Standardized Abundance Indices for Gulf of Mexico Gray Triggerfish (*Balistes capriscus*) Based on Catch Rates as Measured by the Marine Recreational Fisheries Statistics Survey

by

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INTRODUCTION

Stock assessment models require indices of stock abundance. Ideally we would know exactly how many fish there were over the course of an extended time period but we never have comprehensive stock monitoring for marine fish stocks. Instead, we have to rely on sampling schemes to estimate abundance. Whenever possible, it is preferable to rely on stratified random fishery-independent sampling. However, such indices are limited for triggerfish to specific life stages, short timeframes, or both. In the meantime, we have to rely heavily on indices of abundance produced from catch rates in various fisheries. These indices require that we have measures of catches and effort.

The Marine Recreational Fisheries Statistics Survey (MRFSS) is conducted by NOAA to monitor catch, discards, and effort by recreational fishermen in ocean waters off the US. The program uses a telephone survey as well as dockside interviews, the former being more useful for estimating overall catches and the latter for catch rates (catch per unit effort).

Fishing effort is identified by individual angler, but anglers that fished together are also identified under a common leader. Most of the time, a unique leader indicates a distinct trip (e.g., same vessel, same time). However, on rare occasions more than one leader is identified per trip. Unfortunately, the data do not provide codes that would indicate trips, only leaders. Therefore, leader was assumed to be a good proxy for an independent trip. Ideally, one would also account for individuals when analyzing these data. However, such an effort is hampered by the lack of an identifier of individuals through time.

Gulf of Mexico MRFSS intercept data span from 1979 to present. However, the MRFSS program has advised against using data prior to 1981 due to the quality of the data. Prior to 1986, sample sizes were generally low and sampling strata were dynamic. As a result, these years should used with caution. And, while surveys have been conducted in all states but Texas since 1986, the vast majority comes from west Florida and Alabama.

The strengths of using MRFSS data for a catch index include its time span, which is longer than other available fishery-dependent datasets, and the fact that it records information about discards. Other fishery-dependent indices do not.

For statistical purposes, it was assumed that the trip was the appropriate sampling unit. Often, multiple anglers participate on the same trip. In these cases, catch and effort are pooled across all anglers.

For this particular study, records (i.e., a particular species on a particular trip) were eliminated if they had missing values for any of the key characteristic. These were then combined into trips. Trips were included if they came from the charter or private boat mode (date for these modes is most complete), and if they used hook and line gear (most did). Trips were excluded if they came from Texas (incomplete time series) or inshore (unlikely to encounter gray triggerfish).

METHODS

Species Associations

Using fishery-dependent data to develop abundance indices presents problems. Unlike scientific sampling, fishing trips will vary in their likelihood of catching the species of interest. As a result, the catch rates from an active fishery may be less indicative of stock abundance than scientific sampling. Nonetheless, one can potentially infer abundance if care is taken to classify fishing trips and focus on a set of them that provides some consistency through time and across different locations. Care should be taken to include trips that are likely to catch the species of interest in order to provide adequate samples for statistical analyses.

Stephens and MacCall (2004) developed a statistical approach for identifying a subset of all trips of this sort. Their approach uses logistical regression to categorize trips. It develops correlation coefficients between the presence or absence of the species of interest and the presence or absence of every other species. In our case, we limited our consideration to those species that occurred in at least 1 percent of the recorded trips. These coefficients are then used to assign to each trip a probability that it would catch the species of interest based on the presence or absence of other species. Finally, it uses a minimization procedure to select a cutoff probability for which trips to include or exclude. Their paper provides greater technical detail.

Conceptually, this approach is designed to identify fishing trips that were likely to catch the species of interest using the other caught species as an indicator of habitat, gear, and fishing behavior (e.g., time of day, bait use, etc.). As such, it identifies a subset of all trips that were generally likely to catch the species of interest, whether or not that species was caught. One possible limitation of this technique is its reliance on the occurrence of other species. As a result, trips cannot be incorporated into this technique if they do not catch other species.

Some might criticize a catch rate method that ignores trips that caught the focal species. Yet this concern misconstrues the goal, which is to identify trips based on their consistency and then determine the catch rates of the focal species, not vice versa.

Standardization Procedure

In addition to the challenge of inconsistent fishing behavior, fishery-dependent catch-rate based abundance indices are also likely to suffer from a lack of random sampling. The non-randomness comes partly in the form of fishing behavior, which may not correspond to abundance. This challenge cannot be addressed without some fishery-independent measure of abundance. The non-randomness also comes in the form of the waxing and waning of fishing and sampling across time, space, and other factors (e.g., gear). Several statistical techniques exist to standardize catch rates to account for this latter challenge.

We used a method developed by Lo and colleagues (1992). This delta-lognormal technique uses standard generalized linear models (GENMOD; Version 8.02 of the SAS System for Windows © 2000, SAS Institute Inc., Cary, NC, USA) to identify time, space, and other factors that are likely to influence catch rates. It also combines two forms of information: the frequency with which trips catch the species of interest and, on those trips that were successful, the catch per unit time. It assumes a binomial distribution for logit-transformed success data and a normal distribution for ln-transformed catch per unit effort (CPUE) data. The end result is a standardized catch rate per year with an associated standard error.

A number of factors were considered that could have influenced catch rates for gray triggerfish in the Gulf of Mexico MRFSS dataset. Year was of interest as the purpose of this exercise is to develop an index of abundance per year. Consequently, year was forced into the standardization procedure, although it would have been determined significant regardless. Season was also considered. The sample size per season and the nominal catch rates were considered in determining how to assign seasons. The initial choice was to assign Nov-Jan as winter, Feb-Apr as spring, May-Aug as summer, and Sep-Nov as autumn. However, reexamination would suggest that Nov-Feb, Mar-May, Jun-Jul, and Aug-Oct, might provide more balanced sampling and more consistent catch per unit effort (Fig. 1). The definition of season will be explored in the near future. Red snapper season (open or closed) was also assigned to each trip, as was a state (with TX and LA combined into West), and mode.

These factors, and their two-way interactions, were tested in the standardization procedure, but only included if they provided a significant improvement in fit to the model. A significant improvement was defined as a significant Chi-square statistic (at the $\alpha = 0.05$ level) and an overall improvement in fit to the model of at least 1 percent reduction in deviance per degree of freedom.

MRFSS provided 106,415 trips of potential interest from the Gulf of Mexico, characterized by 276,501 records (species by trip). Of all species, gray trigger was encountered on 7,130 of these trips—6.74% of the time, 13th among all species. When records of rare species (landed in < 1% of trips) were eliminated, there were 100,161 trips consisting of 230,591 records for 47 species. Finally, when the species association procedure was run, it identified 7,248 trips as likely to have caught gray trigger, 4,308 of which actually caught gray trigger (59.4%). This indicates that the species association approach threw out 2,822 trips that did catch gray triggerfish. Only 169 of these trips caught only gray triggerfish and therefore were incapable of using species associations. The other 2,653 were excluded because the other species landed were not generally associated with gray trigger.

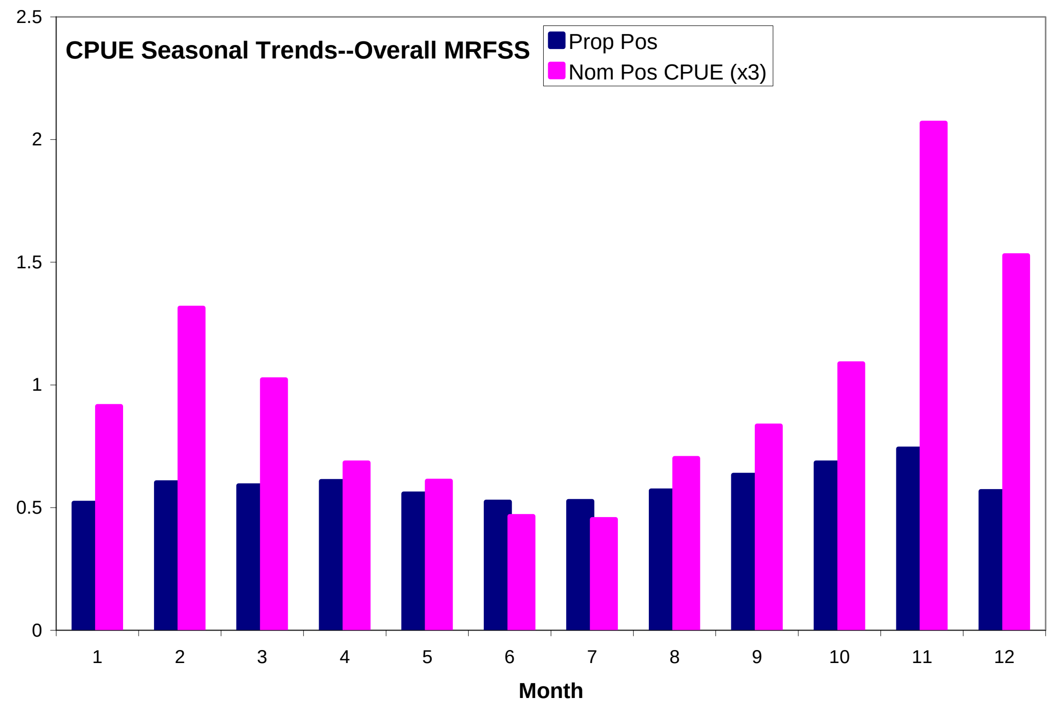

Fig. 1—Seasonal effects in MRFSS Gulf of Mexico gray triggerfish. Dark bars show proportion of trips that caught gray trigger (Prop Pos) while light bars show the catch per unit effort for those positive trips.

RESULTS

A number of species were likely to co-occur with gray triggerfish, while others were likely to indicate that gray trigger were not present (Table 1). Red snapper was most strongly associated with gray triggerfish, followed by vermilion snapper. Red porgy and white grunt were also fairly closely associated. Spotted seatrout was least likely to co-occur with gray trigger, followed by southern kinfish, sailfish, stingrays, and gafftopsail catfish. Other species correlations are listed in Table 1.

Once appropriate trips were identified, sample sizes were examined (Table 2). These were adequate for most strata across all factors, with a few notable exceptions. There were fewer than 50 trips per year prior to 1986 and far fewer samples from the West, both problems that were raised earlier. Additional concerns include the relative lack of samples in the winter, which might be addressed through the change in seasons suggested above. Private boat samples were also relatively rare, as were samples from 1989 and 19990, although they are probably sufficient for analysis.

Table 1—Species associations. Correlations in occurrence between gray trigger and other species.

Species	Correlation Coefficient
red snapper	2.710099
vermilion snapper	1.736527
red porgy	1.013877
white grunt	0.914282
lane snapper	0.682701
gag	0.564091
black grouper	0.506504
black drum	0.469062
sand perch	0.402956
black sea bass	0.343317
greater amberjack	0.329954
cobia	0.29465
blacktip shark	0.24942
gulf flounder	0.24923
red grouper	0.214695
pigfish	0.212405
gray snapper	0.203991
king mackerel	0.187333
blue runner	0.114727
southern flounder	0.094931
little tunny	0.064537
bluefish	0.057268
spanish mackerel	0.025398
sheepshead	-0.00968
mutton snapper	-0.04922
inshore lizardfish	-0.09312
cero	-0.0993
hardhead catfish	-0.1274
red drum	-0.13988
sand seatrout	-0.1438
dolphin	-0.15278
pinfish	-0.15345
yellowtail snapper	-0.23515
bonnethead	-0.26548
scamp	-0.29165
requiem shark genus	-0.38434
crevalle jack	-0.55545
atlantic croaker	-0.63409
great barracuda	-0.68546
ladyfish	-0.75036
blackfin tuna	-0.76348
gafftopsail catfish	-0.83369
stingray genus	-0.88215
sailfish	-1.28328
southern kingfish	-1.67797
spotted seatrout	-1.70116

Table 2—Sample sizes. Number of trips examined by various factors.

YEAR	Trips
1981	29
1982	20
1983	24
1984	10
1985	23
1986	242
1987	159
1988	122
1989	63
1990	72
1991	161
1992	312
1993	217
1994	164
1995	120
1996	162
1997	269
1998	437
1999	777
2000	747
2001	609
2002	718
2003	760
2004	1031

Season	Trips
AUT	1789
SPR	1393
SUM	3316
WIN	750

Red Snapper Season	Trips
CLSD	1122
OPEN	6126

State	Trips
AL	2049
FL	4698
WE	501

Mode	Trips
CB	6001
PB	1247

The proportion of trips that caught gray triggerfish (ProPos) and the catch per unit effort on positive trips (CPUE) are shown in Fig. 2. The early peak in CPUE should be given relatively little weight considering the small sample size for that year, as was true to a lesser extent for the peak in 1990. Otherwise, these data suggest the stock may have increased early in the time series and decreased more recently.

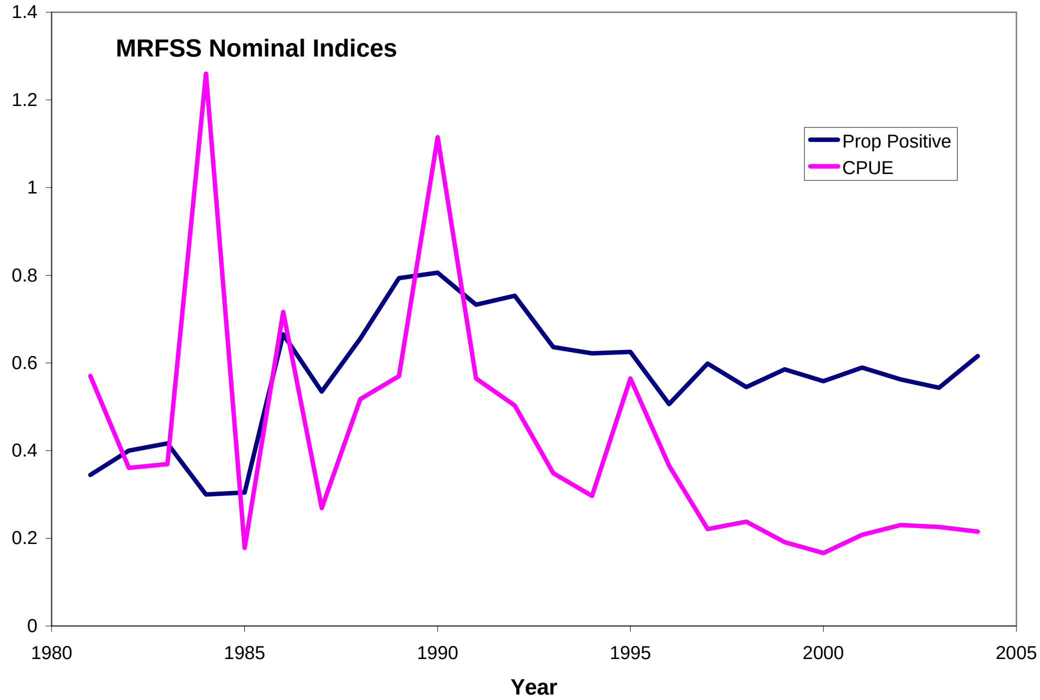

Fig. 2—Nominal CPUE for Gulf of Mexico gray triggerfish. Dark line shows proportion of trips that caught gray trigger (Prop Pos) while light line shows the catch per unit effort for those positive trips.

Diagnostics of the delta-lognormal model indicate the results were robust (Fig. 3). Residuals appear to be evenly distributed and follow a normal distribution.

GLM results are presented in Table 3 and Fig. 4. The delta-lognormal modeling exercise identified the following significant factors and interactions: year, mode, and state for the proportion positive data; and year, season, state, red snapper season, year*state, and year*season on the CPUE data.

These results should be viewed as preliminary pending reexamination of seasons and to correct for the discovery of some unidentified triggerfish, which are most likely to be gray triggers and were more prevalent early in the data series.

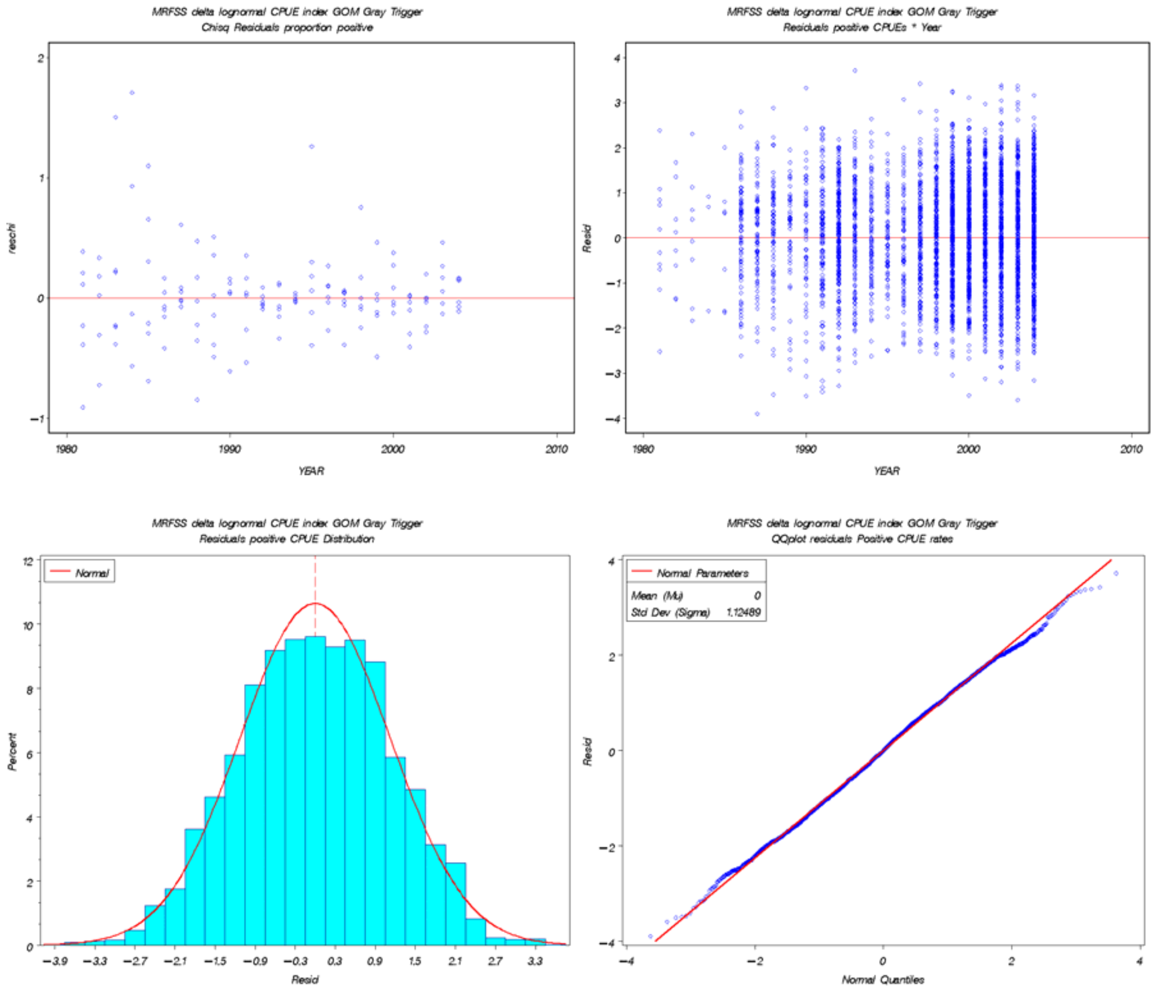

Fig. 3—Diagnostics of the delta-lognormal model. Residuals by year did not show biases or unidentified problems in either the proportion positive (a) or ln(CPUE) (b) portions of the model. Residuals overall of the ln(CPUE) portion fit well to a normal distribution (c), and a Q-Q plot (d) also validated the assumption of normality.

Table 3—Standardized index values per year and confidence intervals.

YEAR	ln(CPUE)	SE
1981	-0.73841	0.664575
1982	-0.13741	0.791705
1983	-0.75398	0.701211
1984	-1.00749	1.129571
1985	-1.28787	0.7645
1986	0.095956	0.228956
1987	-0.3655	0.271743
1988	0.173357	0.328415
1989	0.791917	0.523376
1990	0.846615	0.49101
1991	0.274018	0.297221
1992	0.61553	0.223591
1993	0.035172	0.240358
1994	-0.02243	0.273638
1995	-0.02395	0.325085
1996	-0.40134	0.275559
1997	-0.30689	0.212177
1998	-0.59082	0.169536
1999	-0.29001	0.134901
2000	-0.54454	0.138038
2001	-0.22646	0.150328
2002	-0.32847	0.137688
2003	-0.44001	0.136298
2004	-0.09139	0.124442

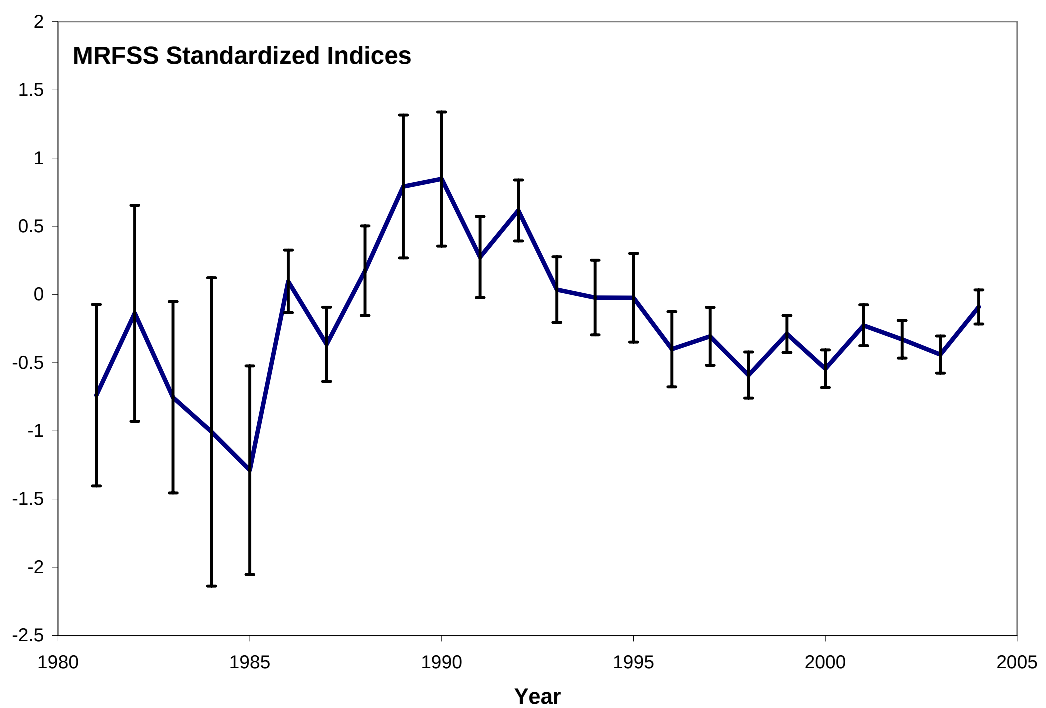

Fig. 4—Standardized index values per year. Ln(CPUE) values shown with error bars representing standard errors.

DISCUSSION

The MRFSS abundance index appears to generally be a quality index. The model will need to rerun including unidentified triggerfish and redefining seasons.

LITERATURE CITED

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