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Recreational catch rates for mutton snapper, *Lutjanus analis* in the Southeast United States from the Marine Recreational Fisheries Statistics Survey and the Headboat Logbook Program.

Robert G. Muller
Research Scientist
Fish and Wildlife Research Institute
Florida Fish and Wildlife Conservation Commission
St. Petersburg, FL

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Introduction

Maunder and Punt (2004) recently reviewed the literature on standardizing catch rates. Traditionally, catch rates are considered to reflect the underlying trends in abundance; in other words, catchability is assumed to be constant relating the catch rate to the underlying abundance. Simply put

$$C = F\overline{N} \tag{1}$$

and

$$F = qE \tag{2}$$

substituting Eq. 2 into Eq. 1 gives

$$C = qE\overline{N} \tag{3}$$

dividing Eq. 3 by E gives

$$\frac{C}{E} = q\overline{N} \tag{4}$$

where *C* is catch, *F* is fishing mortality, $\overline{N}$, is the average abundance, *q* is the catchability and *E* is effort. However, catchability may vary with season, location, life stage, fishing methods, etc. and so catch rates are standardized in the attempt to remove or reduce the factors influencing catchability. The recreational indices calculated here used generalized linear models (GLIM) 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 recreational catch rates, I chose the Poisson distribution because the catches were in numbers of fish.

Methods

The National Marine Fisheries Service has two programs that collect catch rate information on the recreational fisheries in the Southeast US. These programs are the Marine Recreational Fisheries Statistics Survey (MRFSS) and the Headboat Logbook Program (HB). The MRFSS uses a two-stage, stratified sampling approach to estimate what anglers catch and discard. One stage uses a telephone survey to estimate the number of angling trips by stratum and in the other stage interviewers intercept anglers at docks, bridges, beaches, boat ramps, etc. to characterize what anglers catch. The HB is a log of the number of trips, anglers, and catches that the headboat captains submit monthly to NMFS's Beaufort Laboratory. For both sources of recreational information, I only included trips from the core region of the recreational mutton snapper fishery which is in Southeast Florida from Martin through Monroe counties for MRFSS and areas headboat 11 and 12.

Marine Recreational Fisheries Statistics Survey

FWC Fishery Dependent Monitoring program downloaded MRFSS databases from the MRFSS ftp site, ftp://cusk.nmfs.noaa.gov/mrfss/intercept/ag/. The MRFSS interview sites for sampling are drawn randomly by stratum (sub-region, state, year, two-month wave, fishing mode (shore, charterboat, and private/rental boats), and area (estuary or bay, state waters three miles or less offshore, or federal waters three miles or more on the Atlantic coast)). Samplers visit these sites, intercept anglers, examine their catch, and inquire as to whether there were any other fish that the angler caught that were not available to the sampler. MRFSS categorizes the catch in three ways: the fish that the sampler could examine and measure (Type A fish), the fish that were unavailable but were not discarded alive (Type B1 fish) and the fish that were discarded alive (Type B2). This breakdown is useful for determining the efficacy of regulations; however, the total number of fish per interview is the appropriate measure for catch rate because it is less sensitive to regulatory changes. Although MRFSS began in 1979, there was a change beginning in 1981 such that the data from the first two years do not have the same variables for estimating the catch as do the later years and so the recreational time series begins in 1981. Beginning in 1991, MRFSS included a party code to link the ancillary interviews from multiple anglers on the same trip into a single interview. Another addition at that time was the field for the number of anglers fishing on that trip.

Interviews were selected for analysis if anglers reported catching mutton snapper on the trip or if the anglers told the interviewers that they were targeting mutton snapper. Prior to 1986, there were usually less than 10 interviews per year that caught or targeted mutton snapper and so the interviews from these early years were excluded.

Catch rates were calculated two ways from the MRFSS data: an index using data from 1986 to 2006 using trips with a single angler. The data from 2006 is considered preliminary at this time. Another index was developed using data from 1991 to 2006 with the associated interviews collapsed using the party code. The response variable for catch rates was the total number of fish caught, including discards, per trip and these were standardized with a GLIM. Because catch is reported in numbers of fish, I used a Poisson distribution for the error structure of the catch rates with a log link function. Potential explanatory variables in the GLIM were year, two-month wave, fishing mode, area, county, hours fished, number of anglers (only in the second index), and avidity (number of trips in the past 60 days). All of these variables were treated as categorical and hours fished , number of anglers, and avidity had plus groups (8+, 4+, and 10+ respectively based on their catch rates). The stepwise process compared the change in mean deviance (deviance/degrees of freedom) for each of the variables against the mean deviance of the null model. The variable that accounted for the greatest reduction in mean deviance was selected provided that the variable was statistically significant in the model based on its log-likelihood. Typically, all of the variables are statistically significant because the numbers of observations are so large. Maunder and Punt (2004) recommend selecting a cutoff value for the change in mean deviance reduction before the analysis begins. In this case I chose 0.5% based on the recommendation of a CIE reviewer for yellowtail snapper (SEDAR 03). After the first variable had been selected, GLIM runs of this first variable with each of remaining variables were run and these results were checked for the amount of mean deviance reduced and whether the variable was significant. The process was repeated until the remaining variables no longer reduced the mean deviance by at least 0.5% or were not statistically significant at the 0.05 level. To determine the annual values and the variability surrounding the index, the annual least-square means on the link scale were estimated and a Monte Carlo simulation used those least-square means and their standard errors together with random normal deviates to calculate 1000 new estimates in the log scale which were back-transformed.

Headboat logbook

In 1974, the Headboat logbook program began in North Carolina and expanded into Florida's Atlantic coast in June 1978. In this program, headboat captains send in logbook forms that list the vessel, trips, date of the trips, the type of trip (half day morning, half day night, three-quarter day trips, and full day trips), the area fished (I only used Ft. Pierce - Miami (Area 11) and Key Largo - Key West (Area 12)), the fish caught on each trip by species, the weight of the catch by species, and the number of anglers. Beginning in 2005, headboat operators began supplying the number of fish discarded alive or dead. Multi-day trips accounted for less than 1% of the headboat trips and they mostly came from the Dry Tortugas area and these trips were excluded from further analyses. Similarly, the lat-long field was subset to those trips from Southeast Florida: 2480, 2481, 2482, 2580,2680, 2679, and 2780. The number of anglers was treated as categorical data and in 10-angler bins. Rarely were there more than 69 anglers on a trip (0.5% of the trips) and so the 60-69 category became the 60 + category.

Because headboat discards were not reported until 2005 and the index is sensitive to changes in minimum size, the Data Workshop recommended developing two indices with these data: one for the period prior to the implementation of the 12-inch minimum size in the South Atlantic, 1979-1991 and another for the period after the 16-inch minimum size was implemented in January 1995. Because of the brevity of the time period with the 12-inch minimum size limit, 1992-1994, a separate index for that time period was not developed.

Estimating total headboat effort for mutton snapper is a challenge because mutton snapper are frequently taken with other species and there could easily be trips that were in an appropriate area for mutton snapper but no angler on the headboat caught one (this a zero trip that should be included in the analysis even though no mutton snapper were caught). A zero trip could also occur if the headboat was fishing in areas where there was no possibility of catching mutton snapper but these zero trips should be excluded from the analyses. Stephens and MacCall (2004) developed a logistic regression method to distinguish between these two types of zero trips based on the species composition of the catches. They recommend using presence/absence data to avoid any abundance trends in the other species. To narrow the analyses a little, I excluded any species which did not occur on at least 1% of the trips. This was the working species list. For each of the headboat trips, I determined the presence or absence of each species on the working species list including mutton snapper. The logistic regression then used mutton snapper as the dependent variable and the other species as the independent variables as the full model. Any species with a coefficient that was not statistically significant at the 0.05 level was excluded from the analyses. Sometimes the regression was repeated because a species was significant but not significant after the regression was rerun with just the subset of significant species. Using the equation from the final logistic regression, I calculated a probability of each trip being a mutton snapper trip. Stephens and MacCall gave a maximum likelihood method to select a critical value that minimized the number of false-positive trips and the false-negative trips. Thus, trips included in the catch rate analyses were the trips that caught mutton snapper plus the trips that met or exceeded the critical value from the regression. Some people have argued for only using the trips identified by the regression but that excludes many trips that actually had mutton snapper. The intent of this step was to attempt to more fully identify the mutton snapper effort and it did not seem reasonable to exclude many trips that caught mutton snapper.

Once the headboat trips were identified, the catch rates were calculated in a stepwise GLIM similar to the MRFSS catch rates. The response variable was the number of fish caught per trip using a Poisson distribution and a log link function. The potential explanatory variables that could have an impact on catchability were year, month, trip category, number of anglers, area, and lat-long. The hours fished were not explicitly included in the model because they depended on the trip type.

Results

Marine Recreational Fisheries Statistics Survey

The MRFSS users manual (VanVorhees and Kline 1993) recommends calculating catch rates using only interviews with a single angler to avoid treating ancillary interviews as independent interviews. There were 1,998 interviews from the time period 1986 to 2006 with a single angler. The variable, year, reduced the mean deviance by 10.4% and the final model reduced the mean deviance by 17.0% (Table 1). The catch rate of mutton snapper was less than one fish per interview (trip) from 1986 until 1990 and then there was what appears to be an abnormally high cluster of years, 1991 through 1993, followed by a drop in 1994 and then a general, albeit variable, increase afterwards (Figure 1, Table 2). However, the medians for the period, 1991-2006 varied without trend (t-test for slope equal zero, $t = 0.61$, $df = 14$, $P = 0.55$).

The second index used data from 1991-2006 and the ancillary interviews were combined by the party code. There were 3,489 combined interviews. In this analysis, year also reduced the mean deviance the most followed the number of anglers, area, and so on but the final model explained only 8.3% of the total deviance (Table 3). As with the catch rates from the longer time series, the catch rates have been increasing since 1994 (Figure 2, Table 2). Since these two indices were correlated (r = 0.69, df = 14, P < 0.05) in the years that they overlapped, the recommendation is to go with the longer time series. As with the other MRFSS index, the medians from the MRFSS data for the time period, 1991-2006, also varied without trend (t-test for slope equal zero, t = 1.54, df = 14, P = 0.14).

Headboat logbook

For the 1979-91 time period prior to the implementation of the 12-inch minimum size (305 mm TL), there were 94,335 unique headboat trips and 38,160 of those trips caught mutton snapper. The question was should all 56,175 zero trips be included in calculating catch rates with the underlying assumption that the headboats were always fishing in areas that could have caught mutton snapper or should some of them be excluded because the headboats were fishing at location where mutton snapper did not occur? Anglers on headboats caught 222 species but only 52 species occurred on at least 1% of the trips. Thirty-seven species had coefficients in the logistic regression that were statistically significant at the 0.05 level (Figure 3)and this final equation was used to calculate the probability of each trip being a mutton snapper trip. The maximum likelihood profile indicated that the critical value was 0.467 (Figure 4). The Stephens and MacCall's method for distinguishing zero trips reduced the number of zero trips from 56,175 to 14,099 trips and with the 38,160 mutton snapper trips there was a total of 52,259 trips used to calculate the catch rates. If only the critical value was used and the actual catch of mutton snapper was ignored, then the analyses would have used a total of 35,088 trips of which 20,988 trips would have caught mutton snapper. Doing so would have excluded 17,181 headboat trips (45%) with mutton snapper reported.

As with MRFSS, the GLIM identified year as the variable that reduced the mean deviance the most followed by month and trip type. The model reduced the mean deviance by 6.6% (Table 4). The catch rates (Table 2) look like a wave with the crests at 1980 and 1990 and the trough in 1983-87 with narrow error bars because of the large sample size each year (Figure 5). Like the MRFSS index, there was no trend in the catch rates (t-test for slope equal zero, t = -0.18, df = 11, P = 0.86).

In the latter period with the 16-inch minimum size (406 mm TL), 1995-2006, there were 25,748 headboat trips and the captains reported that anglers had caught mutton snapper on 7,630 trips. Anglers caught a total of 155 species but only 55 species were caught on 1% or more of the trips. Thirty-two species had coefficients in the logistic regression on mutton snapper that were statistically significant at the 0.05 level (Figure 6). The maximum likelihood profile indicated that the critical value was 0.373 (Figure 7). Therefore the catch rate analysis included the 7,630 trips that caught mutton snapper during this period and another 3,513 trips that could have caught mutton snapper for a total of 11,143 trips. Again, if we had just used the critical value to select trips, then we would have only used 6590 trips of which 3028 trips would have caught mutton snapper.

The GLIM model reduced the mean deviance by 10.6% and the selected variables were year, month, trip type, and number of anglers (Table 5). The shape of the catch rates (Table 2) was sigmoid with high sections at 1995 and 2001-2003 (Figure 8). The lowest value was in 1999 and the highest was in 2005; however, 2006 was down. As with the earlier period, the overall trend was flat (t-test for slope equal zero, t = 1.16, df = 10, P = 0.27).

All of the indices are plotted together in Figure 9 for comparison. The 1986-1990 values from MRFSS seem abnormally low as if there was a change in sampling.

Literature Cited

Maunder, M. N. and A. E. Punt. 2004. Standardizing catch and effort data: a review of recent approaches. Fisheries Research 70:141-159.

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 Marine Recreational Fisheries Statistics Survey's catch rates in terms of total number of fish per interview for the period, **1986-2006**, from interviews with a single angler. 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	1997	4784.252	2.3957				-1741.81				
Year	1977	4245.603	2.1475	0.2482	10.36%	10.36%	-1472.49	-269.32	538.65	20	0.0000
Wave	1992	4743.179	2.3811	0.0146	0.61%		-1721.28	-20.54	41.07	5	0.0000
Mode_fx	1996	4763.109	2.3863	0.0094	0.39%		-1731.24	-10.57	21.14	1	0.0000
Area_x	1995	4761.015	2.3865	0.0092	0.38%		-1730.19	-11.62	23.24	2	0.0000
Cnty	1993	4532.680	2.2743	0.1214	5.07%		-1616.03	-125.79	251.57	4	0.0000
Num_hrsf	1990	4695.940	2.3598	0.0359	1.50%		-1697.66	-44.16	88.31	7	0.0000
Avidity	1987	4644.522	2.3375	0.0582	2.43%		-1671.95	-69.86	139.73	10	0.0000
With year											
Wave	1972	4220.877	2.1404	0.0071	0.30%		-1460.12	-12.36	24.73	5	0.0002
Mode_fx	1976	4244.867	2.1482	-0.0007	-0.03%		-1472.12	-0.37	0.74	1	0.3908
Area_x	1975	4229.191	2.1414	0.0061	0.25%		-1464.28	-8.21	16.41	2	0.0003
Cnty	1973	4101.256	2.0787	0.0688	2.87%	13.23%	-1400.31	-72.17	144.35	4	0.0000
Num_hrsf	1970	4160.604	2.1120	0.0355	1.48%		-1429.99	-42.50	85.00	7	0.0000
Avidity	1967	4148.126	2.1089	0.0386	1.61%		-1423.75	-48.74	97.48	10	0.0000
With year and cnty											
Wave	1968	4078.153	2.0722	0.0065	0.27%		-1388.76	-11.55	23.10	5	0.0003
Mode_fx	1972	4068.643	2.0632	0.0155	0.65%		-1384.01	-16.31	32.61	1	0.0000
Area_x	1971	4051.287	2.0554	0.0233	0.97%		-1375.33	-24.98	49.97	2	0.0000
Num_hrsf	1966	4026.217	2.0479	0.0308	1.29%		-1362.79	-37.52	75.04	7	0.0000
Avidity	1963	4005.306	2.0404	0.0383	1.60%	14.83%	-1352.34	-47.98	95.95	10	0.0000

Table 1 continued. The stepwise selection process of identifying variables described in the text to include in the Generalized Linear Model for the Marine Recreational Fisheries Statistics Survey's catch rates in terms of total number of fish per interview for the period, **1986-2006**, from interviews with a single angler . 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
With year, cnty, and avidity											
Wave	1958	3982.986	2.0342	0.0062	0.26%		-1341.18	-11.16	22.32	5	0.0005
Mode_fx	1962	3987.158	2.0322	0.0082	0.34%		-1343.26	-9.07	18.15	1	0.0000
Area_x	1961	3957.679	2.0182	0.0222	0.93%		-1328.53	-23.81	47.63	2	0.0000
Num_hrsf	1956	3934.746	2.0116	0.0288	1.20%	16.03%	-1317.06	-35.28	70.56	7	0.0000
With year, cnty, avidity, and num_hrsf											
Wave	1951	3913.314	2.0058	0.0058	0.24%		-1306.34	-10.72	21.43	5	0.0007
Mode_fx	1955	3915.179	2.0026	0.0090	0.38%		-1307.28	-9.78	19.57	1	0.0000
Area_x	1954	3884.776	1.9881	0.0235	0.98%	17.01%	-1292.07	-24.99	49.97	2	0.0000
With year, cnty, avidity, num_hrsf, and area_x											
Wave	1949	3865.148	1.9831	0.0050	0.21%		-1282.26	-9.81	19.63	5	0.0015
Mode_fx	1953	3867.995	1.9805	0.0076	0.32%		-1283.68	-8.39	16.78	1	0.0000

Table 2. Recreational fishery catch per unit effort indices from the Marine Recreational Fisheries Statistics Survey and the headboat logbook. The longer time series, 1986-2006, of MRFSS data only includes trips with a single angler and the shorter time series, 1991-2006, where the ancillary interviews can be linked back to a primary interview for the trip. Because headboat entries are only successful trips, the index was broken where the minimum size changed. The first headboat time series, 1979-1991, preceded the 12-inch minimum size and the second time series was after the 16-inch minimum size was implemented in Southeast Florida. The second set of indices in the table are the indices scaled to their means to facilitate comparisons.

	Number of fish per trip				Scaled to mean			
Year	MRFSS 1986-2006	MRFSS 1991-2006	Headboat 1979-91	Headboat 1995-2006	MRFSS 1986-2006	MRFSS 1991-2006	Headboat 1979-1991	Headboat 1995-2006
1979			2.00				0.87	
1980			2.97				1.30	
1981			3.21				1.41	
1982			2.25				0.99	
1983			1.96				0.86	
1984			1.59				0.70	
1985			2.12				0.93	
1986	0.72		1.73		0.43		0.76	
1987	0.91		1.83		0.54		0.80	
1988	0.94		2.32		0.56		1.01	
1989	0.74		2.50		0.44		1.09	
1990	0.55		3.09		0.33		1.35	
1991	1.85	1.25	2.13		1.10	0.84	0.93	
1992	2.22	1.63			1.32	1.09		
1993	2.39	1.87			1.43	1.25		
1994	1.72	1.17			1.03	0.78		
1995	1.39	1.29		2.20	0.83	0.86		1.09
1996	1.59	0.93		1.80	0.95	0.62		0.89
1997	1.88	1.40		1.67	1.12	0.93		0.83
1998	2.19	1.73		1.96	1.31	1.15		0.97
1999	1.33	1.48		1.36	0.79	0.99		0.67
2000	2.04	1.47		1.45	1.22	0.98		0.72
2001	2.52	1.71		2.54	1.51	1.14		1.26
2002	1.94	1.32		2.22	1.16	0.88		1.10
2003	1.93	1.58		2.46	1.15	1.06		1.22
2004	1.74	1.43		1.97	1.04	0.95		0.98
2005	2.90	1.94		2.89	1.73	1.29		1.43
2006	1.70	1.78		1.70	1.01	1.19		0.84

Table 3. The stepwise selection process of identifying variables described in the text to include in the Generalized Linear Model for the Marine Recreational Fisheries Statistics Survey's catch rates in terms of total number of fish per interview for the period, **1991-2006**. 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	3488	7754.462	2.2232				-2021.33				
Year	3473	7542.912	2.1719	0.0513	2.31%	2.31%	-1915.55	-105.77	211.55	15	0.0000
Wave	3483	7665.030	2.2007	0.0225	1.01%		-1976.61	-44.72	89.43	5	0.0000
Mode_fx	3486	7632.296	2.1894	0.0338	1.52%		-1960.25	-61.08	122.17	2	0.0000
Area_x	3484	7666.760	2.2006	0.0226	1.02%		-1977.48	-43.85	87.70	4	0.0000
Cnty	3484	7678.773	2.2040	0.0192	0.86%		-1983.49	-37.84	75.69	4	0.0000
Num_hrsf	3481	7626.495	2.1909	0.0323	1.45%		-1957.35	-63.98	127.97	7	0.0000
Party	3483	7567.472	2.1727	0.0505	2.27%		-1927.83	-93.50	186.99	5	0.0000
Avidity	3478	7686.421	2.2100	0.0132	0.59%		-1987.31	-34.02	68.04	10	0.0000
With year											
Wave	3468	7474.251	2.1552	0.0167	0.75%		-1881.22	-34.33	68.66	5	0.0000
Mode_fx	3471	7433.030	2.1415	0.0304	1.37%		-1860.61	-54.94	109.88	2	0.0000
Area_x	3469	7420.910	2.1392	0.0327	1.47%		-1854.55	-61.00	122.00	4	0.0000
Cnty	3469	7474.483	2.1547	0.0172	0.77%		-1881.34	-34.21	68.43	4	0.0000
Num_hrsf	3466	7430.786	2.1439	0.0280	1.26%		-1859.49	-56.06	112.13	7	0.0000
Party	3468	7389.858	2.1309	0.0410	1.84%	4.15%	-1839.03	-76.53	153.05	5	0.0000
Avidity	3463	7480.070	2.1600	0.0119	0.54%		-1884.13	-31.42	62.84	10	0.0000
With year and party											
Wave	3463	7329.762	2.1166	0.0143	0.64%		-1808.98	-30.05	60.10	5	0.0000
Mode_fx	3466	7354.627	2.1219	0.0090	0.40%		-1821.41	-17.62	35.23	2	0.0000
Area_x	3464	7267.485	2.0980	0.0329	1.48%	5.63%	-1777.84	-61.19	122.37	4	0.0000
Cnty	3464	7343.400	2.1199	0.0110	0.49%		-1815.80	-23.23	46.46	4	0.0000
Num_hrsf	3461	7296.334	2.1082	0.0227	1.02%		-1792.27	-46.76	93.52	7	0.0000
Avidity	3458	7332.020	2.1203	0.0106	0.48%		-1810.11	-28.92	57.84	10	0.0000

Table 3 continued. The stepwise selection process of identifying variables described in the text to include in the Generalized Linear Model for the Marine Recreational Fisheries Statistics Survey's catch rates in terms of total number of fish per interview for the period, 1991-2006. 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
With year, party, and area_x											
Wave	3459	7209.320	2.0842	0.0138	0.62%		-1748.76	-29.08	58.16	5	0.0000
Mode_fx	3462	7229.463	2.0882	0.0098	0.44%		-1758.83	-19.01	38.02	2	0.0000
Cnty	3460	7242.262	2.0931	0.0049	0.22%		-1765.23	-12.61	25.22	4	0.0000
Num_hrsf	3457	7177.421	2.0762	0.0218	0.98%	6.61%	-1732.81	-45.03	90.06	7	0.0000
Avidity	3454	7208.709	2.0871	0.0109	0.49%		-1748.45	-29.39	58.78	10	0.0000
With year, party, area_x, and num_hrsf											
Wave	3452	7115.427	2.0612	0.0150	0.67%	7.29%	-1701.81	-31.00	61.99	5	0.0000
Mode_fx	3455	7134.290	2.0649	0.0113	0.51%		-1711.24	-21.57	43.13	2	0.0000
Cnty	3453	7156.613	2.0726	0.0036	0.16%		-1722.41	-10.40	20.81	4	0.0003
Avidity	3447	7119.458	2.0654	0.0108	0.49%		-1703.83	-28.98	57.96	10	0.0000
With year, party, area_x, num_hrsf, and wave											
Mode_fx	3450	7071.116	2.0496	0.0116	0.52%	7.81%	-1679.66	-22.16	44.31	2	0.0000
Cnty	3448	7098.373	2.0587	0.0025	0.11%		-1693.29	-8.53	17.05	4	0.0019
Avidity	3442	7054.034	2.0494	0.0118	0.53%		-1671.12	-30.70	61.39	10	0.0000
With year, party, area_x, num_hrsf, wave, and mode_fx											
Cnty	3446	7055.017	2.0473	0.0023	0.10%		-1671.61	-8.05	16.10	4	0.0029
Avidity	3440	7010.623	2.0380	0.0116	0.52%	8.33%	-1649.41	-30.25	60.49	10	0.0000
With year, party, area_x, num_hrsf, wave, mode_fx, and avidity											
Cnty	3436	6995.522	2.0359	0.0021	0.09%		-1641.86	-7.55	15.10	4	0.0045

Table 4. The stepwise selection process of identifying variables described in the text to include in the Generalized Linear Model for the headboat's catch rates in terms of number of fish caught per trip for the period: **1979-1991**. 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	52258	167125.7	3.1981				-24369.73				
Year	52246	162103.2	3.1027	0.0954	2.98%	2.98%	-21858.45	-2511.27	5022.54	12	0.0000
Month	52247	163037.4	3.1205	0.0776	2.43%		-22325.54	-2044.18	4088.37	11	0.0000
Num_angl	52252	166745.4	3.1912	0.0069	0.22%		-24179.58	-190.15	380.29	6	0.0000
Trip type	52254	165707.3	3.1712	0.0269	0.84%		-23660.51	-709.22	1418.44	4	0.0000
Area	52257	166981.6	3.1954	0.0027	0.08%		-24297.66	-72.07	144.13	1	0.0000
Lat-Long	52252	166489.3	3.1863	0.0118	0.37%		-24051.49	-318.24	636.47	6	0.0000
With year											
Month	52235	157850.9	3.0219	0.0808	2.53%	5.51%	-19732.32	-2126.13	4252.26	11	0.0000
Num_angl	52240	161740.3	3.0961	0.0066	0.21%		-21677.03	-181.42	362.85	6	0.0000
Trip type	52242	160392.9	3.0702	0.0325	1.02%		-21003.31	-855.15	1710.30	4	0.0000
Area	52245	161951.2	3.0998	0.0029	0.09%		-21782.49	-75.97	151.93	1	0.0000
Lat-Long	52240	161515.3	3.0918	0.0109	0.34%		-21564.51	-293.94	587.89	6	0.0000
With year and month											
Num_angl	52229	157264.9	3.0111	0.0108	0.34%		-19439.30	-293.02	586.05	6	0.0000
Trip type	52231	156077.9	2.9882	0.0337	1.05%	6.56%	-18845.83	-886.49	1772.97	4	0.0000
Area	52234	157628.9	3.0177	0.0042	0.13%		-19621.30	-111.02	222.04	1	0.0000
Lat-Long	52229	157159.2	3.0090	0.0129	0.40%		-19386.47	-345.85	691.69	6	0.0000
With year, month, and trip type											
Num_angl	52225	155482.8	2.9772	0.0110	0.34%		-18548.27	-297.57	595.13	6	0.0000
Area	52230	156074.9	2.9882	0.0000	0.00%		-18844.34	-1.50	2.99	1	0.0835
Lat-Long	52225	155683.1	2.9810	0.0072	0.23%		-18648.42	-197.42	394.83	6	0.0000

Table 5. The stepwise selection process of identifying variables described in the text to include in the Generalized Linear Model for the headboat's catch rates in terms of number of fish caught per trip for the period: **1995-2006**. 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	11143	37389.15	3.3557				-8893.00				
Year	11132	36758.78	3.3024	0.0533	1.59%		-8577.81	-315.19	630.37	11	0.0000
Month	11132	36352.15	3.2658	0.0899	2.68%		-8374.50	-518.50	1037.01	11	0.0000
Num_angl	11137	37106.72	3.3321	0.0236	0.70%		-8751.79	-141.21	282.43	6	0.0000
Trip type	11139	36100.60	3.2412	0.1145	3.41%	3.41%	-8248.73	-644.28	1288.55	4	0.0000
Area	11142	37358.03	3.3532	0.0025	0.07%		-8877.44	-15.56	31.13	1	0.0000
Lat-Long	11137	36932.69	3.3165	0.0392	1.17%		-8664.77	-228.23	456.47	6	0.0000
With trip type											
Year	11128	35379.31	3.1796	0.0616	1.84%		-7888.08	-360.65	721.29	11	0.0000
Month	11128	35244.81	3.1675	0.0737	2.20%		-7820.83	-427.90	855.80	11	0.0000
Num_angl	11133	35717.37	3.2085	0.0327	0.97%		-8057.11	-191.62	383.23	6	0.0000
Area	11138	36076.68	3.2394	0.0018	0.05%		-8236.76	-11.96	23.92	1	0.0000
Lat-Long	11133	35176.06	3.1599	0.0813	2.42%	5.83%	-7786.45	-462.27	924.55	6	0.0000
With trip type and lat-long											
Year	11122	34586.82	3.1100	0.0499	1.49%		-7491.84	-294.62	589.23	11	0.0000
Month	11122	34305.56	3.0848	0.0751	2.24%	8.07%	-7351.20	-435.25	870.50	11	0.0000
Num_angl	11127	34784.03	3.1264	0.0335	1.00%		-7590.44	-196.01	392.02	6	0.0000
Area	11132	35175.42	3.1601	-0.0002	-0.01%		-7786.13	-0.32	0.64	1	0.4239
With trip type, lat-long, and month											
Year	11111	33741.17	3.0370	0.0478	1.42%	9.50%	-7069.01	-282.20	564.39	11	0.0000
Num_angl	11116	33854.54	3.0458	0.0390	1.16%		-7125.69	-225.51	451.03	6	0.0000
Area	11121	34305.40	3.0850	-0.0002	-0.01%		-7351.12	-0.08	0.16	1	0.6859
With trip type, lat-long, month, and year											
Num_angl	11105	33320.72	3.0008	0.0362	1.08%	10.58%	-6858.78	-210.22	420.45	6	0.0000
Area	11110	33740.32	3.0372	-0.0002	-0.01%		-7068.58	-0.43	0.86	1	0.3549

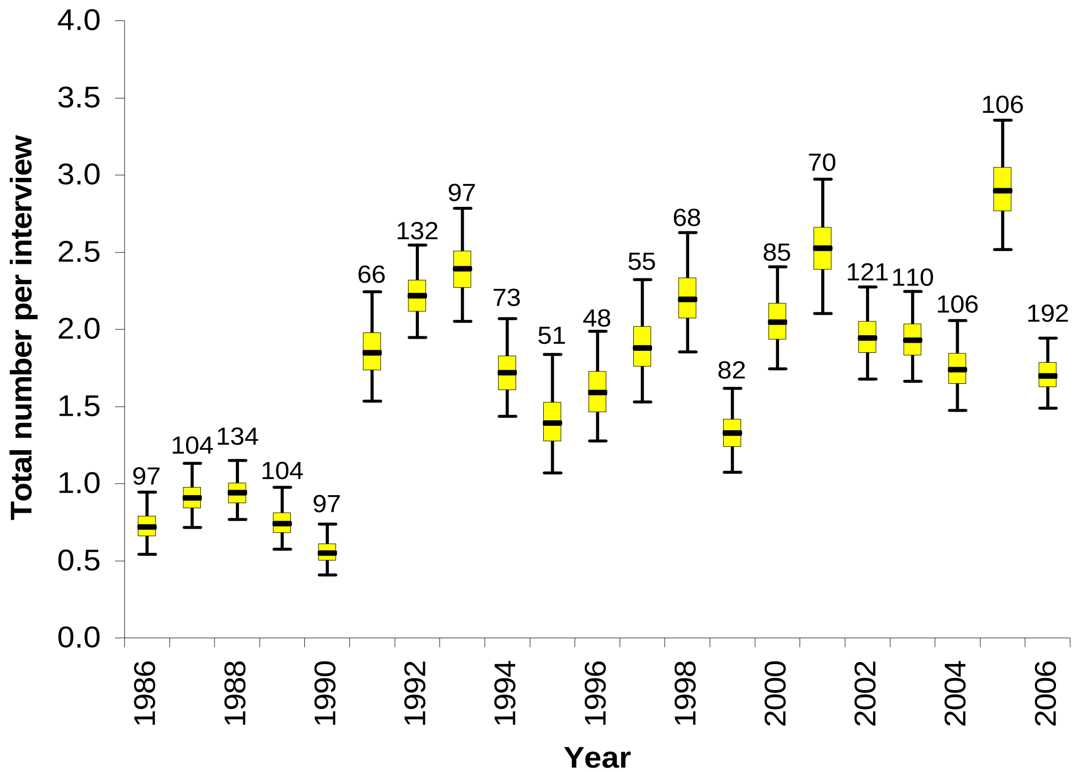

Figure 1. The Marine Recreational Fisheries Statistics Survey's standardized annual catch rates of mutton snapper in the total number of fish per interview including discards from those trips with a single angler in southeast Florida. The vertical bar is the 95% confidence interval, the box is the inter-quartile range (50% of the outcomes), and the horizontal line is the median. The numbers above the figures are the number of interviews for that year.

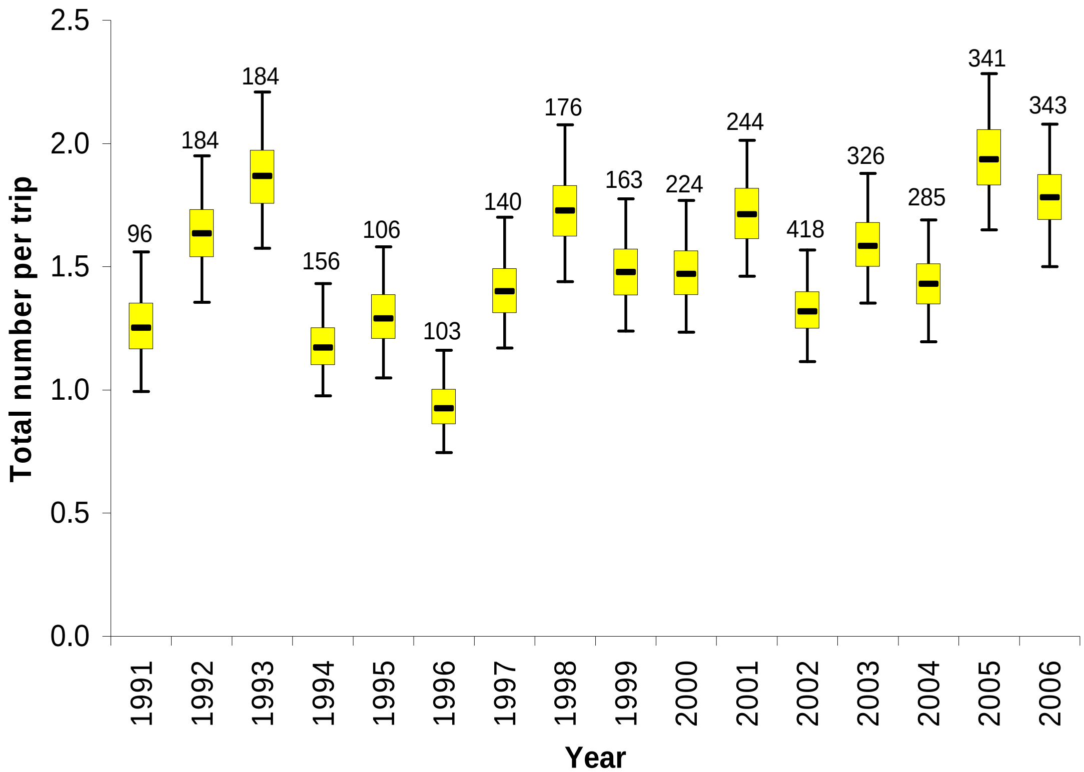

Figure 2. The Marine Recreational Fisheries Statistics Survey's standardized annual catch rates in the total number of fish per interview including discards from those trips that caught or targeted mutton snapper in southeast Florida.. The vertical bar is the 95% confidence interval, the box is the inter-quartile range (50% of the outcomes), and the horizontal line is the median. The numbers above the figures are the number of interviews for that year.

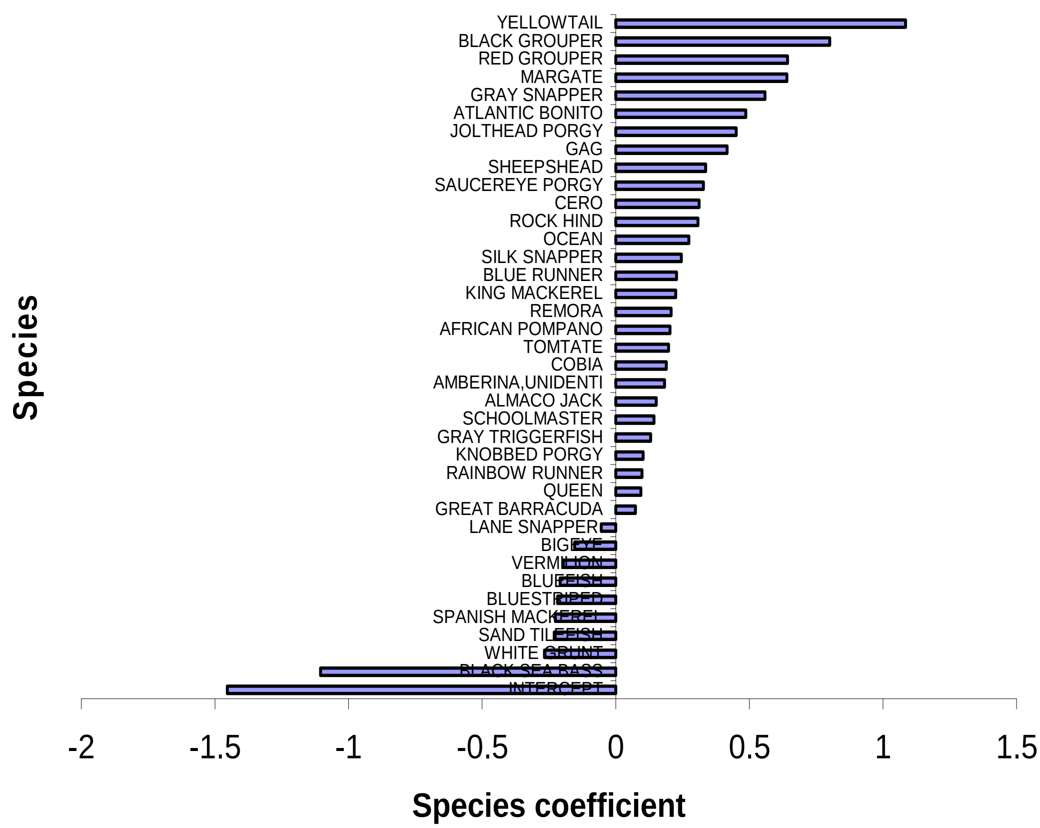

Figure 3. The species and their coefficients that were statistically significant in determining whether a trip should be considered a mutton snapper trip in the 1979-1991 time period.

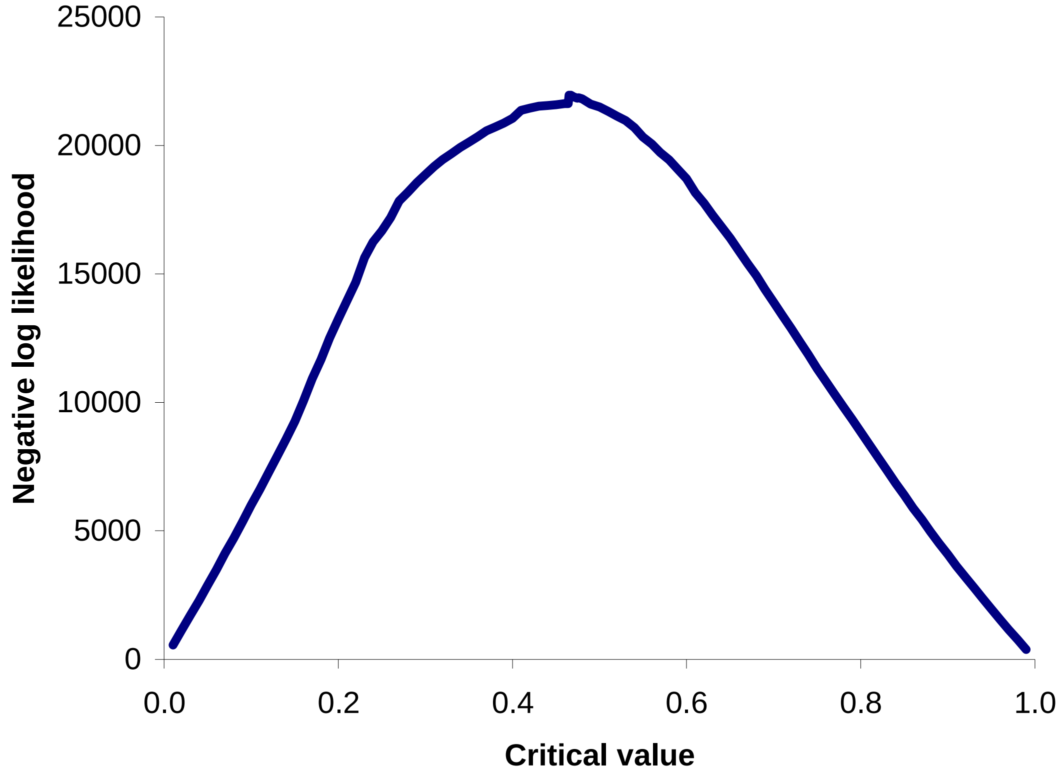

Figure 4. Negative log-likelihood profile for the critical value to identify which trips to include in the mutton snapper catch rate analyses for the 1979-91 time period.

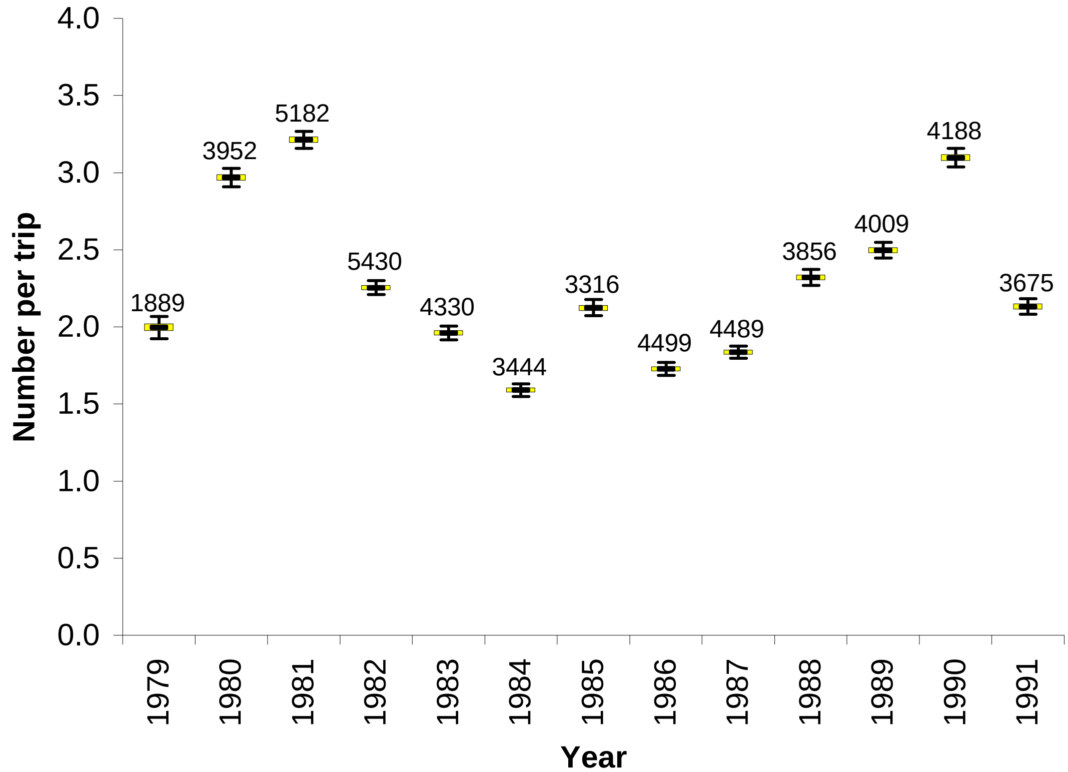

Figure 5. The headboat logbook's standardized annual catch rates for 1979-1991 from southeast Florida in the number of fish caught per trip from those trips that caught mutton snapper or had probability of catching mutton snapper greater or equal to the critical value of 0.467. The vertical bar is the 95% confidence interval, the box is the inter-quartile range (50% of the outcomes), and the horizontal line is the median. The numbers above the figures are the number of interviews for that year.

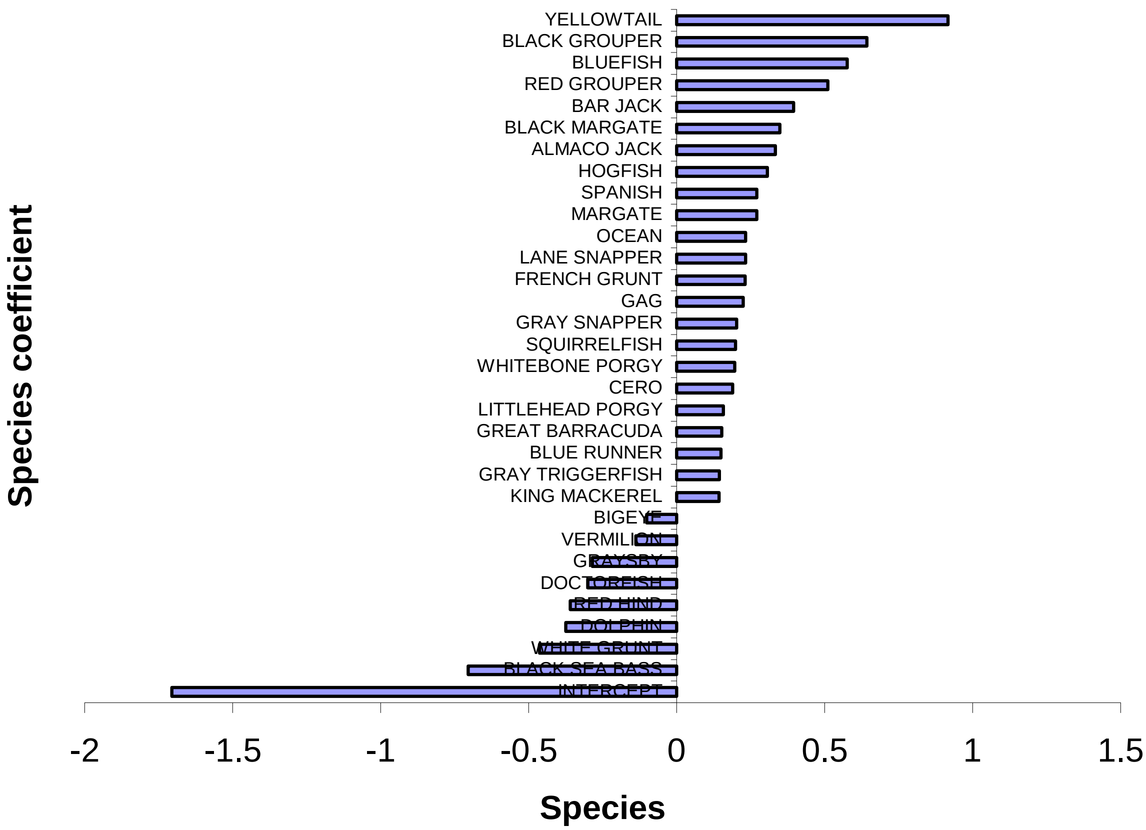

Figure 6. The species and their coefficients that were statistically significant in determining whether a trip should be considered a mutton snapper trip in the 1995-2006 time period.

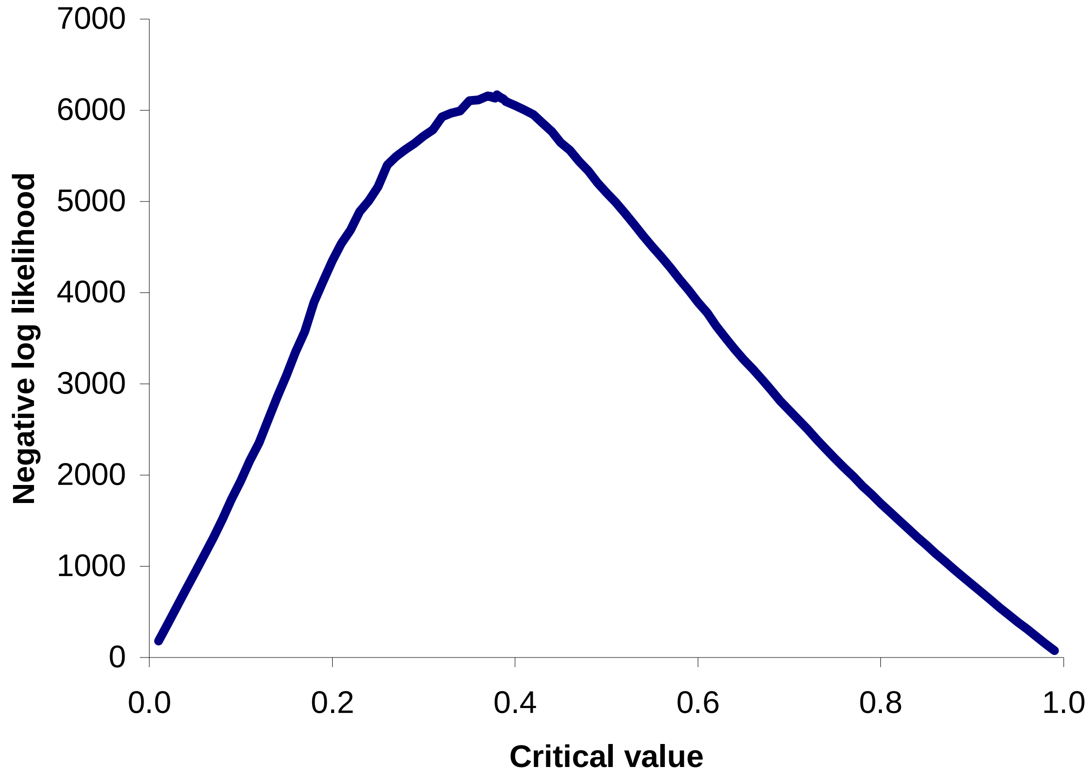

Figure 7. Negative log-likelihood profile for the critical value to identify which trips to include in the mutton snapper catch rate analyses for the 1995-2006 time period.

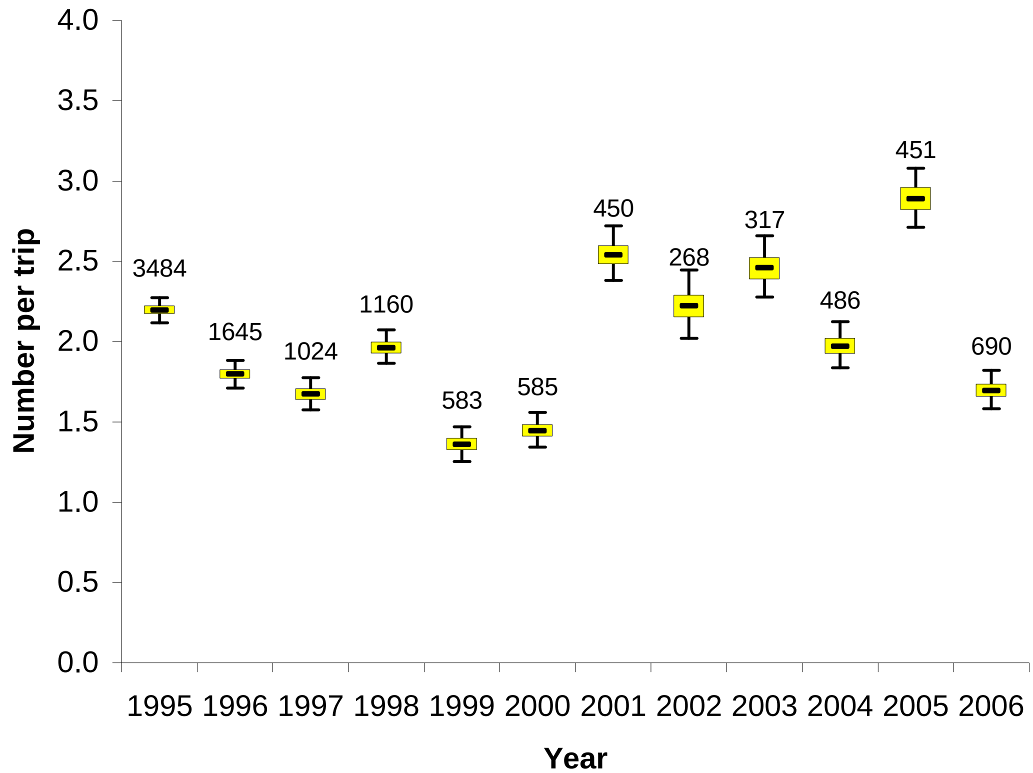

Figure 8. The headboat logbook's standardized annual catch rates for 1995-2006 from southeast Florida in the number of fish caught per trip from those trips that caught mutton snapper or had probability of catching mutton snapper greater or equal to the critical value of 0.373. The vertical bar is the 95% confidence interval, the box is the inter-quartile range (50% of the outcomes), and the horizontal line is the median. The numbers above the figures are the number of interviews for that year.

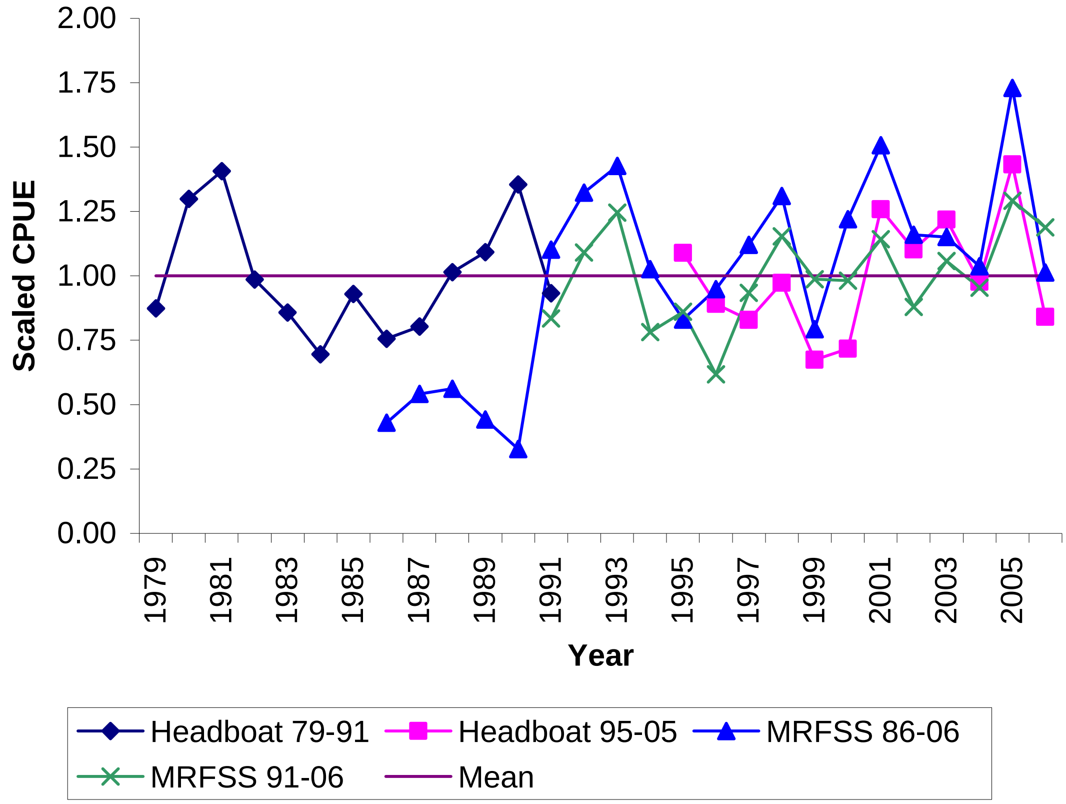

Figure 9. A comparison of the different recreational indices using the values that were scaled to their respective means.