Standardized Abundance Indices for Gulf of Mexico Gray Triggerfish (*Balistes capriscus*) Based on Catch Rates as Measured from Commercial Logbook Entries with Handline Gear

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 of effort.

Bottom fishing vessels operating in the Gulf of Mexico have provided catch and effort information through the NMFS Gulf of Mexico Reef Fish Logbook Program since 1990. However, there was limited participation from Florida through 1992. Generally, assessments have constructed indices starting in 1993 and this effort took the same approach. This dataset has comprehensive spatial coverage of the Gulf of Mexico for the time period under consideration. Its most apparent limitation is the absence of discard information. As a result, the catch rates are most likely underestimated. This weakness would only be deemed an important flaw if there were substantial differences in discarding rates across strata.

Records were restricted to handline fishing (including electric reels) in the Gulf of Mexico between 1993 and 2004. Gray triggers are also caught in traps in the eastern Gulf, but poor quality of effort reporting discourages the development of a trap index. Extreme effort data were apparent in the dataset, and these outliers were eliminated by eliminating records if any of their three effort measures (number of lines, number of hooks per line, and soak time) fell outside of 99% confidence intervals.

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.

Five factors were considered for inclusion in the delta-lognormal model. These included year, which was forced in the model due to our interest in generating patterns through time; season, which was defined using Jan-Mar as winter, Apr-Jun as spring, Jul-Sep as summer, and Oct-Dec as autumn because this appeared to fit the data as well as any pattern (Fig. 1); red snapper season; red snapper permit, defined as having a class 1 permit that would allow substantial red snapper fishing or not; and state.

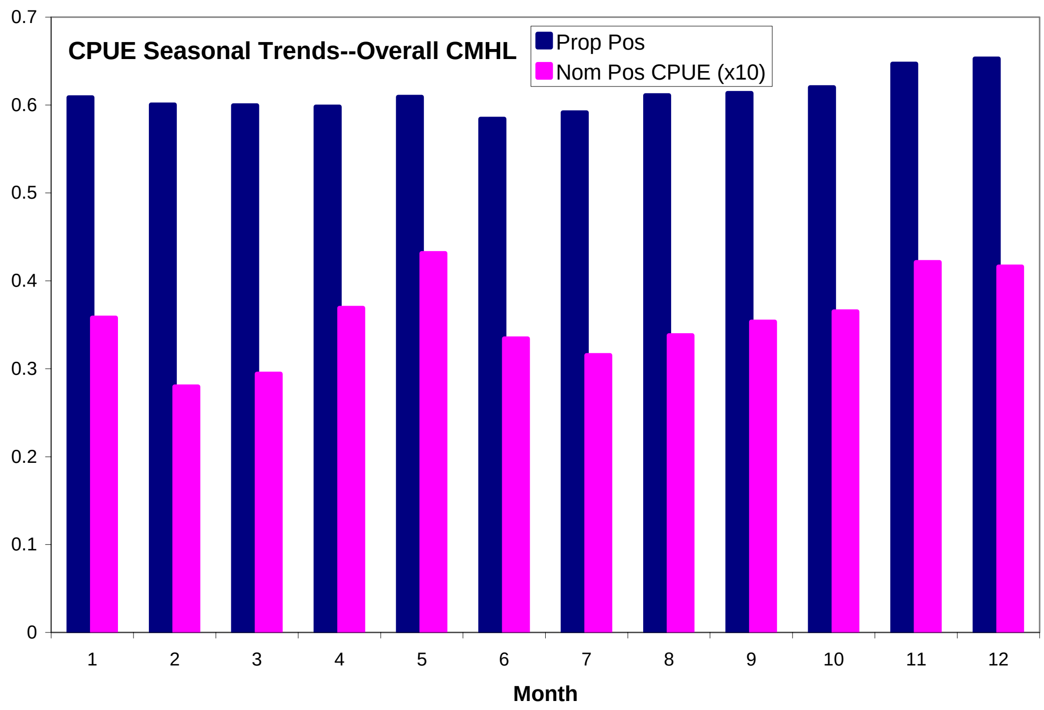

Fig. 1—Seasonal nominal catch rates.

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.

The headboat survey provided 146,776 trips of potential interest from the Gulf of Mexico, characterized by 550,941 records (species by trip). Of all species, gray trigger was encountered on 33,644 of these trips—23% of the time, 6^{th} among all species. When records of rare species (landed in < 1% of trips) were eliminated, there were 145,002 trips consisting of 512,269 records for 40 species. When the species association procedure was run, it identified 32,119 trips as likely to have caught gray trigger, 19,575 (61%) of which actually caught gray trigger.

RESULTS

FIX!!!! 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). Vermilion snapper was most strongly associated with gray triggerfish, followed by red snapper and red porgy. Black sea bass, knobbed porgy, and margate were also fairly closely associated. Yellowtail snapper was least likely to co-occur with gray trigger. Other species correlations are listed in Table 1.

Once appropriate trips were identified, sample sizes were examined (Table 2). They appear to be adequate across all factors and strata.

The proportion of trips that caught gray triggerfish (ProPos) and the catch per unit effort on positive trips (CPUE) are shown in Fig. 2. These data suggest the stock may have decreased recently.

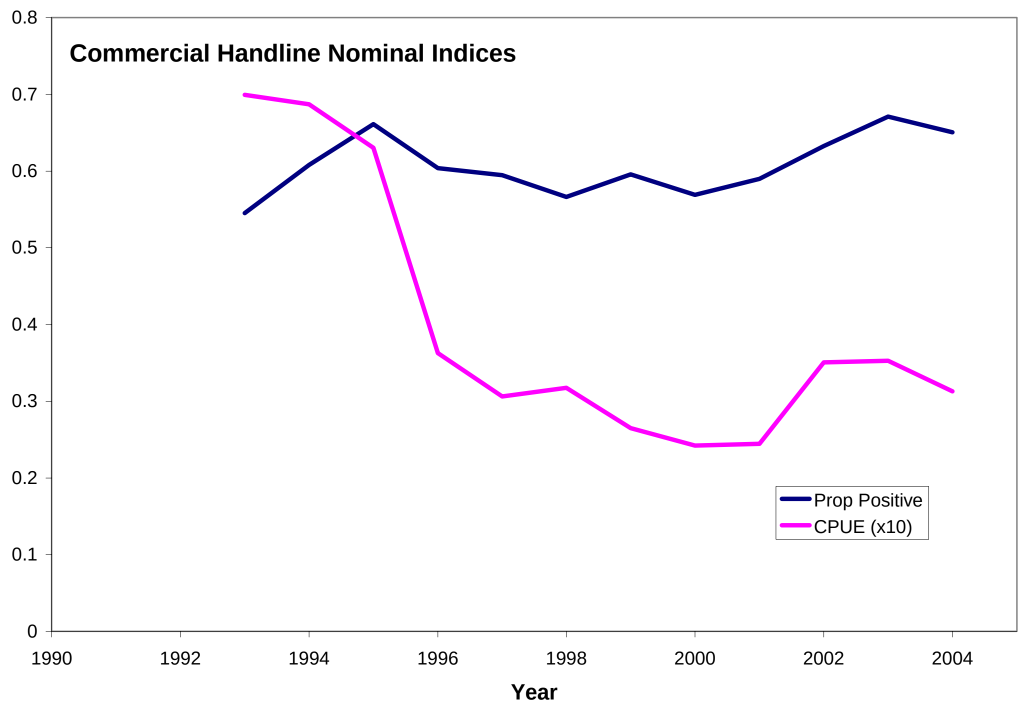

Fig. 2— Nominal CPUE for Gulf of Mexico gray triggerfish. Dark line shows proportion of trips that caught gray trigger (Prop Pos) while light line shows the catch per unit effort for those positive trips.

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

Species	Correlation Coefficient
SNAPPER,VERMILION	1.476057644
SNAPPER,RED	0.967724703
PORGY,RED,UNC	0.962329241
SEA BASSE,ATLANTIC,BLACK,UNC	0.902091148
PORGY,KNOBBED	0.871996667
MARGATE	0.778037215
SNAPPER,LANE	0.714504763
PORGY,JOLTHEAD	0.679845323
GRUNT,WHITE	0.617023415
PORGY,WHITEBONE	0.532568718
JACK,ALMACO	0.517259526
COBIA	0.476461368
GROUPER,WARSAW	0.451471416
BANDED RUDDERFISH	0.444411793
SCAMP	0.441679962
BLUE RUNNER	0.432081501
SNAPPER,MANGROVE	0.404037266
GROUPER,BLACK	0.318396766
HOGFISH	0.306275468
SNAPPER,SILK	0.287771139
GROUPER,GAG	0.284595818
GRUNT,BLUESTRIPED	0.193027456
BLUEFISH	0.165741497
AMBERJACK,LESSER	0.111776117
AMBERJACK,GREATER	0.080111262
DOLPHINFISH	0.046396434
SEA TROUT,WHITE	0.039480821
SNAPPER,QUEEN	0.009539107
KING MACKEREL	0.006066825
HAKE,ATLANTIC,RED & WHITE	-0.024797553
SPANISH MACKEREL	-0.053548179
TUNA,BLACKFIN	-0.064138354
GROUPER,SNOWY	-0.079884386
HIND,SPECKLED	-0.175511207
GROUPER,RED	-0.241628006
GROUPER,YELLOWEDGE	-0.246346908
TILEFISH,BLUELINE	-0.30831694
SNAPPER,MUTTON	-0.481708646
SNAPPER,YELLOWTAIL	-1.236827618

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

YEAR	Trips
1992	1691
1993	2150
1994	1596
1995	2587
1996	2755
1997	2705
1998	3328
1999	2707
2000	2803
2001	3252
2002	3434
2003	3111

Season	Trips
AUT	7202
SPR	8829
SUM	6685
WIN	9403

Red Snapper Season	Trips
CLSD	14387
OPEN	17732

Red Snapper Class 1	Trips
NO	15536
YES	16583

State	Trips
<= 10	14099
11-19	8282
>= 20	9738

State	Trips
AL	6181
FL	11493
LA	10252
TX	4193

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, season, and red snapper permit for the proportion positive data; and year, hooks per line, state, state*hooks, and year*state for the CPUE data. These results should be viewed as fairly fixed, although a small change may occur when a few unidentified triggerfish are added to the analysis and effort is reexamined.

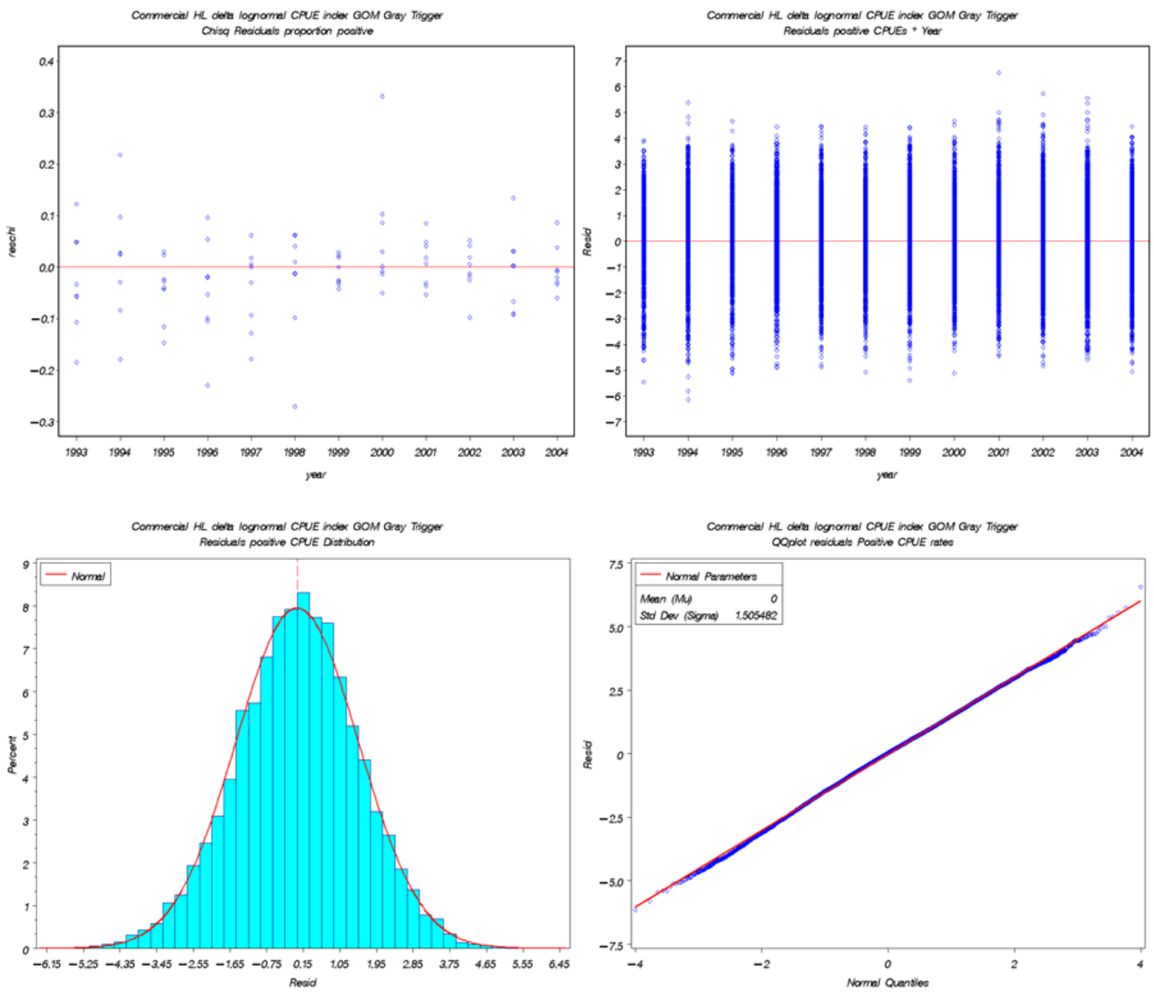

Fig. 3—Diagnostics of the delta-lognormal model. Residuals by year did not show biases or unidentified problems in either the proportion positive (a) or ln(CPUE) (b) portions of the model. Residuals overall of the ln(CPUE) portion fit well to a normal distribution (c), and a Q-Q plot (d) also validated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

DISCUSSION

A few unidentified triggerfish were noted in the dataset, with a temporal pattern of fewer in recent years. As a result, these fish will be incorporated into this index and may change values slightly. Moreover, questions were raised about the appropriateness of hook hours as a measure of effort. Line hours will also be explored.

LITERATURE CITED

Lo, NC, LD Jackson, JL Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49: 2515-2526.

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

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

YEAR	ln(CPUE)	SE
1993	0.066111	0.131782
1994	0.306531	0.119644
1995	0.561	0.142356
1996	0.311129	0.108223
1997	0.247547	0.104575
1998	0.137542	0.104335
1999	0.261546	0.095402
2000	0.124708	0.105021
2001	0.244972	0.103453
2002	0.432149	0.097882
2003	0.61988	0.097557
2004	0.506137	0.101281

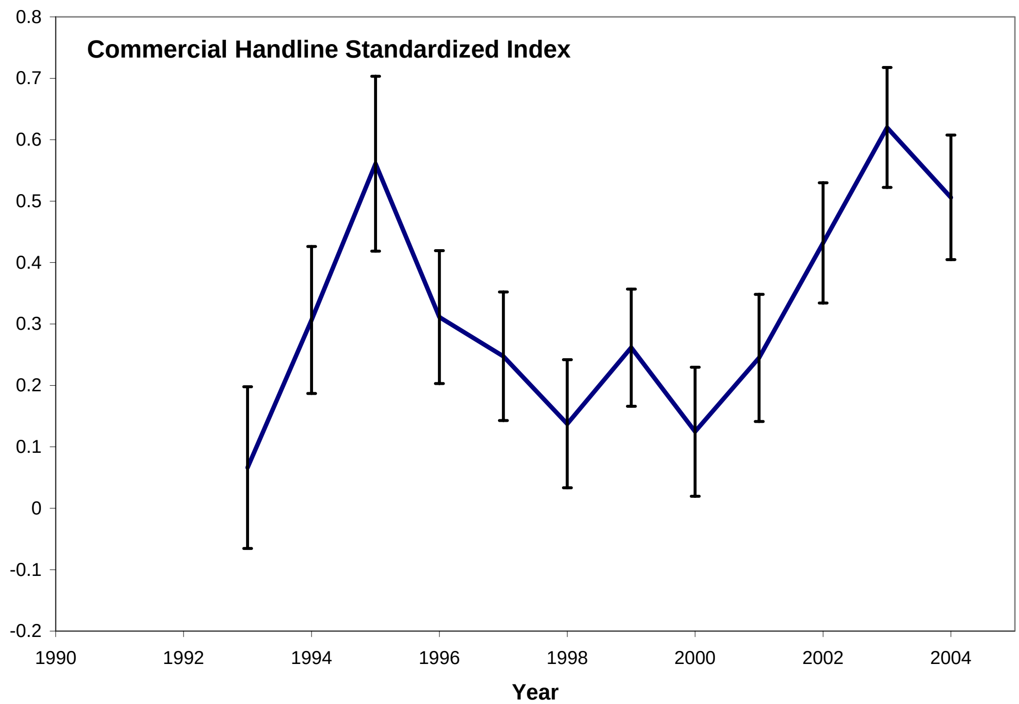

Fig. 4—Standardized index values per year. Ln(CPUE) values shown with error bars representing standard errors.