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SEDAR94-DW-04

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Standardized catch rates of Hogfish (*Lachnolaimus maximus*) from the Southeastern U.S. commercial spear fishery, 1993-2024

Michaela Pawluk[1] and Kevin Thompson

SEDAR94-DW-04

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This document describes the development of the SEDAR 94 commercial logbook index for the Hogfish commercial spear fishery. Initial Hogfish indices of abundance using the Commercial Fisheries Logbook Program data were constructed through 2012 during SEDAR 37 (SEDAR 37-WP-12) and updated through 2017 for the SEDAR 37 Update assessment (SEDAR 37U Assessment Report).

Commercial Fisheries Logbook Program (CFLP) overview

Landings and fishing effort of commercial vessels operating in the Gulf of America (formerly Gulf of Mexico) 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 of America 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 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).

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 spear/dive gear includes number of divers, and hours fished.

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Background

For the SEDAR 37U Hogfish assessment, two indices were constructed using the commercial logbook data for the spear/dive fishery. An East Florida - Keys index which included landings and effort data from logbook statistical areas 1, 2, 3, 2480 – 2482, 2579 – 2580, 2679 – 2680, 2779 – 2780, 2979 – 2981, 3078 – 3081; and a West Florida index which included landings and effort data from logbook statistical areas 4 - 7. Both indices have been updated for this assessment and are presented here. Areas included in the East Florida – Keys, and West Florida indices are shown in Figure 1.

Data Description

Catch per unit effort (CPUE), defined as whole weight per diver hour, from the CFLP logbooks was used to develop an index of abundance for Hogfish landed using diving/spear gear. Thus, the size and age range of fish included in the index is the same as that of landings from the commercial dive 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 three closures of the Hogfish season during the modeling time period (Gulf Fishery closed: 12/02/2013 – 12/31/2013; South Atlantic Fishery closed: 8/24/2017 – 12/31/2017; 11/16/2018 – 12/31/2018). Any trips occurring during closure periods were excluded from analyses.

3. Areas included in the model

Following the methodology from SEDAR 37, only logbook data reported in the statistical areas mentioned above were included in the analyses for the Keys-East Florida and West Florida indices. 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 of America and US Atlantic commercial fishermen until 1993. Therefore, 1993 was chosen as the starting year for the constructed indices. A terminal year of 2024 was used per the SEDAR 94 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. The size limit increased from 12” in 2017 to 16” in the Gulf of America and 14” in the South Atlantic, as such management time period is considered in these models.

Evaluation of explanatory variables

Keys-EFL Index

YEAR – Year was necessarily included, as standardized catch rates by year are the desired outcome. Years modeled were 1993-2024.

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

AREA – Area included three levels: North Keys (N.Keys: stat areas 1 – 3), South Keys (S.Keys: 2481 – 2482), and East Florida (EFL: 2579 – 2580, 2679 – 2680, 2779 – 2780, 2879 – 2880, 2979 – 2981, 3078 – 3081)

DAYS AT SEA – Following S37 methodology, days at sea was not tested for the Keys-EFL region as the majority of trips were single day.

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

MANAGEMENT PERIOD – Management period included 2 levels due to changes in size limits: 1993 – 2017; 2018 – 2024.

WFL Index

YEAR – Year was necessarily included, as standardized catch rates by year are the desired outcome. Years modeled were 1993-2024.

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

AREA – Area included two levels: Central West Florida (CWFL: stat areas 4 & 5), and North West Florida (NWFL: stat areas 6 & 7).

DAYS AT SEA – Days at sea (away) included 2 levels: single day trips (1) and multi-day trips (2 plus).

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

MANAGEMENT PERIOD – Management period included 2 levels: 1993 – 2017; 2018 – 2024.

Analytical decisions

1. Subsetting trips - Use Stephens and MacCall(2004) method.
2. Species included in Stephens and MacCall approach: limit to snapper-grouper complex and remove species with full-year closures, ID issue, or large shifts in desirability over the index period.
3. Apply Stephens and MacCall for dive trips by subregion separately (Keys-EFL, WFL).

Subsetting trips

Effective effort was based on those trips from areas where Hogfish 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 Hogfish in each trip to presence/absence of other species. A trip was then included if its associated probability of catching Hogfish 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 Hogfish 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. For the Keys-EFL model, the stepwise AIC procedure removed management period, but retained all other explanatory variables. For the WFL model, management period was removed from the model, while all other explanatory variables were retained. For both models, 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 the Keys-EFL model, for both distributions, the best model fit removed management period while retaining all other exploratory variables. For the WFL model, the best model fit removed management history and area, while retaining year, season, days at sea, and crew size. The two distributions were compared using AIC. For the Keys-EFL model, the lognormal distribution outperformed the gamma distribution and was therefore applied in the final delta-GLM model. For the WFL model, the gamma distribution outperformed the lognormal distribution, and was therefore applied in the final delta-GLM. Diagnostics suggested a reasonable fit of the standardization procedure.

Differences in methodology compared to previous SEDAR

The documentation for the indices provided in SEDAR 37 & SEDAR 37U was not sufficient to replicate what had been done previously. As a result, it was decided that a standard methodology used to construct CFLP indices would be used. The main difference between what was done for SEDAR 37 and the current analysis was the exclusion of interaction terms in the delta-GLM model, and the exclusion of effort as an explanatory variable. Interactions were not considered in this case as they are not considered in our standard CFLP index procedure. In the case of effort as an explanatory variable, it was decided that including it would be inappropriate as effort is already accounted for in the response variable.

Results and Discussion

For the Keys-EFL index, Stephens and MacCall results showed several species as strong predictors of Hogfish presence, with Gag, Red Snapper, and Blue Runner showing the strongest negative association with Hogfish, and Red Grouper, Grey Snapper, and Jolthead Porgy showing the strongest positive association (Fig. 2). For the WFL index, Yellowtail Snapper and Lane Snapper had the strongest negative association, while Rock Hind had a very strong positive association, and a variety of species had a moderate positive association with Hogfish (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 for the Keys-EFL and WFL indices in Figures 4 and 5, respectively. Diagnostic plots showing the proportion positive and proportion negative trips retained through time are shown for the Keys-EFL and WFL indices in Figures 6 and 7, respectively. For both the Keys-EFL and WFL models, the standardized index was similar to the nominal index and the diagnostic plots for the delta-GLM models are shown in Figures 8 – 11. 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.

For the Keys-EFL model the final index showed a similar pattern to the nominal index, with the general trend of relatively stable abundance through the time series with a slight decrease in more recent years (Fig. 12). For the WFL model the final index followed the nominal index very closely, with general trend showing fairly stable abundance with occasional larger peaks, for example in 2001 and 2009 (Fig. 13). When comparing the results of the standardized index to what was reported in SEDAR 37, for the Keys-EFL model, the trend is reasonably similar, although there are some clear differences (Fig. 14). For the WFL model, the updated standardized index tracks the index provided in SEDAR 37 very closely (Fig. 15). Differences in the updated indices compared to the ones provided in SEDAR 37 are likely a function of the updated data affecting the sub setting procedure with Stephens and MacCall and, to a lesser extent, updates to the modeling procedure to exclude interaction terms and effort as an explanatory variable. Due to a lack of reported sample sizes in the SEDAR 37 working paper, it was impossible to determine the exact cause of the difference in fitted index values between SEDAR 37 and the current analysis. Sample sizes, nominal and standardized indices, proportion positive trips, and CVs are shown in Tables 1 and 2 for the Keys-EFL and WFL indices respectively.

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Table 1. Standardized index for the **Keys-East Florida** commercial dive fishery.

Year	N	Nominal CPUE	Relative nominal	Standardized CPUE	Proportion Positive	CV
1993	151	2.106779	1.662482	1.576332	0.622517	0.145157
1994	162	1.926252	1.520027	1.213107	0.654321	0.126497
1995	141	1.561433	1.232144	1.078217	0.70922	0.147157
1996	113	1.108867	0.875019	0.683008	0.628319	0.17971
1997	303	1.314805	1.037527	0.76377	0.564356	0.119174
1998	295	1.543001	1.217599	1.134519	0.610169	0.103778
1999	212	1.878305	1.482191	0.936236	0.528302	0.146319
2000	269	1.461208	1.153056	0.977246	0.639405	0.105114
2001	341	1.349164	1.06464	0.865822	0.630499	0.094137
2002	374	1.313141	1.036214	0.847579	0.590909	0.098042
2003	218	1.466542	1.157265	1.015281	0.559633	0.137636
2004	260	1.555578	1.227524	1.074269	0.696154	0.097991
2005	221	1.547839	1.221417	1.12441	0.687783	0.104506
2006	143	1.068133	0.842875	0.881824	0.587413	0.127133
2007	165	1.32034	1.041895	1.057246	0.727273	0.114634
2008	121	2.125545	1.677291	1.566609	0.77686	0.137739
2009	100	1.941286	1.53189	1.415393	0.7	0.162582
2010	68	1.955025	1.542731	1.12155	0.632353	0.224723
2011	104	1.574862	1.242741	1.370744	0.634615	0.153826
2012	177	1.044908	0.824548	1.192201	0.542373	0.12868
2013	197	1.57102	1.239709	1.776914	0.695431	0.116174
2014	207	1.390666	1.09739	1.447536	0.570048	0.121146
2015	204	0.951397	0.750758	0.873797	0.583333	0.125602
2016	152	1.364641	1.076853	1.092755	0.598684	0.14862
2017	125	0.950978	0.750427	0.864297	0.568	0.157466
2018	89	0.562657	0.443998	0.636604	0.426966	0.188422
2019	108	0.164539	0.12984	0.235882	0.222222	0.247946
2020	118	0.283115	0.223409	0.391275	0.254237	0.227615
2021	70	0.357639	0.282217	0.472113	0.428571	0.209852
2022	75	0.572533	0.451792	0.808722	0.546667	0.167087
2023	64	0.669781	0.528531	0.84548	0.5	0.220134
2024	120	0.549984	0.433999	0.659261	0.391667	0.183945

Table 2. Standardized index for the **West Florida** commercial dive fishery.

Year	N	Nominal CPUE	Relative nominal	Standardized CPUE	Proportion Positive	CV
1993	32	3.653943	1.070491	0.914063	0.84375	0.171818
1994	31	2.870463	0.840956	0.791605	0.870968	0.213799
1995	39	3.416382	1.000893	1.077495	0.692308	0.21091
1996	53	2.385414	0.698852	0.736807	0.735849	0.231317
1997	70	2.544563	0.745478	0.77705	0.757143	0.137593
1998	50	2.685518	0.786773	0.858722	0.74	0.185429
1999	62	2.324629	0.681044	0.734376	0.758065	0.19118
2000	89	4.219758	1.236258	1.199177	0.853933	0.107491
2001	86	6.225819	1.823971	1.867524	0.825581	0.103126
2002	103	4.275465	1.252578	1.279917	0.728155	0.122794
2003	107	4.547955	1.332409	1.322359	0.859813	0.107272
2004	99	3.163645	0.926849	0.986389	0.727273	0.163179
2005	90	3.469207	1.016369	1.109935	0.688889	0.170246
2006	98	1.707286	0.500182	0.505635	0.653061	0.119826
2007	89	2.805736	0.821993	0.767341	0.730337	0.137262
2008	115	4.111694	1.204598	1.201265	0.852174	0.107649
2009	121	8.20325	2.403297	2.391782	0.801653	0.12114
2010	130	3.572327	1.046581	1.022941	0.853846	0.084264
2011	105	5.225214	1.530825	1.422939	0.866667	0.10639
2012	123	5.319212	1.558363	1.662279	0.853659	0.13408
2013	72	3.167741	0.928049	0.948277	0.819444	0.090597
2014	148	3.769049	1.104214	1.093608	0.864865	0.073398
2015	176	3.750054	1.098649	1.118827	0.886364	0.070232
2016	189	4.121949	1.207603	1.238743	0.820106	0.088281
2017	107	2.914991	0.854002	0.875478	0.869159	0.088945
2018	104	1.959657	0.574118	0.593293	0.903846	0.087592
2019	124	1.823391	0.534197	0.523333	0.814516	0.100919
2020	113	1.378177	0.403763	0.409709	0.725664	0.11096
2021	118	2.126388	0.622966	0.593648	0.864407	0.093634
2022	69	2.301436	0.674249	0.63955	0.869565	0.146998
2023	58	2.565343	0.751566	0.686234	0.827586	0.132222
2024	34	2.62097	0.767863	0.649698	0.882353	0.217918

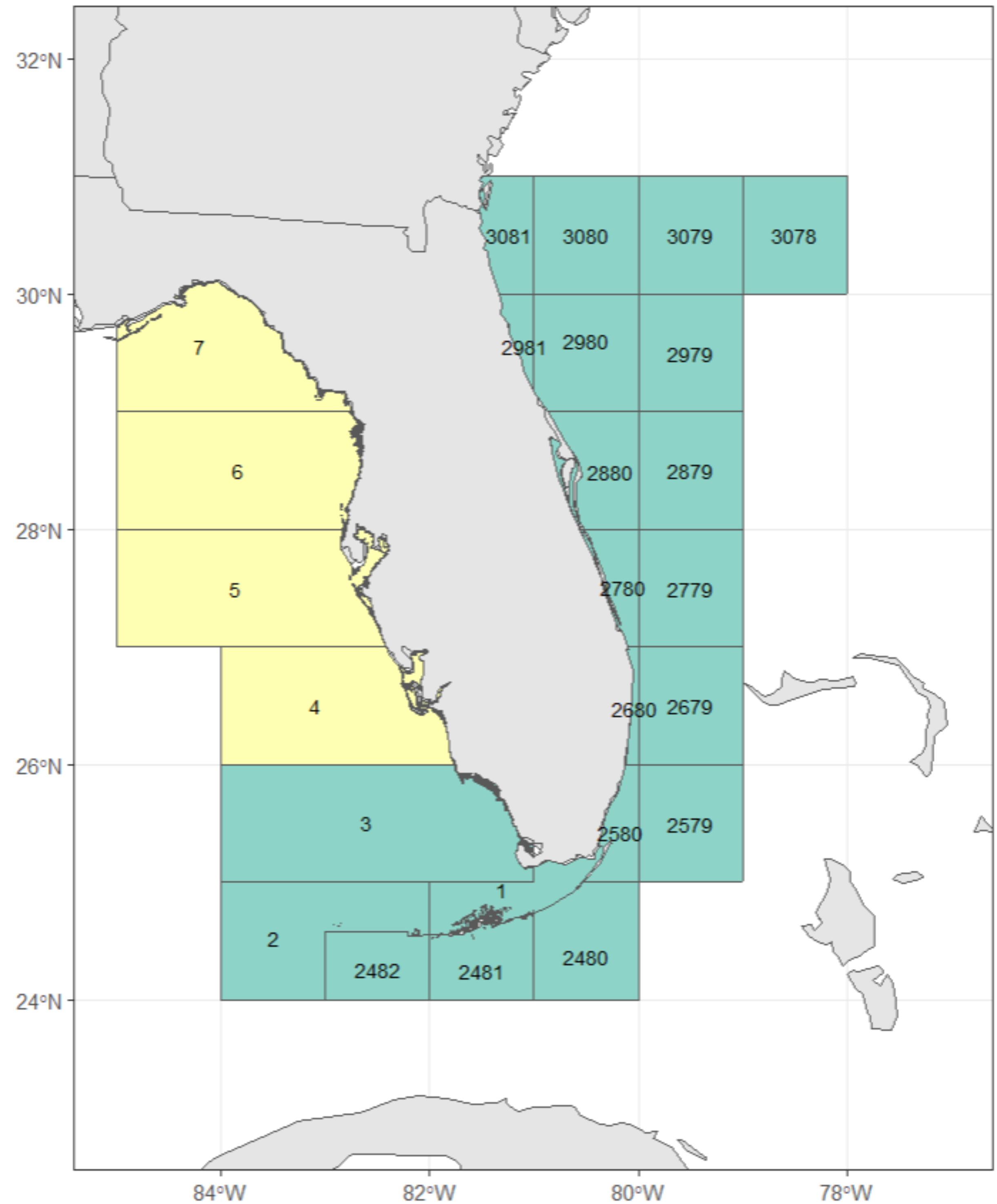


Figure 1. Map of statistical areas used in the **Keys-East Florida** (Green), and the **West Florida** (Yellow) Commercial Dive Indices.

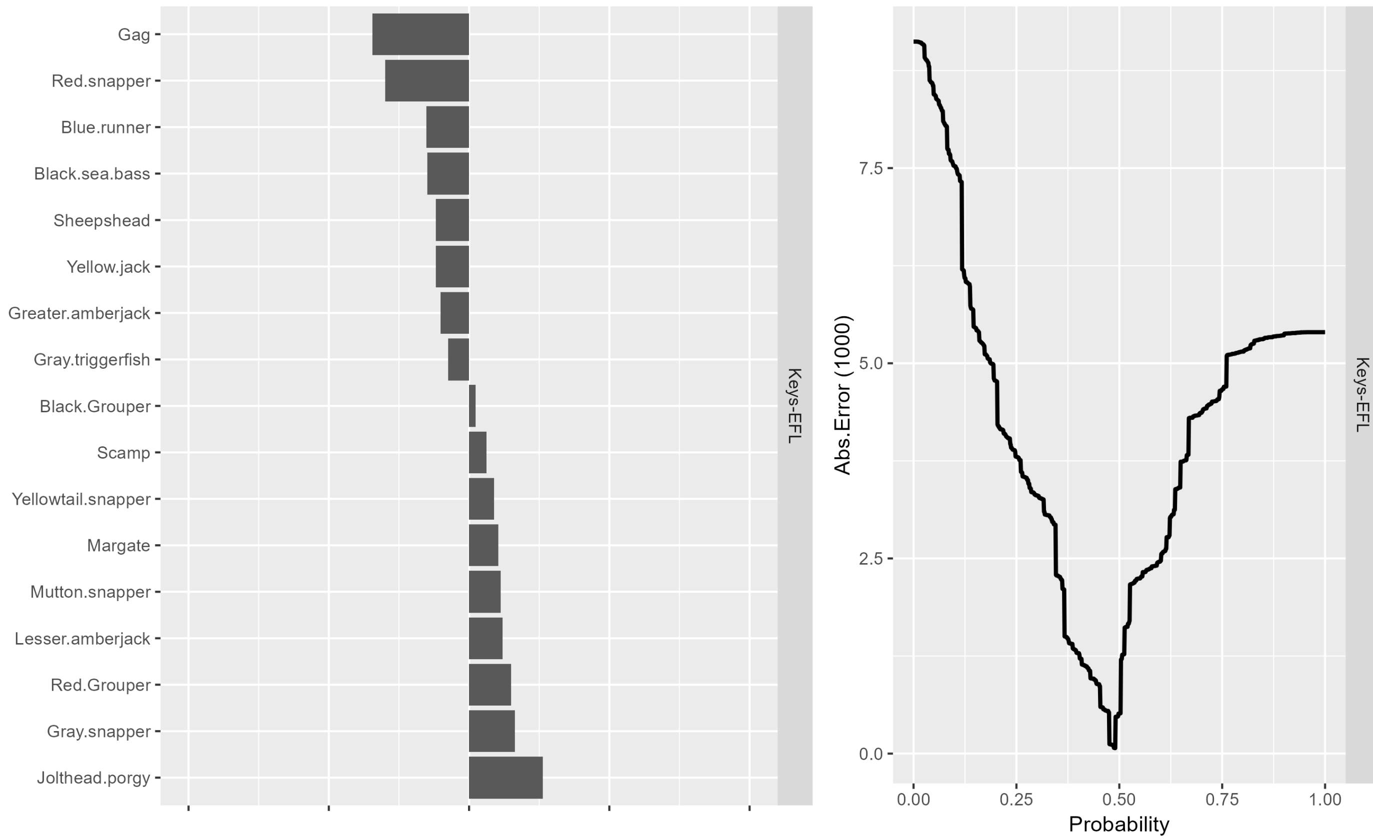


Figure 2. Estimates of species-specific regression coefficients used to predict each trip's probability of catching the focal species for the **Keys-East Florida** (Keys-EFL) dive fishery on the left panel. The right panel shows the absolute difference between observed and predicted number of positive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

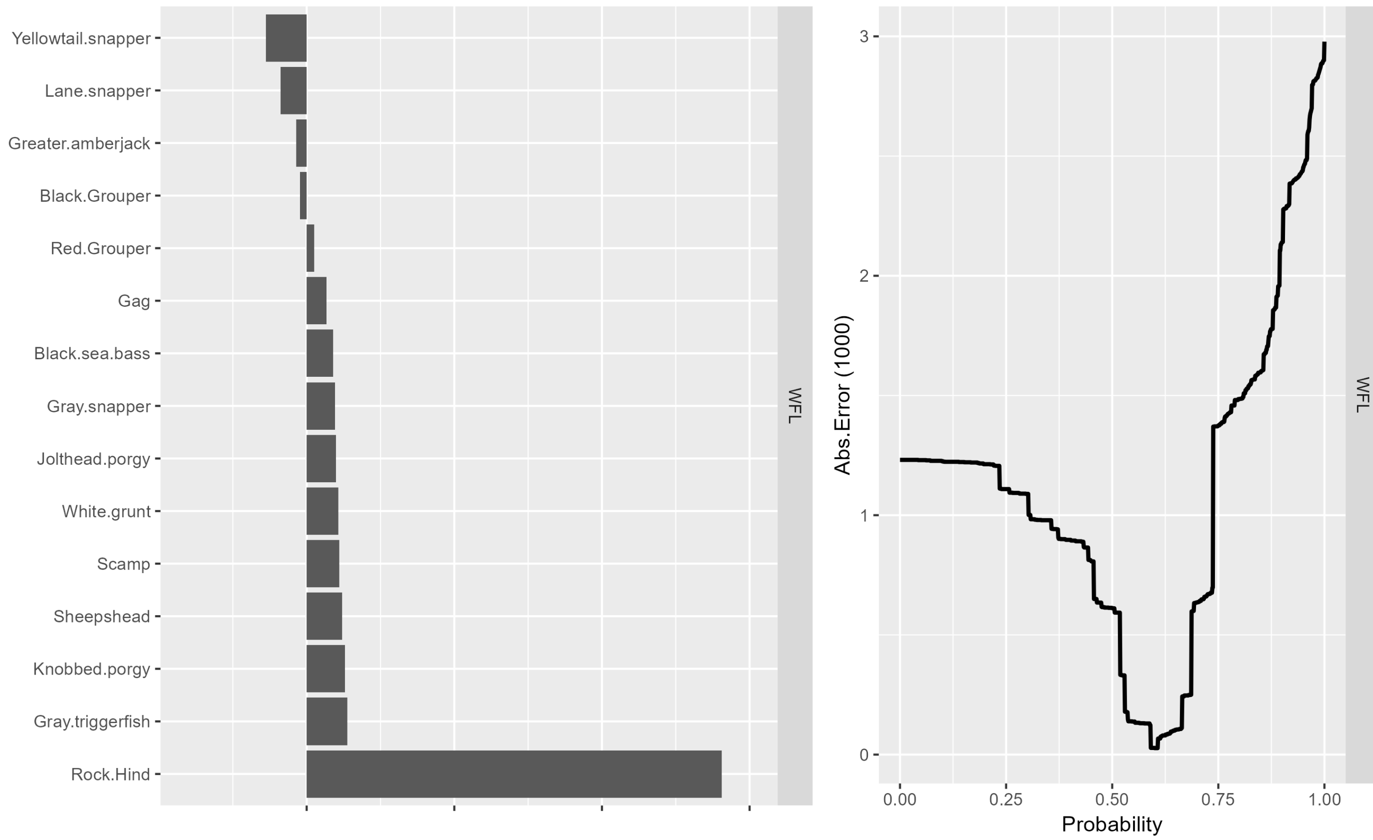
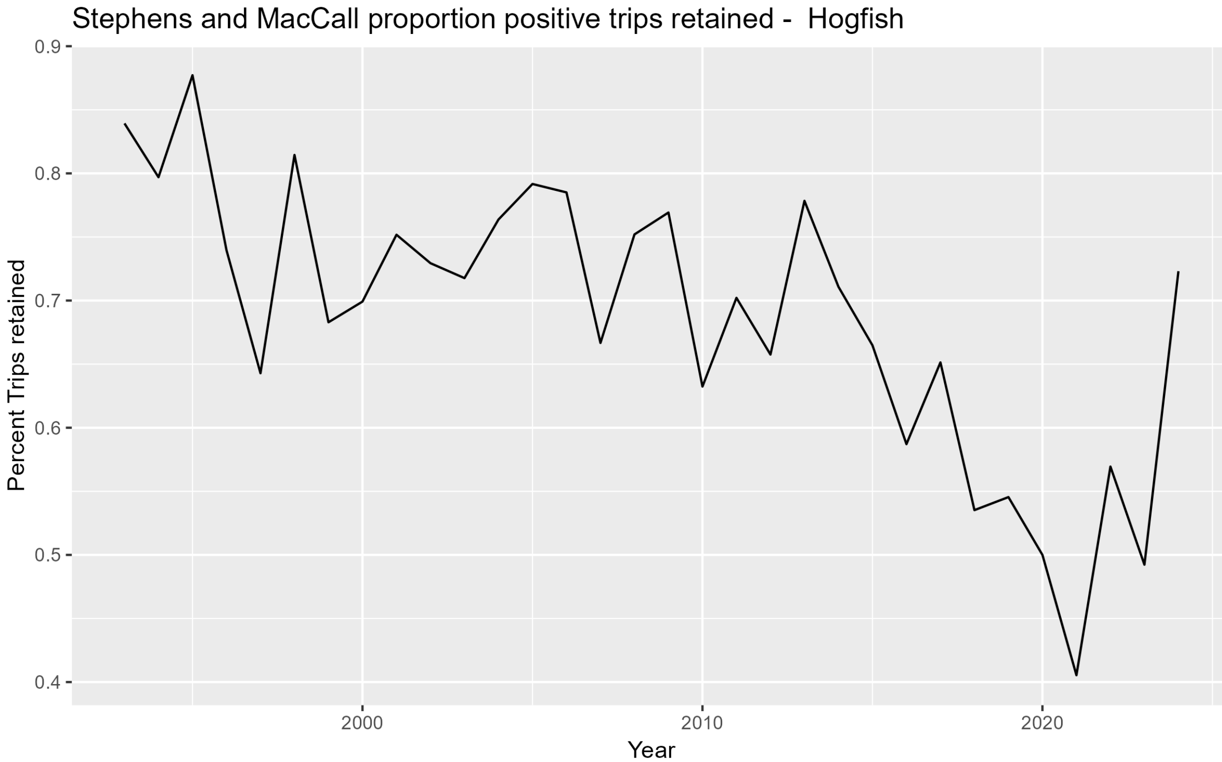


Figure 3. Estimates of species-specific regression coefficients used to predict each trip's probability of catching the focal species for the **West Florida** (WFL) dive fishery on the left panel. The right panel shows the absolute difference between observed and predicted number of positive trips across a range of probability cutoff values.

Figure 4. **Keys-East Florida** commercial dive positive and zero trips retained after subsetting using Stephens and MacCall approach by year for Hogfish.

Figure 5. **West Florida** commercial dive positive and zero trips retained after subsetting using Stephens and MacCall approach by year for Hogfish.



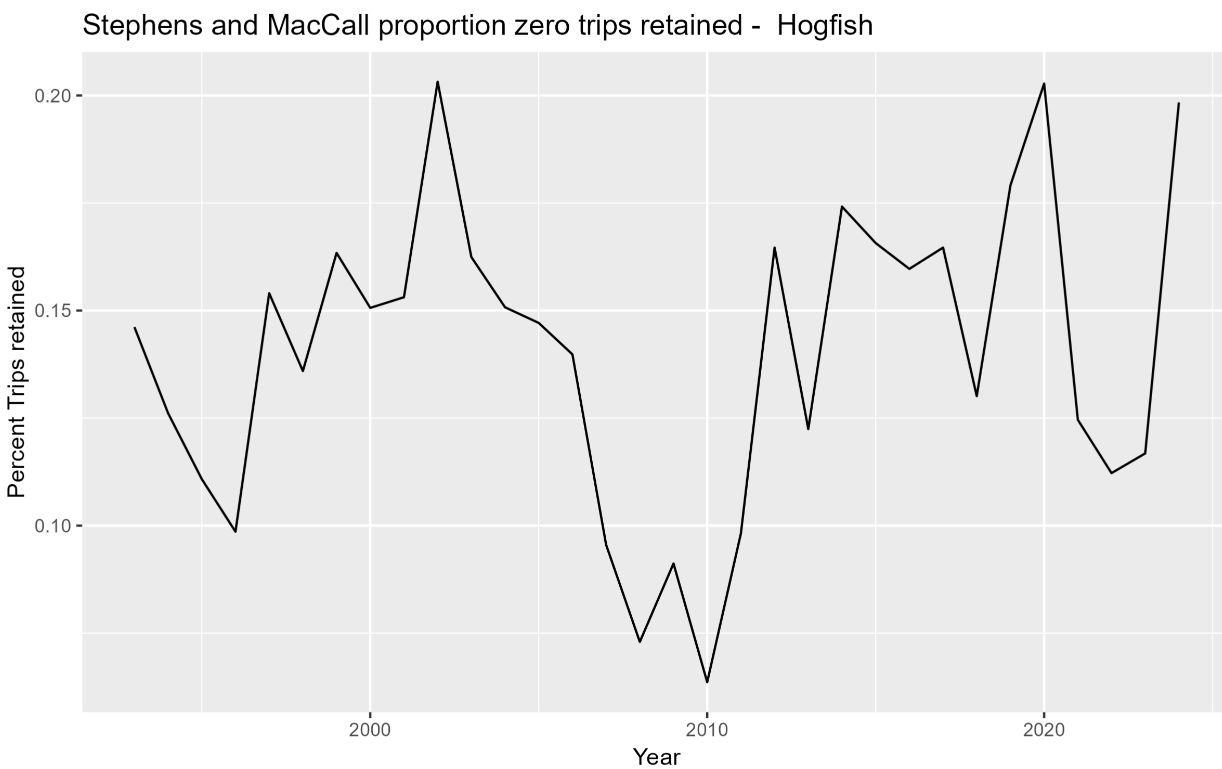
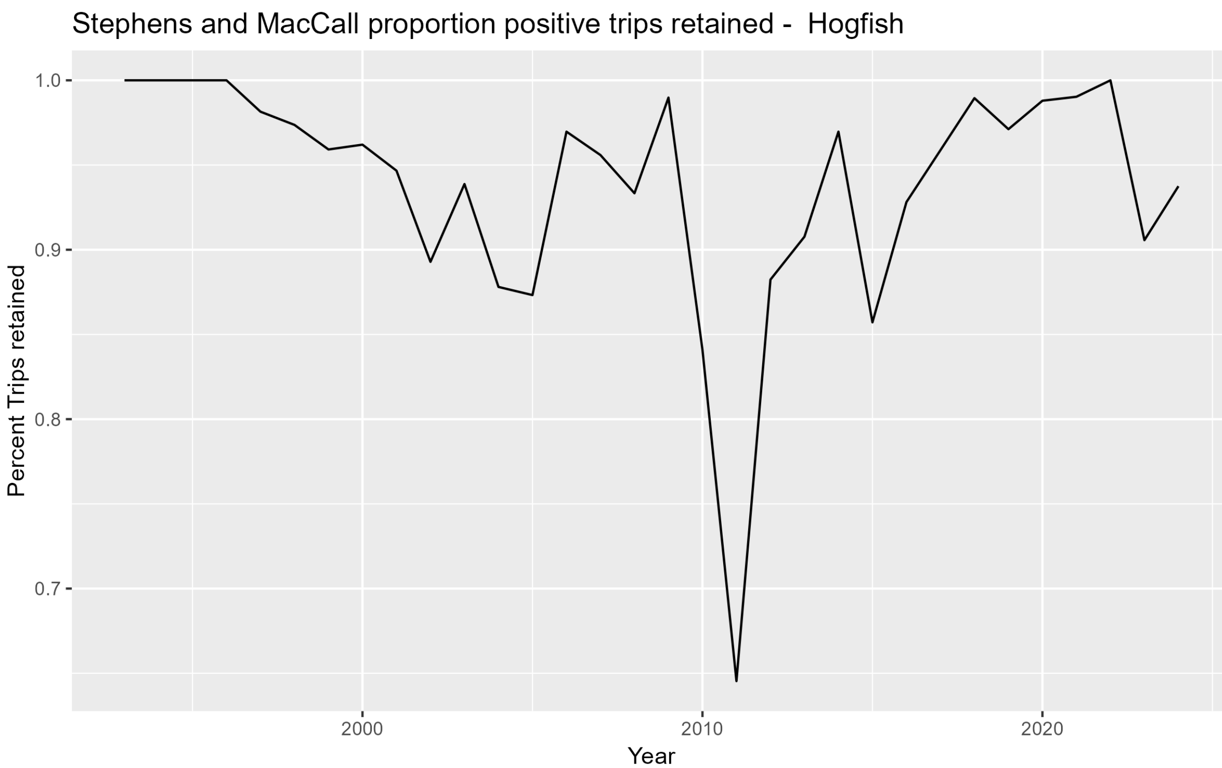


Figure 6. Proportion of positive (top) and zero (bottom) commercial dive trips retained by year after subsetting using Stephens and MacCall approach for the **Keys-East Florida** region.



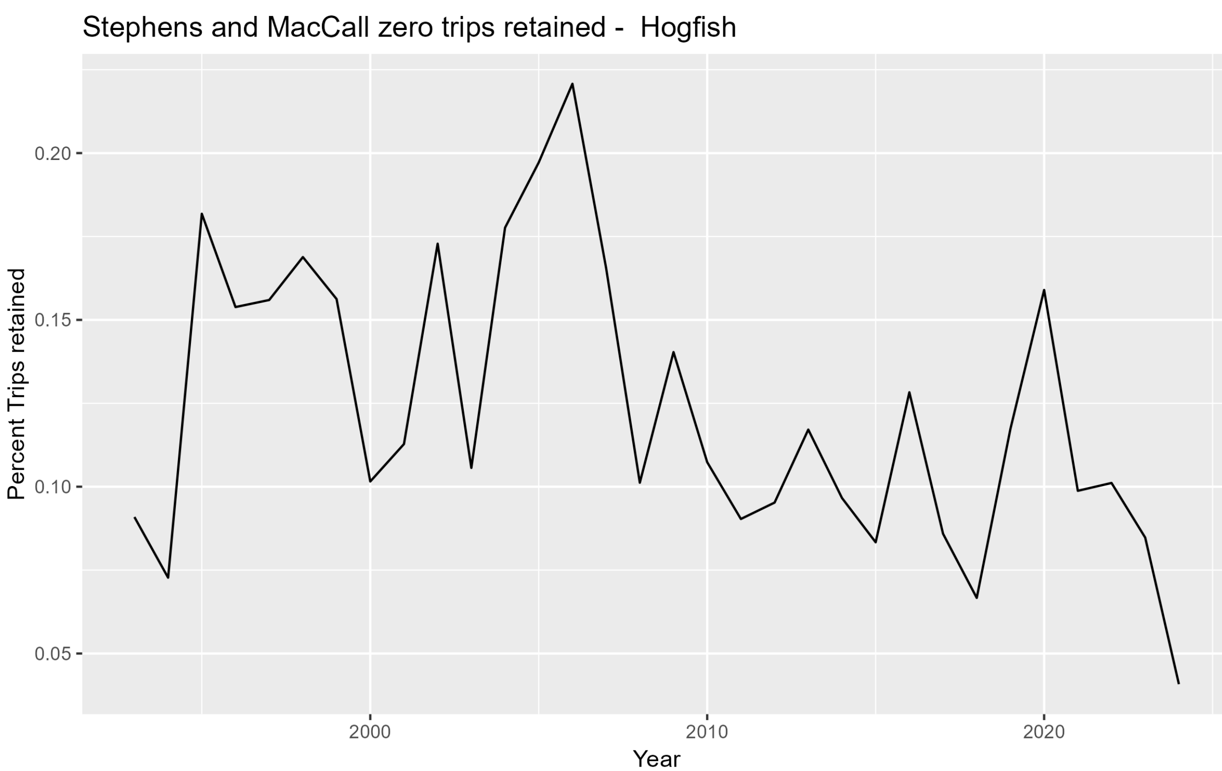


Figure 7. Proportion of positive (top) and zero (bottom) commercial dive trips retained by year after subsetting using Stephens and MacCall approach for the **West Florida** region.

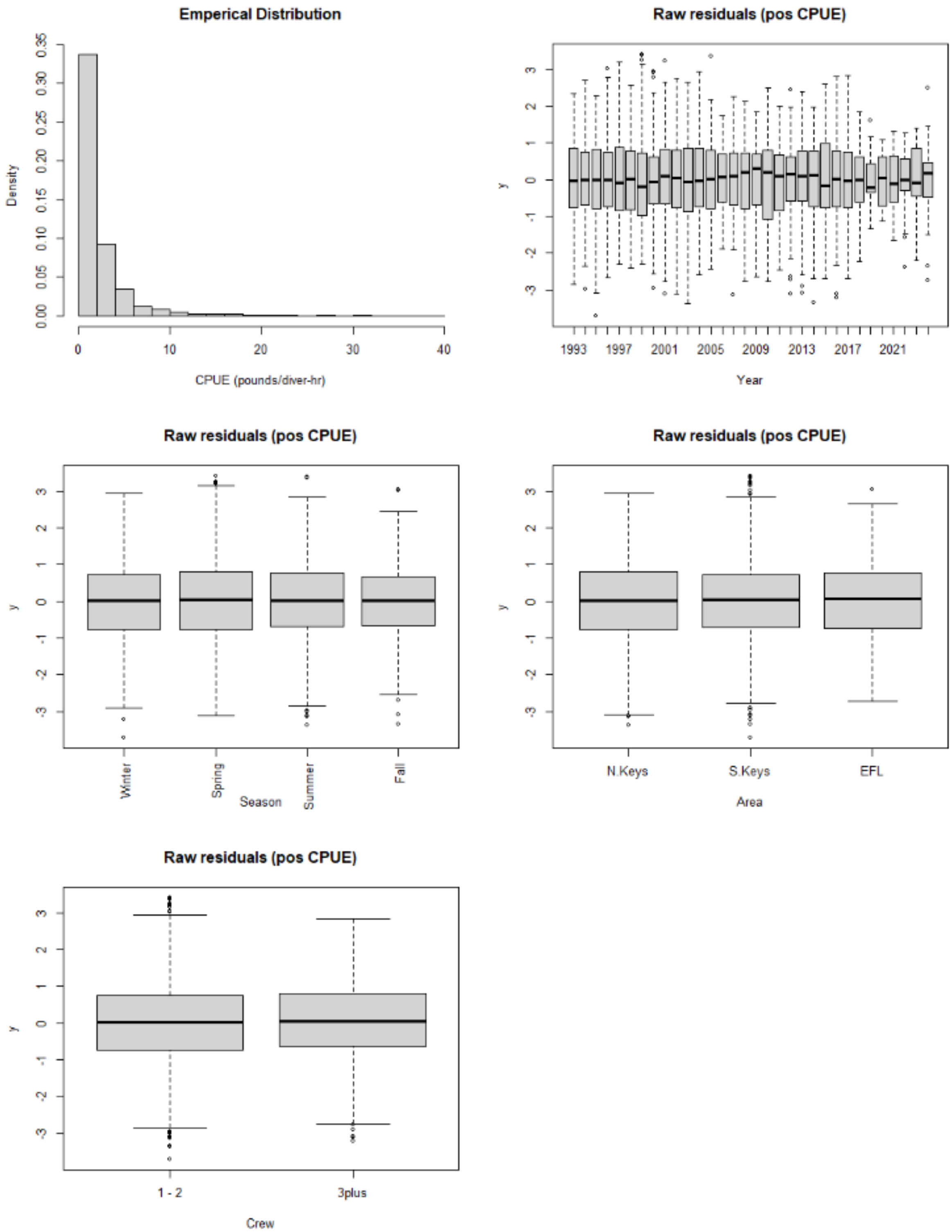


Figure 8. **Keys-East Florida** dive index diagnostics of lognormal submodel fits to positive CPUE data. Top left panel shows the distribution of positive cpue. Box and whisker plots give first, second (median) and third quartiles, as well as limbs that extend to approximately one interquartile range beyond the nearest quartile, and outliers (circles) beyond the limbs. Residuals are raw.

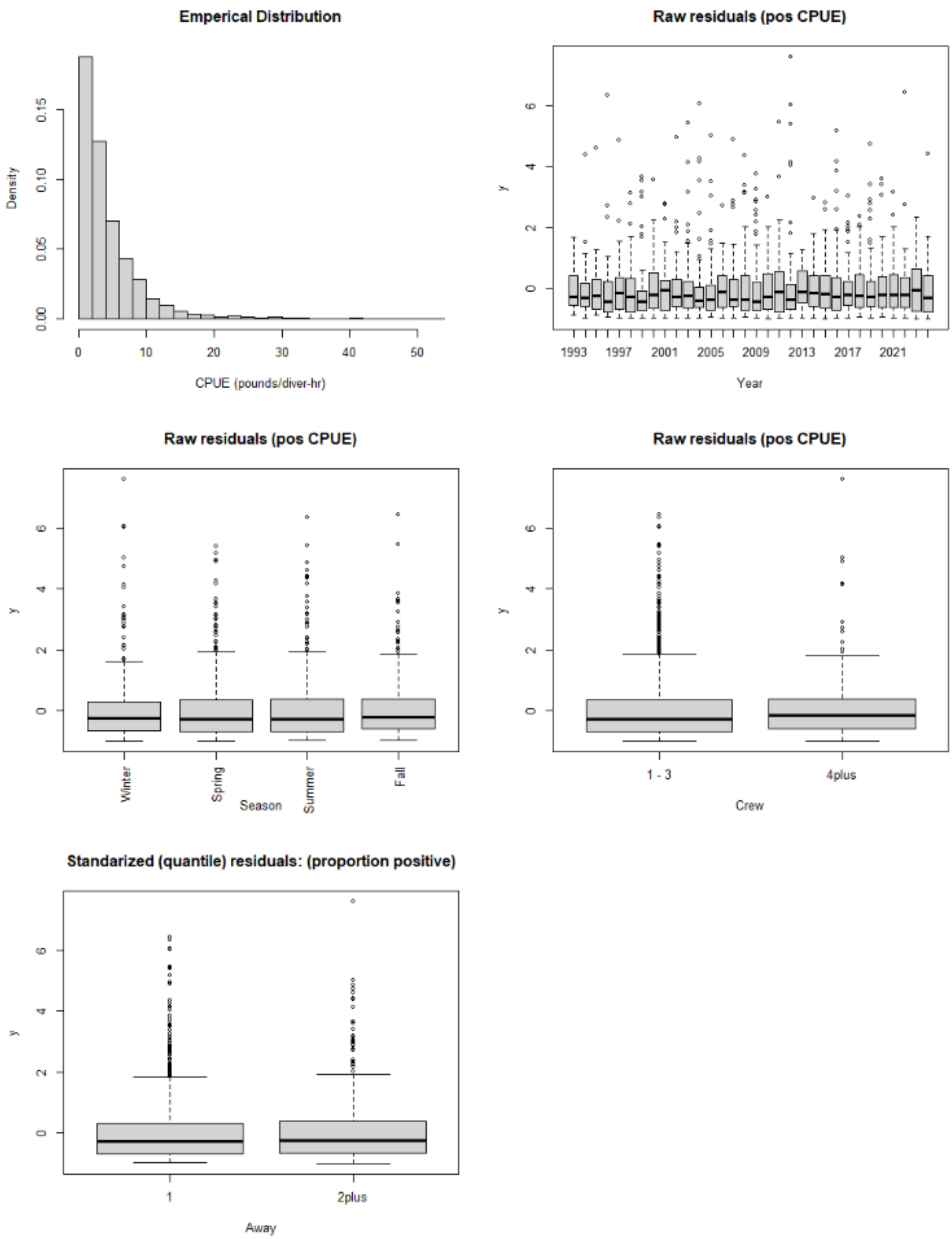


Figure 9. **West Florida** dive index diagnostics of gamma submodel fits to positive CPUE data. Top left panel shows the distribution of positive cpue. Box and whisker plots give first, second (median) and third quartiles, as well as limbs that extend to approximately one interquartile range beyond the nearest quartile, and outliers (circles) beyond the limbs. Residuals are raw.

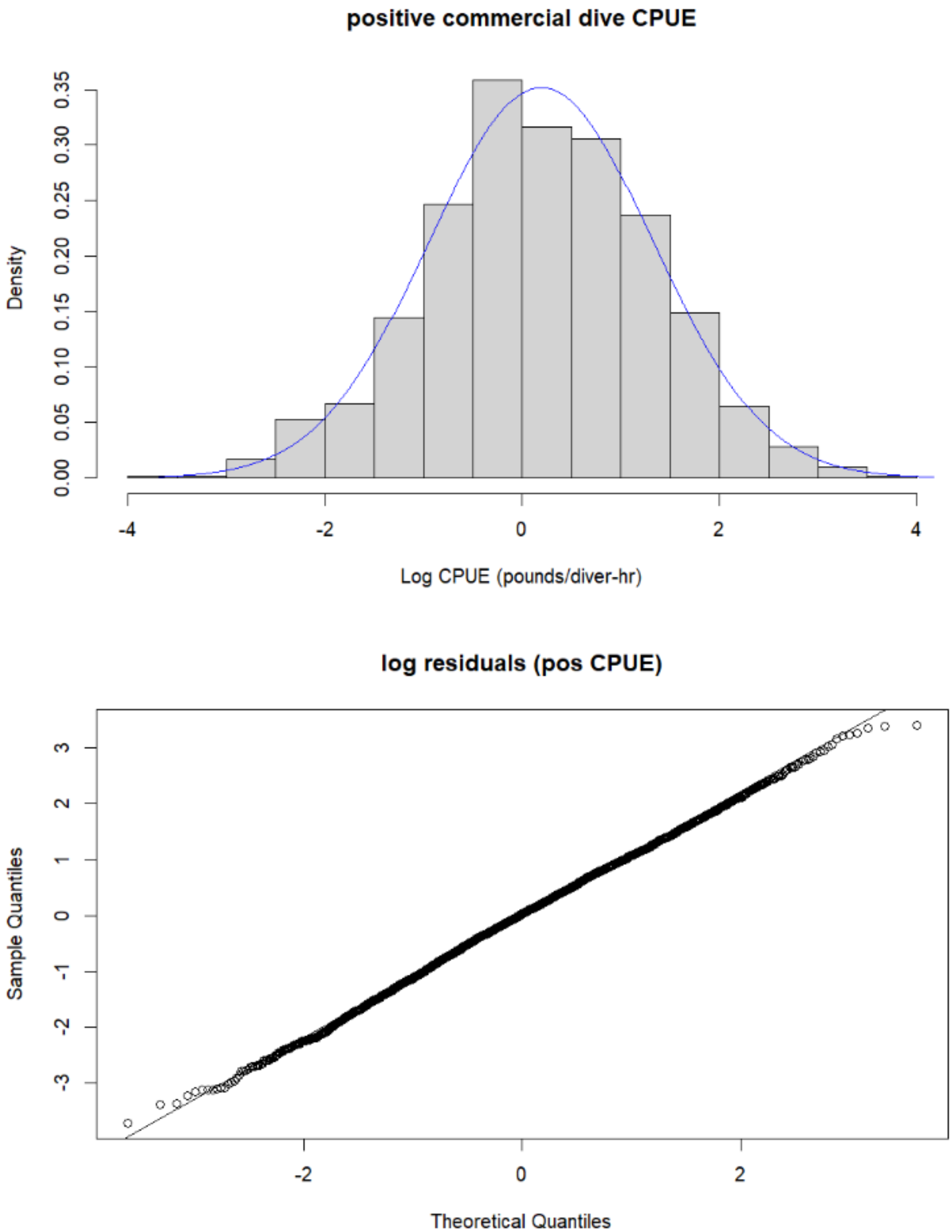
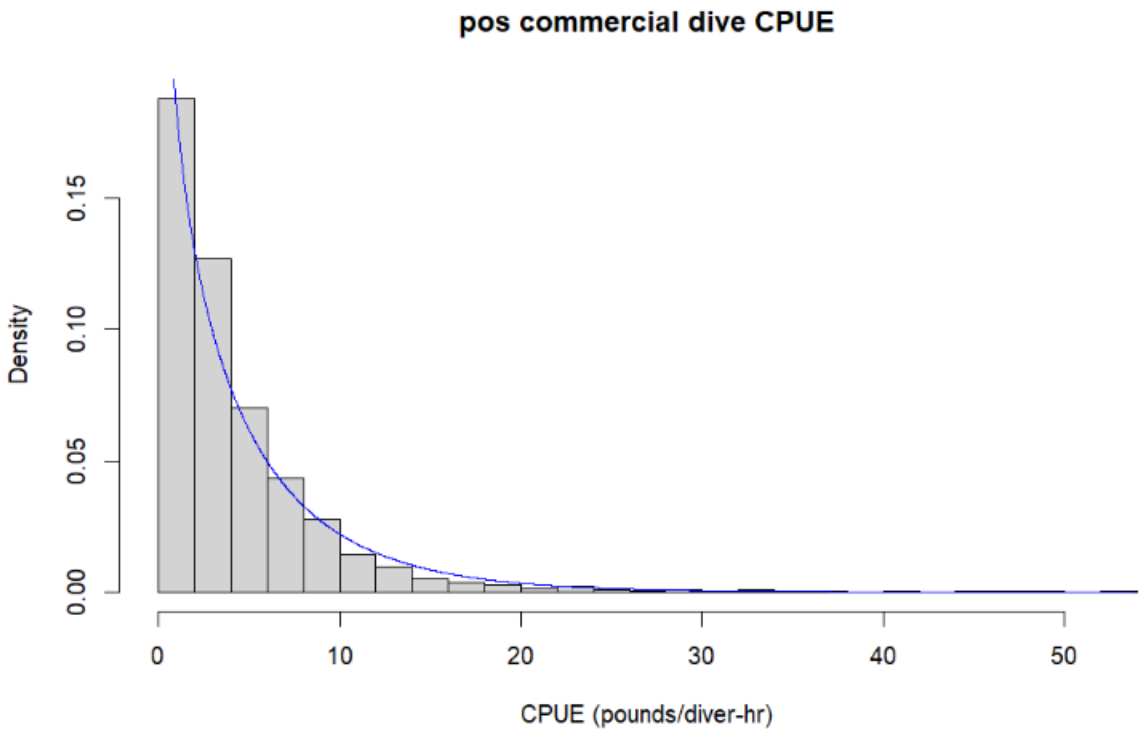


Figure 10. Histogram of empirical log CPUE for the **Keys-East Florida** dive trips, with the lognormal distribution overlaid (top) and the quantile-quantile plot of residuals from the fitted lognormal submodel to the positive cpue catch (bottom).



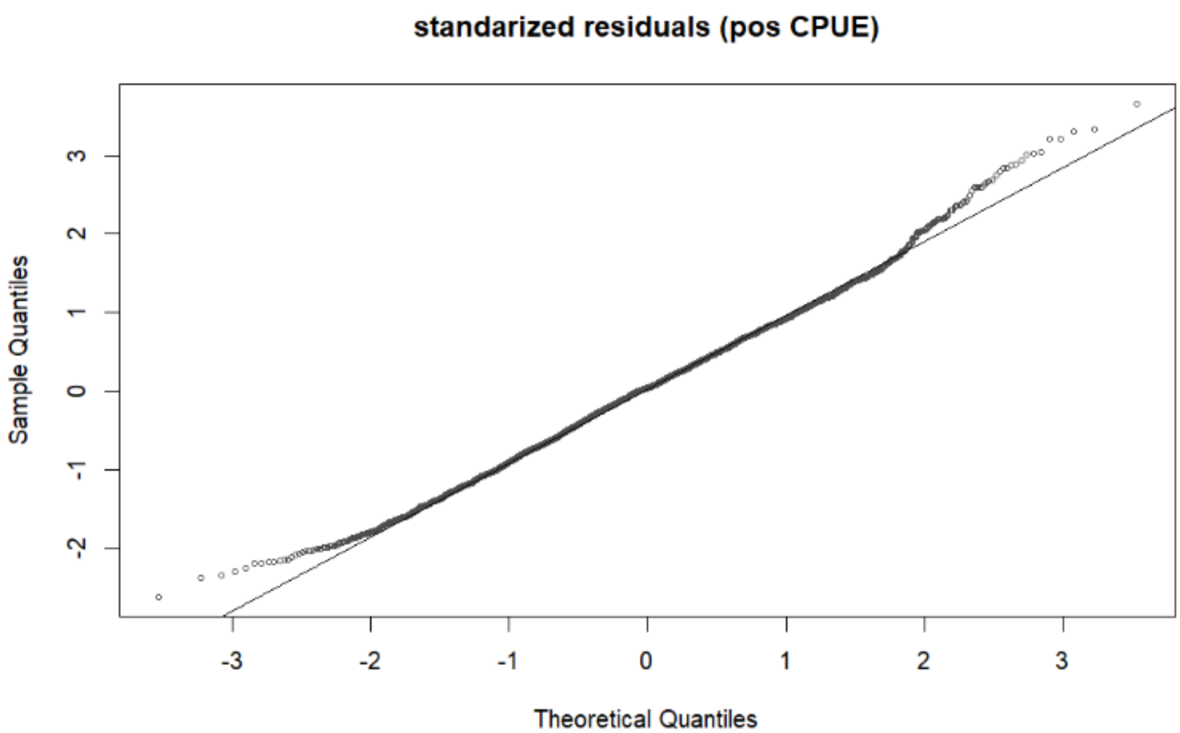


Figure 11. Histogram of empirical CPUE for the **West Florida** dive trips, with the gamma distribution overlaid (top) and the quantile-quantile plot of residuals from the fitted gamma submodel to the positive cpue catch (bottom).

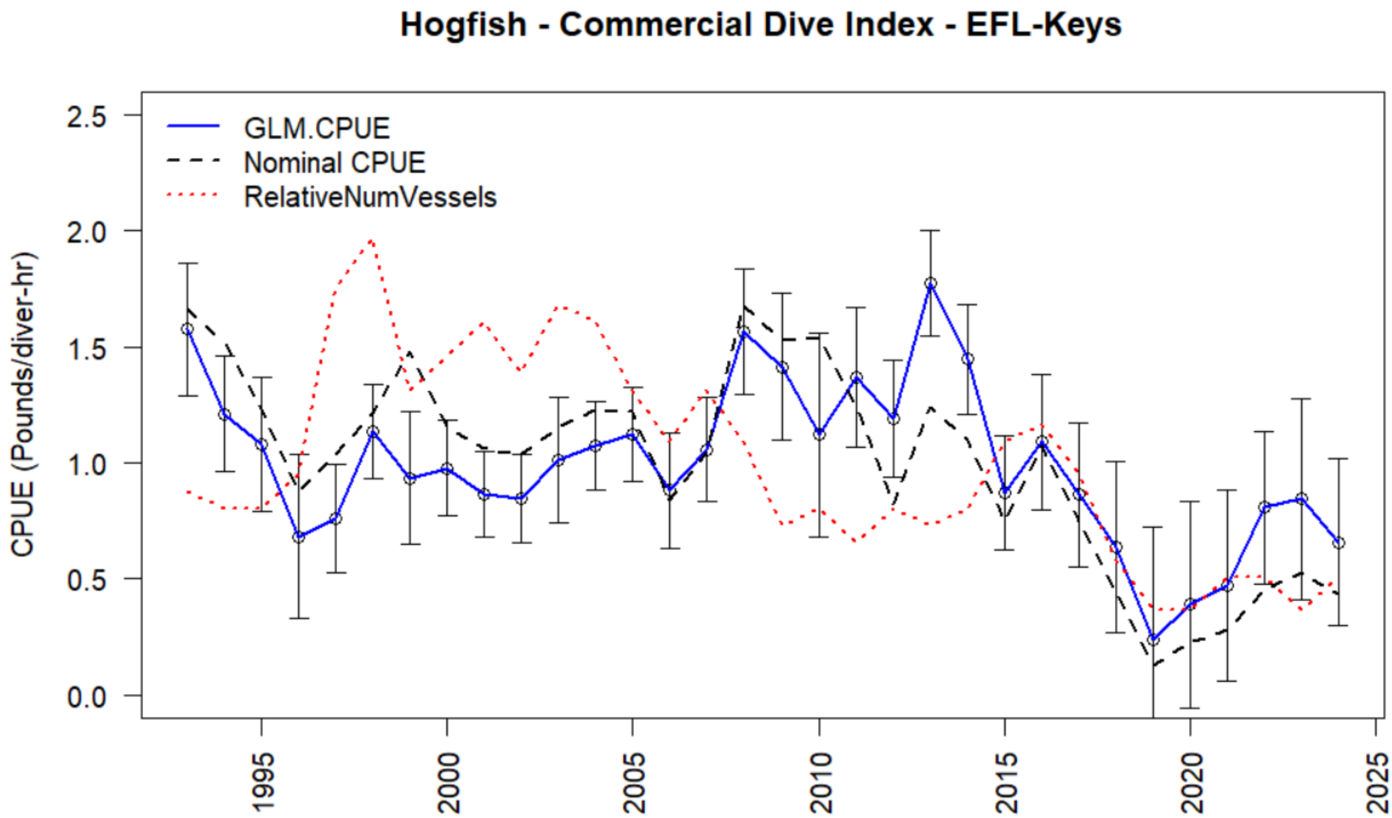


Figure 12. Standardized index of abundance for the **Keys-East Florida** Hogfish commercial dive fleet with nominal index and relative number of vessels in the fishery by year.

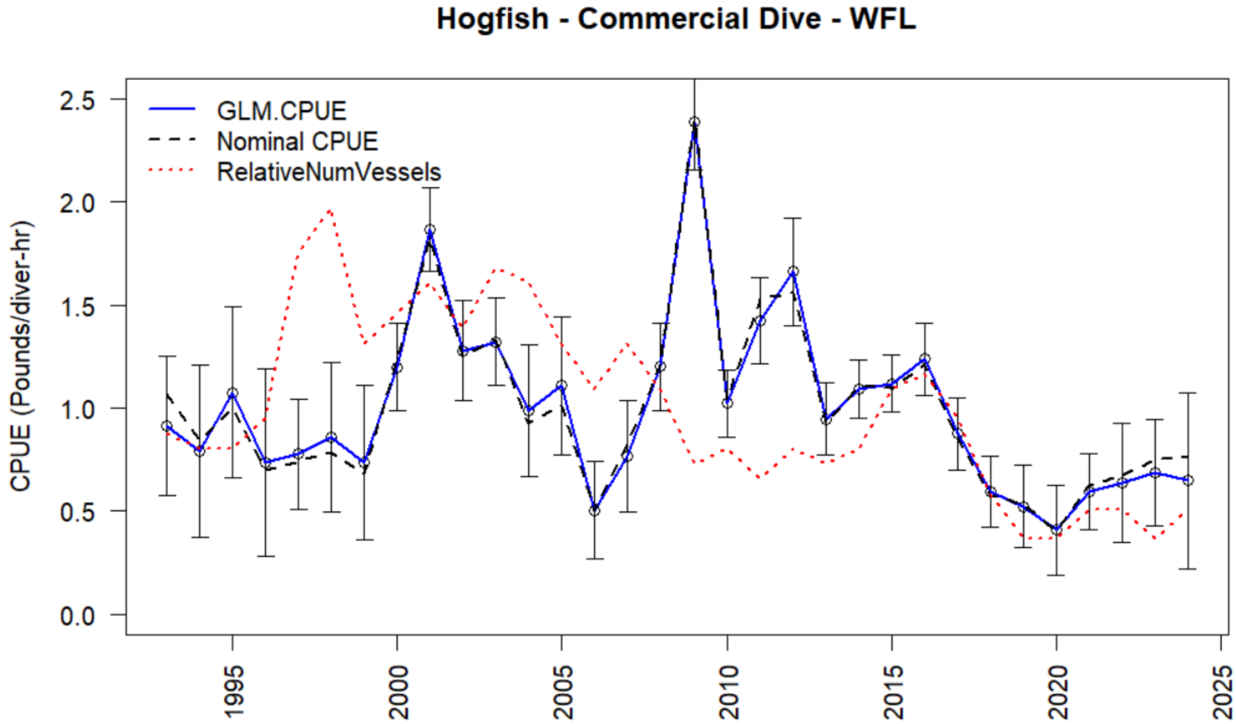


Figure 13. Standardized index of abundance for the **West Florida** Hogfish commercial dive fleet with nominal index and relative number of vessels in the fishery by year.

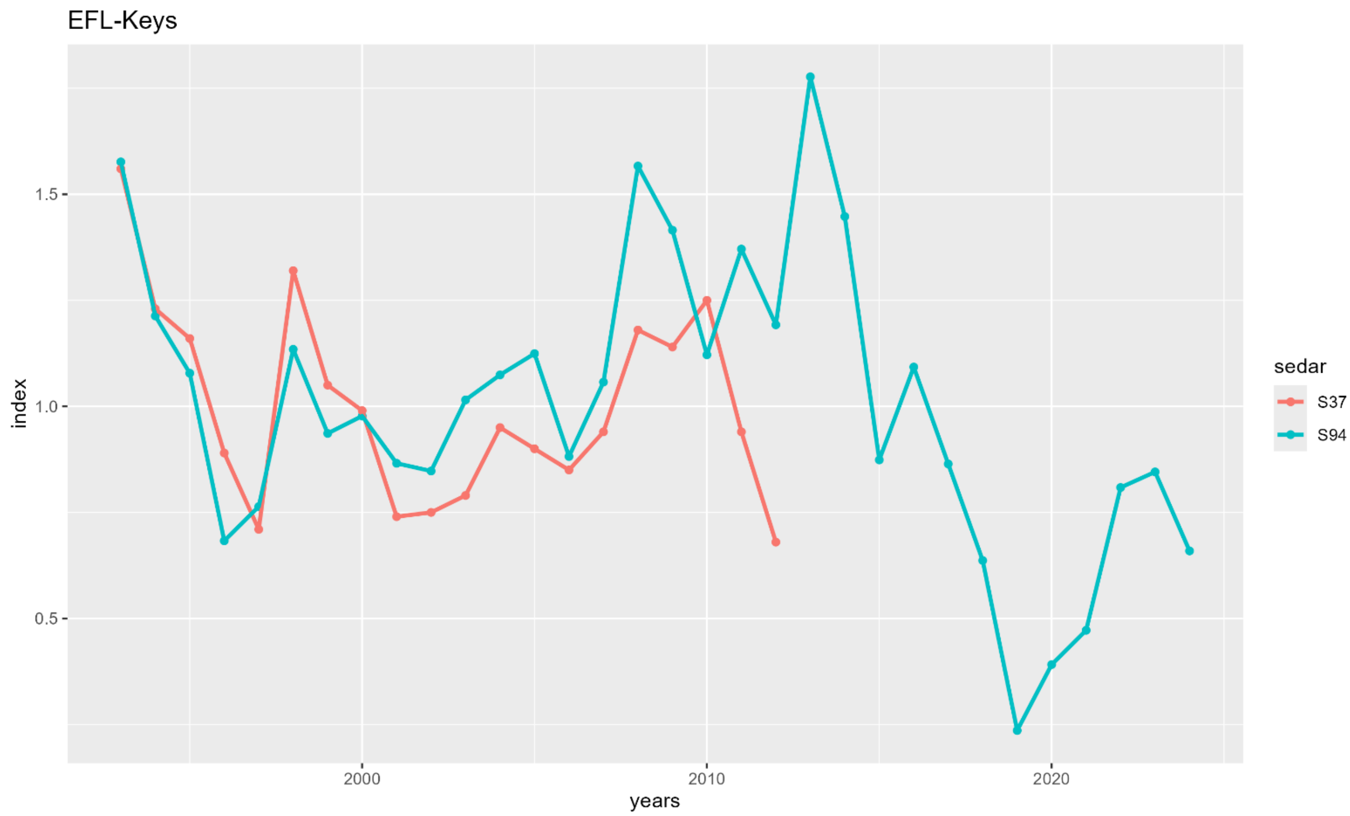


Figure 14. Comparison of SEDAR 94 Hogfish **Keys-East Florida** commercial dive index (S94) to the standardized index values reported in SEDAR 37 (S37).

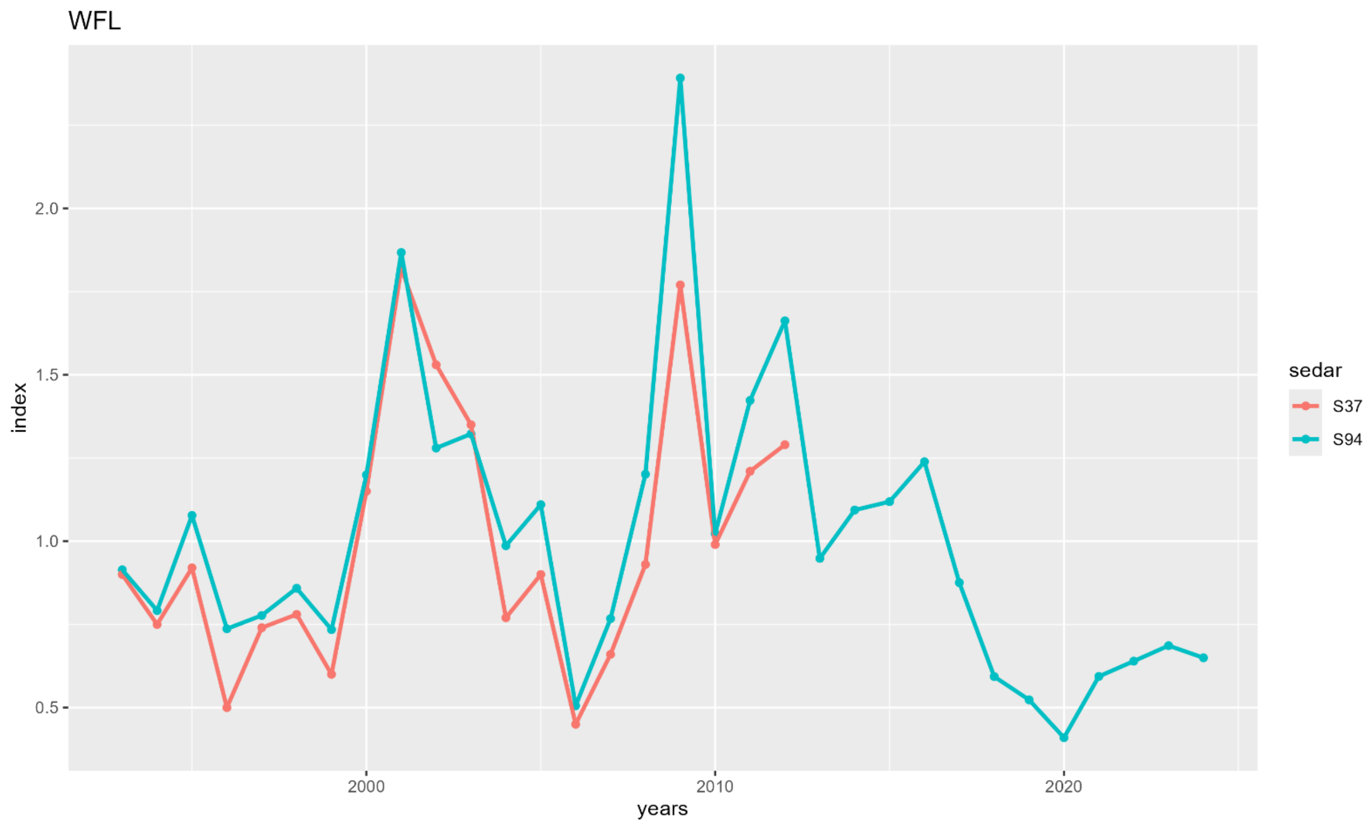


Figure 15. Comparison of SEDAR 94 Hogfish **West Florida** commercial dive index (S94) to the standardized index values reported in SEDAR 37 (S37).