STANDARDIZED CATCH RATES OF RED GROUPER (EPINEPHELUS MORIO) FROM THE U.S. RECREATIONAL FISHERY IN THE GULF OF MEXICO, 1986-2005

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SUMMARY

An index of abundance of red grouper from the United States recreational fishery in the Gulf of Mexico is presented for the period 1986-2005. The index was constructed using Generalized Linear Mixed Models, and a delta-lognormal approach. The index suggests decreasing catch rates from 1990 to the mid-1990s, followed by a general increase in catch rates of red grouper from the mid-1990s to the present.

KEY WORDS

Catch/effort, abundance, MRFSS, private boats, charter boats, multivariate analyses

Sustainable Fisheries Division Contribution No. SFD-2006-037

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1. INTRODUCTION

This document describes the construction of catch rate indices for the recreational fishery for red grouper in the U.S. Gulf of Mexico. The index was constructed for the SEDAR12 red grouper data workshop (St. Petersburg, FL, July 2006).

2. METHODS

2.1 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.

Effort and catch are estimated by leader/trip 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 (red grouper) 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 trip records using species composition. A brief summary of the methodology follows (***adapted from Stephens and McCall, 2004):***

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 red grouper.

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

Then a logistic regression was applied to estimate the probability that red grouper would have been encountered on a trip. Using the regression results, a score (S_j) was assigned to each trip j as a function of the species encountered on that trip:

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

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 red grouper given the vector of presence/absence of the other species observed on the trip (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 trips that observed red grouper, and j- indicates trips that did not observe red grouper. 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 red grouper, π_j is intended to estimate the probability that the trip *j* fished in the habitat of red grouper.

Trip 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 (red grouper predicted to occur when absent) and false negatives (red grouper not expected to occur when present) were considered. The critical value that minimized the number of incorrect predictions was selected. Trip records were included in the CPUE analysis if π (as calculated above) was above the critical value.

2.2 Index Construction

Data included trip records from the Florida west coast. The following exclusions were mode to the dataset:

1. Trips before 1986 were excluded since very few red grouper were reported before 1986.

2. Inshore effort was excluded (very few red grouper)

3. HB were excluded (not available in dataset after 1985)

4. Trips outside of FL were excluded. (Over 95% of the catch occurs off FL)

5. The Stephens and MacCall (2004) approach was used to restrict the dataset to those trips that targeted the habitat of red grouper.

The following factors were examined as possible influences on the proportion positive trips, and the catch rates on positive trips:

FACTOR	LEVELS	VALUES
YEAR	20	1986-2005
MODE	2	CB, PB
SEASON	4	Dec-Feb, Mar-May, Jun-Aug, Sep-Nov
AREA	2	<10 miles offshore >10 miles offshore
REGION	3	SWFL, CWFL, NWFL
RS_SEASON	2	Open, Closed

The factor RS_SEASON is the status of the red snapper fishery (open, closed), this factor was tested, but was not significant in any model

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 trips that observed red grouper and the catch rates on positive trips 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:

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

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 ≥1%. This model then became the base model, and the process was repeated, adding factors and interaction terms individually until no factor or interaction met the criteria for incorporation into the final model. Higher order interaction terms were not examined.

Once a set of fixed factors was identified, the influence of the YEAR*FACTOR interactions were examined. YEAR*FACTOR interaction terms were included in the model as random effects. Selection of the final mixed model was based on the Akaike's Information Criterion (AIC), Schwarz's Bayesian Criterion (BIC), and a chi-square test of the difference between the –2 loglikelihood statistics between successive model formulations (Littell et al. 1996). The final delta-lognormal model was fit using the SAS macro GLIMMIX and the SAS procedure PROC MIXED (SAS Institute Inc. 1997) following the procedures described by Lo et al. (1992). 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.

3. RESULTS

The final binomial and lognormal models were:

- PPT = YEAR + AREA + REGION + YEAR + YEAR*REGION

- LN(CPUE) = YEAR + REGION + MODE + REGION*MODE + YEAR*REGION

The annual proportion of positive trips (PPT: trips that caught red grouper) decreased from ~57% to 27% during 1990 to 1997, and increased thereafter (Fig. 1; Table 1). The estimated PPT in 2004 and 2005 was near 60% (Fig. 1).

Nominal CPUE increased substantially between 1986-1988, then generally declined throughout the remainder of the time series (Fig. 2; Table 1).The estimated CPUE in 2005 is the lowest since 1988 (Fig. 2).

Diagnostic plots were constructed to examine the fit of the components of the delta-lognormal model. The frequency distribution of nominal catch rates is shown in Figures 3. As expected, the distribution is very similar to the expected normal distribution. The distribution of residuals from the binomial model on proportion positive trips and the lognormal model on catch rates, by year is shown in Figure 4. The residuals are generally evenly distributed above and below zero, indicating an acceptable fit to the models. The cumulative normalized residuals (QQ-Plot) from the lognormal model is shown in Figure 5. The QQ-Plot indicates a minimal departure from the assumption of a normal distribution (Fig. 5, red line). This indicates that the assumption of normality was not violated.

The standardized MRFSS index shows no consistent trend in catch rates of red grouper (Fig. 6). During 1986-1990, the catch rates increase rapidly, followed by a steep decline until 1997. Thereafter, the catch rates show a generally increasing trend through 2004. The estimated catch rate during 2005 is lower than 2004, but still higher than the series average (Figure 6; Table 1).

ACKNOWLEDGMENTS

The author thanks Andi Stephens (University of California, Santa Cruz) and Alec McCall (NOAA Fisheries SWFSC) who graciously supplied the R code used to subset the CPUE data, and made themselves available to answer question regarding the technique.

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Table 1. Relative nominal CPUE, number of trips, number of positive trips, proportion positive trips (PPT) and abundance index statistics.

YEAR	TRIPS	POSITIVE TRIPS	PPT	Relative Nominal CPUE	Relative Index	Lower 95% CI	Upper 95% CI	CV
1986	130	45	0.346	0.288	0.688	0.246	1.921	0.549
1987	122	45	0.369	0.582	0.658	0.230	1.880	0.564
1988	139	60	0.432	2.310	0.925	0.381	2.245	0.466
1989	108	58	0.537	1.312	1.318	0.574	3.029	0.435
1990	102	58	0.569	1.776	1.869	0.788	4.433	0.453
1991	110	50	0.455	1.347	1.148	0.446	2.950	0.500
1992	319	187	0.586	1.691	1.267	0.563	2.851	0.423
1993	310	126	0.406	1.063	0.781	0.314	1.942	0.480
1994	354	151	0.427	1.017	0.932	0.397	2.187	0.447
1995	356	160	0.449	1.121	0.769	0.298	1.985	0.502
1996	395	152	0.385	0.872	0.605	0.230	1.593	0.514
1997	384	103	0.268	0.740	0.545	0.199	1.494	0.538
1998	718	290	0.404	0.803	0.755	0.323	1.765	0.445
1999	974	430	0.441	1.010	0.930	0.429	2.015	0.402
2000	667	281	0.421	0.687	1.047	0.488	2.249	0.397
2001	786	344	0.438	0.586	0.869	0.404	1.869	0.397
2002	830	394	0.475	0.669	0.903	0.424	1.923	0.392
2003	1106	540	0.488	0.689	1.113	0.553	2.241	0.361
2004	1486	905	0.609	0.886	1.676	0.923	3.040	0.305
2005	1013	578	0.571	0.551	1.204	0.624	2.324	0.338

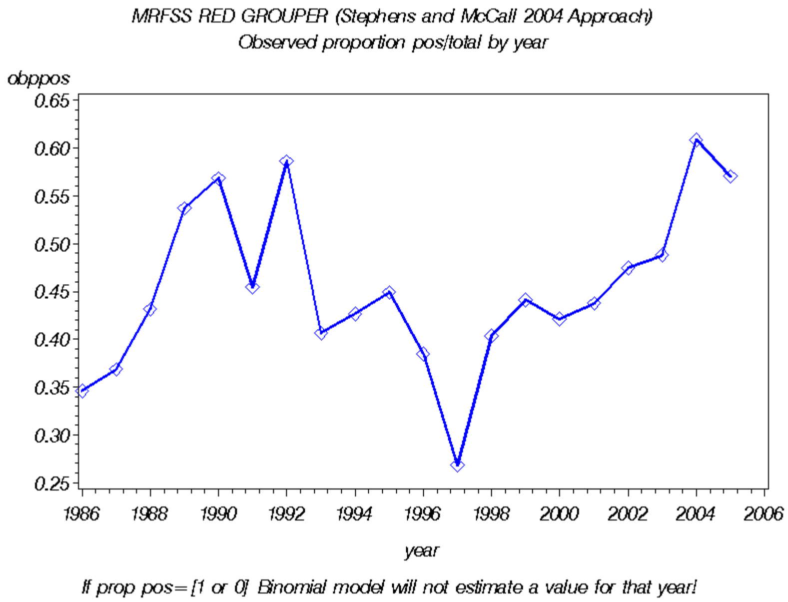


Figure 1. Proportion positive trips by year.

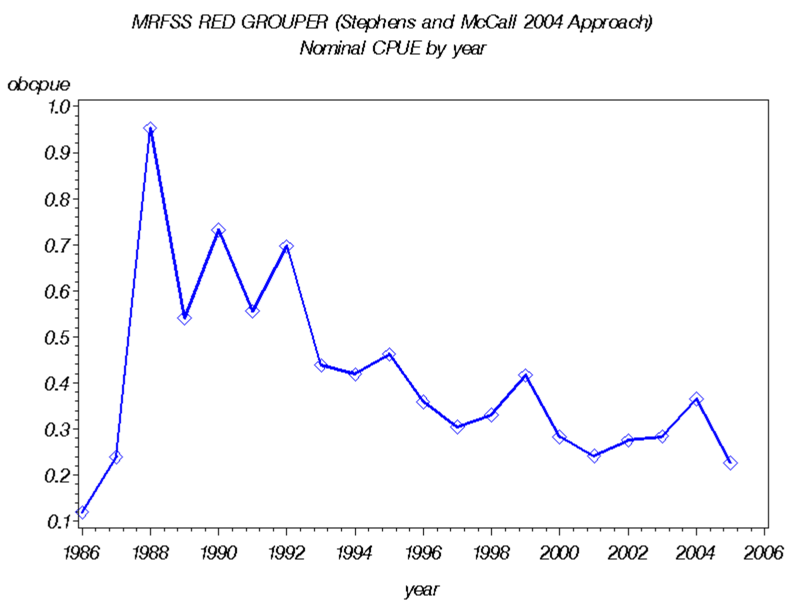


Figure 2. Nominal CPUE by year.

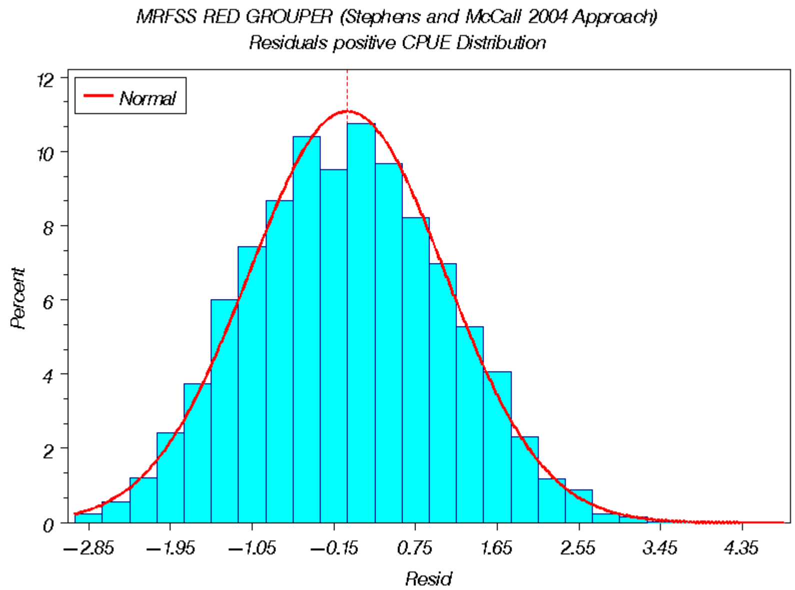
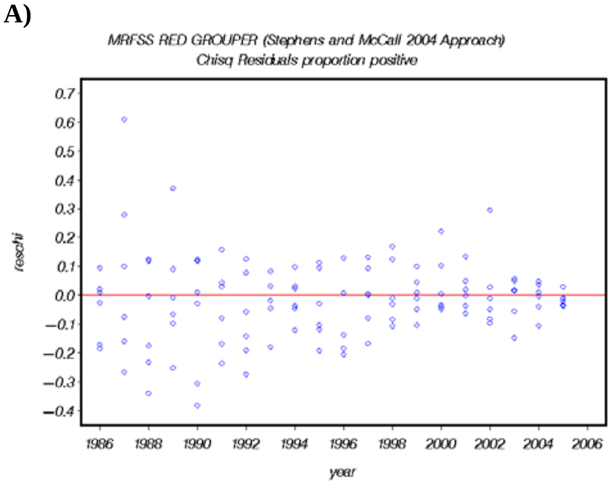


Figure 3. Frequency distribution of catch rates on positive trips. The red line is the expected normal distribution.

A)



B)

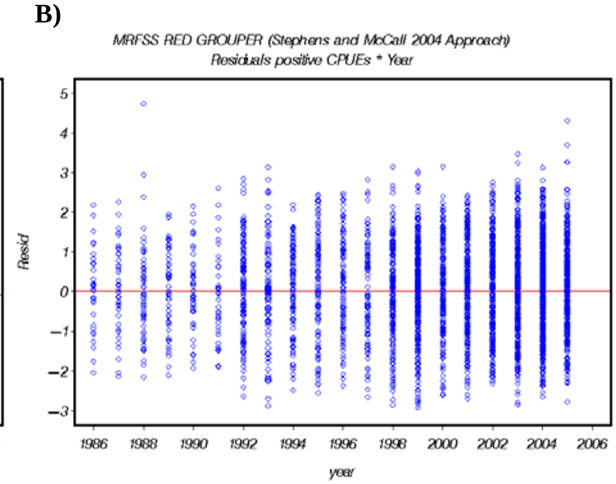


Figure 4. Diagnostic plots for the delta-lognormal model. The distribution of residuals from the binomial model on the proportion of positive trips, by year(**A**) and the distribution of residuals from the lognormal model on catch rates, by year (**B**).

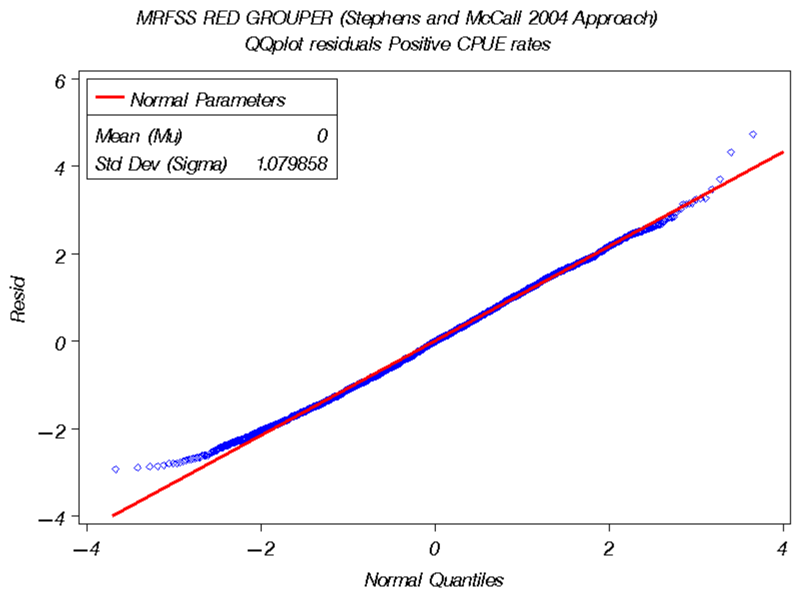


Figure 5. The cumulative normalized residuals (QQ-Plot) from the lognormal model on the catch rates of positive trips. The red line is the expected normal distribution.

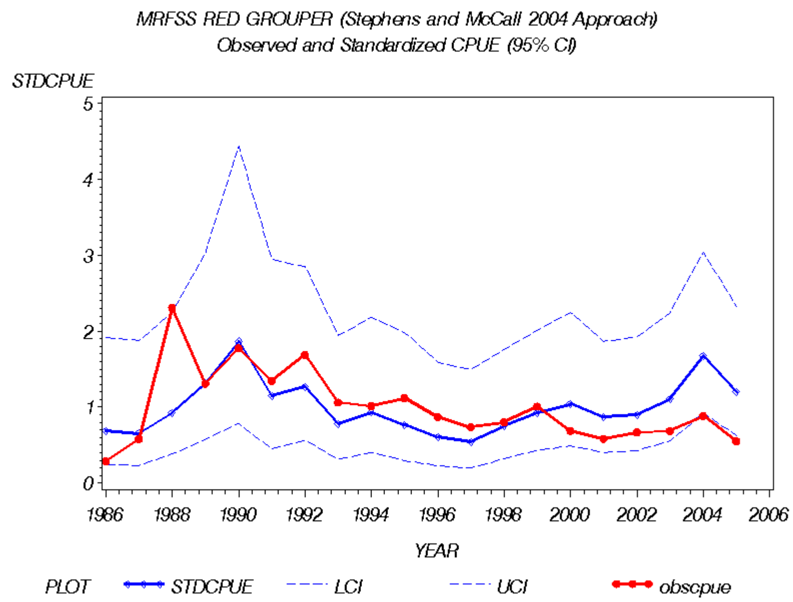


Figure 6. The standardized index with 95% confidence intervals and nominal CPUE.