

FINAL REPORT

U.S. Virgin Islands

Dingell-Johnson Expansion Project F-7

Study V

Mangroves as Nursery Grounds for Recreational Fisheries

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1990

Abstract

Mangrove lagoon areas on St. Thomas and St. John, U.S. Virgin Islands have been sampled on a monthly basis to assess habitat use and nursery importance for fish and important invertebrates. Three study sites of varying degrees of degradation were chosen for study. Visual censuses and standardized trapping have been conducted along the mangrove shoreline, counting all individuals of each species observed or trapped and recording total and standard (trap fish) lengths. The Mangrove Lagoon, St. Thomas site has a small fringe of red mangrove which is moderately to severely degraded. The Hurricane Hole, St. John site represents the "natural" conditions.

Results have demonstrated a significant difference in species diversity, species composition and abundance of fishes between the degraded and natural sites. These differences appear to be directly attributable to degree of pollution. The Vessup Bay site is similar to the middle zone of the Mangrove Lagoon, due as well to impacts from sewage outfall and densely moored boats. Primary differences between sites appear to be related more to water quality than to structural complexity of the substrate. Both visual censuses and trapping have provided indications of annual recruitment cycles into the nursery habitat (eg. Sphyraena barracuda, Ocyurus chrysurus) and nursery value to important coral reef species.

INTRODUCTION

Tropical marine mangrove ecosystems have been relatively well documented as important nursery and juvenile habitat for many species of reef fish and invertebrates (Heald and Odum, 1970; Odum, et al., 1982; Thayer, et al., 1987; Pinto, 1988). The nursery quality of the mangrove system is due mainly to the availability of shelter for juveniles in the prop roots and to an abundant supply of organic detrital food (Ogden and Gladfelter, 1983).

As well, coastal mangroves serve to filter upland runoff of sediment, heavy metals and particulate matter, thus protecting other nearshore communities from sedimentation, toxicity and eutrophication (Bossi and Cintron), 1990. The aerial portion of mangroves is an important wildlife habitat. An additional important feature is the export of particulate organic carbon produced by the decomposition of leaf litter (Lopez, et al., 1988). Although food webs based on this mangrove carbon do exist, the value of this carbon input to secondary consumers in nearshore waters is not clear (Odum, et. al., 1982).

In the Virgin Islands, as in most other tropical countries around the world, coastal mangrove ecosystems are being destroyed at an alarming rate (Odum and Johannes, 1975; Towle, 1985). In less developed areas they are harvested for their wood, bark and other products. In developed countries they are cut down to make marinas or filled to build condominiums and support residential development. They are the sites of sewage treatment plants which discharge up to millions of gallons per day of variously treated effluent into their waters producing eutrophication of prop root communities. Land fills commonly occur behind them, altering the terrestrial conditions necessary for their existence and producing chemical pollutants which make their way into the water as well.

The destruction of these mangrove systems allows for terrigenous sediments to pass directly into the marine environment, seriously affecting nearshore seagrass beds and coral reefs (Ogden and Gladfelter 1983). Over time, nutrients from natural mangrove decomposition processes will be reduced which may lower the productivity of other nearshore marine communities. Additionally, the refuges and nursery habitat for many fishes and invertebrates are destroyed and recruitment into nearby communities is reduced (Ogden and Gladfelter, *ibid*). The destruction of estuaries in Florida and the Gulf of Mexico have been suggested as threatening fishery resources of adjacent waters (Lindall, 1973; 1977).

While the presence of elevated nutrient loads resulting from the discharge of partially treated sewage has been observed to be favorable for mangrove growth (Odum and Johannes, 1975), little has been done to document the effect this has on the nursery value for fish species utilizing the prop root habitat. It is hypothesized that since dissolved oxygen levels are relatively low in most mangrove waters (Austin and Austin, 1971) the input of sewage might lead to mortality of marine mangrove fauna.

Mangrove systems in the U.S.V.I. can best be described as fringing forests along oceanic bays and lagoons. These are characterized by generally having clearer water, sandy substrates and higher, less variable salinities (Odum, et al., 1982). In the northern Virgin Islands the major stands of mangroves occur in Coral Bay, St. John; Mary's creek, St. John; Benner Bay, St. Thomas and the Mangrove Lagoon, St. Thomas. Coral Bay and Mary's Creek are described in Boulon (1986). The Mangrove Lagoon is described in Towle (1985). Benner bay is described in the present study. Of the four areas, the Mangrove Lagoon is the best studied. Water quality and environmental conditions were first described by Grigg and van Eepoel (1971) but have changed considerably since then. Olsen et al. (1973) described the fish communities in the Mangrove Lagoon, however, sampling was primarily conducted in sand and seagrass habitats. The results of that study may not reflect the species and abundances of fish actually utilizing the mangrove prop root habitat.

The present study was initiated to document the nursery value of mangrove prop root communities in the northern U.S. Virgin Islands across a range of environmental conditions from pristine to heavily impacted from sewage discharge and other man produced stresses. Additionally, as a baseline data set, any changes in stress on the systems can be monitored in terms of the fish communities.

METHODS:

Three locations were selected for this study. They represent the three major mangrove embayments in the northern U.S. Virgin Islands. They include Hurricane Hole in Coral Bay, St. John, Vessup Bay, St. Thomas and Benner Bay (the "Mangrove Lagoon") on St. Thomas (Figure 1). The Mangrove Lagoon was subdivided into three portions; inner, middle and outer (Figure 2), to stratify sampling by environmental quality. These five sites represent a spectrum of water and habitat quality, from the inner Mangrove Lagoon, with approximately 0.45 mgpd of "treated" sewage effluent and the St. Thomas Municipal landfill

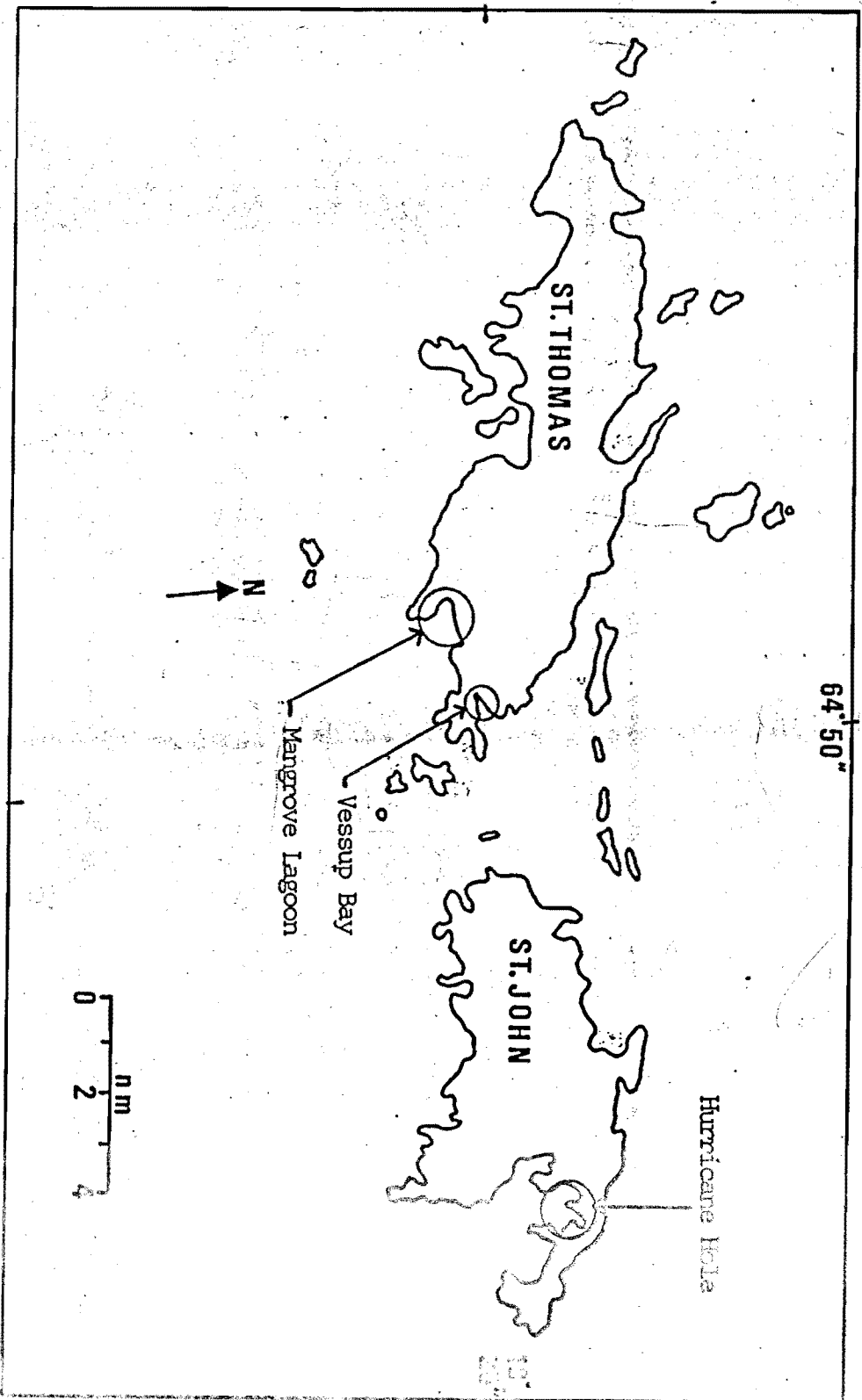


FIGURE 1. Mangrove study sites in the northern U.S. Virgin Islands

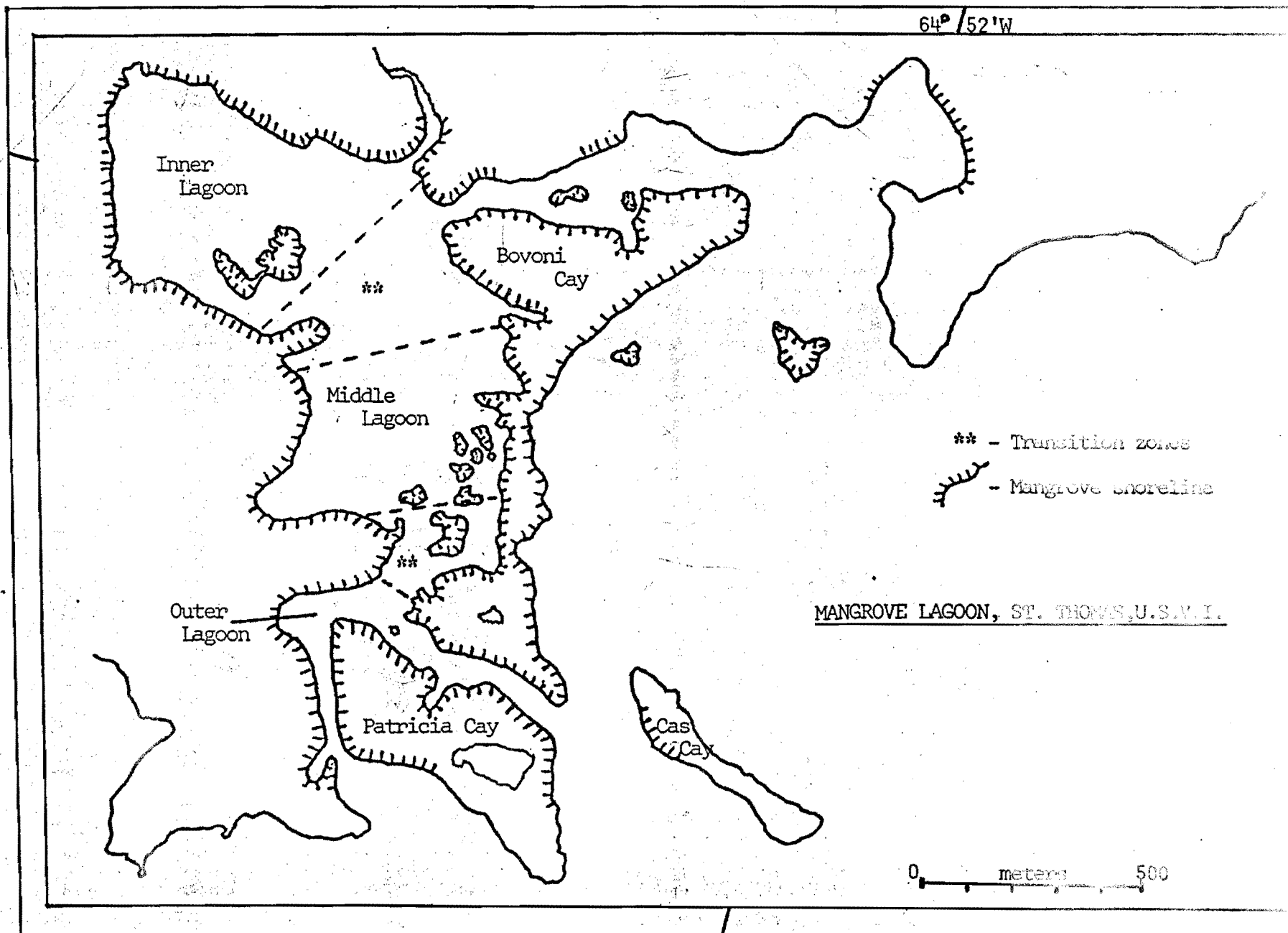


Figure 2. The Mangrove Lagoon, St. Thomas, U.S.V.I., showing subdivisions for sampling.

producing an undetermined amount of leachate, to Hurricane Hole in the Virgin Islands National Park which can still be considered pristine.

Different methodologies or combination of methodologies were selected for the three study sites due to the varying degrees of environmental water quality. Both the inner portion of the Mangrove Lagoon and Vessup Bay are subjected to sewage discharge and are therefore not suitable for a diver to perform visual censuses. For this reason it was decided to use traps in these areas. To be able to compare the inner Mangrove Lagoon to the middle and outer portions it was necessary to use traps there as well. Visual censuses were possible in the middle and outer portions as well as Hurricane Hole. No trapping was conducted in Hurricane Hole due to the distance of the site and the logistics and time needed to transport and sample the traps adequately.

Trapping was conducted in the Mangrove Lagoon and Vessup Bay from late 1986 to early 1990 using 92cm x 56cm x 20cm traps of 1.25cm square vinyl coated hardware cloth. Traps were set for one five day period per month, being pulled, moved, rebaited and reset each day to obtain four samples per trap per month. Traps were set within one meter of the seaward edge of the prop roots with the trap funnel facing the mangroves. Traps were buoyed with hard foam floats. All traps were baited with dwarf herring (Jenkinsia lamprotaenia) in an 8 x 8 x 8 centimeter bait basket of the same material as the traps. All fish caught were placed in a container of sea water, measured (standard and total lengths), enumerated and released at the same location where they were caught. In the Mangrove Lagoon, five traps were set in each portion for a total of 15 traps. Five traps were set in Vessup Bay due to a limited amount of habitat.

Visual censuses were conducted in the middle and outer portions of the Mangrove Lagoon and in the four finger bays in Hurricane Hole from late 1986 to mid 1989. Visual censuses consisted of swimming preestablished, marked 50 - meter transects along the seaward edge of the mangroves. All individuals of all species of fish observed from within the prop root system to approximately two meters seaward of the root line were counted and estimates of size were made. All data was recorded on mylar sheets over preprinted forms. The preprinted forms eliminated having to write down the species names for each transect and thus saves time. Each 50m transect was swum in approximately 20 to 25 minutes. This was slow enough to observe cryptic species and yet fast enough to keep track of fish that might move ahead of the diver and either be not counted or double counted. Large schools of fish had to be estimated in the 10's, 100's or 1000's.

Eight 50m transects were established among the mangrove cays that form the eastern side of the middle Mangrove Lagoon. The western side of the middle Mangrove Lagoon has poorer water quality and the decision was made that visual sampling was unsafe. Eight 50m transects were established in the channels that form the outer lagoon. Four 50m transects were established in each finger bay in Hurricane Hole except for the innermost one (Borck Creek) where water depth or the north side is too shallow to produce significant habitat or to census.

RESULTS:

Species of fish recorded varied considerably between methods used and among locations sampled (Table 1). Although visual censuses generally yielded a greater number of species observed than trapping, the results demonstrated differences among locations based on environmental water quality. The inner Mangrove Lagoon had the lowest number of species observed followed by Vessup Bay, middle Mangrove Lagoon, outer Mangrove Lagoon and Hurricane Hole. The principal species that were observed in visual censuses but not caught in traps were species generally not captured in traps (eg. Sphyrna barracuda, J. lamprotaemia, Atherinomorus stipes, some jacks and very small species like blennies, gobies and , Amblycirrhitus pinos). Most of these species only occur in areas having clean water and, therefore, the results using these methods are most likely an accurate representation of the different species assemblages found in the different study sites.

Mean numbers of species of fish caught per trap differed significantly between locations and years ($P < .001$) (Table 2). Among sites, the Inner Mangrove Lagoon had the fewest numbers of species per trap, followed by Vessup Bay, the Middle Mangrove Lagoon and the Outer Mangrove Lagoon. All sites were significantly different from each other (Table 2). Among years, 1987, 1988 and 1989 showed no significant differences from each other in mean numbers of species caught per trap (Table 2). However, 1986 and 1990, both of which were only partial year samples, did not differ significantly from each other yet were significantly different from the three complete years of trapping.

Mean numbers of individuals of fish caught per trap also differed significantly between locations and years ($P < .001$) (Table 3). Among sites, Vessup Bay and the Inner Mangrove Lagoon were not significantly different while the Outer Mangrove Lagoon had a significantly higher mean number of individuals caught per trap than the Middle Mangrove Lagoon (Table 3). Result among years were similar to the

Table 1. Species observed at each study site by method.

FISH SPECIES	TRAP SAMPLING				VISUAL CENSUS		
	MANGROVE LAGOON			VESSUP BAY	MANGROVE LAGOON		HURRICANE HOLE
	INNER	MIDDLE	OUTER		MIDDLE	OUTER	
<i>Gymnothorax funebris</i>	X	X	X	X	X		
<i>G. moringa</i>			X				
<i>Harengula humeralis</i>					X		
<i>Jenkinsia lamprotaenia</i>					X	X	X
<i>Atherinomorous stipes</i>					X	X	X
<i>Hyporhamphus unifasciatus</i>							X
<i>Synodus intermedius</i>							X
<i>Holocentrus ascensionis</i>		X	X			X	X
<i>Adioryx coruscus</i>				X			X
<i>Aulostomus maculatus</i>				X		X	X
<i>Epinephelus guttatus</i>							X
<i>E. striatus</i>			X			X	X
<i>E. cruentatus</i>							X
<i>E. fulvus</i>							X
<i>Serranus tabacarius</i>						X	
<i>S. tigrinus</i>						X	X
<i>Hypoplectrus</i> spp.			X		X	X	X
<i>Rypticus</i> sp.							X
<i>Apogon binotatus</i>			X				X
<i>Caranx bartholomaei</i>					X	X	X
<i>C. crysos</i>	X						
<i>C. ruber</i>	X					X	X
<i>Trachiotus</i> sp.							X
<i>Lutjanus analis</i>							X
<i>L. apodus</i>	X	X	X	X	X	X	X
<i>L. griseus</i>	X	X	X	X	X	X	X
<i>L. jocu</i>	X				X	X	X
<i>L. mahogoni</i>						X	X
<i>L. synagris</i>		X	X			X	X
<i>L. buccanella</i>							X
<i>Ocyurus chrysurus</i>		X	X	X	X	X	X
<i>Eucinostomus argenteus</i>	X	X	X	X	X	X	X
<i>Anicotrems virginicus</i>					X	X	X
<i>Haemulon album</i>		X				X	
<i>H. macrostomum</i>						X	X
<i>H. melanurum</i>						X	
<i>H. aurolineatum</i>		X	X	X	X	X	X
<i>H. flavolineatum</i>		X	X	X	X	X	X
<i>H. pinnatifidum</i>						X	
<i>H. plumieri</i>					X	X	X

Table 1. cont.

<i>H. sciurus</i>		X	X	X	X	X	X
<i>H. chrysargyreum</i>							X
<i>H. spp.</i>		X	X		X	X	X
<i>Archosargus rhomboidalis</i>	X	X	X	X	X	X	X
<i>Calamus bajonado</i>					X	X	X
<i>C. pennatula</i>						X	
<i>Lagodon rhomboides</i>					X		
<i>Mulloidichthys martinicus</i>						X	X
<i>Pseudupeneus maculatus</i>			X			X	X
<i>Chaetodon capistratus</i>		X	X	X	X	X	X
<i>C. sedentarius</i>							X
<i>Holacanthus ciliaris</i>						X	X
<i>Pomacanthus arcuatus</i>			X			X	
<i>P. paru</i>					X	X	X
<i>Abudefduf saxatilis</i>			X	X	X	X	X
<i>Microspathodon chrysurus</i>		X	X			X	X
<i>Stegastes partitus</i>						X	X
<i>S. dorsopunicans</i>		X	X		X	X	X
<i>S. leucostictus</i>		X	X		X	X	X
<i>S. planifrons</i>			X			X	X
<i>S. variabilis</i>			X		X	X	X
<i>Amblycirrhitus pinos</i>					X	X	X
<i>Halichoeres bivittatus</i>		X	X	X	X	X	X
<i>H. poeyi</i>						X	
<i>H. radiatus</i>						X	X
<i>H. garnoti</i>						X	X
<i>H. maculipinna</i>						X	X
<i>Lachnolaimus maximus</i>		X			X	X	
<i>Thalassoma bifasciatum</i>			X		X	X	X
<i>Scarus croicensis</i>					X	X	X
<i>S. taeniopterus</i>		X	X		X	X	X
<i>S. vetula</i>						X	
<i>S. guacamaia</i>					X		
<i>Nicholsina usta</i>							X
<i>Sparisoma atomarium</i>					X	X	X
<i>S. aurofrenatum</i>			X		X		X
<i>S. chrysopterus</i>		X	X		X	X	X
<i>S. radians</i>		X	X		X	X	X
<i>S. viride</i>					X	X	X
<i>S. caeruleum</i> spp.		X	X		X	X	X
<i>S. chrysaena</i> barronae		X			X	X	X
<i>Labridomus multipinnis</i>				X			
<i>Malacoctenus macropus</i>							X
<i>M. triannulatus</i>							X
<i>Centrolabris affinis</i>				X			
<i>Coryphopterus glaucofraenum</i>					X	X	X

Table 1. cont.

<i>C. personatus</i>							X
<i>Bathygobius soporator</i>	X	X		X			
<i>Balistes vetula</i>							X
<i>Acanthurus bahianus</i>			X		X	X	X
<i>A. chirurgus</i>		X	X		X	X	X
<i>A. coeruleus</i>			X		X	X	X
<i>Cantherhinus pullus</i>						X	X
<i>Monacanthus ciliatus</i>				X			
<i>M. tuckeri</i>							X
<i>Lactophrys trigonus</i>				X			X
<i>L. triqueter</i>							X
<i>L. bicaudalis</i>							X
<i>Canthigaster rostrata</i>		X	X	X		X	X
<i>Sphoeroides testudineus</i>	X	X	X	X	X	X	
<i>S. spengleri</i>						X	X
<i>Diodon hystrix</i>						X	X
<i>Chilomycterus sp.</i>							X
<i>Strombus gigas</i>						X	X
<i>Panulirus argus</i>	X	X	X	X		X	X
TOTAL	11	29	40	22	45	71	85

Table 2. Results of statistical analysis among locations and years for mean numbers of species of fish caught per trap in the Mangrove Lagoon (Inner, Middle, Outer) and Vessup Bay. Underlined means denote no significant difference.

ANOVA results

	DF	SS	F	P
Location	3	3429.12	569.85	<0.001 ***
Year	4	60.94	7.60	<0.001 ***

*** denotes significant difference at $p < 0.001$

CONTRAST results

Among sites: $LSD = .161$, $T = 1.96$, $\alpha = 0.05$

Site	Inner	Middle	Outer	Vessup
Mean	0.98	2.17	4.12	1.34
N	580.00	579.00	573.00	639.00

Among years: $LSD = .237$, $T = 1.96$, $\alpha = 0.05$

Year	1987	1988	1989	1986	1990
Mean	<u>2.11</u>	<u>2.26</u>	<u>2.50</u>	<u>1.55</u>	<u>1.78</u>
N	752.00	700.00	576.00	105.00	238.00

Table 3. Results of statistical analysis among locations and years for mean numbers of individuals of fish caught per trap in the Mangrove Lagoon (Inner, Middle, Outer) and Vessup Bay. Underlined means denote no significant difference.

ANOVA results

	DF	SS	F	P
Location	3.00	70783.39	233.63	<0.001 ***
Year	4.00	3085.39	7.64	<0.001 ***

*** denotes significant difference at $p < 0.001$

CONTRAST results

Among sites : LSD = 1.146, T = 1.96, alpha = 0.05

Site	Vessup	Inner	Middle	Outer
Mean	3.66	2.54	7.04	16.56
N	638.00	580.00	579.00	573.00

Among years: LSD = 1.682, T = 1.96, alpha = 0.05

Year	1987	1988	1989	1986	1990
Mean	<u>7.40</u>	<u>8.48</u>	<u>7.54</u>	<u>3.54</u>	<u>4.88</u>
N	751.00	700.00	576.00	105.00	238.00

results among years for mean number of species per trap (Table 3).

Mean numbers of species of fish observed per 50m visual transect in Hurricane Hole and the Mangrove Lagoon (Middle and Outer combined) differed significantly between locations and years ($P < .001$) (Table 4). Among sites, Hurricane Hole had the greatest number of species per 50m visual transect, followed by the Outer Mangrove Lagoon and the Middle Mangrove Lagoon (Table 4). Among years, 1987 and 1988 showed no significant difference in number of species of fish observed per 50m visual transect (Table 4). 1989 was just significantly different while 1986, with its small sample size, was significantly different. With the exception of 1986, the numbers of species per 50m visual transect decreased annually during the study (Table 4).

Mean numbers of individual fish observed per 50m visual transect in Hurricane Hole and the Mangrove Lagoon (Middle and Outer combined) differed significantly between locations ($P < .001$) but not between years ($P = .152$) (Table 5). Among sites, differences were significant with Hurricane Hole having the greatest number of individual fish observed per 50m visual transect, followed by the Outer Mangrove Lagoon and the Middle Mangrove Lagoon (Table 5). Among years, 1987 and 1988 did not differ significantly in numbers of individual fish per 50m visual transect and 1988 and 1989 did not differ significantly either. 1986, with its small sample size differed significantly from all the other years (Table 5). As with numbers of species, the data suggests an annual decline in numbers of individual fish per 50m visual transect during the study (Table 5).

Eleven species or species groups were analyzed for abundance per 50m visual transect in Hurricane Hole and the Mangrove Lagoon (Middle and Outer combined) (Table 6). Means were calculated using only the transects in which the species or species group was observed. With the exception of Lutjanus apodus and all Scaridae, all other species or species groups were more abundant per 50m visual transect in Hurricane Hole. Archosargus rhomboidalis was practically non-existent at Hurricane Hole and yet relatively common in the Mangrove Lagoon at certain times of the year.

Should have
included all
transects

The same eleven species were analyzed for mean size per 50m visual transect (Table 7). Means were calculated using the range of sizes observed for each species or species group per transect in which they were observed and a size range noted (some observers neglected to record sizes). In every species or species group analyzed, mean sizes of individuals were larger in the Mangrove Lagoon than in Hurricane Hole although only five were determined to be significantly larger.

Table 4. Results of statistical analysis among locations and years for mean numbers of species of fish observed per 50m visual transect in Hurricane Hole and the Mangrove Lagoon. Underlined means denote no significant difference.

ANOVA results

	DF	SS	F	P
Location	2.00	4787.75	221.72	<0.001 ***
Year	3.00	405.15	12.51	<0.001 ***

*** denotes significant difference at $p < 0.001$

CONTRAST results

Among sites : $LSD = .697$, $T = 1.96$, $\alpha = 0.05$

Site	Mid M.L.	Out M.L.	H. Hole
Mean	10.33	15.49	17.42
N	144.00	144.00	277.00

Among years : $LSD = 1.04$, $T = 1.96$, $\alpha = 0.05$

Year	1986	1987	1988	1989
Mean	12.10	<u>15.84</u>	<u>15.56</u>	14.39
N	30.00	116.00	269.00	150.00

Table 5. Results of statistical analysis among locations and years for mean numbers of individual fish observed per 50m visual transect in Hurricane Hole and the Mangrove Lagoon. Underlined means denote no significant difference.

ANOVA results

	DF	SS	F	P
Location	2.00	96.30	125.44	<0.001 ***
Year	3.00	2.04	1.77	0.152 NS

*** denotes significant difference at $p < 0.001$
 NS - no significant difference

CONTRAST results

Among sites : LSD = 31.75, T = 1.96, alpha = 0.05

Site	Middle M.L.	Outer M.L.	H. Hole
Mean	82.35	152.56	240.70
N	144.00	144.00	277.00

Among years : LSD = 47.55, T = 1.96, alpha = 0.05

Year	1986	1987	1988	1989
Mean	307.00	<u>204.33</u>	<u>166.74</u>	153.87
N	30.00	116.00	269.00	150.00

Table 6. Mean number of individuals for eleven species or species groups per 50m visual transect in Hurricane Hole and the Mangrove Lagoon. Means were calculated using only the transects in which the species or species group was observed.] should be all transects

Species or sp. grp.	Hurricane Hole		Mangrove Lagoon	
	Mean	N	Mean	N
Jenkinsia lamprotaenia	8360.00	187.00	2278.00	189.00
Lutjanus apodus	7.36	219.00	9.28	258.00
Ocyurus chrysurus	10.60	186.00	4.63	222.00
Pomadasyidae (Adult)	21.21	611.00	11.70	514.00
Pomadasyidae (Juv.)	98.86	122.00	46.83	60.00
Archosargus rhomboidalis	**	**	6.28	76.00
Chaetodon capistratus	4.21	165.00	3.70	151.00
Pomacentridae	8.04	428.00	4.77	414.00
Scaridae (Adult)	3.38	95.00	7.69	147.00
Scaridae (Juv.)	22.88	250.00	40.55	232.00
Sphyraena barracuda	3.54	142.00	2.31	249.00

** - Only two individuals observed

Table 7. Mean size of individuals in cm for eleven species or species groups per 50m visual transect in Hurricane Hole and the Mangrove Lagoon. Means were calculated using the range of sizes observed for each species or species group per transect in which they were observed and a size range noted.

Species or sp. grp.	Hurricane Hole		Mangrove Lagoon		T Test
	Mean	N	Mean	N	
Jenkinsia lamprotaenia	3.39	126.00	3.77	189.00	*
Lutjanus apodus	10.20	264.00	11.35	189.00	NS
Ocyurus chrysurus	7.51	216.00	8.20	222.00	NS
Pomadasyidae (Adult)	7.89	592.00	11.44	514.00	*
Pomadasyidae (Juv.)	3.93	88.00	4.13	60.00	NS
Archosargus rhomboidalis	4.00	2.00	13.72	76.00	**
Chaetodon capistratus	5.20	211.00	5.96	151.00	*
Pomacentridae	5.72	546.00	5.99	414.00	NS
Scaridae (Adult)	6.77	101.00	10.88	147.00	*
Scaridae (Juv.)	4.13	189.00	4.89	232.00	NS
Sphyraena barracuda	14.79	199.00	21.06	249.00	*

* significantly different at alpha = 0.05

** insufficient observations for analysis

NS - no significant difference

CONCLUSIONS:

The value (or health) of marine mangrove ecosystems in the northern U.S. Virgin Islands is demonstrated to be quantifiable in terms of species richness and abundance by location and unit of mangroves. Based on this investigation it is clear that certain mangrove areas in the northern U.S.V.I. (Hurricane Hole and the Outer Mangrove Lagoon) are functioning as productive nursery habitat for many reef fish species. The relative importance of mangrove areas and seagrass beds as nursery habitat remains to be documented. However, it is indisputable that the destruction of our mangrove nursery areas would certainly have a serious impact on recruitment into other nearshore marine ecosystems, such as coral reefs.

The correlation appears evident between water quality and the numbers of species and individuals of fish present in the mangrove prop root habitat. Effluent from sewage treatment plants is probably the main factor leading to habitat degradation through eutrophication, decrease in dissolved oxygen and increase in suspended solids. An Environmental Impact Statement has been approved by the U.S. Environmental Protection Agency and local authorities to remove the sewage treatment plant from the Mangrove Lagoon. A new plant is to be built and effluent discharged to an ocean outfall. The Vessup Bay plant may be tied into the new system. By removing this type of discharge into these bays it is hoped that the present conditions will reverse and the prop root habitat will be restored to a healthier condition. If this happens, fish communities in these areas should increase in numbers of species and individuals. If sewage effluent is the primary factor leading to the degradation of these areas then future monitoring following cessation of sewage discharge should demonstrate this.

Trapping results indicate that the Vessup and Inner Mangrove Lagoon sites are very similar in both numbers of species and individuals caught per trap. The species caught at these two sites are fish species typically found in very turbid, polluted waters. While most fish caught in these areas appeared healthy, occasional individuals were caught with surface growths or deformities. The Middle and Outer Mangrove Lagoon sites demonstrated a trend towards cleaner water and healthier prop root habitat.

For both numbers of species and individuals per trap, the complete sampling years (1987, 1988, 1989) were not different from each other. 1986 and 1990 were different most likely due to small sample sizes and because they only represent a short sampling period.

Visual census results show a similar trend in numbers of species and individuals per census from the Middle to Outer Mangrove Lagoon and Hurricane Hole. This trend corresponds to the trend in improving water and prop root habitat quality. The most common species or species groups at both locations, excluding J. lamprotaenia, are the grunts (Pomadasyidae) and parrotfish (Scaridae).

It is interesting to note that numbers of individual fish observed per 50m visual transect decreased annually from 1986 to 1989. Likewise, numbers of species per 50m visual transect decreased from 1987 to 1989. It is unlikely that this is an artifact of observer bias (this would actually produce an increasing trend as observers became more proficient) or methodology. If this represents a reduction in recruitment due to overfishing, we may be seeing a downward spiral in fish production that could result in drastic changes in our marine ecosystems. However, the trapping results do not show any significant change during the three core years of the study (1987 to 1989).

The results for mean number of individuals per 50m visual transect in the Mangrove Lagoon vs Hurricane Hole indicate that some species are more abundant in one location or the other. J. lamprotaenia are found to be more abundant in Hurricane Hole, possible due to better water conditions. The same is true for all Pomadasyidae, both adults and juveniles, all Pomacentridae and S. barracuda (many more juveniles than in the Mangrove Lagoon). Scaridae, both adults and juveniles, and A. rhomboidalis are much more abundant in the Mangrove Lagoon, possibly due to more algal growth (food resource) and preferred micro-habitat. L. apodus is also more abundant in the Mangrove Lagoon and is often observed there as larger adults.

It is also interesting to note that of all eleven species or species groups analyzed, all were larger in mean size in the Mangrove Lagoon than in Hurricane Hole. This could be due to greater predation on juveniles or poor water quality reducing juvenile survivorship or recruitment into this habitat.

From the analysis of fish sizes it is obvious that the reef fish species caught in traps and observed in visual censuses are juveniles. They are well below the minimum size at maturity (CFMC, 1985). Mean size by species from visual census data are apparently slightly larger. This may be due to larger individuals not entering the traps as readily. Adult Lutjanus griseus are observed in large numbers in the prop root habitat although juveniles are not commonly observed and, therefore, not commonly caught in traps.

It was obvious during the study that certain species exhibit a strong seasonality in abundance. During the visual censuses, S. barracuda would appear in large numbers (up to 25 per 50 m transect during April and May of each year in the 2 to 3 cm size range. During subsequent censuses the numbers gradually decreased and the sizes of individuals increased. This was clearly a year class which we could follow. O. chrysurus appeared to demonstrate a seasonal trend in abundance based on trap data. Archosargus rhomboidalis demonstrated a seasonality from both trap and visual census data in the Mangrove Lagoon.

The "value" of a mangrove system as a nursery area expressed in numbers of species or individuals per unit of mangroves (eg. 50m) should be a valid means of comparing locations. Additionally, by assigning a "real value" to a location, arguments may be made against development which may reduce the "value" or for a management action which may increase the "value". The "real values" are numbers that resource planners, managers and users can relate to and use to justify protection or enhancement of a mangrove area (e.g. numbers of fish which can recruit to reefs or algal plains to be caught by fishermen, thus increasing or maintaining money flow in the economy). When considering the numbers that are presented for "value" per linear unit of mangrove shoreline it must be understood that this is essentially one moment in time and the long-term "value" is only realized when time and other factors are calculated. By factoring in residence time by species, seasonal changes in abundance and other variables the long-term "value" per linear unit of mangrove shoreline will be considerably more impressive than that which is presented here. At the present time, the information and techniques are not available to us to calculate long-term "value".

The two methods used to sample mangrove prop root habitat yield accurate although somewhat different results, due to biases inherent in each method. The trapping method tends to underrepresent certain species which apparently avoid traps (eg. S. barracuda, L. griseus) or are of such size to pass through the mesh and not be caught (eg. blennies, gobies, A. pinos). The method may also concentrate some species (e.g. O. chrysurus) which yields different results from the visual census method. Conversely, the wariness of certain species may yield a lower frequency of occurrence in the visual censuses. A combination of methods clearly provides a more complete picture of fish assemblages in this habitat than would a single method. Combining these with an unattended continuous recording method such as an underwater video system would certainly answer additional questions and assess the biases of other methods.

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