STANDARDIZED CATCH RATE INDICES FOR VERMILION SNAPPER (*RHOMBOPLITES AURORUBENS*) LANDED DURING 1986-2004 BY THE U.S. GULF OF MEXICO RECREATIONAL FISHERY

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ABSTRACT

Two delta-lognormal indices were constructed for the SEDAR9 vermilion snapper data workshop (New Orleans, Louisiana, June 2005). One index used species composition to subset catch and effort data to exclude trips outside of vermilion snapper habitat. The second index was constructed using all offshore, charter boat and private boat hook and line trips that took place off Alabama and Florida. The indices were constructed using Marine Recreational Fisheries Statistics Survey (MRFSS) data. The indices are quite similar. Both indicate declining catch rates during the 1990s. Catch rates remain at low levels from 1997-2004.

INTRODUCTION

This document describes the construction of catch rate indices for the recreational fishery for vermilion snapper in the ***eastern*** U.S. Gulf of Mexico. These indices were constructed for the SEDAR9 vermilion snapper data workshop (New Orleans, Louisiana, June 2005). They are intended to be considered for use during formal assessment procedures.

METHODS

Data Sources

NOAA Fisheries initiated the Marine Recreational Fisheries Statistics Survey (MRFSS) in 1979 in order to obtain standardized estimates of participation, effort, and catch by recreational fishermen in U.S. marine waters. MRFSS data is collected using two approaches: a telephone survey of households in coastal counties, and dockside interviews of fishermen (intercept survey). MRFSS intercept data was used for the construction of catch rate indices.

MRFSS intercept survey sampling coverage has varied over the time series. Initially, the survey covered shore fishing, as well as charter boat (CB), headboat (HB) and private boat (PB) fishing modes in all Gulf States. During 1982-1984, MRFSS discontinued sampling boat modes in Texas. This program was turned over to the Texas Park and Wildlife Department (TPWD) which began sampling Texas boat modes in the summer of 1983. Headboat sampling gulf wide was transferred to the NOAA Fisheries Headboat Survey (HBS) program in 1986. TPWD continued to survey bay headboats until July, 1991. Vermilion snapper are seldom reported in shore modes, or inshore areas, or before 1986. In addition, vermilion snapper are rarely reported on trips that fished off LA and TX. Therefore, trips used during index construction were restricted to private boats and head boats fishing with hook and line gear off AL and FL during 1986-2004.

Effort and catch are estimated by "leader" for each MRFSS fishing trip (there may be several leaders on a single trip). Inclusion of trips that did not fish within the habitat of the species of interest (vermilion snapper) can contaminate CPUE indices (Stephens and McCall, 2004). In the absence of direct information useful to infer targeting (e.g. depth of fishing, fine-scale fishing location, gear configuration), we used an objective approach recently developed by Stephens and McCall (2004) to subset leader records using species composition. A brief summary of the methodology follows:

First, the species composition from catch records was used to estimate the parameters of a logistic regression. For example, let Y_j be a categorical variable describing the presence/absence of the non-target species for trip j. Similarly, let x_{ij} describe the presence/absence of vermilion snapper.

$$Y_j = \begin{cases} 1 & \text{if the target species is caught} \\ 0 & \text{if the target species is not caught} \end{cases}$$

Then a logistic regression was applied to estimate the probability that vermilion snapper would have been encountered by a leader. Using the regression results, a score (S_j) was assigned to each leader j as a function of the species encountered by that leader:

$$S_j = \exp \sum_{i=0}^{k} x_{ij}\beta_i$$

where the coefficients $\beta_1, \beta_2, \ldots \beta_k$ quantify the predictive effect of each species and β_0 is the intercept of the logistic regression.

This score was then converted into the probability of observing vermilion snapper given the vector of presence/absence of the other species observed by the leader (j).

$$\pi_j = \Pr\{Y_j = 1\} = \frac{S_j}{1 + S_j}$$

Given the coefficients $\beta_0, \beta_1, \ldots, \beta_k$ and the presence/absence indicators $x_{1j}, \ldots, x_{kj}$, the log-likelihood (excluding constants independent of the parameters) is the sum:

$$L\{Y|\beta_0, \ldots, \beta_k, x_{1j}, \ldots, x_{kj}\} = \sum_{j \in j+} \log(\pi_j) + \sum_{j \in j-} \log(1 - \pi_j)$$

where j+ indicates leaders that observed vermilion snapper, and j- indicates leaders that did not observe vermilion snapper. The log-likelihood was maximized using the statistical package R (Ihaka and Gentleman, 1996). The estimated β coefficients reflect the association (positive or negative) between the non-target species and vermilion snapper, π_j is intended to estimate the probability that the party led by leader *j* fished in the habitat of vermilion snapper.

Leader records were selected for CPUE analysis using a critical value. The critical value was determined by examining the relationship between the critical value and the number of incorrect predictions. Both false positives (vermilion snapper predicted to occur when absent) and false negatives (vermilion snapper not expected to occur when present) were considered. The critical value that minimized the number of incorrect predictions was selected. Leader records were included in the CPUE analysis if π (as calculated above) was above the critical value.

Index Development

For each index, the following factors were considered as possible influences on the proportion of leaders that observed vermilion snapper (proportion positive), and the catch rates reported by leader that observed vermilion snapper. The factor REC_SEASON (OPEN/CLOSED) is defined in Table 1.

FACTOR	LEVELS	VALUES
YEAR	19	1986-2004
SEASON	4	WIN = (Dec-Feb) SPR = (Mar-May) SUM = (Jun-Aug) AUT = (Sep-Nov)
MODE	2	Charter (CB) and Private (PB)
REC_SEASON	2	Closed and Open
STATE	2	FL, AL

A delta-lognormal approach (Lo et al., 1992) was used to develop the standardized catch rate indices. This method combines separate generalized linear modeling (GLM) analyses of the proportion of leaders that observed vermilion snapper[1] and the catch rates under leaders that observed vermilion snapper[2] to construct a single standardized index of abundance. Parameterization of each model was accomplished using a GLM procedure (GENMOD; Version 8.02 of the SAS System for Windows © 2000. SAS Institute Inc. Cary, NC, USA). For the lognormal models, the response variable, ln(CPUE), was calculated:

$$\log(CPUE) = \log\left[(A + B1 + B2)/(anglers * hours\ \ fished)\right]$$

[1] Type-3 model, error = binomial, link = logit, response variable = success (where success = 1 if vermilion snapper catch > 0, else success = 0)
[2] Type-3 model, error = normal, link = identity, response variable = logCPUE (where catch ≠ 0).

where A = fish observed, B1 = dead fish not observed and B2 = fish released alive. B1 and B2 catch, as well as effort (angler hours) were corrected for non-interviewed fishermen. When necessary, catch was rounded to the nearest whole number.

A forward stepwise approach was used during the construction of each GLM. First, the GLM model was fit on year. These results reflect the distribution of the nominal data. Next each potential factor was added to the null model individually, and the resulting reduction (%RED) in deviance per degree of freedom (DEV/DF) was examined. The factor that caused the greatest reduction in deviance per degree of freedom was added to the base model if the factor was significant based upon a Chi-Square test (PROB > CHISQ), and the reduction in deviance per degree of freedom was $\geq$1%. This model then became the base model, and the process was repeated, adding factors and two-way interaction terms individually until no factor or interaction met the criteria for incorporation into the final model. Higher order interaction terms were not examined.

The final delta-lognormal models were fitted using a SAS macro, GLIMMIX (glmm800MaOB.sas: Russ Wolfinger, SAS Institute). All factors were modeled as fixed effects except two-way interaction terms containing YEAR (e.g. YEAR*STATE). These were modeled as random effects. To facilitate visual comparison, a relative index and relative nominal CPUE series were calculated by dividing each value in the series by the mean value of the series.

RESULTS AND DISCUSSION

Species Associated with Red Snapper

Coefficients of the logistic regression reflect the association (positive or negative) between the non-target species and vermilion snapper (Table 2). The results are generally as expected. For example, red snapper, porgies, amberjack and gray triggerfish are positively correlated to vermilion snapper while snook, spotted seatrout, yellowtail snapper and blue-striped grunt are negatively correlated.

Species Composition Approach

4,480 leaders were identified for inclusion by the species composition approach. Of these, 2,788 observed vermilion snapper. The final models for the binomial on proportion positive and the lognormal on CPUE were:

PPT= YEAR + MODE

LN(CPUE)= YEAR + REC_SEASON

The linear regression statistics are summarized in Table 3.

Between 40% and 69% of the leaders reported vermilion snapper each year, and there was no obvious annual trend (Fig. 1). Annual nominal CPUE (made relative by dividing each value by the series mean) was highest during 1986, and 1990-1995, then decreased rapidly and remained depressed through 2004 (Fig. 2). The delta-lognormal index is very similar to the nominal CPUE series (Fig. 3). Index statistics are summarized in Table 4.

All Pertinent Data Included

When all offshore charter boat and private boat trips that fished off AL and FL using hook and line gear were included (118,725 leaders, of these 4,500 observed vermilion snapper), the final models for the binomial on proportion positive trips and the lognormal on CPUE were:

PPT= YEAR + MODE + STATE + SEASON + YEAR*SEASON + SEASON*STATE + YEAR*STATE

LN(CPUE)= YEAR + REC_SEASON

The linear regression statistics are summarized in Table 5.

Overall, the results were very similar to the species composition approach, although the proportion of leaders that observed vermilion snapper was quite small, between 2% and 6% annually (Fig. 1). Proportions below 20% may violate the assumptions of the binomial model. Again, there was no obvious trend in the proportion of leaders that reported vermilion snapper. Like the species composition approach, annual nominal CPUE was highest during 1986, and 1990-1995, then decreased rapidly and remained depressed through 2004 (Fig. 2). The delta-lognormal index is very similar to the nominal CPUE series (Fig. 4). Index statistics are summarized in Table 6. The delta-lognormal index constructed using all pertinent data has higher variance than the species composition approach (Figs. 3 and 4). This is due to the YEAR*SEASON and YEAR*STATE interaction terms which were modeled as random effects. Models containing interaction terms modeled as random effects typically have higher variance than those containing only fixed effects.

ACKNOWLEDGMENTS

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Table 1. Red snapper recreational open season definitions.

Year	Rec Season Open	Season length (days)
Before	Always Open	365
1997	Jan 1 – Nov 26	330
1998	Jan 1 – Sep 29	272
1999	Jan 1 – Aug 28	240
2000	Apr 21 – Oct 31	194
2001	Apr 21 – Oct 31	194
2002	Apr 21 – Oct 31	194
2003	Apr 21 – Oct 31	194
2004	Apr 21 – Oct 31	194

Table 2. Association coefficients by species. Positive numbers indicate a positive correlation between a given species and vermilion snapper.

Coefficient	**Common Name**	**Scientific Name**
2.159	red snapper	*Lutjanus campechanus*
1.931	red porgy	*Pagrus pagrus*
1.702	gray triggerfish	*Balistes capriscus*
1.211	tomtate	*Haemulon aurolineatum*
1.000	lane snapper	*Lutjanus synagris*
0.686	almaco jack	*Seriola rivoliana*
0.670	greater amberjack	*Seriola dumerili*
0.546	sand perch	*Diplectrum formosum*
0.366	little tunny	*Euthynnus alletteratus*
0.308	blackfin tuna	*Thunnus atlanticus*
0.281	scamp	*Mycteroperca phenax*
0.272	round scad	*Decapterus punctatus*
0.220	red grouper	*Epinephelus morio*
0.208	bluefish	*Pomatomus saltatrix*
0.147	black grouper	*Mycteroperca bonaci*
0.120	atlantic croaker	*Micropogonias undulatus*
0.110	gray snapper	*Lutjanus griseus*
0.046	pigfish	*Orthopristis chrysoptera*
0.024	cobia	*Rachycentron canadum*
-0.028	pinfish	*Lagodon rhomboides*
-0.087	dolphin	*Coryphaena hippurus*
-0.088	cero	*Scomberomorus regalis*
-0.140	gulf flounder	*Paralichthys albigutta*
-0.142	inshore lizardfish	*Synodus foetens*
-0.150	king mackerel	*Scomberomorus cavalla*
-0.205	gag	*Mycteroperca microlepis*
-0.247	hardhead catfish	*Arius felis*
-0.321	blue runner	*Caranx crysos*
-0.343	white grunt	*Haemulon plumieri*
-0.348	great barracuda	*Sphyraena barracuda*
-0.356	mutton snapper	*Lutjanus analis*
-0.358	blacktip shark	*Carcharhinus limbatus*
-0.386	scaled sardine	*Harengula jaguana*
-0.415	sand seatrout	*Cynoscion arenarius*
-0.445	gafftopsail catfish	*Bagre marinus*
-0.518	spanish mackerel	*Scomberomorus maculatus*
-0.581	crevalle jack	*Caranx hippos*
-0.633	southern puffer	*Sphoeroides nephelus*
-0.689	red drum	*Sciaenops ocellata*
-0.889	sailfish	*Istiophorus platypterus*
-1.051	stingray genus	*Dasyatis spp.*
-1.168	yellowtail snapper	*Ocyurus chrysurus*
-1.214	black sea bass	*Centropristis striata*
-1.299	ladyfish	*Elops saurus*
-1.841	bluestriped grunt	*Haemulon sciurus*
-2.045	bonnethead	*Sphyrna tiburo*
-2.167	southern kingfish	*Menticirrhus americanus*
-2.364	sheepshead	*Archosargus probatocephalus*
-3.360	spotted seatrout	*Cynoscion nebulosus*
-12.454	common snook	*Centropomus undecimalis*

Table 3. Linear regression statistics for the final GLM models on (A) proportion of leaders that observed vermilion snapper and (B) catch rates under leaders that observed vermilion snapper (Species Composition approach).

A)

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                LR Statistics For Type 3 Analysis

                                              Chi-
Source            DF      %RED DEV/DF      Square        Pr > ChiSq
year              18          1.70         142.63          <.0001
MODE               1          2.01         118.42          <.0001
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B)

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                LR Statistics For Type 3 Analysis

                                              Chi-
Source             DF      %RED DEV/DF     Square        Pr > ChiSq
year               18        11.32         429.88          <.0001
REC_SEASON          1         2.95          84.63          <.0001
```

Table 4. Nominal CPUE, proportion of leaders that observed vermilion snapper and index results (SPECIES COMPOSITION METHOD).

YEAR	Nominal CPUE	Proportion Positive	Obs	Rel. Index	LCI	UCI	CV Index
1986	1.477	0.695	187	2.015	1.498	2.709	0.149
1987	1.013	0.611	95	1.024	0.650	1.612	0.230
1988	0.834	0.591	110	0.882	0.564	1.380	0.226
1989	0.766	0.400	90	0.622	0.329	1.178	0.328
1990	1.844	0.678	59	2.422	1.489	3.939	0.247
1991	1.458	0.752	109	1.489	1.045	2.123	0.179
1992	1.395	0.822	219	1.705	1.353	2.149	0.116
1993	1.612	0.757	136	1.903	1.395	2.595	0.156
1994	1.764	0.621	124	1.178	0.799	1.736	0.196
1995	1.768	0.761	67	1.726	1.124	2.651	0.217
1996	1.022	0.582	79	0.884	0.527	1.483	0.263
1997	0.426	0.655	142	0.475	0.316	0.715	0.206
1998	0.585	0.583	223	0.356	0.244	0.519	0.190
1999	0.609	0.642	377	0.406	0.310	0.532	0.136
2000	0.396	0.578	422	0.345	0.258	0.461	0.146
2001	0.518	0.589	411	0.374	0.283	0.495	0.140
2002	0.388	0.521	470	0.303	0.225	0.407	0.149
2003	0.470	0.584	449	0.373	0.285	0.488	0.135
2004	0.655	0.650	711	0.518	0.427	0.628	0.097

Table 5. Linear regression statistics for the final GLM models on (A) proportion of leaders that observed vermilion snapper and (B) catch rates under leaders that observed vermilion snapper (ALL DATA).

A)

LR Statistics For Type 3 Analysis

Source	DF	%RED DEV/DF	Chi-Square	Pr > ChiSq
year	18	0.91	280.30	<.0001
MODE	1	17.73	6966.86	<.0001
STATE	1	5.41	570.78	<.0001
SEASON	3	2.12	156.70	<.0001
year*SEASON	54	1.46	313.19	<.0001
SEASON*STATE	3	1.25	302.20	<.0001
year*STATE	18	1.02	290.83	<.0001

B)

LR Statistics For Type 3 Analysis

Source	DF	%RED DEV/DF	Chi-Square	Pr > ChiSq
year	18	13.63	754.15	<.0001
REC_SEASON	1	1.68	77.06	<.0001

Table 6. Nominal CPUE, proportion of leaders that observed vermilion snapper and index results (ALL DATA).

YEAR	Nominal CPUE	Proportion Positive	Obs	Rel. Index	LCI	UCI	CV Index
1986	1.902	0.047	4092	1.140	0.382	3.400	0.590
1987	0.683	0.026	5483	0.649	0.185	2.279	0.695
1988	0.777	0.029	4363	0.830	0.251	2.746	0.656
1989	0.803	0.026	2851	0.651	0.161	2.622	0.791
1990	1.435	0.030	2330	2.320	0.803	6.708	0.570
1991	2.468	0.063	2398	1.910	0.731	4.990	0.509
1992	1.782	0.051	5163	2.320	0.983	5.478	0.450
1993	1.581	0.044	4383	2.498	1.035	6.030	0.463
1994	1.251	0.031	5045	1.529	0.568	4.121	0.528
1995	1.136	0.028	4471	1.569	0.565	4.360	0.546
1996	0.627	0.021	5509	0.880	0.273	2.836	0.639
1997	0.367	0.028	5770	0.358	0.086	1.487	0.813
1998	0.549	0.035	6773	0.358	0.097	1.328	0.732
1999	0.580	0.036	11015	0.307	0.086	1.095	0.705
2000	0.433	0.038	9771	0.187	0.041	0.845	0.876
2001	0.567	0.038	9538	0.328	0.093	1.162	0.701
2002	0.480	0.036	10021	0.297	0.081	1.092	0.727
2003	0.522	0.039	9803	0.303	0.083	1.100	0.718
2004	1.059	0.062	9946	0.565	0.202	1.581	0.551

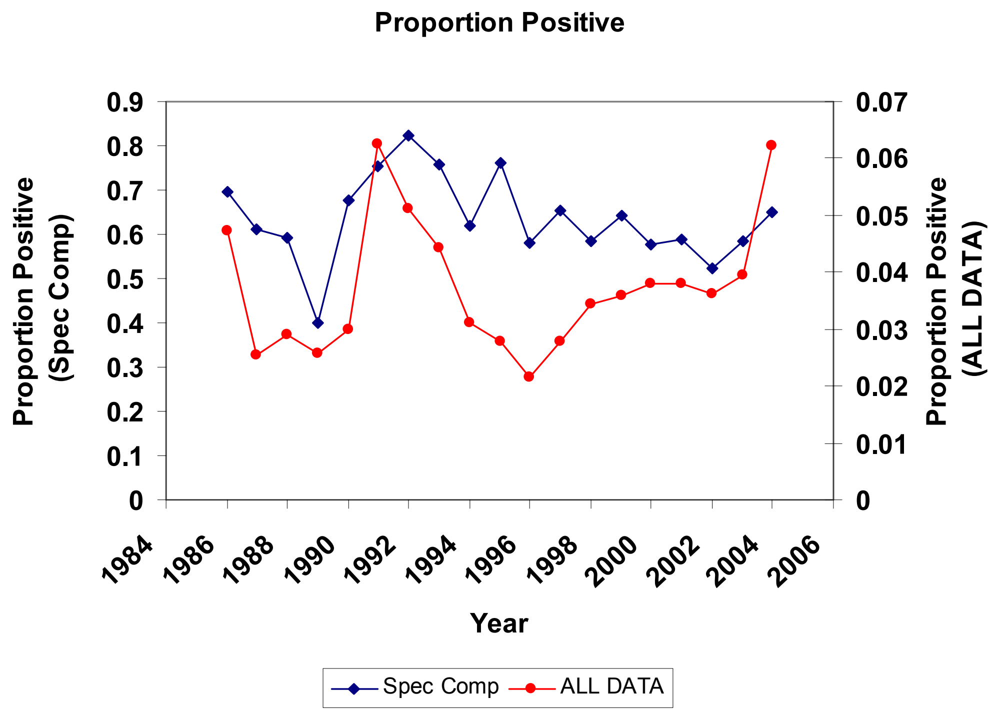

Figure 1. Annual trend in proportion of leaders that observed vermilion snapper.

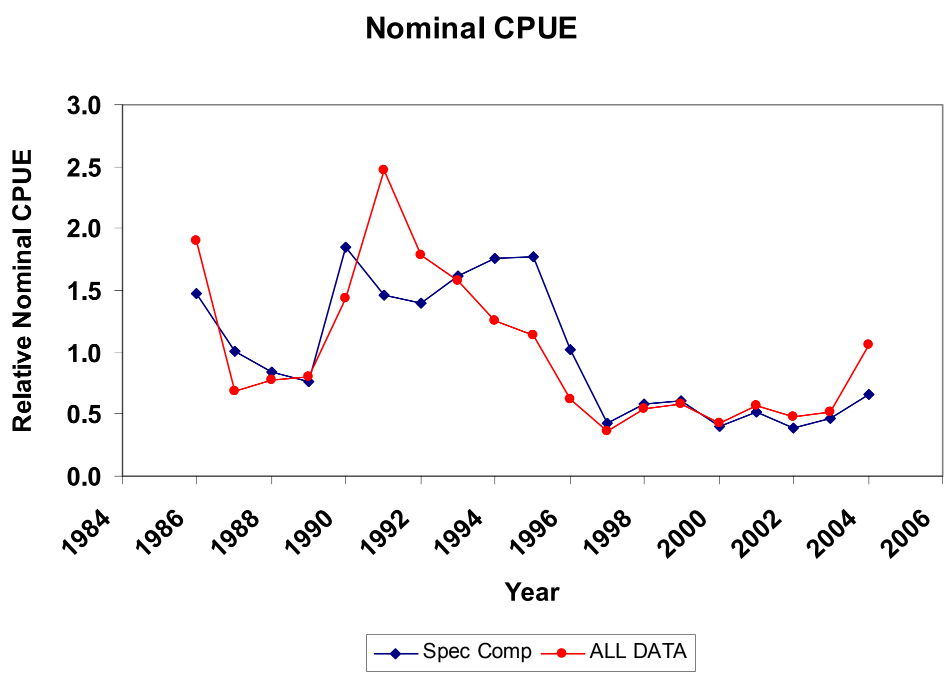

Figure 2. Annual trend in nominal CPUE.

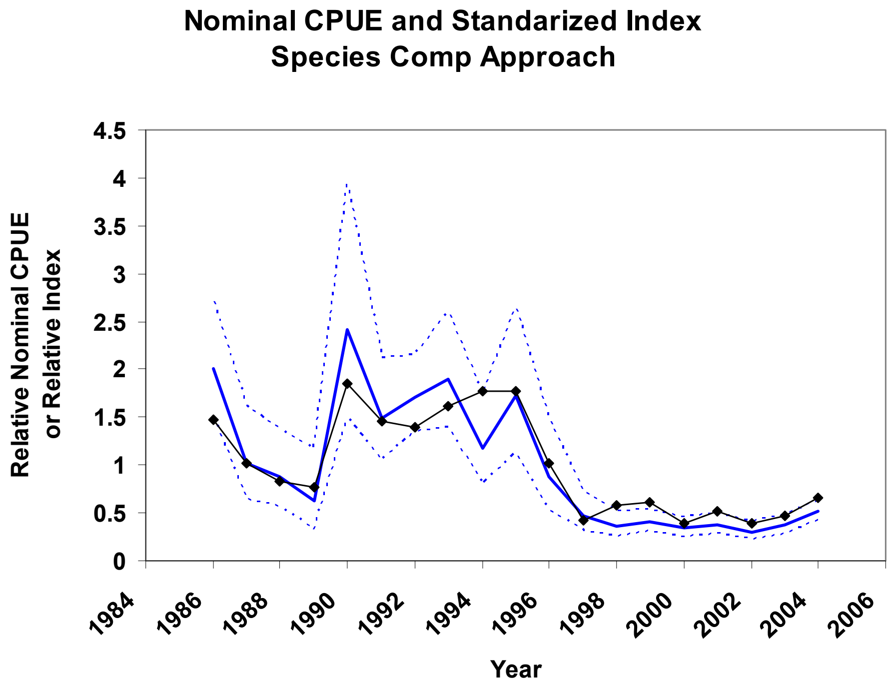

Figure 3. Nominal CPUE (light black line with diamonds) and the delta-lognormal index (heavy blue line no symbols) constructed using the species composition approach. The dotted lines are the upper and lower 95% confidence intervals.

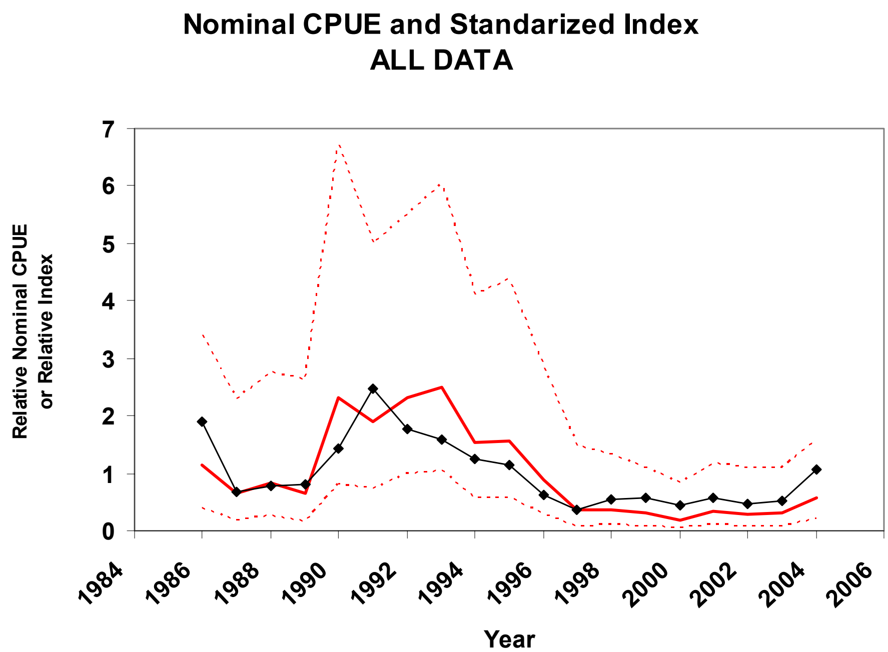

Figure 4. Nominal CPUE (light black line with diamonds) and the delta-lognormal index (heavy red line no symbols) constructed using all hook and line CB and PB trips that fished offshore, off AL and FL. The dotted lines are the upper and lower 95% confidence intervals.