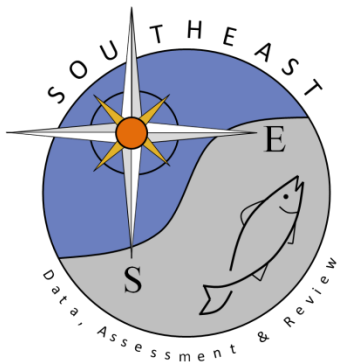


Standardized Catch per Unit Effort for US Gulf of America Gray
Triggerfish (*Balistes capriscus*) from the Southeast Region Headboat
Survey

Matthew A. Nuttall

SEDAR100-DW-09

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**Standardized Catch per Unit Effort for US Gulf of America Gray
Triggerfish (*Balistes capriscus*) from the Southeast Region
Headboat Survey**

**NOAA Fisheries
Southeast Fisheries Science Center
Sustainable Fisheries Division
Data Analysis and Assessment Support Branch**

Matthew A. Nuttall

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Abstract

This working paper describes three fishery-dependent indices of abundance developed for the US Gulf of America Gray Triggerfish stock in the SEDAR 100 stock assessment. These indices are estimated from self-reported headboat logbook data collected by the Southeast Region Headboat Survey (SRHS) using a delta-lognormal approach. Index construction follows established procedures similar to those used in past assessments for this species (SEDAR 43 and 62), but with the SEDAR 100 indices truncated to 2007 to account for increasingly restrictive regulations on regional for-hire vessels.

Introduction

The Southeast Region Headboat Survey (SRHS) collects catch, effort, and biological information from recreational headboats operating throughout the southeast region. As defined by SRHS, headboats are federally-permitted fishing vessels that charge anglers a per-head fee to fish for reef fish and coastal migratory pelagic species, typically over full day (8-10 hrs) or partial day trips (≈ 4 hrs) (Fitzpatrick et al. 2017). Conducted by the Beaufort Lab of the Southeast Fisheries Science Center (SEFSC), the SRHS was first implemented in the Carolinas in 1972 to provide estimates for the growing landings from this mode. The spatial extent of this survey has since grown, covering the entire South Atlantic by 1978 (NC through Monroe county, FL) and the Gulf of America by 1986 (South Padre Island, TX to Naples, FL) (SEDAR 79-DW-06).

The analysis described in this working paper is aimed at constructing indices of abundance for Gulf of America Gray Triggerfish from SRHS headboat data. This analysis relies on industry-reported SRHS logbooks that provide trip-level data on species catch, effort, and associated catch rates. Information collected by these logbooks include vessel identification, a single fishing area for the entire trip (Figure 1), landing location and date, number of anglers, trip duration (in hours) and/or trip type (e.g., half day vs. full day).

Because the SRHS was designed to be a census, the catch records contained in these logbooks comprise the majority of headboat fishing activity across the southeast region, with compliance being near 100 percent since permits became tied to reporting requirements in 2008. Logbook catch records were submitted via paper forms until 2013, when the survey switched to electronic reporting. During this time, paper forms were largely state-specific as space constraints on the form required limiting the listed species to predominant taxa, which varied across the region. Logbook forms also tended to change over time, with most state-specific forms tending to add more species throughout the early years of the survey (SEDAR 79-DW-06, Appendix A in Fitzpatrick et al. 2017).

Methods

Catch per unit effort (CPUE) of Gulf of America Gray Triggerfish by headboat anglers was calculated on an individual trip basis from SRHS logbook data. The CPUE for each trip was estimated as the number of Gray Triggerfish landed on a trip divided by the fishing effort, where effort was the product of the number of anglers and total hours fished. As an estimate of total hours fished, we assumed a full-day of SRHS headboat fishing (as recorded in the trip type field) constitutes 10 hours, with all other trip types scaled proportionally (e.g., half-day = 5 hours). This decision to translate hours fished from trip type is based on the need for consistency in CPUE data, and considered a better alternative to using the trip length field (in hours) which is only available in SRHS logbook data after the switch to electronic reporting (2013+).

Three indices of abundance were constructed from SRHS logbook data for SEDAR 100. Two indices were calculated based on geographic area (i.e., east vs. west of the Mississippi River Delta) to better represent variance and abundance trends in each zone, because effort can significantly vary from year-to-year between the two areas (SEDAR 62-WP-03).

Additionally, at the request of assessment analysts, a gulf-wide index was also provided to support testing of a one-area assessment model in SEDAR 100.

Data Filtering

The following data preparation and filtering techniques are routinely applied to SRHS logbook data when constructing abundance indices:

- Vessels that had fewer than 30 trips in the logbook data base were excluded. Logbooks submitted by vessels that participated infrequently in the fishery are likely to be less representative of true fishery trends. Even if a vessel fished infrequently for one year, the number of trips should be greater than 30.
- Trips with 6 or fewer anglers were excluded. It is rare for a headboat to fish with few anglers. There is anecdotal information that headboats would sometimes fish with just the crew and that logbooks for these trips were submitted. Experienced crew are likely to be more efficient at catching fish than paying customers. Captains may also limit distance to reduce fuel costs for trips with few paying customers.
- Trips with possible data errors were excluded, including trips with multiple catch records for a single species, potentially duplicated effort information, trips that report zero effort (i.e., number of anglers = 0), or trips with catch and effort values outside the 99.9% confidence intervals of the observed ranges.

Beyond these standard filters, SRHS indices for SEDAR 100 Gulf of America Gray Triggerfish required additional decisions. In agreement with procedures followed in past SEDAR stock assessments for this species (SEDAR 62):

- Trips during the closed season for Gray Triggerfish were excluded.

Novel filters to those used in past assessments for this stock (SEDAR 43, 62) were also applied in preparing SRHS logbook data for index construction in SEDAR 100:

- Records after 2007 were excluded. This year was largely chosen due to the perceived effect of circle hooks on the catchability of Gray Triggerfish, the use of which was mandated by Reef Fish Amendment 27 in 2008 (GMFMC 2007). As noted in the last completed assessment for this stock (SEDAR 43), which referenced an unpublished evaluation by Shipp et al., the shift to circle hooks was predicted to have reduced Gray Triggerfish catchability by about a half and was the focus of two sensitivity analyses conducted in SEDAR 43, one to evaluate different changes in

catchability and another to explore truncation in the SRHS headboat indices. While these findings were supported in SEDAR 62-WP-11, which retained hook type (i.e., circle vs. J-hooks) as a predictor of Gulf Gray Triggerfish catch rates, they were contradicted by Garner et al. (2017) who found hook type did not significantly affect the catchability of Gulf Red Snapper or Gulf Gray Triggerfish. However, both of these studies also acknowledge the potential for confounding in their analyses, which did not consider factors like angler skill or gear configuration that could influence the catchability of a stock on a given hook type. Both of these studies also identified hook size to be a strong predictor of Gray Triggerfish catch rates, which could be correlated with hook type if there's a tendency for anglers to select certain hook sizes for a given hook type. Note that the decision to truncate in SEDAR 100 (to 2007) also controls for any possible effects from subsequent changes in management after 2007 (e.g., quotas, size and bag limits, spatial or seasonal closures), the frequency of which has increased over the more recent decade(s) and casts doubt as to whether fishery-dependent datasets are still adequately tracking stock abundance. Taking a precautionary approach (SEDAR 82-DW-06) for the SEDAR 100 SRHS index, the hypothesized (i.e., inconclusive) changes in catchability of Gray Triggerfish and recent frequency of new management regulations warranted limiting SRHS logbook data to the years 1986-2007. This investigation, and the associated filter, was conducted to address the SEDAR 43 recommendation to evaluate methods used in constructing fishery-dependent indices under changes to management regulations.

Subsetting Trips: Species Associations

Because fishery-dependent data are not collected under a formal (e.g., stratified random) sampling design, the sampling intensity in any given area can vary substantially between years. In this, fishery-dependent data, by itself, may be insufficient to identify suitable habitat for the species-of-interest. In other cases, the data may allow for identification of habitat, but the associated sampling may be inconsistent or not reported at a fine enough resolution for the required analysis. Because such habitat designations are needed in controlling for absence (i.e., fish not available to be caught) when predicting the relative presence of species in trip-level catches, the construction of fishery-dependent indices requires some method to quantify effective effort and distinguish trips where a given species was present but not caught (i.e., fishing in suitable habitat) vs. trips where that species was not present (which are excluded from the analysis).

The trip selection approach applied for the SEDAR 100 SRHS index was the Guild Approach method, which applies a pre-defined list of species that are assumed to frequently co-occur with the species-of-interest. For SEDAR 100, and as applied in SEDAR 43 and 62, this guild is defined as all fish in the NOAA reef fish management plan.

- In applying the Guild Approach, the species considered were limited to reef fish species that were consistently identified on SRHS logbook forms across all years (Table A1). This filter was applied to ensure decisions on trip selection were limited

to those species that had a relatively equal chance of being reported on SRHS logbooks, given they were caught. This filter is new to Gray Triggerfish stock assessments but has been researched and applied in past SEDARs (e.g., SEDAR 68-DW-02, 68-DW-18, 88-WP-10).

Standardization

A two-stage delta-lognormal generalized linear model (GLM; Lo et al. 1992) was used to standardize catch rates from SRHS logbooks for any variability or non-randomness not caused by inter-annual fluctuations in stock abundance.

This method combines two separate generalized linear model components, one to describe the relative presence/absence of the focal species across all trips (i.e., proportion of headboat trips that caught at least one fish) and one to describe the catch rates of the focal species in those (positive) trips that successfully caught the species. In the first step, the proportion positive is modeled using a logit regression assuming a binomial error distribution of the response variable. In the second step, the logarithm of CPUE on positive trips was used as the response variable assuming a normal error distribution and an identity link function. The response variable for the lognormal model was calculated as:

$$\ln(CPUE) = \ln(\text{Catch}) / (\text{anglers} \times \text{hours fished})$$

A forward stepwise regression approach was applied to build both of these models, using the GENMOD procedure in SAS (SAS Institute 2008). In this procedure, factors were iteratively added to the base model and tested for retention (one at a time) based on the resultant 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 of 1%. Because the goal of this standardization was to model temporal trends in stock abundance, the year effect was always added as the first factor, whether it explained the most deviance or was even deemed significant. Once a set of fixed factors was identified, first level interactions were examined with significance evaluated between nested models using the likelihood ratio test. These interactions were screened and only retained if the model improvement was significant ($p < 0.0001$). All interaction terms retained in model building were treated as random effects.

Variation in catch rates by vessel was examined using a ‘repeated measures’ approach (Littell et al. 1998). The term repeated measures refers to multiple measurements taken over time on the same experimental unit (i.e. vessel). Specifying the repeated measure “VESSEL” and the subject “VESSEL(YEAR)” allows PROC MIXED to model the covariance structure of the data. This is particularly important because catch rates may vary by vessel and because catch rates by a given vessel that are close in time can have a higher correlation than those far apart in time (Littell et al. 1998). Note that this differs from the approaches taken in SEDARs 43 and 62, which tested and applied vessel as a fixed effect in some models. However, this approach requires estimation of 100+ parameters, and was

not pursued in SEDAR 100 given concerns of model overparameterization, as supported by the multiple convergence issues noted with fixed vessel effects and interactions in past data provisions for Gulf Gray Triggerfish (SEDAR 43-WP-06, SEDAR 62-WP-03).

Once constructed, the binomial and lognormal models were then combined to provide a single standardized index of abundance for SEDAR 100 Gulf of America Gray Triggerfish. Predictions from the binomial (proportion positive) and lognormal (mean CPUE from positive trips) models were calculated from the estimated year effects and multiplied together to produce annual estimates of catch rate. This final delta-lognormal model was fit using the SAS GLIMMIX macro (glmm800MaOB.sas: Russ Wolfinger, SAS Institute) and the PROC MIXED procedure in SAS, which follows the procedures of Lo et al. (1992).

Results and Discussion

Vessel Effects

The SRHS abundance indices constructed during SEDAR 100 model building initially included vessel effects as a 'repeated measure', allowing catch rates to vary by vessel without needing to estimate 100+ fixed effect parameters for the entire headboat fleet. However, this treatment led to clear undesirable patterns in the residuals of the variables selected in the lognormal model for all three indices, suggesting the model structure of the current 'repeated measure' approach is inappropriate for this dataset. Additionally, there remains concern as to whether a vessel effect is needed or estimable for the SRHS headboat fleet. The vast majority of fishing on a headboat is conducted by the general public, whose experience and skillset may vary drastically across anglers within a given trip and across trips for a given vessel. Given the aforementioned modeling issues with vessel effects, as noted in past data provisions (SEDAR 43-WP-06, SEDAR 62-WP-03), and these a priori concerns in the inherent variability of this factor and what driver(s) are truly being captured by a vessel effect, the decision for SEDAR 100 was to exclude vessel from consideration during model building. Future research may focus on evaluating alternative parameterizations of the 'repeated measure' approach, including alternative structures of the associated covariance matrix.

Eastern Index

Trip Selection - Guild Approach

There were 113,133 trip records available in the headboat data base from the eastern Gulf of America with 56,193 encountering Gray Triggerfish as either landings or discards. The aforementioned filters reduced the number of records to 112,362, and trip selection (i.e., Guild Approach) retained 111,327 SRHS logbook records for use in index standardization. The proportion of positive trips from the raw SRHS logbook data was 0.497, which increased to 0.502 after filters and trip selection were applied.

Variable Selection

The following factors were treated as fixed effects and examined for possible influence on the proportion of positive trips and on catch rates of positive trips in the eastern Gulf:

Name	Levels	Details
Year	22	1986-2007
Area	3	Southwest Florida, Florida Middle Grounds, Northwest Florida + Alabama
Season	4	1 (Dec-Feb), 2 (Mar-May), 3 (Jun-Aug), 4 (Sep-Nov)
Trip Duration*	4	Full day, Half day, Three quarter day, Multiday
Hours*	8	5, 7.5, 10, 15, 20, 30, 40, 50
Day/Night*	2	Day, Mixed (i.e., Night+Both)
Red Snapper Season	2	Open, Closed

*Only explored as factors for modeling success in the binomial model as these (effort) variables are confounded with the CPUE response variable in the lognormal model.

Annual Abundance Indices

Final deviance tables for the Eastern Gulf of America index are included in Table 1.

The final models for the binomial (i.e., proportion positive) and lognormal (catch rate of positive trips) models were:

$$\text{ProportionPositive} = \text{Year} + \text{Area} + \text{Year} * \text{Area}$$

$$\ln(\text{CPUE}) = \text{Year} + \text{Area} + \text{Season} + \text{Year} * \text{Area}$$

While the variables selected in the binomial model for SEDAR 100 are the same as those in past assessments (SEDAR 43-WP-06, SEDAR 62-WP-03), the vessel effects retained in the lognormal models of these past assessments were excluded from the list of possible predictors in SEDAR 100. Instead, these vessel effects seem to have been replaced by area effects. Note that when vessel was included in variable selection for SEDAR 100, the same set of variables as those in SEDARs 43 and 62 were retained in the lognormal model for the eastern index, including the vessel interaction terms that were subsequently dropped in those data provisions due to convergence issues.

Diagnostics for each of these GLMs are provided in Figures 2 and 3, respectively, and the resultant annual index is summarized in Table 2. The dispersion parameter for the

binomial component was estimated at 7.00, indicating some overdispersion in the data with respect to the specified model distribution. Predictions for proportion positive ranged between 0.48 and 0.78, but generally remained between 0.58 and 0.69 with a mean of 0.63. As observed in SEDAR 62, the binomial model generally overestimates the proportion positive (Figure 2A). Residual analysis of the binomial model showed no obvious patterns in residuals across factors (Figure 2B-2C). The lognormal model results suggest a decent fit to the data and indicated that the assumption of a lognormal distribution for positive catch rates was appropriate for the data. Residual analysis of the lognormal model also showed no obvious patterns in residuals across factors (Figure 3C-3E).

Figure 4 summarizes the standardized index, corresponding lower and upper 95% confidence limits, and nominal CPUE for the Eastern Gulf of America Gray Triggerfish abundance index. Nominal CPUE values fell within the 95% confidence interval of the standardized index, with the exception of the years 1986, 2001, and 2002. Relative abundance peaked in 1990 (at 2.33) and was at the lowest value in 2001 (at 0.45). In the standardized Eastern index, relative abundance averaged ~0.8 over the first three years (1986-1988), spiked at ~2.3 in 1990, and seems to show a gradual yet variable decline over the rest of the time series. The general trend in this index largely agrees with that in the previous SEDAR stock assessment for Gulf of America Gray Triggerfish (SEDAR 62) but the overall magnitude is slightly lower (Figure 5), a function of the decision to truncate the time series in 2007.

Western Index

Trip Selection - Guild Approach

There were 49,791 trip records available in the headboat data base from the western Gulf of America with 18,760 encountering Gray Triggerfish as either landings or discards. The aforementioned filters reduced the number of records to 48,546, and trip selection (i.e., Guild Approach) retained 39,799 SRHS logbook records for use in index standardization. The proportion of positive trips from the raw SRHS logbook data was 0.377, which increased to 0.468 after filters and trip selection were applied.

Variable Selection

The following factors were treated as fixed effects and examined for possible influence on the proportion of positive trips and on catch rates of positive trips in the western Gulf:

Name	Levels	Details
Year	22	1986-2007
Season	4	1 (Dec-Feb), 2 (Mar-May), 3 (Jun-Aug), 4 (Sep-Nov)
Trip Duration*	4	Full day, Half day, Three quarter day, Multiday

Name	Levels	Details
Hours*	8	5, 7.5, 10, 15, 20, 30, 40, 50
Day/Night*	2	Day, Mixed (i.e., Night+Both)
Red Snapper Season	2	Open, Closed

*Only explored as factors for modeling success in the binomial model as these (effort) variables are confounded with the CPUE response variable in the lognormal model.

Annual Abundance Indices

Final deviance tables for the Western Gulf of America index are included in Table 3.

The final models for the binomial (i.e., proportion positive) and lognormal (catch rate of positive trips) models were:

$$\text{ProportionPositive} = \text{Year} + \text{TripDur} + \text{DayNight} + \text{Year} * \text{TripDur}$$

$$\ln(\text{CPUE}) = \text{Year} + \text{Season} + \text{RS_Season}$$

The variables selected in SEDAR 100 for the Western Index were generally similar to those in past assessments (SEDAR 43-WP-06, SEDAR 62-WP-03). Exceptions included the Day/Night variable which was not selected in the binomial models of past assessments and a Year*Season interaction that was retained in the lognormal models of past assessments. Note that during variable selection for the SEDAR 100 binomial model, no variable significantly reduced the %deviance explained (i.e., >1%) in the second step (Table 3). However, trip duration was close to this threshold (~0.94) and so was retained, which agreed with SEDARs 43 and 62 and allowed variable selection to continue, where subsequent steps identified and selected variables that each significantly reduced the %deviance explained. Additionally, although hours fished had a larger effect on deviance than trip duration, it was not retained due to convergence issues and the high correlation between these two variables, both of which were noted in SEDAR 62 (62-WP-03).

Diagnostics for each of these GLMs are provided in Figures 6 and 7, respectively, and the resultant annual index is summarized in Table 4. The dispersion parameter for the binomial component was estimated at 2.38, indicating some overdispersion in the data with respect to the specified model distribution. Predictions for proportion positive ranged between 0.15 and 0.53, but generally remained between 0.24 and 0.35 with a mean of 0.3. As observed in SEDAR 62, the binomial model generally underestimates the proportion positive (Figure 6A). Residual analysis of the binomial model showed no obvious patterns in residuals across factors (Figure 6B-6D). The lognormal model results suggest a good fit to the data and indicated that the assumption of a lognormal distribution for positive catch rates was appropriate for the data. Residual analysis of the lognormal model also showed no obvious patterns in residuals across factors (Figure 7C-7E).

Figure 8 summarizes the standardized index, corresponding lower and upper 95% confidence limits, and nominal CPUE for the Western Gulf of America Gray Triggerfish abundance index. Nominal CPUE values fell within the 95% confidence interval of the standardized index, with the exception of the year 2000. Relative abundance peaked in 1991 (at 2.52) and was at the lowest value in 2000 (at 0.22). In the standardized Western index, relative abundance increased over the first six years of the time series, going from ~0.7 in 1986 to ~2.5 in 1991, gradually decreased to ~0.2 in 2000, and gradually increased to ~0.9 in 2007. The general trend in this index largely agrees with that in the previous SEDAR stock assessment for Gulf of America Gray Triggerfish (SEDAR 62) but the overall magnitude is slightly lower (Figure 9), a function of truncating the time series in 2007.

Gulf-Wide Index

Trip Selection - Guild Approach

There were 162,924 trip records available in the headboat data base from the entire Gulf of America with 74,953 encountering Gray Triggerfish as either landings or discards. The aforementioned filters reduced the number of records to 160,899, and trip selection (i.e., Guild Approach) retained 151,116 SRHS logbook records for use in index standardization. The proportion of positive trips from the raw SRHS logbook data was 0.46, which increased to 0.493 after filters and trip selection were applied.

Variable Selection

The following factors were treated as fixed effects and examined for possible influence on the proportion of positive trips and on catch rates of positive trips across the entire Gulf:

Name	Levels	Details
Year	22	1986-2007
Area	4	Southwest Florida, Florida Middle Grounds, Northwest Florida + Alabama, western Gulf of America
Season	4	1 (Dec-Feb), 2 (Mar-May), 3 (Jun-Aug), 4 (Sep-Nov)
Trip Duration*	4	Full day, Half day, Three quarter day, Multiday
Hours*	8	5, 7.5, 10, 15, 20, 30, 40, 50
Day/Night*	2	Day, Mixed (i.e., Night+Both)
Red Snapper Season	2	Open, Closed

*Only explored as factors for modeling success in the binomial model as these (effort) variables are confounded with the CPUE response variable in the lognormal model.

Annual Abundance Indices

Final deviance tables for the Gulf-Wide index are included in Table 5.

The final models for the binomial (i.e., proportion positive) and lognormal (catch rate of positive trips) models were:

$$\textit{ProportionPositive} = \textit{Year} + \textit{Area} + \textit{Year} * \textit{Area}$$

$$\ln(\textit{CPUE}) = \textit{Year} + \textit{Area} + \textit{Season} + \textit{Year} * \textit{Area}$$

Diagnostics for each of these GLMs are provided in Figures 10 and 11, respectively, and the resultant annual index is summarized in Table 6. The dispersion parameter for the binomial component was estimated at 10.33, indicating some overdispersion in the data with respect to the specified model distribution. Predictions for proportion positive ranged between 0.45 and 0.73, but generally remained between 0.56 and 0.63 with a mean of 0.59. As observed in the eastern index, the binomial model generally overestimates the proportion positive (Figure 10A). Residual analysis of the binomial model showed no obvious patterns in residuals across factors (Figure 10B-10C). The lognormal model results suggest a decent fit to the data and indicated that the assumption of a lognormal distribution for positive catch rates was appropriate for the data. Residual analysis of the lognormal model also showed no obvious patterns in residuals across factors (Figure 11C-11E).

Figure 12 summarizes the standardized index, corresponding lower and upper 95% confidence limits, and nominal CPUE for the Entire Gulf of America Gray Triggerfish abundance index. Nominal CPUE values fell within the 95% confidence interval of the standardized index, with the exception of the years 1986, 2001, and 2002. Relative abundance peaked in 1990 (at 2.05) and was at the lowest value in 2001 (at 0.45). Like the eastern index, relative abundance in the standardized Gulfwide index averaged ~0.8 over the first three years (1986-1988), spiked at ~2.0 in 1990, and seems to show a gradual yet variable decline over the rest of the time series.

Comments on Adequacy for Assessment

The SRHS abundance indices for SEDAR 100 Gulf of America Gray Triggerfish appear adequate for the time period provided (1986-2007). It was constructed stepwise, starting with a continuity that used the same assumptions applied in past assessments for this stock (i.e., SEDARs 43 and 62) but into which different methodological improvements have been incorporated (i.e., truncation of terminal year, application of species filter, exclusion of vessel effects). The SRHS index has been used in past SEDAR assessments because it provides one of the longest time series (1986+) and has widespread spatial coverage compared to other indices. It was used in the final assessment models of SEDARs 9 and 43, and likely would have been used in SEDAR 62 had that assessment not been cancelled. Uncertainty estimates (CVs) for the SRHS abundance indices provided for SEDAR 100 also appear reasonably constrained, having a mean of 0.37 for the Eastern Index (range: 0.3 – 0.43, Table 2), a mean of 0.2 for the Western Index (range: 0.15 – 0.27, Table 4), and a mean of 0.28 for the Gulf-Wide Index (range: 0.24 – 0.31, Table 6).

The biggest concern with these indices is in the overdispersion parameters for the binomial components of the Eastern and Gulfwide Indices, which are quite high. This indicates greater variability in the presence-absence data than that expected from a binomial distribution, which could be caused by clustered (highly-correlated) data, zero-inflation, or extreme outliers. For SEDAR 100, the relative desirability of Gray Triggerfish seems to be changing over time, as noted in the recent assessment for Atlantic Gray Triggerfish (SEDAR 2024, Section 9), which can affect decisions of individual anglers to land or discard these fish and lead to these types of data issues.

It is important to highlight that SRHS indices are derived from fishery-dependent data and susceptible to these types of trends, which are not being properly controlled for as they would be in the sampling of a well-designed, fishery-independent survey. Such trends may be driven by changes to management regulations for any number of species/stocks interacting with Gray Triggerfish, particularly if they elicit a spatiotemporal shift in angler behavior or change to species targeting (SEDAR 82-DW-06). In this, the SRHS index summarized in this working paper should not be considered as a replacement for a fishery-independent index that adequately tracks and covers the same target population. Instead, the relative value of fishery-dependent indices, like that from SRHS logbooks, is in their coverage of historical years, when changes to fisheries' regulations were relatively rare and the availability of fishery-independent data was limited. From this perspective, the SRHS index provided in this working paper appears adequate for consideration in SEDAR 100, particular given its truncation (in 2007) to exclude recent years where changes in angler behavior are believed most concentrated.

As identified in this working paper, additional research is needed to explore alternative parameterizations of the 'repeated' measures random effect which may be more appropriate for the SRHS headboat fleet.

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Smith, MW, D Goethel, A Rios, and J Isley. 2015. Standardized Catch Rate Indices for Gulf of Mexico Gray Triggerfish (*Balistes capriscus*) landed during 1986-2013 by the Headboat Fishery. SEDAR 43-WP-06. SEDAR, North Charleston, SC. 18 pp.

Table 1. Deviance tables for the generalized linear models for Gray Triggerfish in the **Eastern** Gulf of America. The table shows the order of the factors as they were sequentially added stepwise to each model. Fit diagnostics listed for each factor represent diagnostics from a model with that factor and all other factors listed above it.

Binomial

Factor	DF	Deviance	Residual Df	Residual Deviance	AIC	% Deviance Reduced	log likelihood	Likelihood Ratio Test
Null	1	154,331.8	111,326	154,331.8	154,333.8		-77,165.9	
Year	22	153,130.7	111,305	1,201.1	153,176.8	0.76	-76,565.4	1,201.0
Area	3	112,944.9	111,303	40,185.8	112,997.0	26.24	-56,472.5	40,185.8
Year * Area	40	110,737.1	111,264	2,207.8	110,869.2	1.92	-55,368.6	2,207.8

Lognormal

Factor	DF	Deviance	Residual Df	Residual Deviance	AIC	% Deviance Reduced	log likelihood	Likelihood Ratio Test
Null	1	91,439.2	55,587	91,439.2	185,420.4		-92,709.2	
Year	22	87,995.7	55,566	3,443.5	183,330.6	3.73	-91,642.3	2,133.8
Area	3	64,262.4	55,564	23,733.3	165,864.6	26.97	-82,906.3	17,472.0
Season	4	62,023.9	55,561	2,238.5	163,901.8	3.48	-81,920.9	1,970.8
Year * Area	39	60,125.4	55,523	1,898.5	162,251.6	2.99	-81,056.8	1,728.2

Table 2. Summary of the annual SRHS abundance index constructed for **Eastern** Gulf of America Gray Triggerfish and the data used to inform it, including the total number of trips (N), those positive with Gray Triggerfish catch (Npos), proportion of positive trips (PPT), and the relative nominal (nomCPUE) and standardized CPUE (stdCPUE). Uncertainty estimates are provided as the coefficient of variation (CV) and the upper (UCI) and lower (LCI) 95% confidence intervals.

Year	N	Npos	PPT	nomCPUE	stdCPUE	LCI	UCI	CV
1986	2,660	891	0.3350	0.2583	0.9246	0.4428	1.9306	0.3809
1987	2,581	945	0.3661	0.3318	0.6556	0.2867	1.4992	0.4319
1988	4,054	2,093	0.5163	0.6926	0.7579	0.3444	1.6678	0.4102
1989	4,756	2,660	0.5593	1.0129	1.3309	0.6574	2.6947	0.3640
1990	7,796	4,253	0.5455	1.6431	2.3327	1.2903	4.2172	0.3027
1991	7,112	3,357	0.4720	1.0037	1.3621	0.7384	2.5127	0.3135
1992	7,387	3,921	0.5308	1.3404	1.4190	0.7729	2.6051	0.3109
1993	7,874	4,068	0.5166	1.0394	1.0768	0.5641	2.0556	0.3319
1994	7,315	3,268	0.4468	1.0834	1.1326	0.5652	2.2694	0.3583
1995	5,855	2,841	0.4852	1.1806	0.9622	0.4323	2.1414	0.4166
1996	5,698	2,784	0.4886	1.1105	0.9695	0.4371	2.1504	0.4146
1997	5,630	3,159	0.5611	1.0825	1.0305	0.4749	2.2357	0.4023
1998	4,879	2,847	0.5835	1.0316	1.0255	0.5133	2.0488	0.3567
1999	3,371	1,966	0.5832	1.0670	1.2154	0.6398	2.3088	0.3293
2000	4,397	2,208	0.5022	0.8807	0.6501	0.3110	1.3589	0.3815
2001	4,212	2,071	0.4917	1.1777	0.4464	0.2036	0.9785	0.4080
2002	4,195	2,139	0.5099	1.5102	0.6592	0.3124	1.3914	0.3869
2003	4,328	2,173	0.5021	1.4736	0.7349	0.3470	1.5564	0.3888
2004	4,785	2,210	0.4619	1.0735	0.8188	0.4020	1.6676	0.3672
2005	4,534	2,119	0.4674	0.9777	1.1569	0.6007	2.2281	0.3367
2006	3,693	1,755	0.4752	0.5759	0.6304	0.2990	1.3289	0.3863
2007	4,215	1,860	0.4413	0.4530	0.7080	0.3369	1.4879	0.3845

Table 3. Deviance tables for the generalized linear models for Gray Triggerfish in the **Western** Gulf of America. The table shows the order of the factors as they were sequentially added stepwise to each model. Fit diagnostics listed for each factor represent diagnostics from a model with that factor and all other factors listed above it.

Binomial

Factor	DF	Deviance	Residual Df	Residual Deviance	AIC	% Deviance Reduced	log likelihood	Likelihood Ratio Test
Null	1	55,008.0	39,798	55,008.0	55,010.0		-27,504.0	
Year	22	54,086.6	39,777	921.4	54,132.6	1.62	-27,043.3	921.4
TripDur	4	53,574.3	39,774	512.3	53,628.4	0.94	-26,787.2	512.2
Day/Night	2	53,010.0	39,773	564.3	53,068.0	1.05	-26,505.0	564.4
Year * TripDur	64	52,219.1	39,710	790.9	52,405.0	1.34	-26,109.5	791.0

Lognormal

Factor	DF	Deviance	Residual Df	Residual Deviance	AIC	% Deviance Reduced	log likelihood	Likelihood Ratio Test
Null	1	26,032.4	18,617	26,032.4	59,078.6		-29,538.3	
Year	22	24,091.7	18,596	1,940.7	57,680.2	7.35	-28,817.1	1,442.4
Season	4	23,214.3	18,593	877.4	56,997.4	3.62	-28,471.7	690.8
RS Season	2	22,824.9	18,592	389.4	56,686.6	1.67	-28,314.3	314.8

Table 4. Summary of the annual SRHS abundance index constructed for **Western** Gulf of America Gray Triggerfish and the data used to inform it, including the total number of trips (N), those positive with Gray Triggerfish catch (Npos), proportion of positive trips (PPT), and the relative nominal (nomCPUE) and standardized CPUE (stdCPUE). Uncertainty estimates are provided as the coefficient of variation (CV) and the upper (UCI) and lower (LCI) 95% confidence intervals.

Year	N	Npos	PPT	nomCPUE	stdCPUE	LCI	UCI	CV
1986	1,192	546	0.4581	0.8729	0.6837	0.4300	1.0873	0.2351
1987	1,380	756	0.5478	0.8340	0.8130	0.5298	1.2476	0.2166
1988	1,501	773	0.5150	1.2718	1.0871	0.7359	1.6060	0.1970
1989	1,437	687	0.4781	1.1891	1.0507	0.6819	1.6188	0.2187
1990	1,499	801	0.5344	1.3845	1.5900	1.1142	2.2688	0.1792
1991	1,456	902	0.6195	1.9824	2.5224	1.8643	3.4128	0.1520
1992	2,150	1,160	0.5395	1.6571	1.8071	1.3038	2.5045	0.1643
1993	2,407	1,289	0.5355	1.5673	1.6818	1.1928	2.3712	0.1731
1994	2,692	1,445	0.5368	1.5724	1.5822	1.1162	2.2428	0.1758
1995	2,538	1,247	0.4913	1.2399	1.1646	0.8102	1.6739	0.1829
1996	2,243	1,140	0.5082	1.4145	1.3384	0.9174	1.9527	0.1906
1997	2,132	911	0.4273	0.8966	0.8161	0.5373	1.2396	0.2113
1998	2,201	822	0.3735	0.6391	0.6402	0.4146	0.9886	0.2198
1999	1,202	436	0.3627	0.4460	0.4528	0.2703	0.7582	0.2622
2000	1,504	487	0.3238	0.3628	0.2152	0.1278	0.3625	0.2651
2001	1,694	588	0.3471	0.4584	0.3163	0.1975	0.5064	0.2387
2002	1,811	599	0.3308	0.5428	0.4706	0.3070	0.7214	0.2161
2003	1,651	695	0.4210	0.6455	0.6739	0.4584	0.9907	0.1945
2004	1,710	785	0.4591	0.7459	0.7495	0.5187	1.0830	0.1856
2005	1,724	868	0.5035	0.7094	0.7857	0.5573	1.1075	0.1729
2006	1,816	868	0.4780	0.6987	0.6603	0.4624	0.9429	0.1795
2007	1,859	813	0.4373	0.8690	0.8986	0.6352	1.2711	0.1747

Table 5. Deviance tables for the generalized linear models for Gray Triggerfish in the **Entire** Gulf of America. The table shows the order of the factors as they were sequentially added stepwise to each model. Fit diagnostics listed for each factor represent diagnostics from a model with that factor and all other factors listed above it.

Binomial

Factor	DF	Deviance	Residual Df	Residual Deviance	AIC	% Deviance Reduced	log likelihood	Likelihood Ratio Test
Null	1	209,442.4	151,115	209,442.4	209,444.4		-104,721.2	
Year	22	208,591.5	151,094	850.9	208,637.6	0.39	-104,295.8	850.8
Area	4	167,721.7	151,091	40,869.8	167,775.6	19.59	-83,860.8	40,870.0
Year * Area	61	164,790.5	151,031	2,931.2	164,966.6	1.71	-82,395.3	2,931.0

Lognormal

Factor	DF	Deviance	Residual Df	Residual Deviance	AIC	% Deviance Reduced	log likelihood	Likelihood Ratio Test
Null	1	118,302.9	74,199	118,302.9	245,185.6		-122,591.8	
Year	22	115,197.0	74,178	3,105.9	243,255.6	2.60	-121,604.8	1,974.0
Area	4	89,449.3	74,175	25,747.7	224,493.0	22.35	-112,219.5	18,770.6
Season	4	86,298.0	74,172	3,151.3	221,839.8	3.52	-110,888.9	2,661.2
Year * Area	60	83,441.9	74,113	2,856.1	219,462.6	3.23	-109,640.3	2,497.2

Table 6. Summary of the annual SRHS abundance index constructed for **Entire** Gulf of America Gray Triggerfish and the data used to inform it, including the total number of trips (N), those positive with Gray Triggerfish catch (Npos), proportion of positive trips (PPT), and the relative nominal (nomCPUE) and standardized CPUE (stdCPUE). Uncertainty estimates are provided as the coefficient of variation (CV) and the upper (UCI) and lower (LCI) 95% confidence intervals.

Year	N	Npos	PPT	nomCPUE	stdCPUE	LCI	UCI	CV
1986	3,849	1,437	0.3733	0.4613	0.8708	0.4948	1.5325	0.2884
1987	3,956	1,696	0.4287	0.5196	0.7250	0.4033	1.3034	0.2997
1988	5,554	2,865	0.5158	0.8600	0.8767	0.4987	1.5412	0.2878
1989	6,192	3,343	0.5399	1.0562	1.3091	0.7674	2.2334	0.2719
1990	9,303	5,063	0.5442	1.6157	2.0479	1.2774	3.2834	0.2393
1991	8,568	4,259	0.4971	1.1749	1.4701	0.9127	2.3679	0.2418
1992	9,537	5,080	0.5327	1.4134	1.4809	0.9152	2.3964	0.2442
1993	10,280	5,356	0.5210	1.1681	1.2448	0.7615	2.0350	0.2495
1994	10,005	4,713	0.4711	1.2258	1.2711	0.7566	2.1356	0.2638
1995	8,393	4,089	0.4872	1.2058	1.0470	0.5899	1.8582	0.2928
1996	7,943	3,925	0.4941	1.2053	1.1221	0.6346	1.9841	0.2909
1997	7,759	4,070	0.5246	1.0323	1.0601	0.6034	1.8625	0.2875
1998	7,085	3,672	0.5183	0.9082	0.9416	0.5466	1.6221	0.2770
1999	4,570	2,400	0.5252	0.8972	0.9996	0.5901	1.6933	0.2682
2000	5,900	2,695	0.4568	0.7426	0.5425	0.3028	0.9719	0.2979
2001	5,905	2,659	0.4503	0.9644	0.4481	0.2463	0.8153	0.3061
2002	6,007	2,738	0.4558	1.2093	0.6238	0.3467	1.1225	0.3002
2003	5,979	2,868	0.4797	1.2366	0.7317	0.4126	1.2977	0.2925
2004	6,495	2,995	0.4611	0.9848	0.7971	0.4610	1.3783	0.2790
2005	6,256	2,984	0.4770	0.9033	1.0215	0.6096	1.7117	0.2625
2006	5,506	2,620	0.4758	0.6250	0.6424	0.3669	1.1245	0.2855
2007	6,074	2,673	0.4401	0.5902	0.7260	0.4129	1.2765	0.2879

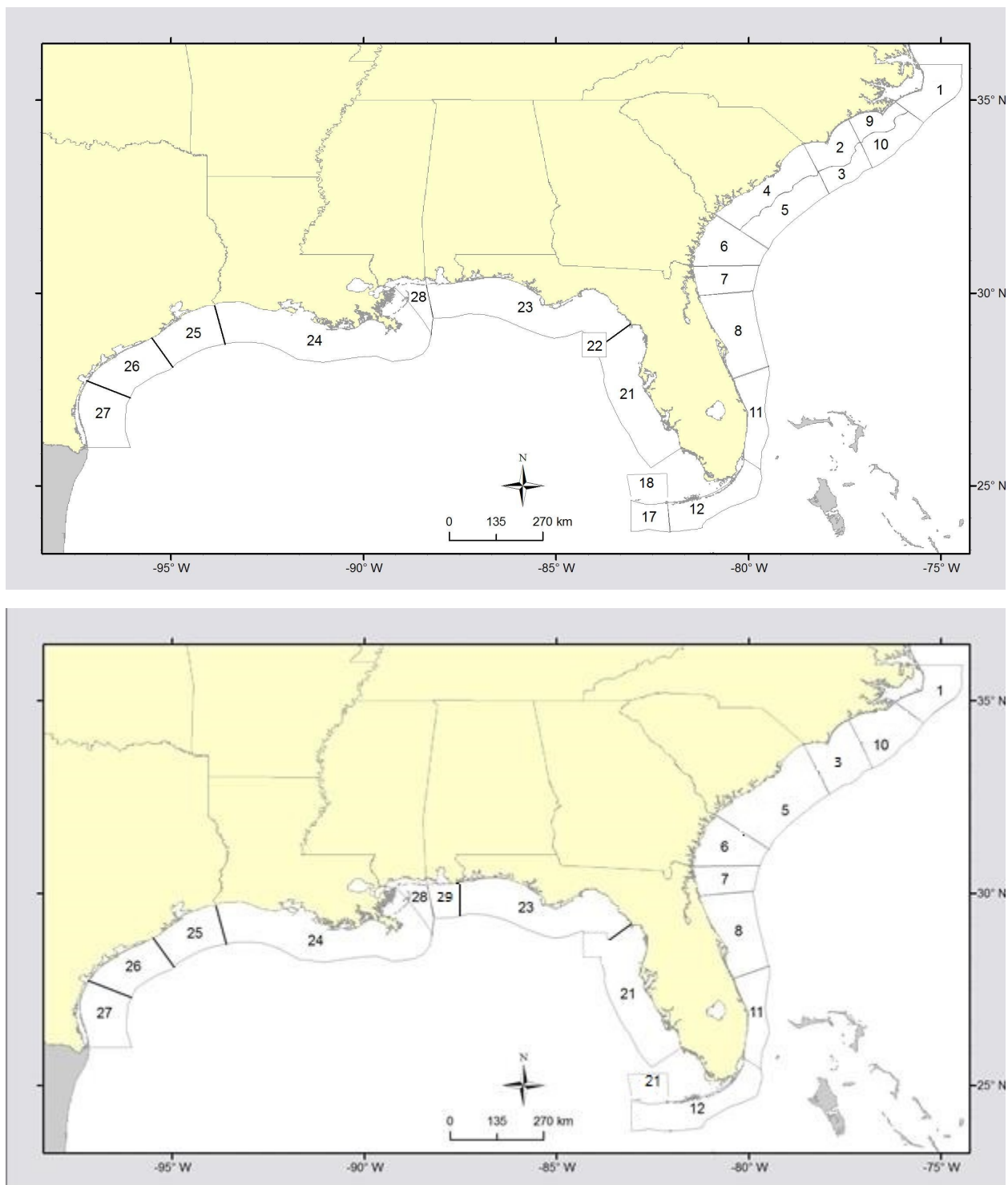


Figure 1. Headboat sampling areas for years prior to 2013 (top) and from 2013 to present (bottom).

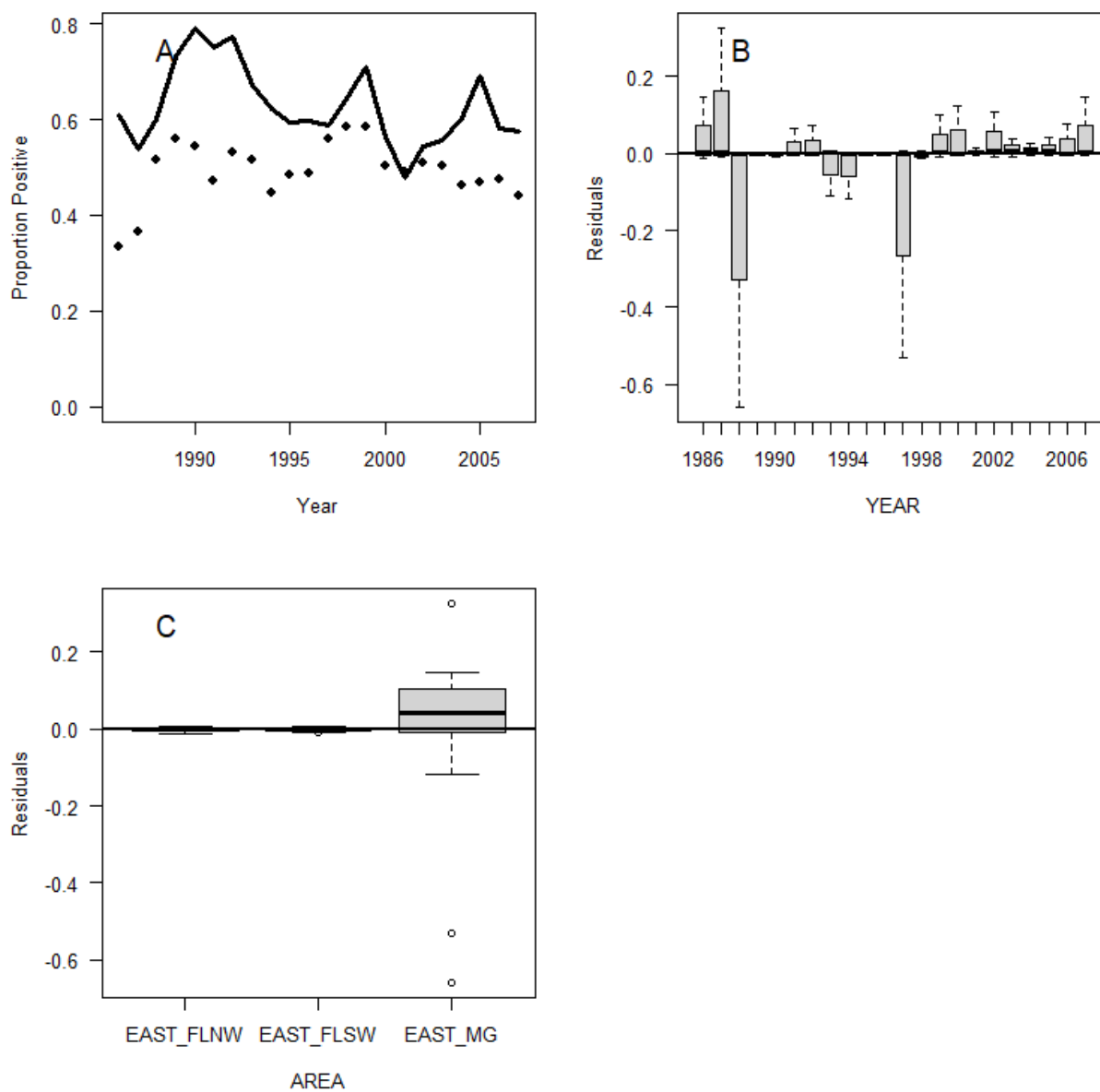


Figure 2. Diagnostic plots for the Binomial component (i.e., proportion positive) of the final delta-lognormal GLM of the **Eastern** Index, including the (A) comparison of observed (solid circles) vs. predicted (solid line) proportion of positive trips (i.e., with Gray Triggerfish catch) by year, and the distribution of residuals by (B) YEAR and (C) AREA.

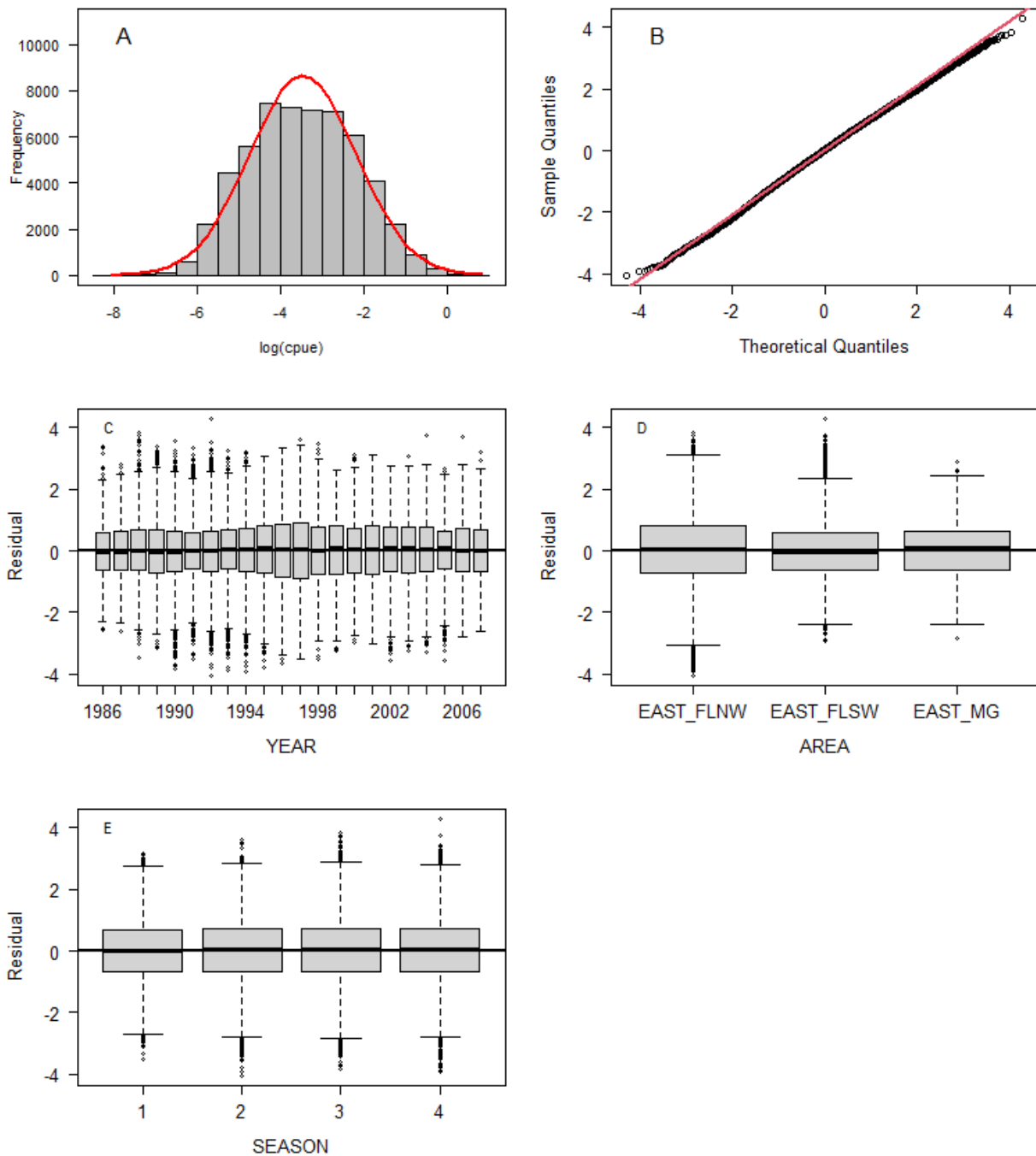


Figure 3. Diagnostic plots for the Lognormal component (i.e., catch rates of Gray Triggerfish from positive trips) of the final delta-lognormal GLM of the **Eastern** Index, including (A) frequency distribution of log-transformed catch rates, (B) cumulative normalized residuals, and the distribution of residuals by (C) YEAR, (D) AREA, and (E) SEASON. The red lines represent the expected normal distribution.

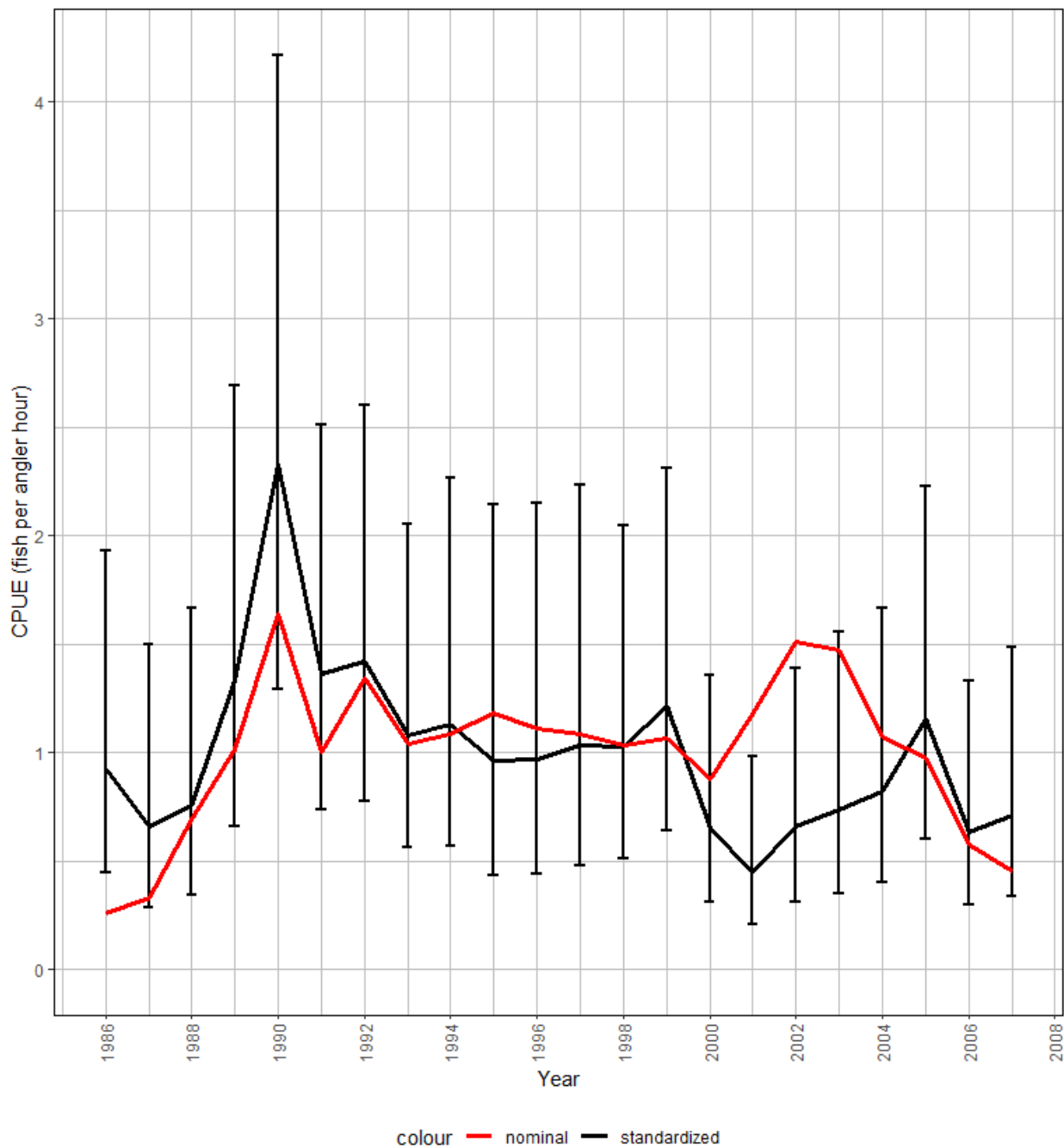


Figure 4. Standardized abundance index (black line), with 95% confidence interval (bars), for **Eastern** Gulf of America Gray Triggerfish as compared to the associated nominal rates (red line), both of which have been rescaled to the mean values of their respective timeseries.

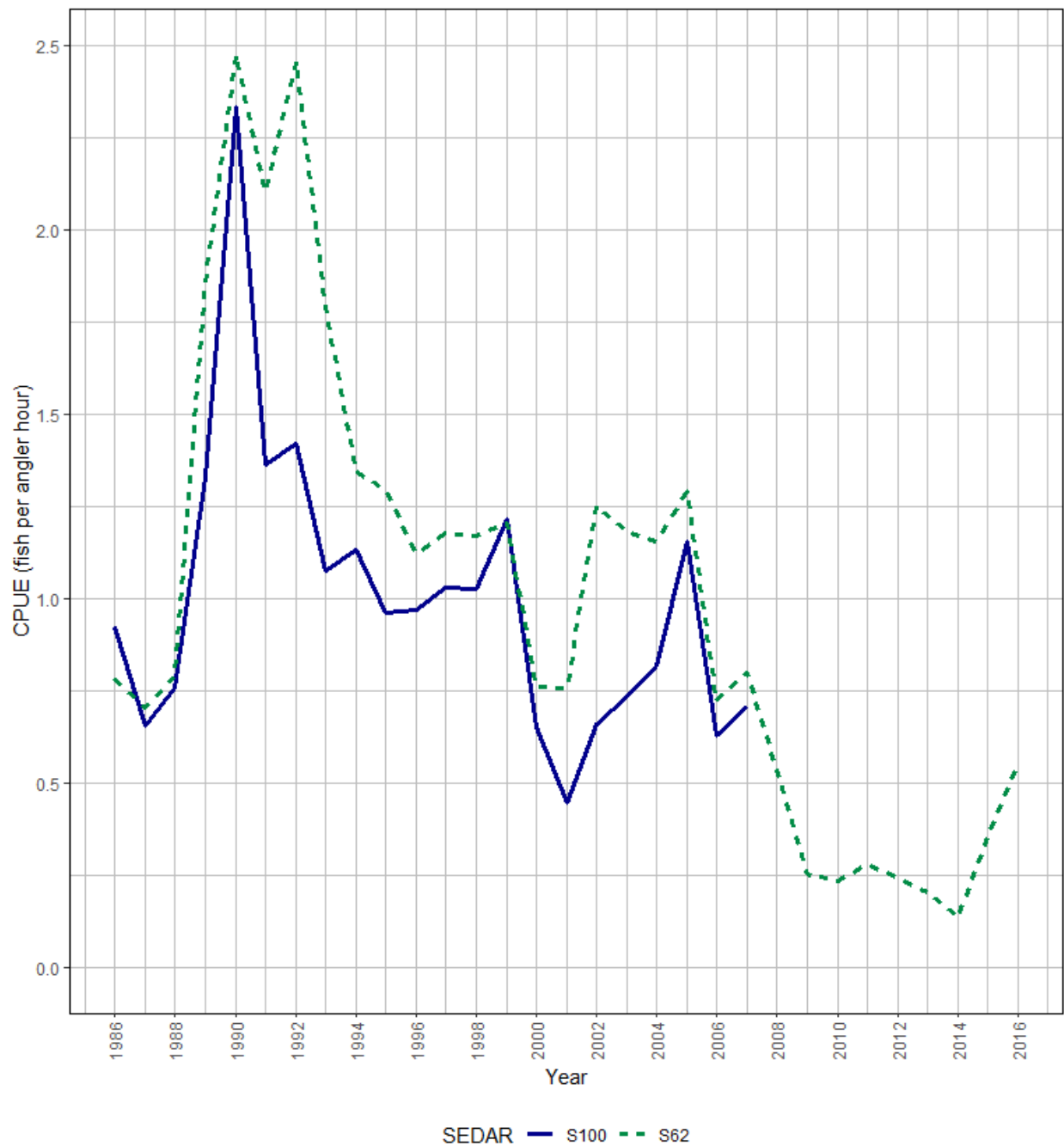


Figure 5. Comparison of standardized abundance indices between SEDAR 100 and SEDAR 62 for **Eastern** Gulf of America Gray Triggerfish, the terminal years of which are 2007 and 2016 (full season closure in 2017), respectively.

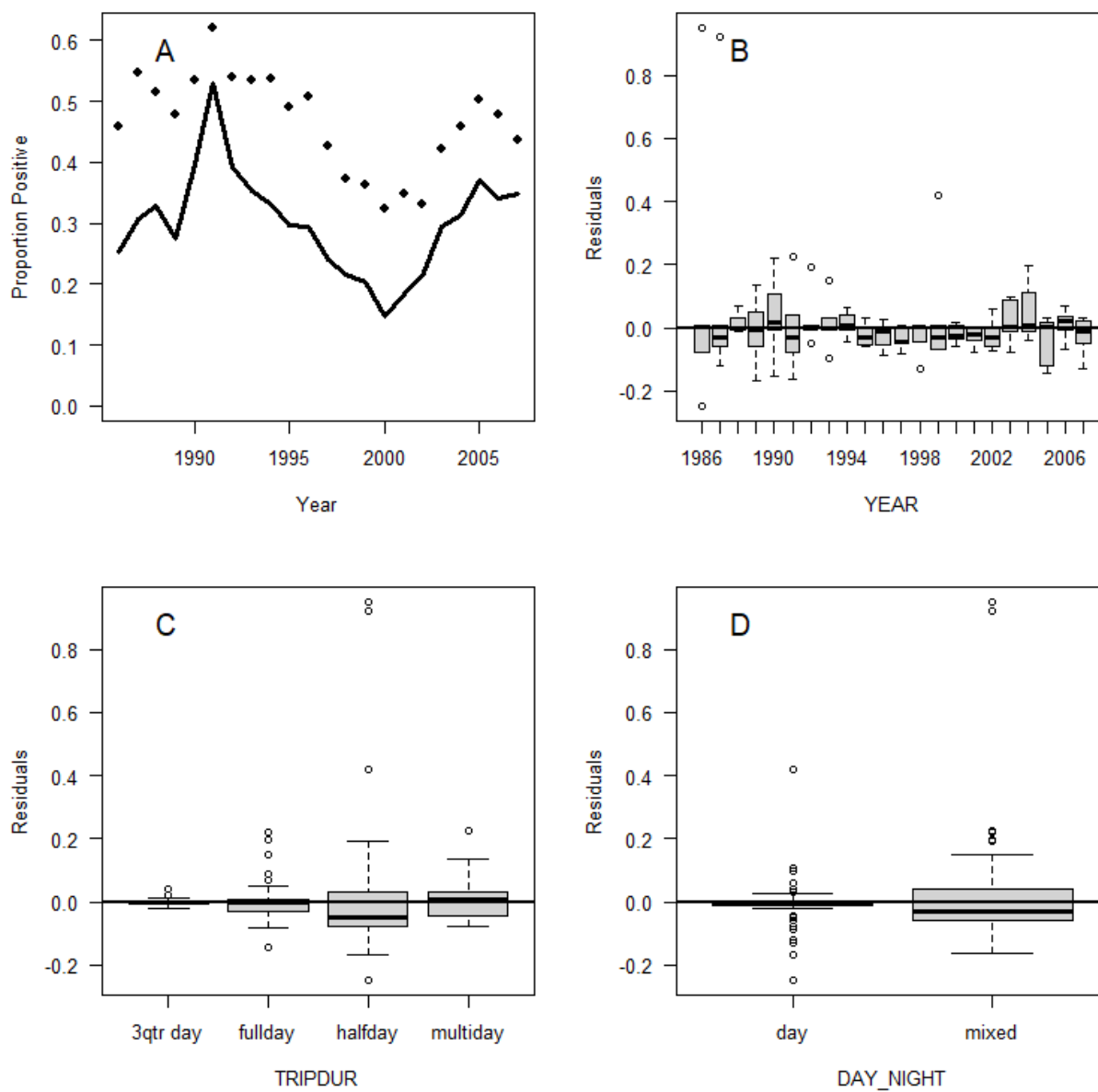


Figure 6. Diagnostic plots for the Binomial component (i.e., proportion positive) of the final delta-lognormal GLM of the **Western** Index, including the (A) comparison of observed (solid circles) vs. predicted (solid line) proportion of positive trips (i.e., with Gray Triggerfish catch) by year, and the distribution of residuals by (B) YEAR, (C) TRIPDUR (i.e., trip duration), and (D) DAY_NIGHT (i.e., time of day).

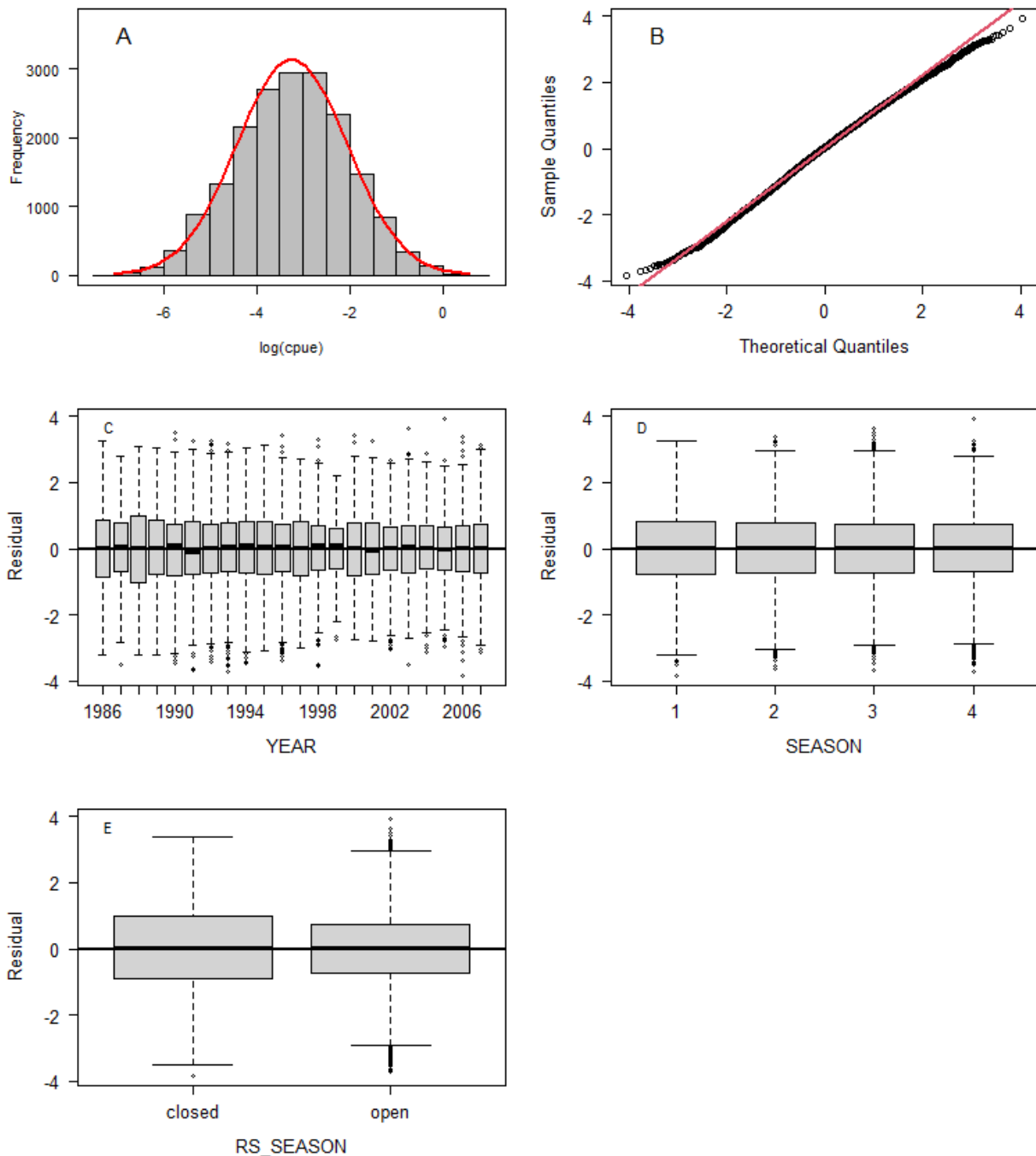


Figure 7. Diagnostic plots for the Lognormal component (i.e., catch rates of Gray Triggerfish from positive trips) of the final delta-lognormal GLM of the **Western** Index, including (A) frequency distribution of log-transformed catch rates, (B) cumulative normalized residuals, and the distribution of residuals by (C) YEAR, (D) SEASON, and (E) RS_SEASON (i.e., Red Snapper Fishing Season). The red lines represent the expected normal distribution.

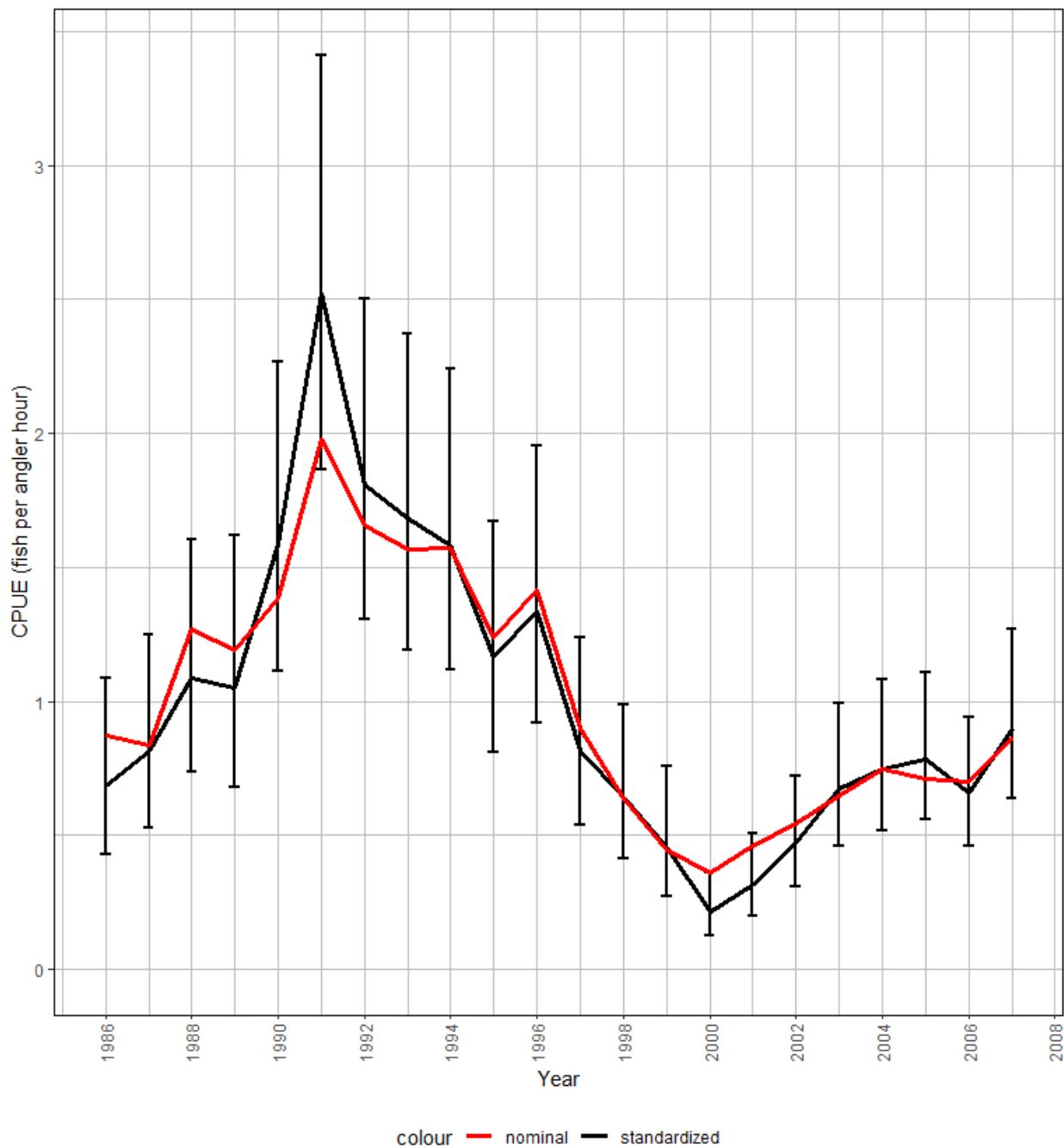


Figure 8. Standardized abundance index (black line), with 95% confidence interval (bars), for **Western** Gulf of America Gray Triggerfish as compared to the associated nominal rates (red line), both of which have been rescaled to the mean values of their respective timeseries.

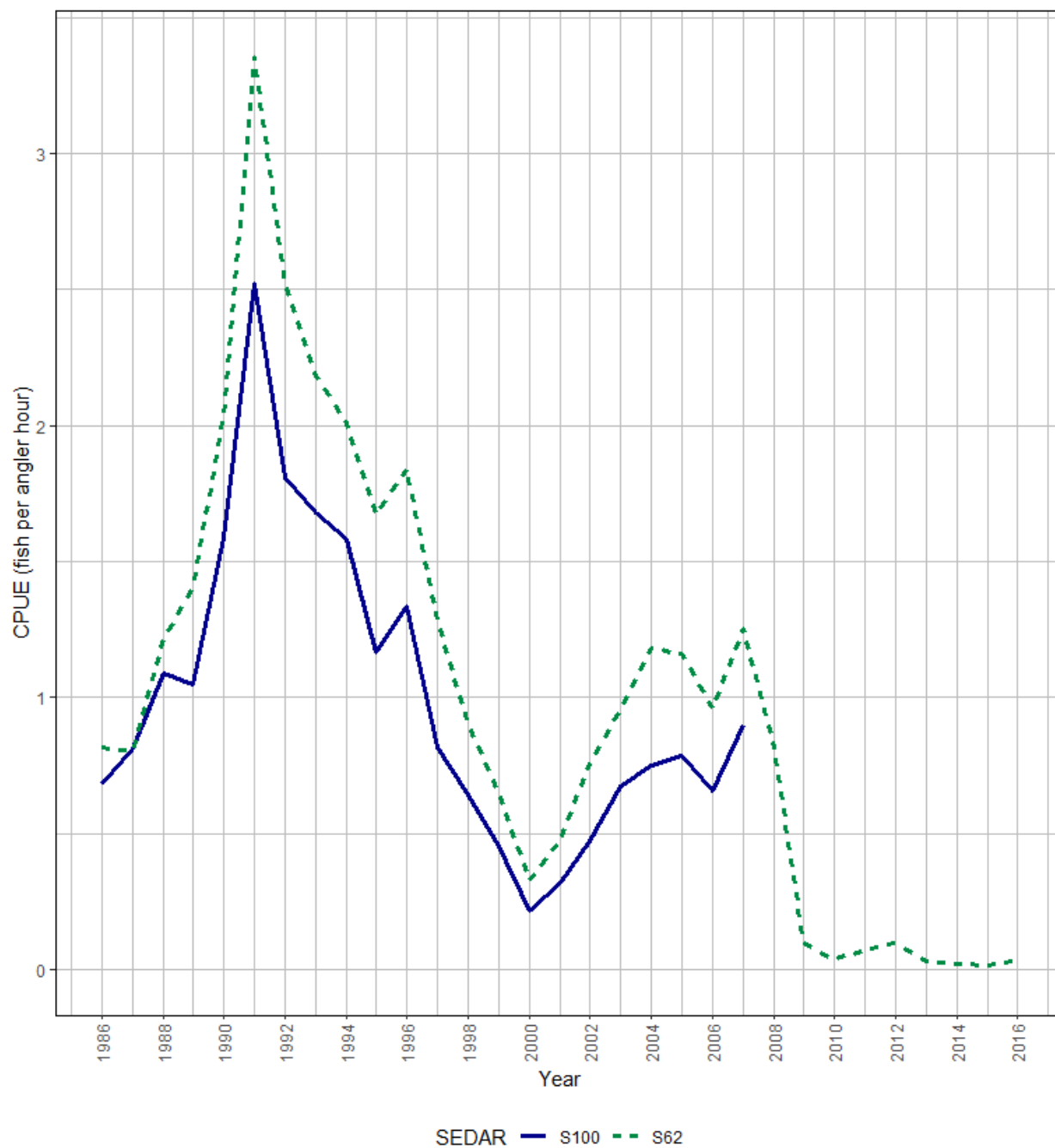


Figure 9. Comparison of standardized abundance indices between SEDAR 100 and SEDAR 62 for **Western** Gulf of America Gray Triggerfish, the terminal years of which are 2007 and 2016 (full season closure in 2017), respectively.

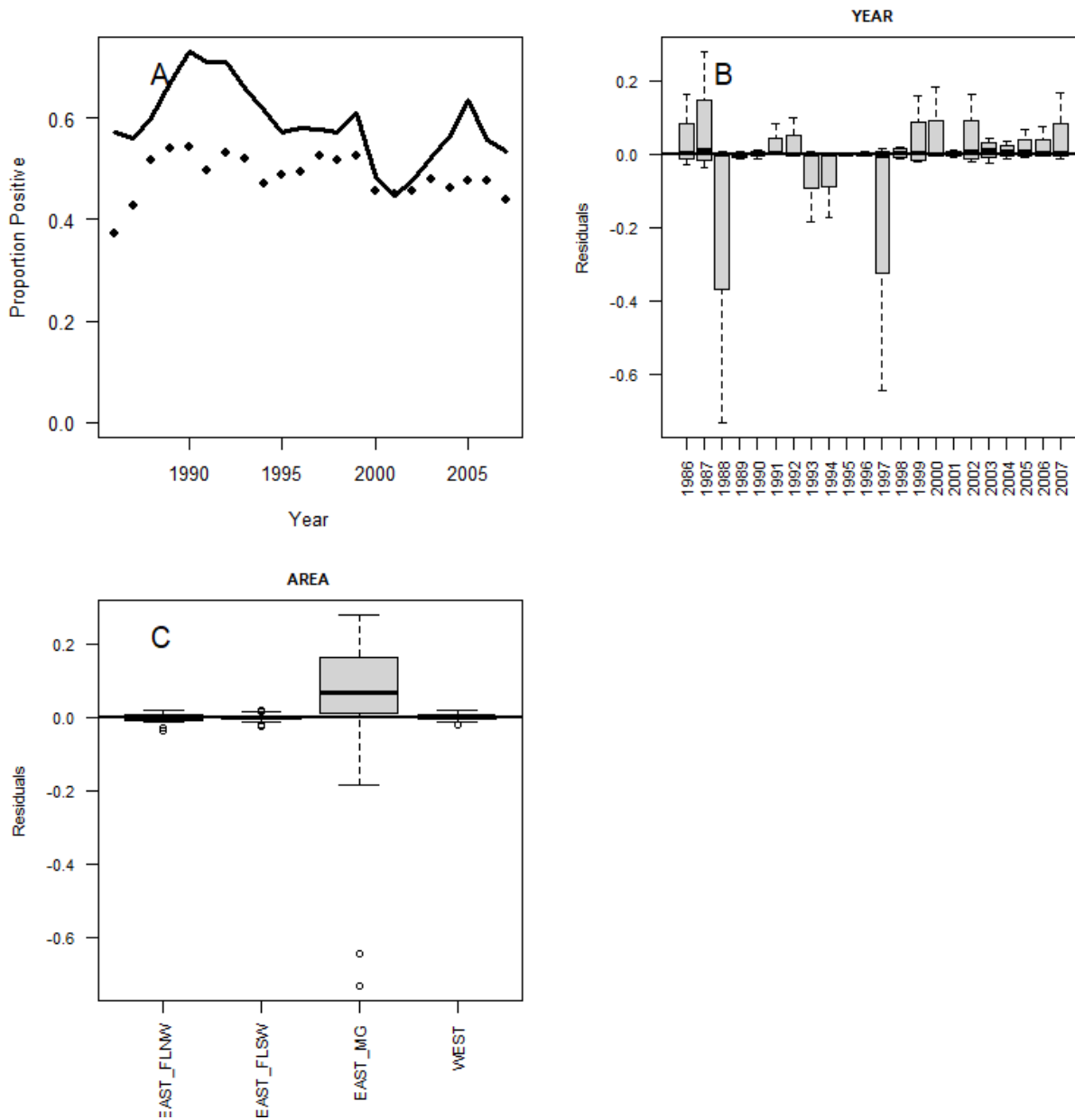


Figure 10. Diagnostic plots for the Binomial component (i.e., proportion positive) of the final delta-lognormal GLM of the **Gulf-Wide** Index, including the (A) comparison of observed (solid circles) vs. predicted (solid line) proportion of positive trips (i.e., with Gray Triggerfish catch) by year, and the distribution of residuals by (B) YEAR and (C) AREA.

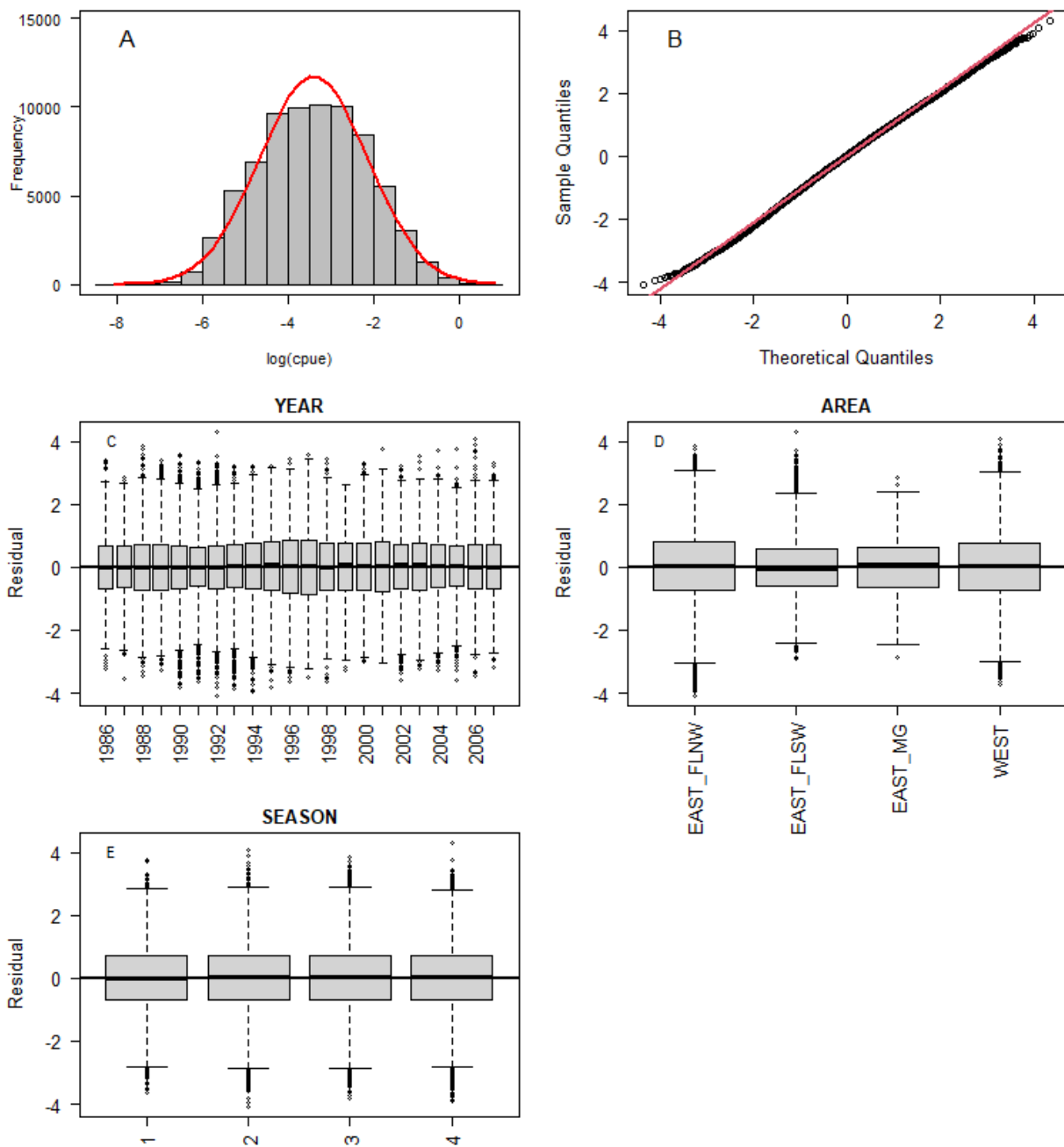


Figure 11. Diagnostic plots for the Lognormal component (i.e., catch rates of Gray Triggerfish from positive trips) of the final delta-lognormal GLM of the **Gulf-Wide** Index, including (A) frequency distribution of log-transformed catch rates, (B) cumulative normalized residuals, and the distribution of residuals by (C) YEAR, (D) AREA, and (E) SEASON. The red lines represent the expected normal distribution.

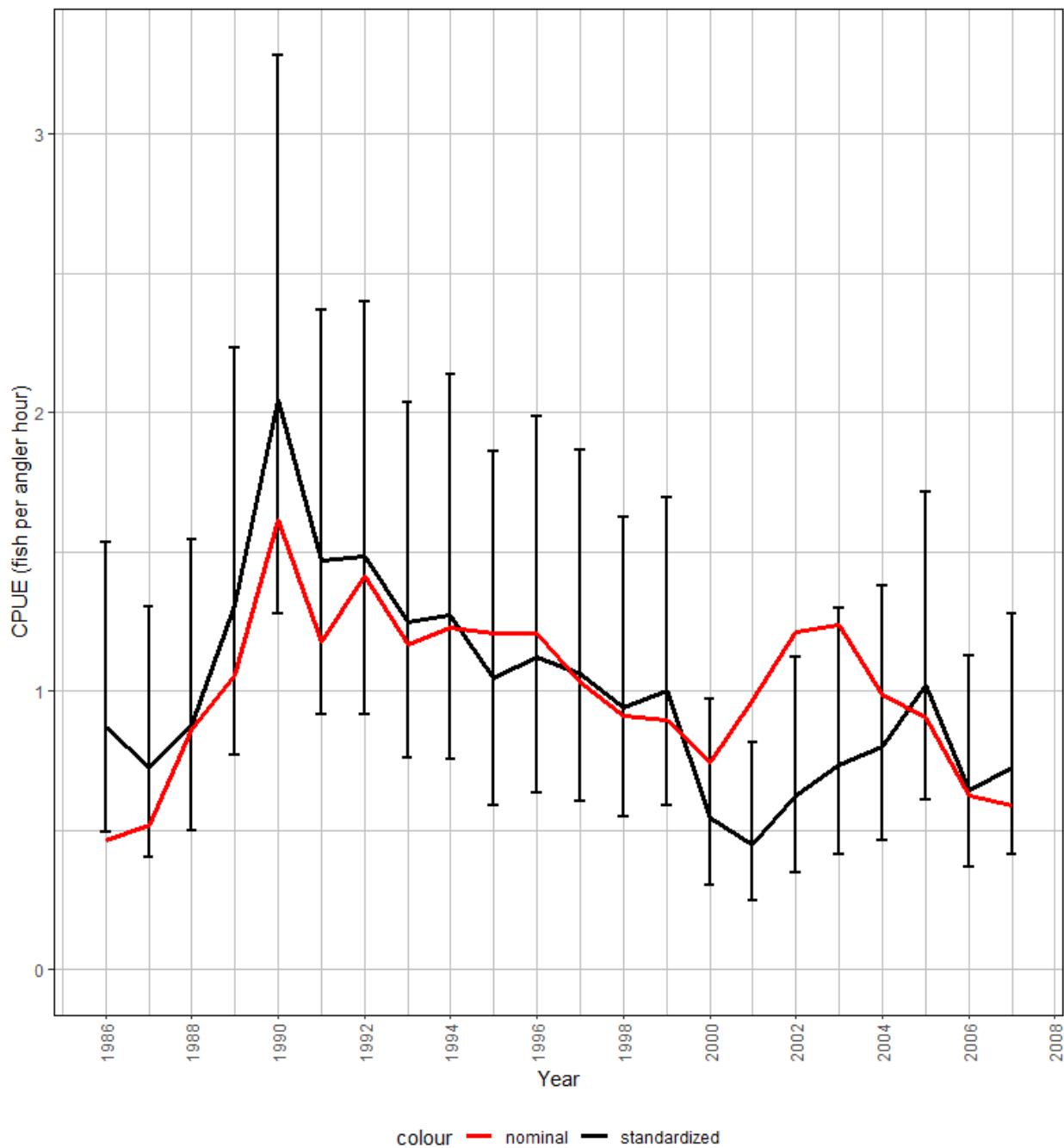


Figure 12. Standardized abundance index (black line), with 95% confidence interval (bars), for Gray Triggerfish across the **entire** Gulf of America as compared to the associated nominal rates (red line), both of which have been rescaled to the mean values of their respective timeseries.

Table A1. The reef fish guild that has been subset to only include those species consistently identified on SRHS logbook forms across all years (Table 1 in SEDAR 68-DW-18). This species list was used to filter the headboat data base for SEDAR 100.

Common	Scientific	Family
Gray triggerfish	<i>Balistes capriscus</i>	Balistidae
Queen triggerfish	<i>Balistes vetula</i>	Balistidae
African pompano	<i>Alectis ciliaris</i>	Carangidae
Blue runner	<i>Caranx crysos</i>	Carangidae
Greater amberjack	<i>Seriola dumerili</i>	Carangidae
Almaco jack	<i>Seriola rivoliana</i>	Carangidae
Atlantic spadefish	<i>Chaetodipterus faber</i>	Ephippidae
Tomtate	<i>Haemulon aurolineatum</i>	Haemulidae
White grunt	<i>Haemulon plumieri</i>	Haemulidae
Bluestriped grunt	<i>Haemulon sciurus</i>	Haemulidae
Squirrelfish	<i>Holocentrus adscensionis</i>	Holocentridae
Mutton snapper	<i>Lutjanus analis</i>	Lutjanidae
Blackfin snapper	<i>Lutjanus buccanella</i>	Lutjanidae
Red snapper	<i>Lutjanus campechanus</i>	Lutjanidae
Cubera snapper	<i>Lutjanus cyanopterus</i>	Lutjanidae
Gray snapper	<i>Lutjanus griseus</i>	Lutjanidae
Lane snapper	<i>Lutjanus synagris</i>	Lutjanidae
Silk snapper	<i>Lutjanus vivanus</i>	Lutjanidae
Vermilion snapper	<i>Rhomboplites aurorubens</i>	Lutjanidae
Bigeye	<i>Priacanthus arenatus</i>	Priacanthidae
Bank sea bass	<i>Centropristis ocyurus</i>	Serranidae
Sand perch	<i>Diplectrum formosum</i>	Serranidae

Common	Scientific	Family
Rock hind	<i>Epinephelus adscensionis</i>	Serranidae
Graysby	<i>Epinephelus cruentatus</i>	Serranidae
Red hind	<i>Epinephelus guttatus</i>	Serranidae
Red grouper	<i>Epinephelus morio</i>	Serranidae
Gag	<i>Mycteroperca microlepis</i>	Serranidae
Scamp	<i>Mycteroperca phenax</i>	Serranidae
Yellowfin grouper	<i>Mycteroperca venenosa</i>	Serranidae
Jolthead porgy	<i>Calamus bajonado</i>	Sparidae
Red porgy	<i>Pagrus pagrus</i>	Sparidae
Great barracuda	<i>Sphyraena barracuda</i>	Sphyraenidae