Standardized Catch Rates of Gray Triggerfish (*Balistes capriscus*) from the Gulf of Mexico Recreational Charterboat and Private Boat Fisheries (MRFSS) 1981-2017

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1. Introduction

The recreational fishery in the Gulf of Mexico is surveyed by the Marine Recreational Fishery Statistics Survey (MRFSS) conducted by NOAA Fisheries, the Texas Marine Sport-Harvest Monitoring Program conducted by the Texas Parks and Wildlife Department (TPWD), and the Headboat Survey (HBS) conducted by NOAA Fisheries. MRFSS has monitored shore based, charterboat and private/rental boat angler fishing in the Gulf of Mexico since 1981. MRFSS data were used to construct an index of gray triggerfish (*Balistes capriscus*) catch rates in the Gulf of Mexico following the same procedures used in SEDAR43. The index was constructed using a delta-lognormal generalized linear model (GLM).

2. Materials and Methods

Marine Recreational Fishery Statistics Survey

MRFSS collects information on participation, effort, and species-specific catch. Data are collected to provide catch and effort estimates in two-month periods ("waves") for each recreational fishing mode (shore fishing, private/rental boat, charterboat, or headboat/charterboat combined) and for each area of fishing (inshore, state Territorial Seas, U.S. Exclusive Economic Zone), in each Gulf of Mexico state (except Texas). Total catch information is collected by MRFSS on fish landed whole and observed by interviewers ("Type A"), fish reported as killed by the fishers ("Type B1") and fish reported as released alive by the fishers ("Type B2").

Data from the MRFSS dockside interviews were used to characterize abundance trends of gray triggerfish in the Gulf of Mexico. Information on effort included hours fished and the number of anglers as reported to the interviewer. Catch that was not observed by the interviewer (B1 and B2) was adjusted upwards by the ratio of non-interviewed to interviewed anglers in each group of anglers. The catch per unit effort was calculated on an individual group basis and was equal to the number of fish caught on a given trip (A + B1 + B2) divided by the effort, where effort was the product of the number of anglers and the total hours fished.

Data Filtering Techniques

Data were filtered following the same steps as SEDAR43 where possible. 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. One difference between the MRFSS data used in SEDAR43 and the MRFSS data used in SEDAR62 is the lack of separation of charter/party data in 1981-1985. For this assessment, the publically available MRFSS dataset was used to construct the index due to staff and time limitations. An index was solely developed for the eastern Gulf of Mexico due to data limitations and lack of representative sampling for the entire time period for the western Gulf of Mexico.

Species Associations

An indirect method was necessary to infer targeting behavior of fishermen because no direct information was available. Following SEDAR43, the guild approach was used to select trips for use in the analysis and is based on species that frequency 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.

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). This method combines separate GLM analyses of the proportion of trips that observed gray triggerfish and the catch rates on positive trips to construct a single standardized index of abundance. In the first step, the proportion positive is modeled 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 pre-specified level (i.e., 1%). Since the goal of the standardization process 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. Higher order interactions were not tested.

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.

3. Results and Discussion

Species Associations

Of 718,052 trip records available in the MRFSS database from the Gulf of Mexico, 604,605 trips occurred in the East and 214,616 trips were classified as either charterboat or party. Of these trips in the East, 11,952 trips encountered gray triggerfish. The guild approach retained 93,202 trips for use in the index standardization. The proportion of positive trips before and after the subsetting routine was applied were 0.056 and 0.128, respectively. Note that 4,181 trips between 1981 and 1985 were not included due to an inability in separating out charter data from the publically available dataset.

Eastern Gulf of Mexico

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

Factor	Levels	Details
Year	37	1981-2017
Season	4	Aug-Oct, Mar-May, Jun-Jul, Nov-Feb
Red Snapper Season	2	Open, Closed
Mode	2	Private, Charterboat
Gray Triggerfish Season	2	Open, Closed
State	3	Alabama, Florida, Mississippi

Table 2 summarizes the standardized index, corresponding lower and upper confidence limits, coefficients of variation, and nominal CPUE. Final deviance tables are included in Table 3. The final models for the binomial and lognormal components were:

Proportion Positive = YEAR + MODE + STATE + SEASON + STATE*SEASON
ln(CPUE) = YEAR + RED SNAPPER SEASON

The standardized index, with 95% confidence intervals, is shown in Figure 1. Nominal values generally fell within the 95% confidence intervals, with exceptions noted in 1982, 1985, 1989, 1992, 1994, 2011, and 2015-2016. Relative abundance has remained relatively low since the mid 1990s, although an increase in CPUE is evident since 2014 (Figure 1).

Diagnostics for each component of the GLM are provided in Figures 2 and 3. The overdispersion parameter for the binomial component was 4.50. The binomial model generally overestimates the proportion positive in the first half of the time series and underestimates it since the 2000s

(Figure 2A). The proportion positive has generally remained between 10-15%, which raised concerns during SEDAR43 about whether the lack of targeting may inhibit the use of the MRFSS data set as a valid source of trends in abundance (Smith et al. 2015). Residual analysis of the binomial model indicated no obvious patterns in the residuals by year (Figure 2B), mode (Figure 2C), state (Figure 2D) or season (Figure 2E).

The lognormal model results suggest a good fit to the data and indicated that the assumption of a lognormal distribution for positive catch was appropriate for the data (Figure 3A-B). Residual analysis of the lognormal model also indicated no obvious patterns in the residuals by year or red snapper season (Figure 3C-D).

Figure 4 provides a comparison of the MRFSS index that resulted from the current analysis to the MRFSS index derived during SEDAR43. Although some slight differences are evident in the early years, the trend and magnitude of the indices are similar. Noticeable differences in the uncertainty are evident between 1981 and 1985, likely due to the exclusion of charter/party data during these years due to data availability. However, all index values for SEDAR62 fall within the confidence intervals of the SEDAR43 index (Figure 5).

Comments on Adequacy for Assessment

The MRFSS index presented in this working paper was deemed adequate for use in the SEDAR43 assessment. However, we reiterate concerns raised during the SEDAR43 Data/Assessment process documented in Smith et al. (2015) such as:

- Whether the MRFSS dataset should be used to infer abundance trends given the low targeting of gray triggerfish
- The gray triggerfish bag limit enacted in 2013 may impact future catch rates and should be more carefully considered within the GLM in future assessments.

4. References

Lo, N.C. L.D. Jacobson, and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49: 2515-2526.

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5. Tables

Table 1. The reef fish guild, as defined by the NOAA reef fish management plan, used to subset the MRFSS database in SEDAR62 and SEDAR43.

Common Name	Scientific Name
Queen snapper	*Etelis oculatus*
Mutton snapper	*Lutjanus analis*
Schoolmaster	*L. apodus*
Blackfin snapper	*L. buccanella*
Red snapper	*L. campechanus*
Cubera snapper	*L. cyanopterus*
Gray snapper	*L. griseus*
Dog snapper	*L. jocu*
Mahogany snapper	*L. mahogoni*
Lane snapper	*L. synagris*
Silk snapper	*L. vivanus*
Yellowtail snapper	*Ocyurus chrysurus*
Wenchman	*Pristipomoides aquilonaris*
Vermilion snapper	*Rhomboplites aurorubens*
Rock hind	*Epinephelus adscensionis*
Speckled hind	*E. drummondhayi*
Red hind	*E. guttatus*
Goliath grouper	*E. itajara*
Red grouper	*E. morio*
Nassau grouper	*E. striatus*
Black grouper	*Mycteroperca bonaci*
Yellowmouth grouper	*M. interstitialis*
Gag grouper	*M. microlepis*
Scamp	*M. phenax*
Yellowfin grouper	*M. venenosa*
Yellowedge grouper	*Hyporthodus flavolimbatus*
Misty grouper	*H. mystacinus*
Warsaw grouper	*H. nigritus*
Snowy grouper	*H. niveatus*
Bank sea bass	*Centropristis ocyurus*
Rock sea bass	*C. philadelphica*
Greater amberjack	*Seriola dumerili*
Gray triggerfish	*Balistes capriscus*
Hogfish	*Lachnolaimus maximus*
Red porgy	*Pagrus pagrus*
Sand perch	*Diplectrum formosum*

Table 2. Numbers of total and positive interviews, proportion of positive interviews (PPT), relative nominal CPUE, and abundance index statistics for the MRFSS index.

YEAR	TRIPS	POSITIVE TRIPS	PPT	RELATIVE NOMINAL CPUE	RELATIVE INDEX	LOWER 95% CI	UPPER 95% CI	CV
1981	238	18	0.076	2.1506	1.9658	0.6636	5.8236	0.5856
1982	476	24	0.05	0.2164	0.9312	0.3505	2.4743	0.5193
1983	278	11	0.04	0.1246	0.4895	0.1237	1.9365	0.7775
1984	239	2	0.008	0.4054	0.1148	0.0103	1.2837	1.8155
1985	246	6	0.024	0.0721	0.4178	0.0744	2.3478	1.0518
1986	1365	228	0.167	3.0268	2.3875	1.6378	3.4804	0.1901
1987	1583	150	0.095	0.6371	0.8242	0.5217	1.3020	0.2317
1988	464	36	0.078	0.7537	0.9904	0.4238	2.3143	0.4442
1989	1102	210	0.191	1.8147	2.7741	1.9100	4.0292	0.1883
1990	796	126	0.158	3.4170	3.0968	1.9261	4.9789	0.2408
1991	1110	169	0.152	2.2983	1.9873	1.2783	3.0897	0.2234
1992	2221	355	0.16	1.3377	1.9321	1.4297	2.6109	0.1514
1993	1892	216	0.114	0.8719	1.2507	0.8541	1.8314	0.1924
1994	2161	238	0.11	0.9911	1.5183	1.0578	2.1794	0.1822
1995	1839	132	0.072	0.6373	0.8992	0.5529	1.4623	0.2468
1996	2048	162	0.079	0.8315	1.0192	0.6551	1.5856	0.2237
1997	2401	267	0.111	0.4853	0.5808	0.4070	0.8287	0.1792
1998	3156	413	0.131	0.6896	0.6869	0.5128	0.9200	0.1469
1999	4910	658	0.134	0.5230	0.5965	0.4660	0.7635	0.1239
2000	4195	562	0.134	0.4330	0.4140	0.3166	0.5413	0.1346
2001	4092	565	0.138	0.7306	0.6860	0.5283	0.8907	0.1311
2002	4713	608	0.129	0.7706	0.6504	0.5029	0.8411	0.1291
2003	4716	556	0.118	0.7287	0.5681	0.4351	0.7418	0.1340
2004	4469	809	0.181	1.0397	0.9211	0.7327	1.1580	0.1148
2005	3434	604	0.176	0.8642	0.7515	0.5814	0.9713	0.1288
2006	2878	435	0.151	0.5298	0.5321	0.3977	0.7119	0.1463
2007	3271	442	0.135	0.5612	0.5125	0.3832	0.6852	0.1460
2008	3760	301	0.08	0.2982	0.2752	0.1963	0.3858	0.1701
2009	2867	284	0.099	0.5464	0.4080	0.2881	0.5778	0.1753
2010	2670	304	0.114	0.7489	0.5636	0.4023	0.7895	0.1698
2011	2867	473	0.165	1.1806	0.7602	0.5734	1.0079	0.1417
2012	3315	414	0.125	0.8394	0.6246	0.4629	0.8427	0.1506
2013	2764	227	0.082	0.6450	0.4609	0.3156	0.6732	0.1911
2014	4001	376	0.094	0.7018	0.5644	0.4129	0.7715	0.1572
2015	3693	454	0.123	1.3771	0.9226	0.6927	1.2289	0.1441

YEAR	TRIPS	POSITIVE TRIPS	PPT	RELATIVE NOMINAL CPUE	RELATIVE INDEX	LOWER 95% CI	UPPER 95% CI	CV
2016	3487	572	0.164	1.8317	1.2982	1.0057	1.6759	0.1282
2017	3393	485	0.143	1.8891	1.6235	1.2387	2.1279	0.1359

Table 3. Final deviance tables for the Eastern Gulf of Mexico gray triggerfish regressions from the MRFSS charterboat and private boat fisheries. The table shows the order of the factors as they were sequentially added to each model. Fit diagnostics listed for each factor were the diagnostics from a model that included that factor and all of the factors listed above it in the tables below.

Binomial Model for Success (whether or not a trip landed gray triggerfish)								
Factor	**DF**	**Deviance**	**Residual Df**	**Residual Deviance**	**AIC**	**% Deviance Reduced**	**Log likelihood**	**Likelihood Ratio Test**
Null	1	71208.9	93201	71208.9	71208.80	-	-35604.4	-
Mode	2	64661.5	93200	64661.5	64661.40	9.19%	-32330.7	6547.4
State	3	62054.1	93198	62054.1	62054.00	4.03%	-31027.0	2607.4
Season	4	61086.1	93195	61086.1	61086.00	1.56%	-30543.0	968.0
Year	37	60458.5	93159	60458.5	60458.60	0.99%	-30229.3	627.4
State* Season	7	59684.1	93153	59684.1	59684.00	1.27%	-29842.0	774.6
Lognormal Model for Catch Rates From Positive Trips								
Factor	**DF**	**Deviance**	**Residual Df**	**Residual Deviance**	**AIC**	**% Deviance Reduced**	**Log likelihood**	**Likelihood Ratio Test**
Null	1	19883.6	11898	19883.6	39877.40	-	-19938.7	-
Year	37	17618.0	11862	17618.0	38437.80	11.13%	-19218.9	1439.6
Red Snapper Season	2	17082.2	11861	17082.2	38070.40	3.03%	-19035.2	367.4

6. Figures

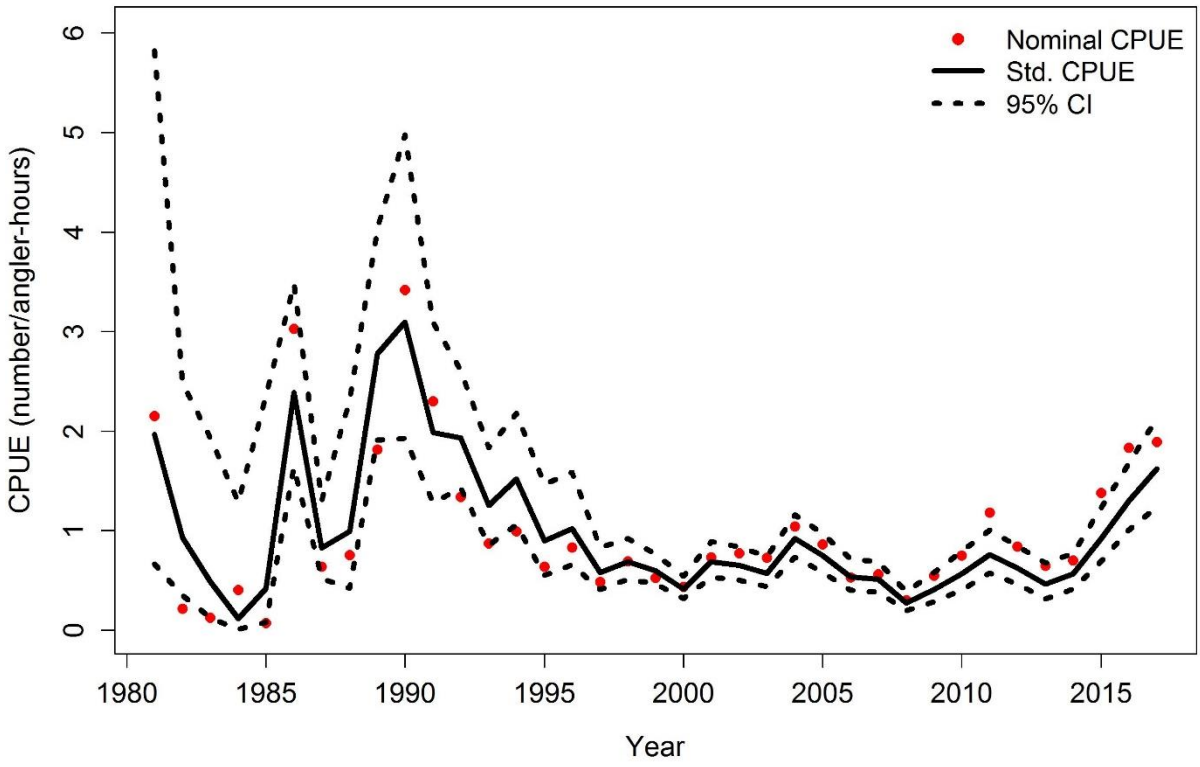

Figure 1. Standardized indices with 95% confidence intervals and nominal CPUE for the gray triggerfish MRFSS index for the Eastern Gulf of Mexico.

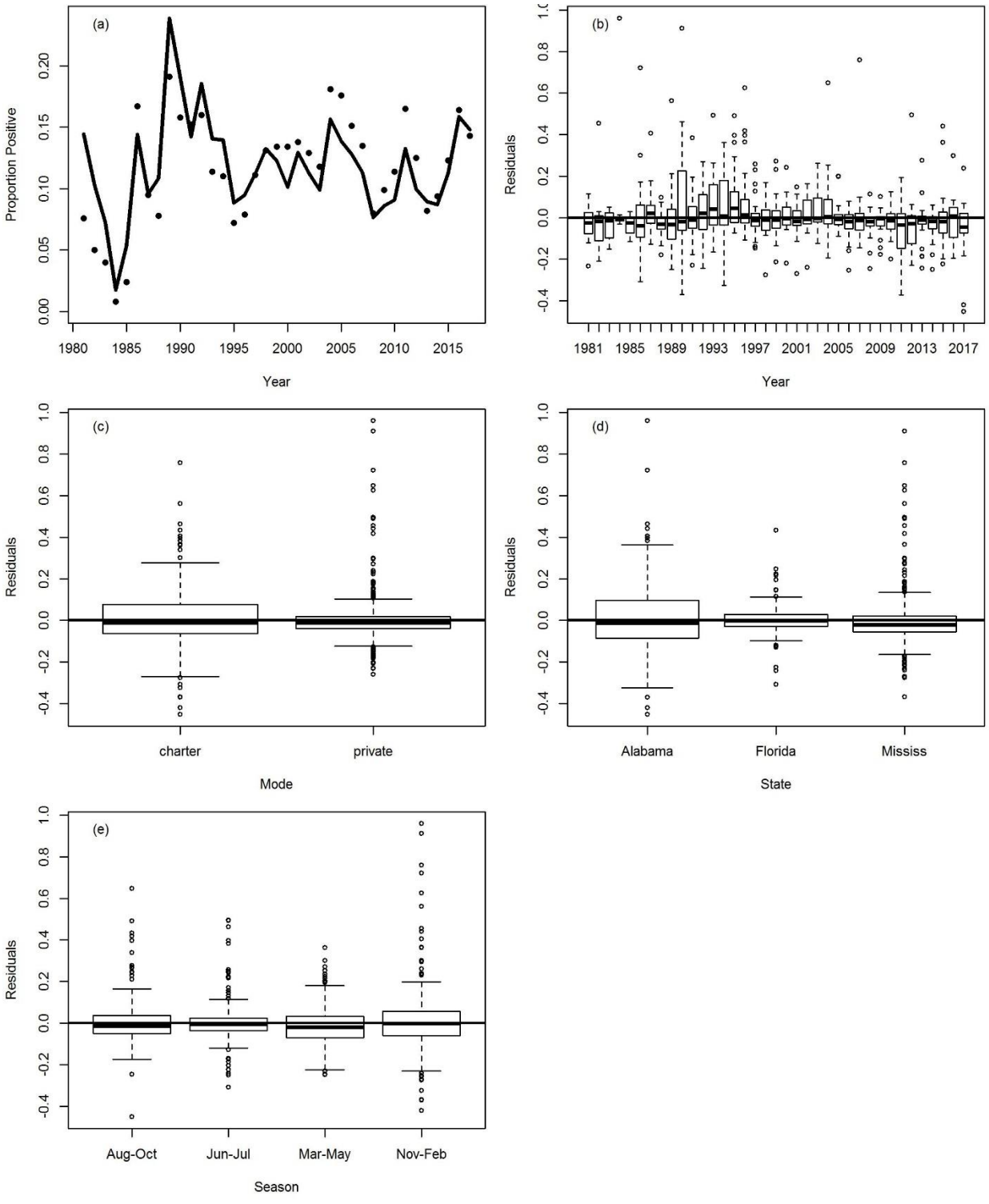

Figure 2. Diagnostic plots for the binomial model for gray triggerfish in the Eastern Gulf of Mexico. Shown here are the predicted (solid line) and observed proportion (dots) of positive trips by year (a), and the residuals from the binomial model by year (b), mode (c), state (d), and season (e).

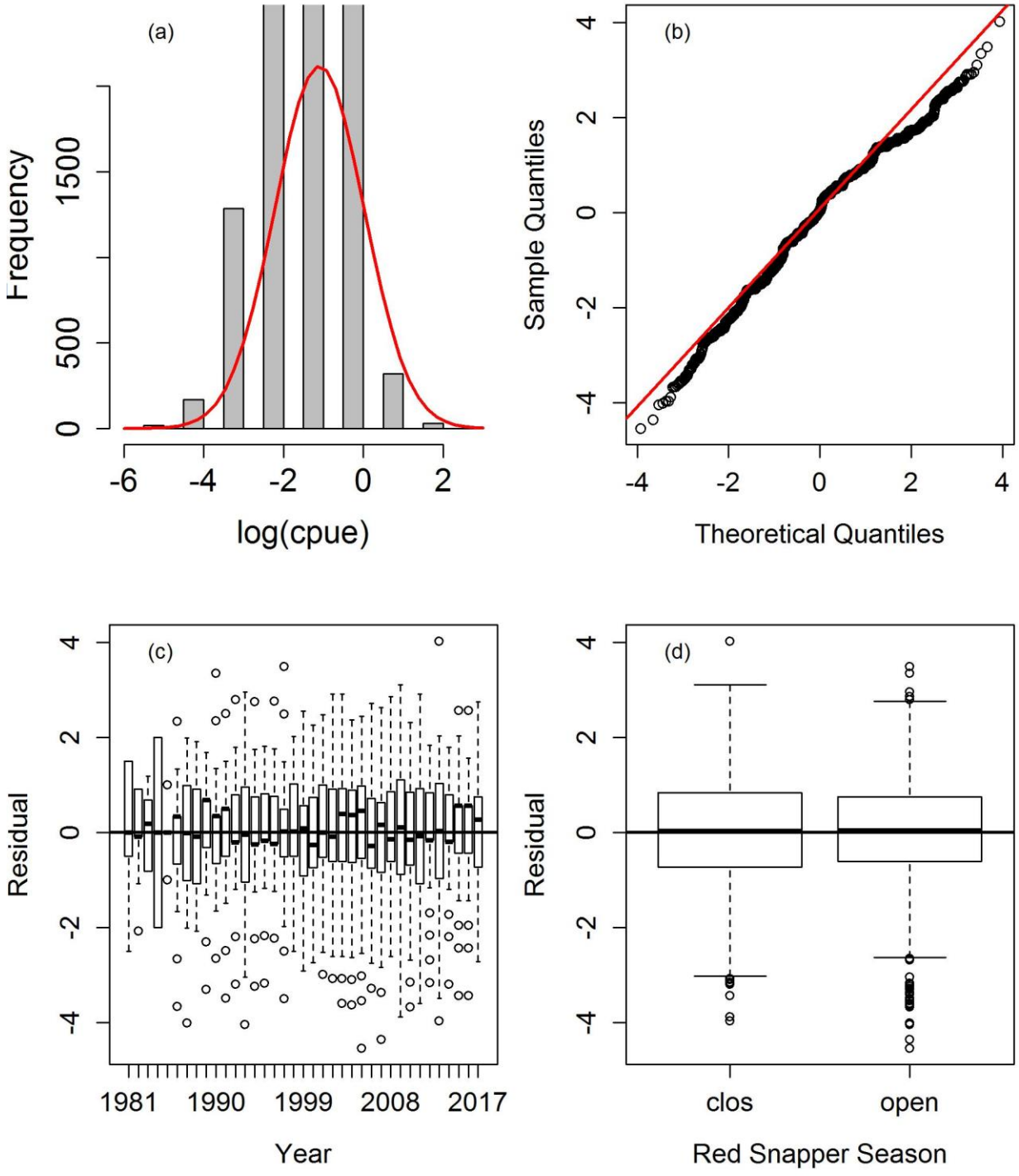

Figure 3. Diagnostic plots for the lognormal model of catch rates on positive trips for gray triggerfish in the Eastern Gulf of Mexico. Shown here are the frequency distribution of catch rates (a), the cumulative normalized residuals (b), and the distribution of residuals by year (c), and red snapper season (d). The red lines represent the expected normal distribution.

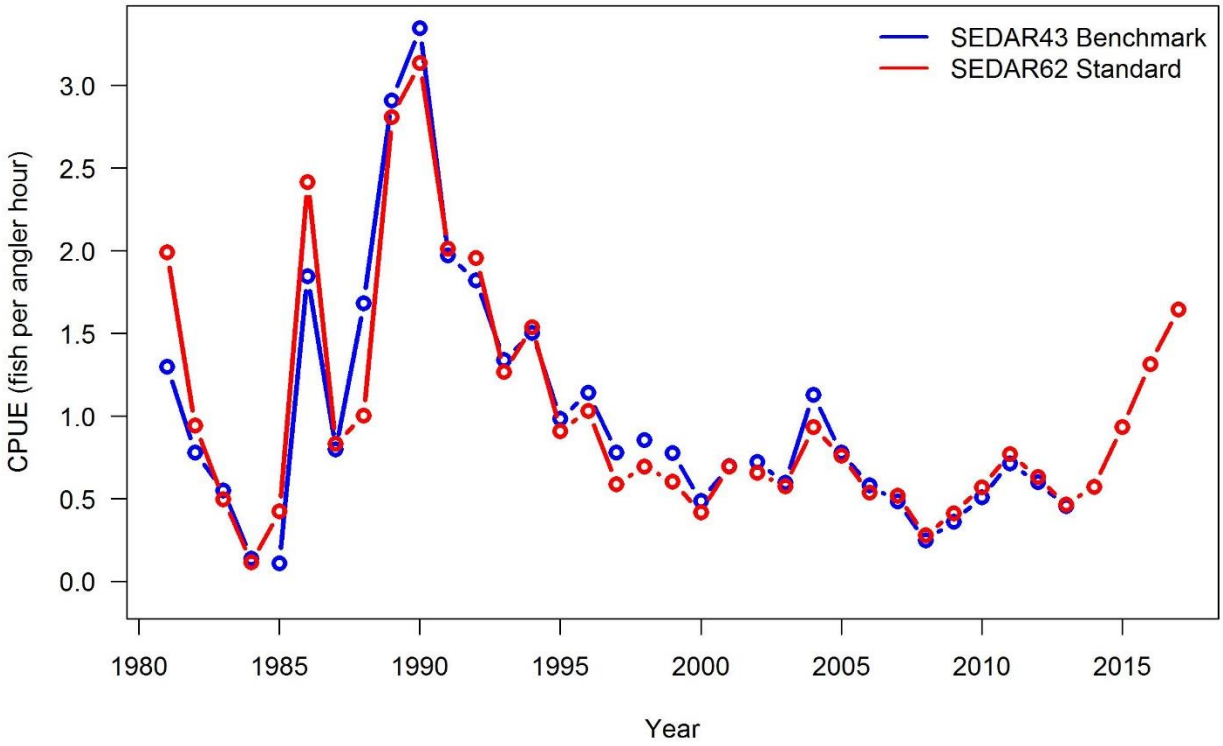

Figure 4. Standardized MRFSS index for gray triggerfish in the Eastern Gulf of Mexico for SEDAR62 compared to the headboat index provided during SEDAR43. For comparison, both indices have been normalized by their respective means.

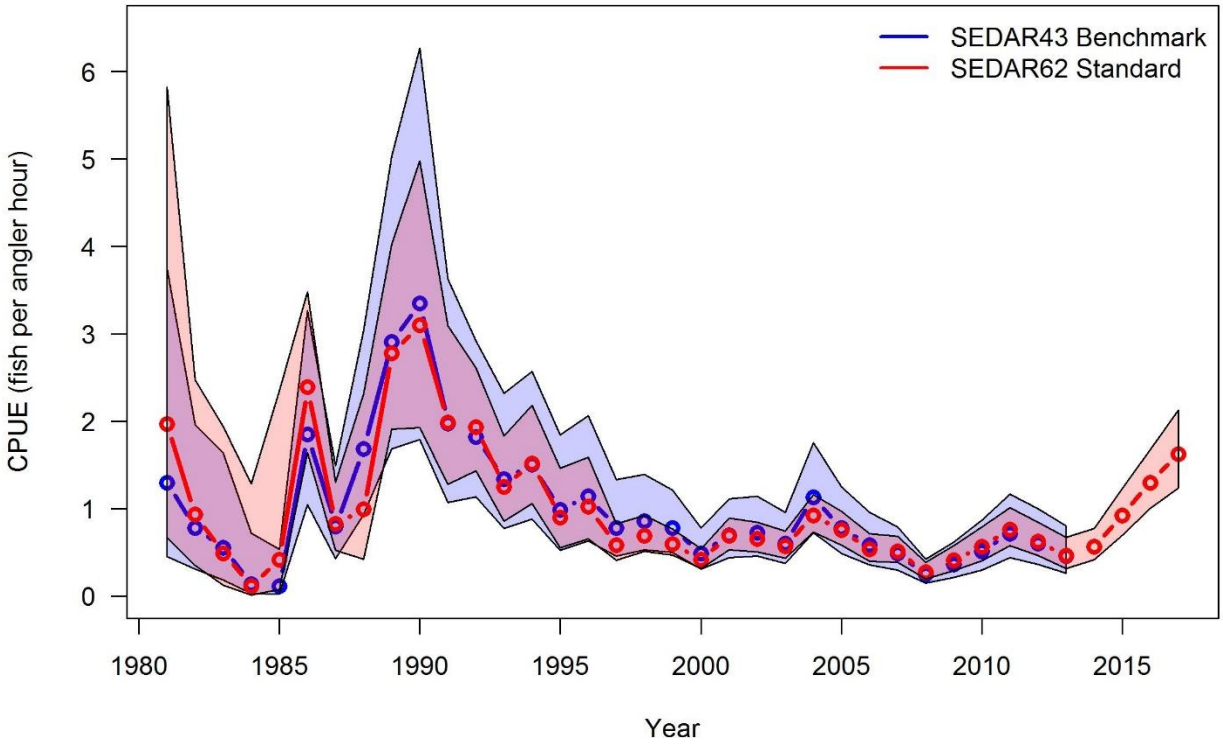

Figure 5. Comparison of MRFSS index for gray triggerfish in the Eastern Gulf of Mexico for SEDAR62 compared to the MRFSS index provided during SEDAR43 with confidence intervals.