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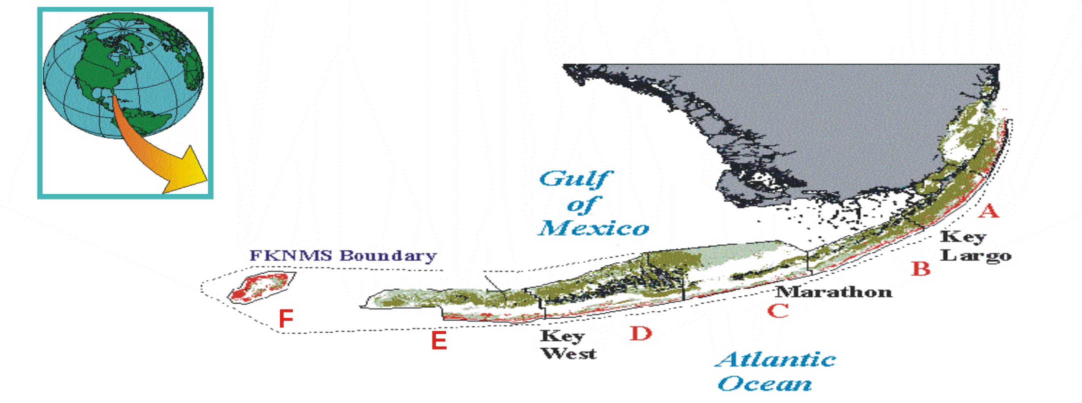
Annual Indices of Abundance of Mutton Snapper for Florida Keys

Alejandro Acosta and Robert Muller
Florida Fish and Wildlife Conservation Commission, Fish and Wildlife Research Institute

Research Program: Stratified-random sampling (SRS) with Visual Point Counts

Survey geographic range:

The survey is conducted in the open-waters of the Florida Keys National Marine Sanctuary (FKNMS). For the purposes of the Fisheries Research, Fisheries Independent program, the sampling universe in the FKNMS was divided into six geographical zones, designated A through F, four of which were sampled during the present study; (Figure 1). Zone A includes all of the waters surrounding Key Largo, the northernmost and largest island in the chain. Zone B extends from the southwestern end of Key Largo along the rest of the Upper Keys to Long Key. Zone C encompasses the Middle Keys from Long Key to Big Pine Key, while Zone D surrounds the Lower Keys (Big Pine Key to Key West) (Figure 1). Visual sampling was only conducted on the Atlantic side of the Keys.



Visual census zones A, B, C & D Ocean side

Figure 1. Map of Fisheries-Independent Monitoring Program sampling areas, divided into 4 zones (A-D), in the Florida Keys National Marine Sanctuary (FKNMS).

Survey sampling method and gear:

Visual Census

The Finfish program currently uses the stationary point count method for its visual surveys. In this method, a stationary diver records the number of individuals of each target species that are observed within an imaginary five-meter radius cylinder and assign length intervals to each. Two divers conduct a total of four point counts at each site. During the visual survey, each diver lays out a 25 meter tape in a pre-determined direction opposite from the other diver. The tapes are laid as straight as possible within the same habitat type, with at least a 15 meter distance between each point count. The first count is conducted at the 10 meter mark, and a second count is conducted at 25 meters. If suitable habitat is not present at the designated mark then the distance is adjusted accordingly. At each survey point, the diver stops and remains still for two minutes, allowing for a settling period. During this time period, the diver records depth, substrate, habitat type, relief, complexity, percent and type of biotic coverage within the area to be surveyed, which is the cylindrical area extending out 5 m from the center point and extending from the substrate to the surface. After the settling period, the diver records the time and begins estimating the number of fish in each five-centimeter size class for all the target species present. The diver has three minutes to allow the fish to naturally redistribute themselves and to list the target species present within the survey cylinder. This time period also allows for cryptic species to reveal themselves for counting.

A habitat-based, random-stratified site selection procedure, based upon the “Benthic Habitats of the Florida Keys” GIS system, was used to select 39 sample sites each month. Sampling sites were randomly selected using a one longitudinal by one latitudinal minute grid (approximately 1nm^2) system. One mile square grids containing areas defined as “Patch Reefs” and “Platform Margin Reefs“ were included in the sampling universe, with further random selection of one of 100 “ micro-grids” within each selected sampling grid (Figure 2). Within each grid chosen for sampling, a second random selection of one of one hundred 0.1′ x 0.1′ “micro-grids” (~ 0.01 nautical mile) determined the nominal location within the grid, providing that micro-grid contained reef or patch reef habitat adequate for sampling purposes (Figure 2). If this was not the case, a randomization procedure was used to relocate the sample to a nearby micro-grid with the desired habitat.

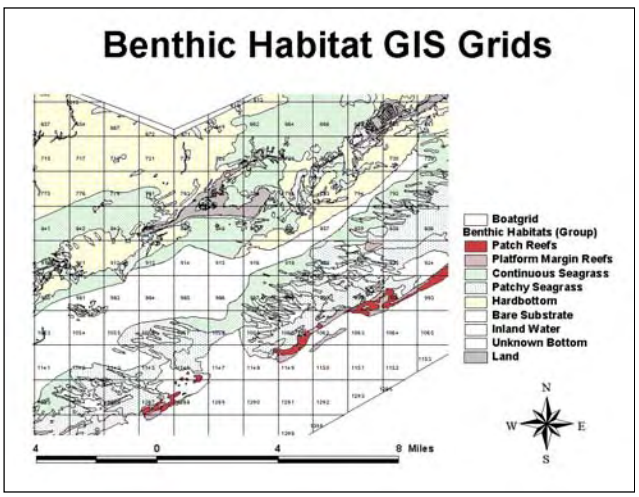


Figure 2. A habitat-based, random-stratified site selection procedure, based upon the “Benthic Habitats of the Florida Keys” GIS system.

Species sampled

These surveys sampled fifty-four species of commercial and recreational importance members of the following families: Haemulidae (thirteen species); Serranidae (thirteen species); Lutjanidae (nine species); Chaetodontidae (seven species); Balistidae (three species); Labridae (three species); Phomacanthidae (two species) and Priacanthidae (two species).

Unit measure of abundance:

Density (# fish/100 m^2) was used as an index of relative abundance. Density estimates by year, season, strata, and zone were used for spatial comparisons.

Temporal and spatial resolution:

The surveys are conducted from April to October, Thirty nine randomly select 39 sites (13 in Zone A, 10 in Zone B, 6 in Zone C and 10 in Zone D) are conducted each month.

Series period:

From 1999 and 2000, we used to sampling gears transects and point counts. Since 2001-2004 and 2006, we sampled with visual point counts.

Indices:

The FWC visual survey index (VS) used the dives conducted from 1999 through 2006. While each dive is frequently considered a cluster sample and the response variable is the combined total number of fish observed by both divers; in this survey, the spatial extent of a single dive can encompass multiple bottom habitat reliefs and so we used the combined number of fish by species by bottom habitat relief observed by divers as the response variable. There were a total of 2198 unique dive/habitat combinations. However, mutton snapper were not found in all of them. Therefore, the number of dive/habitat combinations used to develop the index were all of those that saw mutton snapper (539) plus some additional dives (248) that possibly could have seen mutton snapper. The additional dives were identified through a logistical regression technique (Stephens and MacCall 2004) that used the presence or absence of other species seen to estimate the probability that a dive potentially could have seen mutton snapper. When compared to the dive/habitat combinations that observed mutton snapper, the logistic regression used sixteen species of fish to determine the probability that a trip could have seen mutton snapper. To determine which dives to include in the analyses, the number of false positive dives (the dive's probability based on the logistic regression was at least the critical value but mutton snapper were not observed on that dive) and number of false negative dives (the dive's probability was less than the critical value but mutton snapper were observed on the dive) were tallied for each possible critical value. The curves of the predicted false positive dives and false negative dives crossed at a critical value of 0.345 (Fig. 3).

Once the individual dive/combinations were identified, we estimated the mean number of mutton snapper per dive per habitat by year with a generalized linear model in SAS (PROC GENMOD) that used a Poisson distribution with a log link. The potential explanatory variables were year, month (May-October), zone, bottom habitat relief, secchi distance, and depth. Secchi was categorized by two meter intervals from six or less meters to 26 or more meters. Depth was categorized by 10 feet intervals with all depths greater than 60 feet combined. Variables to include in the model were selected in a stepwise manner using the percent change in mean deviance (deviance/df, 0.5% minimum based on recommendation from SEDAR 3) and that the variable was significant at the 0.05 level. Neither month nor depth was significant in the final model.

The VS index showed lower levels for 2001-2003 and then followed by an increase back to the earlier levels (Fig 4). Similarly, lower VS index were observed in the Middle Keys (zone C) (Fig 5).

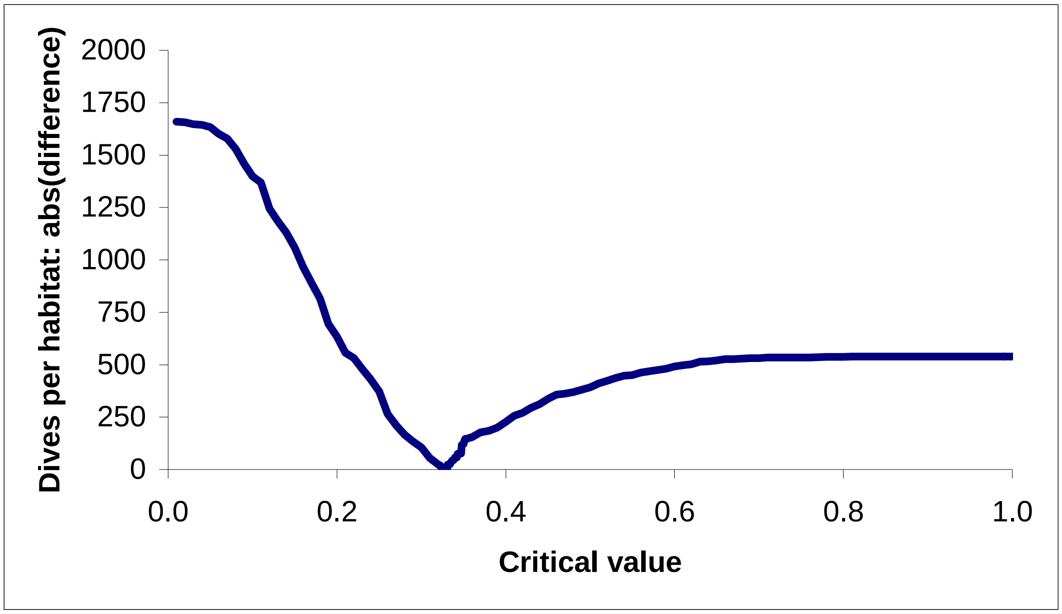


Figure 3. The absolute differences between false positive and false negative dives per habitat for juvenile mutton snapper for each critical value from Stephens and MacCall method.

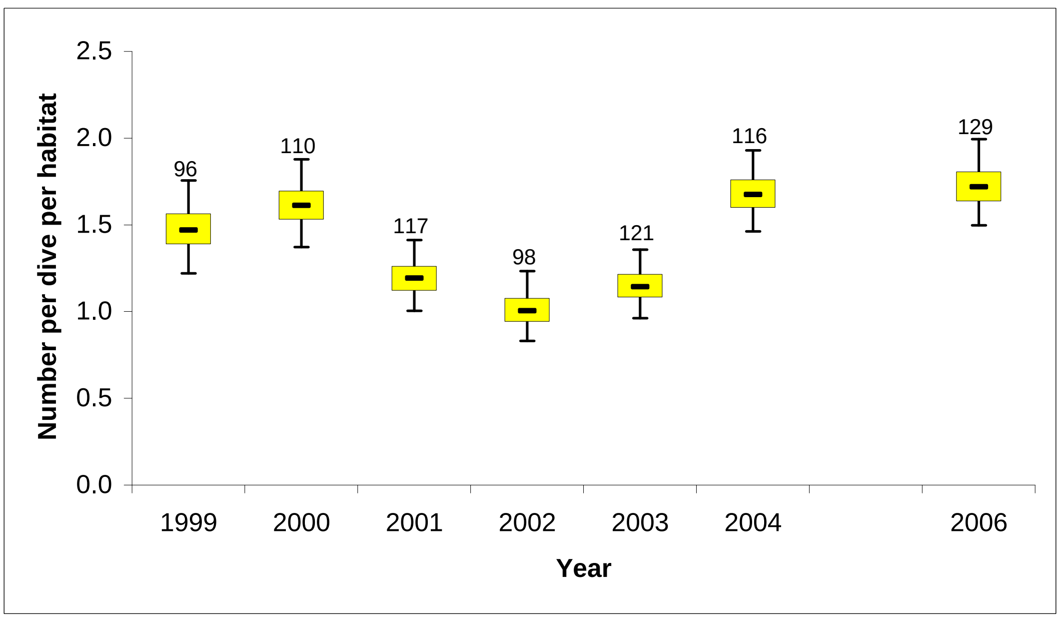


Figure 4. Number of mutton snapper per dive per bottom habitat by year observed by the visual survey. Vertical line – 95% confidence interval, box – inter-quartile range, horizontal line – median, and the number is the number of dive/habitats.

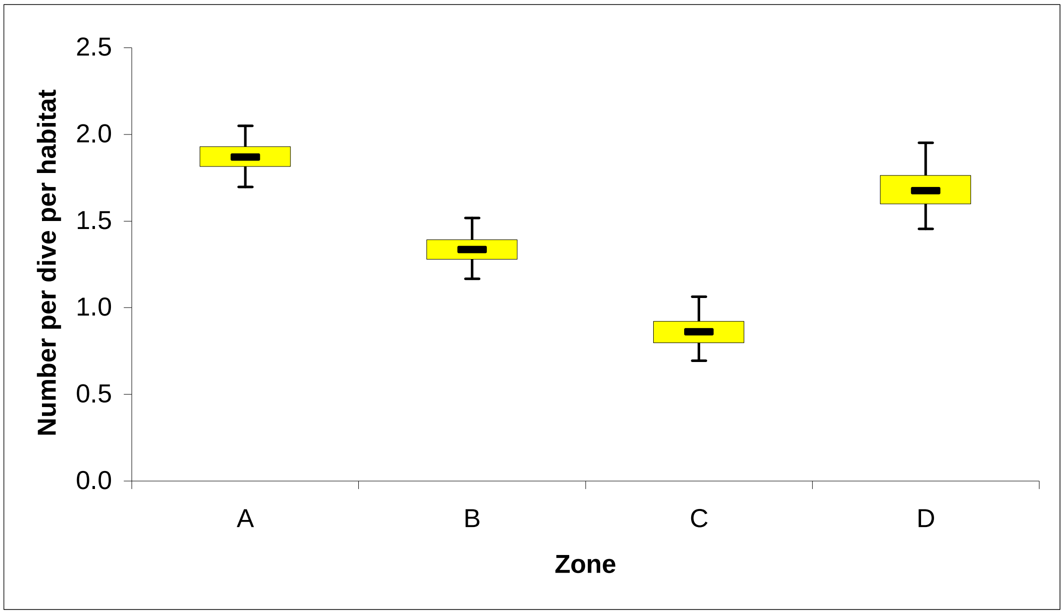


Figure 5. Number of mutton snapper per dive per bottom habitat by zone observed by the visual survey. Vertical line – 95% confidence interval, box – inter-quartile range, horizontal line – median, and the number is the number of dive/habitats.

Because the visual survey estimates the total length of fish as well as the number of fish observed, we were able to re-run the catch rate analyses separating mutton snapper into juveniles (TL < 375 mm, the upper 95 percentile for sexes combined) and adults. As before, additional dive/habitats were identified using the Stephens and MacCall approach and the catch rates were calculated using generalized linear models with the same potential explanatory variables with the addition of the bottom habitat type (edge, intermittent reef, or continuous reef). Table 1 lists the species associated with mutton snapper juveniles and adults. Only four species out of 22 were statistically significant for both life stages.

Divers observed juvenile mutton snappers on 181 dive/habitats with another 131 dive/habitats (critical value = 0.201, Fig. 6) that potentially could have caught mutton snapper. Significant variables reducing the mean deviance in juvenile catch rates included year, zone, secchi distance, bottom habitat type, month, and bottom habitat relief. Juvenile mutton snappers showed a large increase in numbers per dive/habitats observed in 2004 and 2006 (Fig. 7). On average, more juvenile mutton snappers per dive/habitat were observed in the Lower Keys (Zone D, Fig. 8). Divers observed adult mutton snappers on 412 dive/habitats and there were 262 additional dive/habitats that potentially could have caught mutton snappers (critical value = 0.272, Fig. 9). There was no temporal trend with adult mutton snappers ($X^2 = 6.93$, $df = 6$, $P = 0.33$) because only zone and secchi distance reduced the mean deviance in adult catch rates more than 0.5%. The overall mean value was 0.75 mutton snapper per dive per habitat. More adult mutton snappers per dive were observed in the Upper Keys (Fig. 10).

Examining the visual survey data by life stage (juvenile or adult) provides some insights into mutton snapper dynamics. For example, the increase in catch rates in 2004 and 2005 (Fig. 4) was due to divers seeing higher numbers of juveniles (Fig. 7). Conversely, overall there were more mutton snappers in the Upper (Zone A) and Lower Keys (Zone D) than in the Middle Keys (Zone C) (Fig. 5) but that results from the more juveniles being observed per dive in the Lower

Keys (Fig. 8) and more adults in the Upper Keys (Fig. 10).

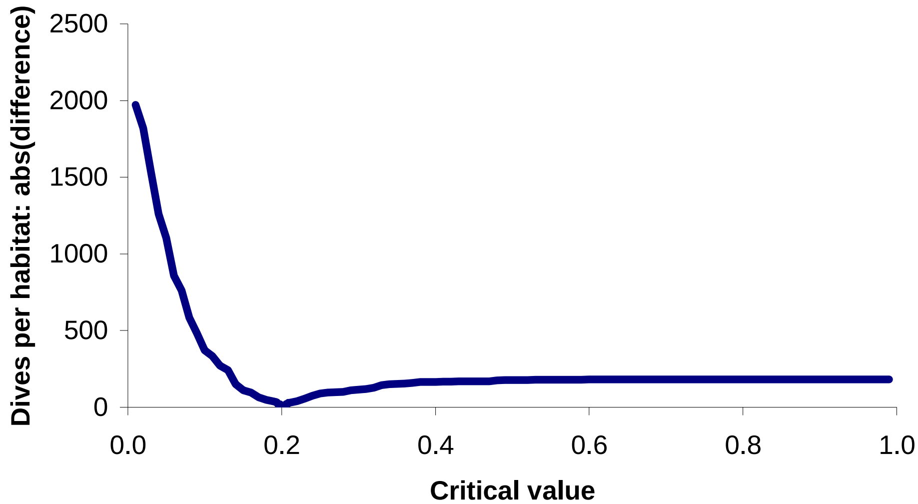


Figure 6. The absolute differences between false positive and false negative dives per habitat for juvenile mutton snapper for each critical value.

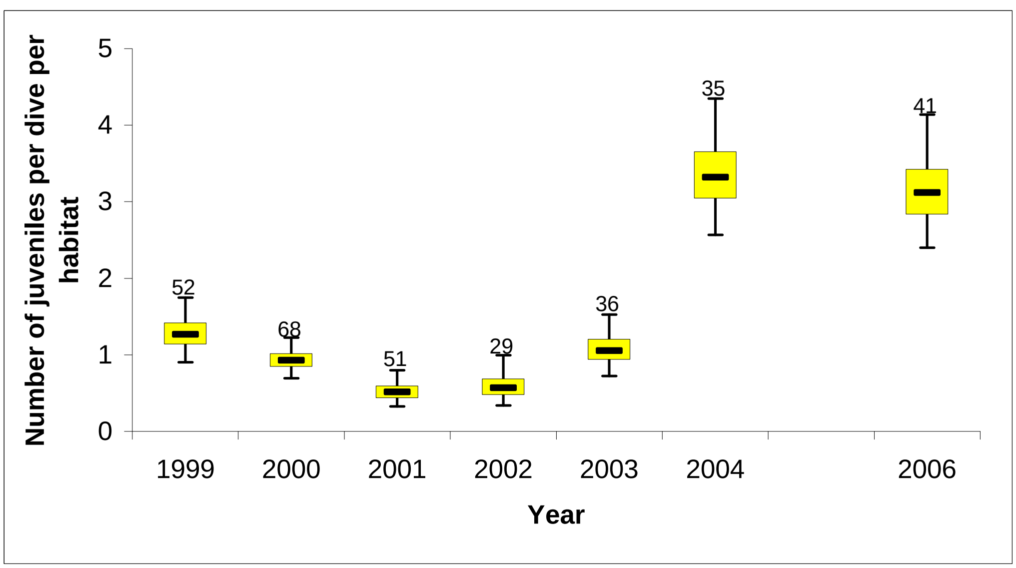


Figure 7. Number of juvenile mutton snapper per dive per bottom habitat by year observed by the visual survey. Vertical line – 95% confidence interval, box – inter-quartile range, horizontal line – median, and the number is the number of dive/habitats.

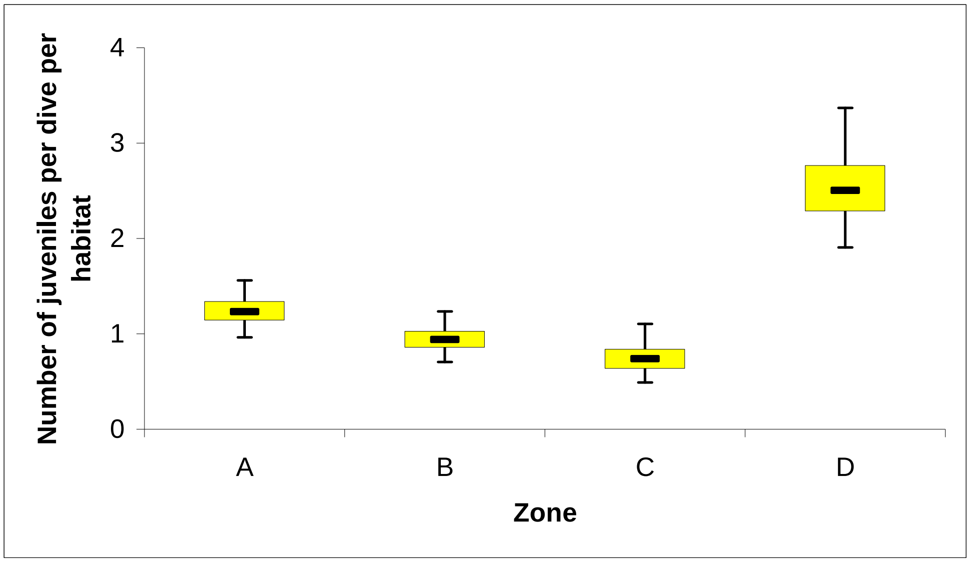


Figure 8. Number of juvenile mutton snapper per dive per bottom habitat by zone observed by the visual survey. Vertical line – 95% confidence interval, box – inter-quartile range, horizontal line – median, and the number is the number of dive/habitats.

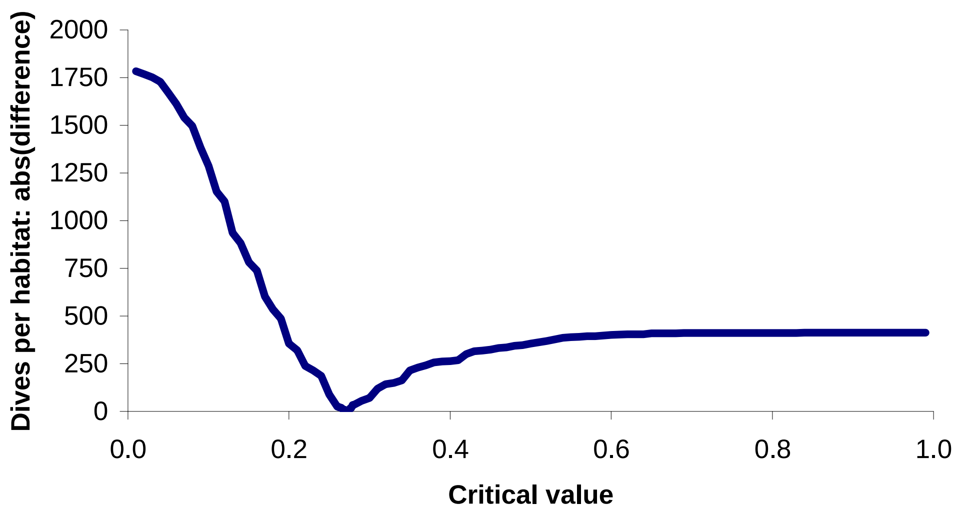


Figure 9. The absolute differences between false positive and false negative dives per habitat for juvenile mutton snapper for each critical value from the Stephens and MAcCAll method.

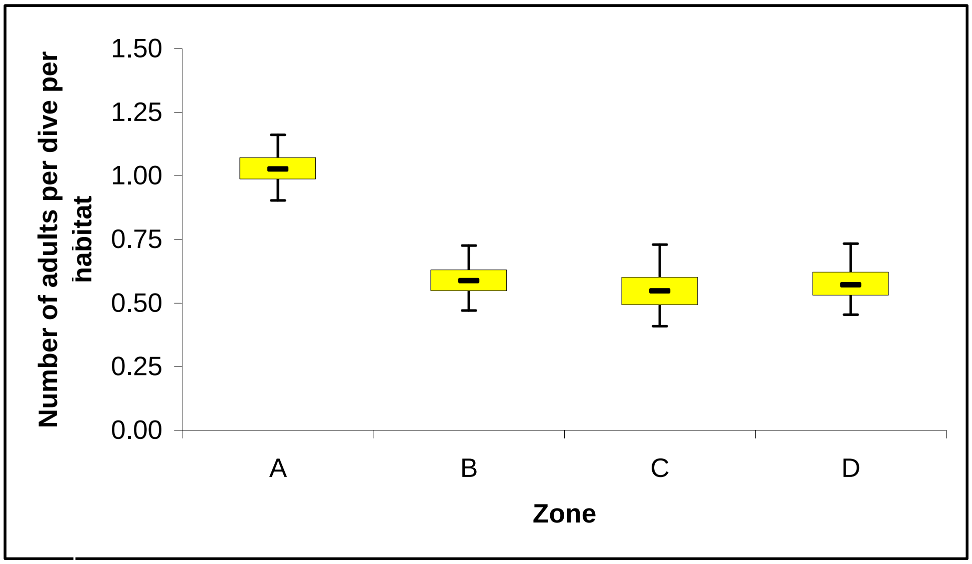


Figure 10. Number of juvenile mutton snapper per dive per bottom habitat by zone observed by the visual survey. Vertical line – 95% confidence interval, box – inter-quartile range, horizontal line – median, and the number is the number of dive/habitats.

Potential advantages: Relatively low-cost and scientifically valid fisheries independent monitoring methods are continually being sought and the use of visual census survey methods to conduct assessment of coral reef ecosystems is an example of a non-destructive and low cost sampling tool. The principal goal of our visual census survey was to evaluate the relative abundance, size structure, and habitat utilization of the reef fish species that comprise local, commercial and recreational fisheries in the Florida Keys reef ecosystem. We feel that the primary attainable criteria for a successful fishery monitoring program using a visual census sampling approach is to establish and maintain a consistent sampling methodology which will track relative changes in abundance and which generate sample sizes adequate to allow meaningful statistical comparisons within the observed range of abundance levels. We feel that our sampling protocol had produced robust density estimates and enough information to meet those two criteria.

Potential problems/limitations: Length frequency information is an essential component for any visual-based monitoring program; estimating fish lengths underwater is not an easy task and there are many possible sources of error, however, we feel that our estimates of fish lengths are very robust due to the rigorous training and testing undertaken by our observers. Some of the main limitations of visual censuses are those inherited with the methodology. We considered that we under sampled the deeper reef habitats of the Florida Keys and as a consequence we are probably missing the larger and more reproductive fishes for some species such as grouper.

Literature Cited

Stephens, A. and A. McCall. 2004. A multispecies approach to subsetting logbook data for purposes of estimating CPUE. Fisheries Research 70:299-310.

Table 1. Logistic regression coefficients for species associated with mutton snapper juveniles and adults.

NODC Code	Scientific name	Common name	Juveniles	Adults
8835020408	Epinephelus morio	red grouper	0.69	
8835020438	Epinephelus fulvus	coney		0.56
8835020439	Epinephelus cruentatus	graysby	-0.80	
8835360102	Lutjanus griseus	gray snapper	0.47	
8835360109	Lutjanus jocu	dog snapper		1.04
8835360112	Lutjanus synagris	lane snapper		0.82
8835360401	Ocyurus chrysurus	yellowtail snapper		-0.33
8835400103	Haemulon album	margate		1.02
8835400110	Haemulon macrostomum	Spanish grunt		-1.10
8835400111	Haemulon melanurum	cottonwick	0.61	
8835400113	Haemulon sciurus	bluestriped grunt		-0.67
8835400116	Haemulon striatum	striped grunt		1.07
8835550101	Chaetodon ocellatus	spotfin butterflyfish	0.41	-0.31
8835550103	Chaetodon capistratus	foureye butterflyfish	-0.53	
8835550107	Chaetodon sedentarius	reef butterflyfish		0.29
8835550301	Holacanthus ciliaris	queen angelfish		0.47
8835550401	Pomacanthus arcuatus	gray angelfish		0.50
8835550402	Pomacanthus paru	French angelfish	0.62	
8839010301	Bodianus pulchellus	spotfin hogfish		-1.99
8839010302	Bodianus rufus	Spanish hogfish	0.51	0.30
8839010901	Lachnolaimus maximus	hogfish	0.86	0.53
8860020202	Balistes vetula	queen triggerfish	0.68	0.76