Domain (island) wide estimates of mutton snapper (*Lutjanus analis*) abundance for three US Caribbean Islands based on habitat-derived densities

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by

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Domain (island) wide estimates of mutton snapper (*Lutjanus analis*) abundance in the US Caribbean based on habitat-derived densities.

Background

Domain (island-wide) estimates of total mutton snapper abundance were calculated for Puerto Rico, and the Virgin Islands (St. Croix and St. John) based on visual census data collected by the National Oceanic and Administration Biogeography Team (NOAA BT). These estimates were calculated to determine the utility of independent fishery monitoring data in determining the fishery status of mutton snappers in the US Caribbean and were requested during the recent Southeast Data, Assessment, and Review (SEDAR 14) workshop held in St. Thomas during March 2007.

In 1999, scientists from NOAA BT initiated joint investigations with several partners to map, characterize, and monitor components of the coral reef ecosystem in the US Caribbean. Digital benthic maps of the marine waters around Puerto Rico and the US Virgin Islands were completed in 2001 and have been published on a CD-ROM and on the web at http://biogeo.nos.noaa.gov/. Between 2001 and 2006, NOAA BT and its partners have used standard visual techniques to collect information on fish, conch and benthic composition at 3,200 randomly chosen locations (Figure 1). These data are available online at http://ccma.nos.noaa.gov/ecosystems/coralreef/reef_fish.html and were pooled among years to derive domain-wide estimates of mutton snapper abundance in Puerto Rico and the Virgin Islands as requested during the SEDAR workshop.

Analytical Methods

Mutton snapper preferences for particular habitats were first explored by analyzing the presence, absence, and abundance of sexually immature and mature mutton snapper in different habitats. Sexually immature (juvenile) mutton snapper were those fish with a total length (TL) < 47 cm where as fish ≥ 47 cm TL were considered adult or sexually mature (Froese and Pauly 2007). Geographic coordinates of point locations sampled by NOAA BT along with data on mutton snapper abundance were imported into ESRI ArcGIS© (Version 9.2). Attributes from the "descriptor" field of the NOAA benthic map, which had 21 classifications, were appended to the NOAA BT mutton snapper data set through a spatial overlay. The resulting data table was used to derive domain-wide estimates of abundance in each habitat weighted by area. Means ± standard errors (S.E.) for abundance of juvenile and adult fish were determined for each benthic habitat in which fish surveys were conducted. Data collection occurred over a seven year period, and data were pooled among years to allow an adequate sample size (n ≥ 2) to calculate means within each habitat type. The following equation was used to calculate total abundance estimates for each life stage:

$$\sum_{h=1}^{l} A_h \overline{X_h}$$

where *A* is the total area of each mapped habitat, *X bar* is the mean density (# of fish / m^2) in each habitat, and *l* is the total number of mapped habitats in each island. A sampling unit was a 25 m long by 4 m wide belt transect or 100 m^2 area. Mean densities were derived from multiple surveys that occurred within each habitat type. A range of the total abundance was calculated with the equation:

$$\sum_{h=1}^{l} A_h \left(\overline{X_h} \pm S.E \right)$$

where S.E. is the standard error of the mean mutton snapper density in each mapped habitat in each island. S.E. values were derived from multiple samples that occurred within each habitat stratum.

Results and Discussion
A total of 57 juvenile and 33 adult mutton snapper were observed in the mapped near-shore waters of the US Caribbean between January 2001 and December 2006 (Tables 1-3). Of these fish, only three mutton snapper juveniles were observed among mapped benthic habitats in La Parguera, PR (Table 1). Mutton snapper were much more abundant in St. Croix and St. John, with a total of 49 and 38 fish occurring in St. Croix and St. John respectively (Tables 2 and 3). Two adult mutton snapper were observed in habitats classified as unknown in St. Croix and were excluded from subsequent analysis (Table 2). Juvenile and adult mutton snapper varied somewhat in their distribution among habitats, with juveniles being more common in mud, sand and seagrass habitats and adults being more frequently observed in hardbottom habitats (Figure 2).

Estimates of total abundance of mutton snapper are given in Table 5. In Puerto Rico, the estimate ranged from 4,979 to 32,750 individuals with a mean of 18,865 sexually immature fish and zero adult fish. It is important to note that the estimate in Puerto Rico is based only on the occurrence of three juvenile fish. In St. Croix, total mutton snapper abundance ranged from 41,487 to 136,943 individuals with a mean of 106,678 individuals. In St. John, total mutton snapper abundance ranged from 3,698 to 28,986 individuals with a mean of 16,342 fish. The large range in these estimates result from the high variability in occurrence of mutton snapper among different habitats (Figure 2).

It is important to note that survey sites were randomly allocated among two main benthic habitat strata (hardbottom and softbottom) rather than the 21 habitat classification scheme used in this analysis. This resulted in a few habitat classifications not being sampled because they were not selected during the sample allocation process (Tables 1-3). As such, mutton snapper presence or absence in those habitats cannot be ascertained, and therefore, such habitats were excluded when total mutton snapper abundance was being estimated. Additionally, areas that were classified as unknown benthic habitats were not included when calculating domain-wide estimates, even though mutton snapper were observed in that habitat classification.

Estimates for Puerto Rico was determined from sampling that occurred in La Parguera, southwest Puerto Rico. Whether or not the variability in mutton snapper occurrence among benthic habitats in La Parguera is representative of the island of Puerto Rico is unknown. Similarly, in St. Croix, sampling occurred only along the northeast coast and around Buck Island, and it is unknown if the spatial distribution of mutton snapper in northeast St. Croix is representative of the entire island.

References
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Kendall, M.S.1, M.E. Monaco, K.R. Buja1, J.D. Christensen, C.R. Kruer, and M. Finkbeiner, R.A. Warner. 2001. (On-line). Methods Used to Map the Benthic Habitats of Puerto Rico and the U.S. Virgin Islands URL: http://biogeo.nos.noaa.gov/projects/mapping/caribbean/startup.htm. Also available on U.S. National Oceanic and Atmospheric Administration. National Ocean Service, National Centers for Coastal Ocean Science Biogeography Program. 2001. (CD-ROM). Benthic Habitats of Puerto Rico and the U.S. Virgin Islands. Silver Spring, MD: National Oceanic and Atmospheric Administration.

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Table 1 the area (ha) of benthic classifications calculated from the NOAA benthic map, the number of surveys, and mutton snapper abundance by life stage and benthic habitat for St. John, US Virgin Islands. Sexually immature = fish < 47 cm TL; sexually mature = fish ≥ 47 cm TL. Dashes indicate habitat classifications that were not sampled for fish.

Habitat descriptor	# of polygons	Area (ha)	# of surveys	# of individuals Immature	Mature	Total
Hardbottom/Reef Rubble	17	63.19	1	0	0	**0**
Macroalgae/Patchy/10-50%	84	9,228.12	16	0	0	**0**
Macroalgae/Patchy/50-90%	15	444.10	21	1	0	**1**
Mangrove	323	7,265.62	89	0	0	**0**
Mud	177	2,178.75	2	0	0	**0**
Reef/Colonized Bedrock	259	2,524.36	4	0	0	**0**
Reef/Colonized Pavement	270	17,394.17	89	0	0	**0**
Reef/Colonized Pavement with Channels	184	30,962.17	166	0	0	**0**
Reef/Linear Reef	498	7,291.08	94	0	0	**0**
Reef/Patch Reef (Aggregated)	302	6,597.59	25	0	0	**0**
Reef/Patch Reef (Individual)	436	1,436.93	23	0	0	**0**
Reef/Scattered Coral-Rock	441	6,867.51	82	2	0	**2**
Reef/Spur and Groove Reef	5	45.28	1	-	-	**-**
Sand	157	2,600.48	91	0	0	**0**
Seagrass/Continuous	495	20,073.76	194	0	0	**0**
Seagrass/Patchy/10-30%	299	5,427.81	31	0	0	**0**
Seagrass/Patchy/30-50%	231	4,394.29	12	0	0	**0**
Seagrass/Patchy/50-70%	226	7,816.43	27	0	0	**0**
Seagrass/Patchy/70-90%	372	24,736.10	47	0	0	**0**
Unknown	81	334,316.81	60	0	0	**0**
Total	**4,872**	**491,664.54**	**1,075**	**3**	**0**	**3**

Table 2 the area (ha) of benthic classifications calculated from the NOAA benthic map, the number of surveys, and mutton snapper abundance by life stage and benthic habitat for St. John, US Virgin Islands. Sexually immature = fish < 47 cm TL; sexually mature = fish ≥ 47 cm TL. Dashes indicate habitat classifications that were not sampled for fish.

Habitat descriptor	# of polygons	Area (ha)	# of surveys	# of individuals		
				Immature	Mature	**Total**
Hardbottom/Reef Rubble	7	15.56	4	0	1	**1**
Hardbottom/Uncolonized Bedrock	7	8.36	1	-	-	**-**
Hardbottom/Uncolonized Pavement	3	3.97	1	-	-	**-**
Macroalgae/Patchy/10-50%	10	1,268.32	1	-	-	**-**
Macroalgae/Patchy/50-90%	6	40.96	3	0	0	**0**
Mangrove	20	133.27	1	-	-	**-**
Mud	6	81.62	1	-	-	**-**
Reef/Colonized Bedrock	43	307.74	31	2	0	**2**
Reef/Colonized Pavement	211	8,173.19	337	13	7	**20**
Reef/Colonized Pavement with Channels	67	11,023.32	155	1	1	**2**
Reef/Linear Reef	160	1,195.32	56	0	1	**1**
Reef/Patch Reef (Aggregated)	62	611.05	105	2	0	**2**
Reef/Patch Reef (Individual)	18	23.43	4	0	0	**0**
Reef/Scattered Coral-Rock	151	1,973.89	134	5	1	**6**
Reef/Spur and Groove Reef	8	56.53	1	-	-	**-**
Sand	53	1,160.02	69	0	0	**0**
Seagrass/Continuous	93	1,317.39	125	7	0	**7**
Seagrass/Patchy/10-30%	66	829.09	78	0	0	**0**
Seagrass/Patchy/30-50%	59	1,243.35	29	0	0	**0**
Seagrass/Patchy/50-70%	55	1,577.80	31	4	0	**4**
Seagrass/Patchy/70-90%	65	969.72	114	2	0	**2**
Unknown	8	38,827.03	2	0	2	**2**
Total	**1,178**	**70,840.93**	**1,283**	**36**	**13**	**49**

Table 3 the area (ha) of benthic classifications calculated from the NOAA benthic map, the number of surveys, and mutton snapper abundance by life stage and benthic habitat for St. John, US Virgin Islands. Sexually immature = fish < 47 cm TL; sexually mature = fish ≥ 47 cm TL. Dashes indicate habitat classifications that were not sampled for fish.

Habitat descriptor	# of polygons	Area (ha)	# of surveys	# of individuals Immature	Mature	Total
Hardbottom/Reef Rubble	13	12.94	1	0	0	**0**
Hardbottom/Uncolonized Bedrock	17	14.99	5	0	0	**0**
Macroalgae/Patchy/10-50%	9	859.47	51	0	0	**0**
Macroalgae/Patchy/50-90%	7	165.02	18	4	0	**4**
Mangrove	15	26.04	1	-	-	**-**
Midshelf Reef	2	257.23	190	6	8	**14**
Mud	1	2.05	1	-	-	**-**
Reef/Colonized Bedrock	69	285.39	29	0	0	**0**
Reef/Colonized Pavement	55	660.52	116	4	3	**7**
Reef/Colonized Pavement with Channels	29	526.18	72	0	1	**1**
Reef/Linear Reef	78	462.54	101	0	1	**1**
Reef/Patch Reef (Aggregated)	13	88.10	43	1	3	**4**
Reef/Patch Reef (Individual)	29	65.49	10	2	1	**3**
Reef/Scattered Coral-Rock	27	85.55	16	0	1	**1**
Sand	42	575.29	89	0	1	**1**
Seagrass/Continuous	42	203.16	20	0	1	**1**
Seagrass/Patchy/10-30%	20	94.09	14	0	0	**0**
Seagrass/Patchy/30-50%	20	118.51	19	1	0	**1**
Seagrass/Patchy/50-70%	23	120.02	27	0	0	**0**
Seagrass/Patchy/70-90%	19	74.67	25	0	0	**0**
Unknown	2	2.14	3	0	0	**0**
Total	**532**	**4,699.41**	**851**	**18**	**20**	**38**

Table 4 shows estimates of total mutton snapper abundance (number of individuals) by life stage for three US Caribbean islands.

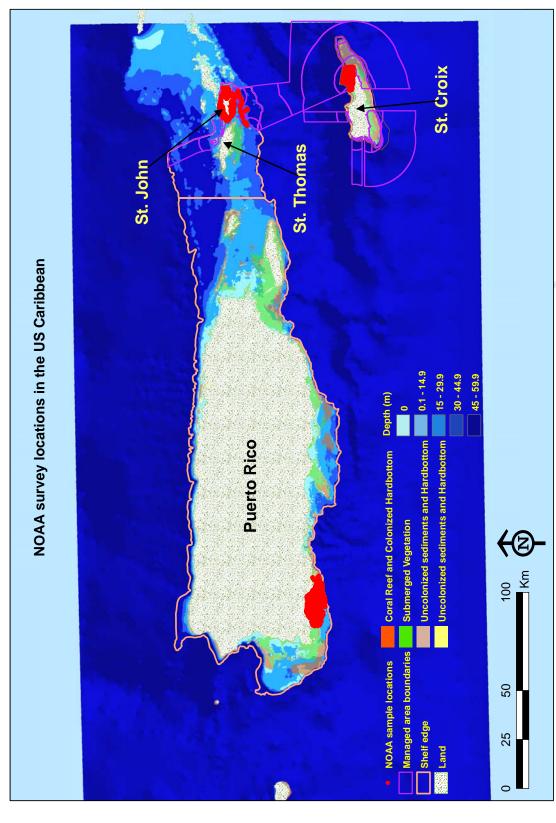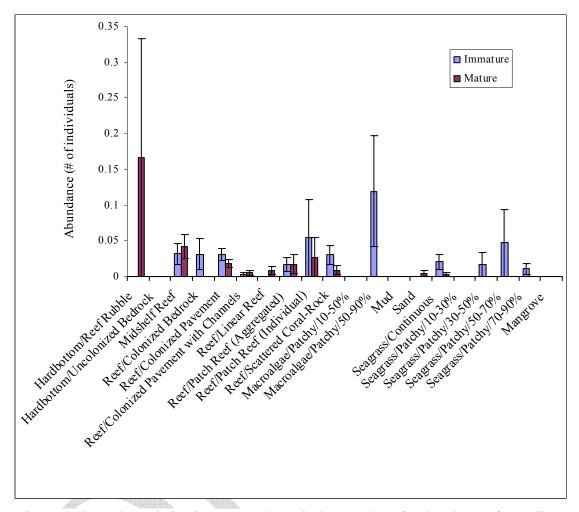| Island	Size of study area (ha)	% of study area sampled	# of surveys	Life stage	Estimated abundance	Range of estimate		
Puerto Rico	157,285	< 0.1	1013	Juvenile	18,865	4,979	-	32,750
				Adult	-	-	-	-
				Total	**18,865**	**4,979**	**-**	**32,750**
St. Croix	32,014	0.1	1275	Juvenile	78,592	30,860	-	126,325
				Adult	28,085	10,618	-	10,618
				Total	**106,678**	**41,478**	**-**	**136,943**
St. John	4,684	0.2	845	Juvenile	8,896	2,146	-	15,645
				Adult	7,447	1,553	-	13,340
				Total	**16,342**	**3,698**	**-**	**28,986**

Figure 1. Map of locations where NOAA Biogeography Team conducted visual censuses for conch (*Strombus gigas*) and mutton snapper (*Lutjanus analis*) between 2001 and 2006.

Figures 2 shows the variation in means and standard errors (S.E) for abundance of sexually immature (juvenile) and mature (adult) mutton snapper among benthic habitats in three US Caribbean islands (Puerto Rico, St. John, and St. Croix). Immature = fish < 47 cm TL; Mature = fish ≥ 47 cm TL (Froese and Pauly 2007).
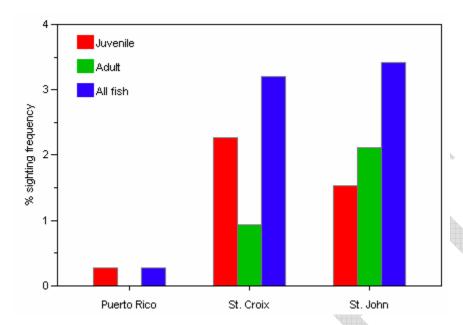
Figure 3 shows sighting frequency of sexually immature, mature, and all mutton snapper in three US Caribbean Islands. Sighting frequency was defined as the percentage of sampled sites where at least one mutton snapper was observed.