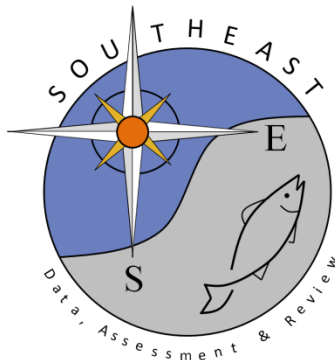


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from the Gulf of America commercial handline fishery, 1999-2023

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SEDAR99-WP-07

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# **Standardized catch rates of King Mackerel (*Scomberomorus cavalla*) from the Gulf of America commercial handline fishery, 1999-2023**

Michaela Pawluk<sup>1</sup> and Kevin Thompson

SEDAR99-WP-07

April 2026

This document describes the development of the SEDAR 99 commercial logbook index for the King Mackerel commercial handline fishery updated through fishing year 2023 (July 1<sup>st</sup>, 2023 – June 30<sup>th</sup>, 2024). Initial King Mackerel indices of abundance using the Commercial Fisheries Logbook Program data were constructed through 2006 during SEDAR 16 (SEDAR 16-DW-22) and updated through 2013 for SEDAR 38 (SEDAR 38-DW-10), and through 2017 for the SEDAR 38 Update assessment (SEDAR 38U Assessment Report).

## **Commercial Fisheries Logbook Program (CFLP) overview**

Landings and fishing effort of commercial vessels operating in the Gulf of America (formerly known as the Gulf of Mexico, hereafter referred to as “the Gulf”) and southeast U.S. Atlantic are monitored by the NMFS Southeast Fisheries Science Center through the Coastal Fisheries Logbook Program (CFLP). The program collects trip-level information from all vessels holding federal permits to fish in waters managed by the regional Fishery Management Councils. Initiated in the Gulf in 1990, the CFLP began collecting logbooks from Atlantic commercial fishers in 1992, when 20% of Florida vessels were targeted. Beginning in 1993, sampling in Florida was increased to require reports from all reef fish vessels permitted in coastal fisheries, and since then has maintained the objective of a complete census of federally permitted vessels across the entire southeast U.S (Atkinson et al. 2021). King Mackerel permit holders were not required to report until 1999, and therefore only data from 1999 onward will be used in these analyses.

For each fishing trip, the CFLP records a unique trip identifier, the landing date, fishing gear deployed, areas fished, number of days at sea, number of crew, gear-specific fishing effort, species caught, and weight of the landings. Fishing effort data available for the handline gear includes number of lines, average number of hooks per line, and total hours fished.

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## Background

The last King Mackerel assessment with clear documentation of the commercial index construction was SEDAR 38. The SEDAR 38 King Mackerel assessment consisted of three separate models, one for the Gulf, one for the South Atlantic, and one for the mixing zone. As a result, multiple indices were constructed using the commercial logbook data for the handline fishery. However, as this assessment only covers the Gulf of America, only one index has been constructed, following the methodology for the Gulf index from SEDAR 38 where possible. The areas included in the Gulf index are statistical areas 3 – 21 and are shown in Figure 1. While landings from the mixing zone during winter months are included in the commercial landings from this model, samples from the mixing zone have been excluded to best approximate the procedure from SEDAR 38.

## Data Description

Catch per unit effort (CPUE), defined as whole weight per hook hour, from the CFLP logbooks was used to develop an index of abundance for King Mackerel landed using handline gear. The size and age range of fish included in the index is the same as that of landings from the commercial handline fleet.

### 1. Outlier removal

Extreme values occur more frequently in self-reported data because there are limited opportunities to validate data. Recent SEDAR stock assessments have removed values at the extreme upper tail of the distribution for CPUE and associated fields in self-reported fishery-dependent data. Values falling outside the 99.9 percentile of the data were excluded from the analyses.

### 2. Data exclusions and assumptions (delayed reporting, multiple gears, area reported, closures)

Data were restricted to include only those trips with landings and effort data reported within 45 days of the completion of the trip to minimize the potential for recall bias (some reporting delays were longer than one year). Also excluded were trips that reported use of multiple gears fished, which prevents designating trip-level catch and effort records to specific gears. Therefore, only trips which reported one gear fished were included in these analyses. For trips that reported fishing in more than one area, the first area reported was used to determine the fishing location associated with the trip. Additionally, there were many partial closures of the King Mackerel season during the modeling time period. Any trips occurring during closure periods, and occurring within the area impacted by the closure, were excluded from analyses.

### 3. Areas included in the model

Following the methodology from SEDAR 38, only logbook data reported in the statistical areas 3\* – 21 were included in the model. Area 3 was mistakenly included in the mixing zone for SEDAR 38, however, it is a Gulf area and therefore was included for this analysis. Trips reported from areas outside of the defined region were excluded.

### 4. Time period

Implemented in 1992, the CFLP did not require reporting from all Gulf and Atlantic commercial reef fish fishermen until 1993, and did not require reporting from all King Mackerel permit holders until 1999. Therefore, 1999 was chosen as the starting year for the constructed index. This is a departure from what was done in SEDAR 38 where a start year of 1993 was used, and from SEDAR 38U where a start year of 1998 was used. The justification for this change in start year is related to the logbook trips not being reflective of the King Mackerel fishery behavior prior to 1999, due to the fact that they were not required to report in the initial years of the program. For this assessment, the fishing year, rather than calendar year, is used. Therefore, this index includes data from the 1999 – 2000 fishing year through the 2023 – 2024 fishing year, as no 2025 data were available, and therefore fishing year 2024 – 2025 would have been a partial year. A terminal year of 2024 was used per the SEDAR 99 Terms of Reference. Some recent fisheries dependent indices have required a temporal truncation due to evidence of shifts in species associations (e.g. SEDAR 79 FL Mutton Snapper). An investigation into the stability of the Stephens and MacCall coefficients for this index found no evidence of shifts in associations, and therefore, no truncation was recommended.

## **Evaluation of explanatory variables**

**FISHING YEAR** – Fishing year was necessarily included, as standardized catch rates by year are the desired outcome. Fishing years modeled were the 1999 – 2000 fishing year through the 2023 – 2024 fishing year.

**SEASON** – Season included four levels: (Winter: Jan – Mar, Spring: Apr – Jun, Summer: Jul – Oct, Fall: Nov – Dec).

**AREA** – Area included nine levels: Areas 3 – 5, Areas 6 & 7, Area 8, Area 9, Areas 10 – 12, Area 13, Areas 14 & 15, Areas 16 & 17, and Areas 18 – 21

**DAYS AT SEA** – Days at sea included four levels: 1, 2, 3, 4+

**CREW SIZE** – Crew size (includes Captain) was pooled into 2 levels: 1 – 3, and 4 plus crew per trip.

**NUMBER OF LINES** – Number of lines included five levels: 1 – 2, 3, 4, 5 – 7, 8+

**HOOKS PER LINE** – Hooks per line included five levels: 1, 2, 3 – 10, 11 – 15, 16+

**GEAR** – Gear included two levels: Handlines/Electric Reels (HL), Trolling (TRL)

**HOURS FISHED** – Hours fished included six levels: 6 hrs or less, between 6 and 8 hrs, between 8 and 12 hrs, between 12 and 24 hrs, between 24 and 48 hrs, more than 48 hrs

## **Analytical decisions**

1. Subsetting trips - Use Stephens and MacCall (2004) method.

2. Species included in Stephens and MacCall approach: remove species with full-year closures, ID issue, or large shifts in desirability over the index period.
3. Apply Stephens and MacCall for Handline/trolling trips by subregion separately (East Gulf: areas 3 – 12, West Gulf: areas 13 – 21).

### **Subsetting trips**

Effective effort was based on those trips from areas where King Mackerel were available to be caught. Without fine-scale geographic information on fishing location, trips to be included in the analysis must be inferred, which was done here using the method of Stephens and MacCall (2004). The method uses multiple logistic regression to estimate a probability for each trip that the focal species was caught, given other species caught on that trip.

A backwards stepwise AIC procedure (Venables and Ripley 1997) was then used to perform further selection among possible species as predictor variables, where the most general model included all listed species as main effects. In this procedure, a generalized linear model with Bernoulli response was used to relate presence/absence of King Mackerel in each trip to presence/absence of other species. A trip was then included if its associated probability of catching King Mackerel was higher than a threshold probability. The threshold was designed to be that which resulted in the same number of predicted and observed positive trips, as suggested by Stephens and MacCall (2004).

### **Standardization**

CPUE was modeled using the delta-GLM approach (Lo, Jacobson, and Squire 1992; Dick 2004; Maunder and Punt 2004). This approach combines two separate generalized linear models (GLMs), one to describe presence/absence of the focal species, and one to describe catch rates of successful trips (trips that caught the focal species). Estimates of variance were based on 1000 bootstrap runs where trips were chosen randomly with replacement (Efron and Tibshirani 1993). All analyses were programmed in R, with much of the code adapted from Dick (2004).

### **Bernoulli submodel**

The Bernoulli component of the delta-GLM is a logistic regression model designed to predict the presence/absence (i.e., availability to be caught) of King Mackerel on any given trip. Initially, all explanatory variables were included in the model as main effects, and then stepwise AIC (Venables and Ripley 1997) with a backwards selection algorithm was used to eliminate those variables that did not improve model fit. The stepwise AIC procedure retained all explanatory variables. Model diagnostics, based on standardized (quantile) residuals, suggested reasonable fits of the Bernoulli submodel.

### **Positive CPUE submodel**

Two parametric distributions were considered for modeling positive values of CPUE, lognormal and gamma. For both distributions, all explanatory variables were initially included as main effects, and then stepwise AIC (Venables and Ripley 1997) with a backwards selection algorithm was used to eliminate those variables that did not improve model fit. For both distributions, the best model fit retained all exploratory variables. The two distributions were compared using

AIC, with the gamma distribution outperforming the lognormal distribution. The gamma distribution was therefore applied in the final delta-GLM model. Diagnostics suggested a reasonable fit of the standardization procedure.

## **Differences in methodology compared to previous SEDAR**

There were several differences in methodology for constructing the index in the current analysis compared to what was done previously. Firstly, regarding the data included in the Gulf model vs. the Mixing zone model, the SEDAR 38 model mistakenly grouped statistical area 3 in with the mixing zone, when it should have been included as part of the Gulf model. The final data set used in constructing the index contained 189 zero catch trips, and 3,063 positive catch trips from statistical area 3, out of a total of 3,828 zero catch trips, 18,523 positive catch trips, representing 4.94 % and 16.54 % of the zero and positive catch trips, respectively. This likely had a significant impact on both the nominal and standardized catch rates.

Additionally, the trip selection method for this analysis differed from what has been done previously. In SEDAR 38, trips were selected based on vessels, where vessels were added to the list by catch share until a certain proportion of the landings had been accounted for. For these analyses, a standard approach of using the Stephens and MacCall procedure for identifying species associations was used in order to identify trips that likely occurred over King Mackerel habitat. This methodology would tend to better select trips in cases where vessels may shift between different target fisheries, and is standard practice for constructing CFLP indices.

Lastly, there were some differences in model specification for the current analysis when compared to SEDAR 38. For the current analysis, no interaction terms were considered to minimize the likelihood of overparameterization. Additionally, two variables were dropped from the explanatory variable list. First, vessel length was dropped as a potential explanatory variable due to assumed correlation with crew size (i.e. larger vessels naturally have a larger crew). Additionally, the variable “target”, which was meant to account for varying levels of targeting from trip to trip for a given vessel, was dropped due to the Stephens and MacCall procedure better isolating trips that are likely to have been King Mackerel trips.

## **Results and Discussion**

For the East Gulf species associations, Stephens and MacCall results showed several species as strong predictors of King Mackerel presence, with Bluestriped Grunt, Red Grouper, Red Snapper, Yellowtail Snapper, and White Grunt showing the strongest negative association with King Mackerel, and Little Tunny, Spanish Mackerel, and Dolphinfish showing the strongest positive association (Fig. 2). For the West Gulf species associations, Stevens and MacCall results showed that Red Snapper and Gray Snapper had the strongest negative association, while Spanish Mackerel, Wahoo, and Marbled Grouper had the strongest positive association with King Mackerel (Fig. 3). Diagnostic plots showing the number of positive and negative trips being retained as a result of the Sephens and MacCall procedure are shown in Figure 4. Diagnostic plots showing the proportion positive and proportion negative trips retained through time are shown in Figure 5. The standardized index was similar to the nominal index and the diagnostic plots for the delta-GLM models are shown in Figures 6 – 8. Residuals of the final model indicated no issues with the selected model variables in terms of skewed data or other patterns that would suggest poor model fits.

The final index showed a similar pattern to the nominal index, with the general trend of an initial increase in abundance followed by a period of stability, and then a slight decrease in more recent years (Fig. 9). When comparing the results of the standardized index to what was reported in SEDAR 38, and SEDAR 38U, the trend is reasonably similar, although there are some clear differences (Fig. 10). Differences in the updated index compared to the ones provided in the previous SEDARs are likely a function of the updated methodology, following our standard practice of sub-setting trips using the Stephens and MacCall procedure as well as, updates to the modeling procedure to exclude interaction terms, and exclude vessel length and “target” as explanatory variables. Sample sizes, nominal and standardized indices, proportion positive trips, and CVs are shown in Table 1.

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Table 1. Standardized index for the Gulf King Mackerel commercial handline fishery.

<b>Fishing Year</b>	<b>N trips</b>	<b>Nominal CPUE</b>	<b>Relative nominal</b>	<b>Standardized CPUE</b>	<b>Proportion Positive</b>	<b>CV</b>
<b>1999</b>	1289	10.78988	0.663267	0.807252	0.771916	0.053735
<b>2000</b>	1051	12.03405	0.739748	0.800851	0.843007	0.051861
<b>2001</b>	1139	10.82385	0.665355	0.71139	0.789289	0.053331
<b>2002</b>	1036	10.43689	0.641569	0.701368	0.783784	0.054264
<b>2003</b>	1132	11.07429	0.680751	0.721983	0.797703	0.050442
<b>2004</b>	1007	9.720444	0.597528	0.599255	0.672294	0.051657
<b>2005</b>	723	12.88385	0.791987	0.759976	0.643154	0.058172
<b>2006</b>	882	12.79426	0.786479	0.798062	0.763039	0.047786
<b>2007</b>	906	11.55817	0.710495	0.796147	0.810155	0.048822
<b>2008</b>	1028	12.91624	0.793978	0.882395	0.753891	0.048536
<b>2009</b>	824	15.46144	0.950435	1.267409	0.872573	0.044012
<b>2010</b>	720	22.63225	1.391233	1.056292	0.854167	0.053757
<b>2011</b>	722	15.56056	0.956527	1.288737	0.885042	0.049091
<b>2012</b>	820	20.67636	1.271002	1.508217	0.94878	0.042845
<b>2013</b>	628	16.20838	0.99635	1.159788	0.942675	0.047541
<b>2014</b>	861	16.44404	1.010836	1.230998	0.893148	0.047468
<b>2015</b>	955	21.42302	1.3169	0.978362	0.865969	0.047561
<b>2016</b>	1111	20.47879	1.258857	1.173018	0.89649	0.043386
<b>2017</b>	1146	25.53558	1.569704	1.356452	0.900524	0.041579
<b>2018</b>	921	22.3076	1.371277	1.242839	0.892508	0.044646
<b>2019</b>	820	23.77791	1.461659	1.174579	0.882927	0.047712
<b>2020</b>	972	18.2128	1.119564	1.063989	0.845679	0.045809
<b>2021</b>	532	15.98247	0.982463	0.983359	0.828947	0.0637
<b>2022</b>	589	19.57282	1.203166	0.971502	0.809847	0.057523
<b>2023</b>	537	17.38813	1.06887	0.96578	0.839851	0.059478

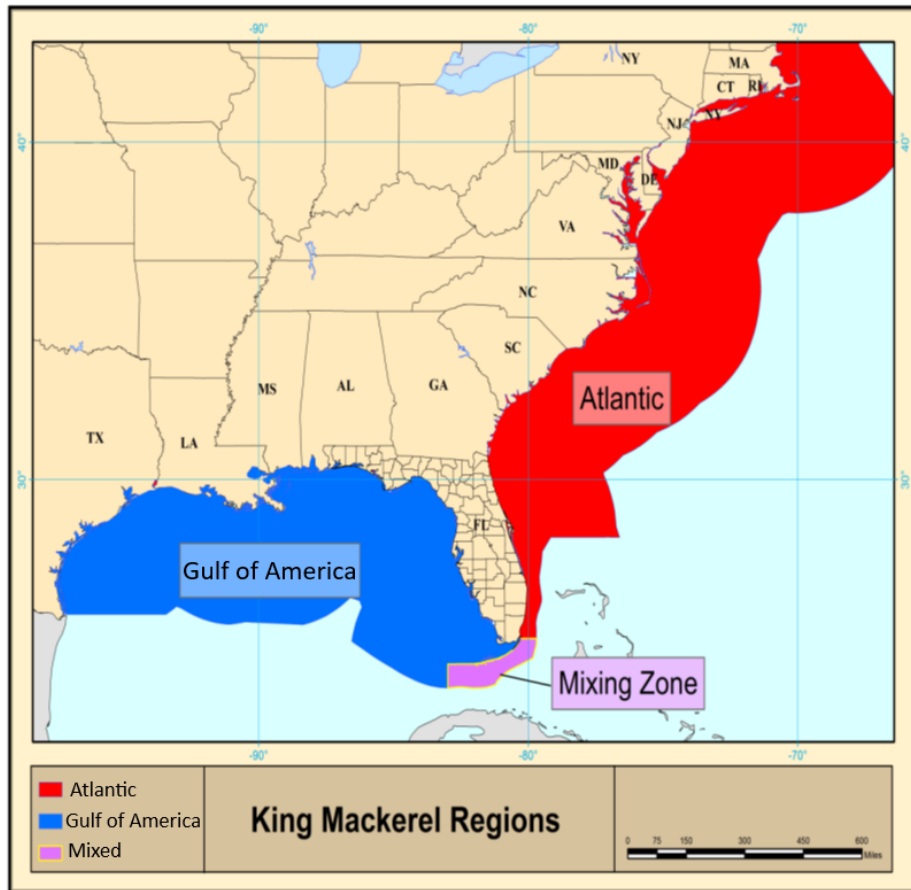
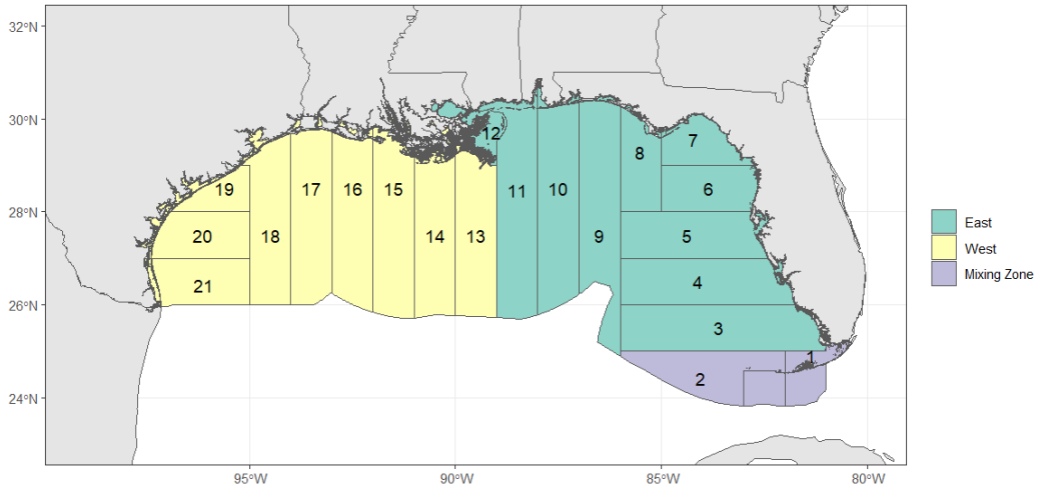


Figure 1. Top: Gulf King Mackerel commercial fisheries subregions as defined by NMFS statistical zones used for the CFLP analysis. Bottom: Gulf King Mackerel commercial fishing subregions as defined for commercial landings. Due to a lack in granularity in the CFLP data, areas 1 and 2 have been excluded from the Gulf index construction.

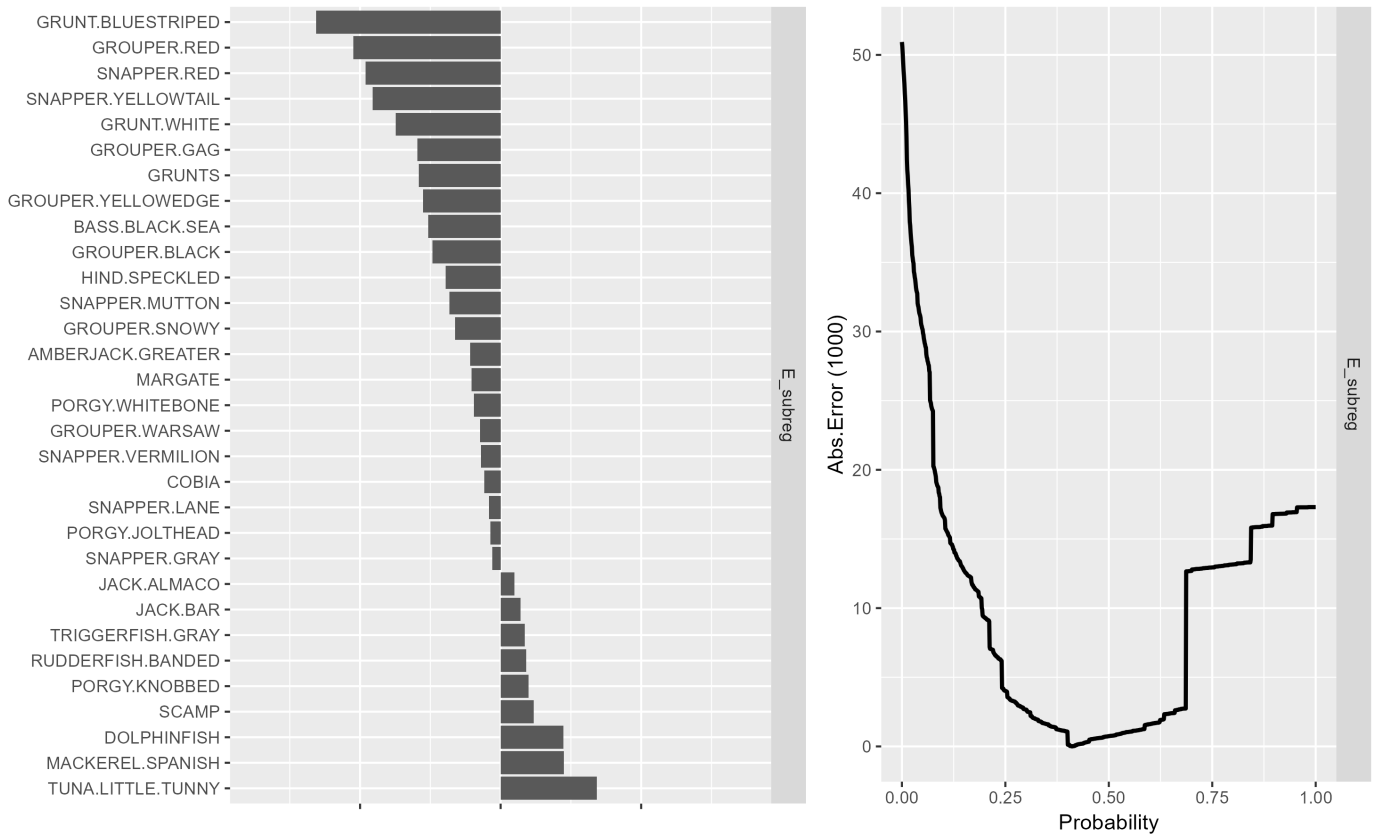


Figure 2. Estimates of species-specific regression coefficients used to predict each trip's probability of catching the focal species for the **East Gulf commercial handline** fishery are shown on the left panel. The right panel shows the absolute difference between observed and predicted number of positive trips across a range of probability cutoff values.

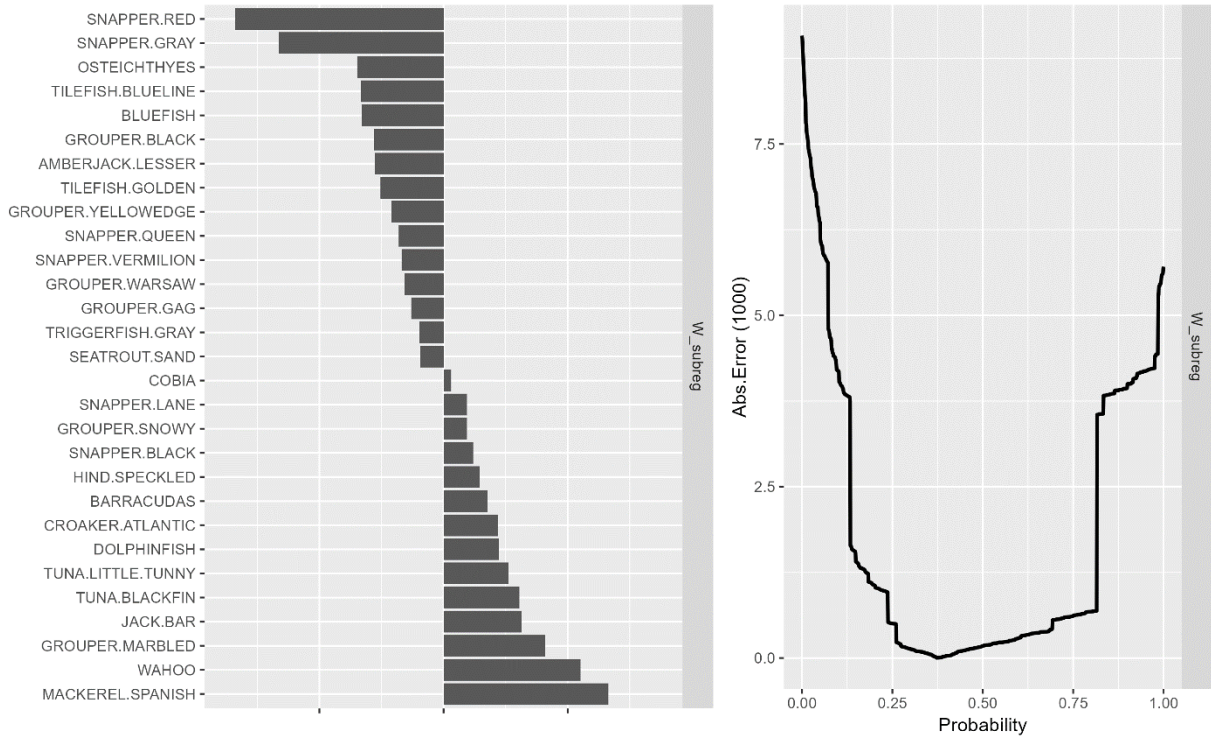


Figure 3. Estimates of species-specific regression coefficients used to predict each trip’s probability of catching the focal species for the **West Gulf commercial handline** fishery are shown on the left panel. The right panel shows the absolute difference between observed and predicted number of positive trips across a range of probability cutoff values.

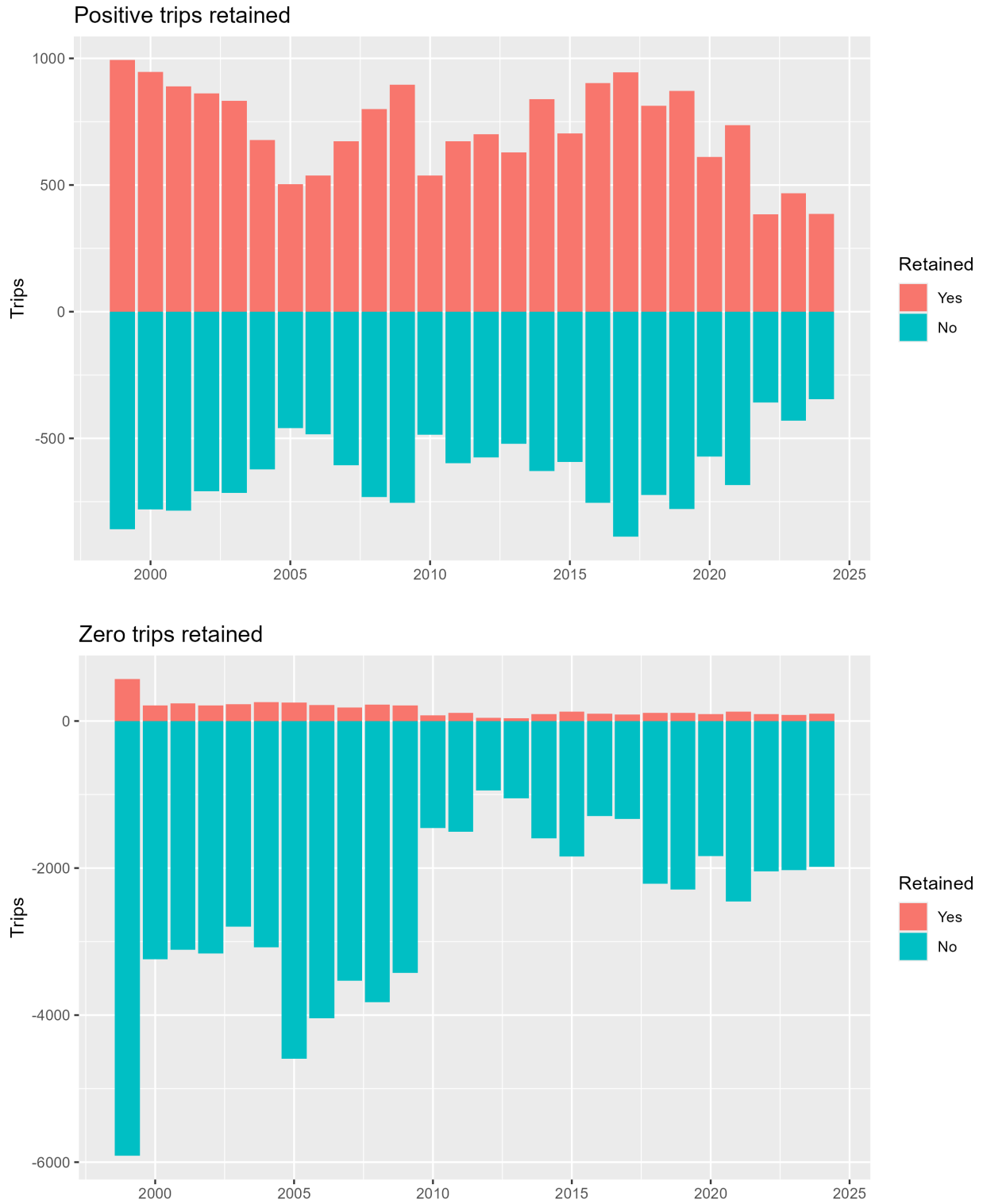


Figure 4. Gulf King Mackerel commercial handline positive and zero trips retained by year after subsetting using the Stephens and MacCall approach.

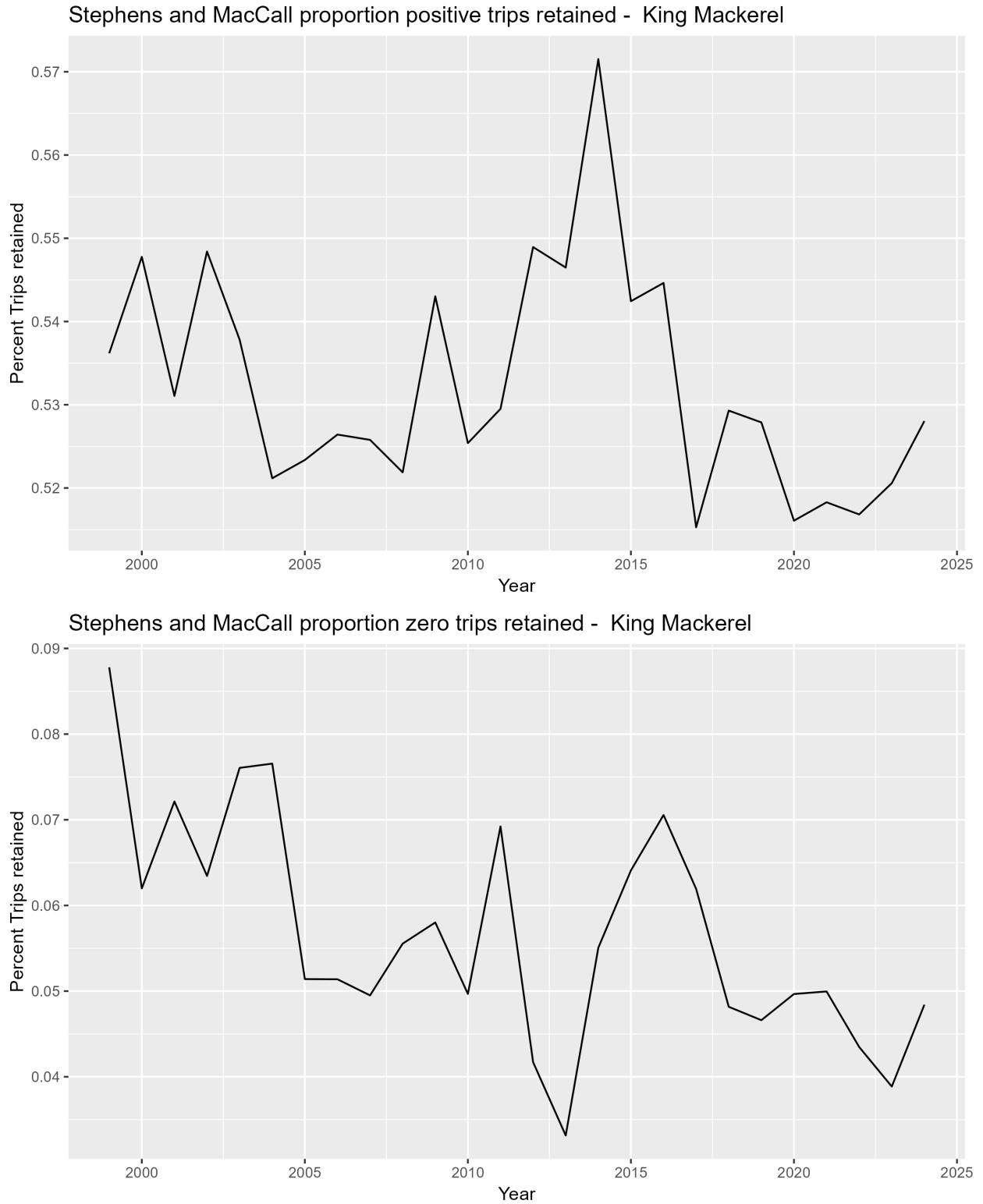


Figure 5. Proportion of positive (top) and zero (bottom) commercial handline trips retained by year after subsetting using Stephens and MacCall approach for Gulf King Mackerel fishery.

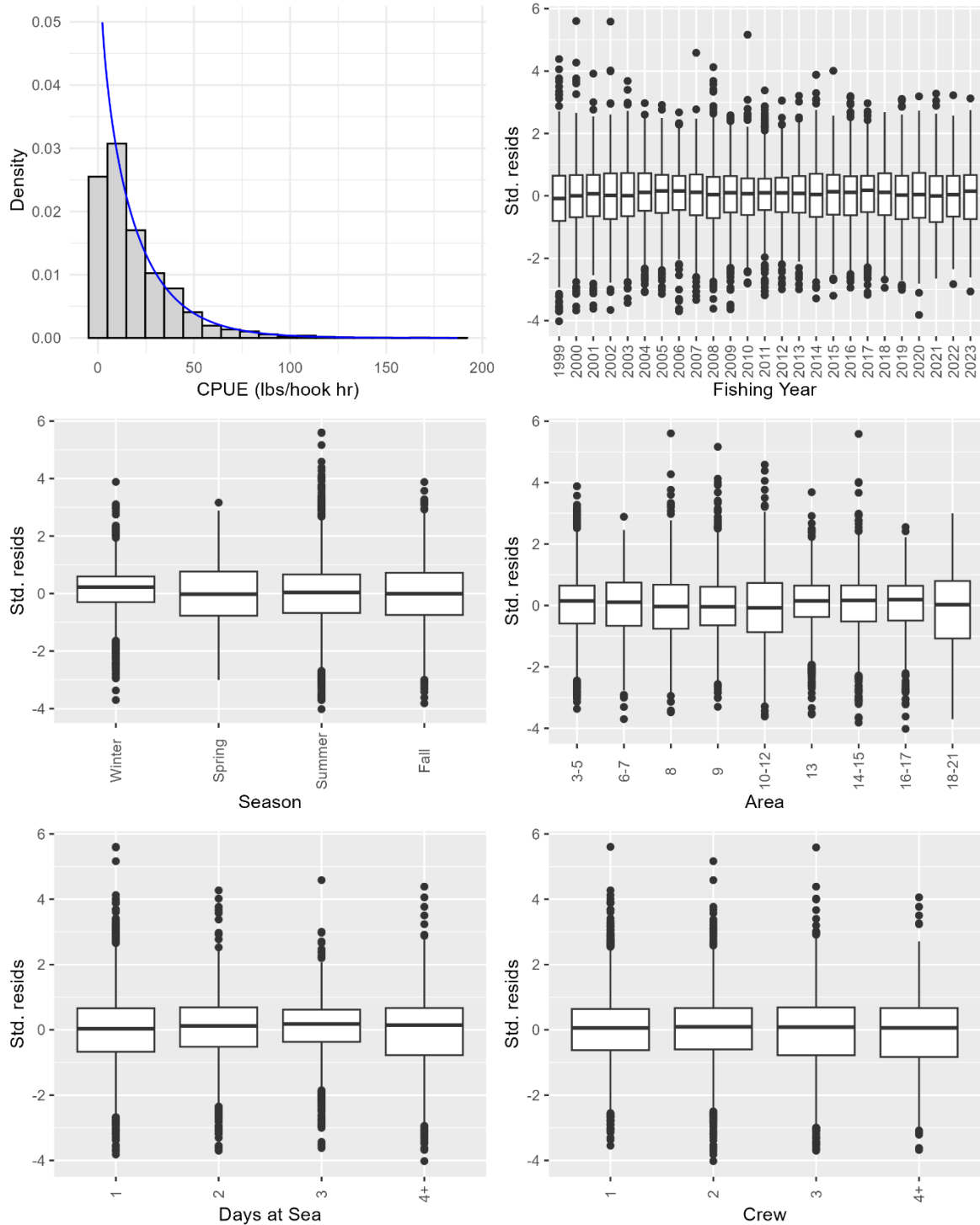


Figure 6. Gulf King Mackerel commercial handline index diagnostics of gamma submodel fits to positive CPUE data. Top left panel shows the distribution of positive cpue. Box and whisker plots give first, second (median) and third quartiles, as well as limbs that extend to approximately one interquartile range beyond the nearest quartile, and outliers (circles) beyond the limbs. Residuals are standardized (quartile) residuals.

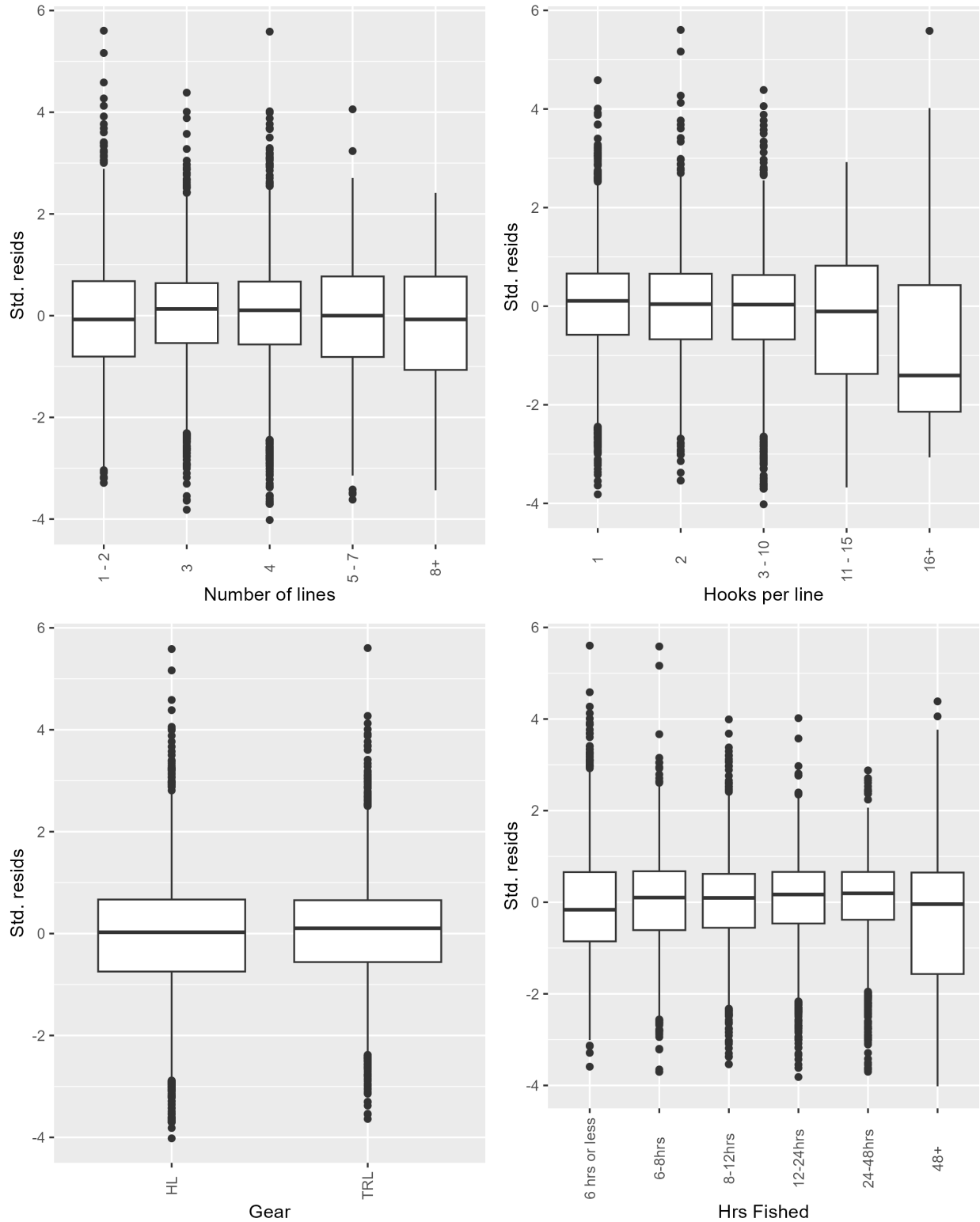


Figure 7. Gulf King Mackerel commercial handline index diagnostics of gamma submodel fits to positive CPUE data, continued. Box and whisker plots represent standardized residuals by explanatory variable as in Figure 6.

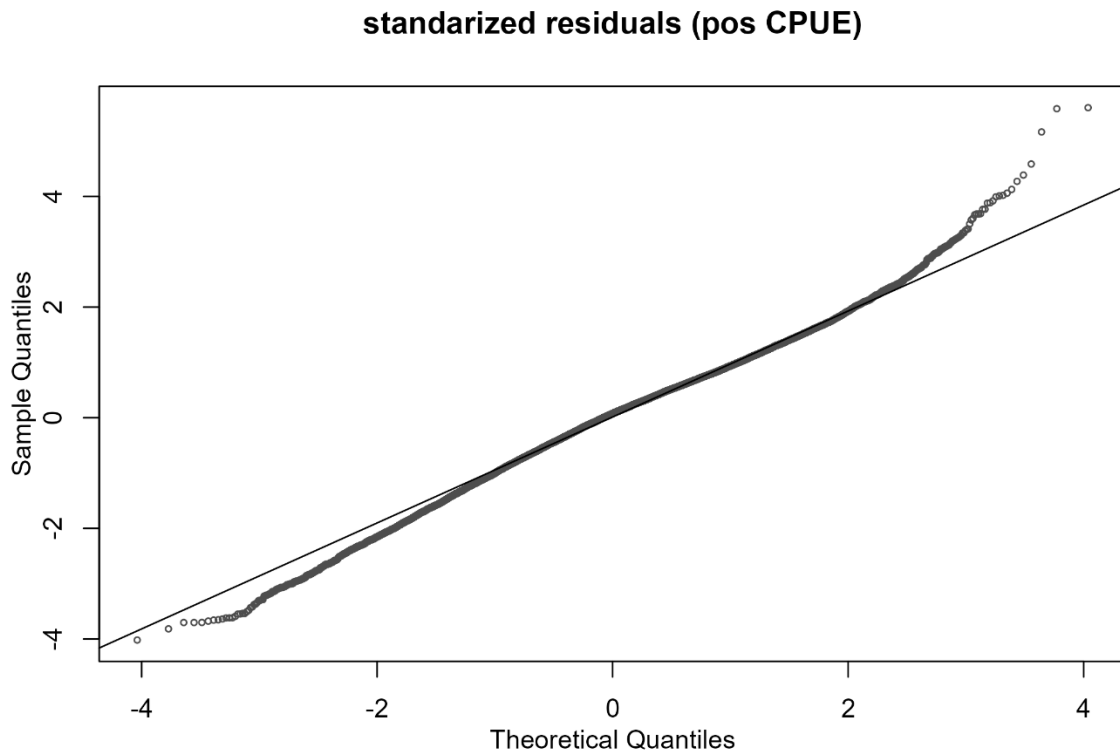
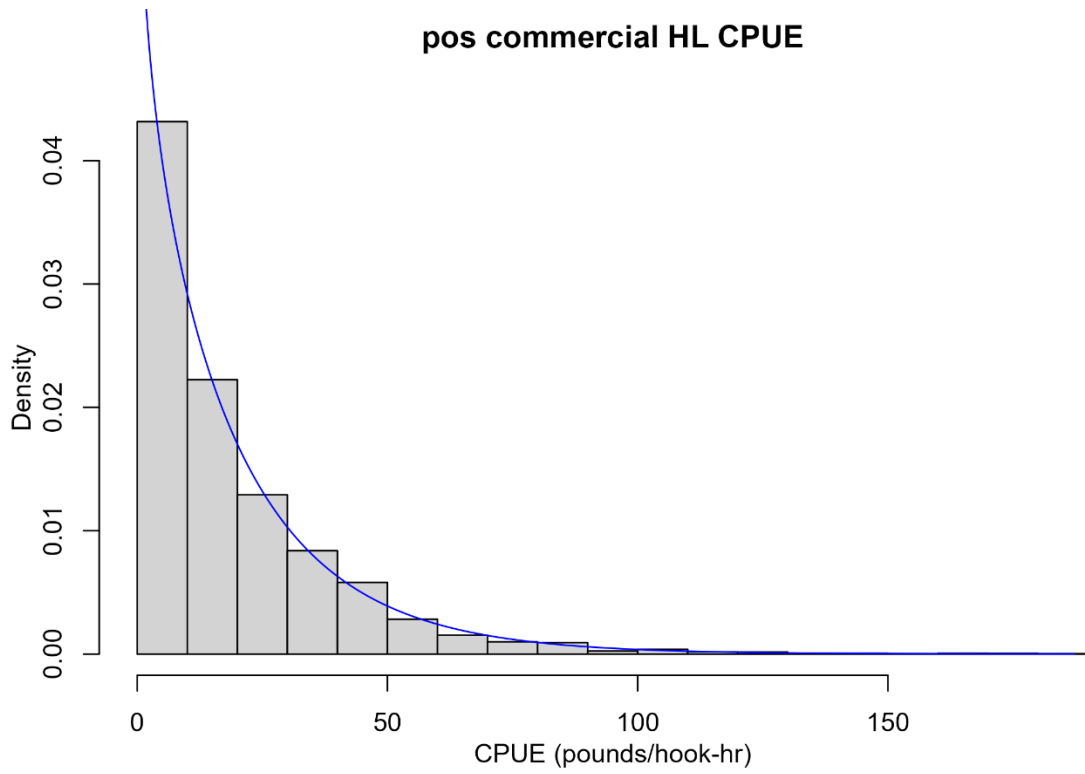


Figure 8. Histogram of empirical CPUE for the Commercial handline trips, with the gamma distribution overlaid (top) and the quantile-quantile plot of residuals from the fitted gamma submodel to the positive cpue catch (bottom).

**King Mackerel - Commercial Handline Index - All Gulf**

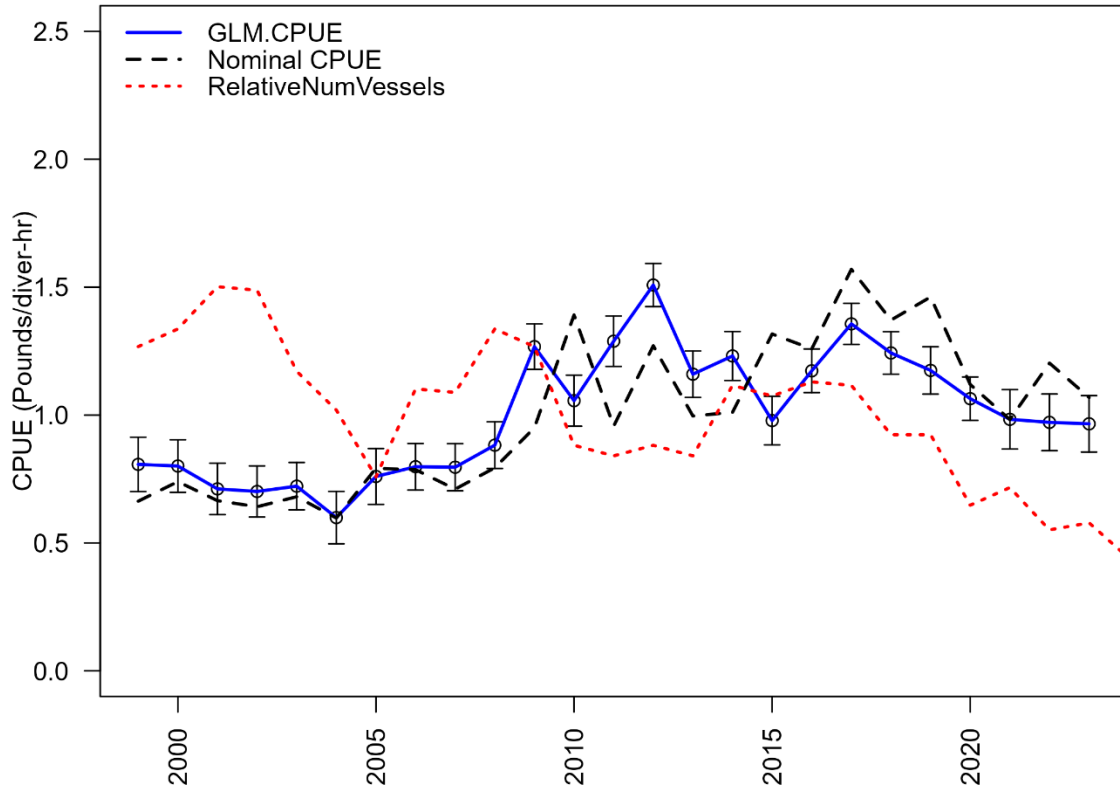


Figure 9. Standardized index of abundance for the Gulf King Mackerel commercial handline fleet with nominal index and relative number of vessels in the fishery by year.



Figure 10. Comparison of SEDAR 99 Gulf King Mackerel commercial handline index (S99) to the standardized index values reported in SEDAR 38 (S38) and in SEDAR 38U (S38U).