

# Reef Fish Community Differences Among the U.S. Virgin Islands and Implications for Management

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## ABSTRACT

Understanding the spatiotemporal relationships of reef fish communities can aid in applying ecosystem-based management principles. Reef fish communities of the U.S. Virgin Islands (USVI) fall under the management purview of the USVI Department of Planning and Natural Resources (DPNR) and NOAA. Management actions and laws are based on territory-wide catch estimates and fishery independent data sets and are therefore applied equally across the three islands of St. Thomas, St. John, and St. Croix. However, fishing practices and intensity differ on St. Croix and a significant distance separates it from St. Thomas and St. John. A multivariate analysis of synoptic fishery-independent reef fish data revealed separation of reef fish communities between St. Thomas and St. Croix. For some species this difference could be fisheries-related. However, non-targeted species and communities also varied significantly within similar habitats, suggesting potential ecological impacts. While both islands possess similar reef habitats (e.g., deep shelf edge reefs, shallow nearshore reefs), these habitats are distributed across a more extensive shelf area on St. Thomas. Reef fish communities differed significantly along a nearshore to offshore gradient while St. Croix reef fish communities did not, suggesting that shelf size may also be influencing reef fish community composition and distribution. These results suggest that reef fish community composition is controlled by the combined effects of resource extraction and biophysical variability.

KEY WORDS: Reef fish communities, US Virgin Islands, multivariate analysis, ecosystem based management, fishery independent data sets

## Las Diferencias en las Comunidades de Peces de Arrecife Entre las US Virgin Islands y Implicaciones para la Gestión

PALABRAS CLAVE: Peces de Arrecife, US Virgin Islands, diferencias en las comunidades, gestión

## Les Différences dans les Communautés de Poissons de Récif Entre Les US Virgin Islands et Implications pour la Gestion

MOTS CLÉS: Poissons de récife, US Virgin Islands, différences dans les communautés, gestion

### INTRODUCTION

Understanding the spatiotemporal relationships of reef fish communities can aid in applying ecosystem-based management principles. Reef fish communities of the U.S. Virgin Islands (USVI) fall under the management purview of the USVI Department of Planning and Natural Resources (DPNR) and NOAA. Management actions and laws are based on territory-wide catch estimates and fishery independent data sets and are therefore applied equally across the three islands of St. Thomas, St. John, and St. Croix. Fishing practices differ between the two islands but fishing effort is split almost evenly between St. Croix and St. Thomas/St. John. However, on St. Thomas/St. John this fishing effort is distributed across a large portion of the Puerto Rico shelf, an area of 10,500 km<sup>2</sup>, while fishing effort on St. Croix 40 miles south of St. Thomas occurs on the more constricted Cruzan shelf, an area of 475 km<sup>2</sup>. St. Croix is also separated by an extension of the deep Anegada passage between St. Thomas and St. Croix which provides a physical barrier between the islands. Differences in environmental characteristics are

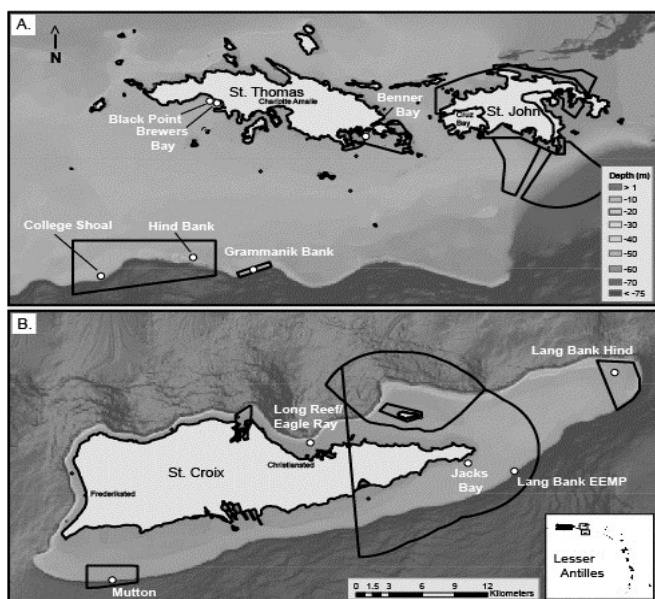
significant structuring forces for coral reef fish communities. Reef fish communities between St. Thomas and St. Croix may therefore be structured primarily by ecological differences and not just fishing pressure and gear types. This study compares reef fish community structure between St. Thomas and St. Croix in order to investigate these potential differences with implications for reef fish management.

### METHODS

#### Site Selection

Data used in the analyses were derived from the long-term data base of the Territorial Coral Reef Monitoring Program (TCRMP). This monitoring began in 2003 with 15 sites: 7 on St. Thomas and 8 on St. Croix. Available resources that varied from year to year determined how many sites were re-surveyed in subsequent years. In 2008, more intensive reef fish monitoring began and the number of sites expanded to 11 on St. Thomas and 14 on St. Croix. Site selection was based on a stratified random design,

such that random sites were surveyed in multiple habitats on each island. The goal of sampling was to record the community structure and fish abundances of key species each year so as to inform management. There were two habitats common to both islands that were sampled with at least two sites on each island: Near-shore shallow (5 - 20 m) and Shelf edge deep (24 - 40 m) (Figure 1). Sites within each habitat exhibited similar characteristics of structure and benthic cover.



**Figure 1.** Map of study region and monitoring sites including A) St. Thomas and St. John located on the south portion of the Puerto Rico shelf, and B) St. Croix on the Cruzan shelf. Black lines indicate protected areas. Large protected area on east end of St. Croix represents the newly instituted East End Marine Reserve.

### Sampling

Sampling at a site consisted of divers performing 10 timed 30 m belt transects to assess fish abundance and size distributions and three timed roving diver surveys to assess fish species richness. To perform a belt transect, a diver attached the end of 30 m transect line to the substrate and counted and assigned into size bins all fish within 2 m of either side of the transect. Total time for each transect was 15 minutes. Roving diver surveys followed the REEF Roving Diver Technique ([www.reef.org](http://www.reef.org)) and consisted of a diver swimming freely throughout the site area identifying any fish species and assigning it to one of four abundance categories:

- i) Single (1 fish was seen),
- ii) Few (2 - 10 fish),
- iii) Many (11 - 100 fish), and
- iv) Abundant (> 100 fish).

Roving diver surveys were timed at 15 minutes in deep habitats and 30 minutes in shallow habitats.

### Data Analysis

Average species richness of fish seen in transects was compared between habitats and between islands using a two-way ANOVA. In order to conform to ANOVA assumptions, fish diversity measures were transformed using a Box-Cox transformation ( $\lambda = 4.03$ ). Fish species richness data were normal and were not transformed. Biomass of each fish species was calculated for all transects based on standardized length-biomass relationships. Bray-Curtis similarity matrices between samples were then constructed for biomass estimates from transects and presence/absence data from roving diver surveys. These similarity matrices were used as a basis for constructing Multidimensional Scaling (MDS) plots to investigate differences in reef fish communities between islands and among habitats within islands. To further distinguish differences between communities, we applied the statistical technique Analysis of Similarities (ANOSIM) developed by Warwick and Clarke (2001) to statistically differentiate between islands. ANOSIM is analogous to single response ANOVA but applied to multivariate datasets, particularly with respect to community data.

### RESULTS

A total of 149 fish species were recorded in transects among the two islands (Appendix A). Of these, 26 species were found only on St. Croix and 13 species were found only on St. Thomas (Table 1). Four of the species found only on St. Thomas included the fishery targeted grouper species *Epinephelus striatus* (Nassau grouper), *Mycteroperca interstitialis* (Yellowmouth grouper), *M. tigris* (Tiger grouper), and *M. venenosa* (Yellowfin grouper). These species were seen infrequently but consistently across years (Table 2).

### Diversity Indices

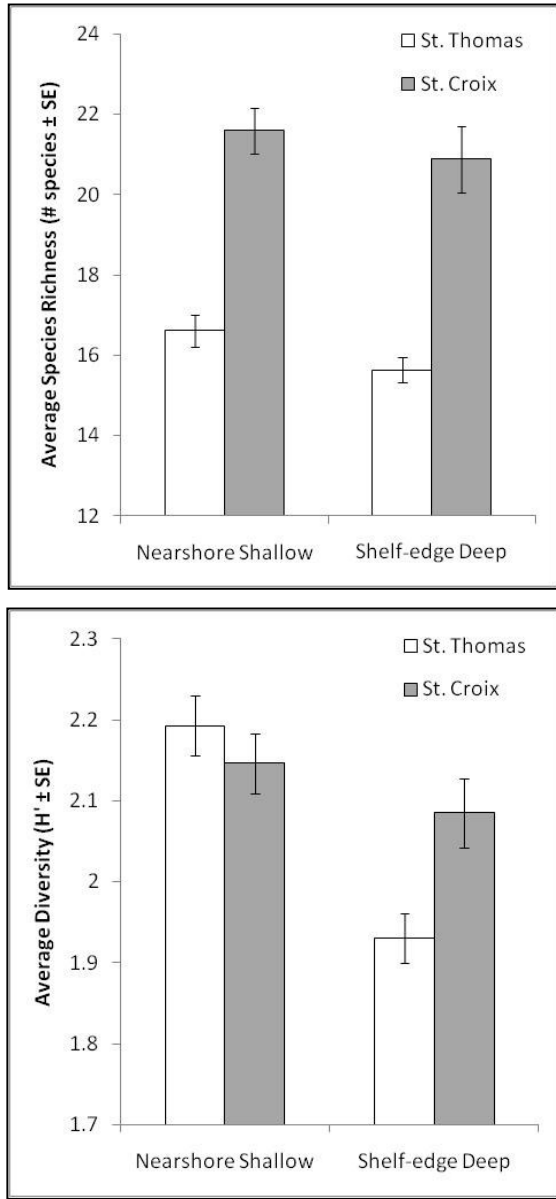
Both species richness and species diversity differed between islands (Figure 2). Fish species richness was significantly higher on St. Croix than on St. Thomas (2-way ANOVA:  $F = 96.81$ ,  $p < 0.0001$ ), but did not vary significantly between the two habitats (2-way ANOVA:  $F = 2.65$ ,  $p = 0.10$ ). Fish species diversity did not differ significantly between St. Thomas and St. Croix in the nearshore but was significantly less in St. Thomas in the shelf edge deep habitat (2-way ANOVA: effect of island  $F = 0.82$ ,  $p = 0.37$ ; effect of habitat  $F = 19.68$ ,  $p < 0.0001$ ; interaction  $F = 5.99$ ,  $p < 0.05$ ).

**Table 1.** Fish species observed only in St. Croix or St. Thomas transects.

St. Croix only		St. Thomas only	
Scientific Name	Common Name	Scientific Name	Common Name
<i>Aluterus scriptus</i>	scrawled filefish	<i>Cosmocampus elucens</i>	shortfin pipefish
<i>Apogon townsendi</i>	belted cardinalfish	<i>Epinephelus striatus</i>	Nassau grouper
<i>Bothus lunatus</i>	peacock flounder	<i>Hypoplectrus aberrans</i>	yellowbelly hamlet
<i>Cantherhines macrocerus</i>	whitespotted filefish	<i>Lutjanus cyanopterus</i>	cupera snapper
<i>Dasyatis americana</i>	southern stingray	<i>Lutjanus jocu</i>	dog snapper
<i>Decapterus macarellus</i>	mackerel scad	<i>Mycteroperca interstitialis</i>	yellowmouth grouper
<i>Diodon holocanthus</i>	long-spined porcupinefish	<i>Mycteroperca tigris</i>	tiger grouper
<i>Enchelycore nigricans</i>	mottled conger moray	<i>Mycteroperca venenosa</i>	yellowfin grouper
<i>Ginglymostoma cirratum</i>	nurseshark	<i>Sargocentron vexillarium</i>	dusky squirrelfish
<i>Gymnothorax funebris</i>	green moray	<i>Scarus guacamaia</i>	rainbow parrotfish
<i>Gymnothorax miliaris</i>	goldentail moray	<i>Seriola rivoliana</i>	alamaco jack
<i>Haemulon melanurum</i>	cottonwick	<i>Sphoeroides spengleri</i>	bandtail puffer
<i>Halichoeres cyanocephalus</i>	yellowcheek wrasse	<i>Stegastes adustus</i>	dusky damselfish
<i>Halichoeres pictus</i>	rainbow wrasse		
<i>Halichoeres poeyi</i>	blackear wrasse		
<i>Hemiramphus brasiliensis</i>	ballyhoo		
<i>Heteroconger longissimus</i>	brown garden eel		
<i>Lactophrys quadricornis</i>	trunkfish		
<i>Malacanthus plumieri</i>	sand tilefish		
<i>Myrichthys breviceps</i>	sharptail eel		
<i>Myrichthys ocellatus</i>	dark spotted eel		
<i>Odontoscion dentex</i>	reef croaker		
<i>Priacanthus arenatus</i>	big eye		
<i>Sparisoma atomarium</i>	greenblotch parrotfish		
<i>Sparisoma radians</i>	bucktooth parrotfish		
<i>Xyrichtys splendens</i>	green razorfish		

**Table 2.** Total numbers of individual fish seen in transects at St. Thomas sites by year. These species were not observed in transects or roving dives on St. Croix.

Year	Nassau grouper	Yellowmouth grouper	Tiger grouper	Yellowfin grouper
	<i>Epinephelus striatus</i>	<i>Mycteroperca interstitialis</i>	<i>Mycteroperca tigris</i>	<i>Mycteroperca venenosa</i>
2003	3	0	6	1
2004	0	0	2	9
2005	2	6	2	2
2006	1	0	2	1
2007	2	1	3	2
2008	4	2	7	2
2009	2	1	2	2



**Figure 2.** Comparisons of reef fish species richness (left) and diversity (right) between St. Thomas and St. Croix in the nearshore shallow and shelf-edge deep habitats.

**Reef Fish Community Differences**

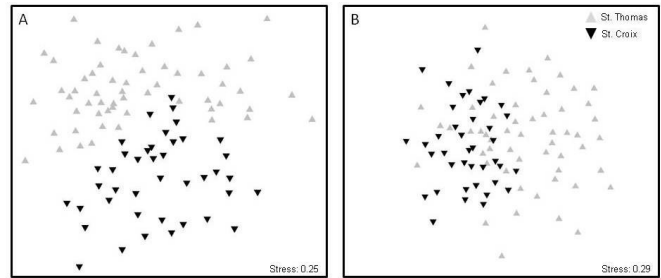
In St. Thomas nearshore shallow habitats parrotfishes, surgeonfishes, and snappers represented a large percentage of the community by biomass, while in St. Croix parrotfishes and surgeonfishes also dominated but so did wrasses and soldierfishes (Table 3). Statistical comparison of reef fish communities of nearshore habitats between islands resulted in significant differences detected between islands for both biomass in transects (ANOSIM,  $R = 0.30$ ,  $p < 0.01$ ; Figure 3A) and presence/absence in roving diver surveys ( $R = 0.56$ ,  $p < 0.01$ ; Figure 4A). Results of differences in biomass should be viewed cautiously, however, since stress of the MDS plot for biomass was

fairly high (0.25) and the ANOSIM R statistic for this comparison was low.

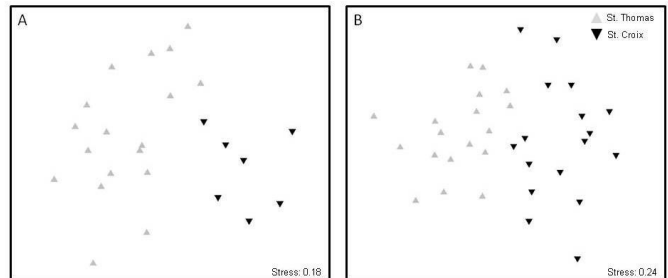
In St. Thomas, shelf edge deep habitats were dominated by snappers and groupers which represent a combined 21% of the total biomass seen (Table 3). This is in contrast to St. Croix where only 3% of the biomass was composed of snappers and groupers, while parrotfishes and leatherjackets (primarily the black durgelon, *Melichthys niger*) dominated (Table 3). Statistical comparison of reef fish communities in shelf edge deep habitats between islands showed significant differences for both biomass (ANOSIM  $R = 0.20$ ,  $p < 0.01$ ; Figure 3B) and presence/absence data ( $R = 0.44$ ,  $p < 0.01$ ; Figure 4B). Again, biomass differences were likely less distinct as evidenced by high MDS stress (0.29) and a low R value.

**DISCUSSION**

Biological, physical and management factors all combine to influence the distribution of coral reef fish assemblages (e.g., Friedlander and Parrish 1998, Alvarez-Filip et al. 2006, Friedlander et al. 2010, McClanahan 2011). Under an ecosystem-based management paradigm, the interactions among these factors must be considered when approaching the assessment and management of coral reef fisheries. The preliminary analysis of a multi-year monitoring data set presented here focused on



**Figure 3.** MDS plots of fish community by biomass comparing St. Thomas and St. Croix within A) nearshore shallow sites and B) shelf-edge deep sites. Each triangle represents a sample (transect).



**Figure 4.** MDS plots of fish community by presence/absence in roving surveys comparing St. Thomas and St. Croix within A) nearshore shallow sites and B) shelf-edge deep sites. Each triangle represents a sample (transect).

identifying the primary differences between the St. Thomas and St. Croix coral reef fish communities that may be important when approaching reef fisheries management from an ecosystem-based approach. The results of this study support that there is greater diversity of reef fish to protect in St. Croix but that benefits of management in St. Croix may be more limited than in St. Thomas. St. Croix reef fish communities tended to be more diverse, however these communities were absent of or showed lower abundances of many commercially important fishery species. While the extent and intensity of management may be influencing these differences, these results also highlight the need for consideration of multiple factors, not just fishing effort, which may be variably affecting coral reef communities in the USVI which would require island-specific management actions.

The abundance, size, enforcement quality and age of marine protected areas (MPAs) can have significant influences on reef fish community structure within as well as outside these areas (Friedlander et al. 2003, Bellwood et al. 2004, Bohnsack et al. 2004). Current protective measures in the USVI region are more extensive and older on the shelf shared by St. Thomas and St. John than in St. Croix. These include the permanent protection of certain identified grouper spawning aggregation sites (SPAGs) on the shelf edge south of St. Thomas as well as the well established Virgin Islands National Park in St. John (Figure 1). The wider shelf of St. Thomas, across which fishing effort may be diluted, and the greater abundance of deep habitats inaccessible to fishing may also be a factor in the presence and higher abundances of fishery species. With the exception of the established Buck Island National Park, St. Croix protective measures include two small seasonal closures and the newly instituted the East End Marine Reserve which has been in place for 1 - 2 years and as yet has little capacity for enforcement. However, fish

species richness and diversity, often indicators of a healthy community, were found to be greater in St. Croix. The target of marine spatial planning in the U.S. Virgin Islands has tended to focus on key fishery species and their reproduction and not on facilitating an increase in fish diversity. Therefore, this disparity in diversity is unlikely the result of targeted management practices. Instead, other factors, possibly environmental variability, may be at work.

The spatial distribution of coral reef fishes in relationship to such environmental variability has been studied and quantified for several decades. Dominant factors have been found to include depth, habitat complexity, and proximity to oceanic waters (as reviewed in Friedlander et al. 2010). These factors influence the availability of food and shelter as well as exposure to predation and competition. In this study, reef fish communities were found to differ between the two islands within similar habitats, presumably with comparative levels of the above factors. However, landscape-scale processes were not investigated and may also be influencing the reef fish community structure differences observed (Pittman et al. 2007). Reef distribution and complexity across the extensive shelf area of St. Thomas may provide larger foraging grounds for predator species like groupers, while a constrained shelf resulting in greater proximity to oceanic waters may be influencing the greater diversity of fish and dominance by planktivorous fish groups on St. Croix. A more in-depth analysis of the habitat features of these sites in relationship to reef fish assemblage structure will provide a greater understanding of important processes that may be influencing community structure at multiple scales. Overall, these results have provided a preliminary comparison of reef fish communities of St. Thomas and St. Croix that are currently managed by one system applied to the entire USVI territory. Overall, reef fish communities were found to be

**Table 3.** Proportion of the total fish biomass that each species group represents.

Species group	Nearshore Shallow		Offshore deep	
	St. Thomas	St. Croix	St. Thomas	St. Croix
Angelfish	1.5	0.8	4.9	1.2
Butterflyfish	0.2	1.3	1.8	1.9
Chromis	2.3	2.9	2.9	3.8
Damselfish	8.6	5.8	1.0	4.3
Goatfish	1.1	2.7	2.9	3.8
Grunt	6.1	4.4	5.7	4.3
Hogfish	0.1	0.5	1.9	0.3
Jacks	2.6	2.2	8.7	1.7
Leatherjackets	0.4	1.5	6.8	30.0
Parrotfish	34.4	15.3	14.3	15.1
Groupers	1.7	3.4	10.0	2.1
Snappers	7.5	2.9	9.4	1.1
Soldierfish	0.1	9.0	2.0	5.8
Squirrelfish	1.9	2.1	1.0	2.2
Surgeonfish	22.3	14.5	4.4	7.2
Wrasse	5.1	11.9	14.2	9.9

distinct between the two islands, reflecting both habitat differences and potential management implications. Analysis of these data in relationship to habitat measures in the future will help to shed light on the relative influence of environmental variability and management on the differences detected. A goal of this work is to contribute to a more comprehensive, ecosystem-based approach to management that will result sustainable local commercial fisheries.

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