2	2	
E. unid.	1		
TOTAL NUMBER	41	31	65
NUMBER OF SPECIES	5	3	5
SNAPPERS			
Lutjanus analis			2
L. apodus	3	6	13
L. griseus	1		105
L. jocu		1	
L. mahogani		5	11
L. synagris			57
Ocyurus chrysurus	7	17	13
TOTAL NUMBER	11	29	201
NUMBER OF SPECIES	3	4	6
TOTAL NUMBER OF FISHES	52	60	266

Table 3. Rank of the twenty numerically dominate species captured in fish traps set around Yawzi Point reef, 1992-3.

Scientific name		Common name	Number captured	Avg size (TL-cm)
Haemulon	sciurus	bluestriped grunt	147	25.67
Acanthurus	coeruleus	blue tang	146	17.67
Haemulon	plumieri	white grunt	141	23.34
Acanthurus	bahianus	ocean surgeonfish	129	18.47
Calamus	sp.	unidentified porgy	127	26.62
Pseudupeneus	maculatus	spotted goatfish	56	24.86
Acanthurus	chirurgus	doctorfish	53	19.94
Lutjanus	apodus	schoolmaster snapper	41	25.96
Sparisoma	aurofrenatum	redband parrotfish	39	24.45
Ocyurus	chrysurus	yellowtail snapper	36	26.25
Lutjanus	synagris	lane snapper	35	24.72
Epinephelus	afer	mutton hamlet	32	24.01
Epinephelus	striatus	Nassau grouper	30	32.98
Holocentrus	adscensionis	longjaw squirrelfish	25	24.99
Sparisoma	viride	stoplight parrotfish	25	25.30
Gerres	cinereus	yellowfin mojarra	19	21.57
Epinephelus	cruentatus	graysby	18	34.74
Mulloidichthys	martinicus	yellow goatfish	15	29.75
Epinephelus	adcenscionis	rock hind	14	28.36
Lutjanus	jocu	dog snapper	12	30.70
Lujanus	analis	mutton snapper	12	32.98
Holocanthus	ciliaris	queen angelfish	12	20.39

Table 4. Rank of the twenty numerically dominate species captured in fish traps set around Yawzi Point reef from August, 1993 to March, 1994.

Scientific name		Common name	Number captured	Avg size (TL-cm)
Acanthurus	coeruleus	blue tang	301	14.36
Acanthurus	bahianus	ocean surgeonfish	194	15.41
Sparisoma	aurofrenatum	redband parrotfish	92	20.26
Sparisoma	chrysopterum	redtail parrotfish	76	20.55
Haemulon	plumieri	white grunt	74	20.31
Acanthurus	chirurgus	doctorfish	44	15.84
Ocyurus	chrysurus	yellowtail snapper	34	28.72
Haemulon	sciurus	bluestriped grunt	33	19.92
Calamus	sp.	unidentified porgy	32	18.97
Chaetodon	striatus	banded butterflyfish	31	12.52
Pseudupeneus	maculatus	spotted goatfish	31	20.97
Haemulon	flavolineatum	french grunt	28	16.83
Holocentrus	rufus	squirrelfish	27	19.83
Epinephelus	guttatus	red hind	25	26.89
Holocentrus	adscensionis	longjaw squirrelfish	20	20.04
Epinephelus	cruentatus	graysby	16	22.13
Holacanthus	tricolor	rock beauty	14	13.80
Lutjanus	synagris	lane snapper	14	19.23
Mulloidichthys	martinicus	yellow goatfish	13	22.58
Lutjanus	apodus	schoolmaster snapper	13	19.54

Table 5. Rank abundance of the ten numerically dominate families captured in fish traps set around Yawzi Point reef during 1982-3 and 1993-4 investigations.

Scientific name	Common name	1982-3 Number captured	%	1993-4 Number captured	%
Acanthuridae	surgeonfishes	328	25.7	539	45.2
Haemulidae	grunts	294	23.1	135	11.3
Sparidae	porgies	127	10.0	32	3.5
Serranidae	groupers .	112	8.8	57	4.7
Lutjanidae	snappers	103	8.1	65	5.5
Mullidae	goatfishes	71	5.6	44	3.7
Scaridae	parrotfishes	69	5.4	184	15.4
Ostraciidae	boxfishes	30	2.5	7	0.6
Holocentridae	squirrelfishes	25	2.0	64	5.4
Pomacanthidae	angelfishes	14	1.1	24	2.2
others		101	7.9	40	3.4

Table [illegible]. Mean number of fish observed per point count twelve months before trapping (BEFORE) and six months during trapping (DURING) on Yawzi Point reef. Reef edge refers to the reef area next to the sand zone (where traps were set). Reef platform refers to the gradually sloping reef area at least 10 m from the edge which had lower topographic complexity and lower number of fishes than the edge. Six to 11 censuses per zone were conducted per sampling date. Standard errors are presented in parentheses.

	REEF EDGE		REEF PLATFORM	
	BEFORE	DURING	BEFORE	DURING
TOTAL FISH (excluding Coryphopterus personatus)	207.86 (+74.45)	186.91 (+97.47)	120.95 (+27.50)	95.24 (+19.34)
PREDATORS	14.92 (+11.32)	6.65 (+1.83)	3.93 (+2.18)	2.71 (+1.57)
HOLOCENTRIDAE squirrelfishes	2.83 (+1.16)	1.62 (+0.65)	1.10 (+1.06)	0.20 (+0.33)
SERRANIDAE groupers	1.02 (+0.37)	1.15 (+0.32)	1.00 (+0.48)	0.88 (+0.56)
LUTJANIDAE snappers	2.12 (+1.14)	1.20 (+0.86)	0.81 (+1.38)	0.51 (+1.09)
HAEMULIDAE grunts	15.14 (+9.10)	10.88 (+9.20)	1.63 (+2.36)	0.41 (+0.81)
SCARIDAE parrotfishes	42.73 (+8.14)	35.44 (+5.48)	28.12 (+7.78)	22.24 (+4.85)
ACANTHURIDAE surgeonfishes	12.35 (+9.56)	6.09 (+0.97)	6.47 (+1.57)	7.10 (+1.28)

Table 7. Mean number of predators observed per transect eight months before trapping (BEFORE) and six months during trapping (DURING) on Yawzi Point reef. Only predators observed in transects which were also captured in traps were included in this analysis. Six to 13 transects per zone were conducted per sampling date. Standard errors are presented in parentheses.

	REEF EDGE		REEF PLATFORM	
	BEFORE	DURING	BEFORE	DURING
PREDATORS	5.99 (+0.94)	4.88 (+0.99)	5.33 (+1.27)	2.10 (+0.49)
HOLOCENTRIDAE squirrelfishes	3.84 (+0.70)	2.55 (+0.69)	2.04 (+0.64)	0.59 (+0.32)
SERRANIDAE groupers	1.27 (+0.13)	1.15 (+0.16)	1.30 (+0.23)	0.80 (+0.15)
LUTJANIDAE snappers	0.35 (+0.19)	0.28 (+0.02)	0.73 (+0.22)	0.21 (+0.13)