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Fishery independent indices of abundance for mutton snapper, *Lutjanus analis*, from REEF fish surveys along Florida's Atlantic coast including the Dry Tortugas.

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Introduction

As essential part of Reef Environmental Education Foundation's (REEF) program is their Fish Survey Project. In this project, divers record their observations on marine populations. The program is quite wide spread with divers from Western Atlantic and Caribbean, Pacific U.S. and Canada, Hawaiian Islands, and the Eastern Tropical Pacific having participated in this program. REEF volunteer divers use a Roving Diver Technique and record their observations on a standard form for the particular region. An advantage of diver observations is that they are independent of size and bag limits. The changes in the number or frequency of occurrence of a particular species, say mutton snapper, are assumed to reflect the changes in the underlying abundance; thus, the dive records can be used to develop a fishery independent indices. An index based on REEF dive surveys was used in the goliath grouper stock assessment (SEDAR6 2004). In addition to recording the numbers of fish seen on a dive, divers also record basic environmental information about the dive site.

Methods

The information that divers provide REEF about their dives includes the experience level of the diver, the survey type, the geographic code of the dive site, the dive date, the surface and bottom temperature, the dive's bottom time, the start time, visibility, average depth of the dive, current, habitat, species and abundance of fish seen (REEF 2007). Divers report the abundance of species as single, few (2-10), many (11-100), and abundant (100+).

REEF provided FWC with an extract from their database of all the dive records from Florida's Atlantic coast including those off the Dry Tortugas for a total of 24,541 dive surveys. The resulting database had records from 1993 to 2007; however, some of the records were eliminated for being incomplete and others because they were from 2007 and the dives from 1993 were eliminated as because they only came from the northern Keys and mostly from July. The working database contained records from 1994 through 2006 with no missing information for habitat, visibility, current, or average depth (22,668 dives). The dive sites were grouped geographically to the Northeast (St. Mary's River - Jupiter Inlet; geo codes 3101, 3200, 3201), Southeast (Jupiter Inlet - Biscayne National Park; geo codes 3300, 3301, 3302), Florida Keys (Key Largo - Key West; 3400,

3403, 3404, 3405, 3406, 3407, 3408), and West of Key West (Marquesas Keys - Dry Tortugas; 3409, 3410). Some of the associated data were sparse towards the ends and were aggregated into plus groups. For example, any dives with average depths greater than 100 feet were combined into a he 100 feet plus group, bottom times were rounded to 10 minute categories and any exceeding 120 minutes were combined into a 120 min plus group. Most of the dives that observed mutton snapper came from only a few habitat types (mixed, high profile reef, low profile reef, ledge, and artificial include wrecks) and so the other habitats were grouped into an 'Other' category.

Three indices were calculated with different subsets of the REEF dive surveys: an index based on all dives on Florida's Atlantic coast; an index based on sites that were visited by divers on at least seven of the 13 years, i.e. more than half, and at which mutton snapper were observed more than once; an index that used a logistic regression of presence or absence of species on the dives to calculate the probability that a dive would observe mutton snapper (Stephens and MacCall 2004). This method is straight-forward -- it uses the presence or absence of every species recorded to calculate a probability of observing a mutton snapper on the dive. The method uses maximum likelihood to determine a critical value that minimizes the false positive and false negative conditions. The final data set consists of all of the dives that observed mutton snapper plus trips with probabilities that exceeded the critical value. These additional trips were the dives that could have seen a mutton snapper but for some reason did not.

As with other indices of abundance, the relationship between the index and the abundance may change. All of the indices were standardized in the attempt to minimize those changes. The REEF indices calculated here used generalized linear models (PROC GENMOD) in SAS version 9.1.3 (SAS Institute, Cary NC) to identify which factors significantly affected the catch rates and to adjust the catch rates accordingly. Generalized linear models were used because they allowed the calculation of catch rates with error distributions in addition to the normal distribution. In the case of the REEF diver information, one measure that REEF recommends is the percent sighting frequency (C. Semmens, REEF. personal communication) and thus the binomial distribution with a logit link function is the appropriate configuration. The potential list of explanatory variables included year, month, zone, experience, visibility, habitat, current, average depth, bottom time, and starting time. Temperature was not included on many dives and including it would have reduced the working dataset. Confidence intervals were estimated with Monte Carlo simulations generating 1000 estimates of the annual proportion of positive dives from the logit least square means and their standard errors.

Results

Of the 22,668 dives in the working dataset, mutton snapper were reported on 3,137 dives. On those dives that recorded mutton snapper, fifty-three percent of the dives reported seeing a single mutton snapper and another 41% reported seeing from 2-10 mutton snapper, i.e. 94% of the dives saw 10 or fewer mutton snapper. Thus, the annual probability of seeing one or more mutton snapper on a dive is reasonable as a suitable fishery independent index of abundance.

While year was significant in the model according to the Type III Sum of Squares, year only accounted for 0.15% of the reduction in mean deviance due to the extensive overlap of the confidence intervals (Table 1). The other variables that were

included in the final reduced model were diver experience, habitat, and average depth. While all of the potential variables were statistically significant except current, none of the other variables achieved the 0.5% reduction in mean deviance criterion. The proportion of positive dives was higher in the earlier years and then has been flat since 2000 (Figure 1).

The second model used only dive sites that mutton snapper had been observed on two or more occasions and these sites were visited on at least seven of the 13 years in the time series, i.e. more than half of the years (14,370 dives with mutton snapper recorded on 2,032 dives). The variables included in this final model zone, bottom time, and start time were different from those in the model using all of the records. Year was more important in this model that in the above model (0.42% vs. 0.15%, Table 2) but there still was a lot of overlap in the confidence limits (Figure 2).

The last model used the Stephens and MacCall (2004) logistical regression based on the observed species per dive to reduce the number of zero dives. Divers recorded 521 species on the 22647 dives (21 dives did not have species records) along Florida's Atlantic coast including the Dry Tortugas. Of those species, there were 213 species occurred on at least 1% of the dives and the presence or absence of these species were used in the logistic regression. Many of the species coefficients were not significant at the 0.05 level and the reduced model used 85 species. The critical value for the REEF dives was 0.21 (Figure 3 a) and that added 2974 zero dives to the 3137 dives with mutton snapper for a total of 6111 dives. These dives were then used in a generalized linear model to estimate the annual proportion of positive dives. The potential variables were the same as in the above models. Year reduced the mean deviance only 0.3% but year was statistically significant (Table 3). Only average depth met the 0.5% criterion; however, all of the variables were statistically significant except visibility. The annual proportion of positive dives decreased reaching a low in 2000 and then has generally increased afterwards (Figure 3b).

Discussion

To compare the three different indices using REEF data (Table 4), each of the indices was scaled to its mean value and then plotted together (Figure 4). The three indices were consistent with higher values in the mid 1990s decreasing until 2000-2001 and then either being stable or showing a slight increase. While there is little evidence to recommend one index over another because year was significant in all three models at $P < 0.001$, I recommend using the index based on the sites that had been visited by REEF divers in at least seven of the 13 years and at which mutton snapper had been observed two or more times because this index had the highest X^2 value (58.8). That this index had the highest X^2 value (best fit) was not surprising because this index was more focused on mutton snapper.

Literature Cited

REEF. 2007. Reef Environmental Education Foundation. World Wide Web electronic publication. www.reef.org. Date of download (26 April 2007).

SEDAR6. 2004. Complete stock assessment report of SEDAR6. Goliath Grouper. Assessment Report 1. SEDAR/SAFMC. One Southpark Circle #306. Charleston, SC 29414.

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

Table 1. The stepwise selection process of identifying variables described in the text to include in the Generalized Linear Model for the all of REEF's dives in terms of proportion of positive dives, **1994-2006**. The selected variables are shaded.

Source	Df	Deviance	Mean Dev	Δ Mean Dev	% change	Cum %	Log like	Δ log like	-2 Δ log like	df	Prob Ho
Null	22667	18222.69	0.8039				-9111.34				
Year	22655	18185.30	0.8027	0.0012	0.15%	0.15%	-9092.65	-18.69	37.39	12	0.0002
With Year											
Month	22644	18160.06	0.8020	0.0007	0.09%		-9080.03	-12.62	25.24	11	0.0084
Zone	22652	18062.73	0.7974	0.0053	0.66%		-9031.37	-61.28	122.57	3	0.0000
Experience	22654	18026.80	0.7957	0.0070	0.87%	1.02%	-9013.40	-79.25	158.50	1	0.0000
Visibility	22649	18022.01	0.7957	0.0070	0.87%		-9011.01	-81.64	163.29	6	0.0000
Habitat	22650	18022.43	0.7957	0.0070	0.87%		-9011.21	-81.44	162.87	5	0.0000
Current	22653	18178.58	0.8025	0.0002	0.02%		-9089.29	-3.36	6.72	2	0.0347
Ave depth	22644	18052.96	0.7973	0.0054	0.67%		-9026.48	-66.17	132.34	11	0.0000
Bottom time	22643	18110.57	0.7998	0.0029	0.36%		-9055.28	-37.37	74.73	12	0.0000
Start time	22653	18090.16	0.7986	0.0041	0.51%		-9045.08	-47.57	95.14	2	0.0000
With Year and Experience											
Month	22643	17995.10	0.7947	0.0010	0.12%		-8997.55	-15.85	31.71	11	0.0008
Zone	22651	17936.09	0.7918	0.0039	0.49%		-8968.04	-45.36	90.72	3	0.0000
Visibility	22648	17890.93	0.7900	0.0057	0.71%		-8945.47	-67.94	135.87	6	0.0000
Habitat	22649	17877.97	0.7893	0.0064	0.80%	1.82%	-8938.98	-74.42	148.83	5	0.0000
Current	22652	18024.51	0.7957	0.0000	0.00%		-9012.26	-1.14	2.29	2	0.3186
Ave depth	22643	17904.60	0.7907	0.0050	0.62%		-8952.30	-61.10	122.20	11	0.0000
Bottom time	22642	17976.80	0.7940	0.0017	0.21%		-8988.40	-25.00	50.00	12	0.0000
Start time	22652	17933.76	0.7917	0.0040	0.50%		-8966.88	-46.52	93.04	2	0.0000
With Year, Experience, and Habitat											
Month	22638	17842.96	0.7882	0.0011	0.14%		-8921.48	-17.50	35.01	11	0.0002
Zone	22646	17801.66	0.7861	0.0032	0.40%		-8900.83	-38.16	76.31	3	0.0000
Visibility	22643	17746.24	0.7837	0.0056	0.70%		-8873.12	-65.86	131.73	6	0.0000
Current	22647	17876.48	0.7894	-0.0001	-0.01%		-8938.24	-0.75	1.49	2	0.4739
Ave depth	22638	17728.87	0.7831	0.0062	0.77%	2.59%	-8864.44	-74.55	149.10	11	0.0000
Bottom time	22637	17835.47	0.7879	0.0014	0.17%		-8917.74	-21.25	42.50	12	0.0000
Start time	22647	17790.73	0.7856	0.0037	0.46%		-8895.37	-43.62	87.24	2	0.0000

Table 2. The stepwise selection process of identifying variables described in the text to include in the Generalized Linear Model for only REEF dives from sites that were visited in seven of the 13 years and mutton snapper were observed more than once in terms of proportion of positive dives, **1994-2006**. The selected variables are shaded.

Source	Df	Deviance	Mean Dev	Δ Mean Dev	% change	Cum %	Log like	Δ log like	-2 Δ log like	df	Prob Ho
Null	14369	11711.75	0.8151				-5855.88				
Year	14357	11652.98	0.8117	0.0034	0.42%	0.42%	-5826.49	-29.39	58.77	12	0.0000
With year											
Month	14346	11641.42	0.8115	0.0002	0.02%		-5820.71	-5.78	11.56	11	0.3974
Zone	14354	11499.69	0.8011	0.0106	1.30%	1.72%	-5749.85	-76.64	153.29	3	0.0000
Experience	14356	11586.05	0.8071	0.0046	0.56%		-5793.02	-33.47	66.93	1	0.0000
Visibility	14351	11582.16	0.8071	0.0046	0.56%		-5791.08	-35.41	70.83	6	0.0000
Habitat	14352	11595.61	0.8079	0.0038	0.47%		-5797.81	-28.68	57.37	5	0.0000
Current	14355	11645.77	0.8113	0.0004	0.05%		-5822.89	-3.60	7.21	2	0.0272
Ave depth	14346	11602.61	0.8088	0.0029	0.36%		-5801.31	-25.18	50.37	11	0.0000
Bottom time	14345	11578.39	0.8071	0.0046	0.56%		-5789.20	-37.30	74.59	12	0.0000
Start time	14355	11560.11	0.8053	0.0064	0.79%		-5780.06	-46.43	92.87	2	0.0000
With year and zone											
Month	14343	11487.06	0.8009	0.0002	0.02%		-5743.53	-6.32	12.63	11	0.3179
Experience	14353	11464.57	0.7988	0.0023	0.28%		-5732.28	-17.56	35.13	1	0.0000
Visibility	14348	11452.67	0.7982	0.0029	0.36%		-5726.33	-23.51	47.02	6	0.0000
Habitat	14349	11439.73	0.7972	0.0039	0.48%		-5719.86	-29.98	59.97	5	0.0000
Current	14352	11495.93	0.8010	0.0001	0.01%		-5747.96	-1.88	3.77	2	0.1521
Ave depth	14343	11464.45	0.7993	0.0018	0.22%		-5732.23	-17.62	35.24	11	0.0002
Bottom time	14342	11401.41	0.7950	0.0061	0.75%	2.47%	-5700.70	-49.14	98.28	12	0.0000
Start time	14352	11412.94	0.7952	0.0059	0.72%		-5706.47	-43.38	86.75	2	0.0000
With year, zone, and bottom time											
Month	14331	11381.78	0.7942	0.0008	0.10%		-5690.89	-9.81	19.63	11	0.0508
Experience	14341	11381.74	0.7937	0.0013	0.16%		-5690.87	-9.83	19.67	1	0.0000
Visibility	14336	11355.46	0.7921	0.0029	0.36%		-5677.73	-22.98	45.95	6	0.0000
Habitat	14337	11349.99	0.7917	0.0033	0.40%		-5674.99	-25.71	51.42	5	0.0000
Current	14340	11400.57	0.7950	0.0000	0.00%		-5700.29	-0.42	0.84	2	0.6586
Ave depth	14331	11355.95	0.7924	0.0026	0.32%		-5677.97	-22.73	45.46	11	0.0000
Start time	14340	11312.65	0.7889	0.0061	0.75%	3.21%	-5656.33	-44.38	88.76	2	0.0000

Table 3. The stepwise selection process of identifying variables described in the text to include in the Generalized Linear Model for only REEF dives that observed mutton snapper or from dives that were identified by Stephens and MacCall's logistic regression as dives that could have had mutton snapper in terms of proportion of positive dives, **1994-2006**. The selected variables are shaded.

Source	Df	Deviance	Mean Dev	Δ Mean Dev	% change	Cum %	Log like	Δ log like	-2 Δ log like	df	Prob Ho
Null	6110	8467.30	1.3858				-4233.65				
Year	6098	8425.72	1.3817	0.0041	0.30%	0.30%	-4212.86	-20.79	41.57	12	0.0000
With Year											
Month	6087	8386.05	1.3777	0.0040	0.29%		-4193.03	-19.83	39.67	11	0.0000
Zone	6095	8399.01	1.3780	0.0037	0.27%		-4199.50	-13.36	26.72	3	0.0000
Experience	6097	8401.72	1.3780	0.0037	0.27%		-4200.86	-12.00	24.01	1	0.0000
Visibility	6092	8422.94	1.3826	-0.0009	-0.06%		-4211.47	-1.39	2.78	6	0.8358
Habitat	6093	8402.95	1.3791	0.0026	0.19%		-4201.47	-11.39	22.77	5	0.0004
Current	6096	8420.69	1.3813	0.0004	0.03%		-4210.34	-2.52	5.04	2	0.0806
Ave depth	6087	8349.25	1.3717	0.0100	0.72%	1.02%	-4174.62	-38.24	76.48	11	0.0000
Bottom time	6086	8412.20	1.3822	-0.0005	-0.04%		-4206.10	-6.76	13.52	12	0.3323
Start time	6096	8415.66	1.3805	0.0012	0.09%		-4207.83	-5.03	10.06	2	0.0065

Table 4. Fishery independent indices from REEF dive surveys in terms of the proportion of positive dives by year for Florida's Atlantic coast including the Dry Tortugas.

	Proportion positive dives			Scaled to mean		
Year	All records	Visited at least 7 years out of 13 years mutton observed more than once	Dives with mutton snapper or identified from regression	All records	Visited at least 7 years out of 13 years mutton observed more than once	Dives with mutton snapper or identified from regression
1994	0.20	0.06	0.54	1.22	1.07	1.04
1995	0.19	0.07	0.62	1.20	1.19	1.18
1996	0.18	0.06	0.59	1.10	1.02	1.13
1997	0.17	0.06	0.43	1.02	1.12	0.84
1998	0.17	0.06	0.56	1.06	1.13	1.08
1999	0.17	0.07	0.49	1.05	1.22	0.95
2000	0.15	0.05	0.44	0.92	0.87	0.84
2001	0.14	0.05	0.54	0.88	0.90	1.04
2002	0.15	0.04	0.50	0.90	0.73	0.96
2003	0.15	0.05	0.50	0.91	0.93	0.96
2004	0.15	0.05	0.49	0.92	0.94	0.94
2005	0.15	0.05	0.52	0.92	0.88	1.00
2006	0.15	0.05	0.53	0.91	0.99	1.03
Mean	0.16	0.055	0.52			

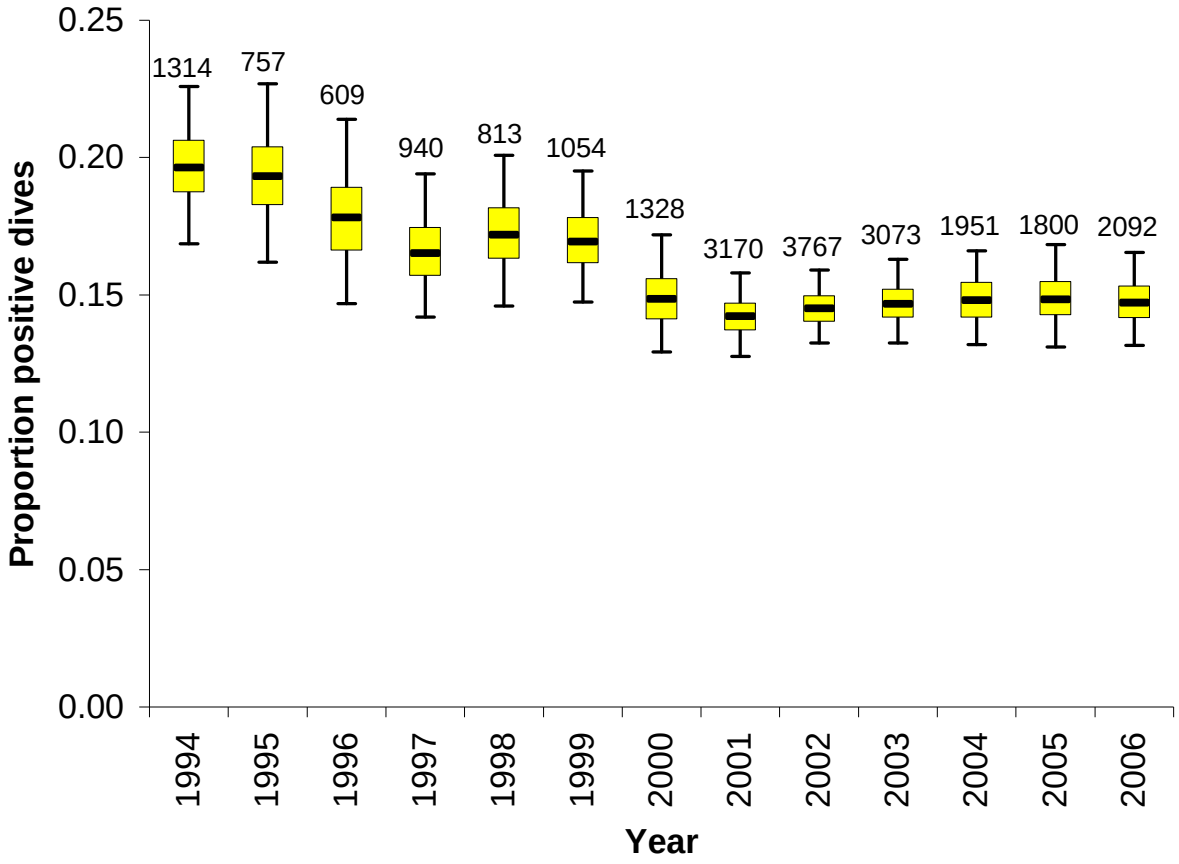


Figure 1. The proportion of positive dives by year from all REEF dive surveys for mutton snapper along the Atlantic coast of Florida including the Dry Tortugas. The variability was simulated with Monte Carlo technique that generated 1000 estimates per year. The vertical line is the 95% confidence interval, the box is the inter-quartile range (50% of the outcomes were in the box), the horizontal line is the median, and the number above the symbol is the number of dives during that year.

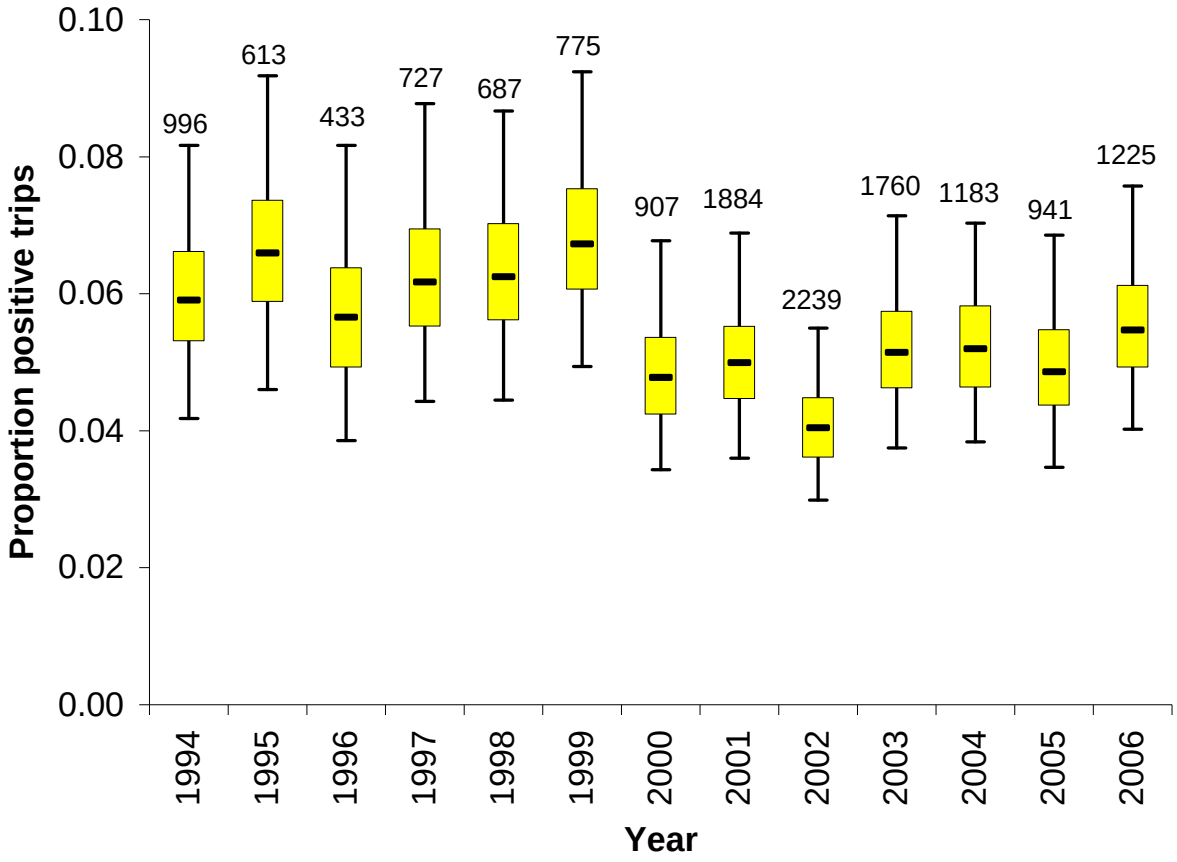
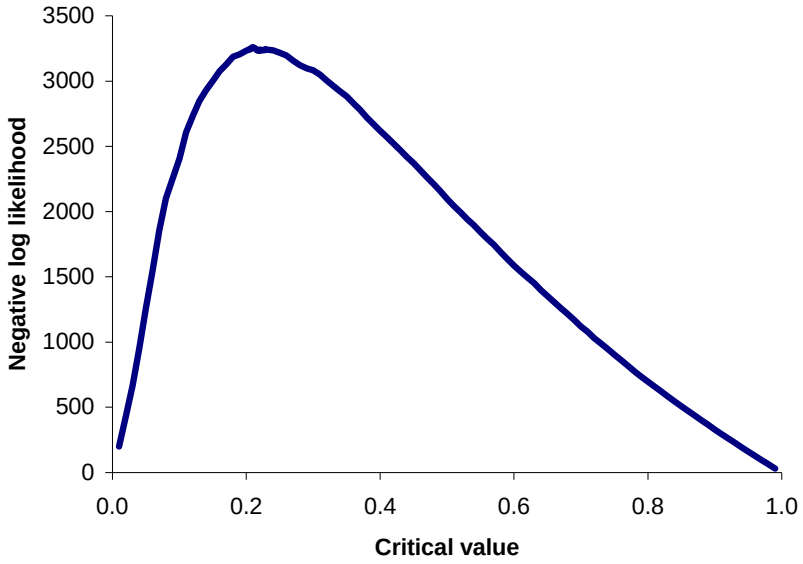


Figure 2. The proportion of positive dives by year from REEF dive surveys for mutton snapper along the Atlantic coast of Florida including the Dry Tortugas using only those sites that had been visited by divers in seven of the 13 years and mutton snapper had been reported on more than one occasion. The variability was simulated with Monte Carlo technique that generated 1000 estimates per year. The vertical line is the 95% confidence interval, the box is the inter-quartile range (50% of the outcomes were in the box), the horizontal line is the median, and the number above the symbol is the number of dives during that year.

a.



b.

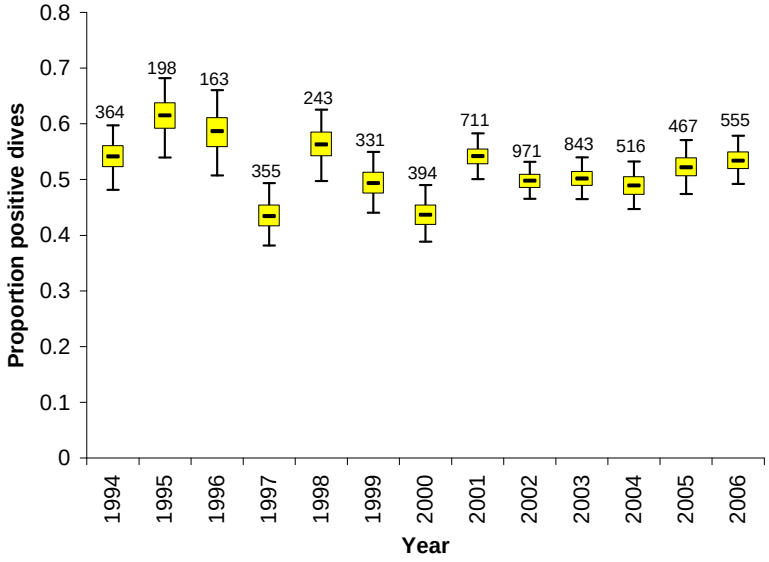


Figure 3. Negative log likelihoods associated with different critical values from the Stephens and MacCall logistic regression method of selecting REEF dives that could have caught mutton snapper (a) and the proportion of positive dives by year. The variability was simulated with Monte Carlo technique that generated 1000 estimates per year. The vertical line is the 95% confidence interval, the box is the inter-quartile range (50% of the outcomes were in the box), the horizontal line is the median, and the number above the symbol is the number of dives during that year.

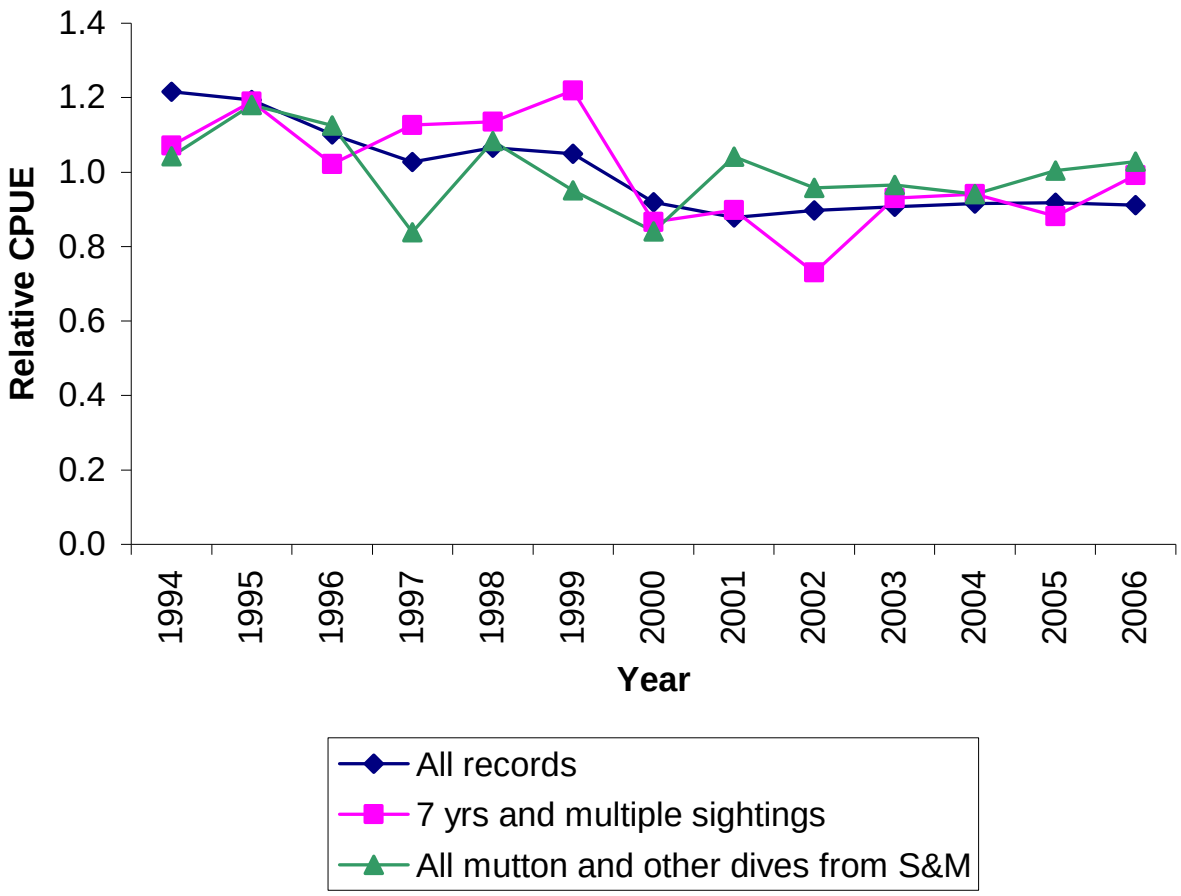


Figure 4. Comparison of the proportion of positive dives by year from three groupings of REEF dive surveys for mutton snapper along the Atlantic coast of Florida including the Dry Tortugas. The indices have been scaled to their respective means.