

Distribution and Abundance of Fish Populations in Various Habitats in the Mutton Snapper (*Lutjanus analis*) Conservation Area on the South Shelf St. Croix, U.S. Virgin Islands

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ABSTRACT

In 1993, the Caribbean Fishery Management Council and US Virgin Islands Government established the Mutton Snapper Seasonal Closed Area (MSSCA) south of St. Croix from 1 March to 30 June to protect a spawning aggregation of mutton snapper (*Lutjanus analis*). Bottom tended fishing gear was subsequently banned year round in the closed area to protect coral reef habitat. The habitat within the closed area was mapped. Using benthic transects and roving diver survey techniques a total of 143 fish species and 19,843 individuals were counted within the MSSCA. Eighty-seven species and 8,477 individuals in the roving surveys and 107 species and 13,552 individuals in the benthic transect surveys. *Eupomacentrus partitus*, *Thalassoma bifasciatum*, *Scarus taeniopterus* were among the most abundant fishes in all benthic habitats. Acanthuridae, Scaridae and Holocentridae were the most abundant marketable fish (MF) families totaling 77.3% of the MF. Family Lutjanidae was not common and comprised 1.46% of MF. Ten individuals of *Lutjanus analis* were observed. One lionfish (*Pterois voltans*) was observed on the outer reef slope in July 2010 in over 250 diver hours from April 2009 to July 2010.

KEY WORDS: Coral reef, fisheries management, *Lutjanus analis*, Virgin Islands

Distribución y Abundancia de las Poblaciones de Peces en Diferentes Hábitats en el Pargo Criollo (*Lutjanus analis*) Área de Conservación en el Sur Plataforma St. Croix, Islas Vírgenes de EE.UU

En 1993, el Concilio caribe de Gestión de Pesquería y EEUU el Gobierno Virgen de Islas estableció el Pargo de Ovino Area Cerrada Estacional (MSSCA) al sur de S. Croix del 1 de marzo – 30 de junio para proteger una agregado de desove de pargo de ovino (analis de *Lutjanus*). El fondo tendió pescando engranaje fue prohibido subsiguientemente año alrededor en el área cerrada para proteger arrecife de coral hábitat. El hábitat dentro del área cerrada fue trazado. Utilizar transects de benthic y vagar técnicas de inspección de buzo un suma de 143 especie de pez y 19.843 individuos fue contado dentro del MSSCA. Ochenta-siete especie y 8.477 individuos en las inspecciones que vagan y 107 especie y 13.552 individuos en las inspecciones de transect de benthic. Partitus de *Eupomacentrus*, bifasciatum de *Thalassoma*, taeniopterus de *Scarus* estuvo entre los peces más abundantes en todos los hábitats de benthic. Acanthuridae, Scaridae y Holocentridae fueron el pez comestible, preferido y más abundante (MF) las familias que totalizan 77,3% del MF. Lutjanidae familiar no fue común y comprendió 1,46% de MF. Diez individuos de analis de *Lutjanus* fueron observados en 2009 y 2010. Sólo un lionfish (voltans de *Pterois*) fue observado en la cuesta exterior de arrecife en julio 2010 a pesar de más de 250 horas de buzo de abril 2009 a julio 2010.

PALABRAS CLAVE: Arrecife de coral, gestión de pesquerías, analis de *Lutjanus*, Islas Vírgenes

Distribution et Abondance des Populations de Poissons dans les Divers Habitats de la Snapper Mouton (*Lutjanus analis*) Zone de Conservation de la Croix du Sud du Plateau Saint-Laurent, les Îles Vierges Américaines

MOTS CLÉS: Poissons, snapper mouton, Îles Vierges Américaines

INTRODUCTION

In 1993, the Caribbean Fishery Management Council (CFMC) declared an area south of St. Croix seasonally closed from 1 March to 30 June to protect the reported spawning aggregation(s) of mutton snapper (*Lutjanus analis*) south of St. Croix. In 1994, the Government of the U.S. Virgin Islands (USVI) followed with a similar declaration, resulting in a 2 nm sq. area seasonally closed to fishing. In 2005 (CFMC) and in 2006 (USVI) a seasonal prohibition on the harvest of mutton snapper from 1 April to 30 June was implemented in federal and territorial waters. From March – July 2009 we used visual censuses,

hook and line catches and fisher interviews to validate the seasonal occurrence of mutton snapper spawning aggregation(s) within the Mutton Snapper Seasonal Area Closure (MSSAC) (Kojis and Quinn 2010a, b) and in May, June and July we dove the area.

The approval of the Sustainable Fisheries Act Amendment to the CFMC Coral Reef Fisheries Management Plan in 2005 prohibited all bottom tended gear including bottom long lines, gillnets or trammel nets, and pots or traps within the MSSCA. The latter regulatory provision was adopted to protect essential fish habitat (EFH). EFH is defined as "those waters and substrate

necessary for spawning, breeding, feeding or growth to maturity" (CFMC 1998). The MSSCA met the criteria for EFH because it was presumed to contain habitat necessary for the spawning and breeding of the mutton snapper (*Lutjanus analis*) and, likely, other species of fish as well.

This study documents fish assemblages within the various EFH habitats in the MSSCA.

MATERIALS AND METHODS

Roving fish and fish transect surveys were conducted in each habitat identified by Prada (2003) to characterize the fish diversity and abundance in habitats in the MSSCA. Common names for fish in the following text, tables and appendices are based on Humann (undated). Fish surveys were conducted in eight of the nine the benthic habitats identified by Prada (2003) and discussed in greater detail in Quinn and Kojis (2010). To ensure that divers were conducting fish surveys in the identified habitat, a Garmin WAAS enabled GPSmap 76Cx was used to locate habitats based on habitat locations on Prada's habitat maps and coordinates provided by Blondeau. When the specified coordinates were located using the GPS, a weight with dive flag attached to a rope was dropped from the boat to mark the habitat. Roving fish surveys and fish transect surveys were done in the vicinity of the marked area. Most surveys were carried out between 7:00 - 11:00 am in June and July 2009. A few surveys were conducted in May and June 2010 from about 14:30 - 17:00.

Fish Transects

At each site, a total of five 20m transects were laid on the substrate within the habitat to record benthos (Quinn and Kojis 2010) and fish populations within specific habitat types. A total area of 400 m² was surveyed for fish at each site. One to four sites were surveyed for each habitat. More sites were surveyed in habitats comprising more of the area of the MSSCA. All fish 2m each side of each transect were identified to species, where possible, and numbers of individuals counted. The recording diver stopped every 5 m along the transect line and recorded the fish observed. Most blennies, gobies, and other very small fish were not recorded as they are cryptic and it would have been time consuming and difficult to accurately count them. Counts of *Acanthurus bahianus* (ocean surgeonfish) and *A. chirurgus* (doctorfish) were combined because they are difficult to distinguish.

Roving Fish Censuses

At each site, one to three roving fish counts were conducted for 15 min. Divers swam around an imaginary outer circumference of the study site and in the vicinity of the site marker, recording species and number of fish observed. Divers did not count small species in the roving fish censuses, (*i.e.* blennies, gobies, pomacentrids, small species of pufferfish, and all wrasses except the three larger wrasses: puddingwife (*Halichoeres radiatus*), hogfish

(*Lachnolaimus maximus*) and Spanish hogfish (*Bodianus rufus*). Numbers of fish in schools were estimated.

Fish Biodiversity

Habitat biodiversity was compared using the Shannon Diversity Index (H'). H' takes into account the number of species and the evenness (relative abundance) of the species. Values increase when there are more unique species or the numbers of individuals of each species are similar (greater evenness).

RESULTS

A total of 132 species (not including species only identified to family or genus unless it was clear that the species was unique, *e.g.* only species recorded in family or genus) and 24,225 fish were recorded (Table 1). Of these 21,564 individuals were included in analyses: 107 species and 13,417 individuals in benthic transects and 87 species and 8,147 individuals in roving fish surveys (Table 2). The mean number of species per site and individuals 100/m² in each habitat for the benthic transect method ranged from 16 - 26.5 and 42 - 176.9, respectively (Table 1). Only one lionfish (*Pterois volitans*) was observed on the outer reef slope in July 2010 in over 250 diver hours from April 2009 to July 2010.

In the transect surveys the Coral Limestone (COLI) and Gorgonian Plain (GOPL) habitats had the most species and individuals in the benthic transect surveys with an average of 31.6 and 26.5 species per site and 176.9 and 170.4 individuals 100/m² (Table 1), respectively. Sand Ripple (SARI) had the fewest species and individuals per 100/m². Dense Algae (DEAL) had the greatest biodiversity (H') and SAIN (Sand with Invertebrates) had the least.

In the roving fish censuses (Table 2), DEAL had the greatest mean number of individuals, owing to the occurrence of two schools of scads. COLI had the greatest mean number of species and biodiversity (H'). SANR had the lowest mean number of individuals and the second lowest number of species after ALIN. SANR is primarily a sand habitat with coral rubble around its periphery. ALIN is a flat, pavement habitat with algae and scattered macro-invertebrates and was the dominant habitat with 49.3% of the substrate in the MSSCA.

HABITAT OVERVIEW

Using the Agglomerative Hierarchical Clustering (XLSTAT 2010) analysis of the fish species recorded in transects by habitat (fish abundance was standardized by 100/m², only species comprising > 1% of total were included), we correlated the fish with habitats using Pearson correlation coefficients and then agglomerated the habitats using weighted pair-group averages (Figure 1). At the 0.80 similarity level there are three major clusters. The first cluster is coral reef on consolidated sediments (COLI, GOPL) characterized primarily by the parrotfishes: princess, striped and stoplight; the black durgon; French

Table 1. Summary of fish transect data by habitats.

	ALIN	COLI	DEAL	GOPL	SAIN	SANR	SARI	SPAL
Total # individuals	2406	3537	478	2726	2315	809	168	978
# individuals/100 m ²	150.4	176.9	59.8	170.4	144.7	50.6	42.0	122.3
Total # species	39	61	29	52	42	42	16	29
Mean # species /site	18.3	31.6	19.5	26.5	19.5	19.3	16	21
Shannon Diversity Index (H')	2.41	3.16	3.45	3.11	2.20	3.26	2.40	2.95
# Lobster	1	2	0	0	0	0	0	0
Number of sites surveyed	4	5	2	4	4	4	1	2

Table 2. Roving fish survey results by habitats.

	ALIN	COLI	DEAL	GOPL	SAIN	SANR	SARI	SPAL
Total # individuals	1233	1489	1064	1302	1028	820	200	1011
Mean # individuals/ survey (SD)	176.10 (119.08)	186.61 (52.64)	354.67 (288.70)	217.00 (145.77)	205.6 (97.88)	102.50 (60.08)	200.0	252.7 5 (271.22)
Total # species	34	57	29	43	38	43	17	27
Mean # species/ survey (SD)	12.28 (3.20)	23.0 (3.2)	18.67 (2.52)	17.83 (5.42)	17.80 (4.97)	14.50 (3.29)	17	12.75 (4.57)
# roving surveys	7	8	3	6	5	8	1	4
Shannon Diversity Index (H')	3.20	4.19	3.53	3.71	3.65	3.79	3.05	2.46

grunt; blackbar soldierfish; and blue chromis. The second cluster is comprised of ALIN, SPAL and SAIN, which are flat pavement habitats, are characterized primarily by the yellowhead wrasse, spotted goatfish, bridled goby, slippery dick, bicolor damselfish, queen triggerfish, sand tilefish, and yellowhead jawfish. SANR, DEAL and SARI, the third cluster comprise two unconsolidated sediment habitats (SANR and SARI) and DEAL, which is more of a consolidated sediment habitat but has pockets of deep sand. Fish characterizing these habitats primarily include the bluehead wrasse, coney, longspine squirrelfish, squirrelfish, three species of surgeonfish, brown chromis, banded butterfly fish, redband parrotfish, foureye butterfly fish and rock beauty.

Population Abundance of Marketable Fish

Marketable fish (MF) is defined as fish commonly recognized as commercially saleable fish on St. Croix. Determination of MF was obtained from the list of port samples (McCarthy and Gedamke 2009), the list of fishes retained in bycatch studies carried out (Anon. 2009), and from discussions with fishers (Table 3). Species that can

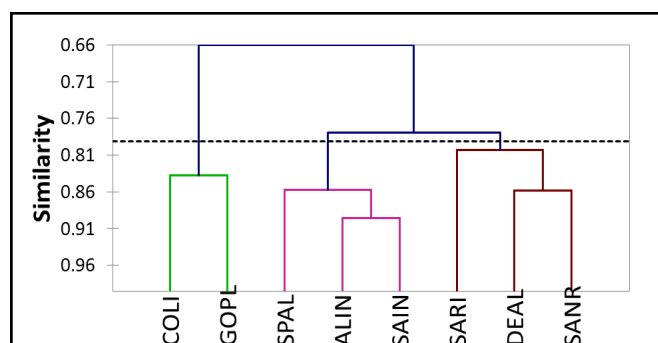


Figure 1. Dendrogram of habitats using Agglomerative Hierarchical Clustering. The dotted line divides the habitats.

be consumed, *i.e.* small pomacentrids and chaetodonts, have been excluded from the analysis because they are not sold. Black durgon were omitted because the meat is considered tough and this species is seldom sold. Creole-fish (*Paranthias furcifer*), Saragassum triggerfish (*Xanthichthys rigens*) and sand tile fish (*Malacanthus plumieri*) were also omitted because they are not commonly targeted.

Table 3. List of the species recorded in roving survey that are marketable fish species on St. Croix.

Family	Scientific Name	Common Name	CFMC FMP Unit ¹
Acanthuridae	<i>Acanthurus coeruleus</i>	Blue Tang	Surgeonfishes Unit
Acanthuridae	<i>Acanthurus bahianus</i> and <i>A. chirurgus</i>	Surgeon - Doctor and Ocean	Surgeonfishes Unit
Balistidae	<i>Balistes vetula</i>	Queen triggerfish ²	Triggerfishes Unit
Balistidae	<i>Canthidermis sufflamen</i>	Ocean triggerfish	Triggerfishes Unit
Carangidae	<i>Caranx crysos</i>	Blue runner	Jacks Unit
Carangidae	<i>Caranx ruber</i>	Bar jack ³	Jacks Unit
Carangidae	<i>Decapterus punctatus</i>	Round scad (Round robin)	
Carangidae	<i>Decapterus sp.</i>	Scad	
Ephippidae	<i>Chaetodipterus faber</i>	Atlantic spadefish	
Holocentridae	<i>Holocentrus adscensionis</i>	Squirrelfish	Squirrelfishes Unit
Holocentridae	<i>Holocentrus rufus</i>	Longspine squirrelfish	Squirrelfishes Unit
Holocentridae	<i>Myripristis jacobus</i>	Blackbar soldierfish ²	Squirrelfishes Unit
Labridae	<i>Bodianus rufus</i>	Spanish hogfish ²	Wrasses Unit
Labridae	<i>Halichoeres radiatus</i>	Puddingwife (doesn't sell well)	Wrasses Unit
Lutjanidae	<i>Lutjanus analis</i>	Mutton snapper ²	Snapper Unit 3
Lutjanidae	<i>Lutjanus apodus</i>	Schoolmaster snapper ²	Snapper Unit 3
Lutjanidae	<i>Lutjanus mahogoni</i>	Mahogany snapper ²	Snapper Unit 3
Lutjanidae	<i>Lutjanus synagris</i>	Lane snapper	Snapper Unit 3
Lutjanidae	<i>Ocyurus chrysurus</i>	Yellowtail snapper	Snapper Unit 4
Lutjanidae	<i>Rhomboplites aurorubens</i>	Vermillion snapper	Snapper Unit 1
Monacanthidae	<i>Aluterus scriptus</i>	Scrawled filefish ⁵	Filefish Unit
Monacanthidae	<i>Cantherhines macrocerus</i>	Whitespotted filefish ⁵	Filefish Unit
Monacanthidae	<i>Cantherhines pullus</i>	Orangespotted filefish ^{4,5}	
Mullidae	<i>Mulloidichthys martinicus</i>	Yellow goatfish	Goatfish Unit
Mullidae	<i>Pseudupeneus maculatus</i>	Spotted goatfish	Goatfish Unit
Ostraciidae	<i>Acanthstracion polygonia</i>	Honeycomb cowfish	Boxfishes Unit
Ostraciidae	<i>Acanthstracion quadricornis</i>	Scrawled cowfish	Boxfishes Unit
Ostraciidae	<i>Lactophrys triqueter</i>	Smooth trunkfish	Boxfishes Unit
Ostraciidae	<i>Lactophrys bicaudalis</i>	Spotted trunkfish	Boxfishes Unit
Ostraciidae	<i>Lactophrys trigonus</i>	Trunkfish	Boxfishes Unit
Pomacanthidae	<i>Holacanthus ciliaris</i>	Queen angelfish	Angelfishes Unit
Pomacanthidae	<i>Holacanthus tricolor</i>	Rock Beauty ⁴	Angelfishes Unit
Pomacanthidae	<i>Pomacanthus arcuatus</i>	Gray angelfish	Angelfishes Unit
Pomadasyidae	<i>Anisotremus virginicus</i>	Porkfish	Grunts Unit
Pomadasyidae	<i>Haemulon carbonarium</i>	Caesar grunt	Grunts Unit
Pomadasyidae	<i>Haemulon aurolineatum</i>	Tomtate	Grunts Unit ⁴
Pomadasyidae	<i>Haemulon flavolineatum</i>	French grunt	Grunts Unit
Pomadasyidae	<i>Haemulon plumieri</i>	White grunt	Grunts Unit
Pomadasyidae	<i>Haemulon sciurus</i>	Bluestriped grunt	Grunts Unit
Scaridae	<i>Scarus coeruleus</i>	Blue parrotfish	Parrotfishes proposed Unit 2
Scaridae	<i>Scarus taeniopterus</i>	Princess parrotfish	Parrotfishes proposed Unit 1
Scaridae	<i>Scarus vetula</i>	Queen parrotfish	Parrotfishes proposed Unit 1
Scaridae	<i>Sparisoma aurofrenatum</i>	Redband parrotfish ⁴	Parrotfishes proposed Unit 1
Scaridae	<i>Sparisoma chrysopterus</i>	Redtail parrotfish	Parrotfishes proposed Unit 1
Scaridae	<i>Sparisoma rubripinne</i>	Yellowtail or Redfin parrotfish	Parrotfishes proposed Unit 1
Scaridae	<i>Sparisoma viride</i>	Stoplight parrotfish	
Scombridae	<i>Scomberomorus maculatus</i>	Spanish mackerel	
Scombridae	<i>Scomberomorus regalis</i>	Cero	
Serranidae	<i>Cephalopholis fulvus</i>	Coney	Grouper Unit 3
Serranidae	<i>Epinephelus adscensionis</i>	Rock Hind	Grouper Unit 3
Serranidae	<i>Epinephelus cruentatus</i>	Graysby ⁴	Grouper Unit 3
Serranidae	<i>Epinephelus guttatus</i>	Red hind	Grouper Unit 3
Sphyraenidae	<i>Sphyraena barracuda</i>	Great barracuda ³	

- ¹ 50 CFR Part 622 - Table 2 of Appendix A to Part 622 - Caribbean Reef Fish - list of species of fish managed by the CFMC.
- ² Frequent ciguatera poisoning occurs (Olson 1988).
- ³ High risk of ciguatera poisoning (Olsen 1988) though still fished and sold on St. Croix.
- ⁴ Only large individuals marketable.
- ⁵ Filefish are only occasionally sold. Customers are reticent to buy them because they consider them ugly fish. Sometimes fishers cut heads off to help sell fish.
- ⁵ Species generally considered too small to sell but are

The estimated relative abundance of the MF species in each family was calculated for each habitat (Table 4) using the benthic transect data. Species in the four families, Acanthuridae (surgeonfishes) (40.02% - three MF), Scaridae (parrotfishes) (22.46% - seven MF), Holocentridae (squirrelfishes) (14.77% - three MF), and Serranidae (groupers) (6.34% - four MF species) had the greatest estimated relative abundance (Table 4) totaling 83.76% of the MF families. The high relative abundance of groupers was a function of the high abundance of the coney (*Cephalopholis fulvus*) in most habitats. Lutjanids (six MF species - including *Lutjanus analis*) were not common and comprised only 1.46% of the MF species (Table 4).

DISCUSSION

Of the 132 species observed only eleven common species (occurrence > 1%) were ubiquitous in the eight MSSCA habitats included in this analysis. Of the eleven ubiquitous species, seven were marketable species: *Acanthurus chirurgus/bahianus*, *Cephalopholis fulvus*, *Holocentrus rufus*, *Haemulon flavolineatum*, *Mulloidichthys martinicus*, *Scarus taeniopterus*, and *Decapterus punctatus*. *D. punctatus* only occurred in the shallower (< 20 m) hard bottom habitats of ALIN, DEAL, SAIN and SPAL. This species though not frequently encountered, was still recorded in large numbers, because it was present in large schools. *Clepticus parrae* was the most habitat specific species of with >80 individuals, occurring only in COLI, and GOPL.

Commercially Harvested Fish Recorded in the MSSCA

Clavijo et al. (1980), Randall (1967) and the Fishbase website were used to categorize fish families and species by general trophic level. We assumed that the number of measured fish summed across all years and gears reflect their importance in the fishery. We recognize that port sampling was not randomized among gears and fishers and that there have likely been changes in the relative abun-

Table 4. Number of individuals 100/m² of marketable species in each commercially harvested family recorded in MSSCA habitats.

	ALIN	COLI	DEAL	GOPL	SAIN	SANR	SARI	SPAL	Total	% of Total
Acanthuridae	2.88	4.75	0.88	10.38	7.75	1.06	1.75	4.13	33.58	40.02%
Balistidae	0	0.05	0	0.31	0.13	0.19	0.25	0	0.93	1.08%
Carangidae	6.31	0.10	12.63	0	0.06	0.19	0	0	19.29	6.57%
Holocentridae	3.25	2.85	0.63	2.50	2.75	1.19	1.00	2.13	16.3	14.77%
Labridae	0.06	0.20	0	0.13	0.06	0.06	0	0	0.51	0.62%
Lutjanidae	0	0.05	0	0.13	0	0	0	0	0.18	1.46%
Monacathidae	0	0.35	0	0.19	0	0	0	0	0.54	0.07%
Mullidae	0	1.2	0	0.6	0.38	0	0	0.5	2.68	1.74%
Ostraciidae	0.063	0.1	0	0.25	0.06	0.13	0.25	0.13	0.983	0.57%
Pomacanthidae	0.13	0.55	0	0.50	0.13	0.06	0	0.13	1.5	0.99%
Pomadasyidae	0	1.15	0	1.38	0	0	0	0	2.53	3.03%
Scaridae	1.44	16.05	0.38	9.31	1.44	0.75	1.75	5.25	36.37	22.46%
Scombridae	0.09	0	0	0	0	0	0	0	0	0.03%
Serranidae	1.25	1.00	0.38	2.88	0.63	0.69	0.5	0	7.33	6.34%
Sphyrnaeidae	0.06	0.15	0.13	0.06	0	0.06	0	0	0.46	0.25%
Total fish 100m⁻²	15.44	28.55	15.00	28.06	13.38	4.38	5.50	12.25	122.56	100.00%
% of Total Fish	12.60%	23.29%	12.24%	22.89%	10.92%	3.57%	4.49%	10.00%		

dance of species in catches over time, however, these data provide information on species that are important to the fishery. While the percentage of marketable fish for each family is based only on the fish recorded in transects, the habitat distribution is based on both the roving fish census and transect techniques.

Carnivorous species — Eight families that are considered generalized carnivores or piscivorous species (Randall 1967) were recorded and are either commercially important, were relatively common, and/or were ecologically important because they are top predators. These eight families are Carangidae (jacks), Holocentridae (squirrelfishes), Lutjanidae (snappers), Pomadasyidae (grunts), Rhinco-dontidae (nurse shark), Serranidae (groupers), Scombridae (mackerels), Sphraenidae (barracuda).

Four species of Carangidae were recorded comprising 6.57% of commercially marketable fish. The schooling, *Decapterus punctatus* (Round Scad) made up the 83% of the carangids recorded. This is an important baitfish, which is sometimes eaten. Bar jacks were the only carangid recorded in port samples with > 300 individuals sampled (McCarthy and Gedamke 2009).

The Holocentridae comprised 14.77% of the marketable fish recorded in transects. Squirrel fishes made up only 1.5% of species with > 300 fish port sampled (McCarthy and Gedamke 2009). The longspine squirrelfish, *Holocentrus rufus*, was the most common holocentrid in this study, comprising 63.8% of squirrelfish recorded. It was also the most common squirrelfish in port samples (1.3%) (McCarthy and Gedamke 2009).

The Lutjanidae are considered generalized carnivores (Randall 1967) consuming fish, crabs, etc., and comprised only 1.46% of the marketable fish recorded in transects (Table 4). The most common snapper recorded was the mahogany snapper (*Lutjanus mahogoni*). Only four individuals of mutton snapper (*L. analis*) were recorded in two habitats in roving fish and transect surveys: ALIN and COLI, though *L. analis* was observed in COLI and GOPL habitats during mutton snapper searches. No snappers were recorded in SANR, SARI or SPAL habitat.

A few nurse sharks (*Ginglymostoma cirratum*) were caught while fishing for mutton snapper and six individuals were recorded from two habitats, COLI and DEAL. This was the only species of shark recorded during this study during any of the activities. The paucity of other shark species is consistent with the findings of Ward-Paige *et al.* (2010), who found that "contemporary sharks, other than nurse sharks, are largely absent on reefs in the greater-Caribbean."

The Serranidae made up 6.34% of the commercially harvested species (Table 4). Four small to medium sized grouper species made up the marketable grouper. The largest of the 4 species, the rock hind, *Epinephelus adscensionis*, grows to 60 cm maximum total length and

most commonly inhabits reefs at depths of 1 - 15 m (Clavijo *et al.* 1980), though it inhabits depths to 30 m (Humann Undated, Randall 1967). It was recorded as common on St. Croix by Clavijo (1980) in the 1970s and comprised 2.31% of the landings in the USVI in the 1980s (Olsen 1988). Only four individuals of this species in two habitats (COLI and SAIN) were recorded.

The next largest species is the red hind, *E. guttatus* (45 cm max TL), which is a reef dwelling species that occurs in both shallow and deep water (Clavijo *et al.* 1980). A total of 33 individuals were recorded in six of the eight habitats surveyed. It comprised 8.71% of the landings in the 1980s (Olsen 1988) and was common in the 1970's (Clavijo *et al.* 1980). This is a very desirable commercial species. The CFMC implemented a seasonal area closure to protect a spawning aggregation on Lang Bank in 1993 (CFMC 1993).

The coney, *Cephalopholis fulvus*, and graysby, *E. cruentatus*, both have a maximum size of 30 cm (Clavijo 1980). Both were common in the 1970's (Clavijo 1980), but only the coney is listed in the USVI landings > 0.01% (Olsen 1988) comprising 2.37% of the landings. The coney is the most common grouper in port samples and was ranked sixth in total number of measured fish (McCarthy and Gedamke 2009). It was also the only grouper with >300 records in port samples. The coney was also the most abundant grouper in transects at Bajo de Sico (Garcia-Sais *et al.* 2004). Eighty graysby were recorded in six habitats and 749 coney in all eight habitats. The relatively high relative abundance of the Serranidae in samples was primarily a function of the ubiquitous presence and high abundance of the coney in most habitats. In general, grouper abundance decreased with size; the largest of the four species, the rock hind, was only represented by four individuals.

No large (> 60 cm TL) grouper species were recorded in 135 dives. Many of the larger grouper are primarily found in water deeper than surveyed in this study. However, Nassau (*E. striatus*) and goliath grouper (*E. itajara*) commonly inhabit the habitats and depths surveyed (this includes roving fish censuses, transect surveys and mutton snapper searches within the MSSCA and to the west of the MSSCA) (Clavijo *et al.* 1980, Kojis Pers. observation). The goliath grouper was not recorded in landings from the 1980's (Olsen 1988). However, the Nassau grouper was a significant component of USVI landings in the 1980s comprising 2.25% of total landings (Olsen 1988).

Two species of Sphraenidae were recorded: the great barracuda (*Sphyaena barracuda*) and the southern sennet (*S. picudilla*). Great barracuda were found in seven of the nine habitat surveyed, missing only in SAIN and SARI, and comprised only 0.25% of the marketable fish. A total of 40 great barracuda were recorded. At each site, usually one or two barracuda, 2 - 2.5 m TL, hovered in the water column. The southern sennet were recorded only in COLI

habitat.

Herbivorous fish—Two families of herbivores, Acanthuridae and Scaridae, made up a total of 62.48% of the MF recorded in transects (Table 4). These two families make up a significant portion of the catch. The top three species in port samples were two parrotfish species (redtail and stoplight parrotfish) and the blue tang. Other parrotfish measured > 300 times were redband, princess, redfin, queen, and unidentified parrotfishes. Parrotfishes comprised 30.5% of fish port sampled > 300 times and acanthurids 16.6%, comprising a total of 47% of fish port sampled > 300 times (McCarthy and Gedamke 2009).

Crucians have a preference for parrotfish. Not only do they enjoy eating parrotfish, especially red parrotfish (initial phase stoplight and redband parrotfishes), but also they sell for less (\$4/lb) than some of the other prized fish such as mutton snapper, which can sell for \$6 - \$7 per lb. Parrotfish are also largely caught as plate sized fish, the preferred eating size. Mutton snapper and some other snappers are often caught at large sizes. Large fish are more expensive just because of the poundage and don't

meet the plate size requirement, but the mutton snapper is a prized food fish.

It appears that the abundance of blue parrotfish has greatly declined in the past 20 years. Of the three large Caribbean parrotfish, midnight (*Scarus coelestinus*), rainbow (*S. guacamaia*) and blue (*S. coeruleus*), only two juvenile blue parrotfish (~ 20 cm) were recorded. In the late 1980s, the midnight and rainbow parrotfish were not reported in landings (reported species comprising ≥ 0.01 percent of commercial landings (Olson 1988), but the blue parrotfish comprised 1.84% of total landings. This was more than most other parrotfish species with exception of the stoplight parrotfish (3.99% of landings). Rainbow parrotfish may be more common in near shore in shallow water than offshore waters.

In conclusion, the MSSCA harbors a high diversity of fish species and a high abundance of commercially harvested coney, surgeonfishes, and parrotfishes. None of the larger grouper species and few of the large snapper and parrotfish species were observed. The diversity of this area is threatened if the invasive Lionfish is successful in

Table 5. Estimate of total number of marketable fish by family in the MSSCA based on the number of fish 100m⁻² and size of habitat. Table 3 lists the marketable species for each family included in this analysis.

	ALIN	COLI	DEAL	GOPL	SAIN	SANR	SARI	SPAL
Acanthuridae	98,294	9,643	246	106,810	126,248	5,109	70	5,617
Balistidae	0	102	0	3,190	2,118	916	10	0
Carangidae	215,360	203	3,536	0	977	916	0	0
Holocentridae	110,923	5,786	176	25,725	44,798	5,736	40	2,897
Labridae	2,048	406	0	1,338	977	289	0	0
Lutjanidae	0	102	0	1,338	0	0	0	0
Monacanthidae	0	711	0	1,955	0	0	0	0
Mullidae	0	2,436	0	6,174	6,190	0	0	680
Ostraciidae	2,150	203	0	2,573	977	627	10	177
Pomacanthidae	4,437	1,117	0	5,145	2,118	289	0	177
Pomadasyidae	0	2,335	0	14,200	0	0	0	0
Scaridae	49,147	32,582	106	95,800	23,458	3,615	70	7,140
Serranidae	42,663	2,030	106	29,635	10,263	3,326	20	0
Sphraenidae	2,048	305	36	617	0	289	0	0
Total fish 100m⁻²	527,070	57,957	4,208	294,500	218,123	21,112	220	16,687
% of Total Fish	46.24%	5.08%	0.37%	25.84%	19.14%	1.85%	0.02%	1.46%
Habitat Area (ha)	341.3	20.3	2.8	102.9	162.9	48.2	0.4	13.6

establishing a large population as they are voracious predators and are known to consume juvenile fish of 50 recreationally and commercially important species (Green and Cote 2009).

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