Standardized Catch Rate Indices for Gulf of Mexico Gray Triggerfish (*Balistes capriscus*) Landed During 1981-2013 by the Recreational and Private Boat Fisheries

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Standardized Catch Rate Indices for Gulf of Mexico Gray Triggerfish (*Balistes capriscus*) Landed During 1981-2013 by the Recreational and Private Boat Fisheries

by

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INTRODUCTION

The Marine Recreational Fisheries Statistics Survey (MRFSS) data set was updated through 2013 and the procedures outlined in SEDAR 9 were implemented to provide standardized abundance indices. Catch-per-unit effort (CPUE) is derived from the MRFSS data using total fish caught on a given trip divided by the amount of angler-hours spent fishing as calculated from dockside interviews, where:

$$\ln(CPUE) = \ln\left[\frac{A+B1+B2}{Anglers*Hours\ Fished}\right]. \quad (1)$$

For the MRFSS data set, *A* were fish caught and observed by the port agent, *B1* were fish reported caught but not observed, and *B2* were fish reported caught, not observed, and released alive.

Trips were eliminated if they had missing values for any of the key factors. Trips were included if they came from the charter or private boat mode (the headboat mode is treated as a separate index), and if they used hook and line gear.

The following data preparation and filtering techniques were applied to the MRFSS dataset:

1. Data from TX were excluded (not available in the dataset after 1985).
2. Data from the entire timeseries, 1981-2013, was included.
3. Interviews that reported shore-based fishing or fishing in inshore waters were excluded.
4. Data from Monroe County were excluded (dividing line with the South Atlantic region).
5. Observations were classified into four regions of the Gulf of Mexico (defined by the State factor).
6. Closed seasons for gray triggerfish were used to define the Gray Triggerfish Season factor.
7. Data from 2010 were excluded.
8. MRFSS data were weighted to account for changes in sampling effort that were implemented in 2000.

Due to data limitations and lack of representative sampling for the entire time period for the western Gulf of Mexico, only an index for the eastern Gulf of Mexico was developed.

METHODS

Species Associations

An indirect method was necessary to infer targeting behavior of fishermen, because no direct information was available. Previously in SEDAR 9 only trips that caught the target species were included in the analysis. However, this approach potentially overinflated the resulting CPUE index, because all trips with no catch of the target species were dropped from the analysis, despite the possibility of a zero catch trip occurring in habitat where the target species was likely to occur. During the 2011 update assessment a new approach was adopted, which involved identifying a guild of species that frequently co-occur with gray triggerfish. The guild was defined as all fish in the NOAA reef fish management plan (Table 1). MRFSS interviews that were retained included all interviews that reported gray triggerfish as well as interviews that reported any of the species included in the reef fish guild.

Index Standardization

A two-step delta-lognormal general linearized model (GLM; Lo et al. 1992) was used to standardize for variability and non-randomness in CPUE data collection methods not caused by the year effect (i.e., to factor out year to year variations in CPUE not due to changes in abundance). The combined approach first modeled the frequency with which trips caught the species of interest (i.e., proportion positive) using a logit regression assuming a binomial distribution of the response variable. In the second step, the logarithm of CPUE on successful trips (those that caught the target species) was used as the response variable assuming a normal distribution and an identity link function. The two models were then combined to provide the final standardized index of abundance.

A forward stepwise regression approach was utilized within the GENMOD procedure of SAS 9.2 (SAS Institute, 2008). In this procedure, potential factors were added to the base model one at a time based on the percent reduction in deviance per degree of freedom. With each run of the model the factor that caused the highest reduction in deviance was added to the base model (assuming the factor was significant based on a Chi-Square test with probability ≤ 0.05) until no factor reduced the percent deviance by the prespecified level (i.e., 1%). Because the goal of the standardization was to model time trends in abundance, it was necessary to force the year effect as a factor even if it was not deemed significant. Two-way interaction terms were then investigated among each of the significant factors using the same stepwise approach. All higher order interactions were ignored.

The final delta-lognormal model was fit using the factors deemed significant in the GENMOD procedure using the SAS macro GLIMMIX (SAS Institute, 2008). Factors were modeled as fixed effects except for interaction terms involving year, which were modeled as random effects. Results of the binomial (proportion positive) and lognormal (mean CPUE on successful trips) were then multiplied to attain a single index of abundance based on the year effect.

RESULTS

Species Associations

There were 589,921 trip records available in the MRFSS data base from the Gulf of Mexico. The guild approach retained 82,571 trips for use in the index standardization. The proportion of positive trips was 12.5% after the subset was taken.

Abundance Indices

A number of factors were investigated that could potentially influence yearly variations in catch rates including: Year, Season, Mode (i.e., private or for hire), State, Red Snapper Season (i.e., open or closed), and Gray Triggerfish Season. The levels and potential values for the various factors are provided in Table 2.

For the binomial component the significant factors were Year, Mode, State, and Season. In the lognormal model Year, Red Snapper Season, State, and Season were found to be significant along with the Year*Red Snapper Season and Year*State interaction terms. The final models were:

$$Proportion\ Positive = Year + Mode + State + Season$$

$$\ln(CPUE) = Year + Red\ Snapper\ Season + State + Season + Year * Red\ Snapper\ Season + Year * State\ . \qquad \textbf{(2)}$$

The final nominal and standardized CPUE (both provided as relative indices where each value is divided by the timeseries mean) along with confidence intervals and coefficients of variation (CVs) are given in Table 3.

Observed and predicted trends in the proportion of positive trips tend to overlap with strong variation in the first decade of the timeseries before leveling to slight fluctuations around 10% positive trips since the late 1990s (Figure 1). The extremely low occurrence of gray triggerfish in the data set may warrant future investigation as to whether the lack of targeting may inhibit the use of the MRFSS data set as a valid source of trends in abundance. Results from the lognormal model indicate a relatively strong fit with only slight deviations from the expected distribution (Figure 2).

Nominal and standardized CPUE tend to overlap for much of the timeseries with the nominal values within the 95% confidence intervals for much of the last two decades (Figure 3). The first decade is characterized by stronger variation with a general increase in both nominal and standardized CPUE from the mid-1980s until the early 1990s. Since that time CPUE has been slowly but steadily declining with limited fluctuations. There was a moderate three year increase from 2008-2011, but the last two years of data indicate a decline from this local peak.

Continuity

Moderate discrepancies exist between the original SEDAR 9 indices, the 2011 updates, and the current estimates (Figure 4). Trends tend to be similar among all three approaches except for a strong 1984 peak in the SEDAR 9 index. Standardized values also generally overlap, but the current model demonstrates slightly elevated values since 1996 compared to SEDAR 9 and the 2011 update. Although attempts have been made to maintain modeling approaches, some alterations have been required since the SEDAR 9 benchmark due primarily to data updates causing changes in the significance of GLM factors. For the binomial, SEDAR 9 indicated that Season and State were not significant, while the current analysis showed that they have since become important factors. Likewise, SEDAR 9 did not list State as a significant factor for the lognormal model, but it is in the current analysis.

SEDAR 9 Model (Nowlis, 2005):

$$Proportion\ Positive = Year + Mode$$
$$\mathbf{ln(}\boldsymbol{CPUE}\mathbf{)} = \boldsymbol{Year + Red\ Snapper\ Season + Season + Year * Season.}$$
(3)

Results from the 2011 update assessment are poorly documented in regards to the standardization of CPUE indices. The best determination that could be made is that the binomial model from the update was identical to the current analysis in terms of significant factors, but two interaction terms were also included (State*Season and Year*State). The lognormal models differed in that Red Snapper Season and Season are significant in the current model, but were not in the 2011 update. Similarly, the 2011 update listed an undocumented variable Recreational Season as being significant, but no determination could be made as to what this variable represented and so it could not be tested in the current analysis.

2011 Update Model:
$$Proportion\ Positive = Year + Mode + State + Season + State * Season + Year * State$$
$$\mathbf{ln(}\boldsymbol{CPUE}\mathbf{)} = \boldsymbol{Year + State + Recreational\ Season + State * Year}\ .$$
(4)

Additionally, SEDAR 9 used all trips that caught gray triggerfish to subset trips from the MRFSS data base, while this was deemed inappropriate for recreational data for the 2011 update. The guild approach as described in the methods was introduced in 2011 and was again utilized in the current analysis.

DISCUSSION

The results and model diagnostics indicate that the MRFSS index is a reliable index of CPUE that can be used in the SEDAR 43 assessment of gray triggerfish. Future work should look into the apparently low targeting of gray triggerfish in the recreational sector in order to determine whether the MRFSS data set should be used to infer abundance trends. The gray triggerfish bag limit enacted in 2013 is likely to impact future catch rates and should be more carefully considered within the GLM in future updates.

LITERATURE CITED

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TABLES

Table 1: The reef fish guild as defined by the NOAA reef fish management plan and used to subset the MRFSS data base.

Species
Queen Snapper
Mutton Snapper
Schoolmaster
Red Snapper
Cubera Snapper
Gray Snapper
Dog Snapper
Mahogany Snapper
Lane Snapper
Silk Snapper
Yellowtail Snapper
Wenchman
Voraz
Vermillion Snapper
Blackfin Snapper
Rock Hind
Speckled Hind
Yellowedge Grouper
Red Hind
Jewfish
Red Grouper
Misty Grouper
Warsaw Grouper
Snowy Grouper
Nassau Grouper
Black Grouper
Yellowmouth Grouper
Gag Grouper
Scamp
Yellowfin Grouper
Southern Sea Bass
Bank Sea Bass
Rock Sea Bass
Tilefish
Greater Amberjack
Gray Triggerfish
Hogfish
Red Porgy
Sand Perch

Table 2: Levels and values for the factors investigated in the GLM.

Factor	Levels	Values
Year	33	1981 - 2013
Season	4	Jan-Mar, Apr-Jun, Jul-Sep, Oct-Dec
Red Snapper Season	2	Closed, Open
Mode	2	Private, For Hire
Gray Trigger Season	2	Closed, Open
State	3	Alabama, Florida, Mississippi

Table 3: Nominal and standardized CPUE values (relative to the timeseries means) along with confidence intervals and CVs for the model estimates.

Western Gulf of Mexico

	Index		Confidence Limits (95%)		
Year	**Standardized**	**Nominal**	**Lower**	**Upper**	**CV**
1981	1.298021	1.950715	0.449852	3.745365	0.569294
1982	0.780012	0.330588	0.309689	1.964612	0.487633
1983	0.55049	0.371538	0.185059	1.637523	0.588171
1984	0.13797	0.324844	0.026578	0.716216	0.984959
1985	0.109193	0.111213	0.022283	0.535083	0.938285
1986	1.848001	2.871576	1.046674	3.26282	0.290083
1987	0.798006	0.650078	0.427008	1.491338	0.320455
1988	1.683405	1.574759	0.933452	3.035884	0.301367
1989	2.908827	1.829512	1.682448	5.029145	0.27896
1990	3.346629	3.799276	1.786561	6.268986	0.321719
1991	1.971824	2.450075	1.072309	3.625906	0.311774
1992	1.82168	1.444984	1.135466	2.922602	0.239697
1993	1.339601	1.030557	0.773149	2.321069	0.2801
1994	1.502775	0.971576	0.880002	2.566282	0.272434
1995	0.983844	0.633721	0.524633	1.845004	0.322315
1996	1.140358	0.826003	0.630809	2.061505	0.302654
1997	0.779723	0.625367	0.456838	1.330816	0.272151
1998	0.856778	0.813107	0.528297	1.3895	0.245336
1999	0.776129	0.600174	0.495873	1.214779	0.226839
2000	0.486889	0.519501	0.305277	0.776542	0.236623
2001	0.697511	0.772949	0.438017	1.110737	0.235813
2002	0.722099	0.878679	0.456029	1.14341	0.232871
2003	0.598154	0.82539	0.374116	0.956358	0.237909
2004	1.128374	0.983181	0.7249	1.756418	0.223985
2005	0.779251	0.800062	0.486876	1.2472	0.23845
2006	0.581913	0.537193	0.354817	0.954357	0.251191
2007	0.484566	0.519719	0.296352	0.792314	0.249615
2008	0.248523	0.274681	0.145812	0.423583	0.271416
2009	0.3613	0.494303	0.210778	0.619315	0.274417
2010	0.509658	0.68323	0.29903	0.868646	0.271406
2011	0.713536	1.080276	0.43678	1.165654	0.249144
2012	0.600081	0.797103	0.361242	0.996833	0.257899
2013	0.454877	0.624068	0.258718	0.799764	0.287854

FIGURES

Figure 1: Diagnostic plots for the binomial model. Observed (black dots) and predicted (black line) proportion positive trips that caught the target species by year.

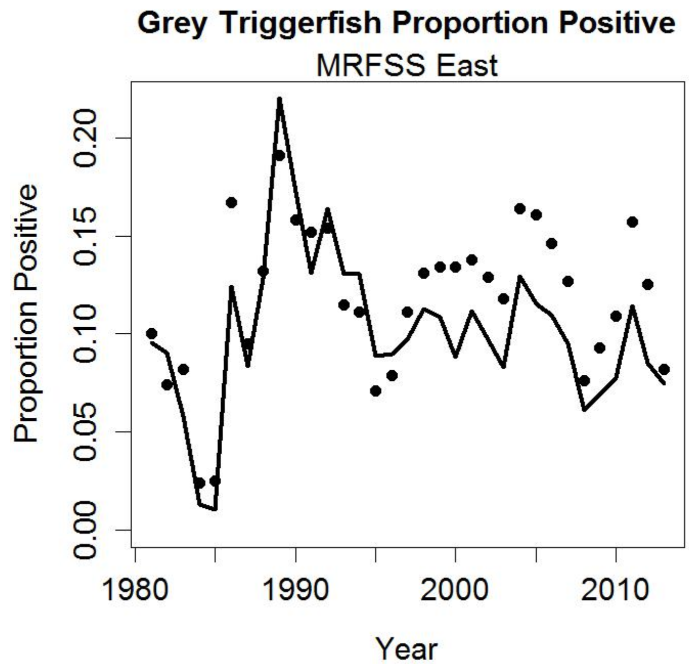

Figure 2: Diagnostic Q-Q plot for the lognormal model.

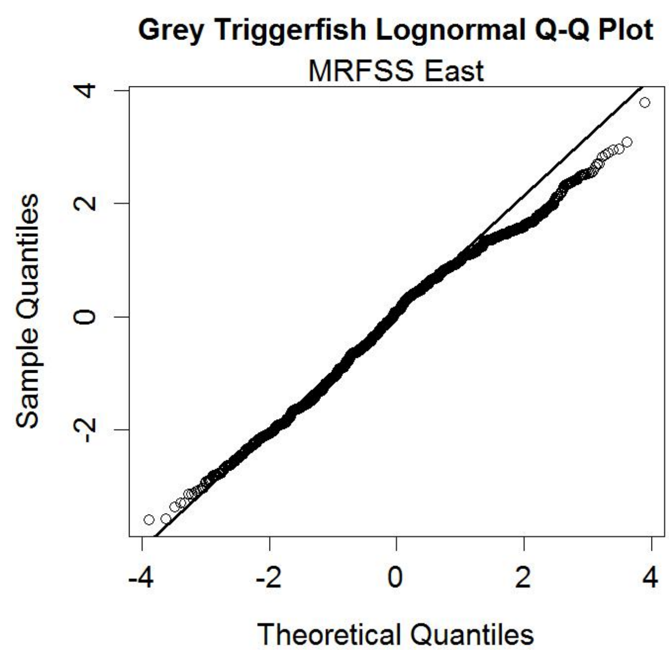

Figure 3: Timeseries plots of nominal (red dots) and standardized (black line) CPUE relative to the mean of the given timeseries. 95% confidence intervals for the standardized CPUE are given by the dashed lines.

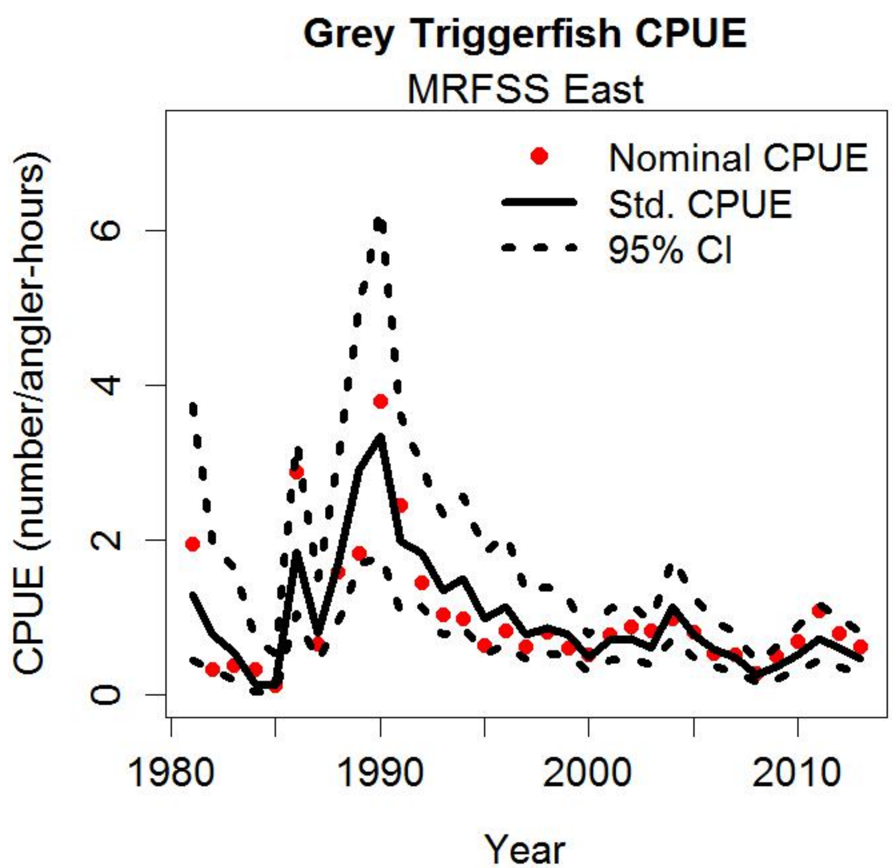

Figure 4: Timeseries plots of the SEDAR 9 (blue line), the 2011 update (red line), and the current SEDAR 43 (gray line) standardized CPUE index.