Updated Standardized Catch Rate Indices for Gulf of Mexico Gray Triggerfish (*Balistes capriscus*) 1993–2017 for the Gulf of Mexico Commercial Handline Fishery

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SEDAR62-WP-05

22 April 2019

Please cite this document as:

Isely, J. Jeffery and Nancie J. Cummings. 2019. Updated Standardized Catch Rate Indices for Gulf of Mexico Gray Triggerfish (*Balistes capriscus*) 1993-2017 for the Gulf of Mexico Commercial Handline Fishery. SEDAR62 WP-05. SEDAR, North Charleston, SC. 14pp.

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by

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SEDAR62-WP-05

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INTRODUCTION

This report provides updated information for the NOAA Fisheries, Southeast Fisheries Science Center (SEFSC) Gulf of Mexico (GOM), Coastal Logbook Program (CLP) commercial handline gear index for Mexico Gray Triggerfish (*Balistes capriscus*). The updated index replaces the previously reported indices from the SEDAR 43 stock evaluation (Smith et al. 2015) and the index reported for SEDAR 9 stock evaluation (Nowlis 2005). For this updated report observations from only commercial vessels using handlines (including electric reels) were used in the analyses; handline gear represent the primary gear used to target gray triggerfish. Data from 1993-2017 were examined for the index development. The approach used for index development generally followed the methods used in SEDAR 43 index development as relates data/outlier exclusions, identifying a subset of trips targeting gray trigger and final model selection and is presented in the following sections.

Catch-per-unit effort (CPUE) was defined as the total pounds of fish caught on a given trip divided by the amount of line-hours spent fishing, where:

$$ln\ (CPUE) = ln\ [(Pounds\ of\ fish/(Number\ of\ Lines*Hours\ Fished\ Per\ Trip)]$$

For the commercial handline data set, effort was estimated as line-hours where the number of hours a line soaked was multiplied by the number of lines set per trip. Two indices (east and west Gulf of Mexico) were calculated based on geographic area (east or west of the Mississippi delta) to better represent the variance and abundance trends in each zone, because effort can vary significantly from year-to-year between the two areas. The updated time series extends from 1993 (when all federally permitted vessels were required to submit a logbook) until 2017 (the terminal year of the updated stock assessment).

Data exclusions:

Trips were eliminated if missing values existed for any of the key factors (e.g., year, month, fishing zone, etc..), were in anyway incomplete as to effort information, appeared to be misreported (e.g., reported zero hours fished) or represented multiple entries for a single trip. Similarly, as effort was reported on a per-trip basis, and not by area fished within a trip, all trips that reported multiple areas were removed from the analysis. Data exclusions generally followed similar rules as adopted for the

previous SEDAR 43 CPUE development analyses.

METHODS

Species Associations

Trip selection was carried out following the procedure as in the previous SEDAR 43 evaluations, using the Stephens and MacCall (S&M) (2004) approach. Briefly, the S&M method subsets the number of trips based on species that co-occur in the catch using a logistic regression to determine commonly associated species. The Stephens and MacCall (2004) approach resulted in a subset of 37,610 trips for the western Gulf of Mexico, for use in the index standardization. . Coefficients of the logistic regression indicated species association and indicated as in the previous SEDAR 43 analyses of commercial handline trips that vermilion snapper and lane snapper were the species most closely associated with gray triggerfish, while yellowedge grouper and king mackerel were most strongly negatively correlated (Table 1A).

For the eastern Gulf of Mexico, the S&M sub-setting approach produced a subset of 137,882 trips for use in the index standardization. Coefficients of the logistic regression indicated species association indicated that vermilion snapper and red porgy were identified as the species most closely associated with gray triggerfish, while mutton snapper and yellowtail snapper were most strongly negatively correlated (Table 1B).

Index Standardization

As in the SEDAR 43 index standardization analyses, a number of independent variables existed in the commercial handline CPUE observation data that could be explored for explaining the variability in the raw data. These were: Year, Season, Area, Red Snapper Season (i.e., open or closed), Red Snapper Permit (whether or not a vessel was permitted in the red snapper fishery), Days Away from Port, Crew Size, and Hook Hours Fished (only for the binomial model as this factor is confounded with effort for the CPUE response variable in the lognormal model). The levels and potential values for the various factors are provided in Table 2.

As in SEDAR 43 index development, the application of the delta-lognormal general linear model (GLM; Lo et al. 1992) was used for index standardization. Use of general linear model standardization methods is a traditionally accepted practice in the analysis of fisheries catch and effort data and is applied to remove variation in the nominal or raw CPUE data. Such variability is due to non-randomness in the nominal (raw) CPUE observations and from auxiliary variables such as time of year (month, season), area of fishing, etc., year-to-year variance that is not thought to be related to changes in abundance. Briefly, the approach involves two modeling steps: the first step models the frequency of with which trips caught the species of interest (i.e., proportion positive) using a logit regression and assuming a binomial distribution of the response variable. In the second step, the logarithm of CPUE on successful trips (i.e., those trips that caught the target species) is used as the response variable assuming a normal distribution and an identity link function. Results of the two models were combined to provide the final standardized index of abundance.

In application, for both the logit and lognormal models, a forward stepwise regression approach is applied within the GENMOD procedure of SAS 9.2 (SAS Institute, 2008). In this procedure, potential auxiliary factors are added to the base model, one factor at a time, based on the percent reduction in deviance per degree of freedom. With each run of the model, the factor that produced 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%). Because the goal of the standardization is to model time trends in abundance, it was necessary to force the year effect as a factor even if it was not deemed significant through the Chi-square

test. Two-way interaction terms were investigated among each of the significant factors using the same stepwise modeling approach however, no interaction effects were found to be significant thus higher order interactions were ignored.

Then, the final delta-lognormal model was fit using the factors deemed significant in the GENMOD procedure using the SAS macro GLIMMIX (SAS Institute, 2008). Auxiliary 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

Western Gulf of Mexico

For the binomial component of the western Gulf of Mexico index, the significant auxiliary factors were: YEAR, CREW_GROUP, AREA_GROUP, HK_HRS_Fished_GROUP. For the lognormal model the significant auxiliary factors were: YEAR, CREW_GROUP, AWAY_GROUP, RS SEASON, and AREA_GROUP.

The final models were:

$$Proportion\ Positive = Year + Crew\_Group + Area\_Group + Hook\ Hours\_Fished\_Group$$

$$ln(CPUE) = Year + Crew\_Group + Away\_Group + RS\_Season + Area\_Group$$

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

Observed and predicted trends in the proportion of positive trips generally followed the same trend throughout the time series. The observed proportion positives generally were low, less than 20% for much of the time series except for 2011 when an increase to ~ 25% occurred followed by a significant decline to 13% in 2011 (Figure 2A). Since 2011, the nominal occurrence of gray triggerfish has risen to about 20%. Results from the lognormal model indicate a relatively strong fit with no obvious patterning in the residuals (Figure 3A), and adherence to distributional assumptions (Figure 3B).

Nominal and standardized CPUE (scaled to the time series mean) generally show similar trends over the time series. During a few years, 1998-2005, nominal CPUE was above the predicted index. Between 2011 and 2016, nominal CPUE was below the predicted index. The nominal values were within the 95% confidence intervals over the entire time series (Figure 4A). Standardized CPUE has been below the mean level since around 2006 and is currently at around 80% of the time series average. The SEDAR 43 predicted index and the SEDAR 62 Updated index generally agree for most of the time series; the main exception is an predicted increase in the SEDAR 43 index for 2005 through 2007 (Figure 5A). Both indices show continued declining CPUE from 2007 through 2013. The updated SEDAR 62 index predicted a slight increasing trend thereafter.

Eastern Gulf of Mexico

For the binomial component of the eastern Gulf of Mexico index the significant factors were: Year, Hk_Hrs_Group, Area_Group, and Away_Group. In the lognormal model Year, Away_Group, Area_Group, and Crew_Group were significant factors.

The final models were:

$$Proportion\ Positive = Year + \text{Hk\_Hrs\_group} + \text{Area\_Group} + \text{Away\_Group}$$

$$ln\ (CPUE) = Year + Away\_Group + Area\_Group + Crew\_Group$$

The final nominal and standardized CPUE (both provided as relative indices where each value is divided by the time-series mean) along with confidence intervals and coefficients of variation (*CV*s) are given in Table 4.

The trend in observed proportion of positive trips generally was non-varying averaging about 20%with the exception of a sharp increase to 25% in 2011, followed by a subsequent decline to 13% in 2012. (Figure 2B). Results from the lognormal model indicate a relatively strong fit with no obvious patterning in the residuals (Figure 3C), and little deviation from the expected lognormal error distribution (Figure 3D).

Nominal and standardized CPUE (scaled to the time-series mean) show similar trends with the nominal values within the 95% confidence intervals for all of the time series (Figure 4B). The early years were characterized by a sharp decline in both nominal and standardized CPUE through 2000, followed by a brief increasing trend through 20032. Standardized CPUE again generally showed a declining trend between 2004 through and 2012 followed by a trend of slight increasing CPUE. The SEDAR 43 predicted index and the SEDAR 62 Updated Index generally are in through 2006 (Figure 5B). The SEDAR 43 index predicted an increase in standardized CPUE through 2007 that was not predicted by the updated SEDAR 62 index. Both indices show declining CPUE trends from 2008-2013. The updated SEDAR 62 index predicted a slight increasing trend thereafter.

References

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Table 1. Coefficients of correlation used by the Stephens and MacCall (2004) species associates sub-setting routine. Species with positive correlation coefficients tended to associate with gray triggerfish, while those with negative correlation coefficients did not. Panel A displays the results for the western Gulf of Mexico and Panel B displays the results from the eastern Gulf of Mexico.

Species	Coefficient
SNAPPER VERMILLION	1.27
SNAPPER,LANE	1.18
GROUPER,BLACK	0.78
GROUPER,GAG	0.57
COBIA	0.57
SCAMP	0.56
ALMACO JACK	0.46
GROUPER,WARSAW	0.45
PORGY,RED	0.43
SNAPPER,RED	0.40
BLUE RUNNER	0.32
SNAPPER,MANGROVE	0.14
GREATER AMBERJACK	0.09
SEA TROUT,WHITE	-0.05
GROUPER,YELLOWEDGE	-0.49
MACKEREL,KING	-0.72

B.

Species	Coefficient
Snapper, Vermilion	1.61
Porgy, Red	1.05
Grunt,White	0.82
Snapper, Red	0.48
Porgy, Whitebone	0.43
Snapper, Mangrove	0.36
Grouper, Black	0.34
Scamp	0.32
Jack, Almaco	0.24
Grouper, Gag	0.16
Grunt, Unclassified	0.14
Amberjack, Greater	0.09
Cobia	0.07
Snapper, Lane	0.01
King Mackerel	0.00
Grouper, Red	-0.07
Snapper, Mutton	-0.39
Snapper, Yellowtail	-1.28

Table 2: Levels and values for the factors investigated for inclusion in the index standardization model.

Western Gulf of Mexico

Factor	Levels	Values
Year	21	1993 – 2017
Area Group	6	16, 17, 21
Crew Group	4	2, 3, 4, 5
RS_Season	2	Closed, Open
Hook Hours Group	5	<=500, 501-1000, 1001-2000, 2001- 4000, 4001+

Eastern Gulf of Mexico

Factor	Levels	Values
Year	21	1993 - 2017
Area Group	6	6, 7, 8, 9, 10, 11
Away Group	6	1, 2, 3, 4, 5, 6
Crew_Group	4	1, 2, 3, 4
Hook Hours Group	5	<100, 101-350, 351-1000, 1001-3000, 3001+

Table 3: Nominal CPUE and standardized index values (scaled to the time-series mean) for the commercial handline fishery in the western Gulf of Mexico. Confidence intervals and CVs are for the standardized index.

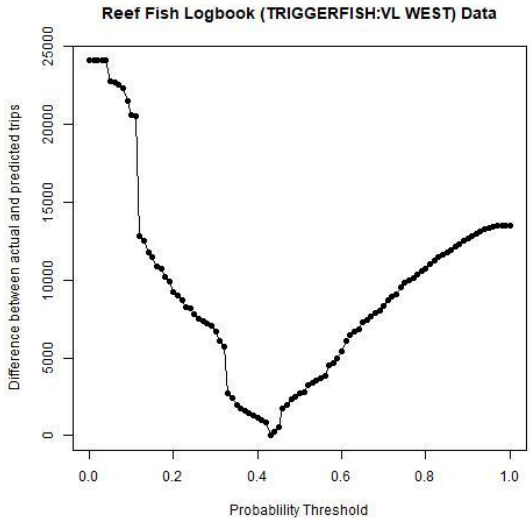
Year	Standardized	Nominal	Lower 95% CI	Upper 95% CI	CV
1993	2.50	0.10	1.40	4.47	0.30
1994	2.52	0.13	1.44	4.42	0.29
1995	1.86	0.08	1.06	3.29	0.29
1996	1.31	0.07	0.73	2.35	0.30
1997	0.96	0.05	0.53	1.73	0.30
1998	0.87	0.06	0.48	1.59	0.31
1999	0.93	0.06	0.52	1.65	0.29
2000	0.61	0.03	0.33	1.11	0.31
2001	0.91	0.06	0.50	1.66	0.31
2002	1.40	0.09	0.78	2.50	0.30
2003	1.38	0.08	0.78	2.46	0.29
2004	1.12	0.06	0.62	2.01	0.30
2005	1.13	0.06	0.63	2.05	0.30
2006	0.73	0.04	0.40	1.33	0.31
2007	0.62	0.03	0.34	1.14	0.31
2008	0.50	0.02	0.27	0.93	0.31
2009	0.47	0.02	0.25	0.85	0.31
2010	0.57	0.04	0.31	1.04	0.31
2011	0.79	0.03	0.44	1.42	0.30
2012	0.46	0.01	0.24	0.88	0.34
2013	0.61	0.03	0.33	1.13	0.32
2014	0.43	0.02	0.23	0.81	0.33
2015	0.68	0.03	0.37	1.25	0.31
2016	0.78	0.03	0.43	1.43	0.31
2017	0.84	0.05	0.46	1.56	0.31

Table 4: Nominal CPUE and standardized index values (scaled to the time-series mean) for the commercial handline fishery in the eastern Gulf of Mexico. Confidence intervals and CVs are for the standardized index.

YEAR	Standardized	Nominal	Lower 95% CI	Upper 95% CI	CV
1993	2.57	0.10	1.47	4.49	0.28
1994	2.54	0.13	1.49	4.35	0.27
1995	1.91	0.08	1.10	3.31	0.28
1996	1.30	0.07	0.74	2.29	0.29
1997	1.01	0.05	0.57	1.79	0.29
1998	0.95	0.06	0.53	1.69	0.29
1999	1.02	0.06	0.59	1.77	0.28
2000	0.69	0.03	0.39	1.23	0.29
2001	1.01	0.06	0.57	1.80	0.29
2002	1.43	0.09	0.82	2.50	0.28
2003	1.37	0.08	0.79	2.39	0.28
2004	1.16	0.06	0.66	2.03	0.29
2005	1.09	0.06	0.62	1.93	0.29
2006	0.72	0.04	0.40	1.29	0.30
2007	0.60	0.03	0.33	1.09	0.30
2008	0.47	0.02	0.26	0.86	0.31
2009	0.43	0.02	0.24	0.78	0.30
2010	0.53	0.04	0.30	0.96	0.30
2011	0.71	0.03	0.40	1.27	0.29
2012	0.39	0.01	0.20	0.74	0.33
2013	0.56	0.03	0.31	1.01	0.31
2014	0.38	0.02	0.20	0.70	0.32
2015	0.61	0.03	0.34	1.09	0.30
2016	0.74	0.03	0.42	1.33	0.30
2017	0.78	0.05	0.43	1.42	0.30

Figure 1: The difference between the number of records in which the target species are observed and those in which they are predicted to occur for each probability threshold using the Stephens and MacCall (2004) approach for the western (A) and eastern (B) Gulf of Mexico.

A.



B.

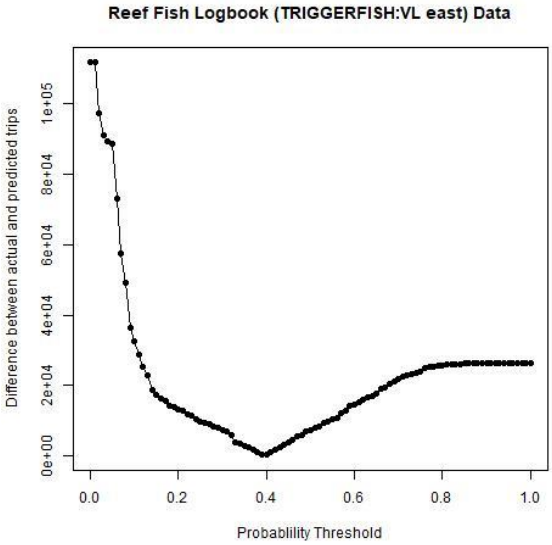
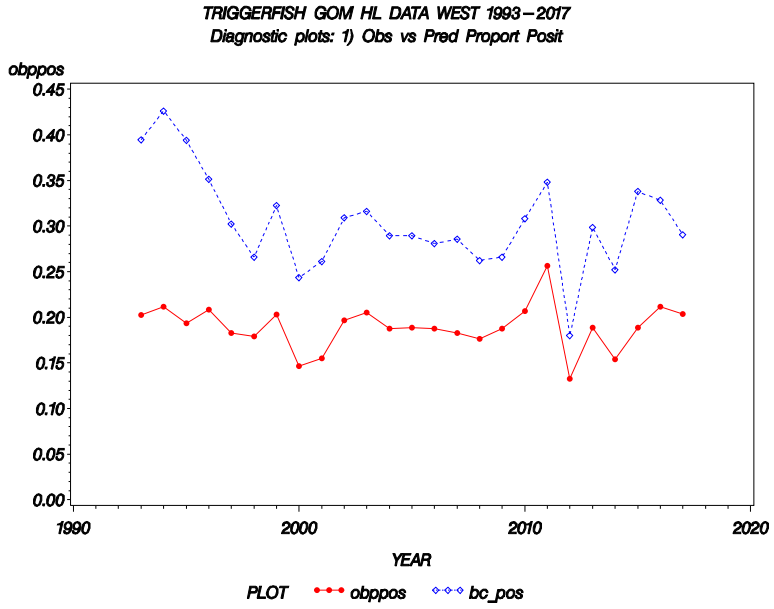


Figure 2. Diagnostic plots for the binomial model. Observed (red line) and predicted (blue line) proportion positive trips that caught the target species by year for the western Gulf of Mexico (A) and the eastern Gulf of Mexico (B).

A.



B.

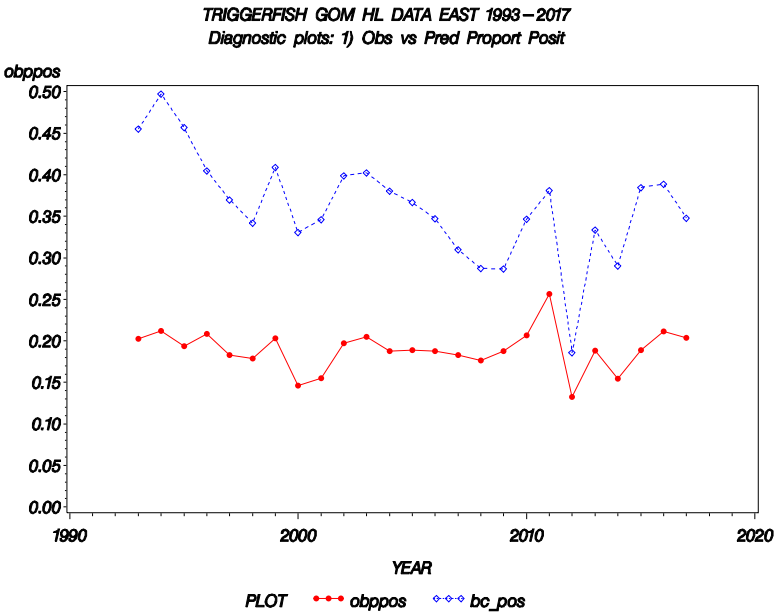
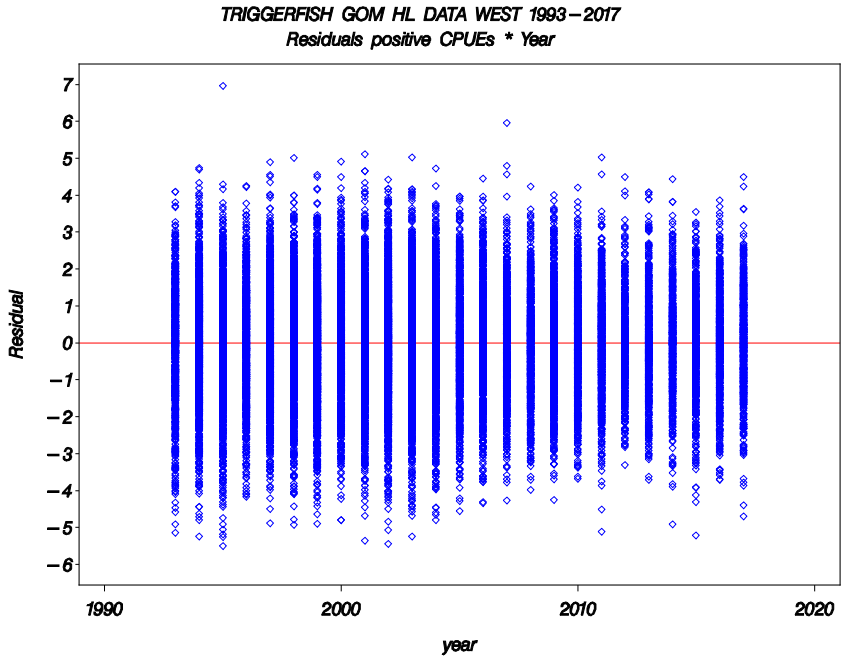
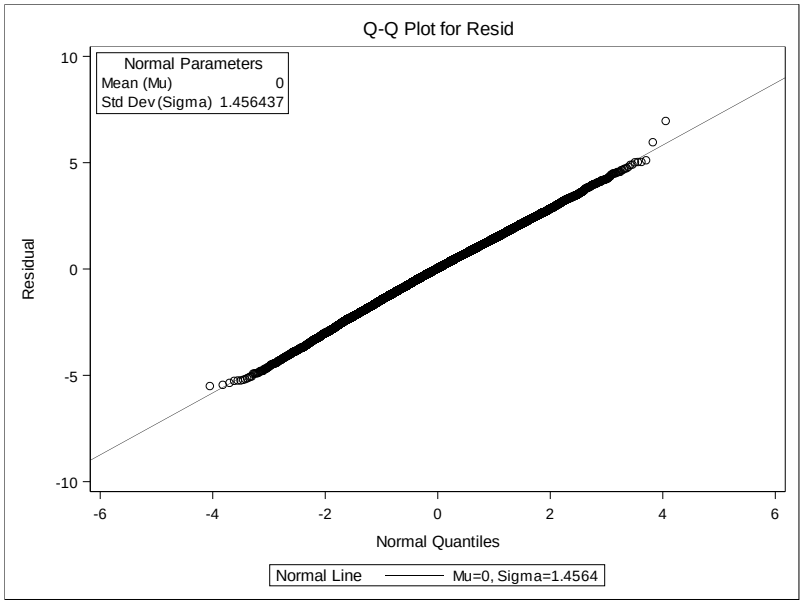


Figure 3. Diagnostic plots for the lognormal model: A) Residuals by year for the western Gulf of Mexico; B) Q-Q plot for the western Gulf of Mexico; C) Residuals by year for the eastern Gulf of Mexico; D) Q-Q plot for the eastern Gulf of Mexico.

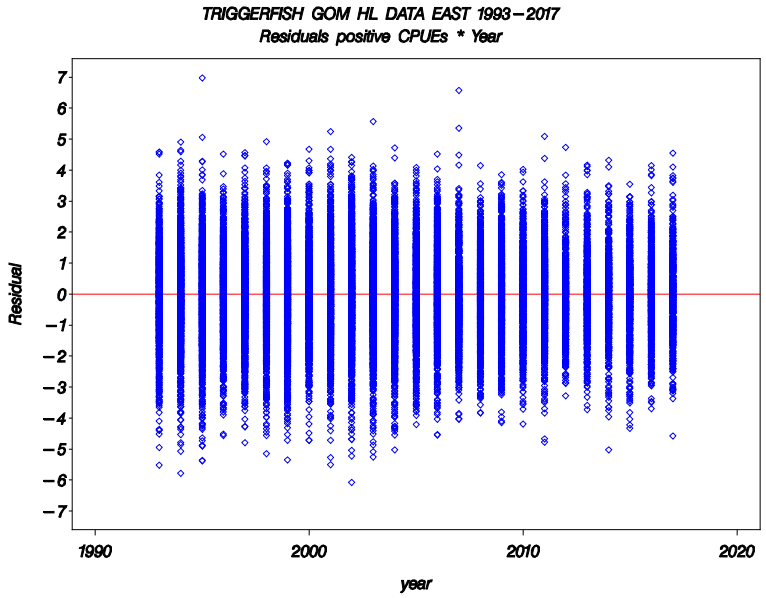
A.



B.



C.


TRIGGERFISH GOM HL DATA EAST 1993–2017
Residuals positive CPUEs * Year
Residual
7
6
5
4
3
2
1
0
–1
–2
–3
–4
–5
–6
–7
1990
2000
2010
2020
year

D.

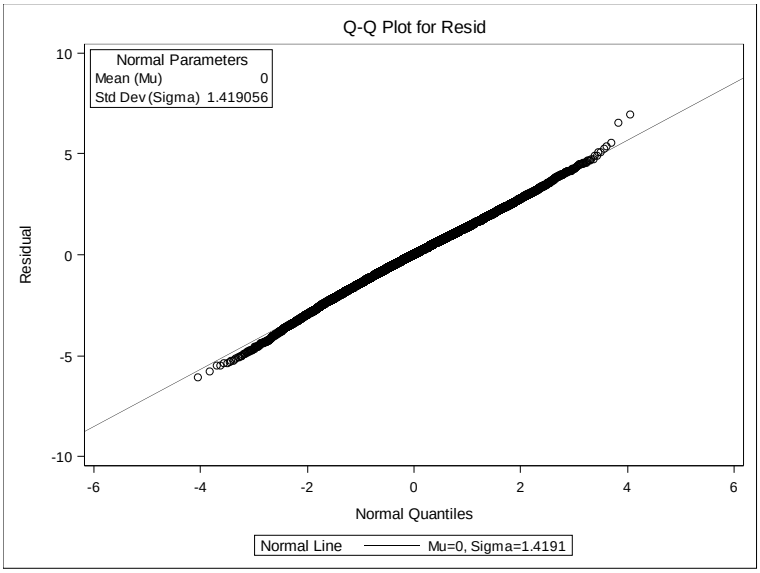
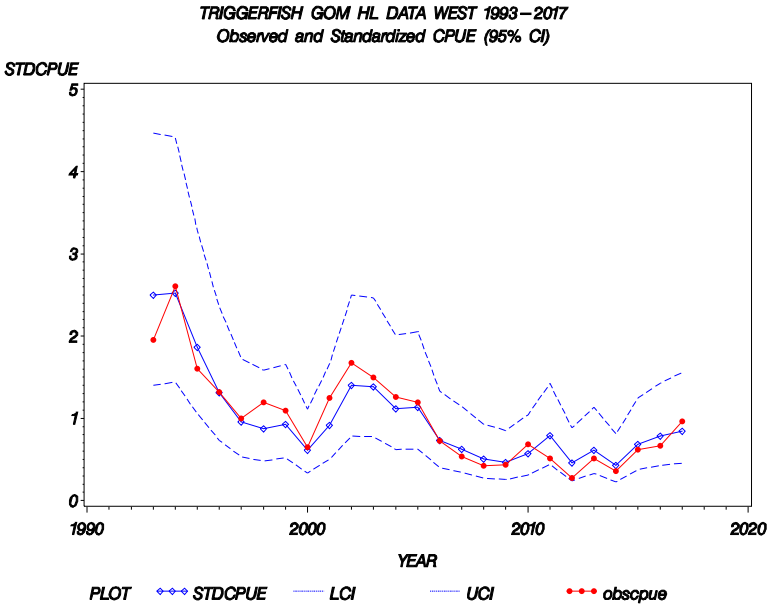

Q-Q Plot for Resid
Normal Parameters
Mean (Mu) 0
Std Dev (Sigma) 1.419056
Residual
10
5
0
-5
-10
-6
-4
-2
0
2
4
6
Normal Quantiles
Normal Line
Mu=0, Sigma=1.4191

Figure 4: Time-series plots of nominal (red lines) and standardized (solid blue line) CPUE relative to the mean of the given time series for the western Gulf of Mexico (A) and the eastern Gulf of Mexico (B). The dashed blue lines give 95% confidence intervals for the standardized CPUE.

A.



B.

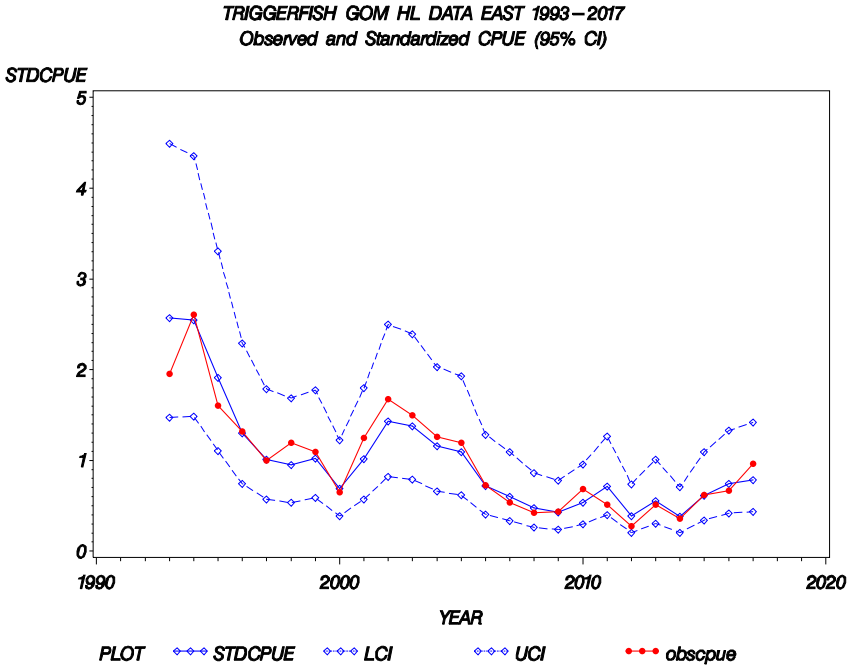
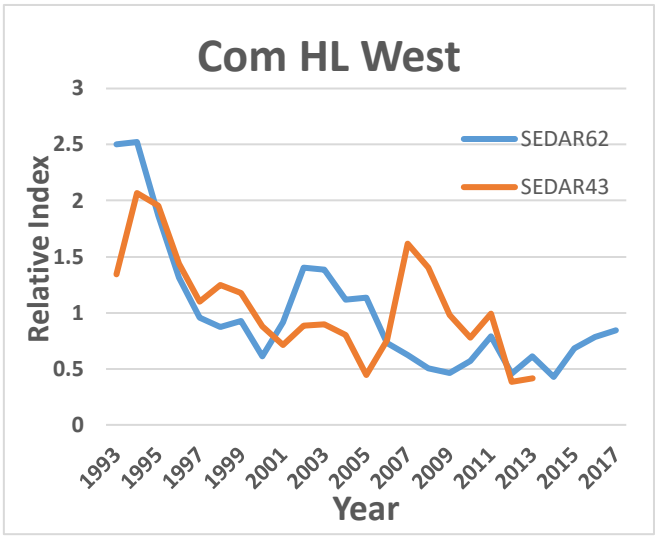


Figure 5: Time-series plots of the SEDAR 43 (purple line and the current SEDAR 62 (green line) standardized CPUE index for the western Gulf of Mexico (A) and eastern Gulf of Mexico (B).

A.



B.