Standardized Catch Rates of Hogfish (*Lachnolaimus maximus*) from the Marine Recreational Information Program (MRIP) for West Florida and the Keys-East Florida, 1991-2024

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Standardized Catch Rates of Hogfish (*Lachnolaimus maximus*) from the Marine Recreational Information Program (MRIP) for West Florida and the Keys-East Florida, 1991-2024

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Introduction

The Marine Recreational Fisheries Statistics Survey (MRFSS) was initiated in 1981 to collect catch, effort, and participation estimates from the recreational sector. MRFSS consisted of a telephone survey of fishing effort and an access point angler intercept survey (APAIS) of angler catch. Intercepts are conducted at public marine fishing access points (boat ramps, piers, beaches, marinas, etc.) to collect individual catch data including number of each species landed (i.e., harvested), number discarded, length, and weight. Access points are selected by a proportional random selection process in order to sample high activity sites most often. From these intercept data, the number of fish harvested or caught (fish harvested and released) per trip can be calculated for each species encountered. These catch rates can provide an indication of population trends over time and are combined with the effort estimates from the telephone survey to produce total catch and harvest estimates.

In 1991, MRFSS made several improvements to the survey and one of which was the linking together of separate intercepts of anglers that fished on the same trip and recording the total number of anglers in the party. Then in 2008, the Marine Recreational Information Program (MRIP) officially replaced MRFSS as a more precise and accurate method for estimating recreational catch and effort. In 2013, the APAIS was implemented to remove bias from the sampling process and in 2015 the Fishing Effort Survey (FES, a mail survey) was launched to improve estimates for those fishing via the private boat and shore effort modes. Lastly in 2018, the MRIP data were re-calibrated to account for the transition away from the Coastal Household Telephone Survey (CHTS) towards the new FES. The calibration model was peer reviewed by reviewers appointed by the Center for Independent Experts (https://www.fisheries.noaa.gov/event/fishing-effort-survey-calibration-model-peer-review).

Catch rates of hogfish from publicly available APAIS data (https://www.fisheries.noaa.gov/recreational-fishing-data/recreational-fishing-data-downloads are standardized using the following methods for the two primary hogfish stocks: West Florida (WFL) and Keys/East Florida (Keys-EFL). Publicly available MRIP data were used to construct standardized indices and to evaluate preliminary catch estimates by fishing mode and gear type. Standardized catch rates were generated by adding the trip catches (number landed plus released;

A + B1 + B2) after all forthcoming filtering and clustering steps had been applied to each area-specific dataset.

Area Descriptions

Standardized MRIP total catch rate (landings plus releases, CPUE) indices were generated for two regions as in SEDAR 37 (SEDAR37-03):

1. Keys/East Florida (Keys-EFL) – Counties: Indian River, Saint Lucie, Martin, Palm Beach, Broward, Miami-Dade, Monroe.
2. West Florida (WFL) – Counties: Franklin, Wakulla, Jefferson, Taylor, Dixie, Levy, Citrus, Hernando, Pasco, Hillsborough, Pinellas, Manatee, Sarasota, Charlotte, Lee, Collier.

Methods

Landings, Releases, and Retained Lengths

Prior to analyzing MRIP total catch per unit effort (CPUE), preliminary hogfish landings and releases (in numbers) compared among gears (hook and line [HL], spear [SP], and other [OT]) and fishing modes (charter [CH], private [PR], and shore [SH]) for each region. These comparisons help to guide the development of standardized indices.

In most years, the majority of removals occur in the Keys-EFL region (Figures 1 and 2). Landings from hook and line gear in WFL have generally increased through time, as have landings from spear until 2016, but spear landings decreased considerably after that time (Figure 1). Hook and line and spear landings in the Keys-EFL were of similar magnitudes, albeit highly variable, from 1981 – 2004. Landings from both gears declined from 1993 – 2001. Spear landings surpassed hook and line landings in the Keys-EFL region since 2005, but landings from both gear types have declined substantially since 2015 (Figure 1).

By fishing mode, charter and shore landings are minimal relative to private landings in both regions (Figure 2). However, charter mode releases in the WFL region are just slightly lower than private mode releases and both have increased since 2015. Shore mode releases in the Keys-EFL region are comparable or greater than private mode releases in some years, whereas charter releases in this region are negligible. Shore mode releases have generally been high since 2018 (Figure 2).

Sampled retained lengths aggregated across all years appear to be very similar among gears and fishing modes (Figures 3 and 4). Charter boats may encounter larger hogfish in the Keys-EFL compared to private and shore modes (Figure 4). However, sample sizes are too limited to make a strong determination.

Data Preparation and Filtering

Before identifying directed effort (i.e., hogfish trips) through species clustering, individual angler trips (identified by ID_CODE) are grouped by fishing party using PRT_CODE from 1991 to present. Some fishing parties were associated with multiple angler-trip characteristics (e.g., multiple fishing modes, counties fished, areas fished, number in fishing party). In these instances

(1,899 records), only the first non-NA value was used to characterize all angler-trips within a fishing party. If multiple gears were reported on a single trip, the first and second reported gear types were retained. Then, the MRIP angler-trip data was aggregated to trip-level data by summing landings and releases of each species, and then calculating the number of interviews, the number of contributors to the catch, median avidity (median number of days fished in the last two months), and median hours fished among anglers on the same trip.

Data were initially filtered following these steps:

1. Data in the Gulf of Mexico and South Atlantic were limited to interviews that took place in WFL and Keys-EFL during wave 1, 1991 through wave 6, 2024.
2. Interviews that reached bag limits for hogfish were retained.
3. Data were not adjusted to account for size limits or closed seasons.
4. 451 angler-trip records were removed with NA unadjusted catch
5. 878,319 angler-trip records were removed with 0 catch
6. There were few positive trips in inland waters (Table 1), therefore data from inland waters were removed.
7. Data from gears other than SPEAR and H&L were removed (Figure 1, Table 2).
8. For WFL (H&L and Spear) and Keys-EFL (Spear), shore mode was removed (Figure 2, Table 3).

Species Clustering

To interpret trends in relative abundance, directed hogfish trips must first be identified. Ideally, these trips have a positive chance of encountering a hogfish, regardless of whether a hogfish was encountered. They presumably occur in favorable hogfish habitat and during the time of day/year when hogfish are available, while using a gear that can successfully catch hogfish.

Without fine-scale spatial and temporal information on fishing locations and associated habitat, clustering methods are used to identify suite of co-occurring species to serve as a proxy for favorable hogfish conditions (Shertzer and Williams 2008). A structural zero would then be a trip that did not encounter a hogfish but did encounter a species within the hogfish cluster. A non-structural zero, which would be removed prior to developing a CPUE index, would be a trip that did not encounter a hogfish nor a species within the cluster.

To measure the association between species, first the data matrix of total catch has rows indicating species and columns indicating samples (or sites) and the similarity between any pair of species is measured (Clarke et al. 2014). Similarities between rare species have little meaning and including them may distort inferred patterns. Field et al. (1982) suggest retaining species that have at least an arbitrary percentage dominance at any one station that results in retaining around 50-60 species

Agglomerative hierarchical cluster analysis was performed with average linkage on the Bray-Curtis similarity measure applied to catch/abundance data for each species (i.e., total unadjusted catch [landed+released] of a species per trip). Several transformations (square root, fourth root) of catches were considered, as well as standardized catches (percent catch, percent square root, percent fourth root) as recommended by Clarke et al (2014). Species catches were standardized across species as a percentage of the total species catch (or the square or fourth root of catch) at all trips (i.e., if a species is found in only one trip, its standardized catch there is 100%). Standardizing catches account for the typically large overall abundance differences between species.

Then, a clustering algorithm is applied to a dendrogram (distance/dissimilarity matrix) to partition species into clusters. There are many clustering algorithms to choose from (see Ezugwu et al. 2022), however this analysis selects clusters based on maximizing the average silhouette widths using the *find_k* function within the dendextend package in R. In short, the larger the silhouette width is, the better the object is clustered. Negative values suggest that the corresponding objects may have been placed in the wrong cluster. In addition, an ordination method, nonmetric multidimensional scaling (NMDS), is used to confirm and visualize the separation of clusters.

CPUE Standardization

To standardize total catch per unit effort (CPUE) time series, trips were first removed if they did not encounter at least one of the species in the cluster. Trips were also removed if median hours fished, number of contributors, or median avidity were not available, and in addition if median hours fished exceeded 24 hours. Years with 3 or less positive or zero observations were removed so that year effects could be estimated for both the binomial and positive submodels.

CPUE was modeled using the delta-glm approach (Dick 2004; Lo et al. 1992; Maunder and Punt 2004). This approach calculates an index as the product of the indices from binomial (probability of catching a hogfish) and positive (trips that caught at least one hogfish) sub-models.

Seven explanatory variables were evaluated for the binomial model. These included:

Year – factor with levels 1981 to 2024 (not including years that were removed with 3 or less positive or zero observations).

Waters Fished – factor, two or three levels depending on the region (nearshore [area_x=1 or 3], offshore [area_x=2 or 4])

Median Hours Fished – median hours fished among anglers; factor (WFL H&L levels: [0.5-3], (3-4], (4 – 6], >6; WFL Spear levels: [0.5 – 1.19], (1.19 – 2], (2 – 4], > 4; Keys-EFL H&L levels: [0.5-3], (3-4], (4 – 6], >6; Keys-EFL Spear levels: [0.5-1.5], (1.5-3], (3-4], >4)

Median Avidity – median days fished in the last two months among anglers; factor (WFL H&L levels: 0-1, 2-5, 6+; WFL Spear levels: 0-2, 3-5, 6-8, 9+; Keys-EFL H&L levels: 0-3, 4-8, 9+; Keys-EFL Spear levels: 0-3, 4-6, 7-10, 11+)

Contributors – the number of contributors to the total catch of the entire trip; factor (WFL H&L levels: 1, 2, 3, 4+; Keys-EFL levels: 1, 2, 3+)

Fishing Mode – mode of fishing; factor (WFL levels: Charter, Private; Keys-EFL Spear levels: Charter, Private; Keys-EFL H&L levels: Shore, Charter, Private)

Season – factor with two levels; Summer (including waves 3-5 or months May-October) and Other (including waves 6-2 or months November-April)

Positive log(CPUE) of hogfish was modeled as a normal distribution. To normalize and reduce patterns in residuals, CPUE was defined as the log of the average number of hogfish caught per contributor (number of hogfish caught per trip [A+B1+B2] divided by the number of contributors to the catch). Several other CPUE definitions and error distributions were explored (e.g., negative binomial, delta Poisson, delta gamma) but diagnostic plots indicated poor fits to the data. The explanatory variables considered for the positive model were the same as those considered for the binomial model, less the number of contributors to the catch. Sample size tables were produced with the number of positive trips per year for each level of each covariate. Additionally, interaction terms with year were graphically explored.

The stats::glm package in R was used to produce positive and binomial sub-models. For both the positive and binomial sub-models, explanatory variables were selected using stepwise forward selection based a reduction in mean deviance by at least 0.5% (via the step function and a custom function in R). The goal of stepwise selection is to produce a model (overall model) that contains the optimal combination of explanatory variables (which explain a significant amount of variation in the response variable) while also being most parsimonious. Stepwise forward selection starts with a null model that includes only an intercept term. At the first step, additional covariates are added to a null model so that there are *n* unique models (n = number of covariates). The lowest deviance of the unique models is compared to that of the null model; if it is lower than the deviance of the null model by at least 0.5% the unique model becomes the new base model. This process repeats itself until no additional covariate sufficiently reduces the deviance.

Index Generation and Evaluation

Confidence intervals and annual means were estimated by simulating the distribution of the predicted means using 10,000 randomly generated residuals; each residual was a random normal deviate times the standard error for its predicted mean which was then added to the least squared means for the year factor in either log scale (for the positive model) or the logit scale (for the binomial model). Lastly, these estimates were back-transformed and multiplied together to estimate a distribution of the number per contributor and the distribution was described in terms of percentiles and a mean. This method allows for the transformation of the response variable from log space back to CPUE without applying an approximate bias correction.

Results

Species Clustering

WFL - H&L (Charter/Private, Nearshore/Offshore)

Prior to running the cluster analysis, rare species that made up less than 1% of trips were removed, retaining 48 species which is near the recommended range of 50-60 species. For West Florida H&L, hogfish is clustered with **littlehead porgy, porgy family, puffer family, and remora family** using the percent fourth root of total catch (Figure 5). This transformation results in the highest silhouette width for hogfish (0.06, overall average silhouette width for the cluster = 0.03). For SEDAR 37, hogfish was clustered with knobbed porgy, littlehead porgy, lane snapper, tomtate, and vermillion snapper.

For many species, the nonmetric multidimensional scaling (NMDS) using the percent fourth root of total catch generally agrees with the cluster results, but puffer and remora family are farther away from the rest of the cluster, suggesting these species could be removed (Figure 6).

The proportion of trips that encountered each species in the cluster is generally very low relative to all other species but has increased since 2010 (Figure 7). Similarly, the number of trips that encountered each species in the cluster has increased for all clustered species since 2010 (Figure 8).

WFL - Spear (Charter/Private, Nearshore/Offshore)

For WFL spear trips, rare species that made up less than 0.25% were removed, resulting in the retention of 62 species. Hogfish is clustered with **gag, gray snapper, red grouper, and white grunt** when taking the fourth root of raw abundance (Figure 9). This transformation results in the highest silhouette width for hogfish (0.282, overall average silhouette width for the cluster = 0.235). The nonmetric multidimensional scaling (NMDS) using the fourth root of total catch aligns well with the cluster results (Figure 10). Hogfish in WFL spear trips was clustered with cobia, gag, gray snapper, greater amberjack, pinfish, and Spanish mackerel in SEDAR 37.

Unlike the WFL H&L cluster, the proportion of angler-trips that encountered species in the WFL Spear cluster generally make up at least 75% of trips (Figure 11). However, some species, such as white grunt and red grouper have declined or are absent in recent years. The number of trips that encountered each species in the cluster has declined considerably since 2016 but so has the overall number of trips (Figure 12). This may suggest that either sampling effort or spear fishing effort in the WFL region has decreased since 2016.

WFL – H&L and Spear (Charter/Private, Nearshore/Offshore)

For WFL H&L and spear trips, species that made up less than 0.1% were removed, retaining 48 species. As with WFL H&L trips, hogfish is clustered with **littlehead porgy, porgy family, puffer family,** and **remora family** using the percent fourth root of total catch (Figure 13). This transformation results in the highest silhouette width for hogfish (0.037, overall average silhouette width for the cluster = 0.022). NMDS lends some support for this hogfish

cluster, however puffer family and remora family are farther from the rest of the group (Figure 14).

Similar to the results for the WFL H&L fishery, the hogfish cluster accounts for a very small proportion of trips (Figure 15), however the number of trips encountering species in the hogfish cluster has increased since 2010 (Figure 16).

Keys-EFL - Hook and Line (Charter/Private/Shore, Nearshore/Offshore)

For Keys-EFL H&L trips, rare species were removed that comprised at most 1% of trips, but hogfish had to be manually added, resulting in a total of 55 species. Hogfish is clustered with **porgy family** and **yellow jack** when taking the percent fourth root of abundance (Figure 17). This transformation results in the highest silhouette width for hogfish (0.045, overall average silhouette width for the cluster = 0.031). NMDS, on the other hand, suggests that yellow jack is not clustered with hogfish and that seabass family may be (Figure 18). The species clustered with hogfish for SEDAR 37 were African pompano, bar jack, knobbed porgy, and whitebone porgy.

The proportion of angler-trips that encountered species in the Keys-EFL H&L cluster is minimal compared to all other species but has increased since 2012 (Figure 19). The increase has primarily been driven by more trips encountering yellow jack. Likewise, the number of angler-trips that encountered porgy family and yellow jack has increased through time, while the number of trips encountering hogfish have remained stable (Figure 20).

Keys-EFL – Spear (Charter/Private, Nearshore/Offshore)

For Keys-EFL Spear trips, limiting the species that make up at least 0.5% of trips retained 45 species which is near the recommended range of around 50-60 species. Hogfish were then clustered with **black grouper, gray snapper, great barracuda, mutton snapper, red grouper,** and **yellow jack** when taking the percent of fourth root abundance (Figure 21). This transformation results in the highest silhouette width for the hogfish cluster (0.071, overall average silhouette width for hogfish = 0.0.074). Also, the NMDS analysis supports these cluster results (Figure 22). For SEDAR 37, hogfish were clustered with black grouper, black margate, and crevalle jack.

The proportion of trips that encountered hogfish declined in 2017 and remained relatively low through 2024 (Figure 23). Alternatively, the proportion of trips that encountered yellow jack and great barracuda have increased in recent years. The total number of angler trips spear fishing in the Keys-EFL region generally increased from 1991 – 2014 (Figure 24). The number of angler trips was among the highest in the time series from 2012-2016, followed by a steep decline through 2021 and then increasing to near average values since 2022 (Figure 24). A similar pattern arises for the number of angler trips encountering hogfish; however the number has remained low since 2017. This may be due in part to the increase in minimum size limit from 12 inches to 16 inches in the fall of 2017.

Keys-EFL – H&L and Spear (Charter/Private, Nearshore/Offshore)

For Keys-EFL H&L and spear trips, limiting the species that make up at least 0.1% of trips kept 55 species which is in the recommended range. The fourth root of catch transformation leads to the highest silhouette width for the hogfish cluster (0.048) and the second highest

silhouette width for hogfish (0.034). Hogfish is clustered with **yellow jack** (Figure 25). However, yellow jack and hogfish are widely separated in the NMDS analysis (Figure 26).

The proportion of trips that encountered hogfish or yellow jack is overall very low (Figure 27). The number of trips that encountered hogfish has decreased since 2010 but has increased for yellow jack (Figure 28).

CPUE Standardization

WFL - H&L (Charter/Private, Nearshore/Offshore)

There were a total of 3, 344 WFL H&L trips within the hogfish cluster that included littlehead porgy, porgy family, puffer family, and remora family and 634 positive trips. The number of trips that encountered at least one species in the cluster, as well as the number of trips that encountered at least one hogfish by year for each level of each covariate are presented in Tables 4 and 5, respectively.

Histograms of hogfish catch per trip including zeros exhibit zero inflation and overdispersion (Figure 29). For positive trips, the CPUE definition that most closely resembles a normal distribution is log(catch per contributor) (Figure 29). Diagnostic plots of residuals also confirmed that log(catch per contributor) resulted in less biased residuals compared to log(catch per trip) or log(catch per median hours fished).

The number released per contributor has increased since 2016 while the number landed per contributor declined slightly, likely corresponding to an increase in minimum size limits in 2017 from 12 inches to 14 inches (Figure 30).

Interaction plots for each covariate and year are presented in Figures 31 and 32. For the binomial model, mean catch per contributor appears to be increasing for the charter mode over time and increasing in the non-summer months after 2007 (Figure 31). Interaction plots for the positive model are quite variable but also show an increase in mean catch per contributor for the charter mode since about 2009 (Figure 32).

The following binomial and positive sub-models are selected by the model selection procedure and are presented in Tables 6 and 7:

Binomial: Presence = year + waters fished + median hours fished + season

Positive Normal: log(catch per contributor) = year + fishing mode + season + median avidity + median hours fished

To evaluate residuals of the binomial model randomization was introduced to produce continuous normal residuals using the ‘qres.binom’ function of the ‘statmod’ package in R. Randomized quantile residuals for the binomial sub-model were normally distributed and showed no pattern across predictor variables (Figure 33). Residuals from the positive sub-model were close to normal but exhibited some underestimation in 2012 (Figures 34). Diagnostic plots of the positive sub-models indicate that residuals are close to normality, variance is homoscedastic, and there are no influential outliers in the dataset (Figure S1).

The observed annual nominal mean CPUE and standardized CPUE for the WFL H&L fishery are provided in **Table 8** and illustrated in **Figure 35** alongside a continuity model based on the index used in the previous assessment (SEDAR37-03). The scaled standardized index (CPUE scaled to the mean) was below average from 1999-2006 and spiked in 2010, all other years were near average. The standardized index is very similar to the nominal mean in most years but is slightly lower than the nominal mean in 2021 and 2022 (Figure 35). The continuity index based on methods used in SEDAR 37 is also very similar to the standardized index but is higher in a few recent years (2020, 2021, and 2023; Figure 35).

WFL – Spear (Charter/Private, Nearshore/Offshore)

Prior to standardizing the CPUE, years with 3 or less positive or zero observations were removed so that year effects could be estimated for both the binomial and positive submodels. This removed years 1991, 2007, 2011, 2012, 2021, 2022, 2023. After all filtering, 593 trips remained for WFL Spear trips within the hogfish cluster that included with gag, gray snapper, red grouper, and white grunt with 368 positive trips. The number of trips that encountered at least one species in the cluster, as well as the number of trips that encountered at least one hogfish by year for each level of each covariate are presented in Tables 9 and 10, respectively.

Histograms of hogfish catch per trip including zeros exhibit zero inflation and overdispersion (Figure 36). For positive trips, the CPUE definition that most closely resembles a normal distribution is log(catch per contributor) (Figure 36). Diagnostic plots of residuals also confirmed that log(catch per contributor) resulted in less biased residuals compared to log(catch per trip) or log(catch per median hours fished).

The number released per contributor is zero or very low for the spear fishery, as there are very few, if any, releases. The number landed per contributor decreased from 1999-2005, quickly increased in 2006 and has since gradually declined with some years of high variability (Figure 37).

Interaction plots for each covariate and year are presented in Figures 38 and 39. For the binomial model, mean catch per contributor was generally higher in offshore waters since 2007 (Figure 38). Interaction plots for the positive model also suggest higher catch rates in offshore waters since 2007 (Figure 39).

The following binomial and positive sub-models are selected by the model selection procedure and are presented in Tables 11 and 12:

Binomial: Presence = year + number of contributors

Positive Normal: log(catch per contributor) = year + median avidity + fishing mode

To evaluate residuals of the binomial model randomization was introduced to produce continuous normal residuals using the ‘qres.binom’ function of the ‘statmod’ package in R. Randomized quantile residuals for the binomial sub-model were normally distributed and showed no pattern across predictor variables (Figure 40), as did residuals from the positive sub-model (Figures 41). Diagnostic plots of the positive sub-models indicate that residuals are close

to normality, variance is homoscedastic, and there are no influential outliers in the dataset (Figure S2).

The observed annual nominal mean CPUE and standardized CPUE for the WFL spear fishery are provided in **Table 13** and illustrated in **Figure 42** alongside a continuity model based on the index used in the previous assessment (SEDAR37-03). The standardized index is similar to the nominal mean in most years but is lower than the nominal mean in 2008-2010 and from 2013-2015 (Figure 42). Trends in the scaled standardized index (CPUE scaled to the mean) show a period of slightly below average values from 2000-2006, followed by above average values from 2008-2010, after which the index remains near average before falling below average in 2024. The continuity index based on methods used in SEDAR 37 is very similar to the standardized index (Figure 42).

WFL – H&L and Spear (Charter/Private, Nearshore/Offshore)

There were a total of 3,675 WFL trips that used H&L and/or spears and encountered at least one species within the hogfish cluster (littlehead porgy, porgy family, puffer family, and remora family) and 962 positive trips. The number of trips that encountered at least one species in the cluster, as well as the number of trips that encountered at least one hogfish by year for each level of each covariate are presented in **Tables 14** and **15**, respectively.

Histograms of hogfish catch per trip including zeros exhibit zero inflation and overdispersion (Figure 43). For positive trips, the CPUE definition that most closely resembles a normal distribution is log(catch per contributor) (Figure 43).

The number landed per contributor decreased from 1991 to 2002 but increased to a time series high in 2010. Since that time, the number landed per contributor decreased through 2021 and has remained mostly stable through 2024. The number released per contributor was mostly negligible through 2016 but has since increased, likely related to an increase in minimum size limits in 2017 from 12 inches to 14 inches (Figure 44).

Interaction plots for each covariate and year are presented in Figures 45 and 46. For the binomial model, mean catch per contributor appears to be higher for spear gear compared to hook and line, generally higher in offshore waters, increasing for the charter mode since 2009, decreasing in summer months after 2010, and increasing slightly in non-summer months after 2007 (Figure 45). Interaction plots for the positive model are variable but also show an increase in mean catch per contributor for the charter mode since about 2009 (Figure 46).

The following binomial and positive sub-models are selected by the model selection procedure and are presented in Tables 16 and 17:

Binomial: Presence = year + gear + waters fished + season

Positive Normal: log(catch per contributor) = year + gear + median avidity + season

To evaluate residuals of the binomial model randomization was introduced to produce continuous normal residuals using the ‘qres.binom’ function of the ‘statmod’ package in R. Randomized quantile residuals for the binomial sub-model were normally distributed and

showed no pattern across predictor variables (Figure 47). Residuals from the positive sub-model were close to normal but exhibited some underestimation in 2012 (Figures 48). Diagnostic plots of the positive sub-models indicate that residuals are close to normality, variance is homoscedastic, and there are no influential outliers in the dataset (Figure S3).

The observed annual nominal mean CPUE and standardized CPUE for the WFL spear and H&L fishery are provided in **Table 18** and illustrated in **Figure 49**. The standardized index resembled the standardized index for WFL hook and line and was mostly below average from 1999-2007, increased in 2010, and has remained near average since that time.

Keys-EFL – H&L, Shore/Charter/Private, Nearshore/Offshore

There were a total of 2,492 Keys-EFL H&L trips within the hogfish cluster that included porgy family and yellow jack and 706 positive trips. The number of trips that encountered at least one species in the cluster, as well as the number of trips that encountered at least one hogfish by year for each level of each covariate are presented in Tables 19 and 20, respectively.

Histograms of hogfish catch per trip including zeros exhibit zero inflation and overdispersion (Figure 50). For positive trips, the CPUE definition that most closely resembles a normal distribution is log(catch per contributor) (Figure 50). Diagnostic plots of residuals also confirmed that log(catch per contributor) resulted in less biased residuals compared to log(catch per trip) or log(catch per median hours fished).

The number of landings per contributor has been steadily declining since 1991, reaching the lowest in the time series in 2018 and 2019, while the number of releases per contributor has increased since 2011 (Figure 51). The steep decline in landings per contributor in 2018 is likely due to an increase in minimum size limits in 2017 from 12 inches to 16 inches.

Interaction plots for each covariate and year are presented in Figures 52 and 53. For the binomial model, mean catch per contributor has generally been higher in nearshore waters compared to offshore waters since 2005 (Figure 52). Similarly, positive hogfish catch per contributor has been higher in nearshore waters compared to offshore waters in most years since 2001 (Figure 53).

The following binomial and positive sub-models are selected by the model selection procedure and are presented in Tables 21 and 22:

Binomial: Presence = year + fishing mode

Positive Normal: log(catch per contributor) = year + fishing mode + season + waters fished

To evaluate residuals of the binomial model randomization was introduced to produce continuous normal residuals using the ‘qres.binom’ function of the ‘statmod’ package in R. Randomized quantile residuals for the binomial sub-model were normally distributed and showed no pattern across predictor variables (Figure 54). Residuals from the positive sub-model also showed little to no patterns across predictor variables (Figures 55). Diagnostic plots of the positive sub-models indicate that residuals are close to normality, variance is homoscedastic, and there are no influential outliers in the dataset (Figure S3).

The observed annual nominal mean CPUE and standardized CPUE for the Keys-EFL H&L fishery are provided in **Table 23** and illustrated in **Figure 56** alongside a continuity model based on the index used in the previous assessment (SEDAR37-03). The scaled standardized index (CPUE scaled to the mean) was at or above average from 1991-2017 but has been below average since 2018 (Figure 56). The standardized index is very similar to the nominal mean in most years but is slightly lower than the nominal mean from 1992-1995 (Figure 56). The continuity index based on methods used in SEDAR 37 is in general agreement with the standardized index but is higher since 2014 (Figure 56).

Keys-EFL - Spear, Charter/Private, Nearshore/Offshore

Prior to standardizing the CPUE, years with 3 or less positive or zero observations were removed so that year effects could be estimated for both the binomial and positive submodels. This removed years 2019 and 2020. After all filtering, 1,160 trips remained for the Keys-EFL Spear trips within the hogfish cluster that included black grouper, gray snapper, great barracuda, mutton snapper, red grouper, and yellow jack. There were 697 positive trips. The number of trips that encountered at least one species in the cluster, as well as the number of trips that encountered at least one hogfish by year for each level of each covariate are presented in Tables 24 and 25, respectively.

Histograms of hogfish catch per trip including zeros exhibit zero inflation and overdispersion (Figure 57). For positive trips, the CPUE definition that most closely resembles a normal distribution is log(catch per contributor) (Figure 57). Diagnostic plots of residuals also confirmed that log(catch per contributor) resulted in less biased residuals compared to log(catch per trip) or log(catch per median hours fished).

The number released per contributor is zero or very low for the spear fishery, as there are very few, if any, releases. The number landed per contributor decreased from 1991-1998, then remained stable but variable through 2017 and has steeply declined since that time (Figure 58).

Mean catch per contributor for both the binomial and positive sub models have declined steadily in offshore waters, while remaining mostly stable in nearshore waters until a drop occurred in 2018 (Figures 59 and 60).

The following binomial and positive sub-models are selected by the model selection procedure and are presented in Tables 26 and 27:

Binomial: Presence = year + number of contributors + waters fished

Positive Normal: log(catch per contributor) = year + fishing mode + median avidity + median hours fished

To evaluate residuals of the binomial model randomization was introduced to produce continuous normal residuals using the ‘qres.binom’ function of the ‘statmod’ package in R. Randomized quantile residuals for the binomial sub-model were normally distributed and showed no pattern across predictor variables (Figure 61), as did residuals from the positive sub-model (Figures 62). Diagnostic plots of the positive sub-models indicate that residuals are close

to normality, variance is homoscedastic, and there are no influential outliers in the dataset (Figure S4).

The observed annual nominal mean CPUE and standardized CPUE are provided in **Table 28** and illustrated in **Figure 63** alongside a continuity model based on the index used in the previous assessment (SEDAR37-03). The trends in the standardized index are similar to those for the nominal mean in most years (Figure 63). The scaled standardized index (CPUE scaled to the mean) remained near average from 1991-2017 but has since been less than 50% of the mean in 2018 and 2021-2024. The continuity index based on methods used in SEDAR 37 displays a very similar pattern but is slightly above the standardized index in recent years. The reduction in the standardized index in recent years may be due, at least in part, to the decrease in bag limit to 1 fish and an increase in minimum size limits in 2017 from 12 inches to 16 inches (Figure 63).

Keys-EFL– H&L and Spear (Shore/Charter/Private, Nearshore/Offshore)

There were a total of 1,919 Keys-EFL trips that used H&L and/or spears and encountered at least one species within the hogfish cluster (hogfish, **yellow jack**) and 1,012 positive trips. The number of trips that encountered at least one species in the cluster, as well as the number of trips that encountered at least one hogfish by year for each level of each covariate are presented in Tables 29 and 30, respectively.

Histograms of hogfish catch per trip including zeros exhibit zero inflation and overdispersion (Figure 64). For positive trips, the CPUE definition that most closely resembles a normal distribution is log(catch per contributor) (Figure 64).

The number landed per contributor decreased from 1991-1995, then increased slightly, albeit variable, through 2014 and has steeply declined since that time (Figure 65). The number released per contributor increased from a low in 2009 through 2014 and has since remained stable (Figure 65).

Since 2000, mean catch per contributor for the binomial sub model has been slightly higher in nearshore waters, generally highest in the private mode and for spear gear, and has dropped since 2017 (Figure 66). Mean positive catch per contributor has declined since 2017 in offshore waters but has remained fairly stable in nearshore waters (Figure 67).

The following binomial and positive sub-models are selected by the model selection procedure and are presented in Tables 31 and 32:

Binomial: Presence = year + gear + fishing mode

Positive Normal: log(catch per contributor) = year + fishing mode + gear + waters fished + median avidity

To evaluate residuals of the binomial model randomization was introduced to produce continuous normal residuals using the ‘qres.binom’ function of the ‘statmod’ package in R. Randomized quantile residuals for the binomial sub-model were normally distributed and showed no pattern across predictor variables (Figure 68), as did residuals from the positive sub-model (Figures 69). Diagnostic plots of the positive sub-models indicate that residuals are close

to normality, variance is homoscedastic, and there are no influential outliers in the dataset (Figure S5).

The observed annual nominal mean CPUE and standardized CPUE are provided in **Table 33** and shown in **Figure 70**. The standardized index is similar to the nominal mean from 1995 – 2013 but it has exceeded the nominal mean from 2018 - 2024 (Figure 70). The scaled standardized index (CPUE scaled to the mean) was near average from 1991-2013, above average from 2014 to 2015, but has been below average in 2018, 2019, and 2022 – 2024. The scaled standardized index for the Keys-EFL H&L and spear gears closely resembles that for the H&L fishery.

Discussion

Across regions, H&L and spear gears target different species and therefore possibly different habitats. The H&L fishery encounters porgies whereas the spear fishery encounters snappers and groupers. Since about 2010, the proportion of trips in the H&L cluster in both regions have increased. This may suggest that the H&L fishery is expanding or is still developing. The number of interviews of spear in WFL have been low since 2018 and in the Keys-EFL region from 2019-2021 which may be due, at least partially, to the COVID-19 pandemic.

The CPUE for both gears in the WFL region has been higher offshore in recent years, whereas in the Keys-EFL region it has been higher in nearshore areas in recent years. For WFL, standardized CPUE for both gears were below average from around 1999-2006 and above average from 2008 – 2010. The standardized CPUE for spear gear was below average in 2024. For the Keys-EFL region, both spear and H&L standardized CPUE have been below average since 2018, which may be due to the increase in minimum size limits and decrease in bag limits enacted in the fall of 2017.

As with any fishery dependent CPUE, caution is warranted when inferring trends in abundance as changes in angler targeting behavior, fishing techniques, and regulation changes can lead to changes in CPUE that are not reflective of changes in abundance (Maunder and Punt 2004; Mace and Wilberg 2020). Minimum sizes and bag limits, which restrict the sizes or total number of individuals allowed to be landed may lead to a censored representation in the catches (Mace and Wilberg 2020). Therefore, it is prudent to evaluate the need for any fishery dependent index relative to fishery independent indices designed to monitor changes in abundance. The Reef Fish Census (RVC) fish survey, for instance, could offer an alternative to an MRIP CPUE as it may have similar spatial coverage; however, in Southeast FL the SEFCRI RVC survey was only initiated in 2013.

Releases are rarely reported for the spear fishery, therefore changes in catchability may occur with changes to the minimum size limit. Since releases are reported for the hook and line fishery, the CPUE should not be as sensitive to increases in the minimum size limits compared to the spear fishery. However, the hook and line fishery may still be developing, so there may be confounding effects of changes in catchability that have not been accounted for in the standardization. Additionally, changes in catchability may occur in the Keys-EFL region in 2017 due to the bag limit reduction.

References

Arbelaitz, O., Gurrutxaga, I., Muguerza, J., Pérez, J. M., & Perona, I. (2013). An extensive comparative study of cluster validity indices. Pattern recognition, 46(1), 243-256.

Burnham, K.P. and D.R. Anderson. 2002. Model Selection and Multimodel Inference: A Practical Information-Theoretic Approach. 2nd edn. Springer, Berlin.

Clarke, K.R., Gorley, R.N., Somerfield, P.J., Warwick, R.M. (2014)
Change in marine communities: an approach to statistical analysis and interpretation, 3rd edition. PRIMER-E: Plymouth

Cooper, W. 2014. Recreational catch per unit effort of Hogfish (Lachnolaimus maximus) in the Southeast US using MRFSS-MRIP intercept data, 1991-2012. SEDAR37-03.

Dick, E.J. 2004. Beyond 'lognormal vs. gamma': discrimination among error distributions for generalized linear models. Fisheries Research 70:347-362.

Ezugwu, A. E., Ikotun, A. M., Oyelade, O. O., Abualigah, L., Agushaka, J. O., Eke, C. I., & Akinyelu, A. A. (2022). A comprehensive survey of clustering algorithms: State-of-the-art machine learning applications, taxonomy, challenges, and future research prospects. Engineering Applications of Artificial Intelligence, 110, 104743.

Field, J. G., Clarke K. R., and Warwick, R. M. (1982). A Practical Strategy for Analysing Multispecies Distribution Patterns. Mar. Ecol. Prog. Ser. 8: 37-52.

Legendre, P., & Legendre, L. (1998). Numerical ecology. Elsevier.

Lo, N.C., L.D. Jacobson, J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Canadian Journal Fisheries and Aquatic Sciences 49:2515-2526.

Mace MM, Wilberg MJ. 2020. Using censored regression when estimating abundance with CPUE data to account for daily catch limits. Canadian Journal Fisheries and Aquatic Sciences 77 :716–22. https:// doi.org/ 10.1139/ cjfas-2019 -0093

Maunder, M.N. and A.E. Punt. 2004. Standardizing catch and effort data: a review of recent approaches. Fisheries Research 70:141-159.

Shertzer, K. W., and E. H. Williams. 2008. Fish assemblages and indicator species: reef fishes off the southeastern United States. Fishery Bulletin 106:257-269.

Tables

Table 1. Number of positive trips per year and waters fished for the WFS and Keys-EFL. The number of positive trips prior to 1991 may overestimate the true number of trips that caught at least one Hogfish.

Year	West Florida Shelf			Keys-EFL		
	Inland	Nearshore	Offshore	Inland	Nearshore	Offshore
1981			5	1	15	10
1982		3	1		18	
1983		2		1	9	1
1984					18	6
1985					8	
1986		1	5		10	1
1987		5	11	1	37	7
1988		4	12		15	4
1989		5	7		15	2
1990			3		21	3
1991		6	4		6	3
1992		6	9	11	31	12
1993		7	10	1	29	10
1994		5	13	5	37	13
1995		4	16		22	15
1996	1	3	11		10	22
1997	1	6	12	1	18	9
1998		10	16	3	19	15
1999		12	24	5	19	21
2000		2	10	1	10	6
2001		8	13		14	16
2002	1	5	11	1	19	6
2003	1	7	25	1	25	21
2004		5	9		32	23
2005	1	3	11	2	25	12
2006	1	3	11		20	11
2007	1	8	9	6	34	16
2008	4	13	12	4	25	20
2009	4	15	12	2	28	11
2010	2	11	12	1	19	8
2011	2	13	9	1	24	7
2012	1	6	19	2	38	16
2013		11	18	1	37	28
2014	7	21	25	4	68	32
2015		11	27	6	75	27
2016	1	17	31	3	37	33

Year	West Florida Shelf			Keys-EFL		
	Inland	Nearshore	Offshore	Inland	Nearshore	Offshore
2017		17	45	2	27	15
2018		6	32	1	10	6
2019	1	6	32	1	7	1
2020		5	31	1	13	3
2021	1	9	39	4	28	6
2022	1	3	29	3	25	7
2023		14	40	2	28	6
2024	1	15	58	4	34	3

Table 2. Number of positive trips per year and gear for the WFS and Keys-EFL, not including inshore waters. The number of positive trips prior to 1991 may overestimate the true number of trips that caught at least one Hogfish. The number of positive trips may be less than the sum of the number of positive trips by gear due to anglers reporting the use of multiple gears on a single trip.

Year	West Florida Shelf				Keys-EFL			
	H&L	SPEAR	OTHER	Total Positive Trips	H&L	SPEAR	OTHER	Total Positive Trips
1981	1	4		5	3	22		25
1982		4		4	1	15	3	18
1983		2		2	1	9		10
1984					14	10		24
1985					8			8
1986	3	3		6	6	5		11
1987	4	14		16	19	25		44
1988	1	7	8	16	4	1	14	19
1989	2	11		12	15	2		17
1990	2	2		3	14	13		24
1991	3	9	1	10	5	5		9
1992	9	5	2	15	22	23	3	43
1993	8	11		17	28	17		39
1994	10	10		18	28	30		50
1995	15	9	1	20	28	13		37
1996	10	11		14	18	15		32
1997	11	14		18	16	11	1	27
1998	12	16		26	20	15		34
1999	11	26		36	20	24		40
2000	9	4		12	7	9		16
2001	8	15		21	16	14		30
2002	9	7		16	11	18		25
2003	19	20		32	26	22		46
2004	5	10		14	30	30		55
2005	9	8		14	19	20		37
2006	5	11		14	16	16		31
2007	9	9		17	18	34		50
2008	14	17		25	24	25		45
2009	14	16		27	15	26		39
2010	12	16		23	11	16		27
2011	12	15		22	12	20		31
2012	9	21		25	18	37		54
2013	9	22		29	37	34		65
2014	28	27		46	44	58		100

Year	H&L	SPEAR	OTHER	Total Positive Trips	H&L	SPEAR	OTHER	Total Positive Trips
2015	26	17		38	41	66		102
2016	29	27		48	23	49		70
2017	50	16		62	23	20		42
2018	28	10		38	10	6		16
2019	28	12		38	8			8
2020	29	7		36	15	1		16
2021	48	2		48	29	7		34
2022	28	5		32	23	11		32
2023	49	7		54	27	10		34
2024	69	6		73	27	14		37

Table 3. Number of positive trips per year and fishing mode for the WFS and Keys-EFL. The number of positive trips prior to 1991 may overestimate the true number of trips that caught at least one Hogfish.

Year	West Florida Shelf			Keys-EFL		
	CH	PR	SH	CH	PR	SH
1981		5			25	
1982		4			15	
1983		2			10	
1984					18	5
1985					6	2
1986	4	2			10	1
1987	4	12		2	40	2
1988		8			5	
1989	2	10		1	16	
1990		3			24	
1991		9			9	
1992		13			40	
1993		17			36	3
1994		18			45	5
1995		18	1		36	1
1996		13	1		31	1
1997		18		1	24	1
1998	7	19		4	29	1
1999	3	33		4	33	3
2000		12		1	12	3
2001	3	17	1	3	26	1
2002	3	13		4	20	1
2003	5	27		13	30	3
2004	2	12		13	39	3
2005	2	12		8	23	6
2006	1	13		5	25	1
2007	3	14		3	47	
2008	2	21	2	13	30	2
2009	2	24	1	3	36	

2010	2	21		8	18	1
2011	4	18		5	25	1
2012	9	16		5	47	2
2013	2	27		12	49	4
2014	13	33		14	79	7
2015	14	24		9	85	8
2016	13	35		8	60	2
2017	25	37		10	32	
2018	22	16		2	10	4
2019	16	22		2	4	2
2020	18	18		3	10	3
2021	39	9		3	18	13
2022	18	14		7	20	5
2023	32	22		8	17	9
2024	47	25	1	8	14	15

Table 4. Number of trips per year and covariate for the WFL H&L CPUE.

Year	Waters Fished		Median Hours Fished				Median Avidity			Number of Contributors				Fishing Mode		Season	
	Nearshore	Offshore	[0.5,3]	(3,4]	(4,6]	(6,24.5]	[0,1]	(1,5]	(5,63]	1	2	3	4+	CH	PR	Other	Summer
1991	15	4	9	5	4	1	6	9	4	4	9	3	3	1	18	4	15
1992	23	20	13	8	10	12	9	21	13	6	18	15	4	-	43	14	29
1993	22	20	16	5	13	8	13	14	15	3	16	10	13	1	41	13	29
1994	28	46	25	15	22	12	18	36	20	12	29	14	19	4	70	24	50
1995	24	38	15	11	23	13	17	25	20	10	24	16	12	6	56	19	43
1996	35	24	17	14	22	6	10	31	18	12	22	21	4	2	57	15	44
1997	33	22	15	11	21	8	17	17	21	14	24	12	5	3	52	15	40
1998	54	30	23	16	38	7	39	23	22	11	22	17	34	30	54	32	52
1999	59	48	19	29	40	19	40	37	30	11	48	25	23	18	89	68	39
2000	33	36	11	16	29	13	27	20	22	6	21	21	21	15	54	21	48
2001	47	53	19	28	34	19	45	24	31	8	39	14	39	20	80	46	54
2002	52	54	22	23	43	18	52	29	25	7	41	28	30	32	74	51	55
2003	36	65	27	21	39	14	48	35	18	6	41	20	34	25	76	64	37
2004	11	41	13	11	19	9	29	18	5	1	9	14	28	29	23	31	21
2005	13	38	11	11	20	9	21	19	11	1	13	11	26	19	32	26	25
2006	10	20	6	10	10	4	14	9	7	4	8	6	12	9	21	19	11
2007	16	13	8	4	13	4	18	10	1	4	5	5	15	11	18	19	10
2008	28	25	11	11	29	2	28	14	11	3	25	11	14	12	41	28	25
2009	23	15	10	7	16	5	11	15	12	4	11	10	13	5	33	22	16
2010	13	15	6	9	11	2	12	10	6	2	7	8	11	6	22	12	16
2011	33	26	16	16	22	5	26	21	12	1	20	13	25	16	43	35	24
2012	36	43	25	17	31	6	49	15	15	2	17	20	40	36	43	44	35
2013	36	39	23	15	19	18	26	28	21	4	30	13	28	18	57	35	40
2014	49	72	39	25	42	15	54	32	35	9	30	26	56	49	72	67	54
2015	57	90	51	33	48	15	67	39	41	6	47	40	54	55	92	71	76
2016	75	127	56	45	79	22	116	43	43	5	53	35	109	103	99	73	129
2017	91	118	67	54	62	26	117	55	37	21	58	41	89	95	114	128	81
2018	46	88	46	26	49	13	70	39	25	15	33	29	57	63	71	73	61
2019	38	118	43	48	45	20	84	44	28	12	33	48	63	65	91	79	77
2020	48	90	41	39	44	14	73	30	35	16	32	33	57	56	82	77	61
2021	46	141	58	51	68	10	114	54	19	11	38	18	120	125	62	98	89
2022	52	80	39	34	47	12	79	32	21	20	30	23	59	67	65	69	63
2023	78	134	60	75	56	21	137	43	32	21	46	26	119	128	84	94	118
2024	125	166	117	76	73	25	189	60	42	17	58	59	157	181	110	153	138

Table 5. Number of positive trips per year and covariate for the WFL H&L CPUE.

Year	Waters Fished		Median Hours Fished				Median Avidity			Number of Contributors				Fishing Mode		Season	
	Nearshore	Offshore	[0.5,3]	(3,4]	(4,6]	(6,24.5]	[0,1]	(1,5]	(5,63]	1	2	3	4+	CH	PR	Other	Summer
1991	2	1	2	-	1	-	-	2	1	-	3	-	-	-	3	-	3
1992	3	6	5	-	3	1	1	3	5	3	4	2	-	-	9	4	5
1993	2	6	4	1	3	-	1	4	3	-	3	1	4	-	8	1	7
1994	-	10	4	2	2	2	3	5	2	1	5	2	2	-	10	2	8
1995	1	13	6	3	3	2	-	5	9	2	7	4	1	-	14	3	11
1996	2	7	8	1	-	-	-	4	5	4	3	2	-	-	9	2	7
1997	4	7	7	1	-	3	-	3	8	8	2	1	-	-	11	4	7
1998	7	5	5	-	5	2	6	4	2	1	4	1	6	6	6	3	9
1999	3	8	3	1	3	4	2	3	6	2	4	2	3	2	9	8	3
2000	2	7	1	2	3	3	2	2	5	3	3	1	2	-	9	3	6
2001	3	4	1	4	1	1	2	3	2	1	3	-	3	1	6	3	4
2002	4	5	2	1	1	5	3	3	3	1	3	3	2	1	8	4	5
2003	4	15	8	4	5	2	9	6	4	3	4	5	7	4	15	7	12
2004	1	4	2	1	2	-	2	2	1	-	1	2	2	2	3	4	1
2005	1	8	3	-	4	2	4	3	2	-	1	3	5	2	7	3	6
2006	2	3	3	-	2	-	3	1	1	-	3	-	2	1	4	3	2
2007	5	4	4	1	3	1	6	3	-	-	1	3	5	3	6	6	3
2008	5	7	6	1	4	1	3	3	6	1	7	2	2	2	10	6	6
2009	8	5	5	2	4	2	3	5	5	1	3	4	5	2	11	5	8
2010	5	7	1	3	6	2	5	4	3	1	3	6	2	1	11	2	10
2011	5	7	2	4	4	2	4	4	4	-	1	4	7	3	9	6	6
2012	2	7	7	1	-	1	6	2	1	1	2	3	3	4	5	7	2
2013	6	3	1	2	3	3	4	3	2	1	5	-	3	2	7	4	5
2014	10	18	14	3	7	4	11	9	8	2	5	5	16	13	15	19	9
2015	9	17	15	4	5	2	16	4	6	-	7	7	12	14	12	22	4
2016	13	16	9	10	7	3	16	5	8	1	9	5	14	13	16	12	17
2017	15	33	22	9	11	6	28	10	10	6	10	13	19	25	23	36	12
2018	5	23	11	7	6	4	16	7	5	2	4	6	16	20	8	23	5
2019	5	23	9	4	10	5	15	10	3	2	8	7	11	15	13	18	10
2020	3	26	11	7	8	3	18	6	5	-	6	9	14	17	12	24	5
2021	9	39	11	16	20	1	36	9	3	1	6	6	35	39	9	32	16
2022	2	26	6	6	14	2	17	6	5	3	5	5	15	18	10	19	9
2023	14	35	15	15	15	4	31	13	5	3	12	6	28	32	17	28	21
2024	13	54	28	13	19	7	46	15	6	3	9	11	44	47	20	41	26

Table 6. Deviance table for the final binomial sub-model for the WFL H&L data.

Factor	Df	Resid. Df	Resid. Dev	Deviance	% Deviance Reduced	Family	Dispersion
NULL	1	3343	3247.912	3247.912	-		
waters	1	3342	3183.98	63.93131	1.94		
median_hrsfcat	3	3339	3150.543	33.43741	0.94		
season	1	3338	3130.783	19.76	0.58		
year	33	3305	3058.36	72.423	1.29	Binomial	1.02

Table 7. Deviance table for the final positive sub-model for the WFL H&L data.

Factor	Df	Resid. Df	Resid. Dev	Deviance	% Deviance Reduced	Family	Dispersion
NULL	1	633	686.4741	686.4741	-		
year	33	600	648.8726	37.60151	0.28		
fishing_mode	1	599	628.7158	20.15675	2.94		
season	1	598	619.373	9.342814	1.28		
median_avidityca t	2	596	611.0536	8.319441	0.97		
median_hrsfcat	3	593	601.2524	9.801151	1.05	Gaussian	1.01

Table 8. Nominal mean CPUE and final modeled index for the WFL H&L data.

Year	Num Sampling Events	Num Positive	Prop Positive	Nominal Mean	Nominal CV	Std Index	Std CV	Std Low 95	Std Up 95	Scaled Std Index	Scaled Std Low 95	Scaled Std Up 95
1991	19	3	0.16	0.21	3.33	0.20	0.88	0.03	0.63	1.32	0.21	4.24
1992	43	9	0.21	0.25	2.91	0.15	0.47	0.06	0.32	1.01	0.38	2.17
1993	42	8	0.19	0.30	2.96	0.19	0.50	0.06	0.42	1.25	0.42	2.83
1994	74	10	0.14	0.13	3.46	0.08	0.46	0.03	0.17	0.52	0.20	1.13
1995	62	14	0.23	0.46	2.98	0.21	0.37	0.09	0.39	1.38	0.63	2.63
1996	59	9	0.15	0.23	2.58	0.19	0.49	0.07	0.42	1.27	0.46	2.85
1997	55	11	0.20	0.32	2.54	0.23	0.42	0.09	0.47	1.54	0.63	3.15
1998	84	12	0.14	0.11	3.36	0.11	0.41	0.05	0.22	0.73	0.31	1.46
1999	107	11	0.10	0.08	4.44	0.05	0.44	0.02	0.10	0.32	0.12	0.65
2000	69	9	0.13	0.14	3.66	0.10	0.48	0.04	0.23	0.70	0.26	1.53
2001	100	7	0.07	0.07	4.69	0.04	0.57	0.01	0.10	0.28	0.09	0.69
2002	106	9	0.09	0.05	4.07	0.04	0.49	0.02	0.09	0.28	0.10	0.63
2003	101	19	0.19	0.27	3.24	0.15	0.33	0.07	0.26	0.98	0.50	1.73
2004	52	5	0.10	0.09	4.84	0.04	0.70	0.01	0.12	0.29	0.07	0.81
2005	51	9	0.18	0.12	2.71	0.09	0.48	0.03	0.20	0.61	0.23	1.34
2006	30	5	0.17	0.12	3.27	0.08	0.68	0.02	0.22	0.54	0.13	1.48
2007	29	9	0.31	0.20	2.50	0.14	0.45	0.05	0.29	0.94	0.34	1.98
2008	53	12	0.23	0.46	2.68	0.23	0.41	0.10	0.46	1.54	0.65	3.08
2009	38	13	0.34	0.35	2.39	0.19	0.36	0.09	0.36	1.31	0.61	2.41
2010	28	12	0.43	0.83	1.91	0.56	0.38	0.25	1.05	3.76	1.66	7.08
2011	59	12	0.20	0.26	3.02	0.13	0.40	0.05	0.26	0.87	0.36	1.73
2012	79	9	0.11	0.25	3.44	0.14	0.49	0.05	0.31	0.93	0.33	2.06
2013	75	9	0.12	0.11	3.03	0.10	0.49	0.03	0.21	0.64	0.23	1.39
2014	121	28	0.23	0.33	2.92	0.17	0.27	0.10	0.27	1.11	0.65	1.78
2015	147	26	0.18	0.17	3.59	0.09	0.28	0.05	0.15	0.60	0.34	0.99
2016	202	29	0.14	0.24	3.86	0.14	0.26	0.08	0.22	0.91	0.52	1.46
2017	209	48	0.23	0.26	2.67	0.16	0.20	0.11	0.23	1.08	0.71	1.56
2018	134	28	0.21	0.26	2.96	0.13	0.27	0.07	0.20	0.85	0.48	1.37
2019	156	28	0.18	0.18	3.23	0.11	0.27	0.06	0.17	0.71	0.40	1.14
2020	138	29	0.21	0.27	3.14	0.14	0.26	0.08	0.22	0.94	0.55	1.50
2021	187	48	0.26	0.33	3.09	0.18	0.21	0.11	0.26	1.18	0.77	1.72
2022	132	28	0.21	0.50	4.77	0.19	0.27	0.11	0.31	1.28	0.74	2.06
2023	212	49	0.23	0.40	3.56	0.20	0.20	0.13	0.29	1.35	0.89	1.94
2024	291	67	0.23	0.27	3.38	0.15	0.18	0.11	0.21	1.02	0.71	1.41

Table 9. Number of trips per year and covariate for the WFL Spear CPUE.

Year	Waters Fished		Median Hours Fished				Median Avidity				Number of Contributors				Fishing Mode		Season	
	Nearshore	Offshore	[0.5,1.19]	(1.19,2]	(2,4]	(4,13]	[0,2]	(2,5]	(5,8]	(8,61]	1	2	3	4+	CH	PR	Other	Summer
1991	5	4	2	2	3	2	2	4	3	-	3	5	1	-	-	9	2	7
1992	7	9	6	4	6	-	3	7	4	2	5	9	-	2	-	16	-	16
1993	5	10	4	4	5	2	8	1	3	3	6	1	4	4	-	15	1	14
1994	8	10	5	5	4	4	5	4	3	6	8	8	-	2	-	18	3	15
1995	5	16	5	9	5	2	3	7	9	2	12	5	3	1	2	19	2	19
1996	3	23	8	9	8	1	7	7	11	1	9	11	5	1	-	26	4	22
1997	8	19	13	8	4	2	3	5	10	9	19	4	4	-	1	26	6	21
1998	7	21	11	8	2	7	8	6	7	7	13	11	3	1	1	27	7	21
1999	10	22	9	7	9	7	3	5	10	14	11	9	7	5	1	31	9	23
2000	3	7	-	6	2	2	2	3	3	2	4	3	3	-	-	10	3	7
2001	11	14	4	8	7	6	9	3	7	6	8	9	3	5	2	23	10	15
2002	3	19	6	5	4	7	8	5	4	5	9	7	2	4	2	20	5	17
2003	10	20	4	15	5	6	12	7	3	8	4	14	5	7	2	28	1	29
2004	7	16	2	12	7	2	6	3	8	6	5	7	9	2	-	23	8	15
2005	4	12	6	5	3	2	4	5	5	2	3	5	6	2	1	15	6	10
2006	2	13	5	7	2	1	6	4	2	3	5	5	4	1	-	15	4	11
2007	3	8	5	3	2	1	3	3	1	4	2	4	4	1	-	11	5	6
2008	10	12	5	11	4	2	2	7	7	6	1	13	6	2	-	22	6	16
2009	12	8	5	7	5	3	5	7	3	5	4	8	6	2	-	20	3	17
2010	12	9	3	8	2	8	9	2	4	6	6	2	8	5	2	19	3	18
2011	11	5	4	1	7	4	3	8	1	4	3	6	1	6	1	15	5	11
2012	5	18	3	18	1	1	10	7	3	3	5	6	9	3	8	15	12	11
2013	12	24	4	15	9	8	8	15	4	9	12	16	6	2	-	36	7	29
2014	16	18	11	10	8	5	7	10	9	8	7	11	8	8	2	32	6	28
2015	7	17	8	6	5	5	3	10	3	8	6	8	3	7	-	24	5	19
2016	9	25	8	8	12	6	11	9	8	6	4	13	9	8	2	32	9	25
2017	5	18	9	6	3	5	8	4	5	6	6	7	5	5	-	23	12	11
2018	2	12	1	2	3	8	5	6	1	2	4	4	4	2	2	12	4	10
2019	4	15	5	5	6	3	7	4	6	2	6	7	4	2	1	18	4	15
2020	3	8	2	3	3	3	3	5	1	2	4	2	3	2	1	10	4	7
2021	1	4	-	2	3	-	2	1	1	1	1	3	1	-	-	5	1	4
2022	1	6	1	3	-	3	2	1	3	1	3	1	1	2	-	7	1	6
2023	-	8	3	1	-	4	2	-	3	3	2	4	1	1	-	8	2	6
2024	3	8	1	1	2	7	5	-	3	3	2	2	2	5	-	11	1	10

Table 10. Number of positive trips per year and covariate for the WFL Spear CPUE.

Year	Waters Fished		Median Hours Fished				Median Avidity				Number of Contributors				Fishing Mode		Season	
	Nearshore	Offshore	[0.5,1.19]	(1.19,2]	(2,4]	(4,13]	[0,2]	(2,5]	(5,8]	(8,61]	1	2	3	4+	CH	PR	Other	Summer
1991	5	4	2	2	3	2	2	4	3	-	3	5	1	-	-	9	2	7
1992	3	2	2	1	2	-	-	4	1	-	1	4	-	-	-	5	-	5
1993	5	6	4	3	3	1	7	1	1	2	4	1	3	3	-	11	1	10
1994	5	5	4	3	1	2	2	2	3	3	5	4	-	1	-	10	1	9
1995	1	8	4	2	3	-	1	4	4	-	3	4	2	-	-	9	2	7
1996	1	10	4	4	3	-	4	2	5	-	4	4	3	-	-	11	1	10
1997	3	11	4	5	3	2	1	2	6	5	10	2	2	-	-	14	3	11
1998	4	12	7	5	-	4	5	4	4	3	7	6	2	1	1	15	2	14
1999	9	17	8	6	6	6	2	5	7	12	9	8	5	4	1	25	6	20
2000	-	4	-	1	1	2	1	2	1	-	1	1	2	-	-	4	1	3
2001	5	10	3	6	3	3	3	3	5	4	6	5	1	3	2	13	5	10
2002	1	6	3	2	1	1	3	1	2	1	1	5	-	1	2	5	2	5
2003	6	14	4	10	3	3	7	5	3	5	2	11	2	5	2	18	1	19
2004	4	6	1	6	3	-	2	1	3	4	2	3	4	1	-	10	3	7
2005	2	6	4	2	1	1	3	2	2	1	1	2	3	2	1	7	2	6
2006	1	10	5	4	1	1	4	3	1	3	3	3	4	1	-	11	3	8
2007	3	6	4	2	2	1	3	3	-	3	1	4	4	-	-	9	4	5
2008	7	10	4	8	3	2	1	6	6	4	-	11	5	1	-	17	4	13
2009	7	8	4	4	4	3	4	6	1	4	3	7	4	1	-	15	2	13
2010	9	7	1	6	2	7	7	1	3	5	2	2	7	5	2	14	3	13
2011	11	4	4	1	7	3	3	7	1	4	3	6	1	5	1	14	5	10
2012	5	16	2	17	1	1	9	7	2	3	5	6	7	3	8	13	12	9
2013	6	16	2	9	6	5	4	10	3	5	5	10	6	1	-	22	5	17
2014	13	14	9	7	7	4	6	8	8	5	4	8	7	8	2	25	6	21
2015	3	14	5	4	4	4	1	8	2	6	1	6	3	7	-	17	4	13
2016	5	22	6	6	10	5	11	8	5	3	2	8	9	8	1	26	9	18
2017	4	12	6	5	2	3	5	3	4	4	4	5	4	3	-	16	8	8
2018	1	9	1	2	2	5	4	3	1	2	4	3	3	-	2	8	3	7
2019	2	10	3	3	5	1	4	3	3	2	4	3	4	1	1	11	2	10
2020	1	5	1	1	2	2	2	3	1	-	1	2	1	2	1	5	3	3
2021	-	2	-	1	1	-	2	-	-	-	-	1	1	-	-	2	-	2
2022	1	4	1	2	-	2	1	-	3	1	2	1	-	2	-	5	1	4
2023	-	7	3	1	-	3	2	-	2	3	2	4	1	-	-	7	2	5
2024	-	6	1	-	2	3	5	-	1	-	1	-	2	3	-	6	-	6

Table 11. Deviance table for the final binomial sub-model for the WFL Spear data.

Factor	Df	Resid. Df	Resid. Dev	Deviance	% Deviance Reduced	Family	Dispersion
NULL	1	592	787.2463	787.2463	-		
year	26	566	732.2346	55.01172	2.72		
num_cntrbtrscat	3	563	718.391	13.84363	1.33	Binomial	1.05

Table 12. Deviance table for the final positive sub-model for the WFL Spear data.

Factor	Df	Resid. Df	Resid. Dev	Deviance	% Deviance Reduced	Family	Dispersion
NULL	1	367	262.5905	262.5905	-		
year	26	341	242.0905	20.49998	0.78		
median_avidityca t	3	338	236.8102	5.280282	1.3		
fishing_mode	1	337	234.8763	1.933931	0.51	Gaussian	0.70

Table 13. Nominal mean CPUE and final modeled index for the WFL Spear data.

Year	Num Sampling Events	Num Positive	Prop Positive	Nominal Mean	Nominal CV	Std Index	Std CV	Std Low 95	Std Up 95	Scaled Std Index	Scaled Std Low 95	Scaled Std Up 95
1991	9	9	1	-	-	-	-	-	-	-	-	-
1992	16	5	0.312	1.397	3.097	0.732	0.55	0.214	1.758	0.724	0.212	1.738
1993	15	11	0.733	1.88	1.174	2.048	0.326	1.016	3.597	2.025	1.005	3.557
1994	18	10	0.556	2.247	2.171	1.347	0.342	0.636	2.414	1.332	0.629	2.387
1995	21	9	0.429	1.199	1.86	0.967	0.379	0.414	1.824	0.956	0.409	1.804
1996	26	11	0.423	0.488	1.431	0.577	0.356	0.261	1.056	0.571	0.258	1.044
1997	27	14	0.519	1.02	1.214	1.222	0.298	0.647	2.064	1.208	0.64	2.041
1998	28	16	0.571	1.036	1.253	1.06	0.276	0.587	1.728	1.048	0.58	1.709
1999	32	26	0.812	1.314	1.347	1.019	0.213	0.657	1.497	1.008	0.65	1.48
2000	10	4	0.4	0.595	1.404	0.764	0.578	0.2	1.895	0.755	0.198	1.874
2001	25	15	0.6	0.967	1.377	0.857	0.282	0.471	1.414	0.847	0.466	1.398
2002	22	7	0.318	0.561	2.163	0.533	0.448	0.199	1.117	0.527	0.197	1.104
2003	30	20	0.667	1.031	1.124	0.946	0.247	0.556	1.463	0.935	0.55	1.447
2004	23	10	0.435	0.86	1.541	0.873	0.381	0.38	1.66	0.863	0.376	1.641
2005	16	8	0.5	0.461	1.454	0.443	0.405	0.179	0.892	0.438	0.177	0.882
2006	15	11	0.733	0.816	1.002	0.803	0.316	0.399	1.382	0.794	0.395	1.367
2007	11	9	0.818	-	-	-	-	-	-	-	-	-
2008	22	17	0.773	1.645	0.962	1.348	0.266	0.767	2.164	1.333	0.758	2.14
2009	20	15	0.75	1.713	1.042	1.449	0.281	0.792	2.396	1.433	0.783	2.369
2010	21	16	0.762	1.694	1.096	1.429	0.261	0.817	2.275	1.413	0.808	2.25
2011	16	15	0.938	-	-	-	-	-	-	-	-	-
2012	23	21	0.913	-	-	-	-	-	-	-	-	-
2013	36	22	0.611	1.26	1.331	1.153	0.245	0.678	1.774	1.14	0.67	1.754
2014	34	27	0.794	0.981	1.042	0.857	0.208	0.554	1.25	0.847	0.548	1.236
2015	24	17	0.708	1.164	1.401	0.779	0.267	0.443	1.26	0.77	0.438	1.246
2016	34	27	0.794	1.349	1.023	1.246	0.215	0.798	1.838	1.232	0.789	1.817
2017	23	16	0.696	1.168	0.989	1.153	0.278	0.632	1.886	1.14	0.625	1.865
2018	14	10	0.714	1.142	1.218	1.031	0.324	0.504	1.807	1.019	0.498	1.787
2019	19	12	0.632	1.036	1.145	1.095	0.313	0.555	1.891	1.083	0.549	1.87
2020	11	6	0.545	1.061	1.531	0.905	0.444	0.334	1.884	0.895	0.33	1.863
2021	5	2	0.4	-	-	-	-	-	-	-	-	-
2022	7	5	0.714	-	-	-	-	-	-	-	-	-
2023	8	7	0.875	-	-	-	-	-	-	-	-	-
2024	11	6	0.545	0.59	1.262	0.67	0.464	0.23	1.416	0.662	0.227	1.4

Table 14. Number of trips per year and covariate for the WFL Spear and H&L CPUE.

Year	Waters Fished		Median Hours Fished				Median Avidity			Number of Contributors				Fishing Mode		Season		Gear		
	Nearshore	Offshore	[0.5,3]	(3,4]	(4,5.5]	(5.5,24.5]	[0,2]	(2,5]	(5,63]	1	2	3	4+	CH	PR	Other	Summer	Both	H&L	SPEAR
1991	18	7	14	5	4	2	10	9	6	7	11	4	3	1	24	6	19	3	16	6
1992	25	23	18	8	8	14	15	19	14	7	22	15	4	-	48	14	34	1	42	5
1993	27	24	22	7	10	12	24	10	17	7	17	13	14	1	50	14	37	2	40	9
1994	33	49	32	15	14	21	30	26	26	17	32	14	19	4	78	24	58	2	72	8
1995	25	41	18	12	19	17	24	21	21	11	26	17	12	6	60	20	46	6	56	4
1996	35	29	21	15	13	15	19	24	21	13	25	22	4	2	62	15	49	7	52	5
1997	35	27	21	12	14	15	23	13	26	18	26	13	5	3	59	16	46	7	48	7
1998	57	41	33	16	23	26	47	22	29	18	27	18	35	31	67	34	64	2	82	14
1999	68	64	35	32	23	42	55	29	48	20	56	29	27	19	113	74	58	1	106	25
2000	33	39	13	16	14	29	34	16	22	7	21	23	21	15	57	22	50	1	68	3
2001	51	62	29	28	21	35	54	20	39	14	42	15	42	22	91	50	63	2	98	13
2002	53	60	27	24	28	34	64	21	28	8	46	28	31	34	79	53	60	-	106	7
2003	39	75	39	21	24	30	64	27	23	7	50	21	36	26	88	65	49	8	93	13
2004	15	46	22	11	11	17	37	12	12	3	12	17	29	29	32	33	28	1	51	9
2005	15	41	16	11	13	16	31	12	13	2	15	13	26	19	37	27	29	3	48	5
2006	11	28	14	10	9	6	21	8	10	7	10	10	12	9	30	21	18	2	28	9
2007	19	18	14	5	8	10	25	8	4	5	8	9	15	11	26	23	14	1	28	8
2008	34	30	20	13	20	11	35	12	17	3	32	14	15	12	52	30	34	6	47	11
2009	29	21	18	8	13	11	22	13	15	7	17	13	13	5	45	23	27	3	35	12
2010	19	20	13	10	9	7	20	7	12	4	9	12	14	7	32	15	24	5	23	11
2011	41	28	22	18	15	14	37	18	14	4	26	13	26	17	52	39	30	5	54	10
2012	40	55	40	17	17	21	61	14	20	6	22	25	42	41	54	51	44	5	74	16
2013	41	54	37	18	10	30	40	27	28	9	39	19	28	18	77	39	56	2	73	20
2014	60	79	51	28	27	33	66	29	44	12	36	31	60	49	90	69	70	9	112	18
2015	59	100	57	35	31	36	78	34	47	7	51	42	59	55	104	74	85	5	142	12
2016	80	142	68	50	49	55	136	36	50	7	61	41	113	104	118	79	143	8	194	20
2017	93	128	77	54	43	47	142	37	42	25	63	43	90	95	126	134	87	5	204	12
2018	47	97	50	27	36	31	86	30	28	19	36	32	57	65	79	76	68	-	134	10
2019	39	127	52	49	32	33	102	31	33	16	35	51	64	66	100	80	86	2	154	10
2020	49	95	44	40	25	35	81	27	36	17	34	34	59	57	87	80	64	-	138	6
2021	46	141	58	51	32	46	134	34	19	11	38	18	120	125	62	98	89	2	185	-
2022	53	83	41	34	24	37	91	21	24	21	31	23	61	67	69	70	66	1	131	4
2023	78	139	62	75	35	45	158	23	36	22	49	27	119	128	89	96	121	2	210	5
2024	125	170	117	77	46	55	219	33	43	18	58	60	159	181	114	153	142	2	289	4

Table 15. Number of positive trips per year and covariate for the WFL Spear and H&L CPUE.

Year	Waters Fished		Median Hours Fished				Median Avidity			Number of Contributors				Fishing Mode		Season		Gear		
	Nearshore	Offshore	[0.5,3]	(3,4]	(4,5.5]	(5.5,24.5]	[0,2]	(2,5]	(5,63]	1	2	3	4+	CH	PR	Other	Summer	Both	H&L	SPEAR
1991	5	4	7	-	1	1	2	4	3	3	5	1	-	-	9	2	7	3	-	6
1992	5	8	9	-	1	3	2	5	6	4	7	2	-	-	13	4	9	1	8	4
1993	7	10	10	3	2	2	10	2	5	4	4	4	5	-	17	2	15	2	6	9
1994	5	13	11	2	3	2	6	4	8	6	8	2	2	-	18	2	16	2	8	8
1995	2	16	9	4	3	2	2	6	10	3	9	5	1	-	18	4	14	5	9	4
1996	2	11	11	2	-	-	4	2	7	5	5	3	-	-	13	2	11	7	2	4
1997	6	12	13	2	-	3	2	3	13	12	4	2	-	-	18	5	13	7	4	7
1998	10	16	15	-	6	5	11	6	9	8	9	2	7	7	19	5	21	2	10	14
1999	12	24	19	4	3	10	5	7	24	11	12	6	7	3	33	14	22	1	10	25
2000	2	10	3	2	3	4	3	4	5	4	3	3	2	-	12	4	8	1	8	3
2001	7	13	11	4	-	5	5	5	10	7	6	1	6	3	17	7	13	2	5	13
2002	5	11	7	2	2	5	6	4	6	2	8	3	3	3	13	6	10	-	9	7
2003	7	25	20	4	3	5	14	9	9	4	13	6	9	5	27	8	24	7	12	13
2004	5	9	11	1	2	-	4	2	8	2	4	5	3	2	12	6	8	1	4	9
2005	3	11	8	-	2	4	7	3	4	1	3	5	5	2	12	4	10	3	6	5
2006	3	11	11	-	2	1	6	4	4	3	5	4	2	1	13	5	9	2	3	9
2007	8	9	10	2	3	2	10	4	3	1	4	7	5	3	14	10	7	1	8	8
2008	11	12	15	3	3	2	4	7	12	1	14	5	3	2	21	8	15	6	6	11
2009	14	11	13	3	4	5	8	9	8	4	9	7	5	2	23	6	19	3	10	12
2010	11	12	8	4	5	6	11	3	9	3	5	10	5	2	21	5	18	5	7	11
2011	13	9	8	6	3	5	8	8	6	3	7	4	8	4	18	10	12	5	7	10
2012	6	19	22	1	-	2	12	7	6	5	7	8	5	9	16	14	11	5	4	16
2013	11	18	15	5	3	6	9	11	9	6	14	6	3	2	27	8	21	2	7	20
2014	21	25	26	6	6	8	16	13	17	5	11	10	20	13	33	21	25	9	19	18
2015	11	27	21	6	4	7	18	8	12	1	11	9	17	14	24	25	13	5	21	12
2016	17	31	20	15	5	8	24	9	15	3	16	11	18	13	35	18	30	8	21	19
2017	17	43	32	9	10	9	36	9	15	10	15	15	20	25	35	42	18	4	44	12
2018	6	32	15	8	5	10	25	5	8	6	7	9	16	22	16	26	12	-	28	10
2019	6	32	18	5	6	9	20	10	8	6	10	10	12	16	22	19	19	2	26	10
2020	4	31	14	8	4	9	21	8	6	1	8	10	16	18	17	27	8	-	29	6
2021	9	39	11	16	10	11	42	3	3	1	6	6	35	39	9	32	16	2	46	-
2022	3	29	8	6	7	11	20	4	8	4	6	5	17	18	14	20	12	1	27	4
2023	14	40	17	15	9	13	39	6	9	4	15	7	28	32	22	30	24	2	47	5
2024	13	58	28	14	12	17	58	6	7	4	9	12	46	47	24	41	30	2	65	4

Table 16. Deviance table for the final binomial sub-model for the WFL Spear and H&L data.

Factor	Df	Resid. Df	Resid. Dev	Deviance	% Deviance Reduced	Family	Dispersion
NULL	1	3674	4225.51	4225.51	-		
year	33	3641	4148.43	77.07	0.93		
gear_type	2	3639	2832.16	1316.27	31.4		
waters	1	3638	2788.51	43.65	1.02		
season	1	3637	2751.39	37.12	0.87	Binomial	1.06

Table 17. Deviance table for the final positive sub-model for the WFL Spear and H&L data.

Factor	Df	Resid. Df	Resid. Dev	Deviance	% Deviance Reduced	Family	Dispersion
NULL	1	961	990.53	990.53	-		
year	33	928	934.28	56.26	2.33		
gear_type	2	926	860.73	73.55	7.49	Gaussian	0.9
median_aviditycat	2	924	846.11	14.62	1.34		
season	1	923	831.55	14.56	1.43		

Table 18. Nominal mean CPUE and final modeled index for the WFL Spear and H&L data.

Year	Num Sampling Events	Num Positive	Prop Positive	Nominal Mean	Nominal CV	Std Index	Std CV	Std Low 95	Std Up 95	Scaled Std Index	Scaled Std Low 95	Scaled Std Up 95
1991	25	9	0.36	0.8	1.809	0.996	0.434	0.306	2.004	0.984	0.302	1.979
1992	48	13	0.271	0.641	4.02	1.119	0.272	0.64	1.825	1.105	0.632	1.803
1993	51	17	0.333	0.676	2.169	1.581	0.241	0.965	2.444	1.562	0.953	2.414
1994	82	18	0.22	0.579	4.198	1.104	0.235	0.678	1.692	1.09	0.67	1.671
1995	66	18	0.273	0.523	2.691	1.149	0.232	0.71	1.753	1.135	0.701	1.732
1996	64	13	0.203	0.261	2.268	0.822	0.332	0.387	1.449	0.812	0.382	1.431
1997	62	18	0.29	0.492	1.936	1.157	0.242	0.702	1.788	1.143	0.693	1.766
1998	98	26	0.265	0.378	2.287	1	0.196	0.668	1.431	0.988	0.66	1.413
1999	132	36	0.273	0.384	2.771	0.667	0.177	0.46	0.926	0.659	0.454	0.915
2000	72	12	0.167	0.207	2.93	1.11	0.284	0.616	1.826	1.096	0.608	1.804
2001	113	20	0.177	0.239	3.102	0.662	0.245	0.392	1.024	0.654	0.387	1.011
2002	113	16	0.142	0.158	3.781	0.729	0.255	0.429	1.151	0.72	0.424	1.137
2003	114	32	0.281	0.446	2.319	1.097	0.178	0.764	1.518	1.084	0.755	1.499
2004	61	14	0.23	0.351	2.575	0.798	0.281	0.441	1.309	0.788	0.436	1.293
2005	56	14	0.25	0.2	2.284	0.666	0.267	0.383	1.067	0.658	0.378	1.054
2006	39	14	0.359	0.384	1.786	0.669	0.278	0.374	1.102	0.661	0.369	1.089
2007	37	17	0.459	0.55	1.686	0.854	0.238	0.528	1.326	0.844	0.522	1.31
2008	64	23	0.359	0.674	1.95	1.001	0.206	0.653	1.462	0.989	0.645	1.444
2009	50	25	0.5	0.87	1.687	1.043	0.197	0.703	1.506	1.03	0.694	1.488
2010	39	23	0.59	1.293	1.332	1.641	0.203	1.088	2.38	1.621	1.075	2.351
2011	69	22	0.319	0.576	2.207	1.006	0.211	0.65	1.477	0.994	0.642	1.459
2012	95	25	0.263	0.609	2	1.238	0.224	0.763	1.85	1.223	0.754	1.827
2013	95	29	0.305	0.544	2.199	1.089	0.19	0.736	1.538	1.076	0.727	1.519
2014	139	46	0.331	0.459	2.25	0.853	0.146	0.637	1.119	0.843	0.629	1.105
2015	159	38	0.239	0.308	2.984	0.727	0.162	0.526	0.987	0.718	0.52	0.975
2016	222	48	0.216	0.362	2.862	1.106	0.147	0.82	1.456	1.092	0.81	1.438
2017	221	60	0.271	0.35	2.307	1.082	0.13	0.831	1.382	1.069	0.821	1.365
2018	144	38	0.264	0.35	2.52	0.958	0.163	0.689	1.306	0.946	0.681	1.29
2019	166	38	0.229	0.281	2.621	0.977	0.162	0.701	1.324	0.965	0.692	1.308
2020	144	35	0.243	0.339	2.813	1.047	0.171	0.741	1.437	1.034	0.732	1.419
2021	187	48	0.257	0.328	3.085	1.075	0.149	0.794	1.42	1.062	0.784	1.403
2022	136	32	0.235	0.533	4.474	1.175	0.178	0.819	1.638	1.161	0.809	1.618
2023	217	54	0.249	0.429	3.358	1.236	0.139	0.937	1.603	1.221	0.926	1.583
2024	295	71	0.241	0.285	3.247	0.987	0.127	0.764	1.251	0.975	0.755	1.236

Table 19. Number of trips per year and covariate for the Keys-EFL H&L CPUE.

Year	Waters Fished		Median Hours Fished				Median Avidity			Number of Contributors			Fishing Mode			Season	
	Nearshore	Offshore	[0.5,3]	(3,4]	(4,6]	(6,25]	[0,3]	(3,8]	(8,61]	1	2	3+	CH	PR	SH	Other	Summer
1991	11	6	2	5	5	5	9	6	2	7	6	4	1	12	4	6	11
1992	44	19	17	9	26	11	29	23	11	16	27	20	9	48	6	33	30
1993	69	10	32	18	14	15	39	18	22	41	20	18	-	45	34	23	56
1994	49	17	27	10	17	12	30	16	20	20	17	29	3	50	13	29	37
1995	46	17	25	12	20	6	25	13	25	25	19	19	4	43	16	38	25
1996	19	21	13	9	16	2	15	17	8	13	7	20	4	27	9	24	16
1997	16	11	5	4	11	7	15	5	7	3	7	17	8	16	3	18	9
1998	19	12	8	7	9	7	15	8	8	7	9	15	6	22	3	19	12
1999	26	17	11	14	11	7	22	7	14	13	12	18	10	27	6	32	11
2000	19	19	10	8	16	4	20	10	8	13	7	18	15	18	5	25	13
2001	26	27	13	14	14	12	28	12	13	16	15	22	17	27	9	33	20
2002	38	16	19	12	14	9	32	12	10	20	10	24	17	22	15	33	21
2003	32	40	11	16	30	15	37	20	15	15	26	31	37	26	9	47	25
2004	44	37	26	16	23	16	43	27	11	14	24	43	31	41	9	54	27
2005	32	32	19	12	19	14	45	12	7	13	12	39	34	26	4	50	14
2006	21	24	16	8	17	4	24	7	14	6	21	18	18	26	1	32	13
2007	28	32	23	12	14	11	38	15	7	10	15	35	24	33	3	33	27
2008	47	50	37	25	22	13	68	17	12	26	23	48	49	28	20	58	39
2009	18	19	7	7	19	4	22	7	8	9	9	19	12	19	6	21	16
2010	28	19	21	10	12	4	31	8	8	13	9	25	18	20	9	29	18
2011	24	17	7	13	16	5	25	10	6	9	12	20	18	17	6	28	13
2012	35	30	24	16	17	8	39	14	12	11	24	30	25	34	6	44	21
2013	54	34	34	25	19	10	54	22	12	18	32	38	26	53	9	51	37
2014	71	43	37	31	35	11	56	28	30	27	42	45	26	73	15	74	40
2015	86	41	46	24	44	13	64	31	32	36	55	36	24	85	18	83	44
2016	68	31	37	26	28	8	47	25	27	37	29	33	31	55	13	59	40
2017	47	28	27	19	24	5	39	17	19	25	30	20	21	49	5	53	22
2018	33	35	25	19	16	8	42	17	9	19	25	24	31	31	6	30	38
2019	49	26	28	15	21	11	42	16	17	25	26	24	26	36	13	46	29
2020	50	30	25	24	21	10	39	28	13	33	18	29	25	40	15	47	33
2021	87	26	46	20	26	21	62	33	18	47	29	37	31	45	37	54	59
2022	101	25	42	25	46	13	65	35	26	59	28	39	30	61	35	62	64
2023	109	46	61	24	49	21	93	35	27	60	45	50	38	77	40	72	83
2024	152	37	48	49	57	35	103	41	45	118	36	35	35	65	89	118	71

Table 20. Number of positive trips per year and covariate for the Keys-EFL H&L CPUE.

Year	Waters Fished		Median Hours Fished				Median Avidity			Number of Contributors			Fishing Mode			Season	
	Nearshore	Offshore	(3,4]	(4,6]	(6,25]	[0.5,3]	(3,8]	(8,61]	[0,3]	1	2	3+	CH	PR	SH	Other	Summer
1991	2	3	-	3	2	-	3	-	2	2	-	3	-	5	-	1	4
1992	15	7	5	9	3	5	9	5	8	4	10	8	-	22	-	8	14
1993	22	6	8	7	4	9	10	8	10	6	12	10	-	25	3	14	14
1994	19	9	3	5	6	14	9	7	12	6	10	12	-	25	3	9	19
1995	18	10	9	8	1	10	6	17	5	8	10	10	-	27	1	22	6
1996	7	11	2	8	2	6	10	4	4	4	5	9	-	17	1	12	6
1997	12	3	4	6	1	4	4	4	7	1	5	9	-	14	1	9	6
1998	11	9	3	7	4	6	5	7	8	2	5	13	4	15	1	10	10
1999	12	8	7	5	1	7	4	5	11	3	9	8	4	13	3	13	7
2000	4	3	1	2	1	3	3	1	3	4	2	1	1	3	3	4	3
2001	7	9	2	5	3	6	2	6	8	6	6	4	2	13	1	10	6
2002	8	3	1	-	3	7	4	4	3	2	5	4	4	6	1	5	6
2003	14	12	6	9	4	7	6	7	13	4	14	8	11	12	3	17	9
2004	15	15	10	10	1	9	13	6	11	3	12	15	10	17	3	23	7
2005	8	9	3	4	5	5	4	5	8	8	2	7	6	7	4	11	6
2006	9	6	3	7	-	5	3	7	5	1	8	6	5	9	1	12	3
2007	10	7	4	2	2	9	6	3	8	2	8	7	3	14	-	11	6
2008	15	9	9	2	3	10	3	2	19	2	6	16	13	10	1	15	9
2009	8	7	2	7	2	4	1	6	8	2	4	9	3	12	-	10	5
2010	5	6	3	4	1	3	1	1	9	2	1	8	7	3	1	7	4
2011	8	3	3	5	2	1	4	1	6	1	2	8	5	5	1	10	1
2012	13	5	5	5	2	6	3	4	11	2	9	7	4	12	2	11	7
2013	22	14	10	4	5	17	8	2	26	5	13	18	11	21	4	18	18
2014	30	14	14	9	6	15	13	13	18	10	16	18	11	26	7	30	14
2015	31	10	10	15	4	12	12	11	18	11	19	11	5	28	8	29	12
2016	16	7	5	8	1	9	6	8	9	7	7	9	3	18	2	12	11
2017	12	11	8	6	1	8	4	5	14	2	11	10	10	13	-	17	6
2018	5	5	3	2	-	5	7	-	3	6	1	3	2	4	4	3	7
2019	7	1	-	2	1	5	2	1	5	3	4	1	2	4	2	3	5
2020	12	3	3	4	1	7	5	2	8	7	5	3	2	10	3	9	6
2021	25	4	5	3	7	14	8	6	15	15	5	9	3	13	13	10	19
2022	17	5	3	7	3	9	7	4	11	10	5	7	5	12	5	10	12
2023	20	6	5	10	2	9	9	5	12	11	8	7	5	12	9	10	16
2024	26	1	1	11	4	11	3	5	19	18	4	5	6	6	15	14	13

Table 21. Deviance table for the final binomial sub-model for the Keys-EFL H&L data.

Factor	Df	Resid. Df	Resid. Dev	Deviance	% Deviance Reduced	Family	Dispersion
NULL	1	2491	2970.709	2970.709	-		
year	33	2458	2823.224	147.4856	3.69		
fishing_mode	2	2456	2784.839	38.3849	1.23	Binomial	1.03

Table 22. Deviance table for the final positive sub-model for the Keys-EFL H&L data.

Factor	Df	Resid. Df	Resid. Dev	Deviance	% Deviance Reduced	Family	Dispersion
NULL	1	705	494.0453	494.0453	-		
year	33	672	463.9084	30.13686	1.49		
fishing_mode	2	670	425.4751	38.43331	7.89		
waters	1	669	421.3971	4.077967	0.73	Gaussian	0.63

Table 23. Nominal mean CPUE and final modeled index for the Keys-EFL H&L data.

Year	Num Sampling Events	Num Positive	Prop Positive	Nominal Mean	Nominal CV	Std Index	Std CV	Std Low 95	Std Up 95	Scaled Std Index	Scaled Std Low 95	Scaled Std Up 95
1991	17	5	0.294	0.459	2.067	0.304	0.553	0.088	0.714	1.413	0.409	3.318
1992	63	22	0.349	0.426	2.398	0.22	0.262	0.126	0.349	1.022	0.586	1.622
1993	79	28	0.354	0.914	4.001	0.289	0.227	0.179	0.436	1.343	0.832	2.026
1994	66	28	0.424	0.492	1.699	0.29	0.223	0.183	0.434	1.348	0.85	2.017
1995	63	28	0.444	0.665	2.924	0.344	0.221	0.215	0.511	1.599	0.999	2.375
1996	40	18	0.45	0.544	1.541	0.36	0.272	0.202	0.586	1.673	0.939	2.723
1997	27	15	0.556	0.314	1.147	0.234	0.28	0.127	0.383	1.087	0.59	1.78
1998	31	20	0.645	0.422	1.441	0.287	0.238	0.17	0.437	1.334	0.79	2.031
1999	43	20	0.465	0.413	1.511	0.312	0.255	0.181	0.494	1.45	0.841	2.296
2000	38	7	0.184	0.161	2.545	0.12	0.486	0.042	0.259	0.558	0.195	1.204
2001	53	16	0.302	0.431	2.157	0.299	0.294	0.158	0.499	1.39	0.734	2.319
2002	54	11	0.204	0.211	2.485	0.162	0.368	0.073	0.304	0.753	0.339	1.413
2003	72	26	0.361	0.432	2.417	0.309	0.225	0.191	0.462	1.436	0.888	2.147
2004	81	30	0.37	0.308	1.913	0.229	0.211	0.147	0.336	1.064	0.683	1.562
2005	64	17	0.266	0.235	2.026	0.194	0.289	0.104	0.323	0.902	0.483	1.501
2006	45	15	0.333	0.297	2.145	0.214	0.304	0.11	0.364	0.995	0.511	1.692
2007	60	17	0.283	0.253	2.645	0.177	0.293	0.096	0.297	0.823	0.446	1.38
2008	97	24	0.247	0.206	2.629	0.185	0.243	0.112	0.288	0.86	0.521	1.338
2009	37	15	0.405	0.391	1.895	0.249	0.296	0.131	0.422	1.157	0.609	1.961
2010	47	11	0.234	0.223	2.568	0.2	0.371	0.09	0.373	0.929	0.418	1.733
2011	41	11	0.268	0.149	1.938	0.145	0.365	0.066	0.27	0.674	0.307	1.255
2012	65	18	0.277	0.378	2.463	0.234	0.285	0.127	0.386	1.087	0.59	1.794
2013	88	36	0.409	0.339	1.742	0.237	0.193	0.159	0.339	1.101	0.739	1.575
2014	114	44	0.386	0.529	2.676	0.295	0.178	0.204	0.41	1.371	0.948	1.905
2015	127	41	0.323	0.479	2.187	0.262	0.19	0.178	0.373	1.218	0.827	1.733
2016	99	23	0.232	0.294	2.88	0.154	0.255	0.09	0.242	0.716	0.418	1.125
2017	75	23	0.307	0.326	2.693	0.217	0.252	0.128	0.34	1.008	0.595	1.58
2018	68	10	0.147	0.119	2.568	0.102	0.399	0.044	0.199	0.474	0.204	0.925
2019	75	8	0.107	0.096	4.076	0.066	0.451	0.025	0.139	0.307	0.116	0.646
2020	80	15	0.188	0.236	2.641	0.158	0.324	0.079	0.28	0.734	0.367	1.301
2021	113	29	0.257	0.259	2.342	0.161	0.224	0.1	0.243	0.748	0.465	1.129
2022	126	22	0.175	0.142	2.604	0.105	0.263	0.06	0.169	0.488	0.279	0.785
2023	155	26	0.168	0.17	3.009	0.105	0.243	0.063	0.163	0.488	0.293	0.758
2024	189	27	0.143	0.14	2.983	0.097	0.247	0.058	0.152	0.451	0.27	0.706

Table 24. Number of trips per year and covariate for the Keys-EFL Spear CPUE.

Year	Waters Fished		Median Hours Fished				Median Avidity				Number of Contributors			Fishing Mode		Season	
	Nearshore	Offshore	[0.5,1.5]	(1.5,3]	(3,4]	(4,11]	[0,3]	(3,6]	(6,10]	(10,50]	1	2	3+	CH	PR	Other	Summer
1991	11	1	4	4	3	1	3	3	3	3	7	4	1	-	12	1	11
1992	27	13	9	14	6	11	13	9	10	8	20	13	7	-	40	5	35
1993	21	8	10	10	5	4	5	6	10	8	12	12	5	-	29	3	26
1994	31	11	17	13	4	8	15	5	7	15	22	10	10	-	42	6	36
1995	12	9	4	5	3	9	7	6	7	1	12	5	4	-	21	5	16
1996	6	16	4	8	4	6	9	7	2	4	6	11	5	1	21	5	17
1997	11	6	2	6	3	6	4	2	7	4	4	5	8	1	16	2	15
1998	16	12	9	10	3	6	8	5	7	8	9	11	8	-	28	8	20
1999	14	19	3	15	3	12	9	8	7	9	15	10	8	-	33	13	20
2000	10	4	6	4	1	3	2	3	4	5	8	4	2	-	14	6	8
2001	11	13	14	6	-	4	5	5	8	6	13	8	3	1	23	11	13
2002	22	6	15	6	2	5	5	9	11	3	13	8	7	1	27	10	18
2003	21	17	17	8	6	7	11	3	13	11	13	19	6	2	36	7	31
2004	31	18	10	22	5	12	17	16	8	8	15	22	12	5	44	18	31
2005	20	8	8	7	8	5	9	8	7	4	12	7	9	3	25	10	18
2006	14	4	7	4	1	6	5	5	6	2	7	7	4	-	18	8	10
2007	33	12	17	12	5	11	15	9	14	7	15	16	14	-	45	19	26
2008	16	18	13	7	9	5	13	5	10	6	8	15	11	-	34	14	20
2009	26	6	5	15	3	9	4	3	13	12	8	12	12	1	31	10	22
2010	19	6	7	8	4	6	6	2	5	12	4	14	7	1	24	11	14
2011	18	7	10	5	3	7	10	3	3	9	14	6	5	-	25	8	17
2012	34	24	17	19	12	10	15	17	12	14	26	17	15	1	57	17	41
2013	25	26	16	14	9	12	18	15	6	12	21	20	10	1	50	15	36
2014	57	31	21	34	16	17	30	18	16	24	34	32	22	3	85	25	63
2015	60	32	21	33	17	21	26	27	18	21	29	32	31	5	87	27	65
2016	36	39	14	22	16	23	19	18	21	17	22	30	23	6	69	14	61
2017	29	10	10	10	7	12	12	11	9	7	22	8	9	-	39	8	31
2018	14	9	4	7	4	8	9	4	6	4	6	4	13	-	23	4	19
2019	7	11	6	9	3	-	7	1	6	4	9	8	1	-	18	3	15
2020	4	8	4	4	3	1	2	3	4	3	6	2	4	2	10	3	9
2021	10	7	1	6	3	7	6	3	-	8	7	7	3	-	17	3	14
2022	25	14	4	16	12	7	16	10	7	6	20	10	9	7	32	6	33
2023	18	14	3	14	6	9	11	8	7	6	9	16	7	3	29	8	24
2024	30	12	7	18	7	10	14	7	5	16	18	18	6	9	33	8	34

Table 25. Number of positive trips per year and covariate for the Keys-EFL Spear CPUE.

Year	Waters Fished		Median Hours Fished				Median Avidity				Number of Contributors			Fishing Mode		Season	
	Nearshore	Offshore	[0.5,1.5]	(1.5,3]	(3,4]	(4,11]	[0,3]	(3,6]	(6,10]	(10,50]	1	2	3+	CH	PR	Other	Summer
1991	5	-	1	3	-	1	2	1	1	1	2	2	1	-	5	-	5
1992	14	8	5	7	3	7	8	6	4	4	8	9	5	-	22	2	20
1993	11	6	4	8	3	2	4	3	4	6	5	8	4	-	17	1	16
1994	22	6	9	10	4	5	11	3	6	8	10	9	9	-	28	3	25
1995	4	9	2	4	3	4	4	4	4	1	7	3	3	-	13	5	8
1996	3	12	2	8	2	3	7	5	1	2	3	8	4	-	15	3	12
1997	5	6	1	3	2	5	3	2	3	3	3	2	6	1	10	-	11
1998	8	7	4	6	1	4	6	2	3	4	4	6	5	-	15	5	10
1999	9	14	2	11	2	8	8	6	6	3	9	7	7	-	23	9	14
2000	6	3	4	2	1	2	1	2	2	4	6	2	1	-	9	3	6
2001	7	7	8	4	-	2	3	4	4	3	7	4	3	1	13	6	8
2002	15	3	10	3	2	3	1	8	6	3	8	5	5	1	17	8	10
2003	12	10	8	7	2	5	5	1	7	9	5	13	4	2	20	2	20
2004	22	7	5	16	3	5	9	14	2	4	7	15	7	3	26	11	18
2005	16	4	7	4	4	5	7	5	5	3	9	5	6	2	18	6	14
2006	11	4	6	4	1	4	3	5	6	1	6	5	4	-	15	7	8
2007	26	8	14	8	3	9	9	8	10	7	12	11	11	-	34	13	21
2008	12	12	10	5	6	3	8	4	8	4	5	11	8	-	24	10	14
2009	20	4	2	13	2	7	1	1	11	11	6	8	10	-	24	5	19
2010	13	2	4	4	2	5	4	1	3	7	-	11	4	1	14	8	7
2011	13	4	8	4	1	4	7	1	3	6	11	5	1	-	17	6	11
2012	25	11	12	9	8	7	11	11	7	7	16	11	9	1	35	12	24
2013	16	16	10	10	5	7	11	9	3	9	11	12	9	1	31	14	18
2014	39	19	14	20	12	12	23	13	11	11	19	23	16	3	55	17	41
2015	49	17	17	20	12	17	18	19	12	17	18	27	21	4	62	22	44
2016	22	27	11	17	9	12	12	15	12	10	14	19	16	6	43	9	40
2017	16	4	4	7	2	7	6	8	5	1	9	5	6	-	20	3	17
2018	5	1	1	2	1	2	3	-	2	1	2	1	3	-	6	-	6
2020	1	-	-	-	1	-	-	1	-	-	1	-	-	1	-	-	1
2021	5	2	-	3	2	2	2	1	-	4	2	3	2	-	7	-	7
2022	9	1	-	6	1	3	4	1	2	3	4	4	2	2	8	-	10
2023	9	1	1	7	1	1	4	3	1	2	3	6	1	3	7	-	10
2024	11	2	3	6	-	4	6	2	1	4	5	5	3	4	9	-	13

Table 26. Deviance table for the final binomial sub-model for the Keys-EFL Spear data.

Factor	Df	Resid. Df	Resid. Dev	Deviance	% Deviance Reduced	Family	Dispersion
NULL	1	1159	1560.573	1560.573	-		
year	31	1128	1471.347	89.22583	3.13		
num_cntrbtrscat	2	1126	1453.787	17.55991	0.99		
waters	1	1125	1441.562	12.22482	0.72	Binomial	1.03

Table 27. Deviance table for the final positive sub-model for the Keys-EFL Spear data.

Factor	Df	Resid. Df	Resid. Dev	Deviance	% Deviance Reduced	Family	Dispersion
NULL	1	696	401.1638	401.1638	-		
year	31	665	369.6425	31.52136	3.56		
fishing_mode	1	664	363.0266	6.615836	1.58		
median_avidityca t	3	661	356.8337	6.192895	1.19		
median_hrsfcat	3	658	350.8804	5.953286	1.14	Gaussian	0.53

Table 28. Nominal mean CPUE and final modeled index for the Keys-EFL Spear data.

Year	Num Sampling Events	Num Positive	Prop Positive	Nominal Mean	Nominal CV	Std Index	Std CV	Std Low 95	Std Up 95	Scaled Std Index	Scaled Std Low 95	Scaled Std Up 95
1991	12	5	0.417	0.689	0.326	0.473	0.225	0.453	0.63	0.868	1.459	0.481
1992	40	22	0.55	0.746	0.166	0.223	0.463	0.63	0.731	0.85	1.114	0.224
1993	29	17	0.586	0.687	0.172	0.251	0.397	0.565	0.669	0.794	1.064	0.253
1994	42	28	0.667	0.763	0.144	0.189	0.51	0.66	0.752	0.852	1.069	0.189
1995	21	13	0.619	0.862	0.235	0.273	0.475	0.695	0.835	1	1.397	0.273
1996	22	15	0.682	0.721	0.179	0.248	0.418	0.594	0.704	0.829	1.12	0.248
1997	17	11	0.647	0.572	0.173	0.302	0.292	0.447	0.554	0.674	0.956	0.306
1998	28	15	0.536	0.502	0.134	0.267	0.282	0.406	0.487	0.582	0.8	0.268
1999	33	23	0.697	0.926	0.185	0.2	0.601	0.794	0.91	1.042	1.336	0.2
2000	14	9	0.643	0.812	0.261	0.321	0.387	0.624	0.782	0.967	1.403	0.327
2001	24	14	0.583	0.779	0.205	0.263	0.445	0.634	0.755	0.897	1.244	0.261
2002	28	18	0.643	0.765	0.185	0.242	0.454	0.635	0.749	0.88	1.167	0.244
2003	38	22	0.579	0.739	0.16	0.217	0.465	0.626	0.725	0.839	1.087	0.218
2004	49	29	0.592	0.501	0.096	0.193	0.332	0.433	0.494	0.561	0.71	0.193
2005	28	20	0.714	0.733	0.16	0.218	0.456	0.621	0.72	0.831	1.081	0.219
2006	18	15	0.833	0.598	0.14	0.234	0.352	0.501	0.587	0.682	0.903	0.237
2007	45	34	0.756	0.741	0.126	0.171	0.521	0.651	0.735	0.821	1.009	0.171
2008	34	24	0.706	0.615	0.124	0.201	0.402	0.527	0.606	0.69	0.886	0.202
2009	32	24	0.75	0.734	0.151	0.205	0.47	0.628	0.723	0.828	1.065	0.206
2010	25	15	0.6	0.454	0.122	0.27	0.251	0.366	0.441	0.529	0.727	0.272
2011	25	17	0.68	0.71	0.167	0.236	0.424	0.591	0.696	0.813	1.077	0.237
2012	58	36	0.621	0.54	0.093	0.171	0.376	0.475	0.534	0.598	0.74	0.172
2013	51	32	0.627	0.503	0.091	0.18	0.346	0.439	0.496	0.559	0.696	0.18
2014	88	58	0.659	0.739	0.102	0.137	0.557	0.669	0.733	0.805	0.954	0.137
2015	92	66	0.717	0.745	0.096	0.128	0.571	0.678	0.74	0.806	0.943	0.128
2016	75	49	0.653	0.532	0.077	0.144	0.396	0.478	0.527	0.581	0.693	0.144
2017	39	20	0.513	0.531	0.126	0.238	0.32	0.442	0.519	0.608	0.813	0.24
2018	23	6	0.261	0.119	0.057	0.483	0.041	0.078	0.108	0.147	0.259	0.476
2019	18	-	-	-	-	-	-	-	-	-	-	-
2020	12	1	0.083	-	-	-	-	-	-	-	-	-
2021	17	7	0.412	0.228	0.093	0.408	0.09	0.161	0.213	0.278	0.453	0.41
2022	39	10	0.256	0.186	0.068	0.366	0.084	0.137	0.175	0.224	0.348	0.362
2023	32	10	0.312	0.248	0.089	0.359	0.113	0.185	0.235	0.297	0.46	0.356
2024	42	13	0.31	0.233	0.074	0.317	0.116	0.179	0.223	0.276	0.401	0.316

Table 29. Number of trips per year and covariate for the Keys-EFL Spear and H&L CPUE.

Year	Waters Fished		Median Hours Fished				Median Avidity			Number of Contributors			Fishing Mode			Season		Gear		
	Nearshore	Offshore	[0.5,2.5]	(2.5,4]	(4,5]	(5,24.5]	[0,4]	(4,9]	(9,61]	1	2	3+	CH	PR	SH	Other	Summer	Both	H&L	SPEAR
1991	6	1	2	2	2	1	3	2	2	1	4	2	-	6	1	3	4	1	4	2
1992	38	13	13	11	9	18	27	14	10	11	25	15	8	41	2	23	28	4	34	13
1993	62	3	25	21	5	14	34	8	23	40	15	10	-	34	31	15	50	5	52	8
1994	47	4	22	11	7	11	25	7	19	19	13	19	3	37	11	14	37	7	26	18
1995	38	7	9	16	7	13	22	6	17	21	11	13	4	26	15	26	19	2	39	4
1996	12	15	2	9	7	9	12	9	6	6	4	17	4	18	5	9	18	1	22	4
1997	17	10	2	6	6	13	12	5	10	2	4	21	7	18	2	15	12	1	21	5
1998	22	5	6	8	5	8	13	5	9	7	6	14	5	19	3	19	8	-	21	6
1999	19	11	7	12	4	7	17	6	7	8	10	12	9	17	4	22	8	3	21	6
2000	11	10	6	6	2	7	11	6	4	11	5	5	7	11	3	11	10	-	14	7
2001	12	12	5	6	2	11	13	4	7	7	4	13	10	10	4	16	8	-	20	4
2002	17	11	9	10	2	7	12	9	7	8	8	12	13	14	1	15	13	3	17	8
2003	24	30	9	15	6	24	29	10	15	9	23	22	30	20	4	28	26	1	38	15
2004	38	35	24	23	8	18	45	20	8	10	27	36	31	37	5	51	22	6	45	22
2005	21	28	15	12	6	16	35	7	7	12	8	29	27	19	3	31	18	1	33	15
2006	19	21	14	11	7	8	21	6	13	10	16	14	16	23	1	30	10	1	29	10
2007	30	33	23	14	10	16	37	17	9	17	21	25	17	44	2	31	32	-	34	29
2008	44	46	30	32	10	18	61	16	13	23	23	44	43	30	17	54	36	3	68	19
2009	25	17	6	14	9	13	16	9	17	10	11	21	10	30	2	17	25	2	22	18
2010	17	18	8	15	6	6	21	2	12	3	14	18	17	16	2	22	13	-	22	13
2011	22	12	12	8	7	7	19	7	8	15	7	12	10	20	4	19	15	-	18	16
2012	38	28	18	25	11	12	35	13	18	21	22	23	21	40	5	35	31	-	39	27
2013	40	30	22	28	9	11	45	13	12	17	27	26	23	42	5	43	27	3	44	23
2014	72	33	33	47	10	15	54	19	32	29	43	33	20	72	13	51	54	2	56	47
2015	81	28	32	41	19	17	54	24	31	35	44	30	23	73	13	53	56	4	58	47
2016	44	35	24	31	14	10	42	15	22	25	26	28	27	45	7	32	47	2	46	31
2017	38	17	13	21	10	11	36	6	13	11	23	21	20	34	1	34	21	-	40	15
2018	28	21	12	21	8	8	33	10	6	13	14	22	26	18	5	16	33	-	42	7
2019	36	16	11	18	7	16	33	10	9	18	18	16	26	13	13	31	21	-	51	1
2020	36	18	11	27	4	12	31	13	10	22	13	19	23	21	10	31	23	-	52	2
2021	62	16	15	32	9	22	47	16	15	41	15	22	22	21	35	29	49	3	72	3
2022	64	12	18	24	17	17	47	12	17	39	15	22	27	21	28	38	38	-	68	8
2023	80	27	24	40	23	20	67	16	24	47	29	31	32	40	35	48	59	3	96	8
2024	116	20	19	54	17	46	80	13	43	93	24	19	30	29	77	86	50	8	120	8

Table 30. Number of positive trips per year and covariate for the Keys-EFL Spear and H&L CPUE.

Year	Waters Fished		Median Hours Fished				Median Avidity			Number of Contributors			Fishing Mode			Season		Gear		
	Nearshore	Offshore	[0.5,2.5]	(2.5,4]	(4,5]	(5,24.5]	[0,4]	(4,9]	(9,61]	1	2	3+	CH	PR	SH	Other	Summer	Both	H&L	SPEAR
1991	4	-	2	-	2	-	2	1	1	-	2	2	-	4	-	1	3	1	1	2
1992	22	8	11	6	6	7	13	9	8	7	15	8	-	30	-	7	23	4	13	13
1993	24	3	12	8	3	4	9	6	12	9	11	7	-	24	3	11	16	5	14	8
1994	34	2	18	7	4	7	17	7	12	13	12	11	-	31	5	7	29	7	12	17
1995	20	5	5	10	3	7	8	2	15	7	7	11	-	24	1	20	5	2	19	4
1996	7	8	1	3	4	7	5	6	4	2	4	9	-	14	1	5	10	1	10	4
1997	14	4	1	6	5	6	5	5	8	1	4	13	1	16	1	7	11	1	12	5
1998	15	5	5	6	3	6	9	3	8	4	3	13	4	15	1	13	7	-	14	6
1999	15	7	7	8	4	3	12	5	5	6	9	7	4	15	3	14	8	3	13	6
2000	9	4	4	5	-	4	5	4	4	8	4	1	1	9	3	6	7	-	7	6
2001	9	5	5	3	2	4	6	2	6	5	3	6	3	10	1	9	5	-	10	4
2002	14	4	9	5	-	4	5	8	5	7	7	4	4	13	1	9	9	3	7	8
2003	21	13	9	11	3	11	14	6	14	7	18	9	13	18	3	17	17	1	19	14
2004	31	18	20	16	6	7	26	16	7	7	23	19	13	33	3	31	18	5	23	21
2005	19	10	11	8	5	5	18	5	6	12	5	12	8	18	3	14	15	1	13	15
2006	15	10	8	7	6	4	10	5	10	7	9	9	5	19	1	19	6	1	14	10
2007	25	15	18	10	6	6	20	14	6	13	15	12	3	37	-	19	21	-	14	26
2008	24	17	17	16	3	5	25	9	7	7	13	21	13	26	2	25	16	3	19	19
2009	22	10	5	12	7	8	8	9	15	7	10	15	3	29	-	13	19	2	12	18
2010	14	8	4	10	4	4	11	2	9	2	11	9	8	13	1	13	9	-	10	12
2011	18	7	11	4	5	5	12	6	7	12	6	7	5	19	1	15	10	-	9	16
2012	31	11	14	16	7	5	20	10	12	15	16	11	5	35	2	19	23	-	17	25
2013	30	21	21	18	3	9	31	10	10	13	20	18	12	35	4	28	23	3	27	21
2014	56	26	25	38	5	14	42	15	25	21	34	27	14	61	7	36	46	2	36	44
2015	61	19	28	27	14	11	34	21	25	25	32	23	9	63	8	37	43	4	32	44
2016	27	23	18	16	11	5	22	12	16	16	18	16	8	40	2	16	34	2	17	31
2017	20	11	7	14	4	6	18	5	8	7	11	13	10	21	-	20	11	-	20	11
2018	8	5	5	4	2	2	6	6	1	6	1	6	2	7	4	3	10	-	9	4
2019	6	1	3	2	1	1	6	-	1	3	3	1	2	3	2	3	4	-	7	-
2020	12	2	4	7	1	2	7	5	2	7	5	2	3	8	3	7	7	-	13	1
2021	22	5	6	13	1	7	16	4	7	14	5	8	3	12	12	8	19	2	22	3
2022	19	3	6	8	1	7	12	3	7	9	6	7	7	11	4	9	13	-	16	6
2023	22	4	7	9	6	4	14	5	7	11	9	6	7	10	9	9	17	3	20	3
2024	26	2	7	7	3	11	17	3	8	20	4	4	7	6	15	13	15	4	20	4

Table 31. Deviance table for the final binomial sub-model for the Keys-EFL Spear and H&L data.

Factor	Df	Resid. Df	Resid. Dev	Deviance	% Deviance Reduced	Family	Dispersion
NULL	1	1918	2654.55	2654.55	-		
year	33	1885	2338.78	315.77	10.35		
gear_type	2	1883	1960.55	378.23	14.42		
fishing_mode	2	1881	1843.72	116.84	4.41	Binomial	1.05

Table 32. Deviance table for the final positive sub-model for the Keys-EFL Spear and H&L data.

Factor	Df	Resid. Df	Resid. Dev	Deviance	% Deviance Reduced	family	Dispersion
NULL	1	1011	675.87	675.87	-		
year	33	978	645.39	30.47	1.29		
fishing_mode	2	976	589.26	56.14	8.4		
gear_type	2	974	553.94	35.32	5.24		
waters	1	973	549.26	4.68	0.63		
median_avidityca t	2	971	544.73	4.54	0.52	Gaussian	0.56

Table 33. Nominal mean CPUE and final modeled index for the Keys-EFL Spear and H&L data.

Year	Num Sampling Events	Num Positive	Prop Positive	Nominal Mean	Nominal CV	Std Index	Std CV	Std Low 95	Std Up 95	Scaled Std Index	Scaled Std Low 95	Scaled Std Up 95
1991	7	4	0.571	1.535	1.678	0.699	0.54	0.175	1.613	1.064	0.266	2.455
1992	51	30	0.588	1.079	1.986	0.705	0.187	0.472	0.985	1.073	0.718	1.499
1993	65	27	0.415	1.138	3.431	0.642	0.204	0.414	0.93	0.977	0.63	1.415
1994	51	36	0.706	0.976	1.256	0.662	0.165	0.465	0.892	1.007	0.708	1.357
1995	45	25	0.556	0.575	1.32	0.664	0.188	0.447	0.932	1.01	0.68	1.418
1996	27	15	0.556	0.713	1.326	0.738	0.236	0.44	1.119	1.123	0.67	1.703
1997	27	18	0.667	0.499	1.355	0.463	0.206	0.3	0.673	0.705	0.457	1.024
1998	27	20	0.741	0.65	1.234	0.565	0.193	0.377	0.805	0.86	0.574	1.225
1999	30	22	0.733	0.898	1.15	0.894	0.176	0.621	1.239	1.36	0.945	1.886
2000	21	13	0.619	0.758	1.106	0.747	0.244	0.442	1.148	1.137	0.673	1.747
2001	24	14	0.583	0.714	1.329	0.889	0.229	0.549	1.344	1.353	0.835	2.045
2002	28	18	0.643	0.841	1.272	0.794	0.205	0.519	1.156	1.208	0.79	1.759
2003	54	34	0.63	0.803	1.484	0.86	0.145	0.638	1.13	1.309	0.971	1.72
2004	73	49	0.671	0.685	1.127	0.708	0.127	0.548	0.897	1.077	0.834	1.365
2005	49	29	0.592	0.669	1.457	0.711	0.161	0.513	0.956	1.082	0.781	1.455
2006	40	25	0.625	0.664	1.36	0.66	0.174	0.459	0.909	1.004	0.699	1.383
2007	63	40	0.635	0.721	1.171	0.622	0.167	0.435	0.843	0.947	0.662	1.283
2008	90	41	0.456	0.521	1.818	0.651	0.148	0.477	0.858	0.991	0.726	1.306
2009	42	32	0.762	0.984	0.947	0.767	0.158	0.551	1.021	1.167	0.839	1.554
2010	35	22	0.629	0.628	1.239	0.682	0.187	0.46	0.957	1.038	0.7	1.456
2011	34	25	0.735	0.927	1.352	0.718	0.174	0.497	0.985	1.093	0.756	1.499
2012	66	42	0.636	0.8	1.465	0.657	0.152	0.478	0.868	1	0.727	1.321
2013	70	51	0.729	0.71	1.136	0.668	0.124	0.521	0.843	1.017	0.793	1.283
2014	105	82	0.781	1.215	1.329	0.931	0.105	0.753	1.135	1.417	1.146	1.727
2015	109	80	0.734	1.08	1.132	0.847	0.11	0.674	1.037	1.289	1.026	1.578
2016	79	50	0.633	0.768	1.509	0.603	0.139	0.452	0.782	0.918	0.688	1.19
2017	55	31	0.564	0.678	1.776	0.683	0.175	0.472	0.939	1.039	0.718	1.429
2018	49	13	0.265	0.187	1.887	0.315	0.302	0.16	0.533	0.479	0.243	0.811
2019	52	7	0.135	0.129	3.589	0.351	0.405	0.144	0.689	0.534	0.219	1.049
2020	54	14	0.259	0.35	2.117	0.702	0.264	0.394	1.116	1.068	0.6	1.698
2021	78	27	0.346	0.339	1.988	0.499	0.182	0.341	0.696	0.759	0.519	1.059
2022	76	22	0.289	0.242	1.884	0.462	0.213	0.293	0.678	0.703	0.446	1.032
2023	107	26	0.243	0.247	2.417	0.4	0.217	0.247	0.589	0.609	0.376	0.896
2024	136	28	0.206	0.213	2.343	0.383	0.213	0.243	0.563	0.583	0.37	0.857

Figures

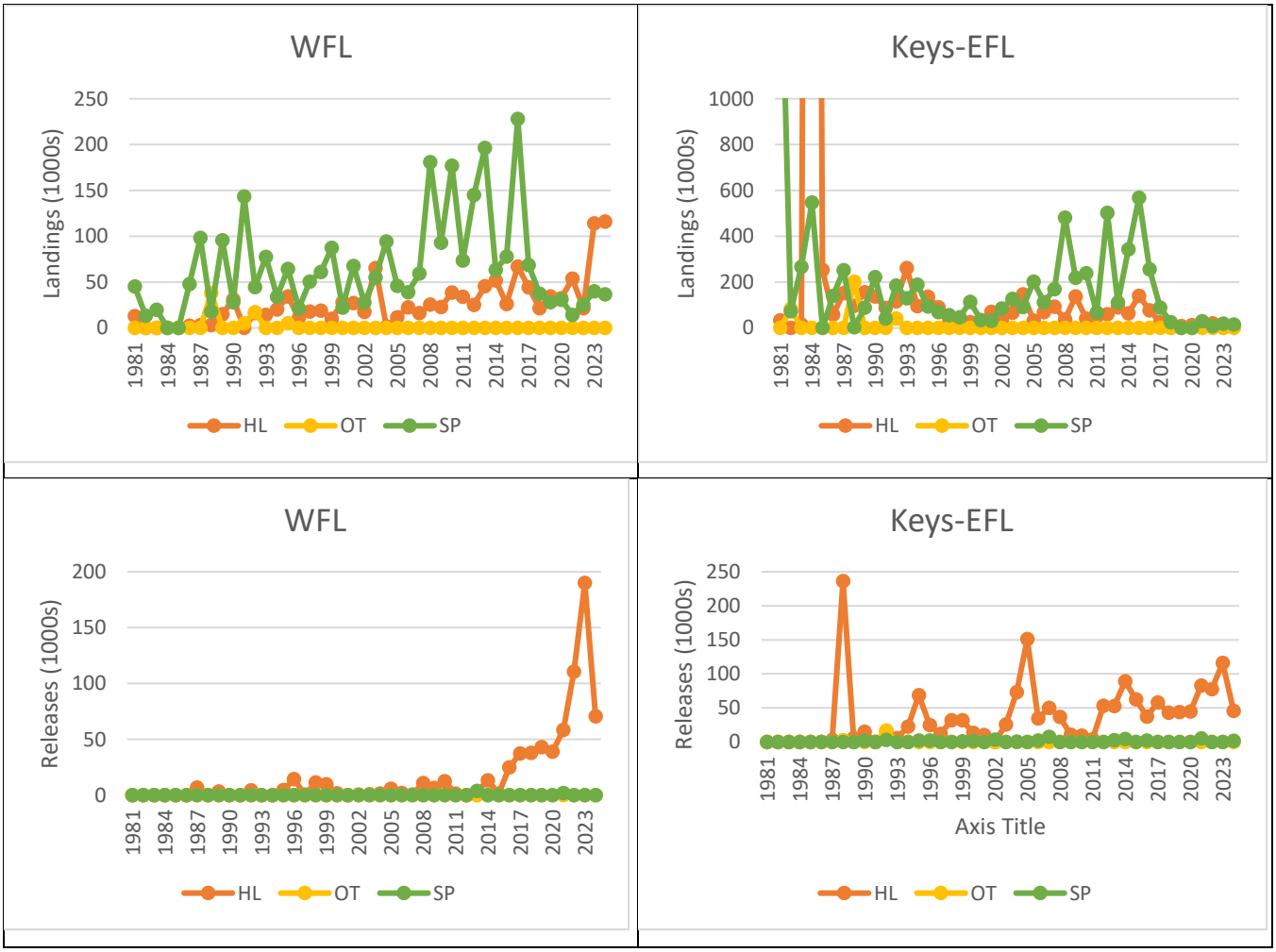

Figure 1. Preliminary landings and releases (in 1000s) of hogfish by region and gear (Hook and Line [HL], Spear [SP], and Other [OT]). Note that landings and releases in some years have PSEs > 50%.

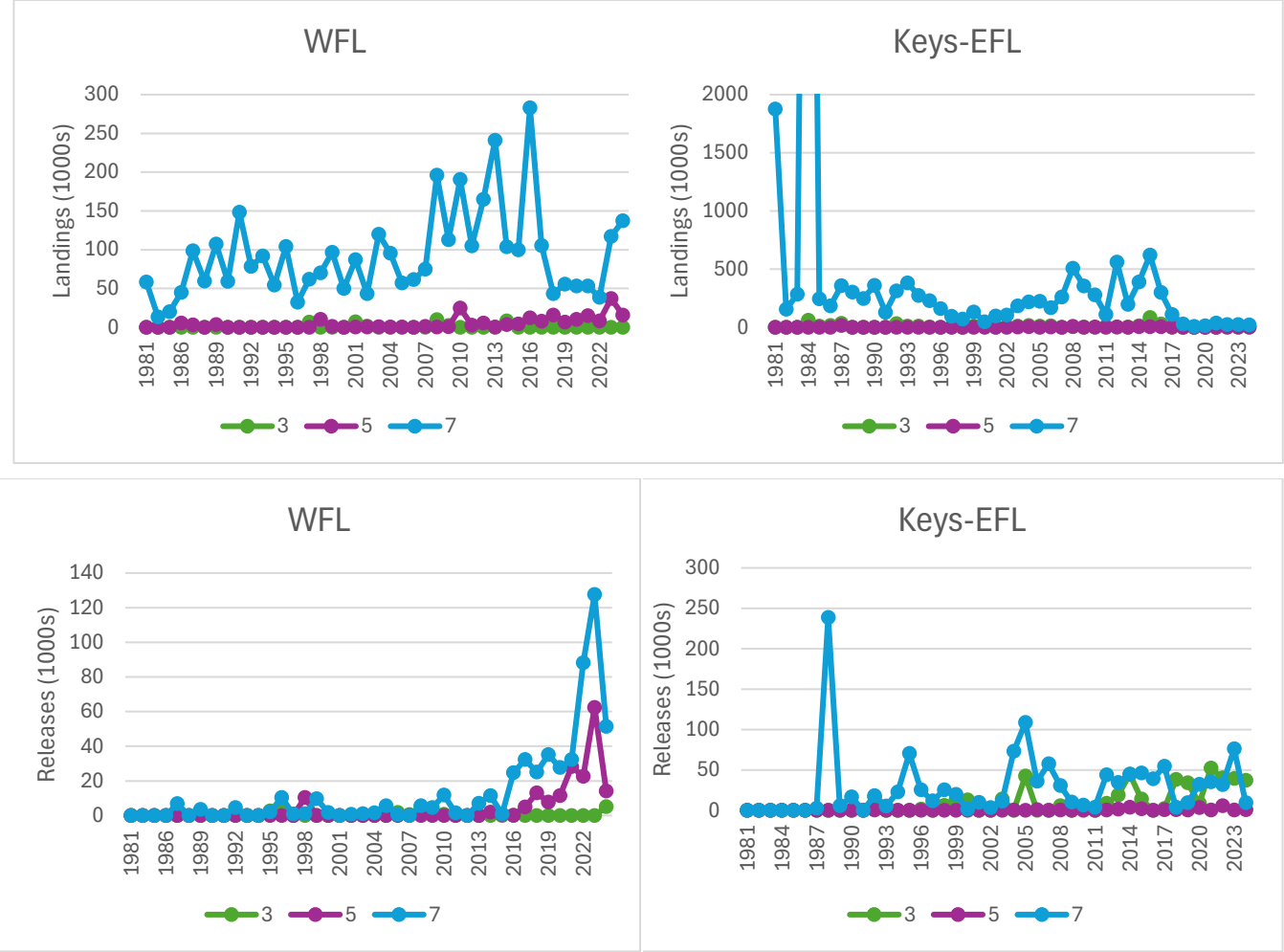

Figure 2. Preliminary landings and releases (in 1000s) of hogfish by region and fishing mode (Private [7], Shore [3], and Charter [5]). Note that landings and releases in some years have PSEs > 50%.

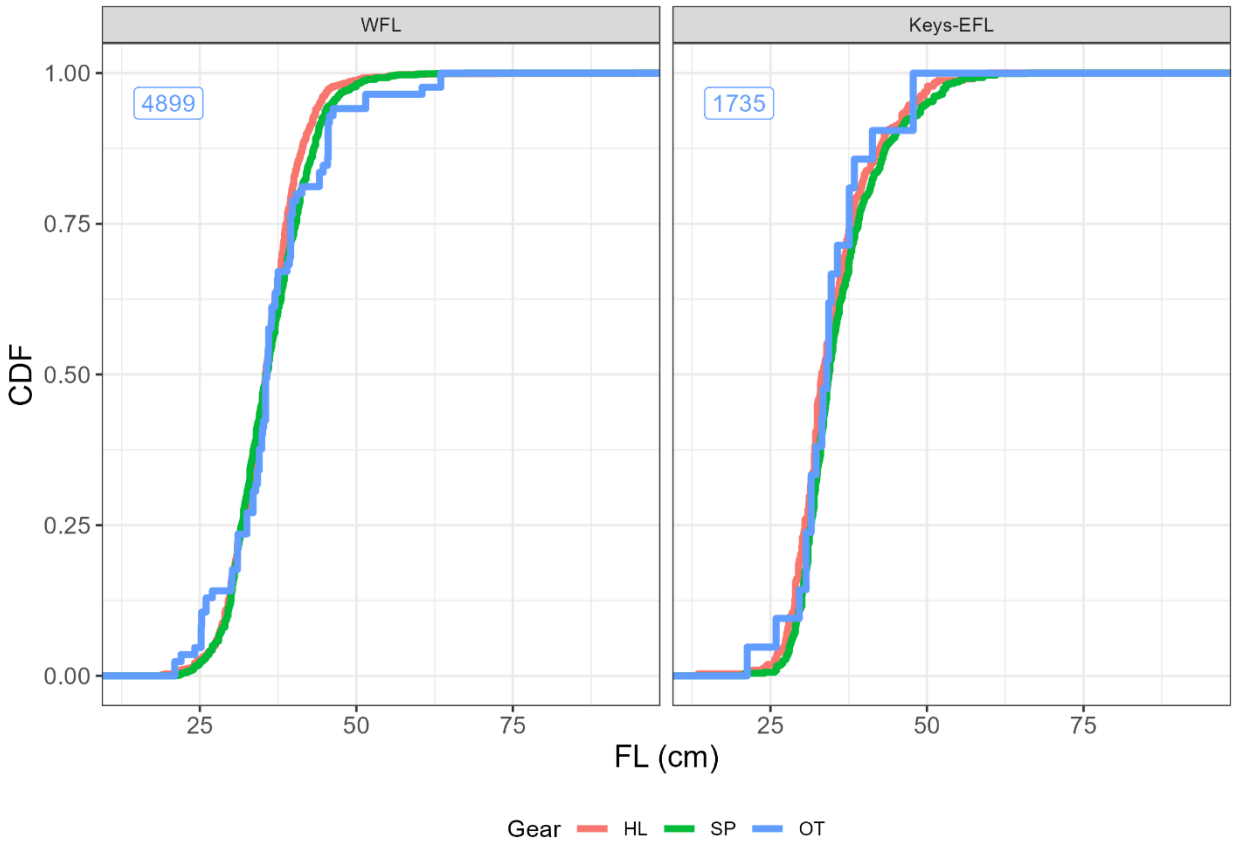

Figure 3. Sampled fork lengths [FL] in mm of landed Hogfish by region and gear (Hook and Line [HL], Spear [SP], and Other/Unknown [OT]). Minimum size limits (in fork length) in federal waters of the South Atlantic (SAFMC) enacted in 1/1995 and 8/2017 were 30.5 cm (12 in.) and 40.6 (16 in.), respectively. For the Gulf, minimum size limits in federal waters enacted in 11/1999 and 8/2017 were 30.5 cm (12 in) and 35.6 cm (14 in), respectively. The state of Florida enacted a 12-inch minimum size limit (in fork length) in 1994 and applied the SAFMC and GMFMC regulations starting in 2018.

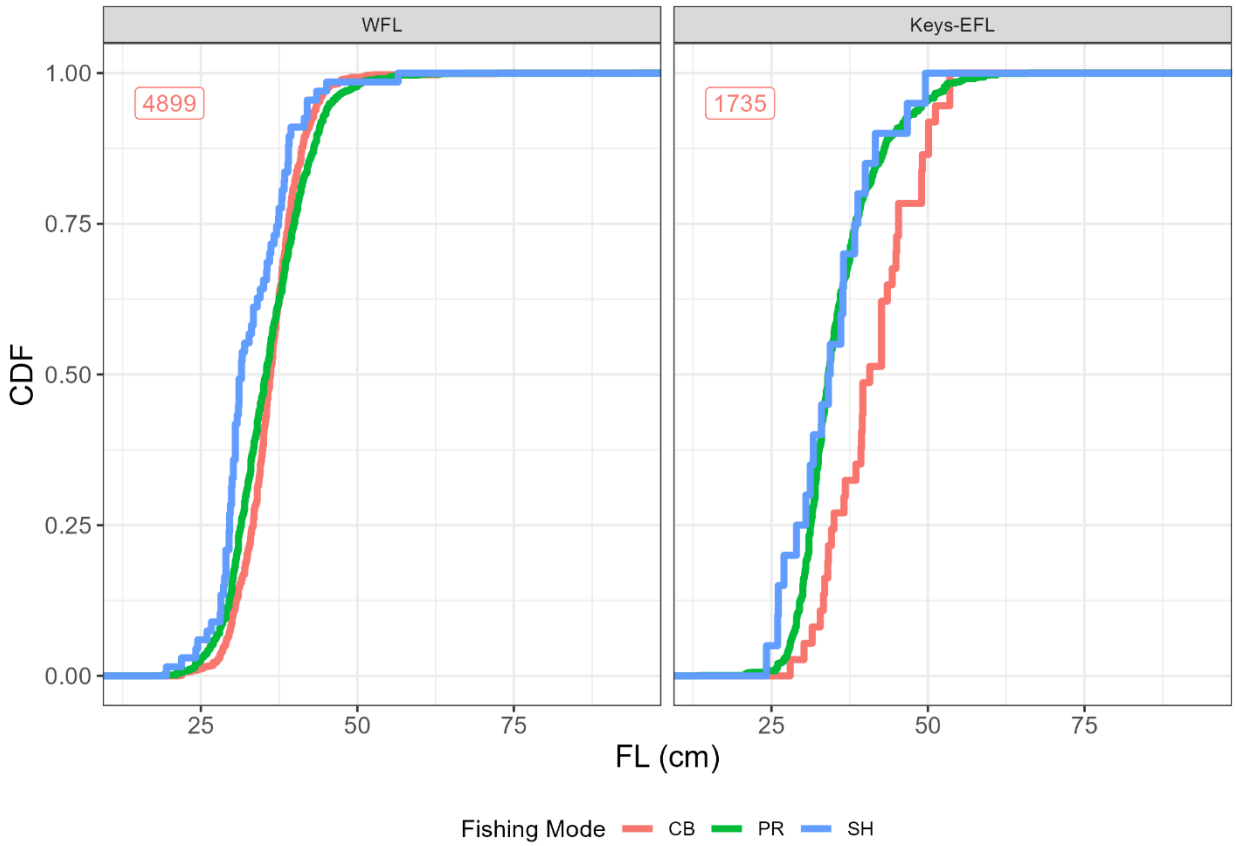

Figure 4. Sampled fork lengths [FL] in mm of landed Hogfish by region and fishing mode (Private [PR], Shore [SH], and Charter [CB]). Minimum size limits (in fork length) in federal waters of the South Atlantic (SAFMC) enacted in 1/1995 and 8/2017 were 30.5 cm (12 in.) and 40.6 (16 in.), respectively. For the Gulf, minimum size limits in federal waters enacted in 11/1999 and 8/2017 were 30.5 cm (12 in) and 35.6 cm (14 in), respectively. The state of Florida enacted a 12-inch minimum size limit (in fork length) in 1994 and applied the SAFMC and GMFMC regulations starting in 2018.

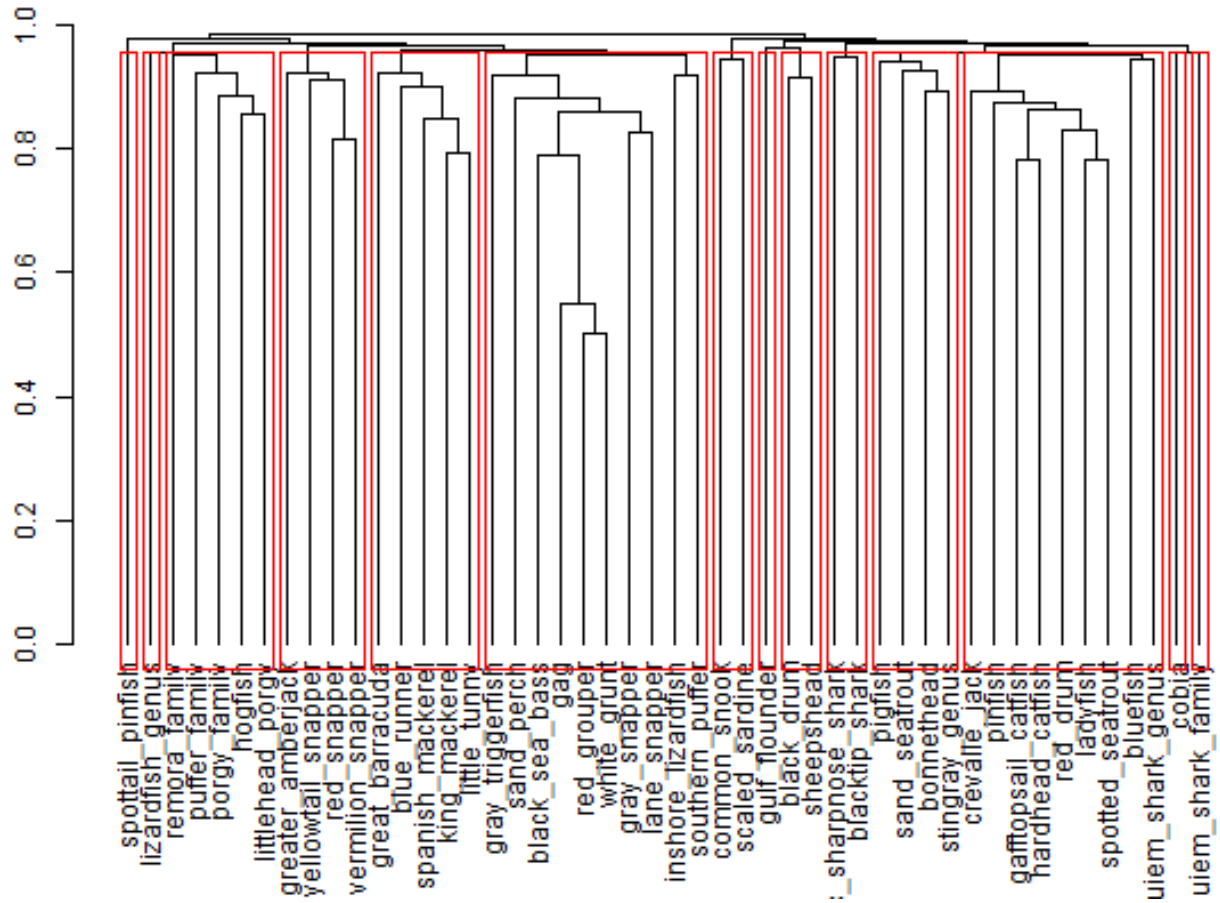

Figure 5. Dendrogram and resulting clusters that maximize average silhouette width of the percent fourth root of total catch for WFL H&L (charter and private mode, nearshore and offshore).

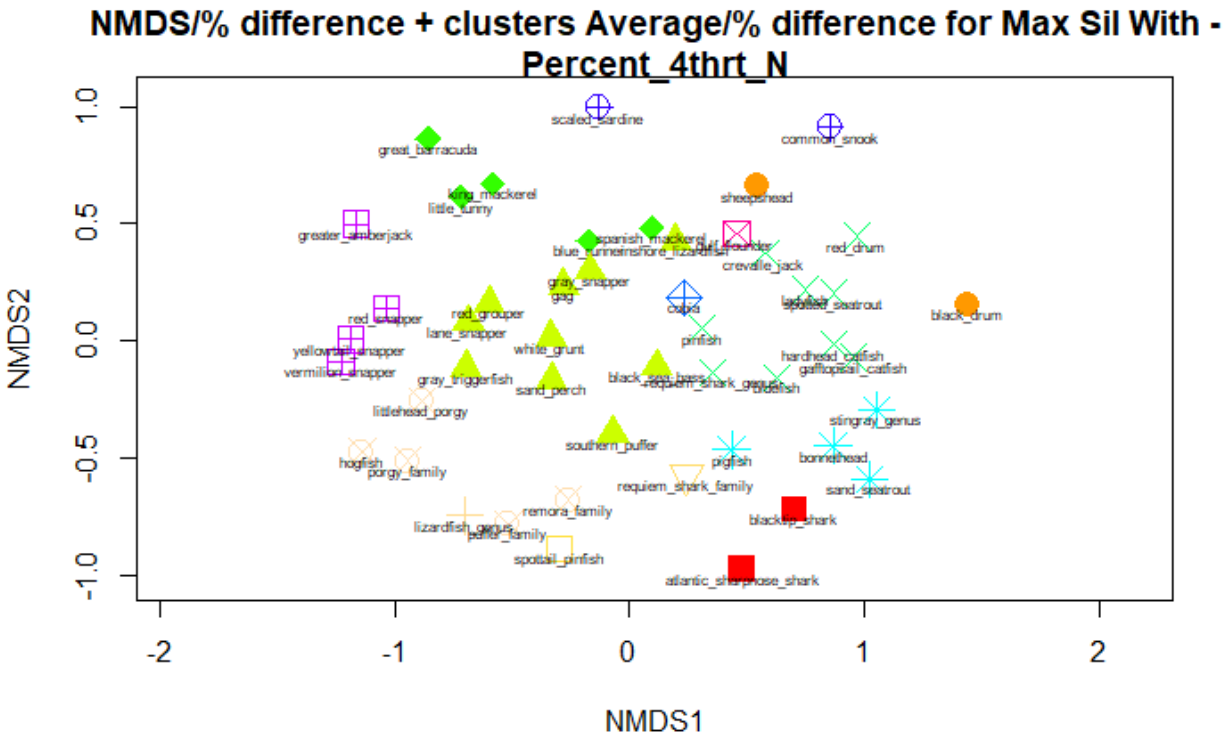

Figure 6. Non-metric multi-dimensional scaling (NMDS) ordination plot. Point type and color identify clusters resulting in the maximum average silhouette width of the percent fourth root of total catch in WFL H&L (charter and private mode, nearshore and offshore).

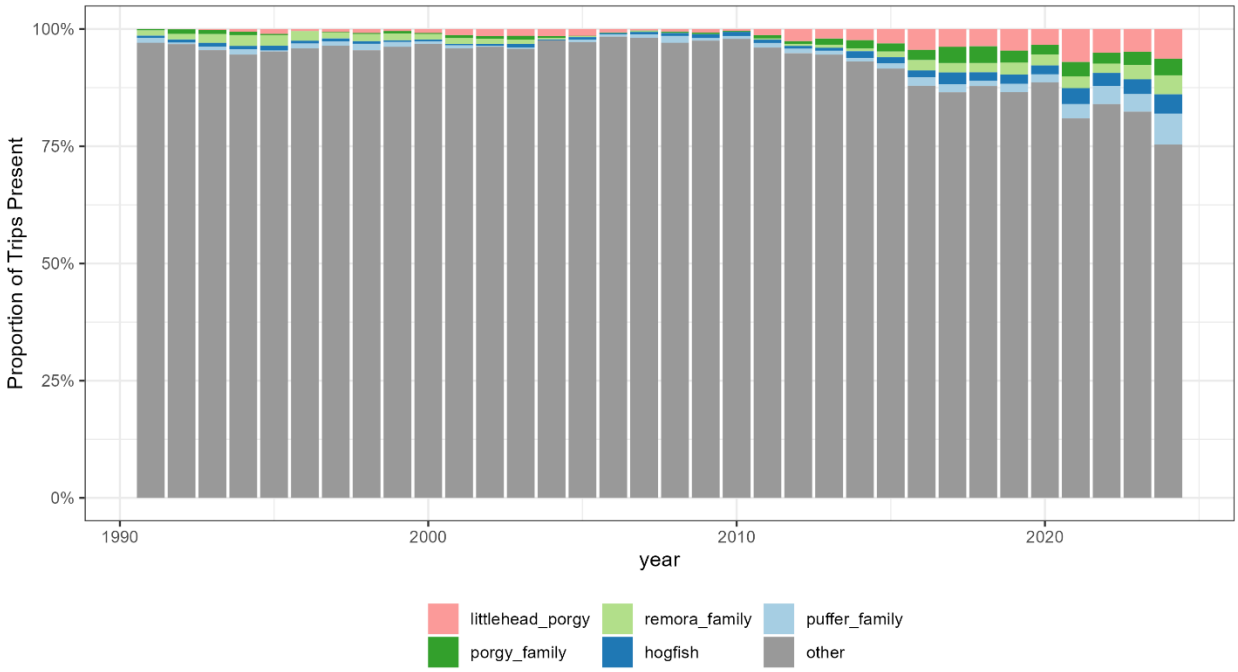

Figure 7. Proportion of angler trips with species present identified by the clustering method in WFL H&L (charter and private mode, nearshore and offshore) in addition to all other species ('other').

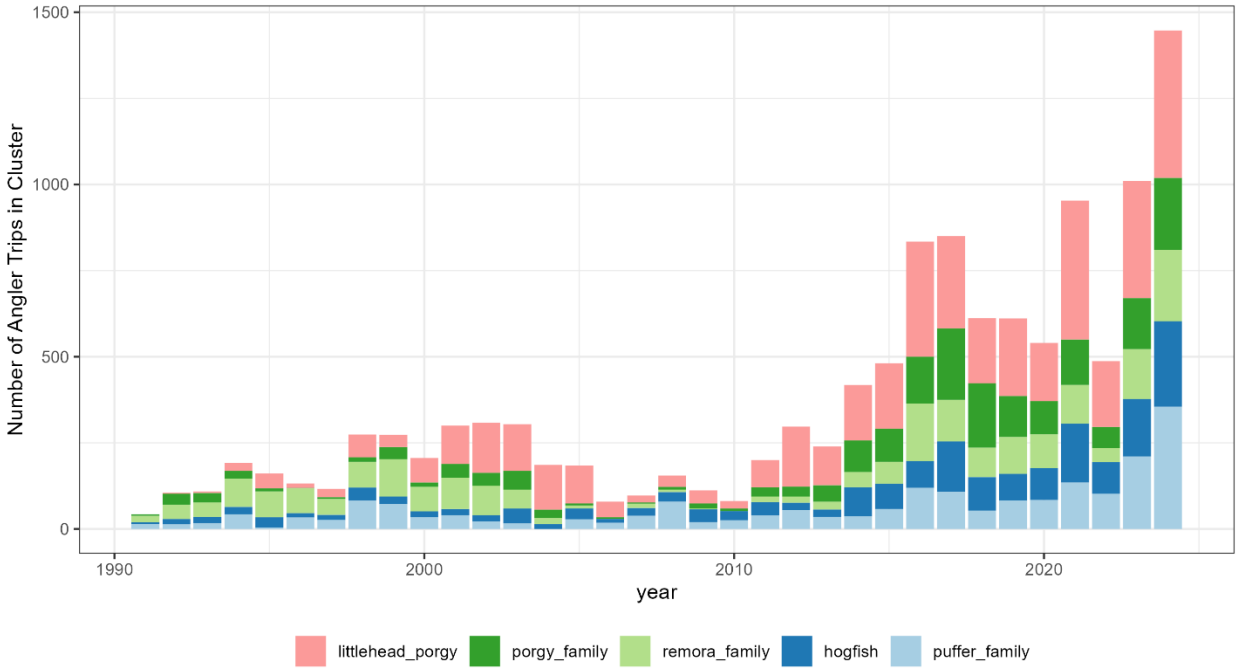

Figure 8. Number of angler trips by species that encountered at least one species identified by the clustering method in WFL H&L (charter and private mode, nearshore and offshore)

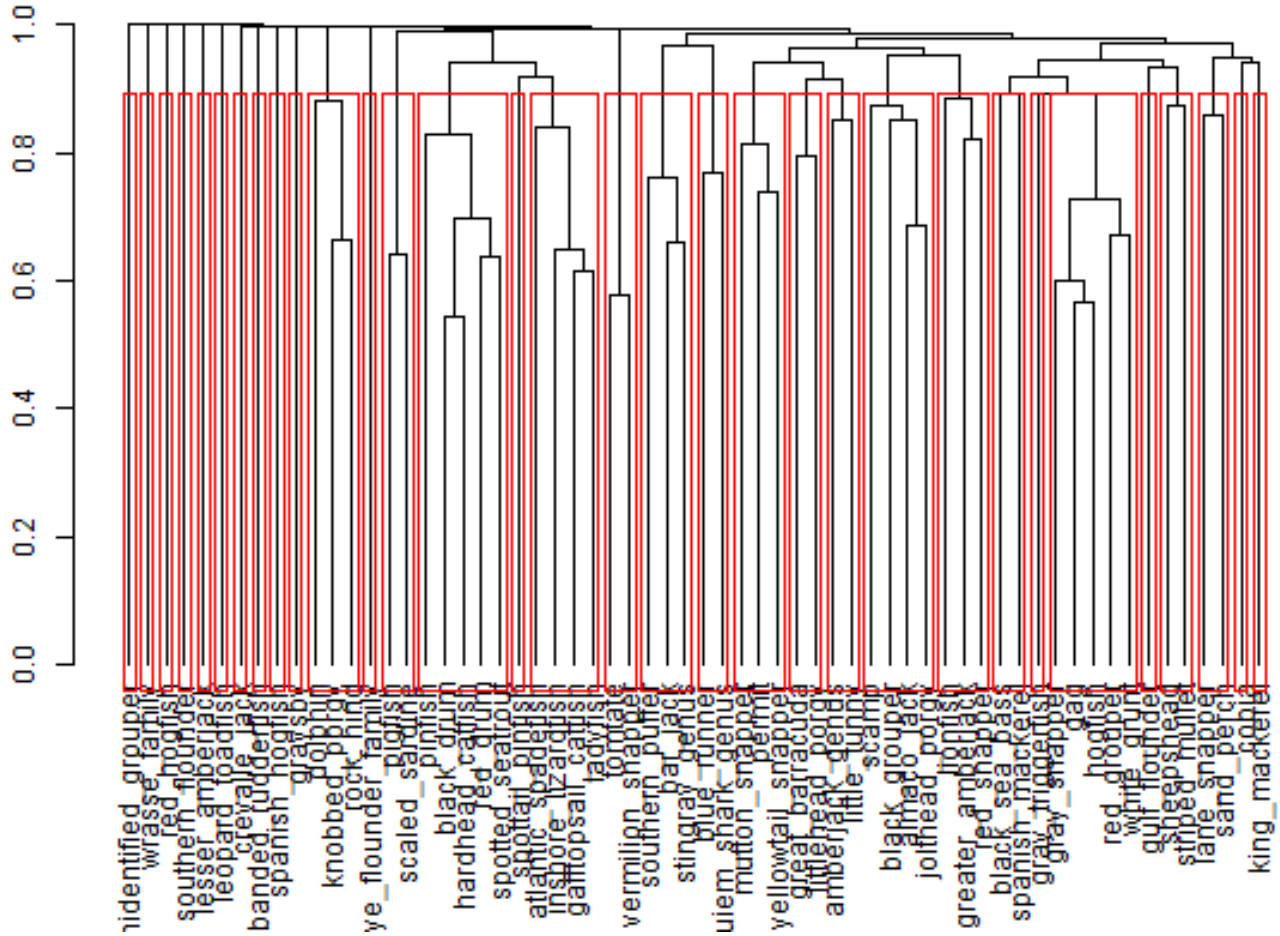

Figure 9. Dendrogram and resulting clusters that maximize average silhouette width of the fourth root of catches (landings + releases) for WFL Spear trips (charter and private mode, nearshore and offshore).

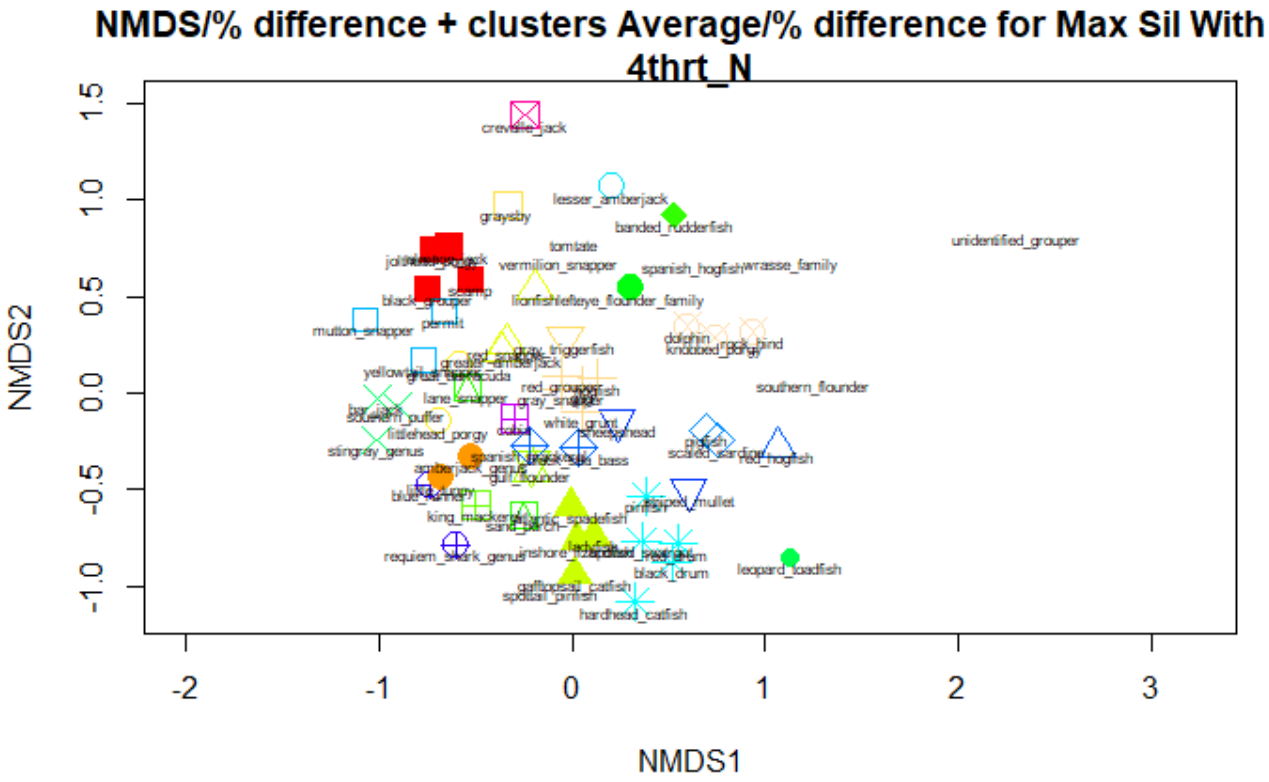

Figure 10. Non-metric Multi-dimensional scaling (NMDS) ordination plot. Point type and color identify clusters resulting in the maximum average silhouette width of fourth root of catches (landings + releases) in WFL Spear trips (charter and private mode, nearshore and offshore).

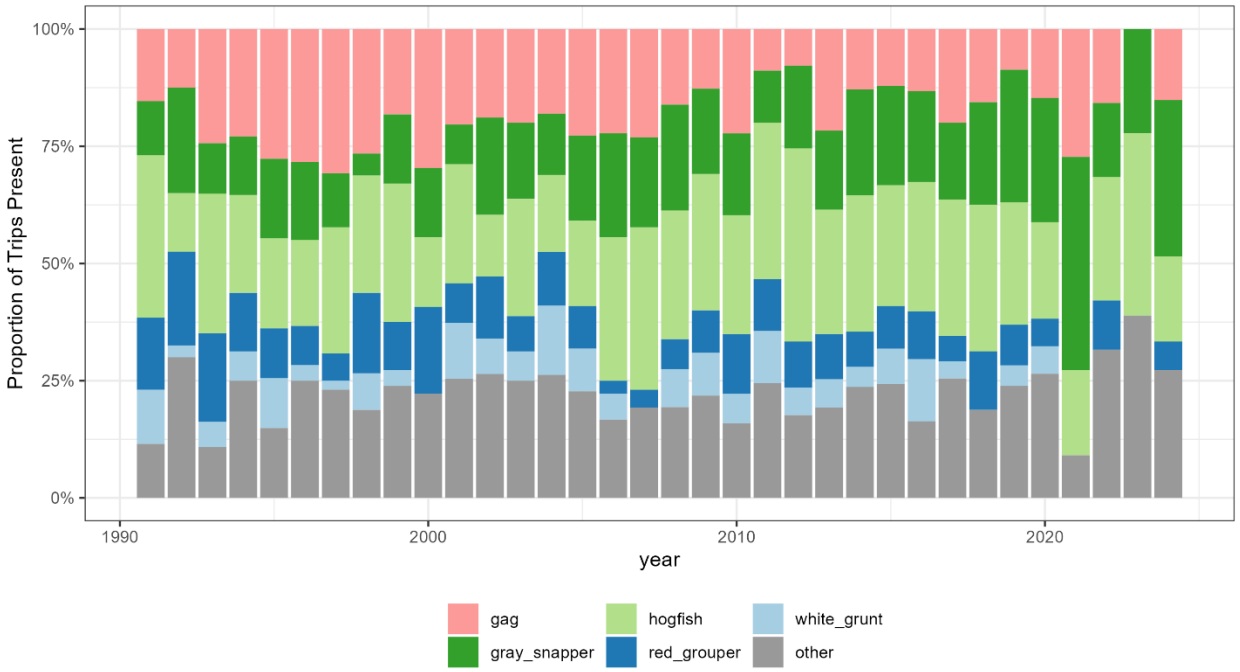

Figure 11. Proportion of WFL Spear (charter and private mode, nearshore and offshore) angler-trips with species present identified by the clustering method, in addition to all other species ('other').

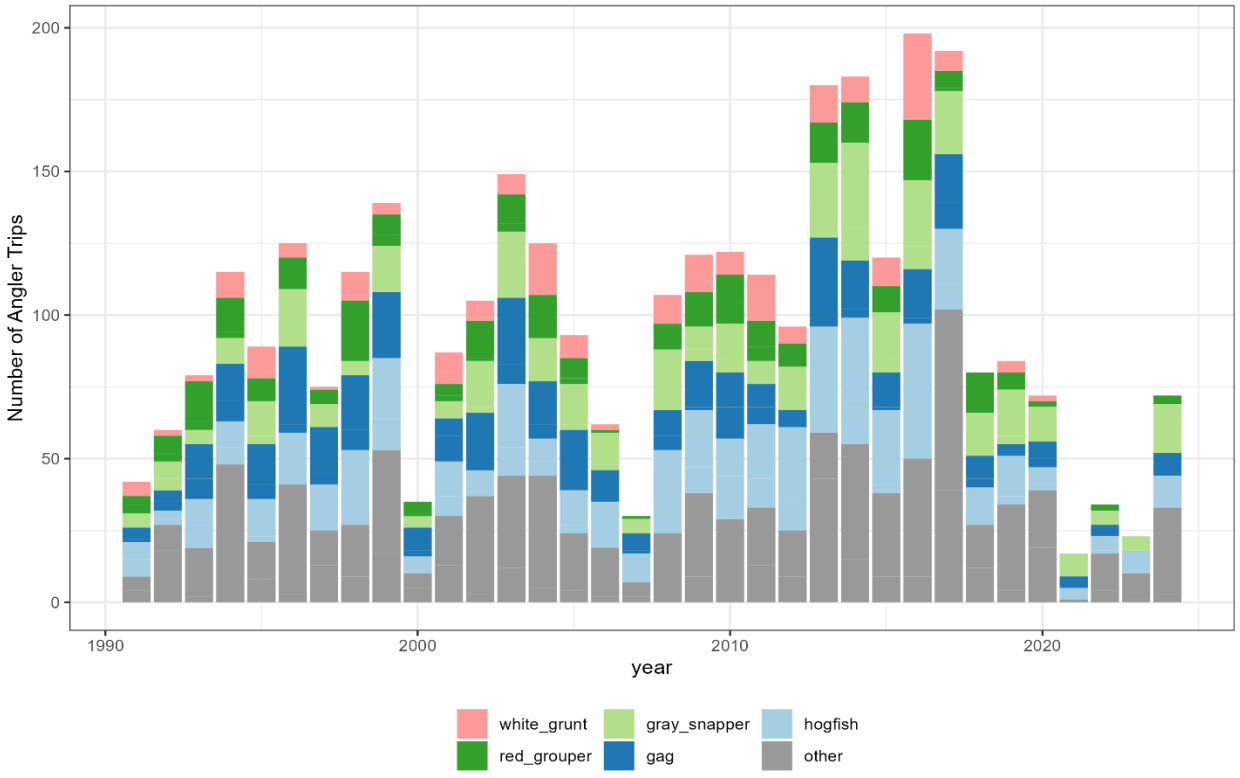

Figure 12. Number of angler trips by species in WFL Spear (charter and private mode, nearshore and offshore).

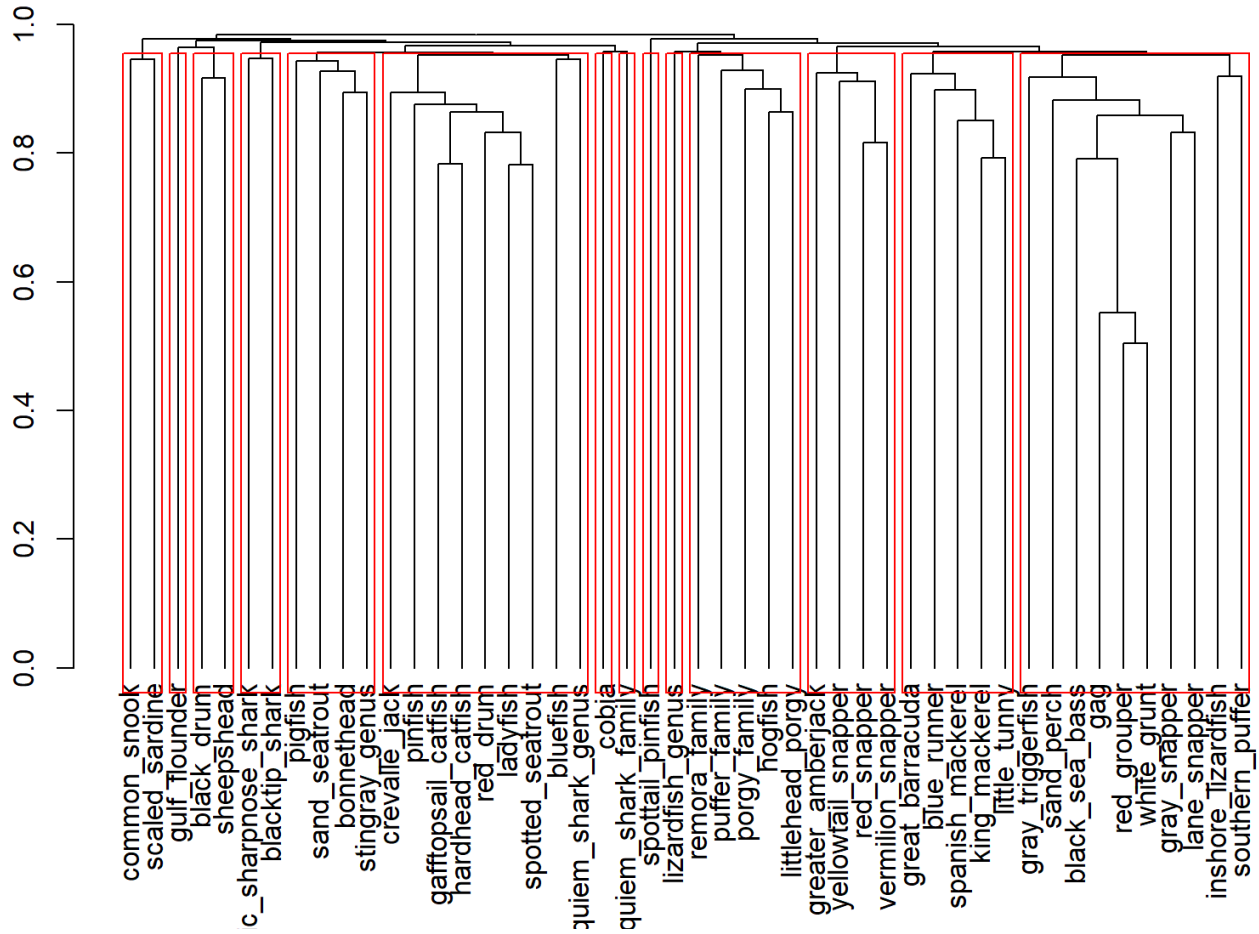

Figure 13. Dendrogram and resulting clusters that maximize average silhouette width of the fourth root of catch (landings + releases) for WFL H&L and Spear trips (charter and private modes, nearshore and offshore).

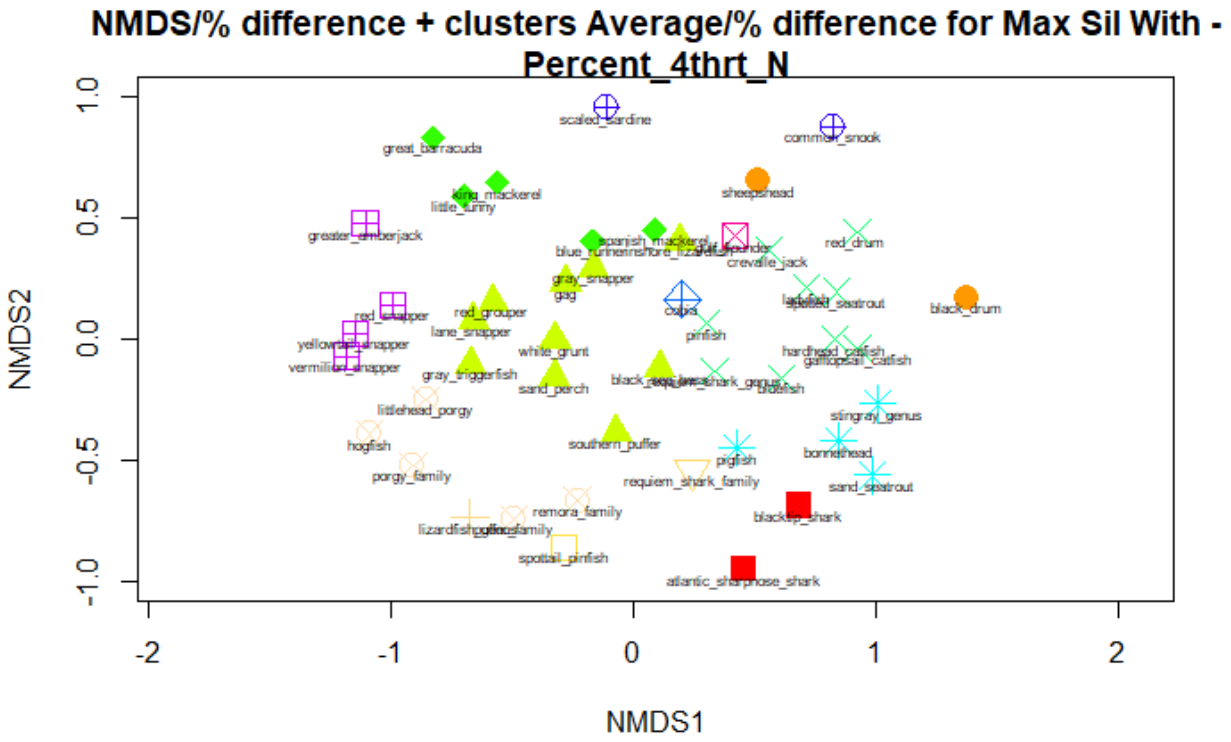

Figure 14. Non-metric Multi-dimensional scaling (NMDS) ordination plot. Point type and color identify clusters resulting in the maximum average silhouette width of the percent fourth root of catches (landings + releases) in WFL Spear and H&L trips (charter, private modes, nearshore and offshore).

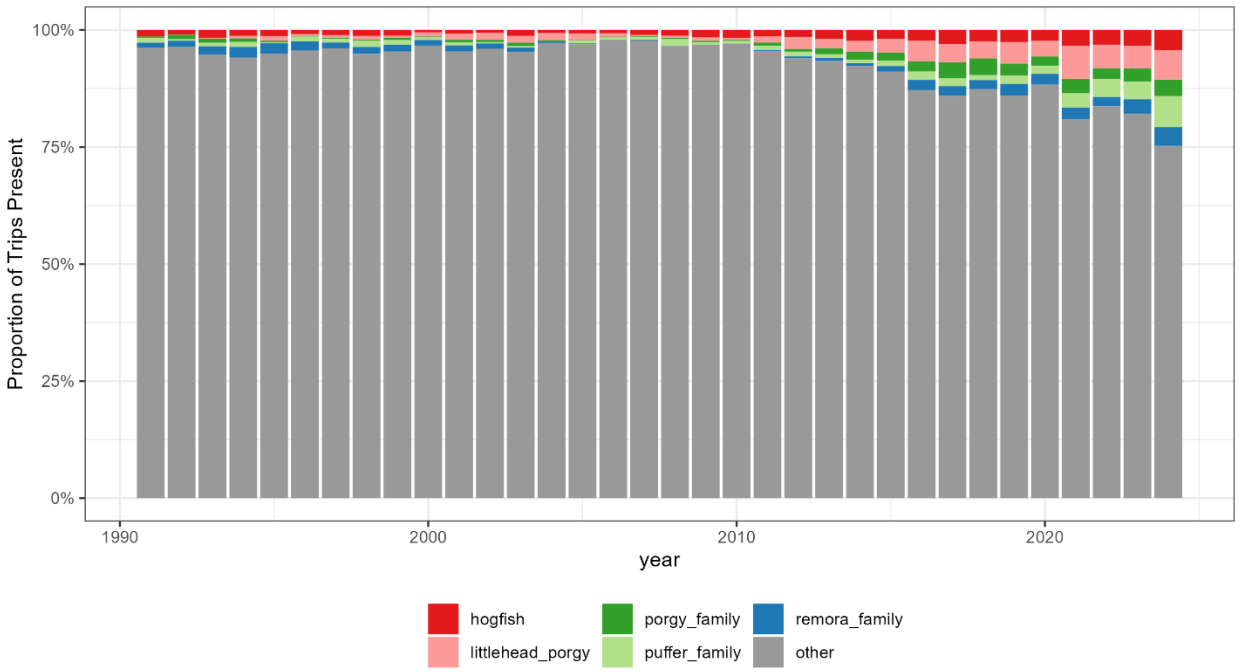

Figure 15. Proportion of WFL Spear and H&L (charter and private modes, nearshore and offshore) trips with species present identified by the clustering method, in addition to all other species ('other').

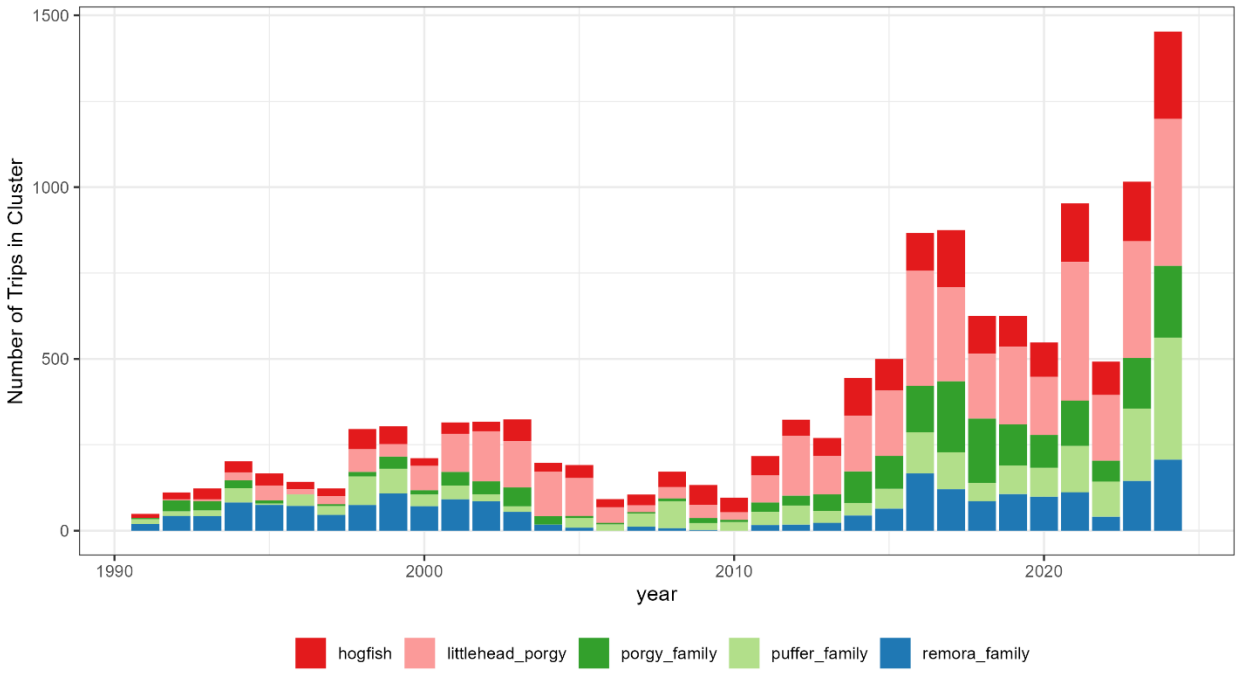

Figure 16. Number of trips by species in WFL Spear and H&L (charter and private modes, nearshore and offshore).

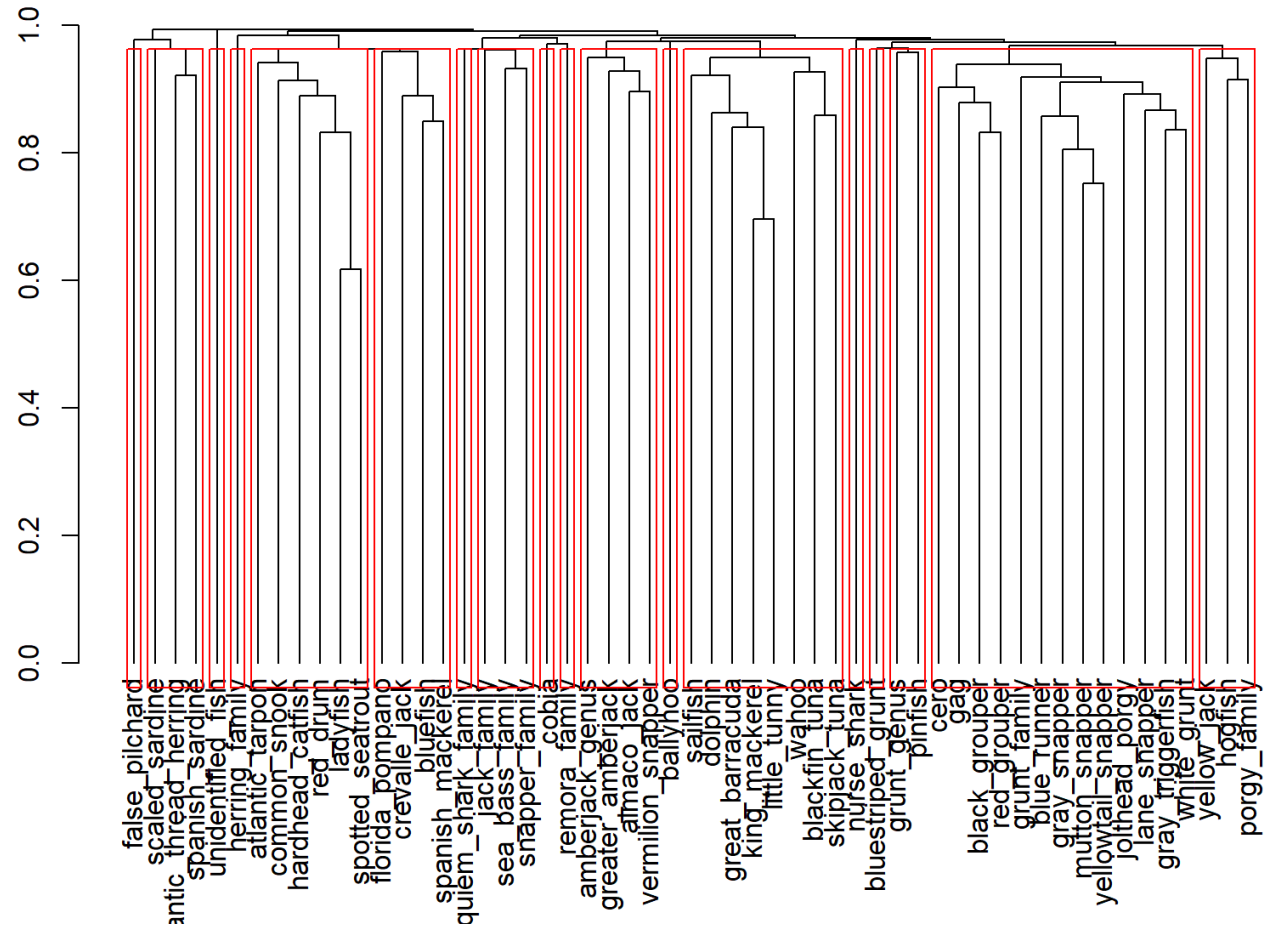

Figure 17. Dendrogram and resulting clusters that maximize average silhouette width of the percent fourth root of catch (landings + releases) for Keys-EFL H&L trips (shore, charter, private modes, nearshore and offshore).

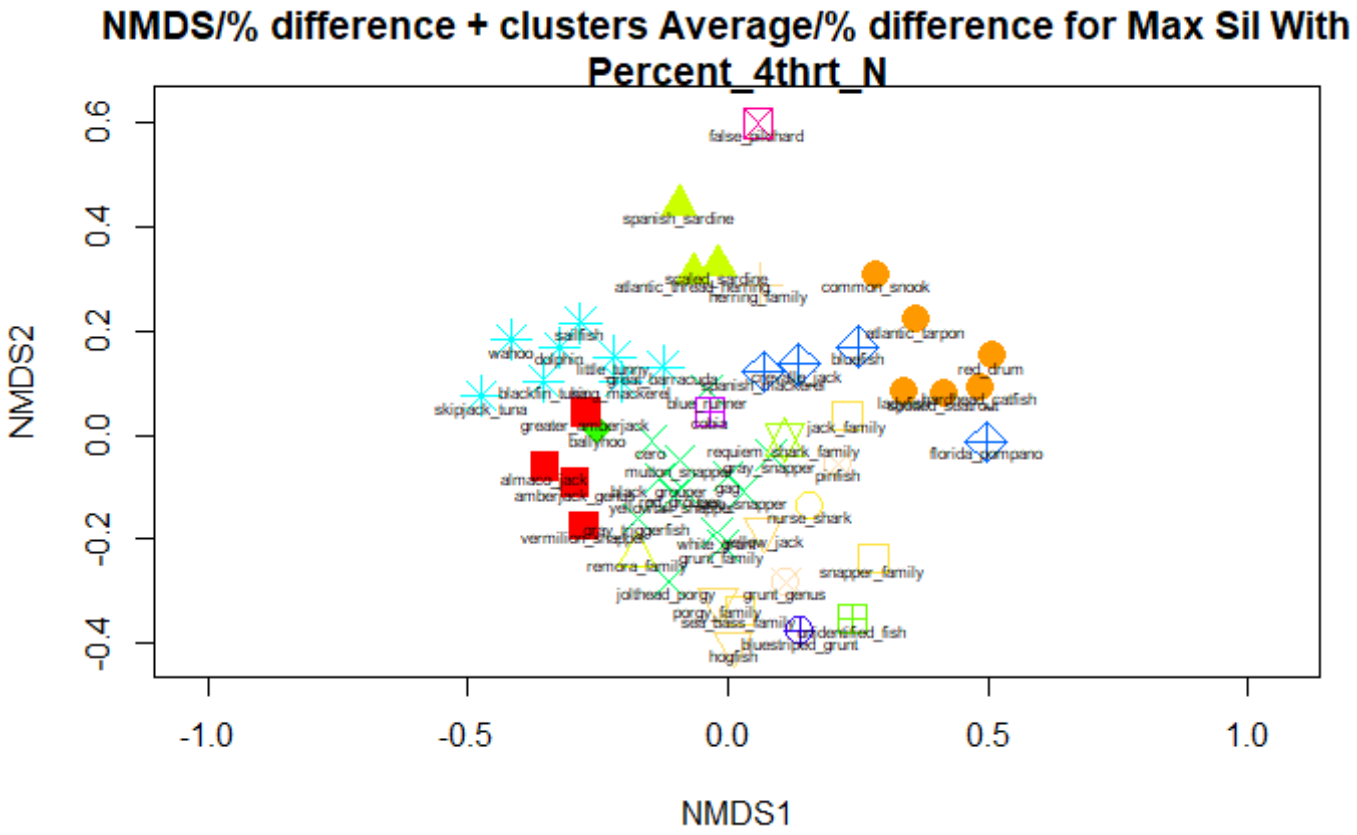

Figure 18. Non-metric Multi-dimensional scaling (NMDS) ordination plot. Point type and color identify clusters resulting in the maximum average silhouette width of fourth root of catches (landings + releases) in Keys-EFL H&L trips (shore, charter, private modes, nearshore and offshore).

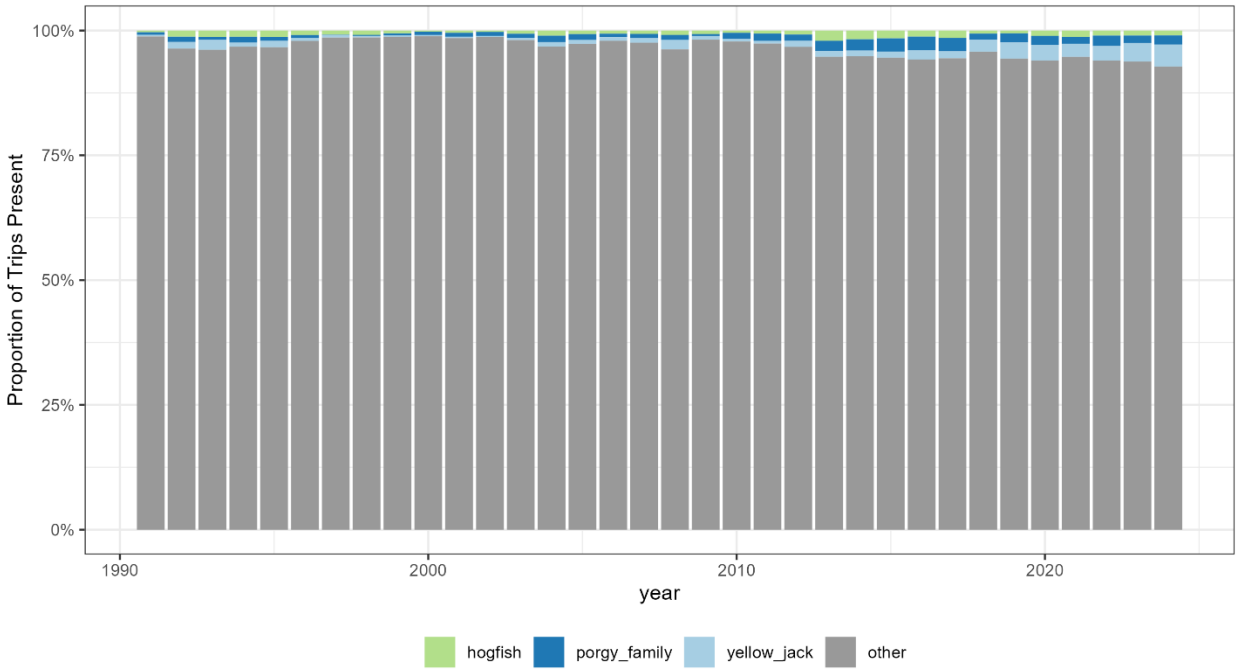

Figure 19. Proportion of Keys-EFL H&L (shore, charter, and private modes, nearshore and offshore) angler-trips with species present identified by the clustering method, in addition to all other species ('other').

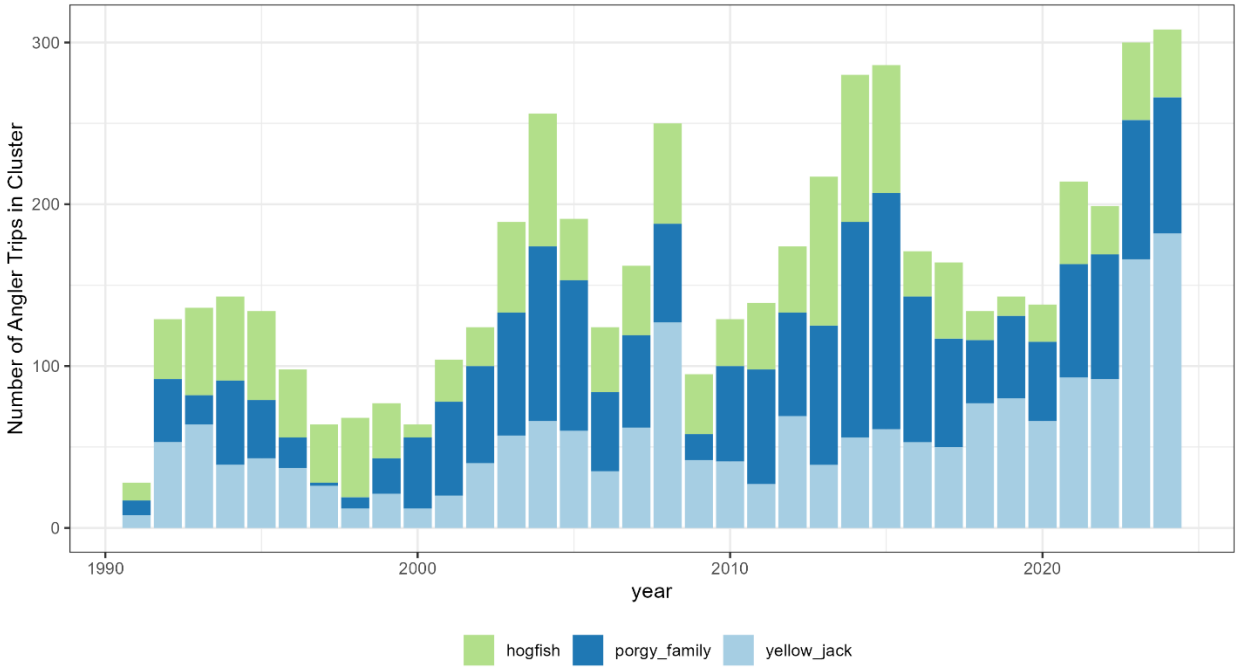

Figure 20. Number of angler trips by species in Keys-EFL H&L (shore, charter, and private modes, nearshore and offshore).

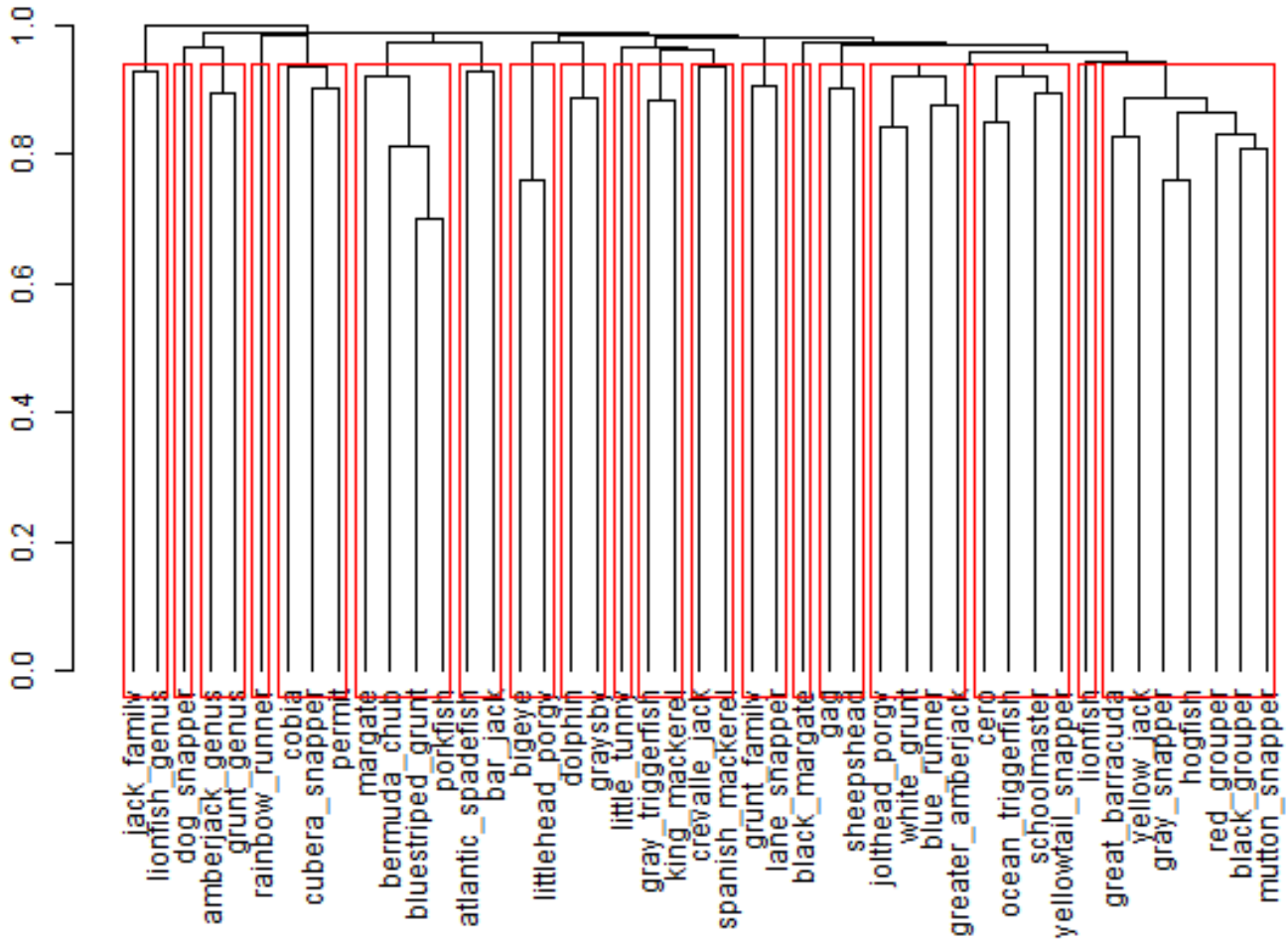

Figure 21. Dendrogram and resulting clusters that maximize average silhouette width of the percent fourth root of catch (landings + releases) for Keys-EFL Spear trips (charter and private modes, nearshore and offshore).

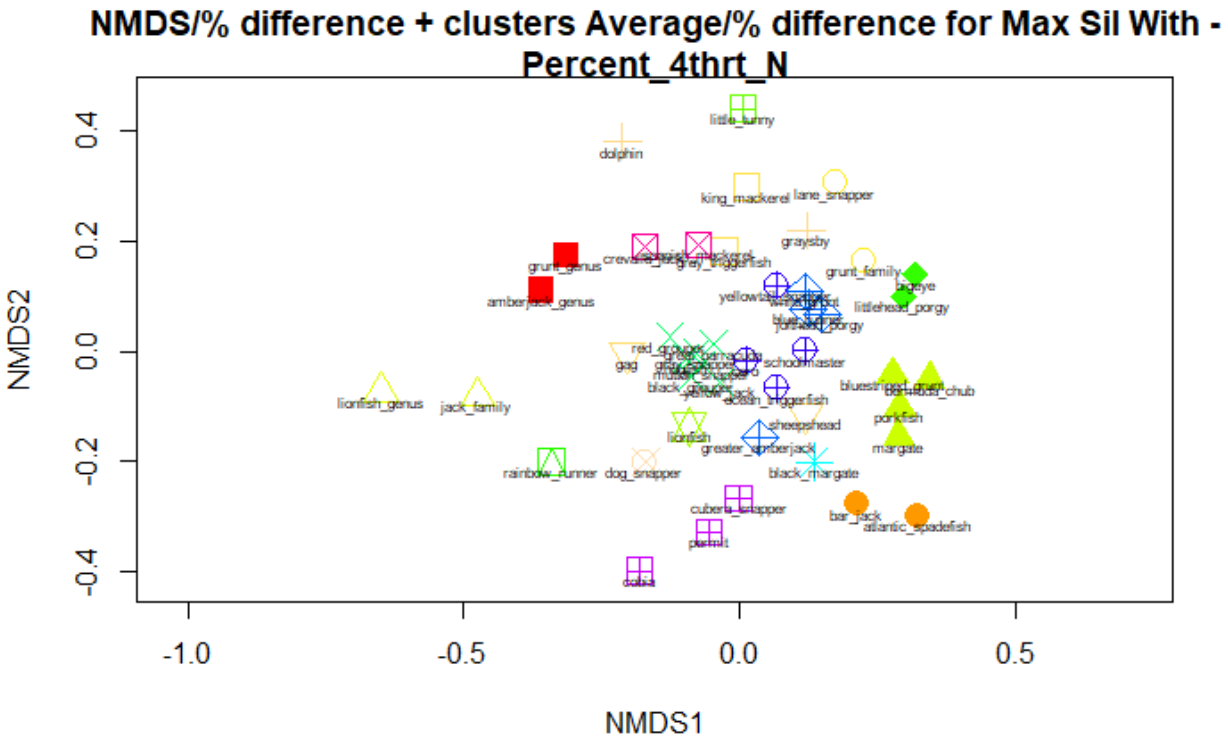

Figure 22. Non-metric Multi-dimensional scaling (NMDS) ordination plot. Point type and color identify clusters resulting in the maximum average silhouette width of fourth root of catches (landings + releases) in Keys-EFL Spear trips (charter and private modes, nearshore and offshore).

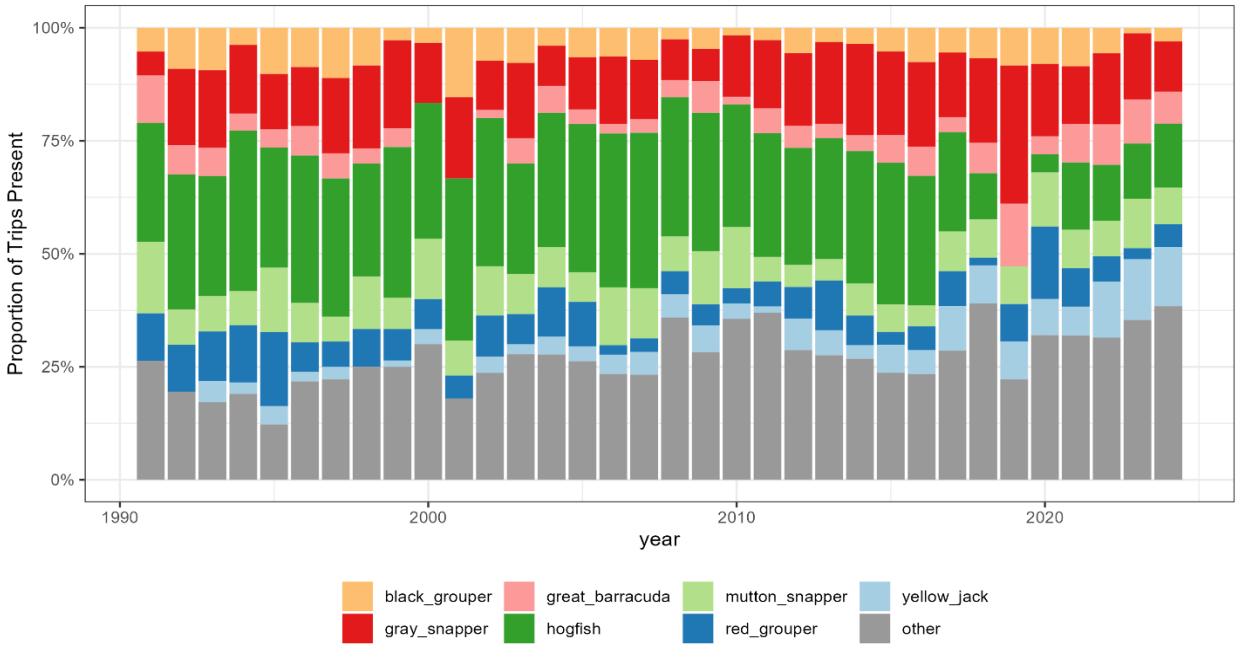

Figure 23. Proportion of Keys-EFL Spear (charter and private modes, nearshore and offshore) angler-trips with species present identified by the clustering method, in addition to all other species ('other').

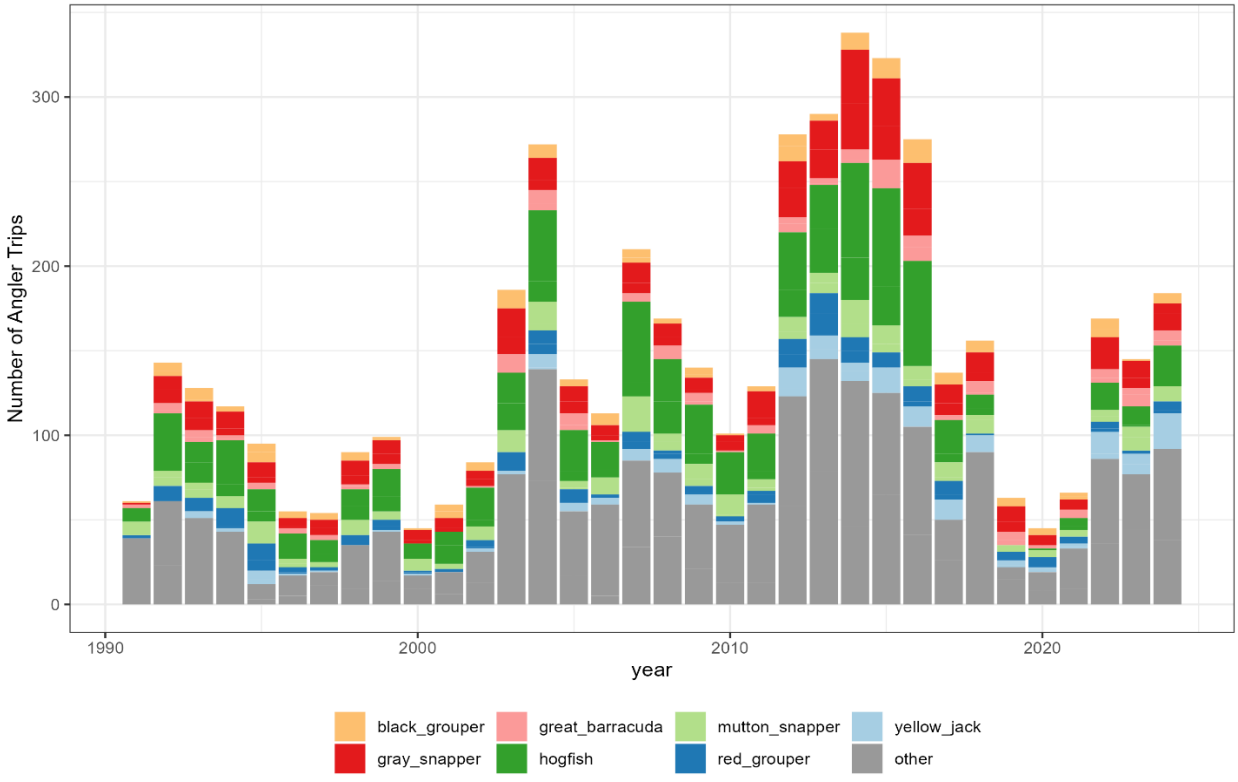

Figure 24. Number of angler trips by species for spear in the Keys-EFL (charter and private modes, nearshore and offshore).

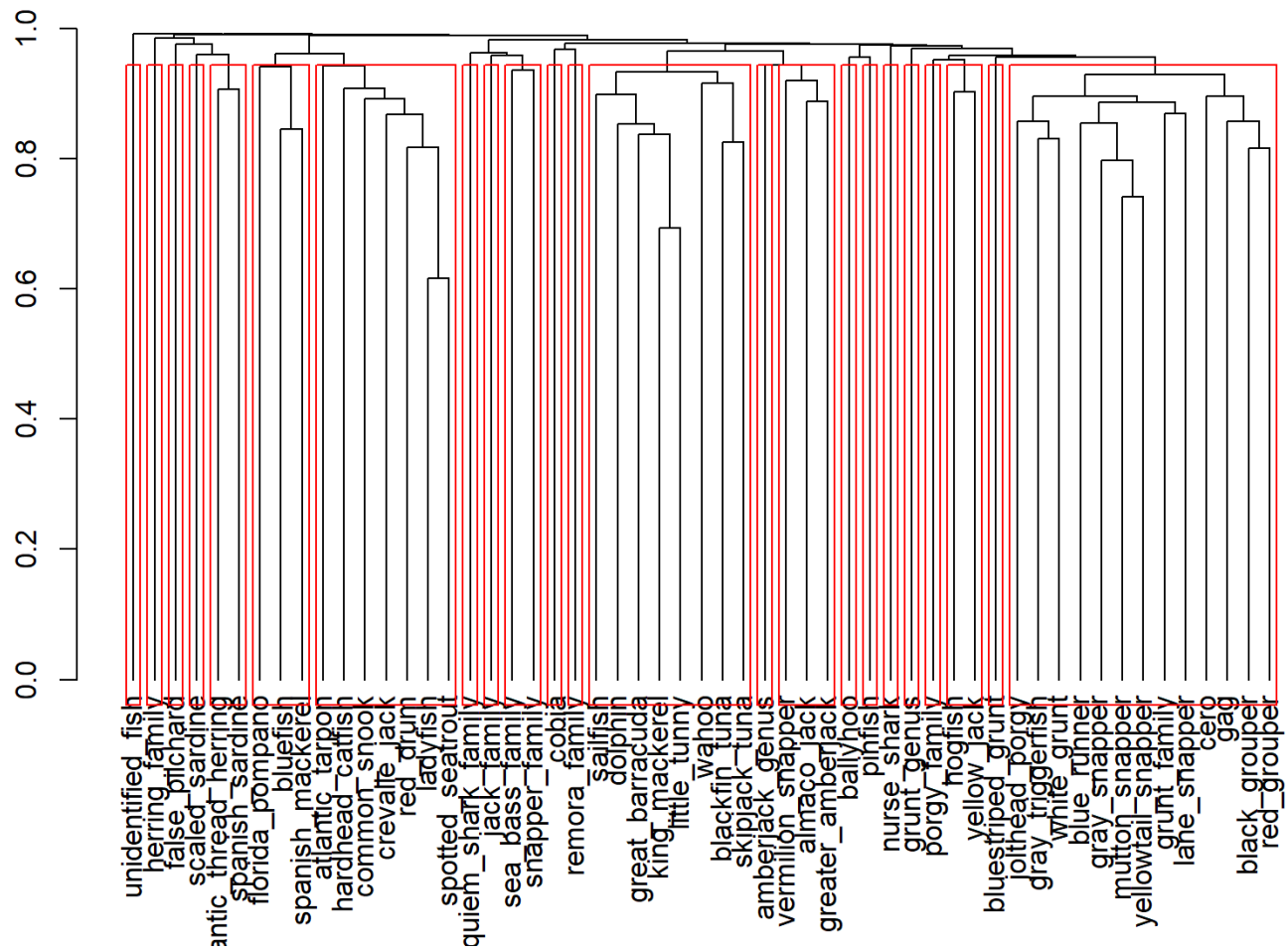

Figure 25. Dendrogram and resulting clusters that maximize average silhouette width of the fourth root of catch (landings + releases) for Keys-EFL Spear and H&L trips (charter and private modes, nearshore and offshore).

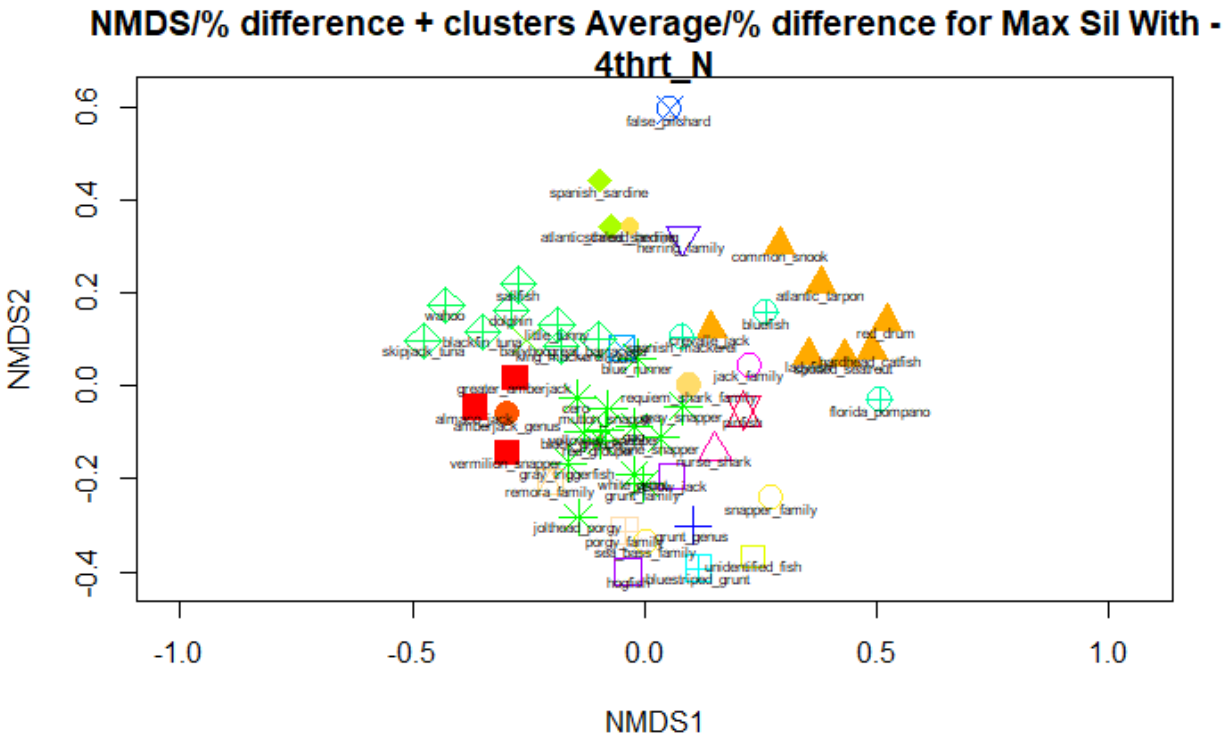

Figure 26. Non-metric Multi-dimensional scaling (NMDS) ordination plot. Point type and color identify clusters resulting in the maximum average silhouette width of fourth root of catches (landings + releases) in Keys-EFL Spear and H&L trips (charter and private modes, nearshore and offshore).

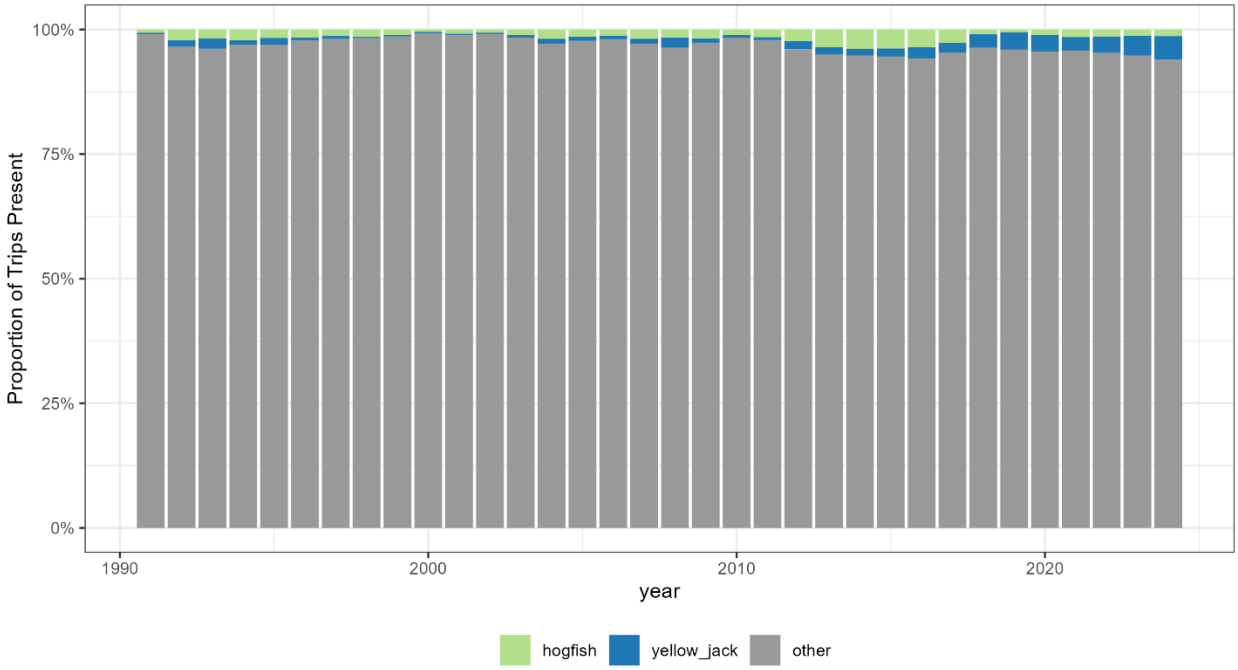

Figure 27. Proportion of Keys-EFL Spear and H&L (charter and private modes, nearshore and offshore) trips with species present identified by the clustering method, in addition to all other species ('other').

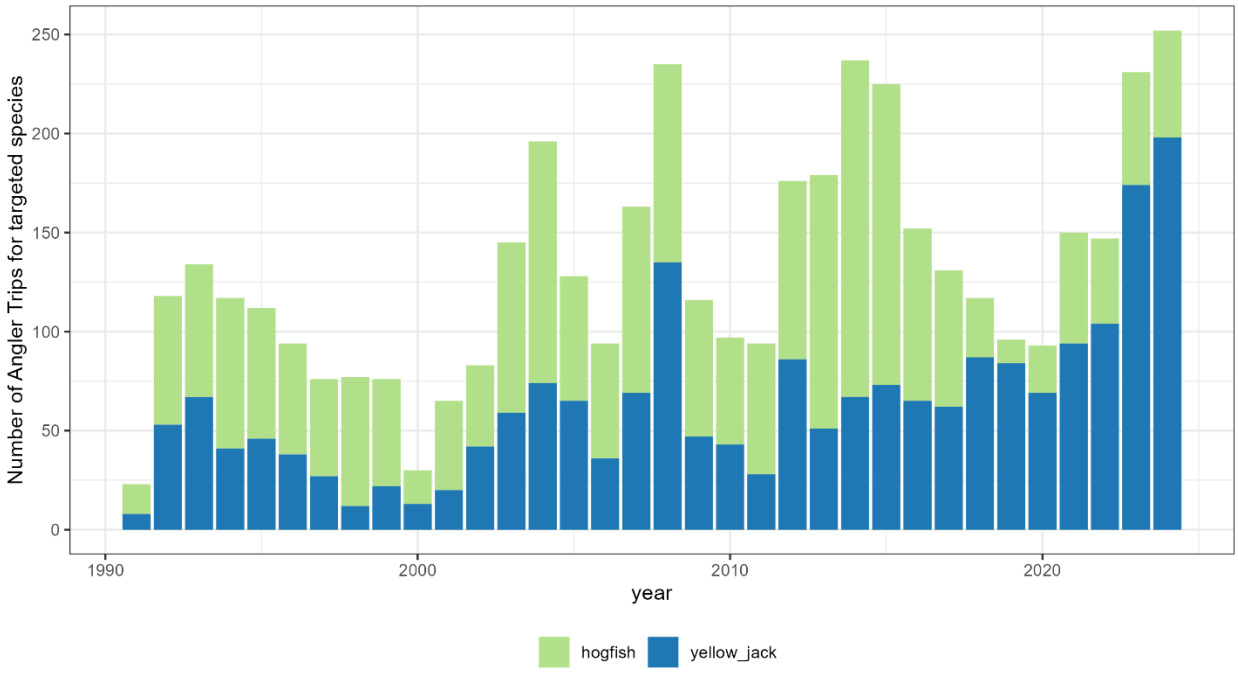

Figure 28. Number of trips by species for spear and H&L in the Keys-EFL (charter and private modes, nearshore and offshore).

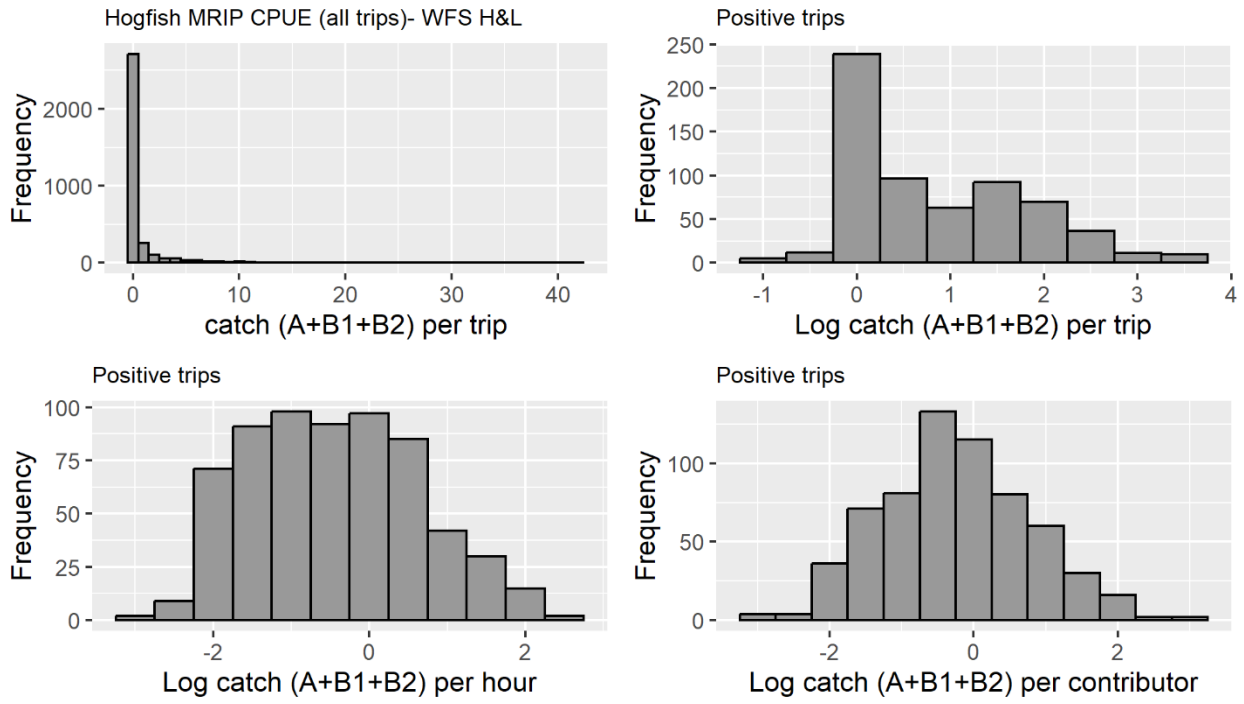

Figure 29. Histograms of hogfish catch per trip within the species cluster including zeros (top left), log(catch per trip) for positive trips (top right), log (catch per median hour fished) for positive trips (bottom left), and a histogram of log(catch per contributor) for positive trips (bottom right) for the WFL H&L data (charter and private mode, nearshore and offshore).

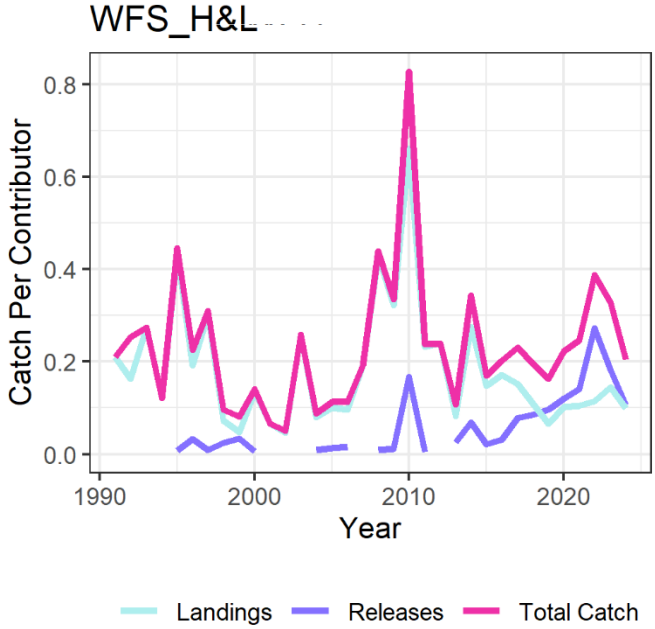

Figure 30. A comparison of mean nominal total catch per contributor (magenta), landings per contributor (light blue), and releases per contributor (dark blue) for the WFL H&L data (charter and private mode, nearshore and offshore).

Figure 31. Interaction plots between year and considered covariates for the binomial model using the WFL H&L data (charter and private mode, nearshore and offshore) using mean catch per contributor.

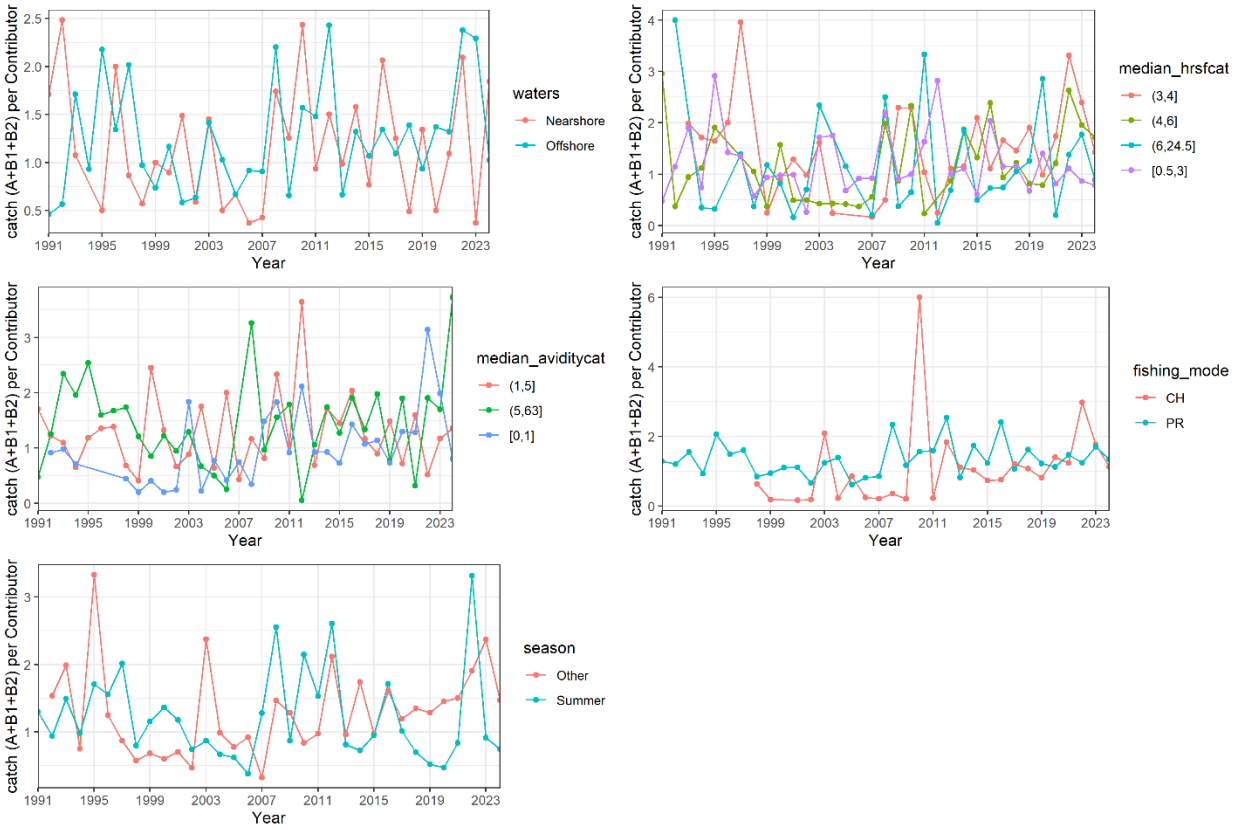

Figure 32. Interaction plots between year and considered covariates for the positive model using the WFL H&L data (charter and private mode, nearshore and offshore) using mean catch per contributor.

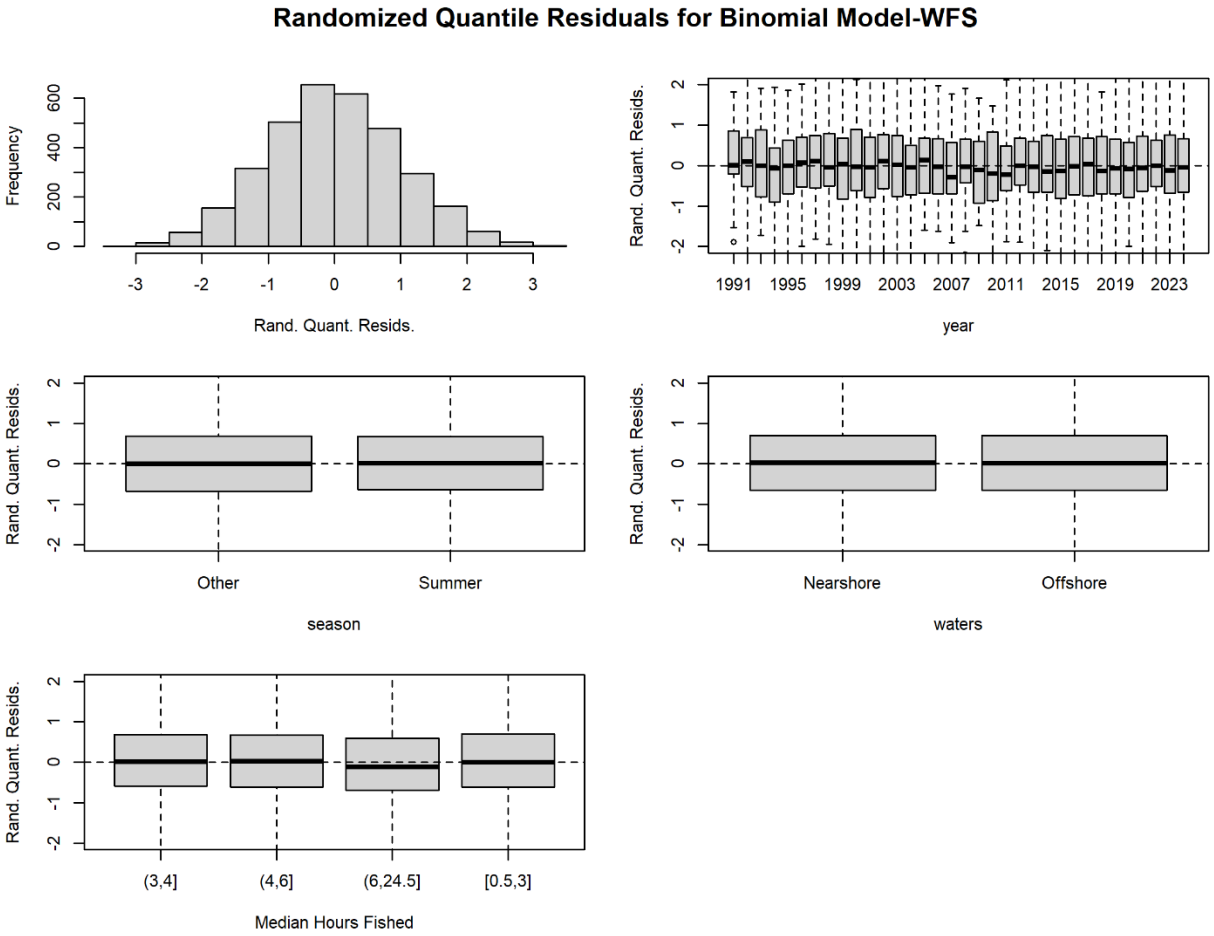

Figure 33. Randomized quantile residuals for the WFL H&L binomial model.

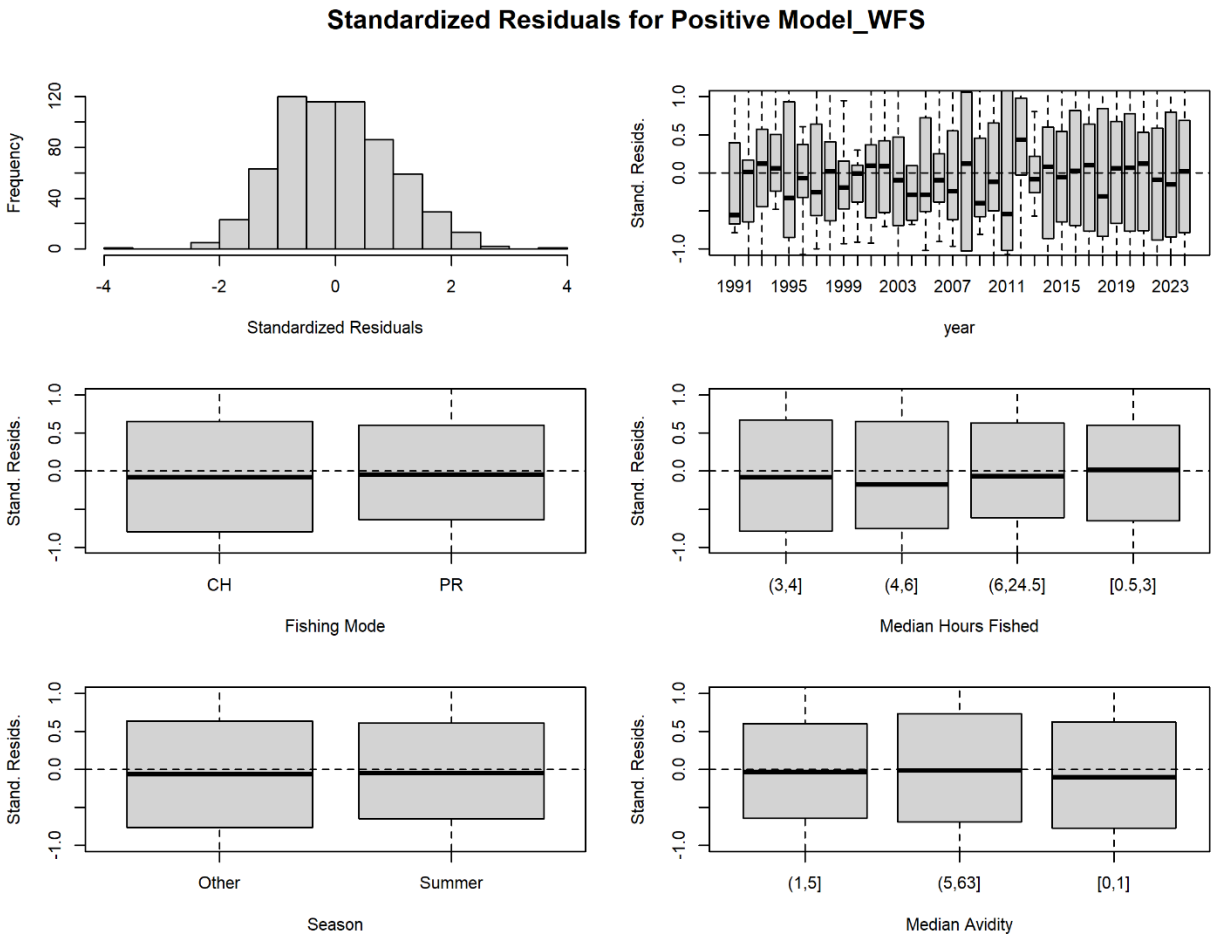

Figure 34. Standardized Pearson residuals for the WFL H&L positive Model.

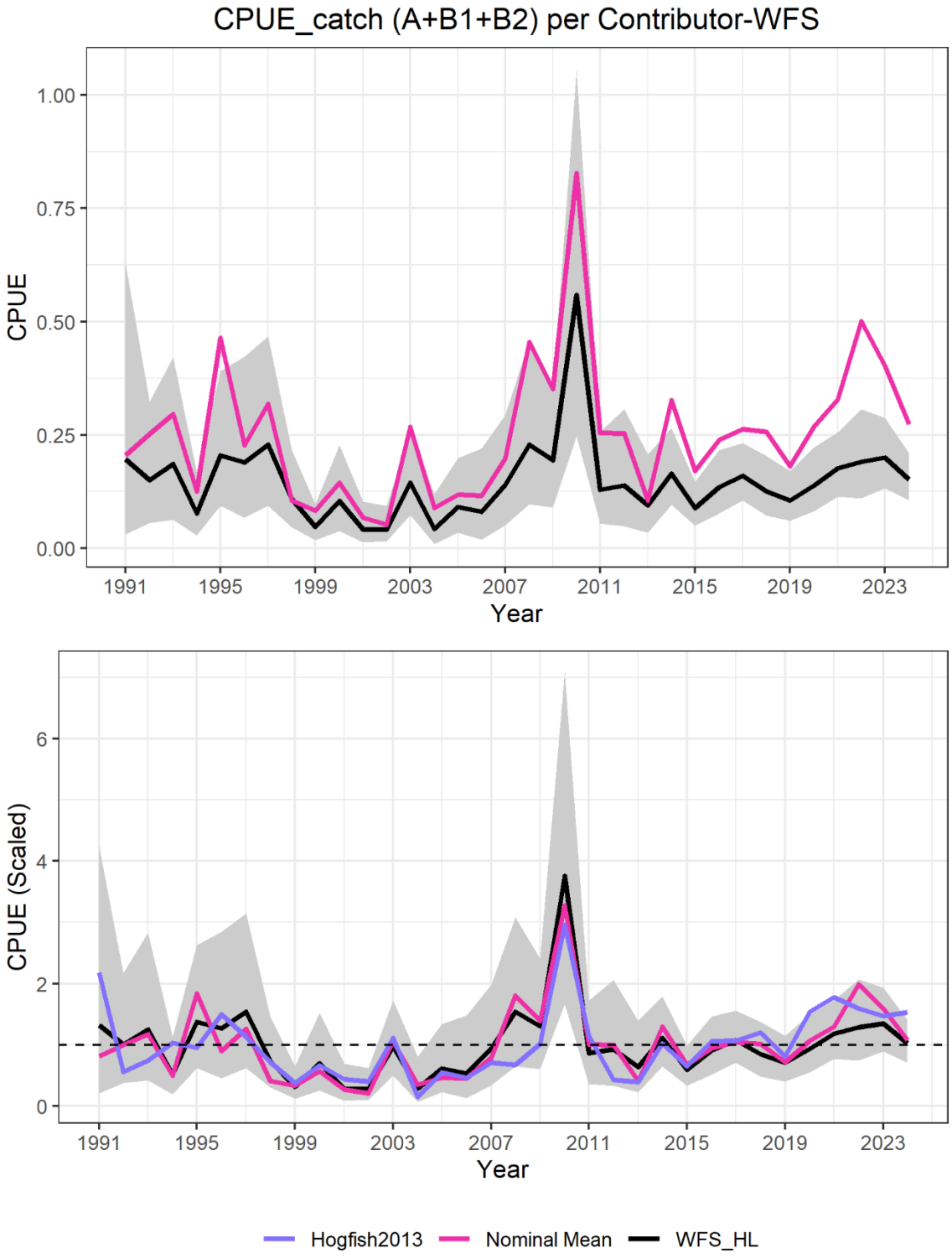

Figure 35. Standardized MRIP catch rate index (black line) of hogfish for the WFL H&L fishery with 95% confidence intervals (grey ribbon), along with the nominal CPUE (magenta line) and the standardized CPUE from a continuity model based on SEDAR 37 (blue line).

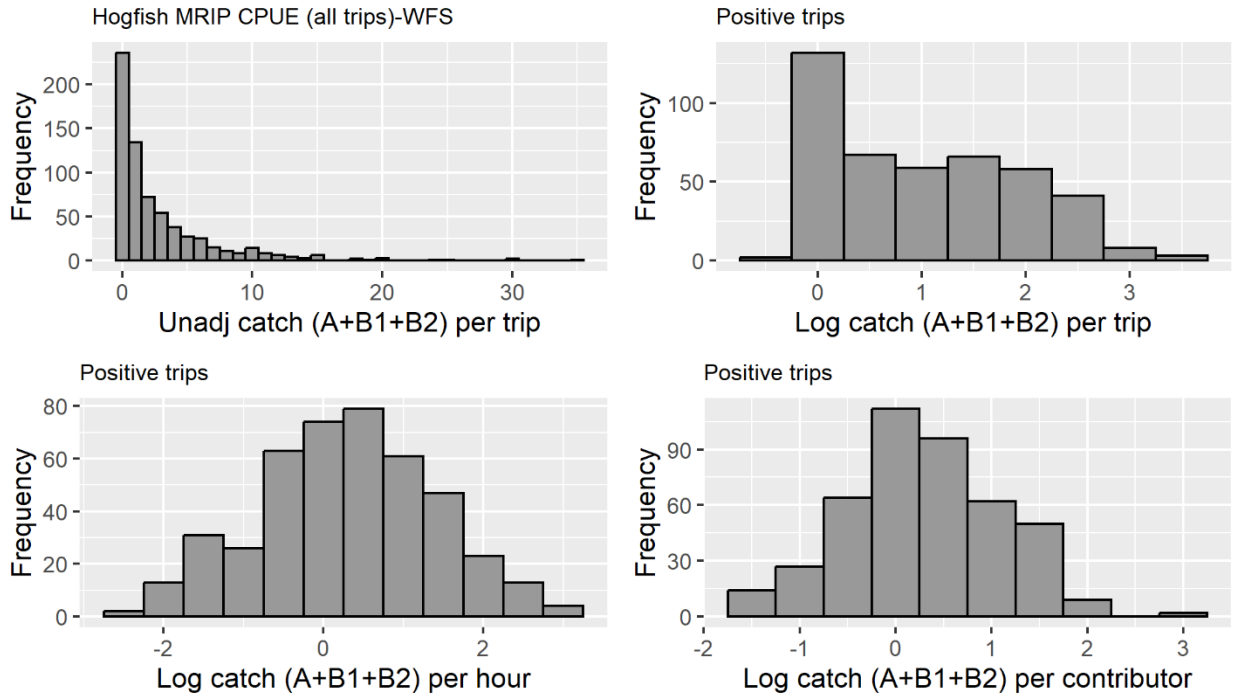

Figure 36. Histograms of hogfish catch per trip within the species cluster including zeros (top left), log(catch per trip) for positive trips (top right), log (catch per median hour fished) for positive trips (bottom left), and a histogram of log(catch per contributor) for positive trips (bottom right) for the WFL Spear data (charter and private mode, nearshore and offshore).

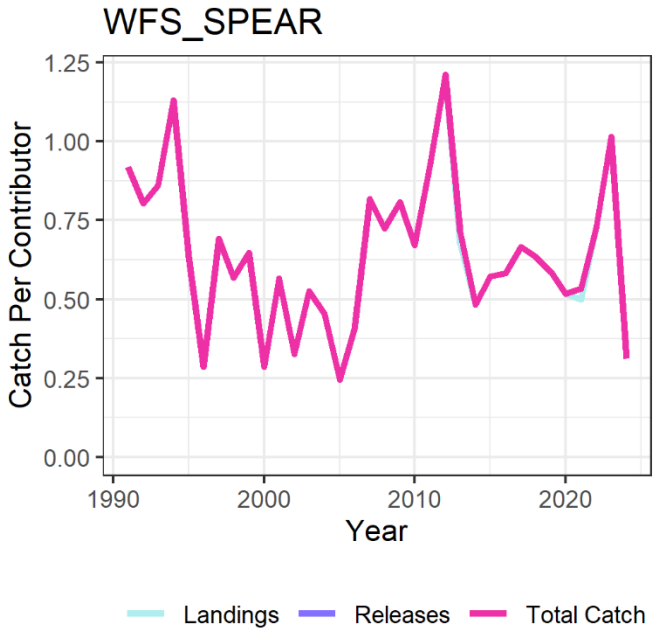

Figure 37. A comparison of mean nominal total catch per contributor (magenta), landings per contributor (light blue), and releases per contributor (dark blue) for the WFL Spear data (charter and private mode, nearshore and offshore).

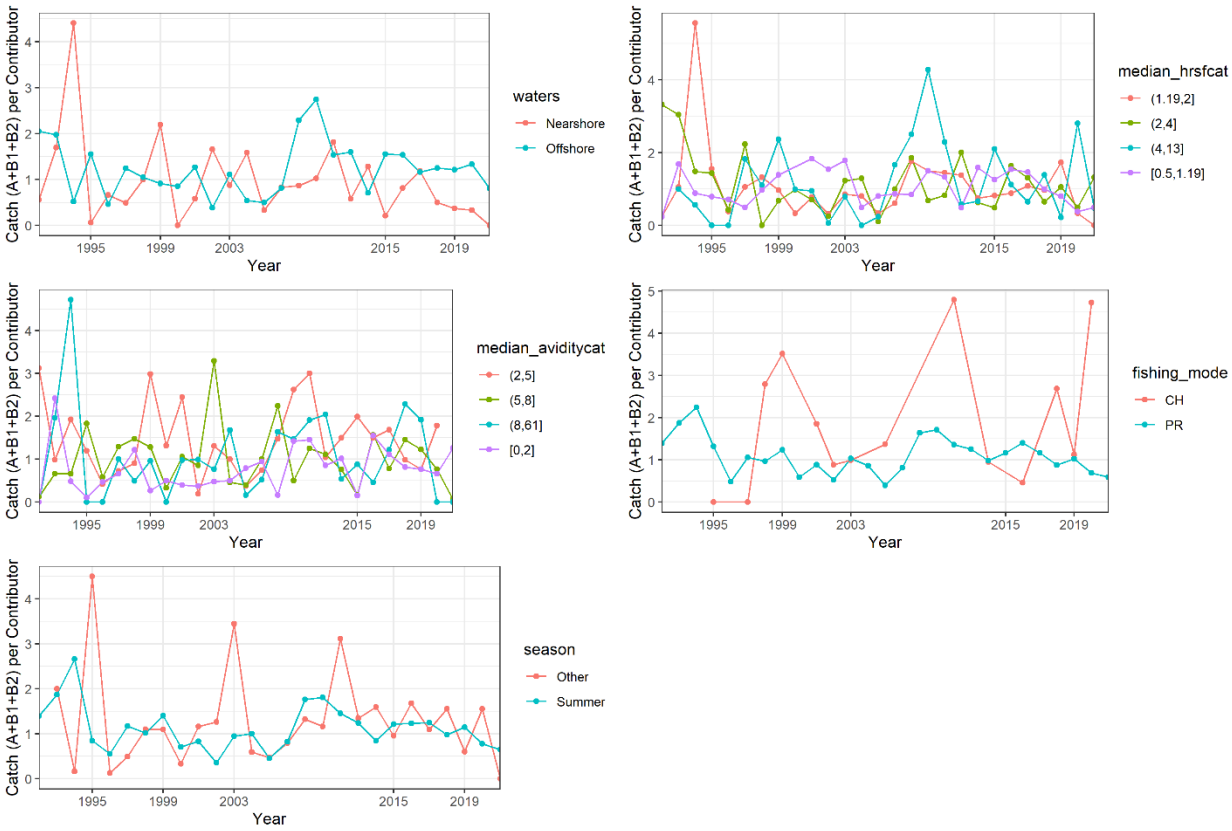

Figure 38. Interaction plots between year and considered covariates for the binomial model using the WFL Spear data (charter and private mode, nearshore and offshore) using mean catch per contributor.

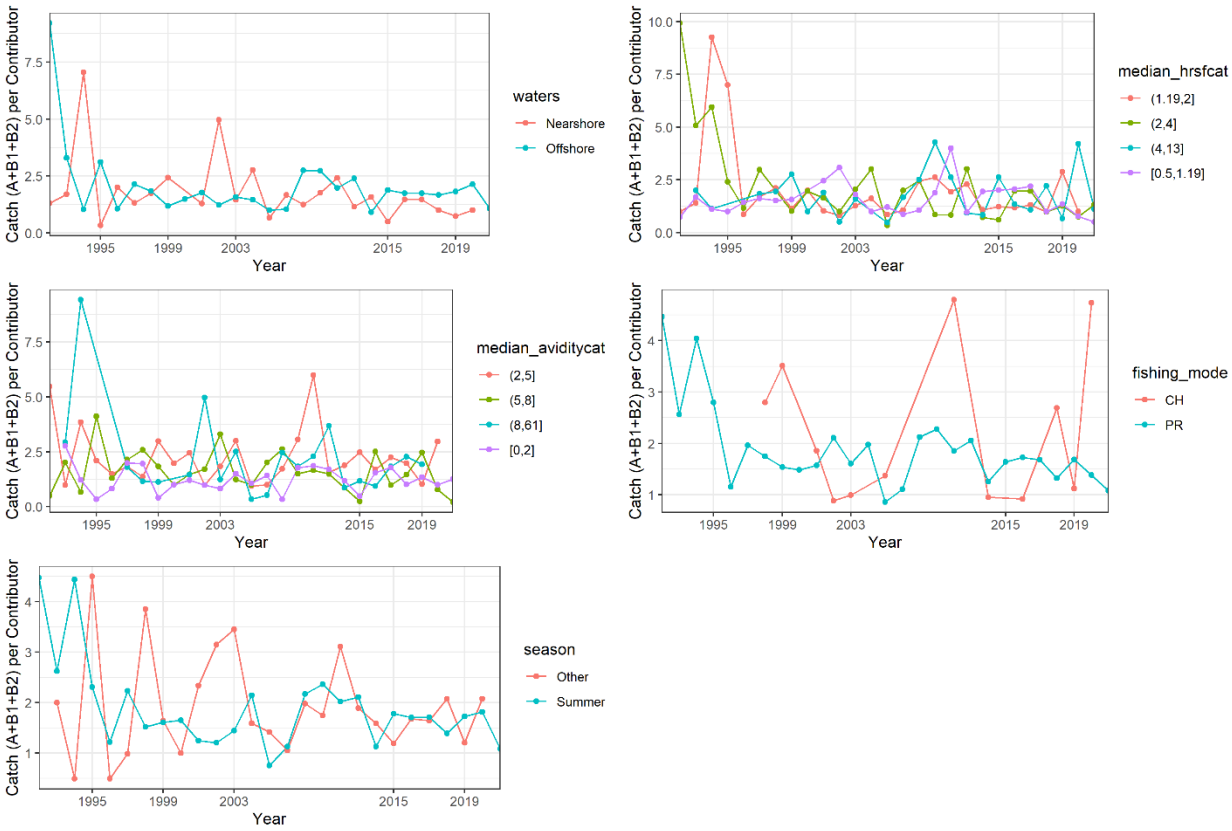

Figure 39. Interaction plots between year and considered covariates for the positive model using the WFL Spear data (charter and private mode, nearshore and offshore) using mean catch per contributor.

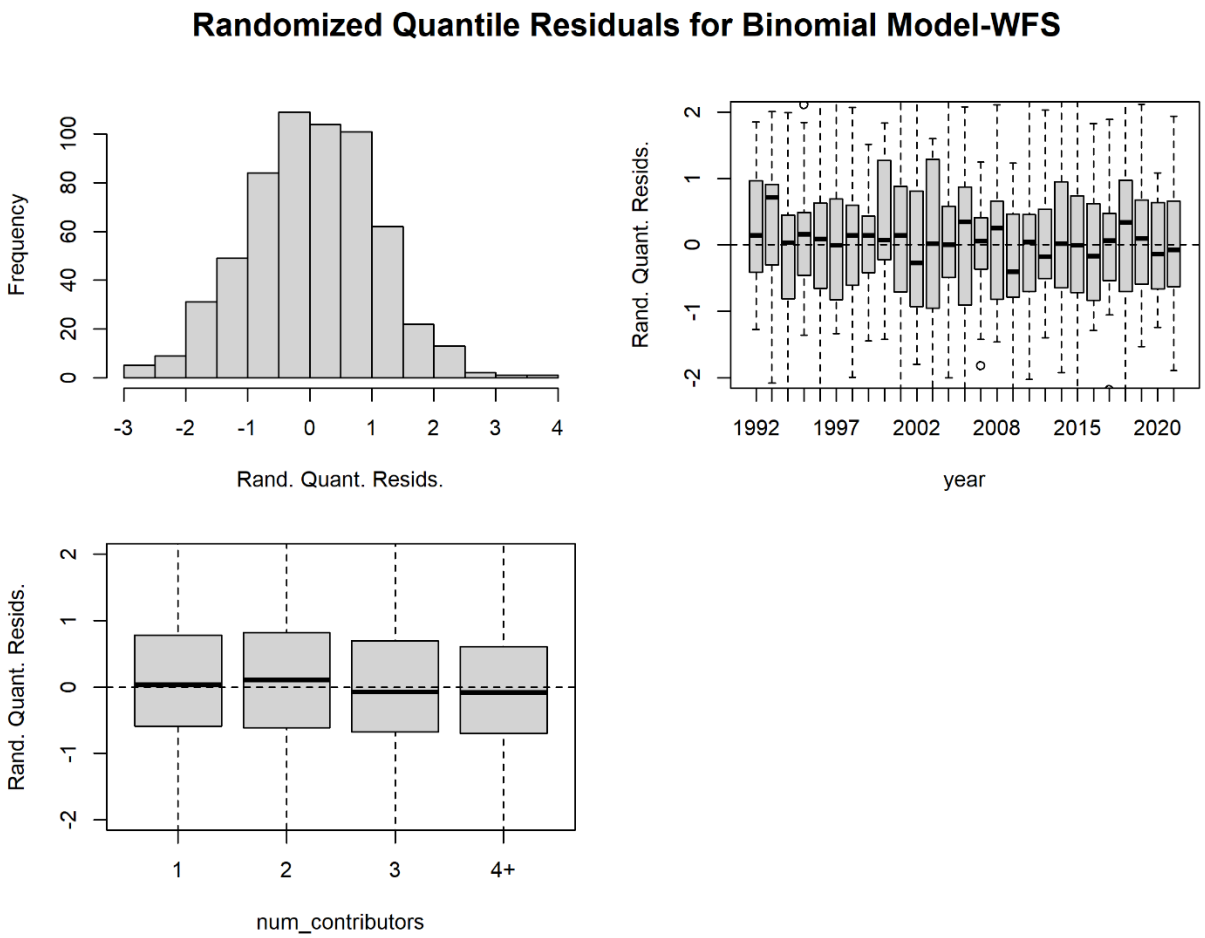

Figure 40. Randomized quantile residuals for the WFL Spear binomial model.

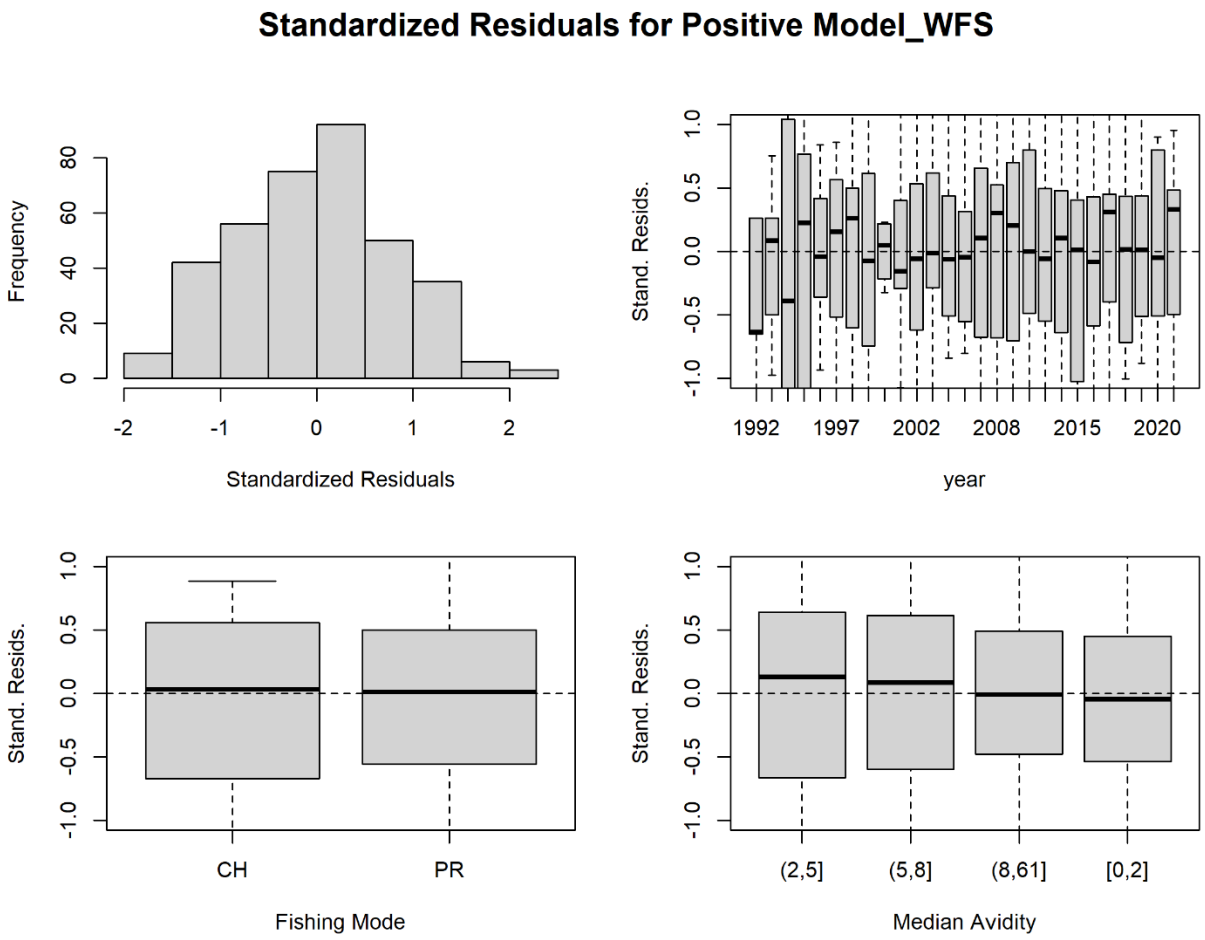

Figure 41. Standardized Pearson residuals for the WFL Spear positive Model.

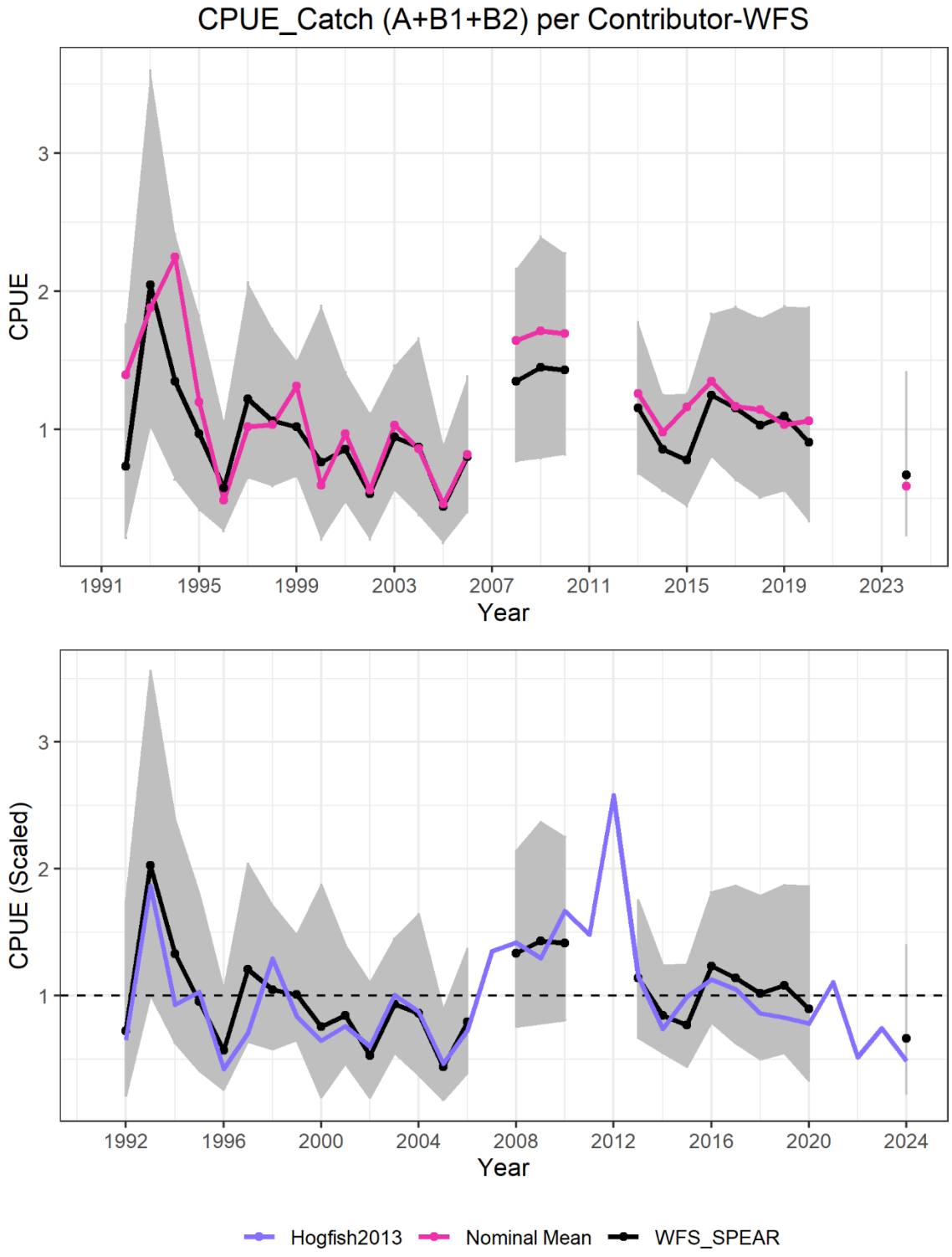

Figure 42. Standardized MRIP catch rate index (black line) of hogfish for the WFL Spear fishery with 95% confidence intervals (grey ribbon), along with the nominal CPUE (magenta line) and the standardized CPUE from a continuity model based on SEDAR 37 (blue line).

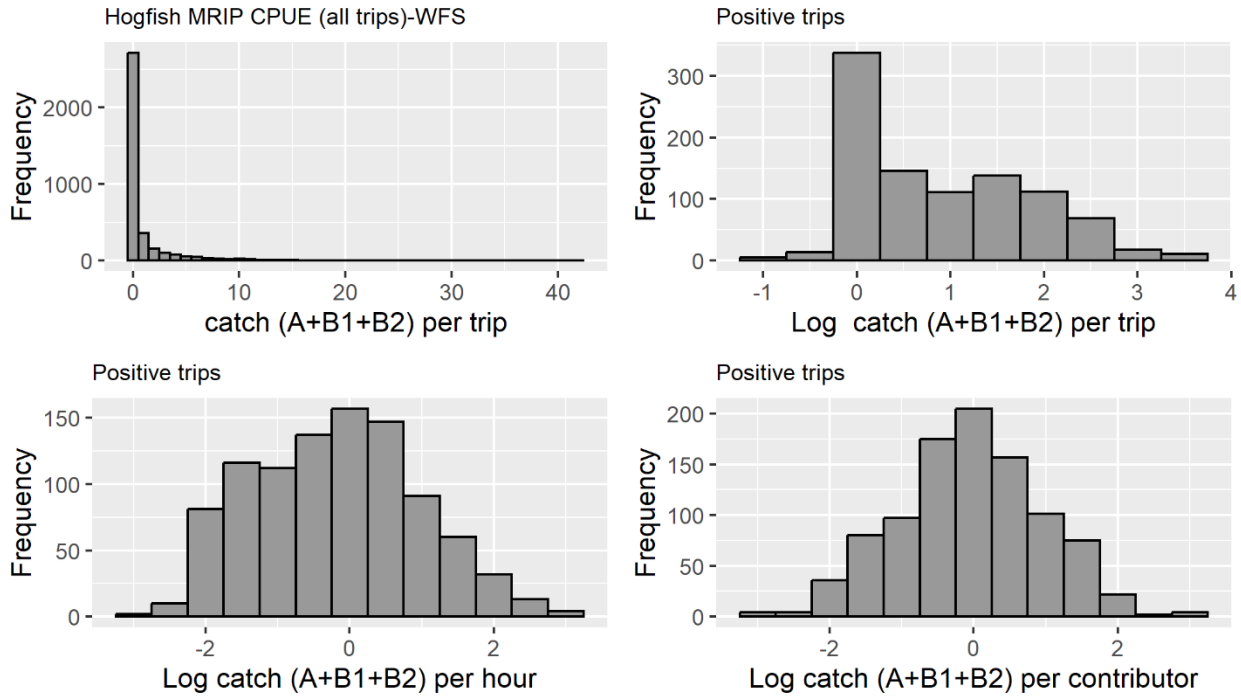

Figure 43. Histograms of hogfish catch per trip within the species cluster including zeros (top left), log(catch per trip) for positive trips (top right), log (catch per median hour fished) for positive trips (bottom left), and a histogram of log(catch per contributor) for positive trips (bottom right) for the WFL Spear and H&L data (charter and private mode, nearshore and offshore).

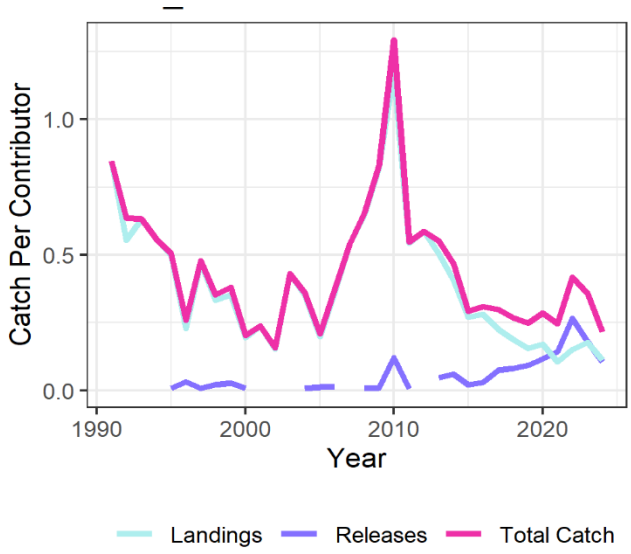

Figure 44. A comparison of mean nominal total catch per contributor (magenta), landings per contributor (light blue), and releases per contributor (dark blue) for the WFL Spear and H&L data (charter and private mode, nearshore and offshore).

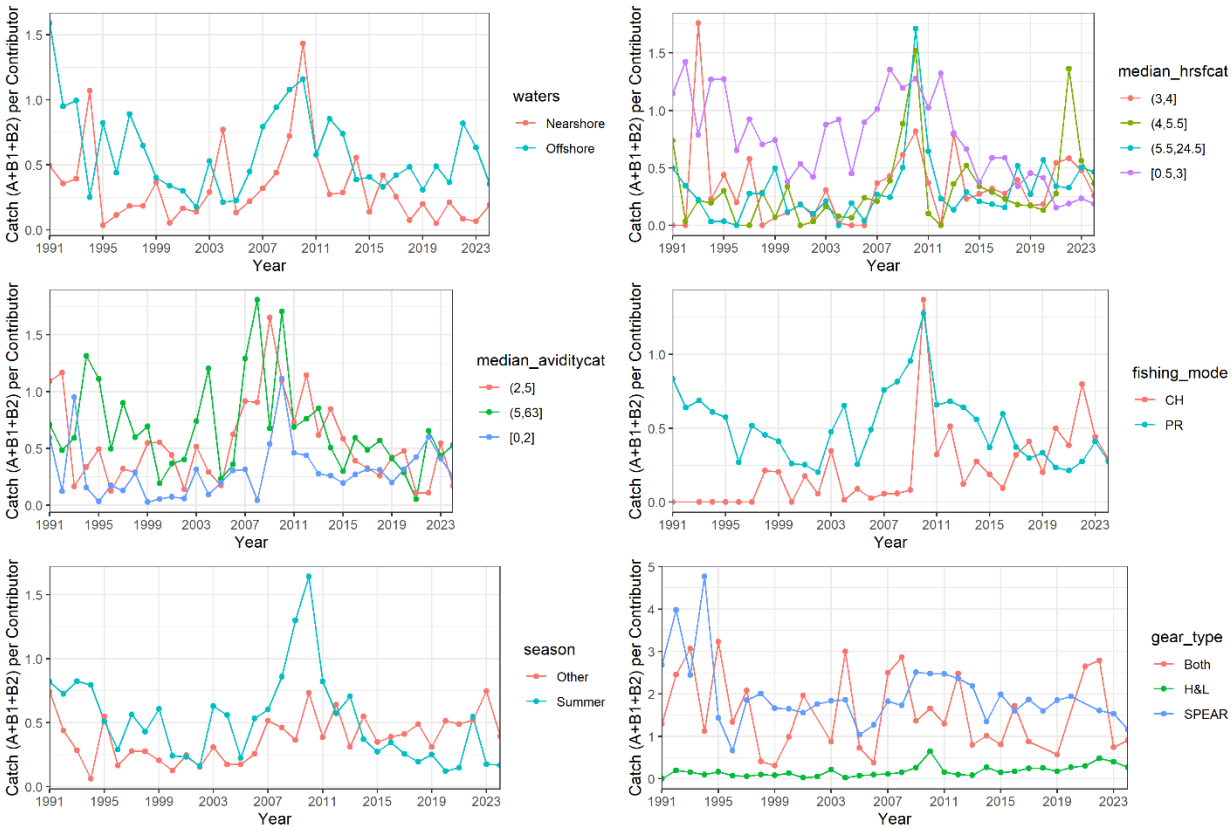

Figure 45. Interaction plots between year and considered covariates for the binomial model using the WFL Spear and H&L data (charter, and private mode, nearshore and offshore) using mean catch per contributor.

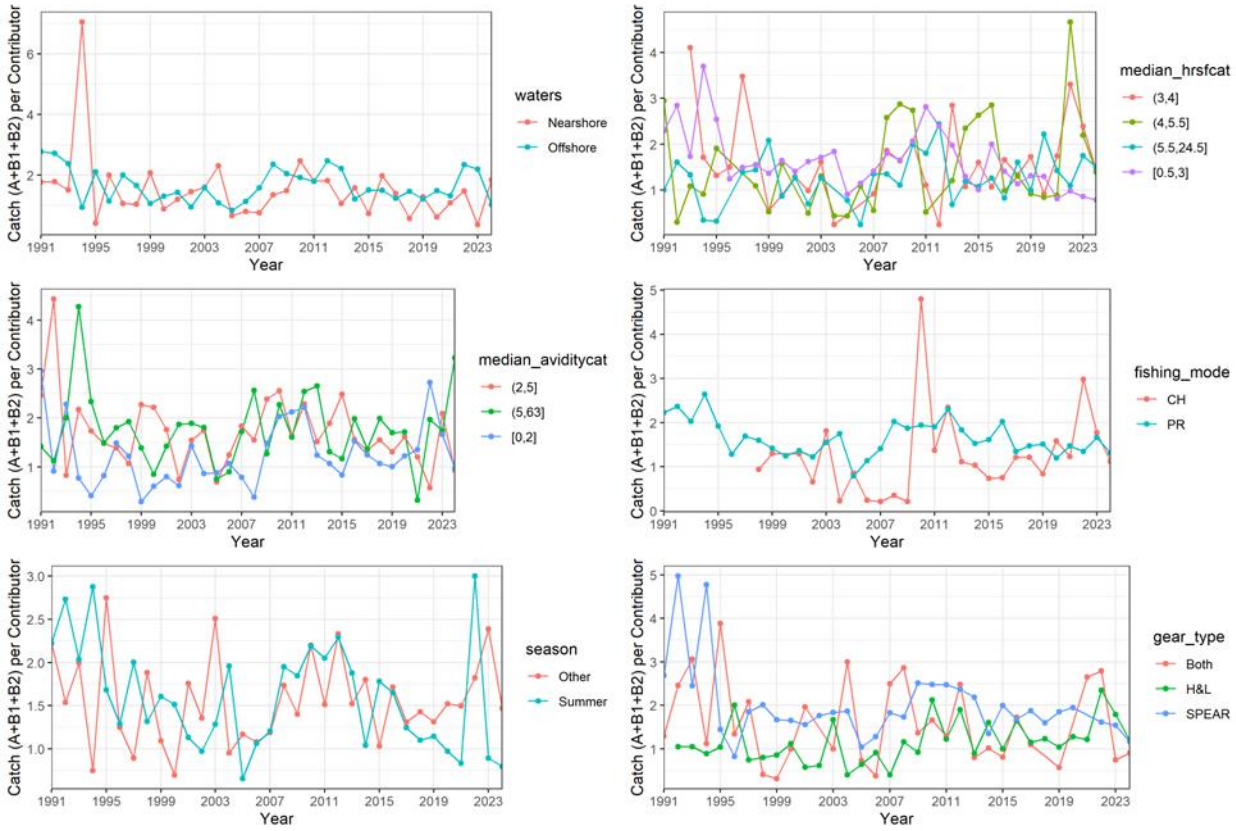

Figure 46. Interaction plots between year and considered covariates for the positive model using the WFL Spear and H&L data (charter, and private mode, nearshore and offshore) using mean catch per contributor.

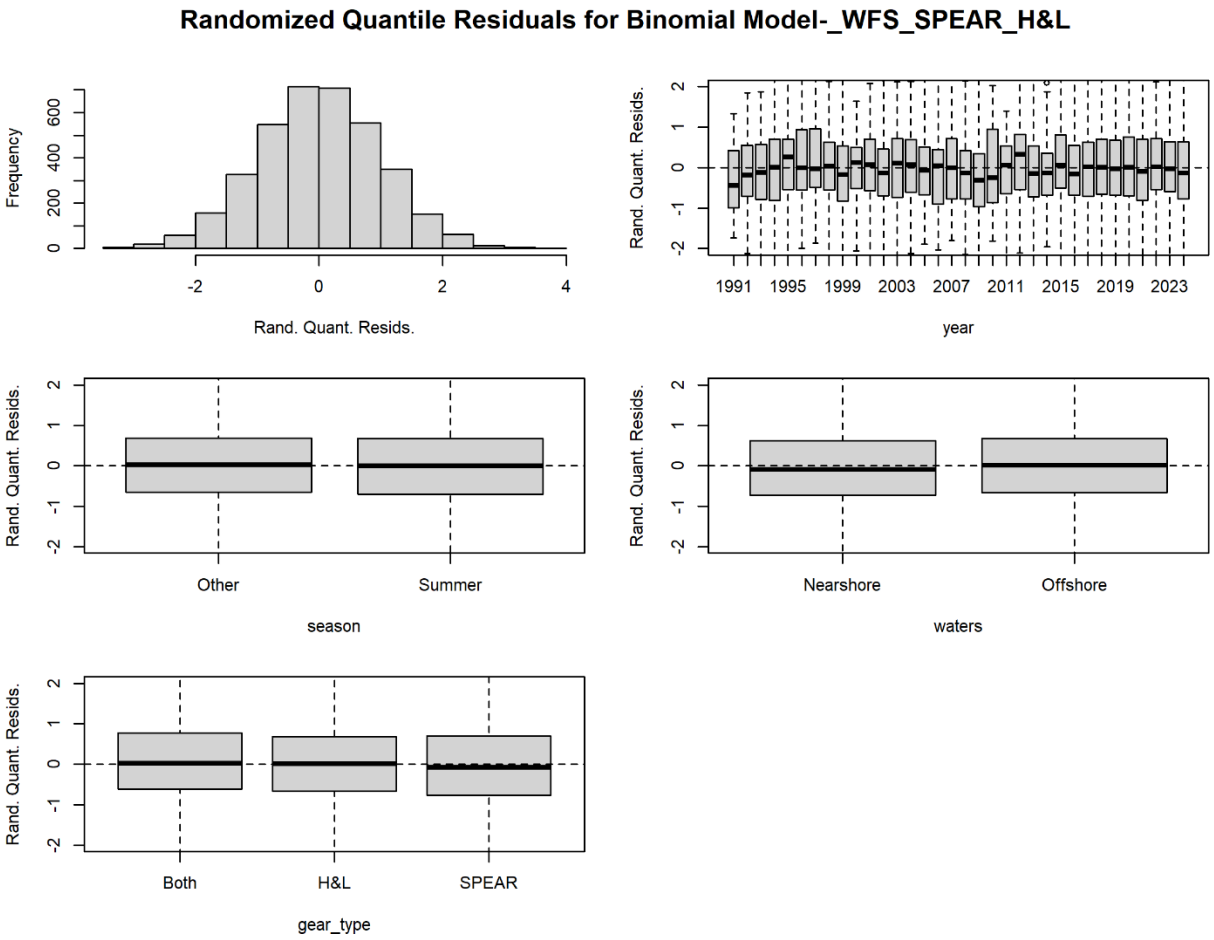

Figure 47. Randomized quantile residuals for the WFL Spear and H&L binomial model.

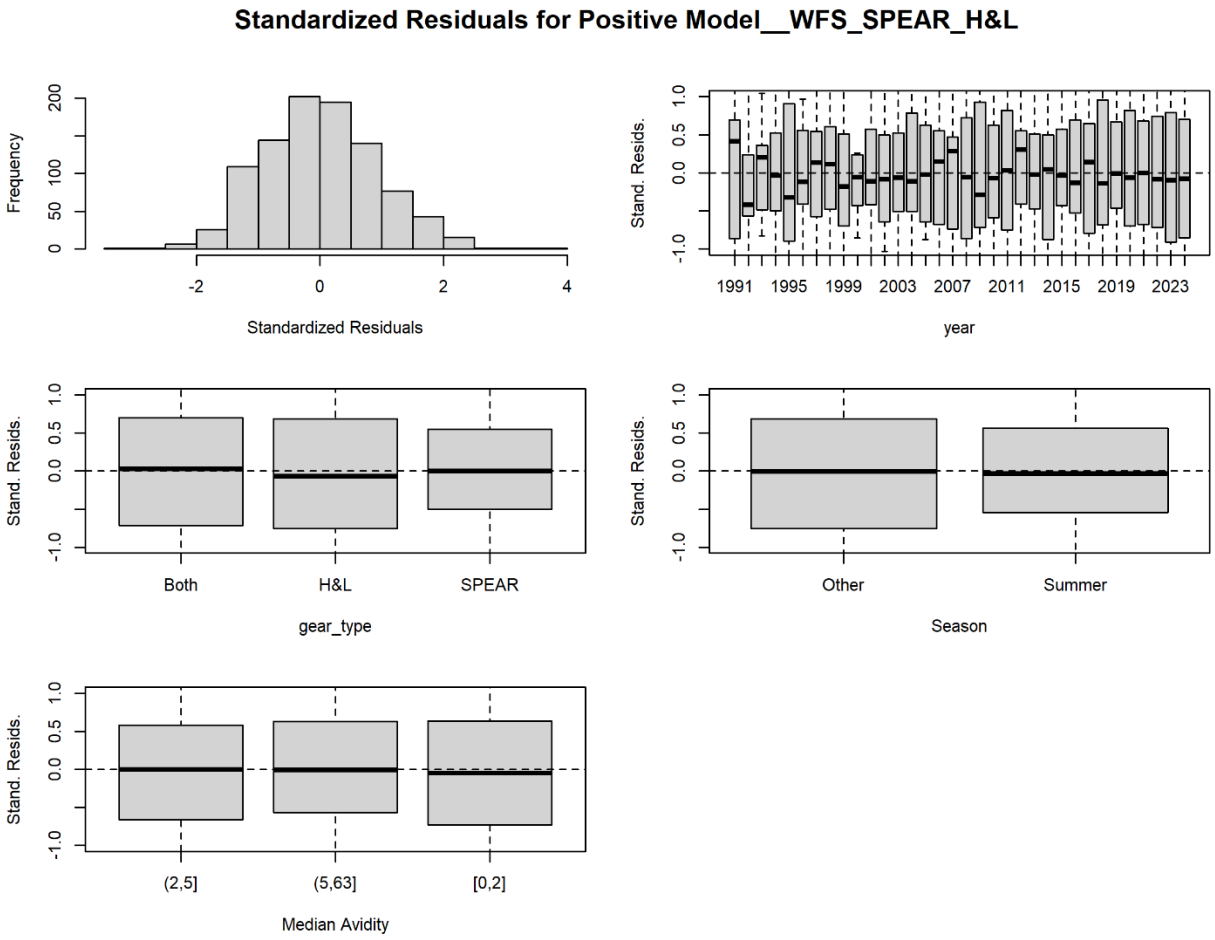

Figure 48. Standardized Pearson residuals for the WFL Spear and H&L positive Model.

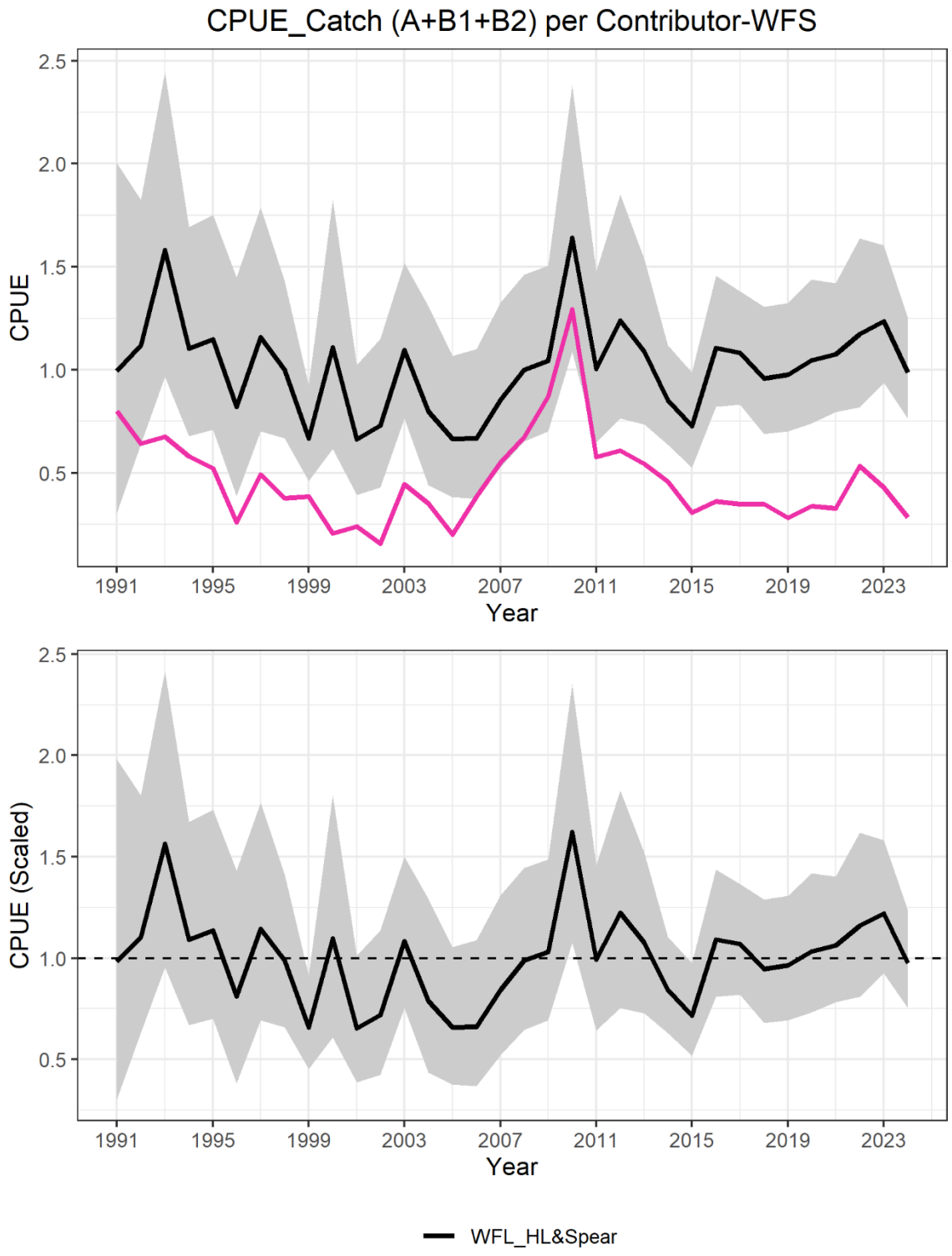

Figure 49. Standardized MRIP catch rate index (black line) of hogfish for WFL Spear and H&L fishery with 95% confidence intervals (grey ribbon), along with the nominal CPUE (magenta line).

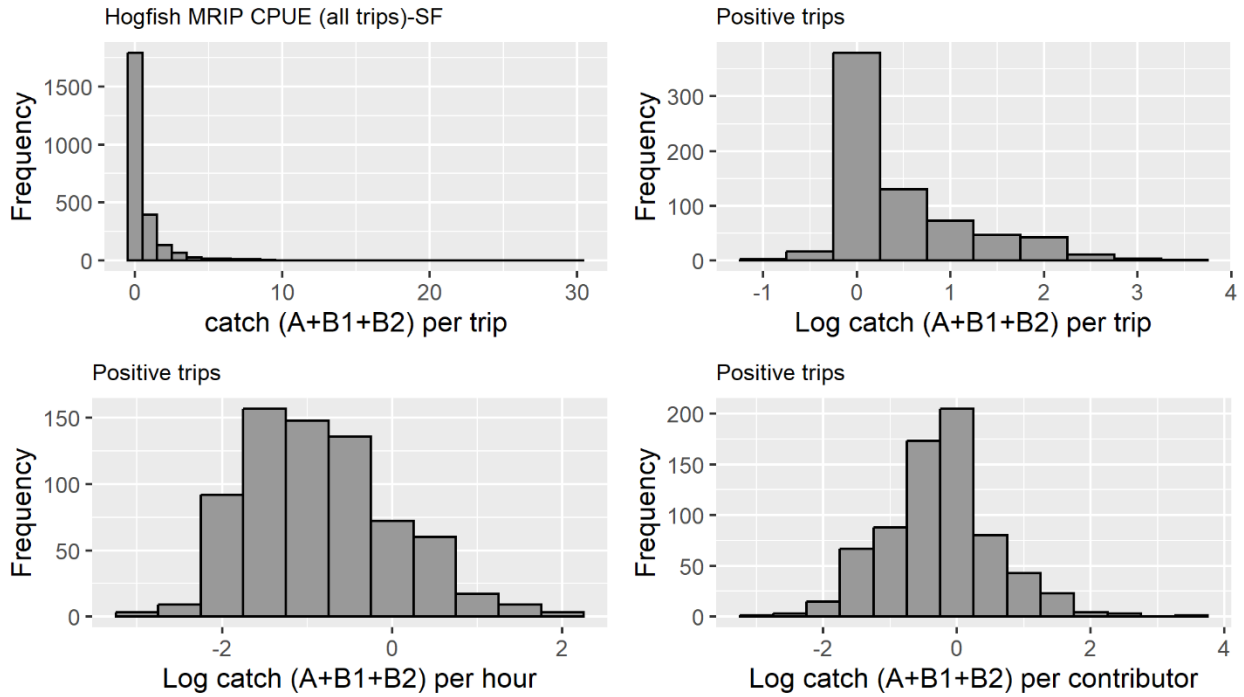

Figure 50. Histograms of hogfish catch per trip within the species cluster including zeros (top left), log(catch per trip) for positive trips (top right), log (catch per median hour fished) for positive trips (bottom left), and a histogram of log(catch per contributor) for positive trips (bottom right) for the Keys-EFL H&L data (shore, charter, and private mode, nearshore and offshore).

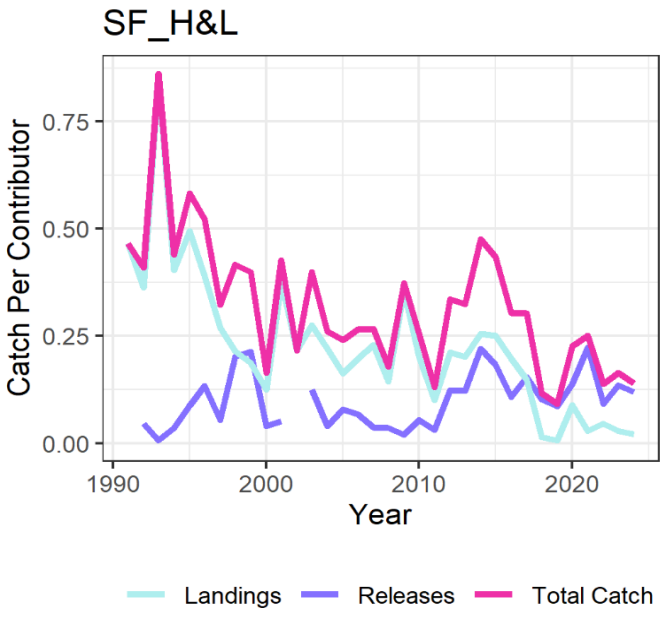

Figure 51. A comparison of mean nominal total catch per contributor (magenta), landings per contributor (light blue), and releases per contributor (dark blue) for the Keys-EFL H&L data (shore, charter, and private mode, nearshore and offshore).

Figure 52. Interaction plots between year and considered covariates for the binomial model using the Keys-EFL H&L data (shore, charter, and private mode, nearshore and offshore) using mean catch per contributor.

Figure 53. Interaction plots between year and considered covariates for the positive model using the Keys-EFL H&L data (shore, charter, and private mode, nearshore and offshore) using mean catch per contributor.

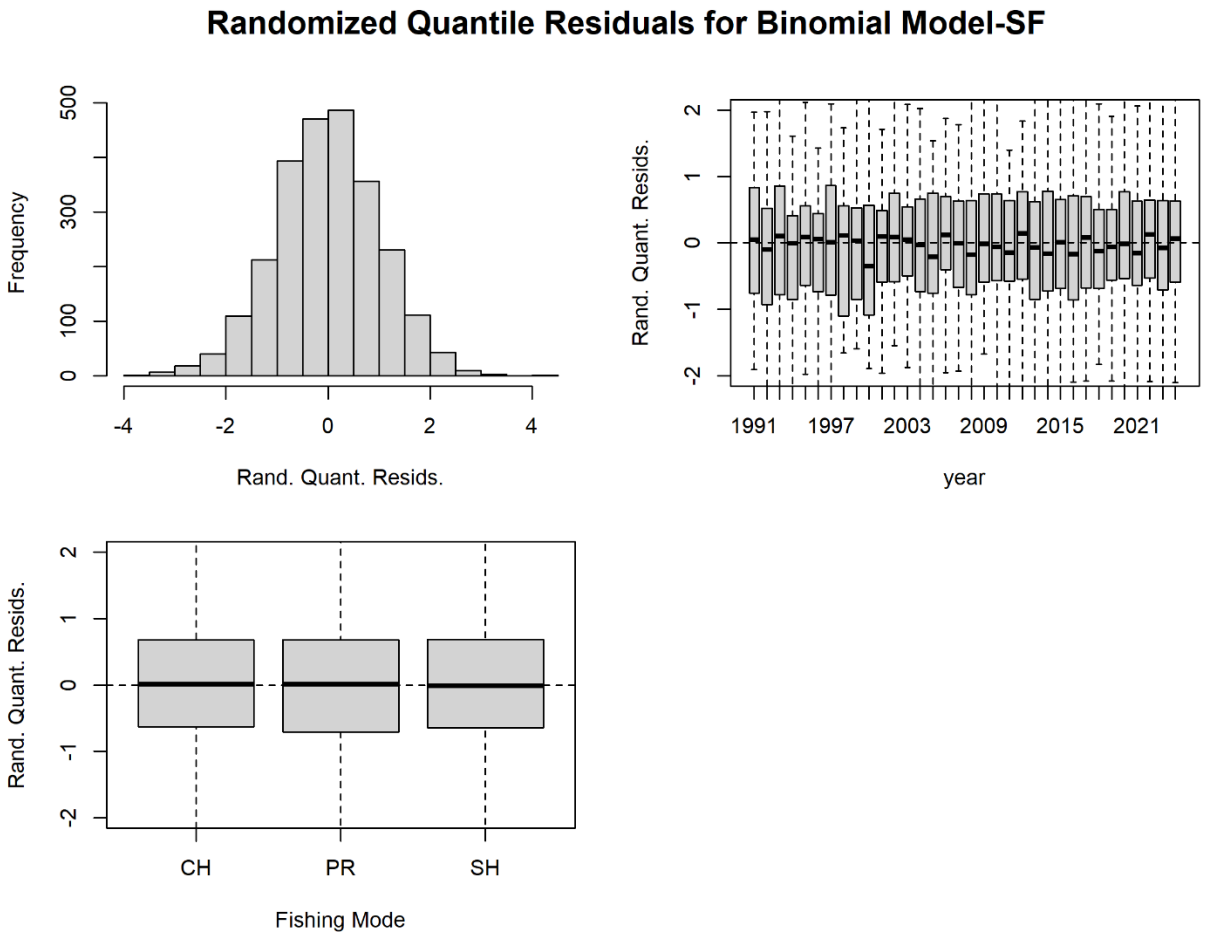

Figure 54. Randomized quantile residuals for the Keys-EFL H&L binomial model.

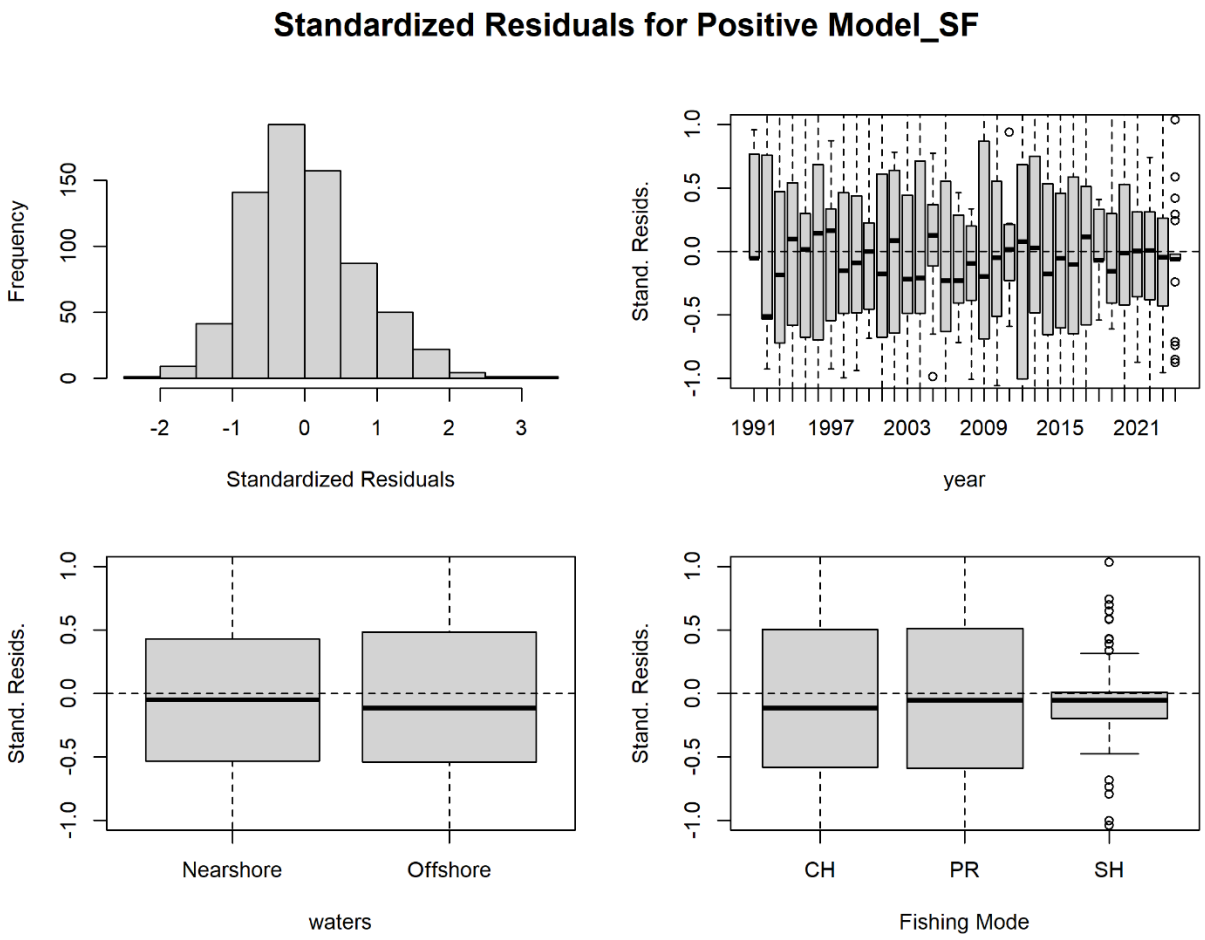

Figure 55. Standardized Pearson residuals for the Keys-EFL H&L positive Model.

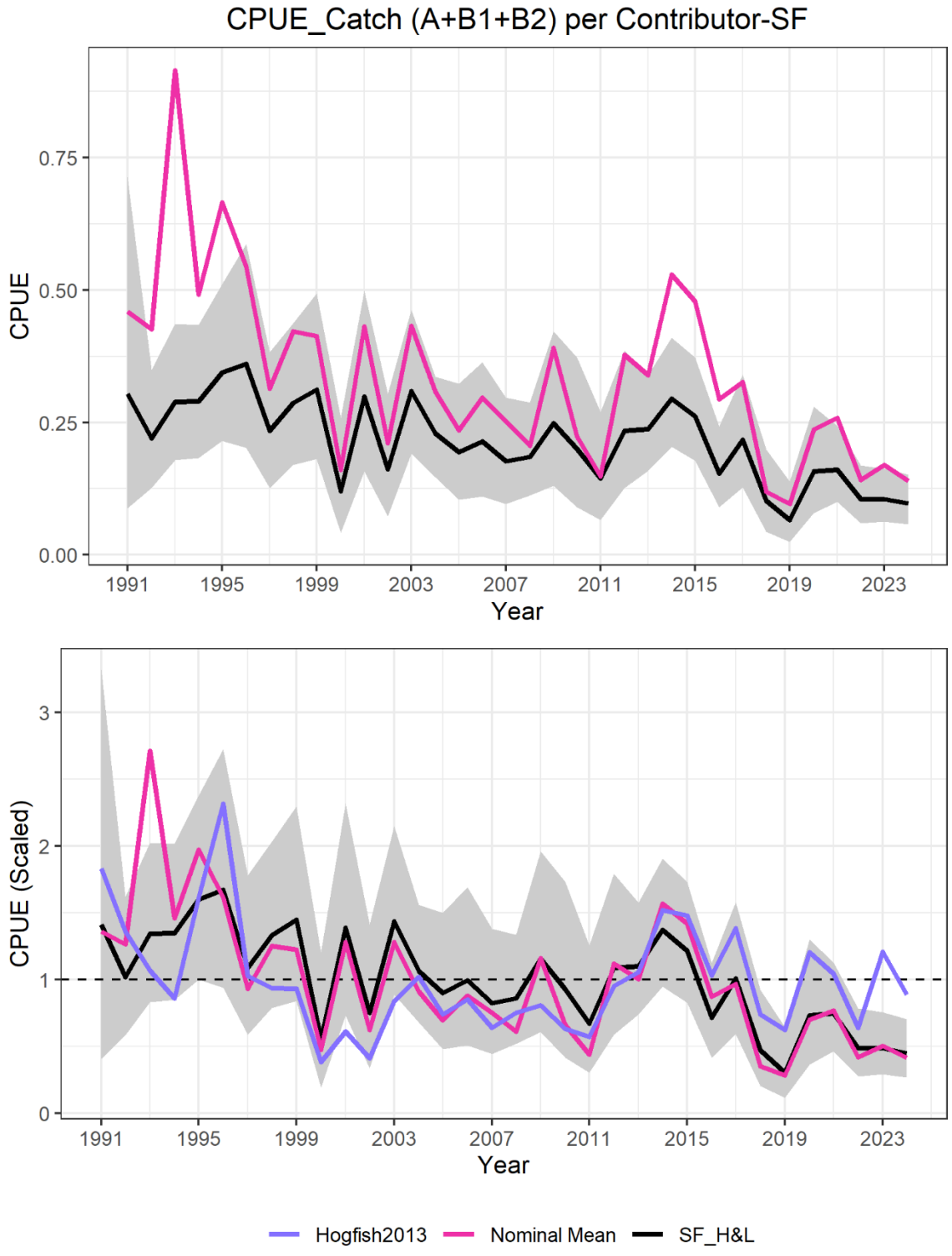

Figure 56. Standardized MRIP catch rate index (black line) of hogfish for the Keys-EFL H&L fishery with 95% confidence intervals (grey ribbon), along with the nominal CPUE (magenta line) and the standardized CPUE from a continuity model based on SEDAR 37 (blue line).

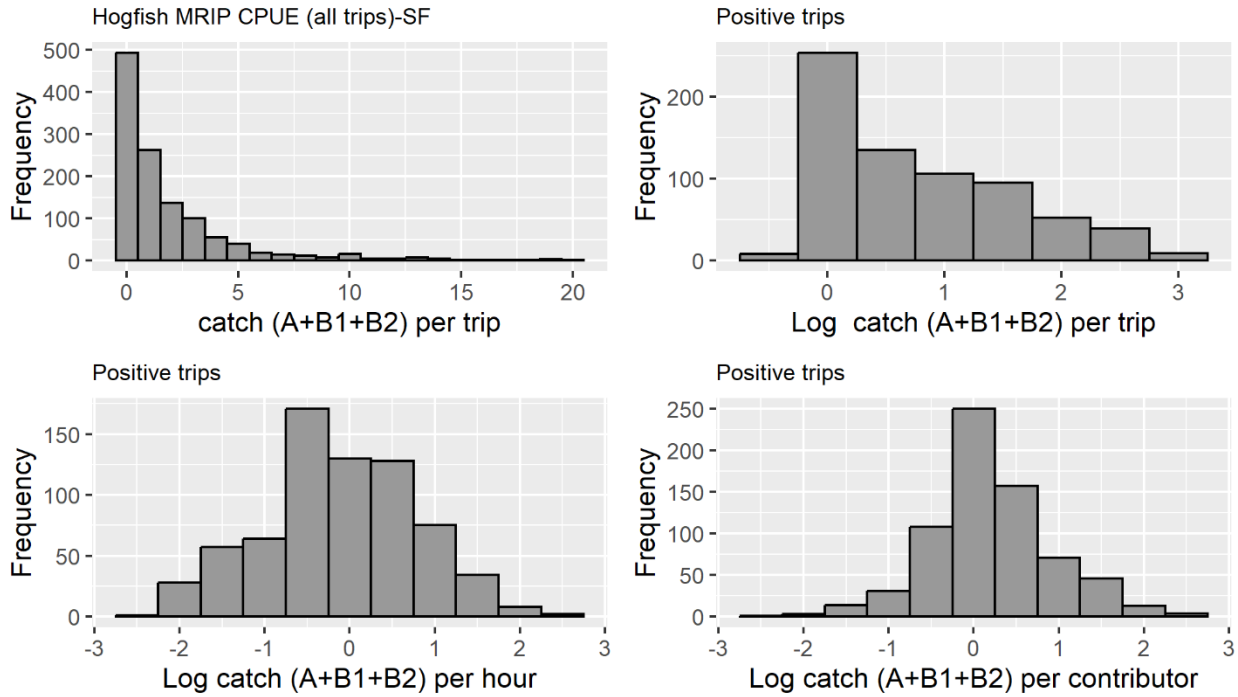

Figure 57. Histograms of hogfish catch per trip within the species cluster including zeros (top left), log(catch per trip) for positive trips (top right), log (catch per median hour fished) for positive trips (bottom left), and a histogram of log(catch per contributor) for positive trips (bottom right) for the Keys-EFL Spear data (charter and private modes, nearshore and offshore).

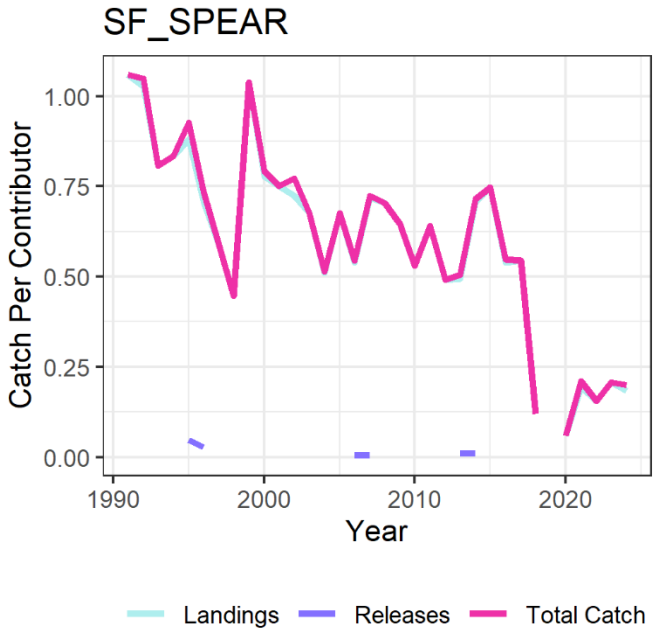

Figure 58. A comparison of mean nominal total catch per contributor (magenta), landings per contributor (light blue), and releases per contributor (dark blue) for the Keys-EFL Spear data (charter and private modes, nearshore and offshore).

Figure 59. Interaction plots between year and considered covariates for the binomial model using the Keys-EFL Spear data (charter and private modes, nearshore and offshore) using mean catch per contributor.

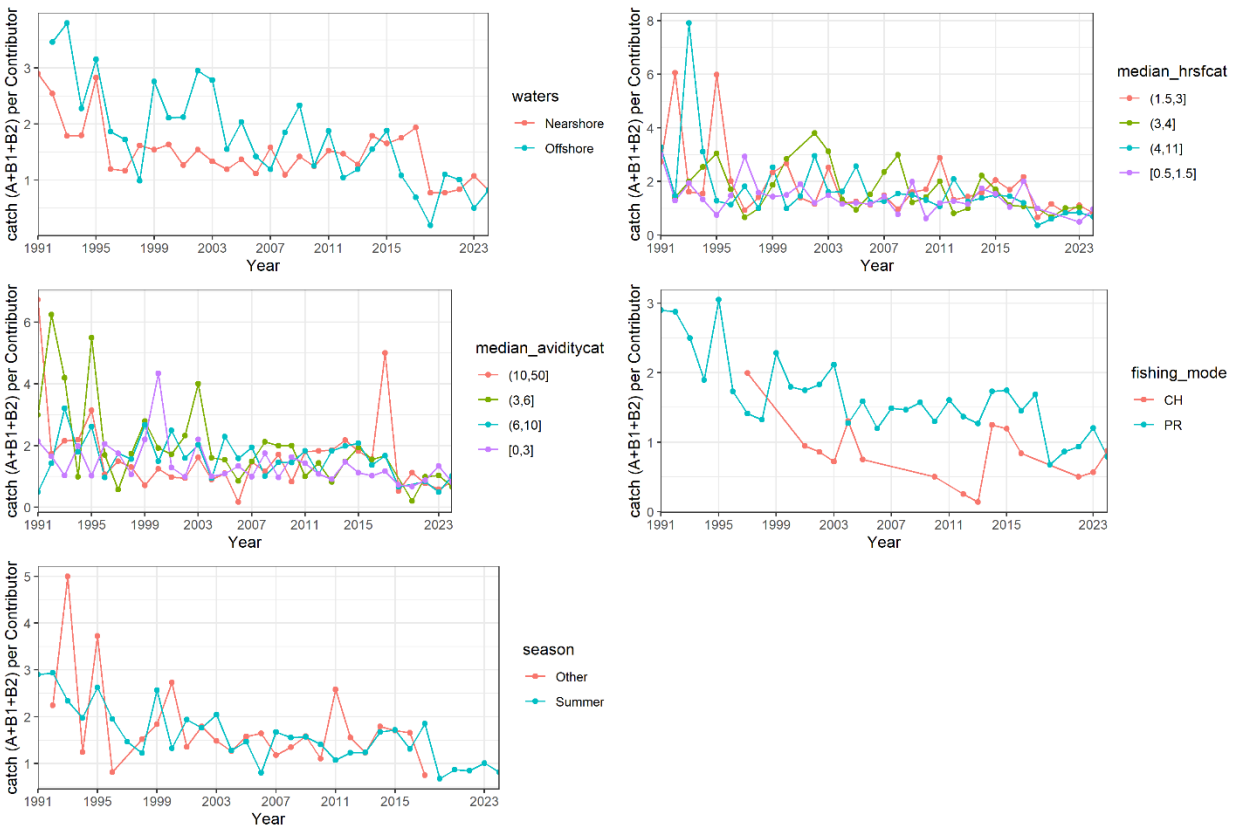

Figure 60. Interaction plots between year and considered covariates for the positive model using the Keys-EFL Spear data (charter and private modes, nearshore and offshore) using mean catch per contributor.

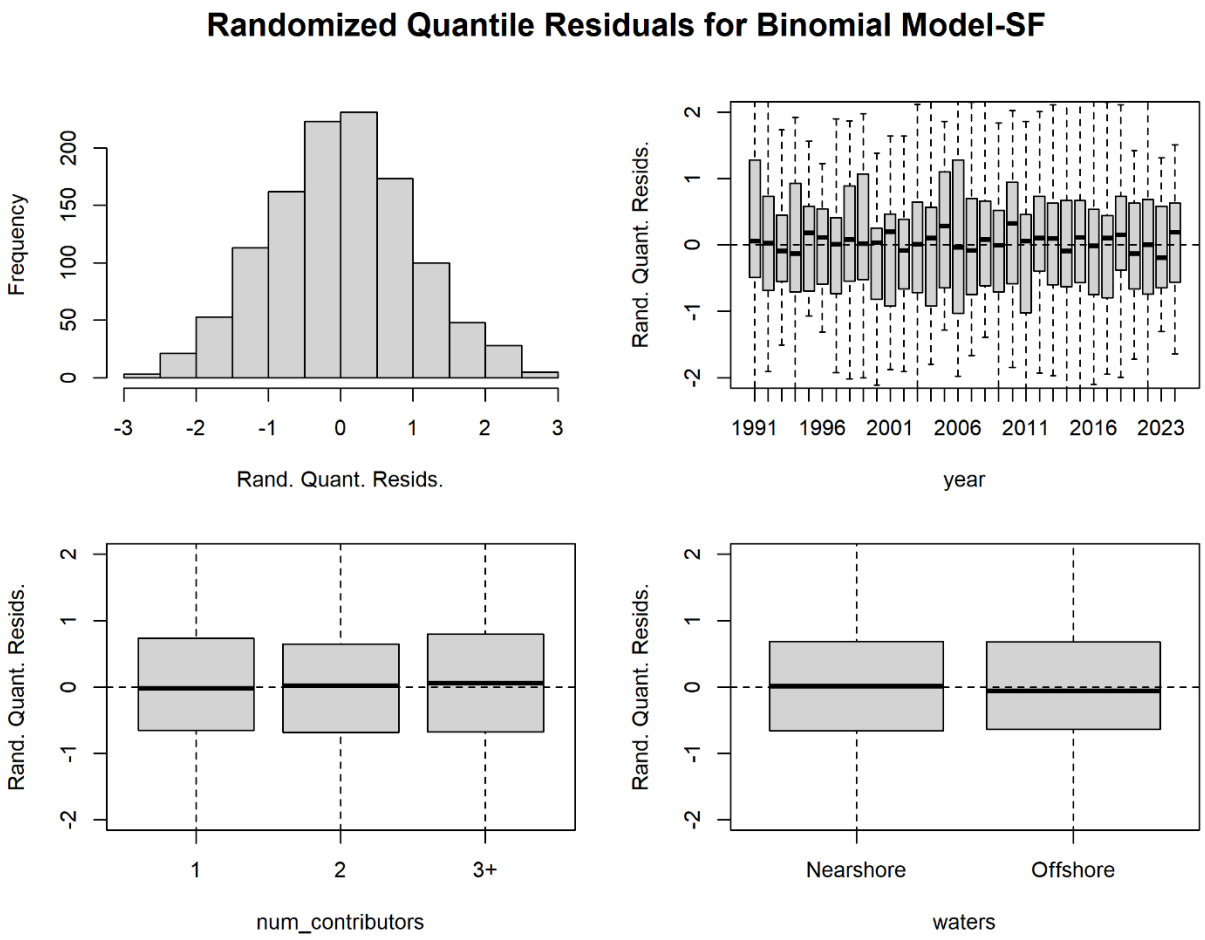

Figure 61. Randomized quantile residuals for the Keys-EFL Spear binomial model.

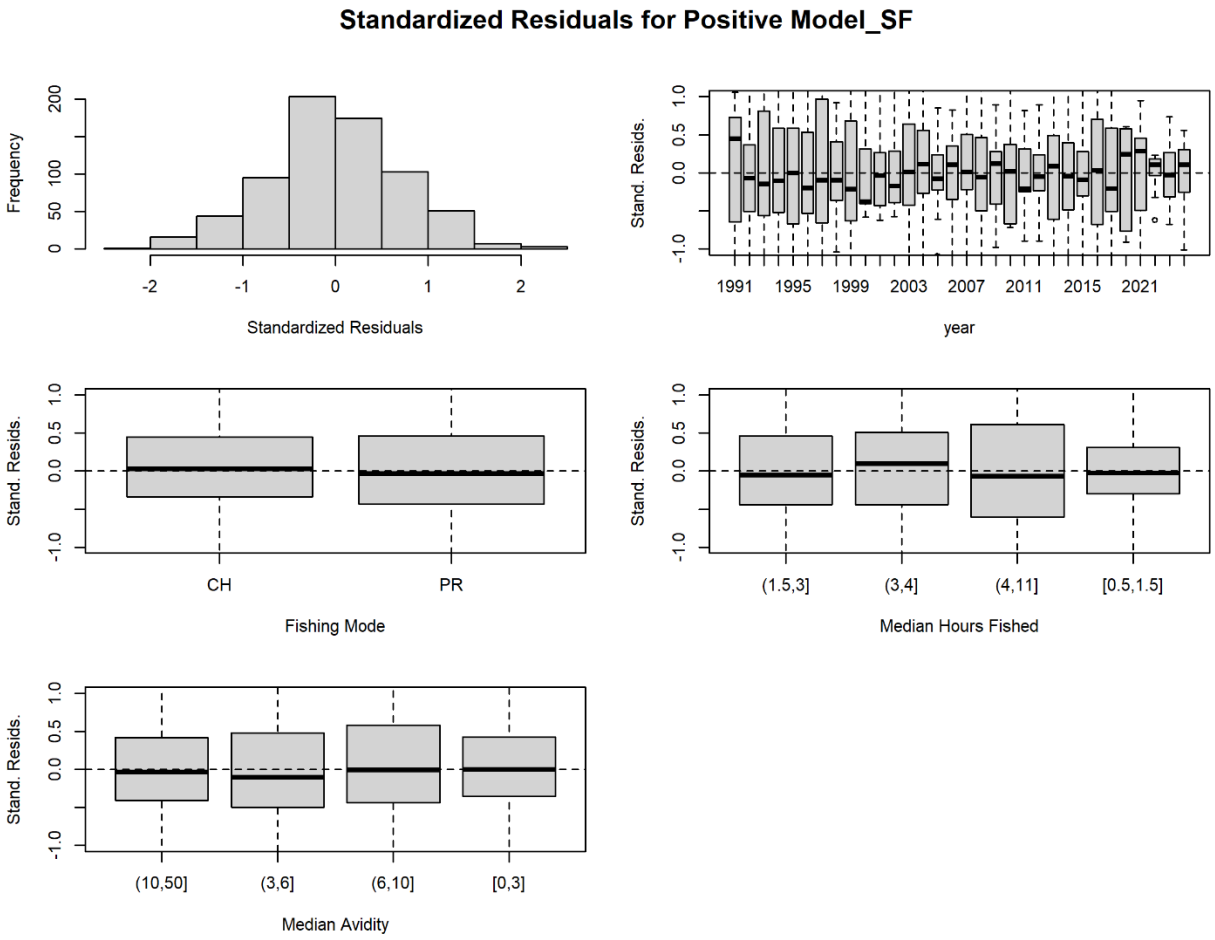

Figure 62. Standardized Pearson residuals for the Keys-EFL Spear positive Model.

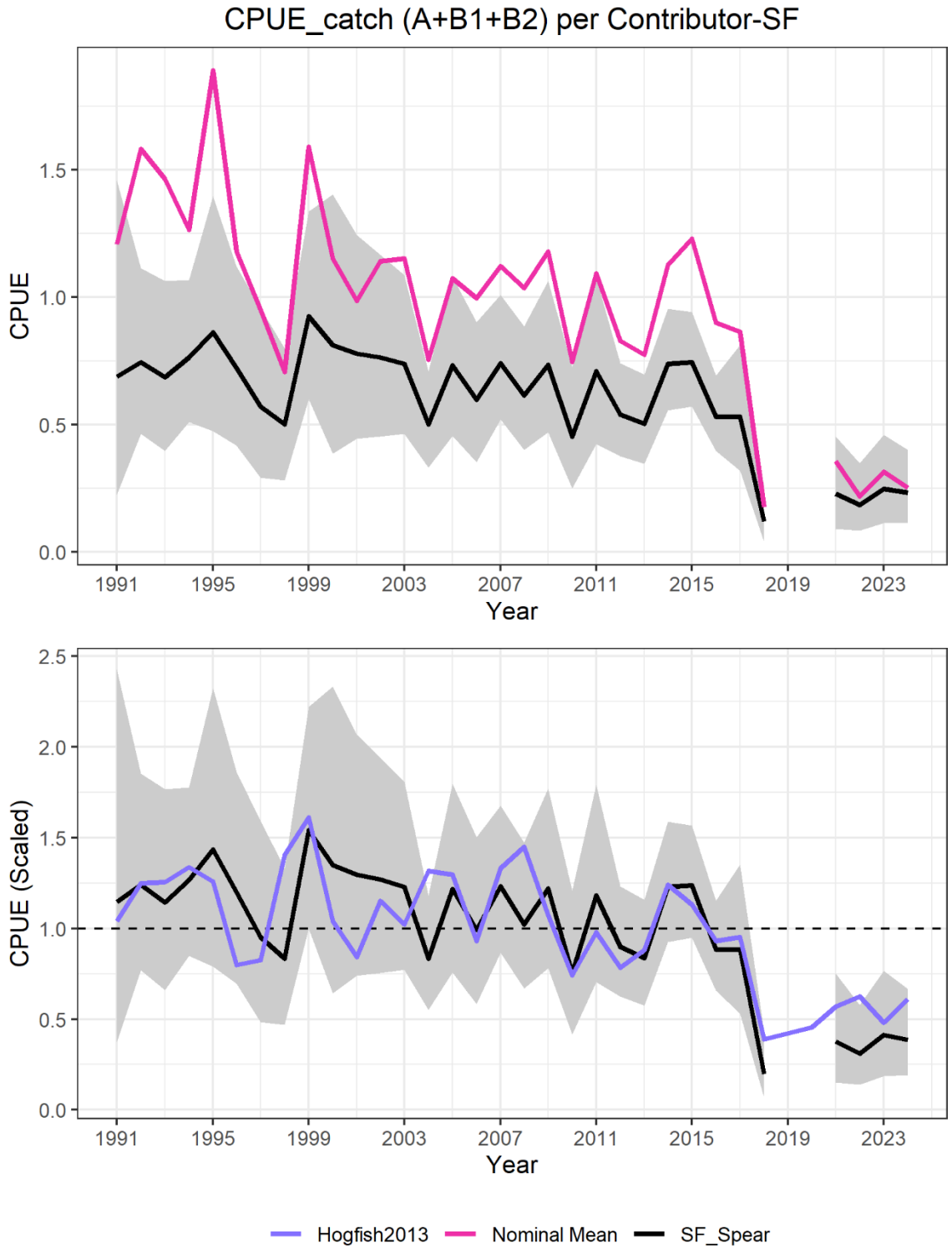

Figure 63. Standardized MRIP catch rate index (black line) of hogfish for the Keys-EFL Spear fishery with 95% confidence intervals (grey ribbon), along with the nominal CPUE (magenta line) and the standardized CPUE from a continuity model based on SEDAR 37 (blue line).

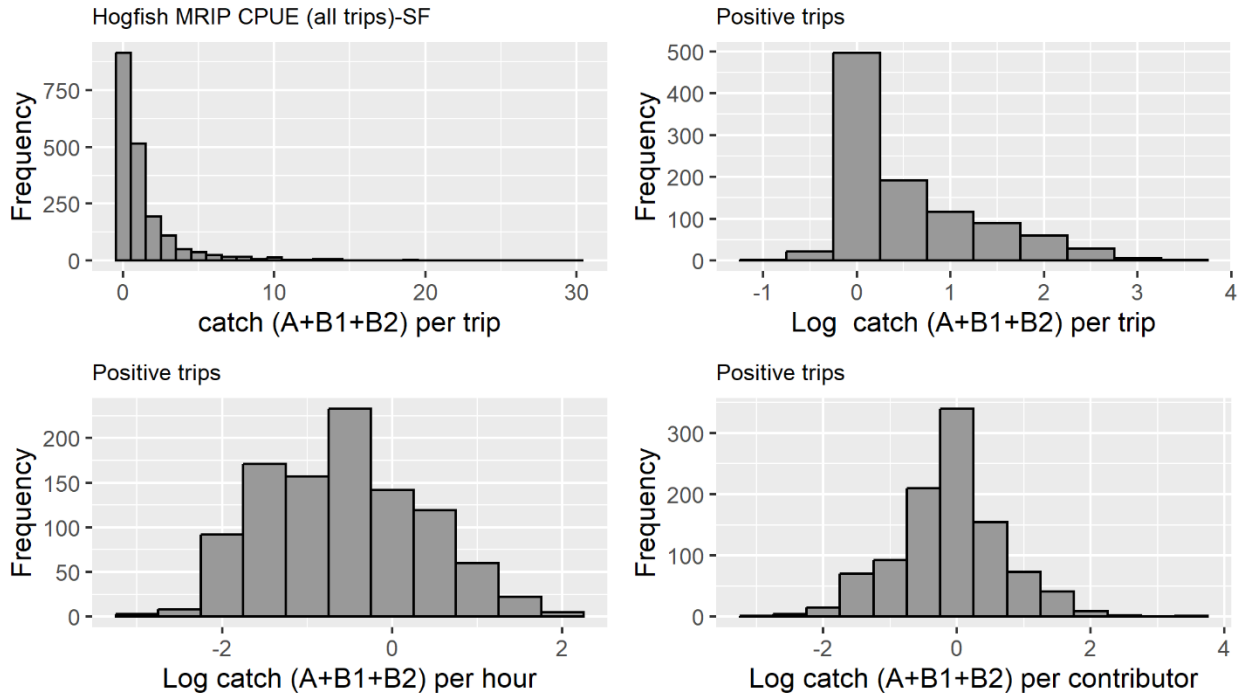

Figure 64. Histograms of hogfish catch per trip within the species cluster including zeros (top left), log(catch per trip) for positive trips (top right), log (catch per median hour fished) for positive trips (bottom left), and a histogram of log(catch per contributor) for positive trips (bottom right) for the Keys-EFL Spear and H&L data (shore, charter and private modes, nearshore and offshore).

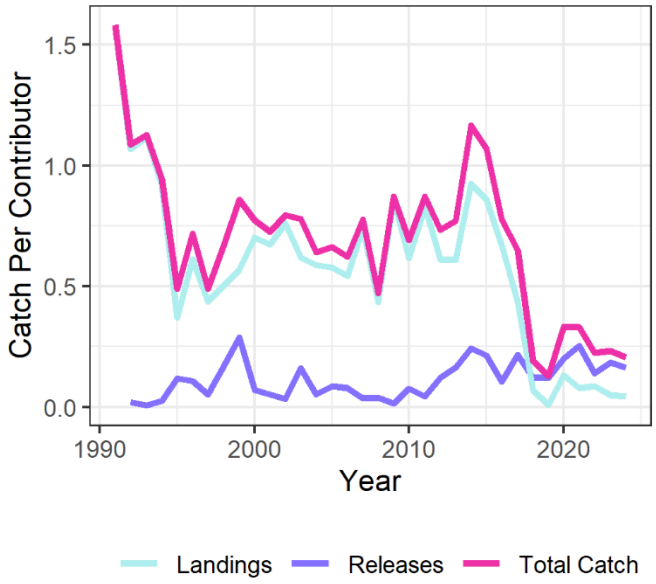

Figure 65. A comparison of mean nominal total catch per contributor (magenta), landings per contributor (light blue), and releases per contributor (dark blue) for the Keys-EFL Spear and H&L data (shore, charter and private modes, nearshore and offshore).

Figure 66. Interaction plots between year and considered covariates for the binomial model using the Keys-EFL Spear and H&L data (shore, charter and private modes, nearshore and offshore) using mean catch per contributor.

Figure 67. Interaction plots between year and considered covariates for the positive model using the Keys-EFL Spear and H&L data (shore, charter and private modes, nearshore and offshore) using mean catch per contributor.

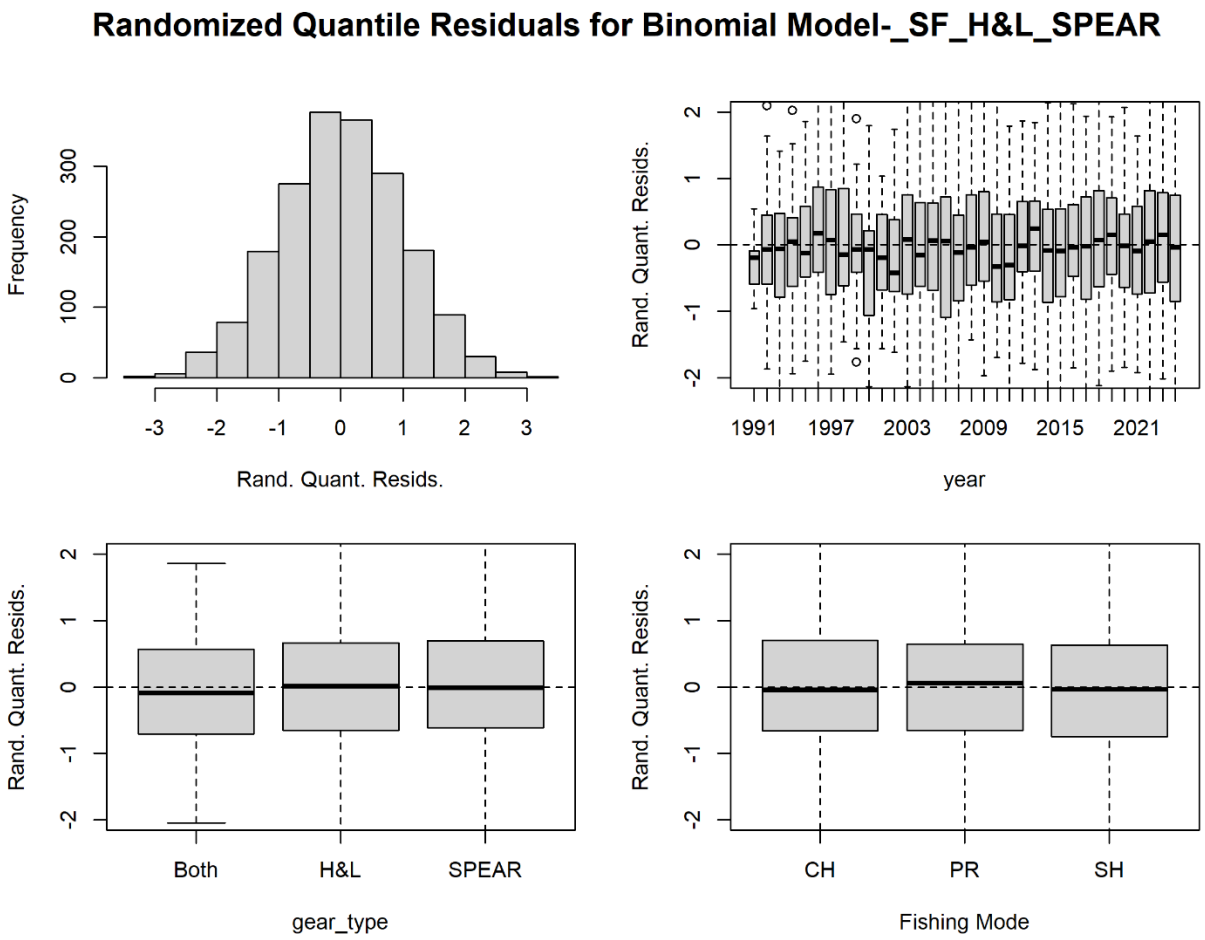

Figure 68. Randomized quantile residuals for the Keys-EFL Spear and H&L binomial model.

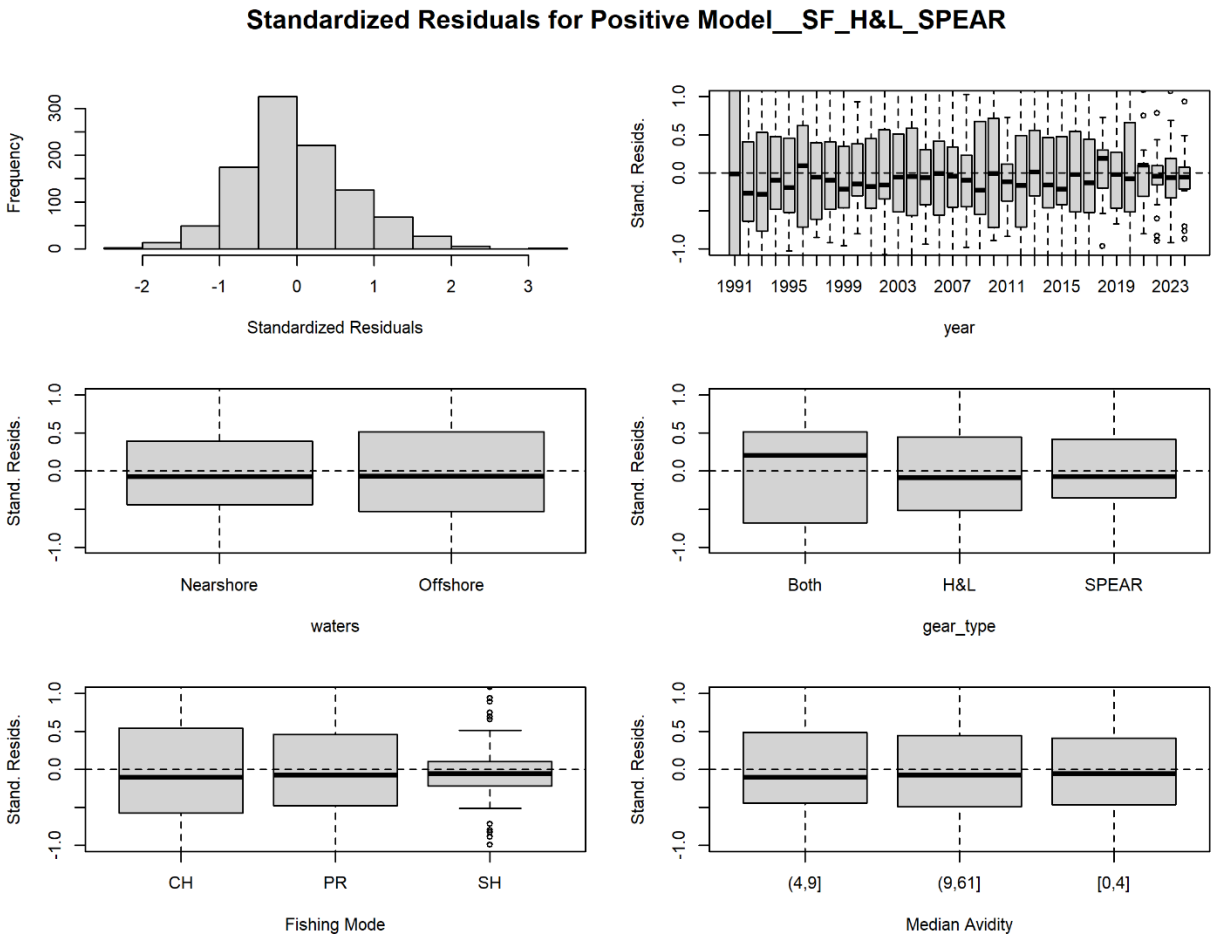

Figure 69. Standardized Pearson residuals for the Keys-EFL Spear and H&L positive Model.

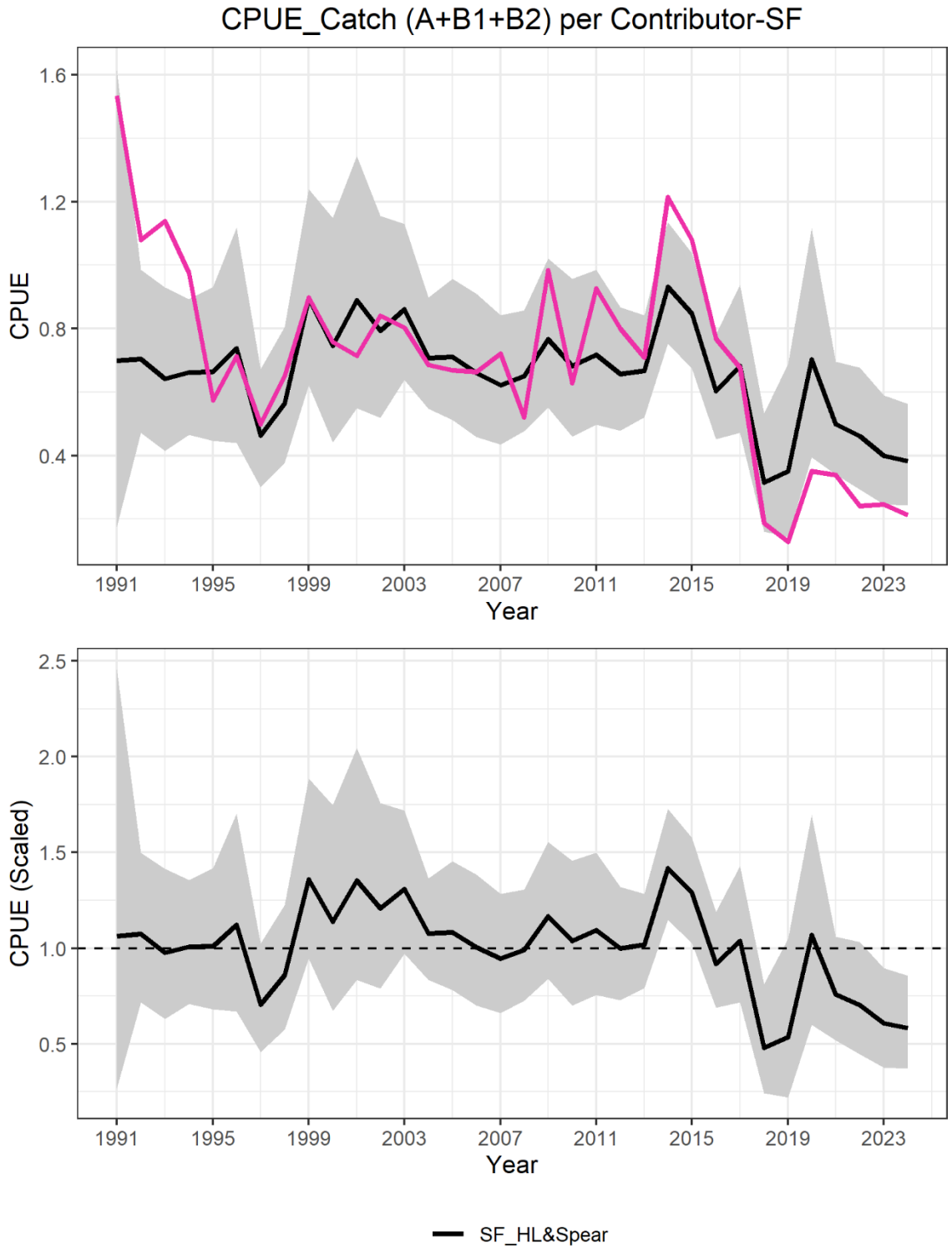

Figure 70. Standardized MRIP catch rate index (black line) of hogfish for the Keys-EFL Spear and H&L fishery with 95% confidence intervals (grey ribbon), along with the nominal CPUE (magenta line).

Supplementary Materials

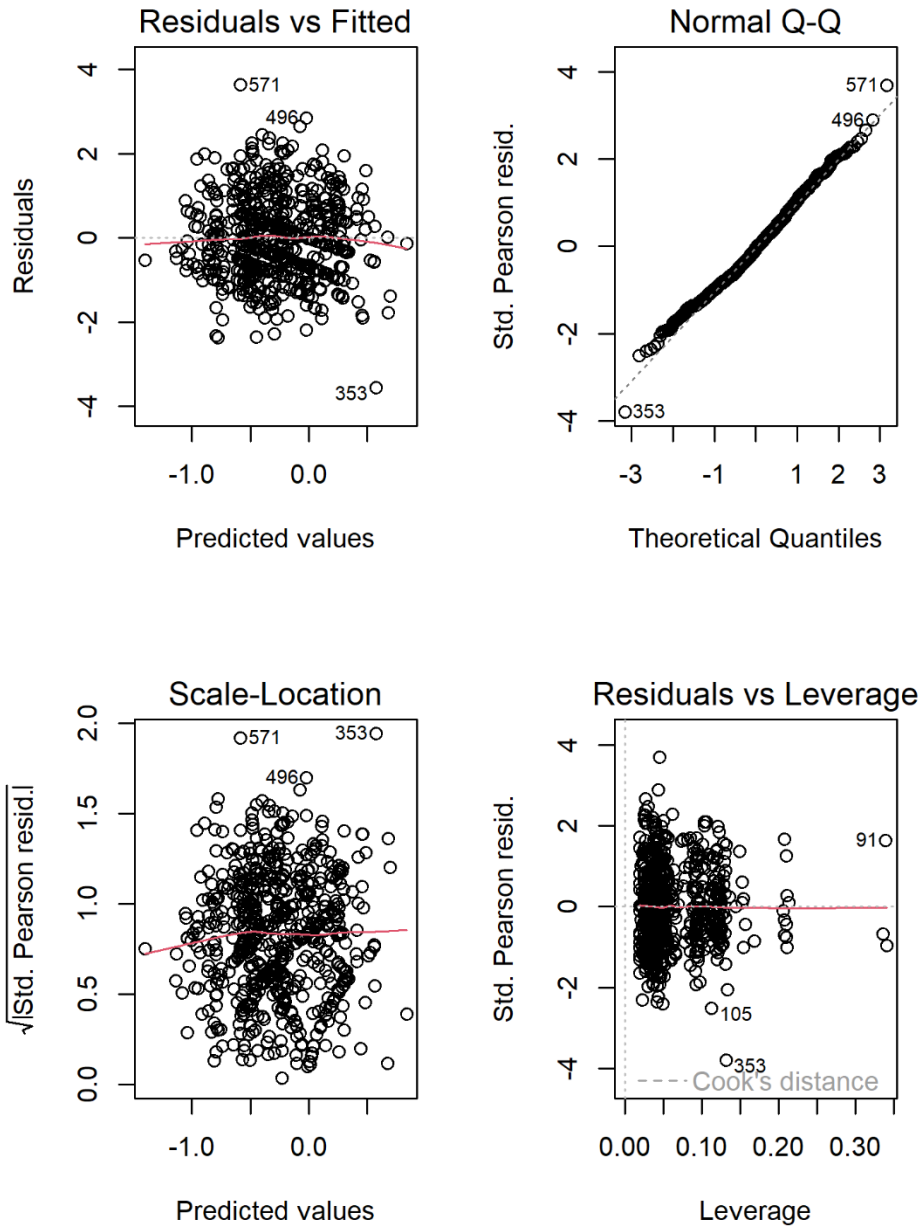

Figure S1. Diagnostic plots for the WFL H&L positive model.

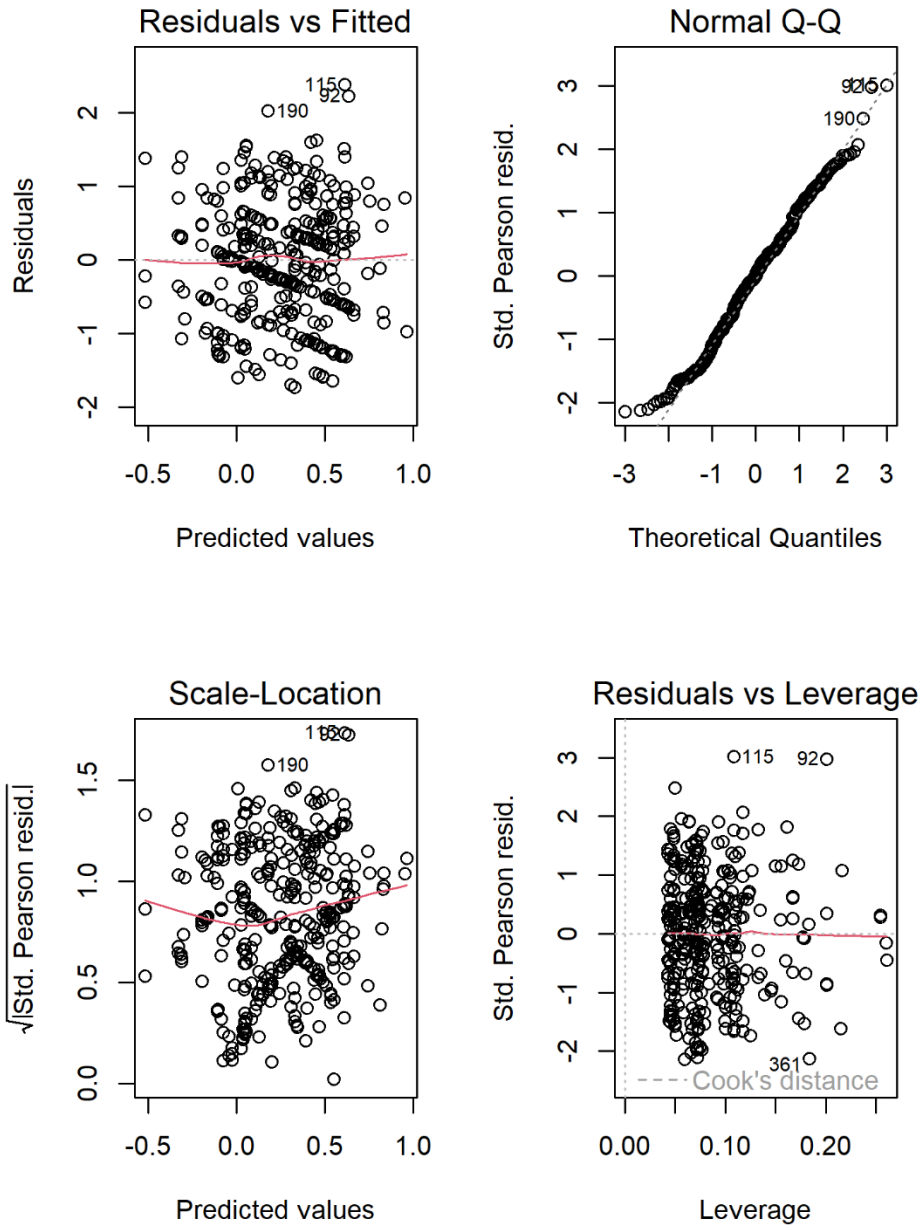

Figure S2. Diagnostic plots for the WFL Spear positive model.

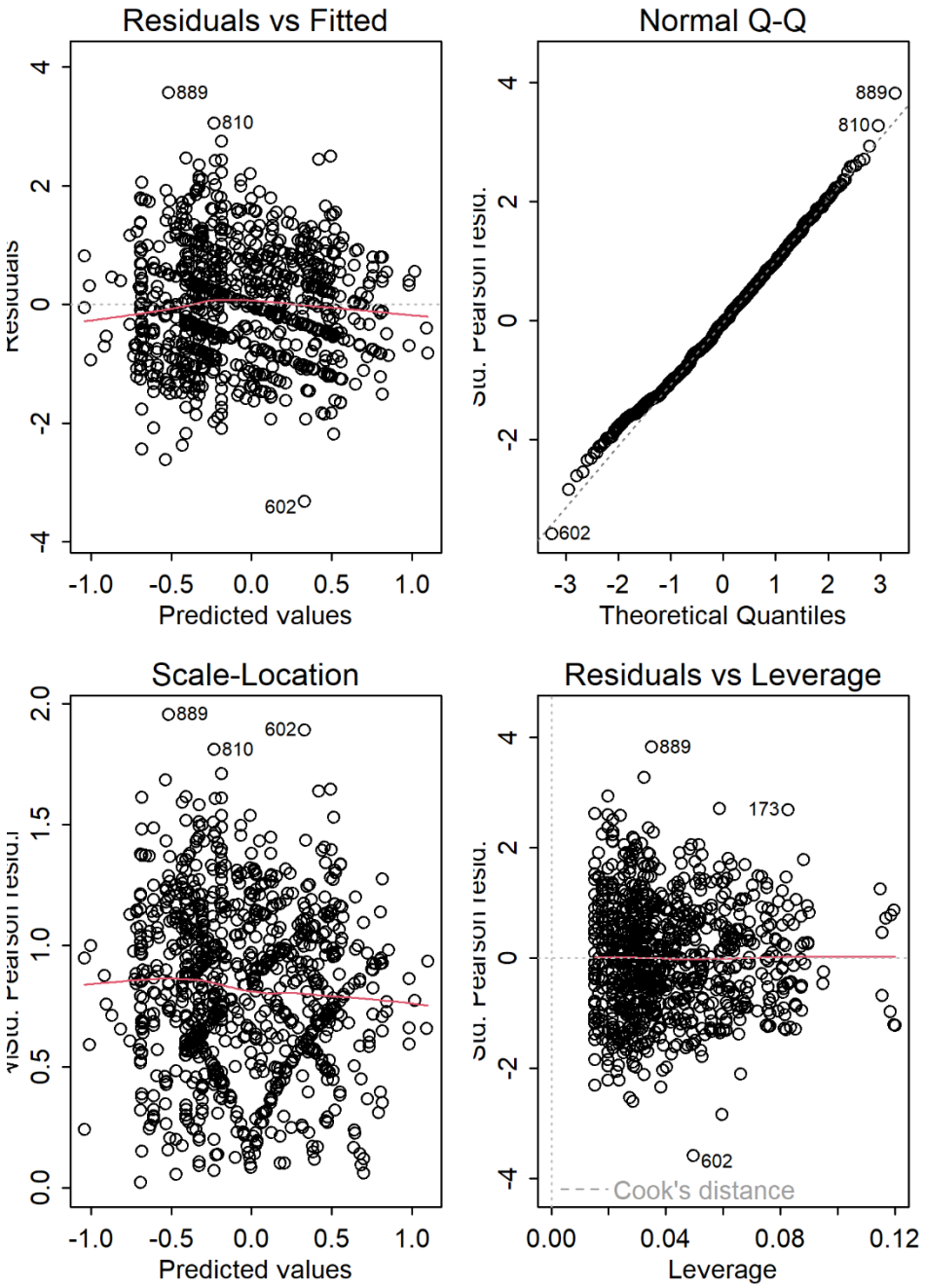

Figure S3. Diagnostic plots for the WFL H&L and Spear positive model.

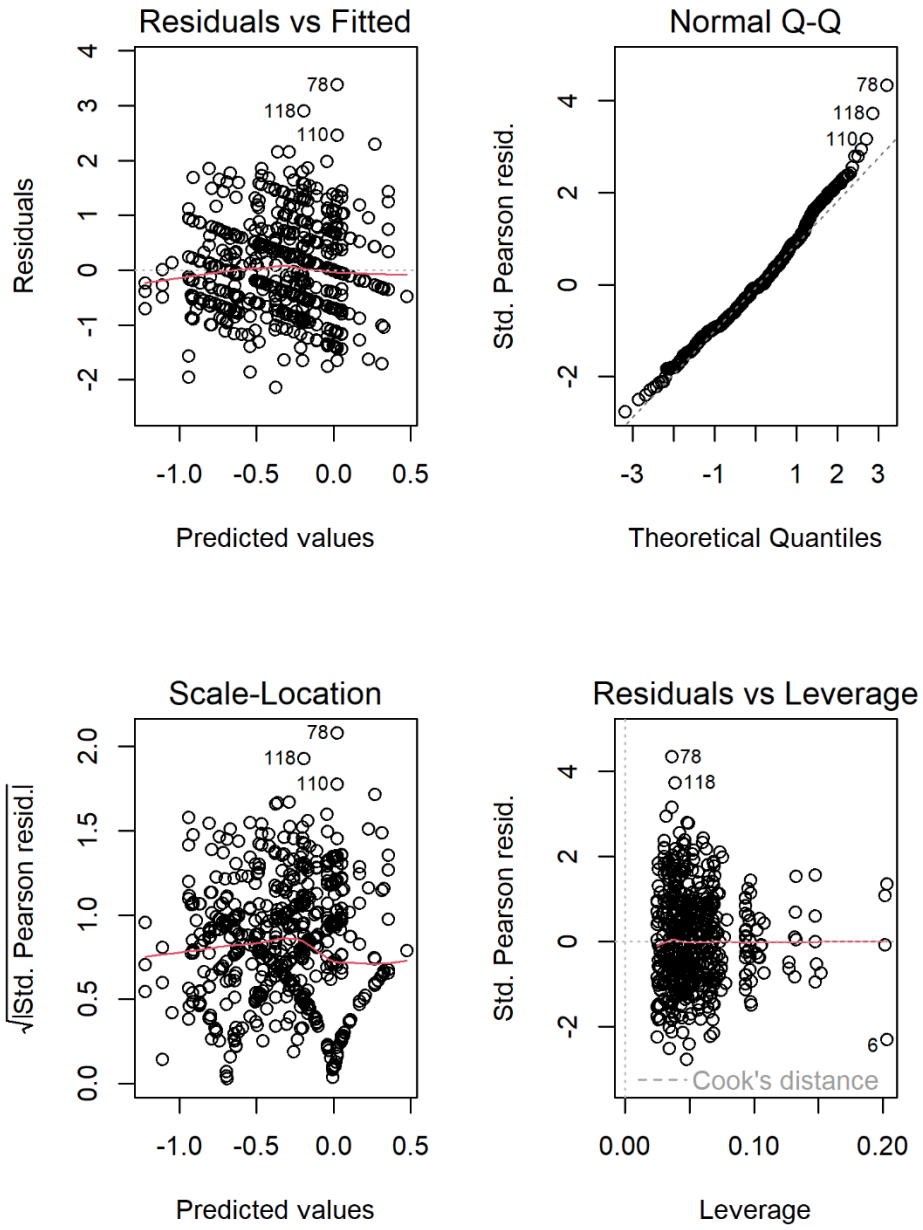

Figure S4. Diagnostic plots for the Keys-EFL H&L positive model.

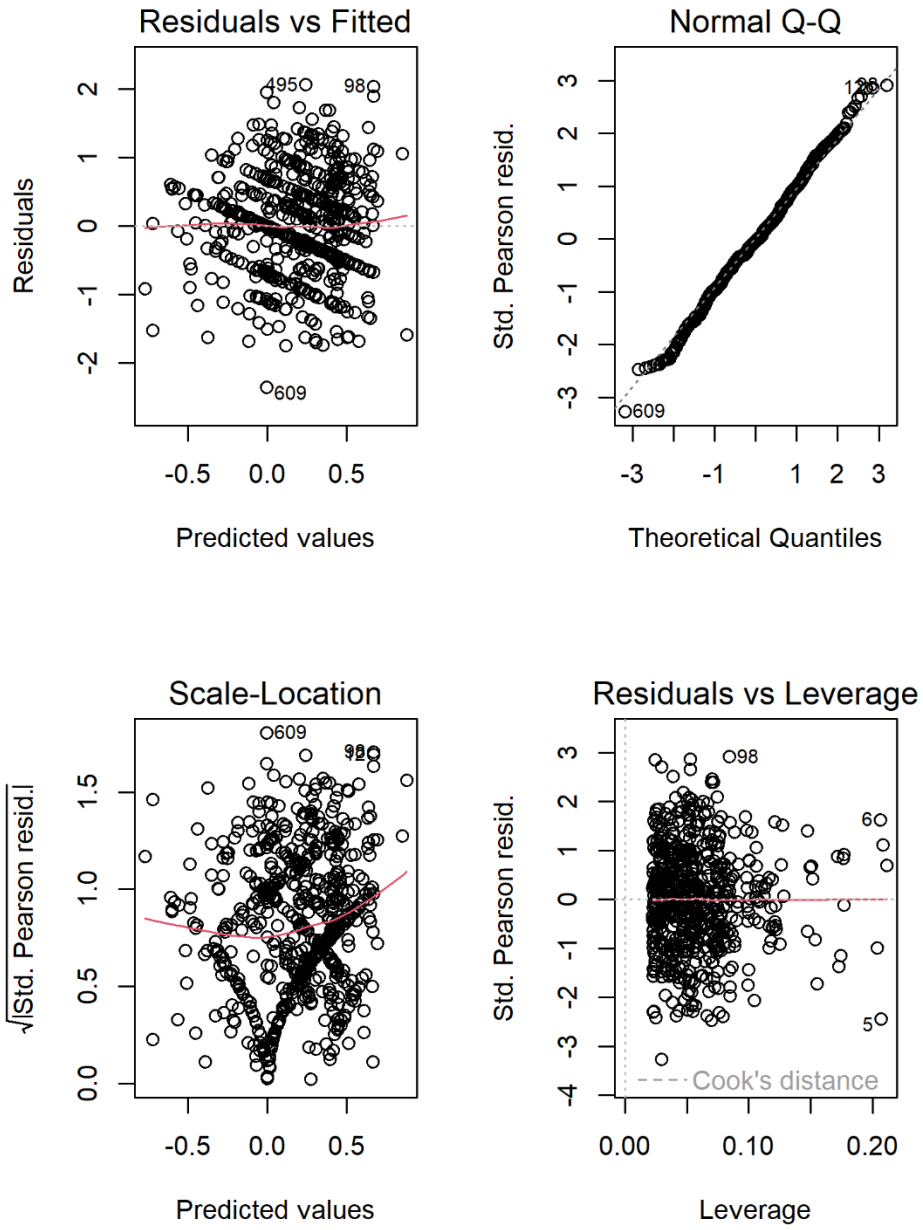

Figure S5. Diagnostic plots for the Keys-EFL Spear positive model.

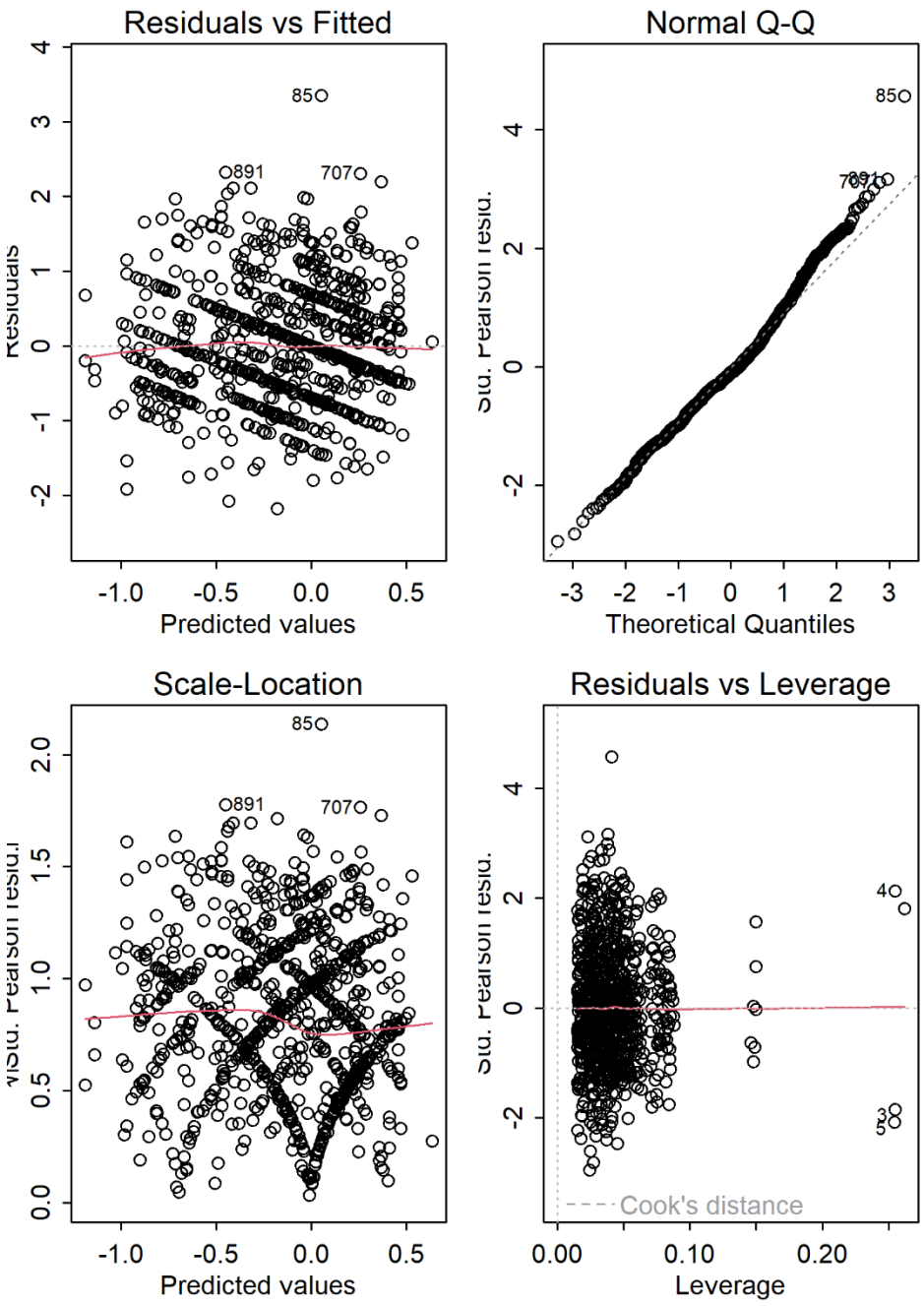

Figure S6. Diagnostic plots for the Keys-EFL H&L and Spear positive model.

Addendum to Standardized Catch Rates of Hogfish (*Lachnolaimus maximus*) from the Marine Recreational Information Program (MRIP) for West Florida and the Keys-East Florida, 1991-2024

August 20, 2025

Overview

This addendum includes methods and results of two additional MRIP CPUE scenarios identified during the Hogfish Data Workshop. The first scenario limited the WFL H&L CPUE index to include only the private boat mode. There was evidence of increasing CPUE for the charter boat mode. As such, excluding the charter mode eliminated bias from a potentially developing charter fishery in this region. The second scenario limited the years for the Keys-EFL H&L CPUE index to 1991 – 2016. This scenario removed years with lower bag limits in the Keys-EFL region, reducing the sensitivity of this index to management regulation changes.

Species Clustering

WFL - H&L (Private, Nearshore/Offshore)

Prior to running the cluster analysis, rare species that made up less than 0.5% of trips were removed, retaining 67 species. For West Florida H&L (private mode only), hogfish was clustered with **littlehead porgy and porgy family** using the percent square root of total catch (Figure A1). This transformation resulted in the highest silhouette width for hogfish (0.05, overall average silhouette width for the cluster = 0.03).

Keys-EFL - Hook and Line (Charter/Private/Shore, Nearshore/Offshore) 1991-2016

For Keys-EFL H&L trips from 1991-2016, rare species were removed that comprised at most 1% of trips. Since hogfish made up less than 1% of trips, it was manually added back, resulting in a total of 48 species. Hogfish was clustered with **jolthead porgy** when taking the square root of catch (Figure A2) and was not clustered with other species under other transformations. The square root of catch resulted in the highest silhouette width for hogfish (0.051, overall average silhouette width for the cluster = 0.031).

CPUE Standardization

WFL - H&L (Private, Nearshore/Offshore)

There were a total of 1,059 WFL private mode H&L trips within the hogfish cluster that included littlehead porgy and porgy family and 336 positive trips. The number of trips that encountered at least one species in the cluster, as well as the number of trips that encountered at least one hogfish by year for each level of each covariate are presented in Tables A1 and A2, respectively.

Histograms of hogfish catch per trip including zeros exhibit zero inflation and overdispersion (Figure A3). For positive trips, the CPUE definition that most closely resembles a normal distribution is log(catch per contributor) (Figure A3).

The number released per contributor has increased since 2016 while the number landed per contributor declined considerably in 2017, likely corresponding to an increase in minimum size limits in 2017 from 12 inches to 14 inches (Figure A4). The landing rate has steadily increased since 2019 along with the release rate, resulting in an increasing CPUE since 2018 (Figure A4).

For the binomial model, mean catch per contributor appears to have increased in offshore waters and decreased in nearshore waters since 2021 (Figure A5), whereas the positive catch rates show a declining trend in nearshore waters since 2016 (Figure A6).

The following binomial and positive sub-models are selected by the model selection procedure and are presented in Tables A3 and A4:

Binomial: Presence = year + median hours fished

Positive Normal: log(catch per contributor) = year + season + median avidity + median hours fished

Randomized quantile residuals for the binomial sub-model were normally distributed and showed no pattern across predictor variables (Figure A7). Residuals from the positive sub-model were close to normal but exhibited some underestimation in 2012 (Figures A8).

The observed annual nominal mean CPUE and standardized CPUE for the WFL H&L fishery are provided in **Table A5** and illustrated in **Figure A9**; The scaled standardized index (CPUE scaled to the mean) was below average from 1999-2006 and spiked in 2008 and 2010. The index was mostly below the long-term mean from 2012 to 2021 but has increased in recent years (Figure A9).

Keys-EFL - Hook and Line (Charter/Private/Shore, Nearshore/Offshore) 1991-2016

There were a total of 1,203 H&L trips from 1991 – 2016 in the Keys-EFL region within the hogfish cluster that included jolthead porgy and 442 positive trips. The number of trips that encountered at least one species in the cluster, as well as the number of trips that encountered at least one hogfish by year for each level of each covariate are presented in Tables A6 and A7, respectively.

Histograms of hogfish catch per trip including zeros exhibit zero inflation and overdispersion (Figure A10). For positive trips, the CPUE definition that most closely resembles a normal distribution is log(catch per contributor) (Figure A10).

The number released per contributor has increased since 2009 while the number landed per contributor has decreased during that time. From 2014-2016, both the number released and the number landed per contributor have decreased (Figure A11).

For the binomial and positive models, mean catch per contributor appears to have increased in nearshore waters for the shore mode since 2014 (Figures A12 and A13).

The following binomial and positive sub-models are selected by the model selection procedure and are presented in Tables A8 and A9:

Binomial: Presence = year + fishing mode + number of contributors

Positive Normal: log(catch per contributor) = year + waters fished + fishing mode

Randomized quantile residuals for the binomial sub-model were normally distributed and slightly overestimated shore mode CPUE (Figure A14). Residuals from the positive sub-model were close to normal but exhibited some overestimation by year (Figures A15).

The observed annual nominal mean CPUE and standardized CPUE for the Keys H&L fishery are provided in **Table A10** and illustrated in **Figure A16**; The scaled standardized index (CPUE scaled to the mean) was below average from 1997-1999 but fluctuated around the mean through 2016 (Figure A16).

Tables

Table A1. Number of trips per year and covariate for the WFL private mode H&L CPUE.

Year	Waters Fished		Median Hours Fished				Median Avidity				Number of Contributors			Season	
	Nearshore	Offshore	[0.5,3]	(3,4.5]	(4.5,6]	(6,24.5]	[0,1]	(1,4]	(4,7]	(7,51]	1	2	3+	Other	Summer
1991	2	3	2	2	1			2	2	1		5			5
1992	12	11	10	2	5	6	4	8	4	7	4	11	8	6	17
1993	6	12	7	2	7	2	3	10	2	3		6	12	5	13
1994	5	21	9	7	6	4	4	11	7	4	5	10	11	8	18
1995	3	23	9	6	7	4	4	8	6	8	2	14	10	10	16
1996	4	11	10	4	1		1	6	1	7	4	7	4	6	9
1997	6	15	9	2	5	5	5	2	4	10	9	7	5	7	14
1998	8	3	4	1	4	2	3	4		4	2	5	4	4	7
1999	9	18	5	8	6	8	6	7	7	7	4	12	11	23	4
2000	3	18	4	4	8	5	5	7	5	4	4	6	11	7	14
2001	14	23	7	9	13	8	11	11	5	10	2	18	17	16	21
2002	16	26	7	10	17	8	12	11	13	6	2	24	16	16	26
2003	18	31	15	16	13	5	15	23	1	10	5	19	25	28	21
2004	3	15	4	3	6	5	2	10	4	2		4	14	10	8
2005	2	18	3	3	9	5	6	6	5	3		4	16	9	11
2006	3	10	4	3	4	2	4	6	2	1	1	6	6	7	6
2007	4	4	3	2	2	1	4	4			1	1	6	5	3
2008	7	12	5	6	7	1	4	6	1	8	1	13	5	8	11
2009	13	11	7	6	7	4	4	11	4	5	2	7	15	11	13
2010	5	10	2	5	6	2	7	2	4	2	1	5	9	4	11
2011	14	13	7	8	9	3	8	9	3	7	1	9	17	15	12
2012	2	22	10	5	6	3	6	5	5	8	1	10	13	14	10
2013	20	20	10	7	11	12	8	13	7	12	3	19	18	15	25
2014	25	32	16	9	21	11	9	18	10	20	7	16	34	31	26
2015	14	43	16	16	19	6	6	16	13	22	1	25	31	25	32
2016	20	39	12	13	25	9	20	17	11	11	3	23	33	23	36
2017	33	40	23	12	24	14	18	26	9	20	12	30	31	46	27
2018	21	25	11	13	14	8	13	16	9	8	7	15	24	26	20
2019	11	35	6	15	11	14	16	12	10	8	7	10	29	24	22
2020	16	26	12	11	12	7	15	9	7	11	6	17	19	20	22
2021	7	24	10	9	8	4	9	12	4	6	4	15	12	23	8
2022	9	18	4	3	16	4	6	9	5	7	7	6	14	14	13
2023	9	32	6	13	16	6	14	14	3	10	6	15	20	21	20
2024	10	34	13	12	12	7	15	15	5	9	5	15	24	22	22

Table A2. Number of positive trips per year and covariate for the WFL private mode H&L CPUE.

Year	Waters Fished		Median Hours Fished				Median Avidity				Number of Contributors			Season	
	Nearshore	Offshore	[0.5,3]	(3,4.5]	(4.5,6]	(6,24.5]	[0,1]	(1,4]	(4,7]	(7,51]	1	2	3+	Other	Summer
1991	2	1	2	1				1	1	1		3			3
1992	3	6	5		3	1	1	3		5	3	4	2	4	5
1993	2	6	4	1	3		1	4	1	2		3	5	1	7
1994		10	4	2	2	2	3	5	1	1	1	5	4	2	8
1995	1	13	6	3	3	2		5	3	6	2	7	5	3	11
1996	2	7	8	1				4		5	4	3	2	2	7
1997	4	7	7	1		3		1	3	7	8	2	1	4	7
1998	4	2	3		1	2	2	2		2	1	3	2		6
1999	3	6	3	2	1	3	1	2	2	4	2	4	3	7	2
2000	2	7	1	3	2	3	2	2	2	3	3	3	3	3	6
2001	3	3	1	4	1		1	3	1	1	1	3	2	2	4
2002	3	5	1	1	1	5	2	2	3	1	1	3	4	3	5
2003	4	11	6	4	3	2	5	6	1	3	2	4	9	5	10
2004	1	2	2		1			1	1	1		1	2	2	1
2005	1	6	1		4	2	3	2	1	1		1	6	2	5
2006	1	3	3		1		2	1		1		3	1	2	2
2007	3	3	3	1	1	1	3	3				1	5	3	3
2008	4	6	5	2	2	1	1	3		6	1	6	3	4	6
2009	7	4	4	3	2	2	2	4	2	3	1	3	7	3	8
2010	4	7	1	3	5	2	5	2	2	2	1	3	7	2	9
2011	4	5	2	3	2	2	1	4		4		1	8	3	6
2012		5	4			1	2	1	1	1		2	3	4	1
2013	4	3	1	1	2	3	2	2	1	2	1	4	2	2	5
2014	5	10	7		4	4	2	4	3	6	2	4	9	7	8
2015	4	8	6	3	3		2	2	3	5		7	5	8	4
2016	7	9	6	3	5	2	5	3	4	4	1	7	8	5	11
2017	9	14	8	3	7	5	4	8	3	8	5	5	13	13	10
2018	3	5	3	2	2	1	1	3	1	3	2	3	3	6	2
2019	5	8	3	2	4	4	2	6	2	3	2	4	7	6	7
2020	2	10	3	1	5	3	4	4	2	2		5	7	7	5
2021	4	5	3	4	1	1	3	4	1	1	1	4	4	5	4
2022	1	9	1		7	2	2	3	3	2	2	3	5	7	3
2023	4	13	4	5	5	3	7	5	2	3	3	7	7	9	8
2024	2	18	6	4	5	5	7	9	1	3	3	6	11	10	10

Table A3. Deviance table for the final binomial sub-model for the WFL private mode H&L data.

Factor	Df	Resid. Df	Resid. Dev	Deviance	% Deviance Reduced	Family	Dispersion
NULL	1	1038	1307.887	1307.887	-		
year	31	1007	1239.638	68.2485	2.3		
median hrsfcat	3	1004	1209.69	29.94836	2.08	Binomial	1.04

Table A4. Deviance table for the final positive sub-model for the WFL private mode H&L data.

Factor	Df	Resid. Df	Resid. Dev	Deviance	% Deviance Reduced	Family	Dispersion
NULL	1	335	290.7981	290.7981	-		
year	31	304	266.2764	24.52164	-0.9		
median_hrsfcat	3	301	256.1046	10.17177	2.86		
median_aviditycat	3	298	249.4258	6.678886	1.58	Gaussian	0.83

Table A5. Nominal mean CPUE and final modeled index for the WFL private mode H&L data.

Year	Num Sampling Events	Num Positive	Prop Positive	Nominal Mean	Nominal CV	Std Index	Std CV	Std Low 95	Std Up 95	Scaled Std Index	Scaled Std Low 95	Scaled Std Up 95
1991	5	3	0.60									
1992	23	9	0.39	0.47	2.03	0.31	0.43	0.12	0.64	0.84	0.33	1.73
1993	18	8	0.44	0.69	1.81	0.53	0.44	0.20	1.10	1.44	0.55	2.97
1994	26	10	0.39	0.36	1.91	0.28	0.40	0.12	0.56	0.77	0.32	1.52
1995	26	14	0.54	1.11	1.79	0.63	0.32	0.32	1.09	1.70	0.86	2.95
1996	15	9	0.60	0.89	0.99	0.74	0.41	0.30	1.47	2.00	0.80	3.98
1997	21	11	0.52	0.84	1.37	0.58	0.37	0.26	1.08	1.57	0.69	2.92
1998	11	6	0.55	0.46	1.61	0.44	0.48	0.15	0.96	1.18	0.40	2.59
1999	27	9	0.33	0.32	2.19	0.21	0.42	0.08	0.42	0.57	0.23	1.13
2000	21	9	0.43	0.47	1.87	0.40	0.39	0.17	0.76	1.07	0.46	2.07
2001	37	6	0.16	0.18	2.84	0.14	0.56	0.04	0.34	0.38	0.11	0.91
2002	42	8	0.19	0.13	2.55	0.14	0.47	0.05	0.31	0.38	0.14	0.83
2003	49	15	0.31	0.38	2.07	0.32	0.33	0.16	0.57	0.87	0.43	1.54
2004	18	3	0.17	0.23	3.10	0.19	0.86	0.03	0.62	0.52	0.09	1.68
2005	20	7	0.35	0.22	1.81	0.27	0.48	0.09	0.58	0.72	0.26	1.58
2006	13	4	0.31	0.25	2.24	0.23	0.64	0.05	0.61	0.62	0.14	1.65
2007	8	6	0.75									
2008	19	10	0.53	1.23	1.47	0.75	0.37	0.34	1.39	2.03	0.92	3.78
2009	24	11	0.46	0.54	1.88	0.36	0.36	0.16	0.66	0.97	0.44	1.79
2010	15	11	0.73	1.14	1.30	0.98	0.32	0.49	1.70	2.66	1.34	4.62
2011	27	9	0.33	0.53	2.03	0.36	0.43	0.14	0.73	0.98	0.39	1.98
2012	24	5	0.21	0.53	2.43	0.28	0.62	0.08	0.74	0.77	0.20	2.00
2013	40	7	0.18	0.14	2.33	0.16	0.51	0.05	0.37	0.44	0.15	0.99
2014	57	15	0.26	0.46	2.64	0.29	0.33	0.15	0.52	0.79	0.39	1.41
2015	57	12	0.21	0.26	3.06	0.16	0.38	0.07	0.29	0.42	0.19	0.80
2016	59	16	0.27	0.65	2.44	0.49	0.31	0.25	0.85	1.32	0.69	2.29
2017	73	23	0.32	0.34	2.03	0.24	0.27	0.14	0.39	0.66	0.37	1.06
2018	46	8	0.17	0.28	3.00	0.19	0.47	0.07	0.42	0.52	0.19	1.13
2019	46	13	0.28	0.35	2.61	0.25	0.35	0.12	0.46	0.68	0.32	1.25
2020	42	12	0.29	0.32	3.07	0.22	0.37	0.10	0.41	0.60	0.27	1.11
2021	31	9	0.29	0.43	2.09	0.29	0.43	0.11	0.58	0.78	0.31	1.56
2022	27	10	0.37	0.46	1.88	0.42	0.39	0.18	0.80	1.13	0.49	2.16
2023	41	17	0.42	0.70	2.43	0.47	0.28	0.26	0.78	1.28	0.69	2.11
2024	44	20	0.46	0.61	1.64	0.50	0.27	0.29	0.81	1.37	0.78	2.19

Table A6. Number of trips per year and covariate for the Keys-EFL H&L CPUE.

Year	Waters Fished		Median Hours Fished				Median Avidity			Number of Contributors					Fishing Mode			Season	
	Nearshore	Offshore	[0.5,3]	(3,4]	(4,5]	(5,24.5]	[0,2.5]	(2.5,8]	(8,61]	1	2	3	4	5+	CH	PR	SH	Other	Summer
1991	16	5	2	10	3	6	9	8	4	6	5	4	5	1	1	15	5	11	10
1992	20	5	6	6	4	9	11	9	5	5	11	6		3	1	22	2	9	16
1993	31	5	11	11	7	7	10	11	15	7	10	12	5	2		32	4	22	14
1994	35	4	18	6	4	11	12	17	10	6	11	13	8	1		35	4	17	22
1995	26	6	11	12	4	5	7	7	18	7	11	9	3	2		31	1	25	7
1996	7	8	2	1	5	7	3	7	5	2	3	4	5	1	1	13	1	9	6
1997	42	2	6	10	11	17	10	12	22	2	16	14	10	2	2	41	1	36	8
1998	29	10	9	11	6	13	17	8	14	3	9	11	6	10	9	29	1	30	9
1999	33	10	12	9	8	14	16	14	13	10	13	13	6	1	8	32	3	33	10
2000	9	12	3	9	1	8	10	9	2	6	3	2	3	7	10	8	3	15	6
2001	10	10	4	4	2	10	9	7	4	7	4	3	1	5	7	12	1	13	7
2002	21	15	16	7	3	10	15	15	6	4	7	7	6	12	21	13	2	15	21
2003	26	18	14	13	3	14	21	13	10	6	15	4	6	13	30	11	3	33	11
2004	39	35	34	23	6	11	42	24	8	6	18	9	13	28	40	31	3	59	15
2005	25	23	28	10	4	6	30	14	4	8	5	4	5	26	32	13	3	35	13
2006	29	16	22	10	8	5	24	13	8	4	11	7	5	18	25	19	1	31	14
2007	14	14	16	5	2	5	18	6	4	4	7	2	4	11	13	15		17	11
2008	33	21	20	16	8	10	36	9	9	4	14	12	14	10	30	23	1	33	21
2009	25	9	11	8	7	8	16	10	8	5	5	11	3	10	14	19	1	19	15
2010	26	18	17	11	8	8	29	10	5	2	8	10	5	19	30	13	1	20	24
2011	22	11	15	7	4	7	25	6	2	1	7	3	9	13	25	7	1	25	8
2012	38	19	26	16	7	8	35	15	7	4	19	11	6	17	30	25	2	36	21
2013	49	25	37	18	2	17	44	18	12	9	24	14	10	17	31	38	5	51	23
2014	55	39	30	32	11	21	50	25	19	11	27	18	17	21	40	46	8	56	38
2015	102	31	42	41	23	27	65	40	28	17	43	20	19	34	55	66	12	85	48
2016	72	19	39	31	7	14	53	27	11	9	19	11	12	40	53	36	2	42	49

Table A7. Number of positive trips per year and covariate for the Keys-EFL H&L CPUE.

Year	Waters Fished		Median Hours Fished				Median Avidity			Number of Contributors					Fishing Mode			Season	
	Nearshore	Offshore	[0.5,3]	(3,4]	(4,5]	(5,24.5]	[0,2.5]	(2.5,8]	(8,61]	1	2	3	4	5+	CH	PR	SH	Other	Summer
1991	2				2		2						1	1		2		1	1
1992	12	5	3	4	4	6	6	7	4	2	8	6		1		17		6	11
1993	17	2	8	5	3	3	5	7	7	5	7	4	2	1		16	3	10	9
1994	17	2	10	2	1	6	8	7	4	5	6	2	5	1		16	3	6	13
1995	17	4	6	8	3	4	3	3	15	5	7	6	2	1		20	1	17	4
1996	5	6	2	1	4	4	1	6	4	2	1	3	4	1		10	1	5	6
1997	11	1	1	4	3	4	4	4	4	1	2	3	4	2		11	1	7	5
1998	10	4	4	3	2	5	5	4	5	2	2	4	4	2	4	9	1	9	5
1999	12	4	7	4	2	3	5	6	5	3	7	2	4		4	9	3	10	6
2000	4	3	3	1		3	3	3	1	4	2		1		1	3	3	4	3
2001	5	5	2	2	2	4	3	3	4	3	3	3	1		2	7	1	7	3
2002	7	3	6	1		3	3	3	4	2	5		2	1	4	5	1	5	5
2003	12	8	4	6	3	7	10	4	6	4	10	1	4	1	11	6	3	16	4
2004	15	13	8	10	6	4	10	13	5	2	11	5	5	5	10	15	3	23	5
2005	7	7	5	3	2	4	7	4	3	6	1	1	2	4	6	5	3	10	4
2006	9	6	5	3	4	3	4	4	7	1	8	3	3		5	9	1	12	3
2007	7	7	7	3	1	3	7	5	2	2	6	2	2	2	3	11		10	4
2008	15	7	8	9	2	3	16	4	2	2	5	7	7	1	13	8	1	15	7
2009	8	6	3	2	5	4	6	2	6	2	4	4	3	1	3	11		9	5
2010	4	6	3	3	2	2	8	1	1	2	1	4	1	2	7	2	1	7	3
2011	6	3		3	2	4	5	3	1	1	2	1	2	3	5	3	1	9	
2012	13	4	6	4	4	3	9	4	4	2	8	4	2	1	4	11	2	11	6
2013	19	11	14	9		7	20	8	2	4	12	4	5	5	11	15	4	18	12
2014	25	13	13	12	2	11	15	11	12	8	15	7	6	2	11	20	7	25	13
2015	29	7	11	8	9	8	13	12	11	10	16	5	3	2	5	23	8	25	11
2016	14	5	8	4	4	3	5	7	7	6	6	2	4	1	3	14	2	9	10

Table A8. Deviance table for the final binomial sub-model for the Keys-EFL H&L data.

Factor	Df	Resid. Df	Resid. Dev	Deviance	% Deviance Reduced	Family	Dispersion
NULL	1	1202	1582.102	1582.102	-		
year	24	1178	1512.567	69.53508	2.45		
num_cntrbtrscat	4	1174	1384.778	127.7896	7.94		
fishing_mode	2	1172	1347.766	37.01204	2.25	Binomial	1.03

Table A9. Deviance table for the final positive sub-model for the Keys-EFL H&L data.

Factor	Df	Resid. Df	Resid. Dev	Deviance	% Deviance Reduced	Family	Dispersion
NULL	1	441	330.481	330.481	-		
year	24	417	306.4765	24.0045	1.93		
waters	1	416	284.2485	22.22803	6.89		
fishing_mode	2	414	273.5433	10.70523	3.01	Gaussian	0.66

Table A10. Nominal mean CPUE and final modeled index for the Keys-EFL H&L data.

Year	Num Sampling Events	Num Positive	Prop Positive	Nominal Mean	Nominal CV	Std Index	Std CV	Std Low 95	Std Up 95	Scaled Std Index	Scaled Std Low 95	Scaled Std Up 95
1991	21	2	0.10									
1992	25	17	0.68	0.80	1.80	0.46	0.24	0.27	0.71	1.25	0.75	1.93
1993	36	19	0.53	1.37	3.66	0.40	0.25	0.23	0.62	1.08	0.63	1.68
1994	39	19	0.49	0.55	1.65	0.35	0.26	0.20	0.55	0.94	0.54	1.49
1995	32	21	0.66	0.63	1.13	0.49	0.22	0.30	0.74	1.33	0.83	2.00
1996	15	11	0.73	0.88	1.11	0.65	0.29	0.34	1.09	1.78	0.94	2.96
1997	44	12	0.27	0.15	1.96	0.12	0.35	0.06	0.22	0.34	0.16	0.61
1998	39	14	0.36	0.21	2.28	0.20	0.29	0.11	0.33	0.54	0.29	0.90
1999	43	16	0.37	0.35	1.78	0.30	0.29	0.16	0.50	0.82	0.44	1.35
2000	21	7	0.33	0.29	1.79	0.30	0.44	0.11	0.62	0.82	0.31	1.68
2001	20	10	0.50	0.60	1.62	0.60	0.32	0.30	1.04	1.62	0.81	2.82
2002	36	10	0.28	0.26	2.11	0.30	0.36	0.13	0.55	0.81	0.37	1.50
2003	44	20	0.46	0.58	2.11	0.55	0.23	0.34	0.82	1.48	0.92	2.24
2004	74	28	0.38	0.29	1.81	0.34	0.20	0.22	0.48	0.92	0.60	1.32
2005	48	14	0.29	0.24	1.99	0.35	0.28	0.19	0.58	0.95	0.52	1.57
2006	45	15	0.33	0.30	2.15	0.35	0.28	0.19	0.57	0.95	0.53	1.54
2007	28	14	0.50	0.33	1.41	0.41	0.26	0.24	0.66	1.12	0.65	1.79
2008	54	22	0.41	0.35	1.96	0.38	0.23	0.23	0.57	1.03	0.62	1.54
2009	34	14	0.41	0.41	1.89	0.37	0.28	0.20	0.60	1.01	0.55	1.64
2010	44	10	0.23	0.23	2.56	0.39	0.35	0.18	0.72	1.07	0.50	1.96
2011	33	9	0.27	0.14	1.99	0.22	0.36	0.10	0.41	0.60	0.27	1.11
2012	57	17	0.30	0.40	2.43	0.35	0.27	0.20	0.57	0.96	0.54	1.55
2013	74	30	0.41	0.32	1.69	0.31	0.20	0.20	0.45	0.85	0.56	1.21
2014	94	38	0.40	0.60	2.57	0.47	0.18	0.32	0.65	1.27	0.87	1.76
2015	133	36	0.27	0.40	2.40	0.30	0.21	0.20	0.44	0.83	0.53	1.20
2016	91	19	0.21	0.25	3.09	0.24	0.27	0.13	0.39	0.65	0.36	1.05

Figures

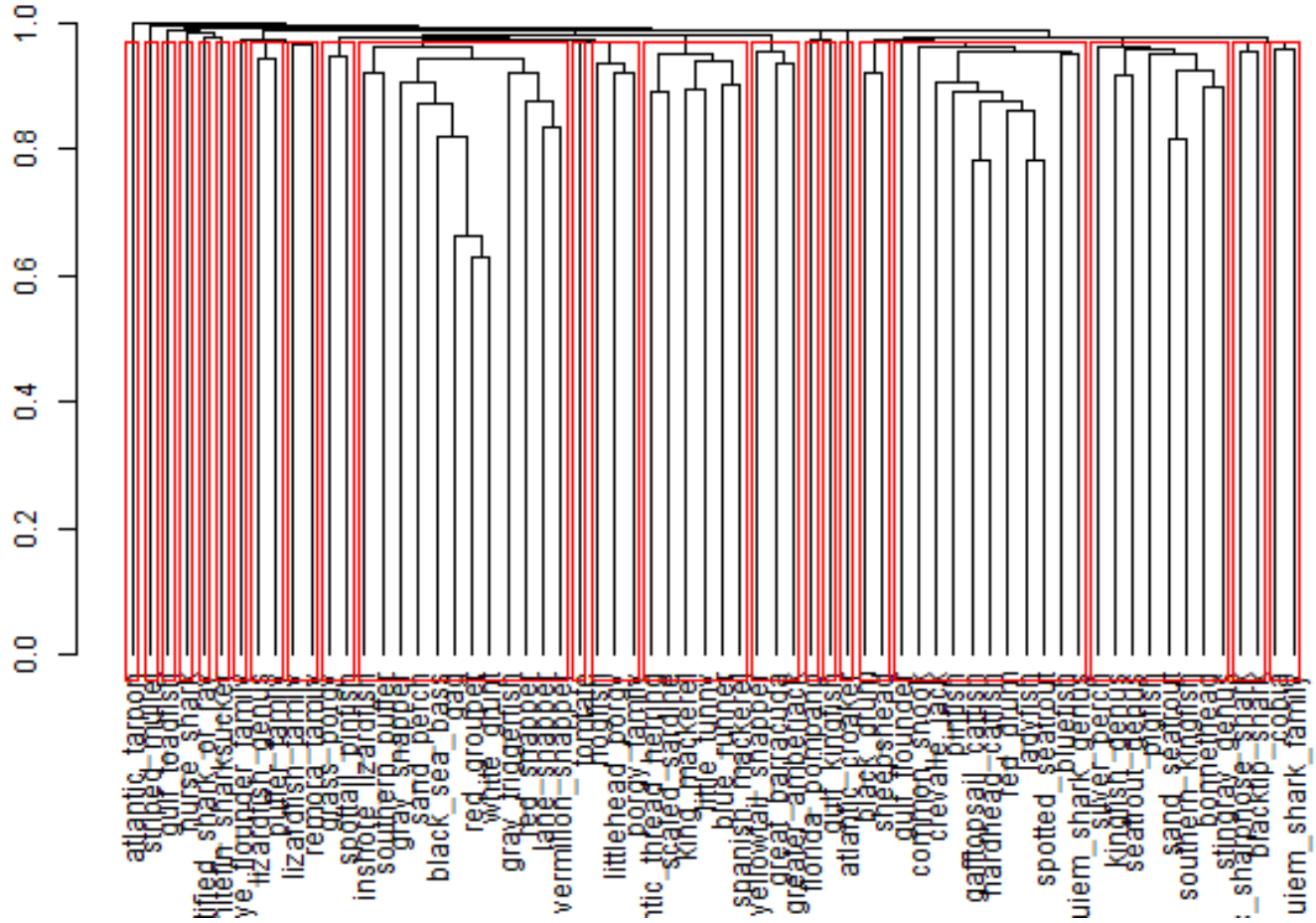

Figure A1. Dendrogram and resulting clusters that maximize average silhouette width of the percent square root of catch (landings + releases) for WFL H&L trips (private mode, nearshore and offshore).

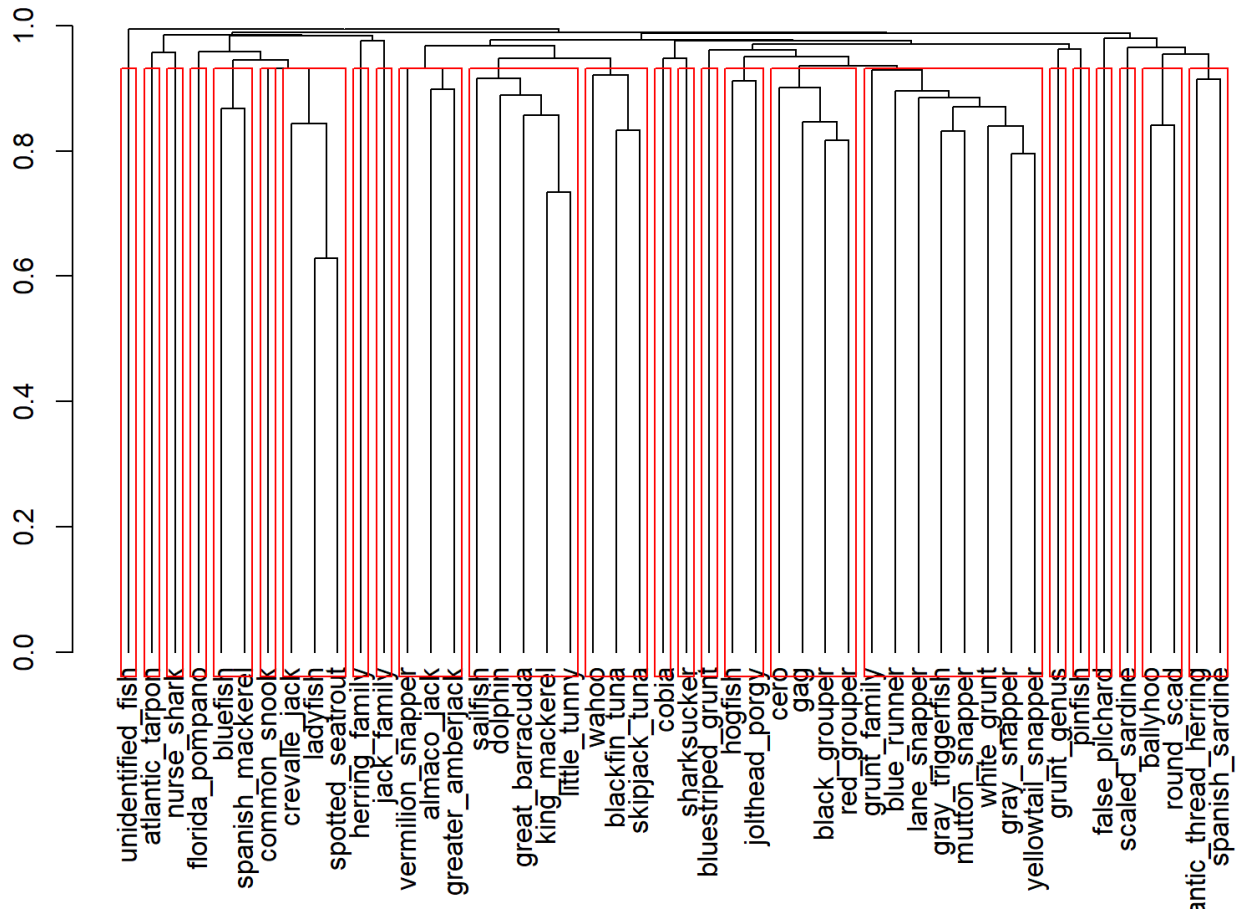

Figure A2. Dendrogram and resulting clusters that maximize average silhouette width of the square root of catch (landings + releases) for Keys-EFL H&L trips from 1991-2016.

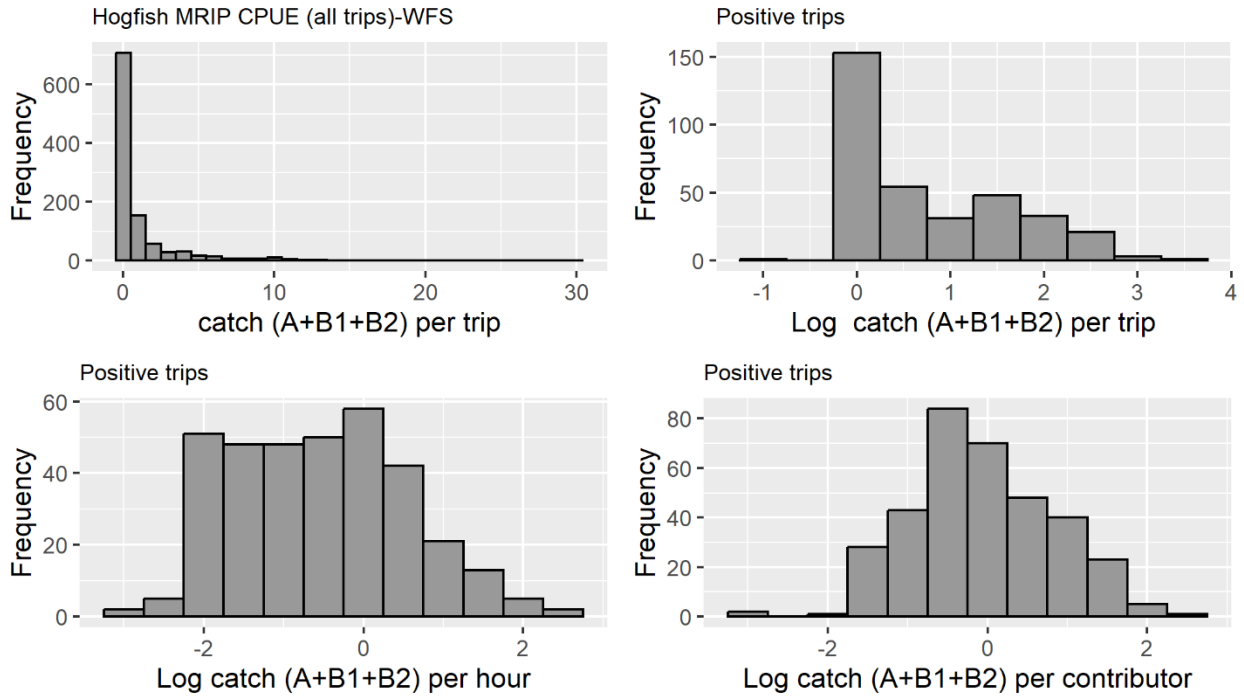

Figure A3. Histograms of hogfish catch per trip within the species cluster including zeros (top left), log(catch per trip) for positive trips (top right), log (catch per median hour fished) for positive trips (bottom left), and a histogram of log(catch per contributor) for positive trips (bottom right) for the WFL H&L data (private mode, nearshore and offshore).

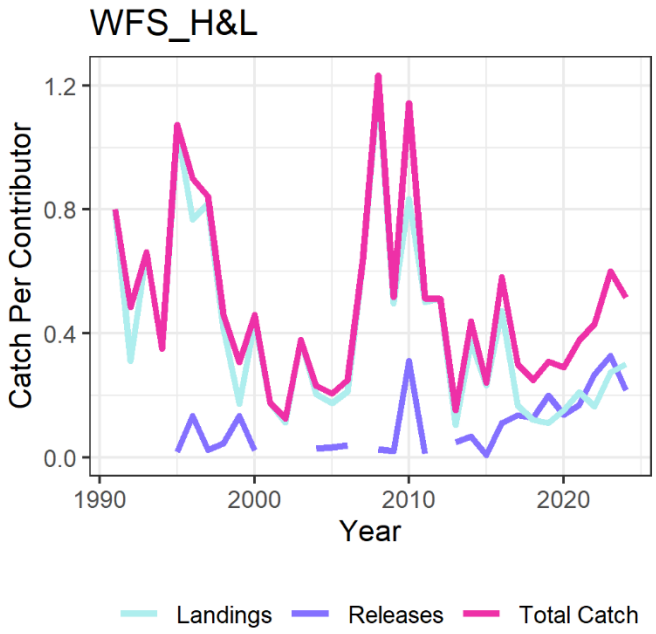

Figure A4. A comparison of mean nominal total catch per contributor (magenta), landings per contributor (light blue), and releases per contributor (dark blue) for the WFL H&L data (private mode, nearshore and offshore).

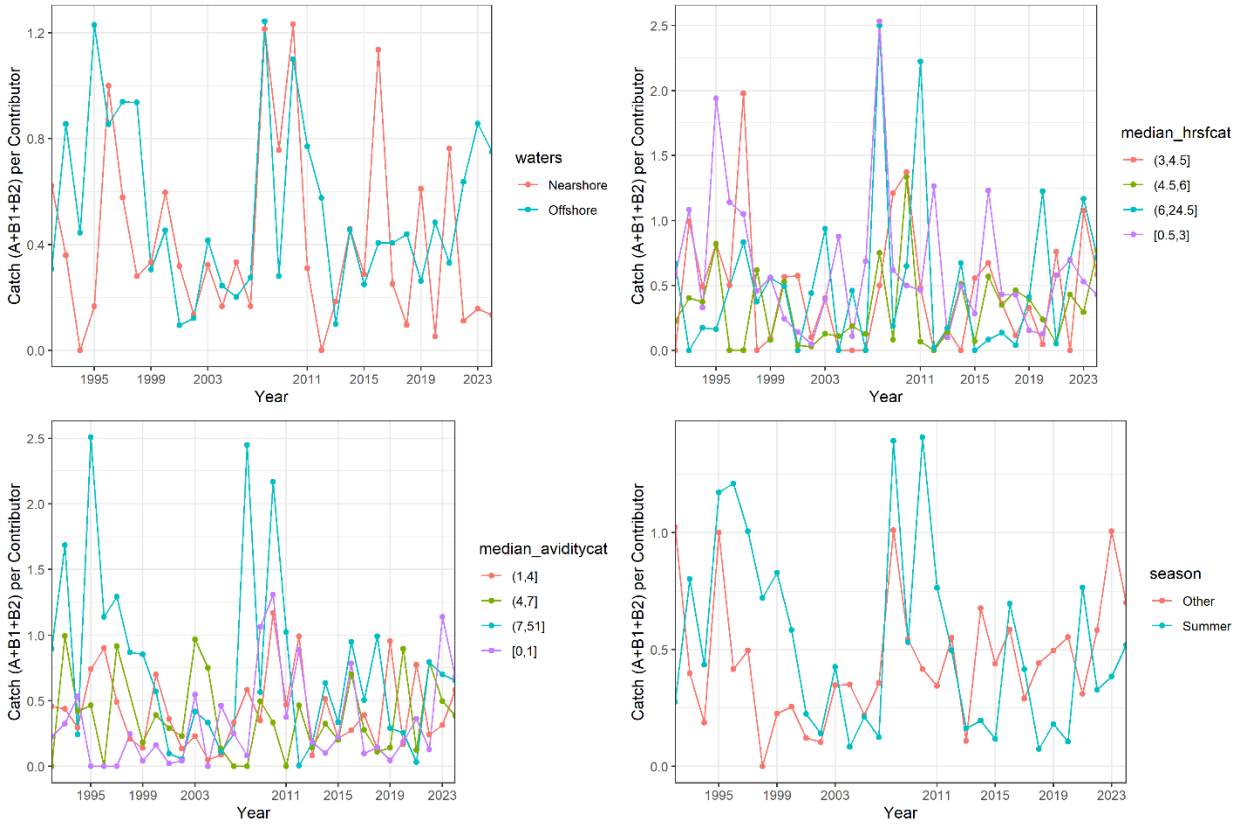

Figure A5. Interaction plots between year and considered covariates for the binomial model using the WFL H&L data (private mode, nearshore and offshore) using mean catch per contributor.

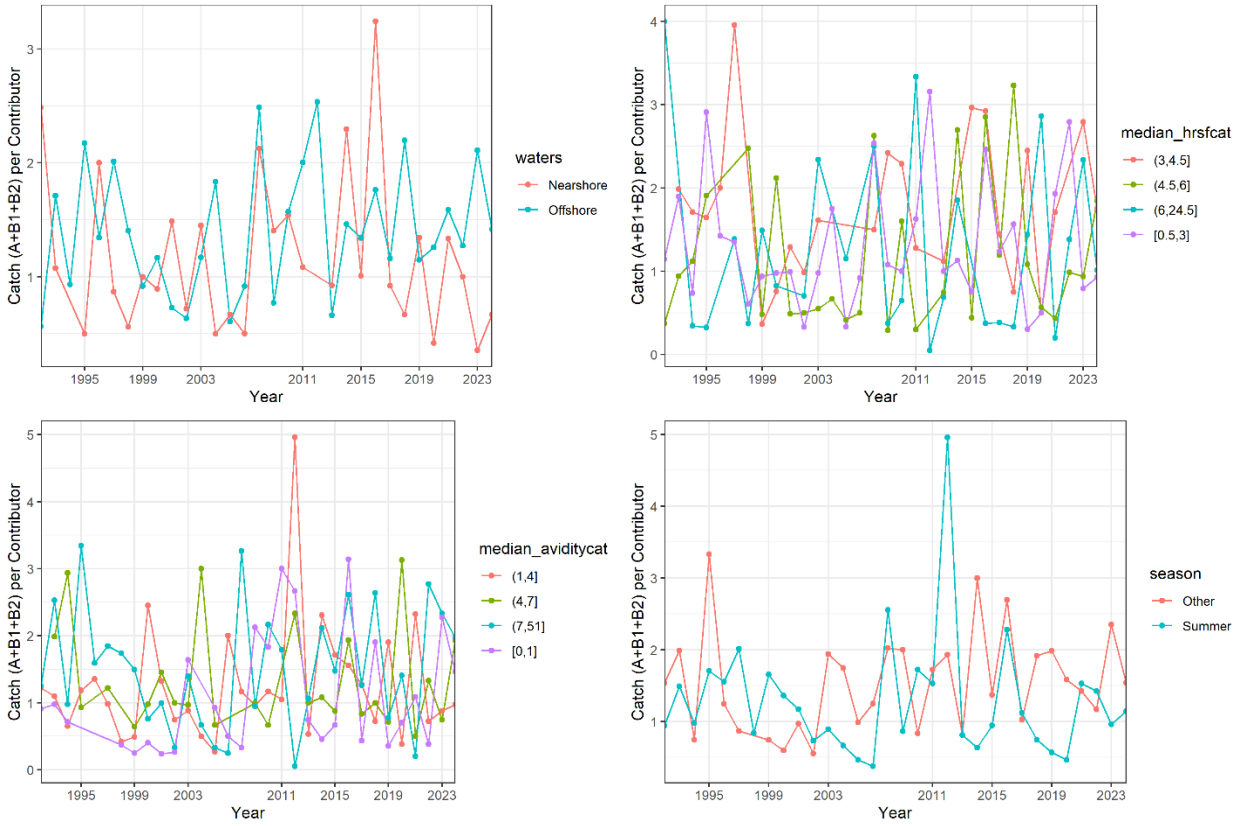

Figure A6. Interaction plots between year and considered covariates for the positive model using the WFL H&L data (private mode, nearshore and offshore) using mean catch per contributor.

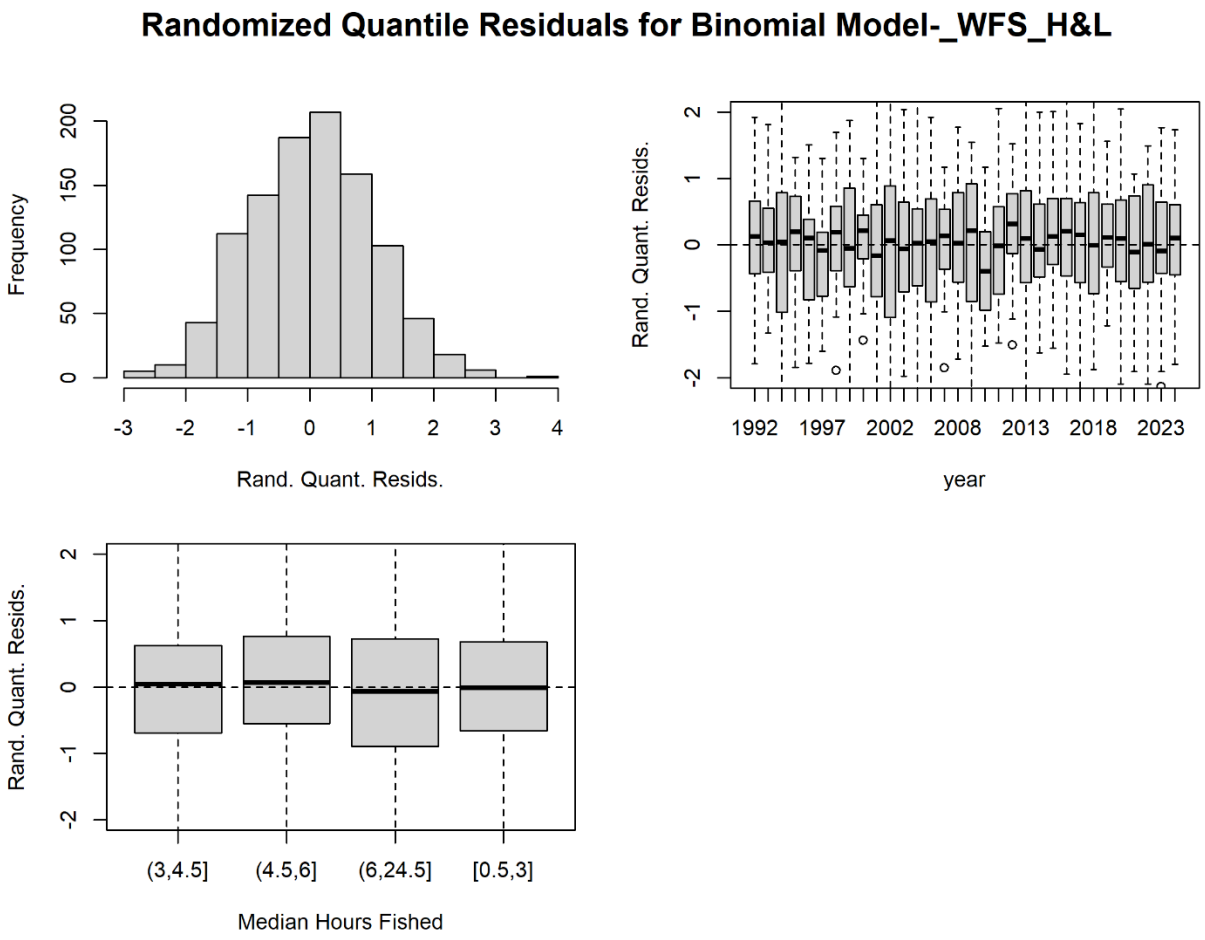

Figure A7. Randomized quantile residuals for the WFL H&L binomial model.

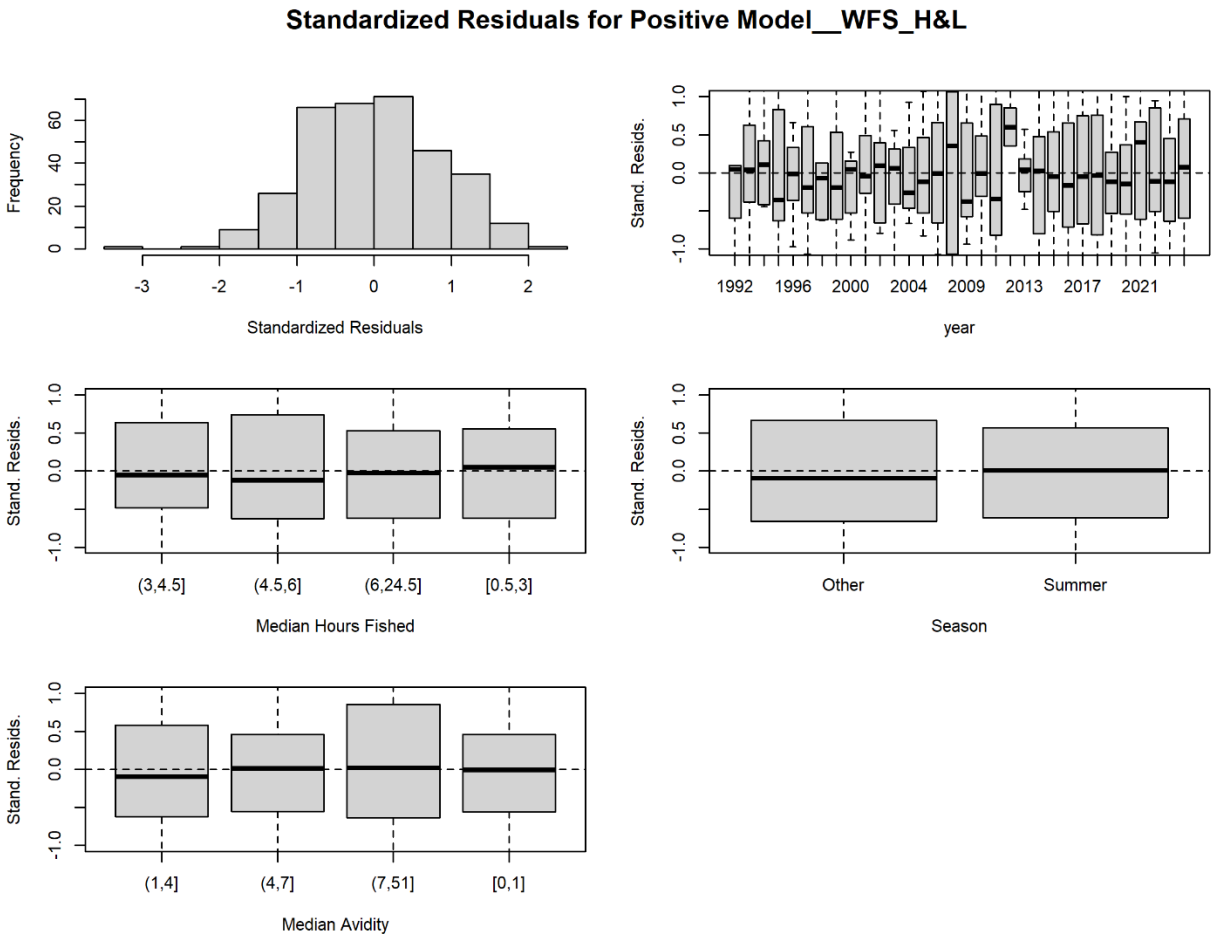

Figure A8. Standardized Pearson residuals for the WFL H&L positive Model.

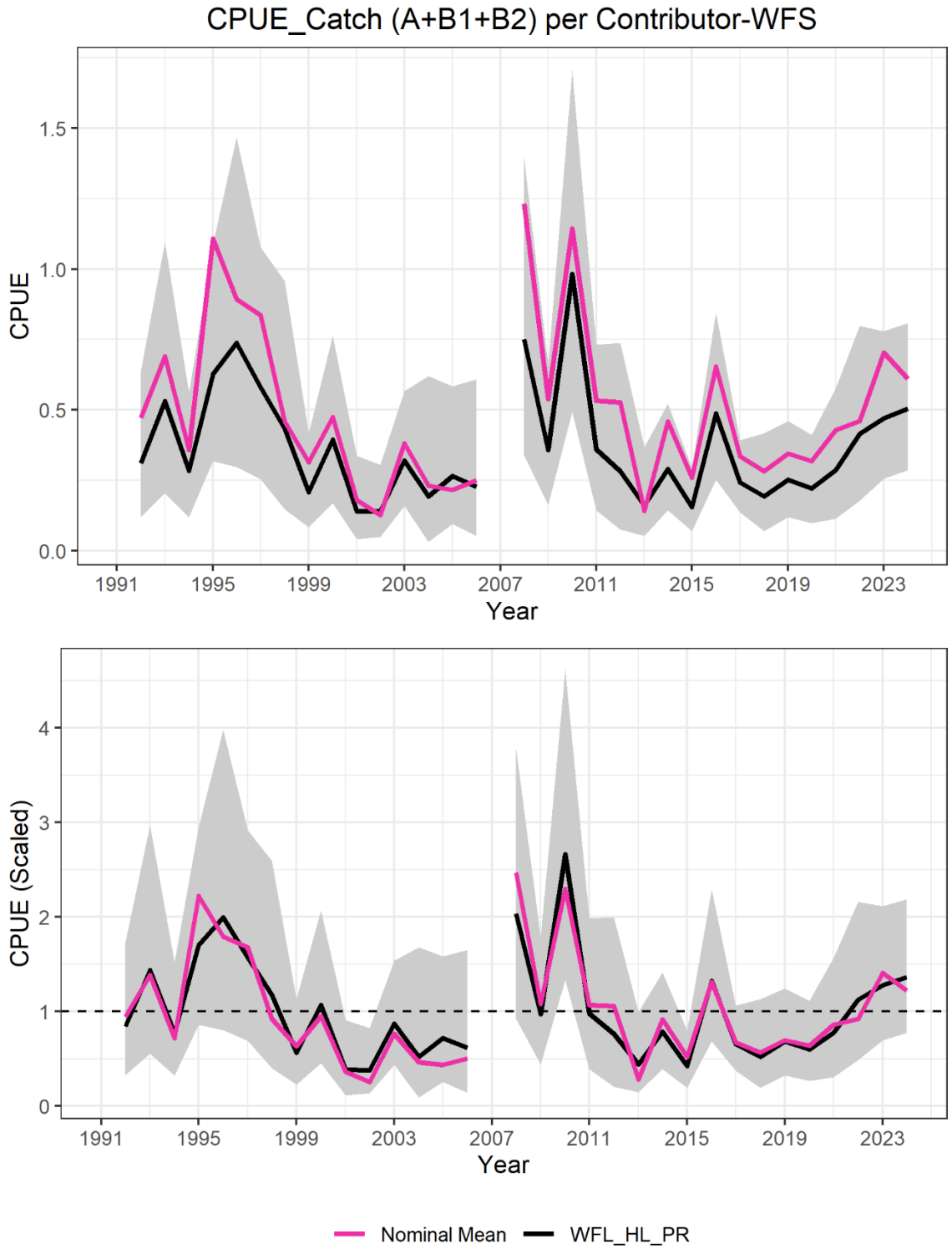

Figure A9. Standardized MRIP catch rate index (black line) of hogfish for the WFL H&L fishery with 95% confidence intervals (grey ribbon), along with the nominal CPUE (magenta line).

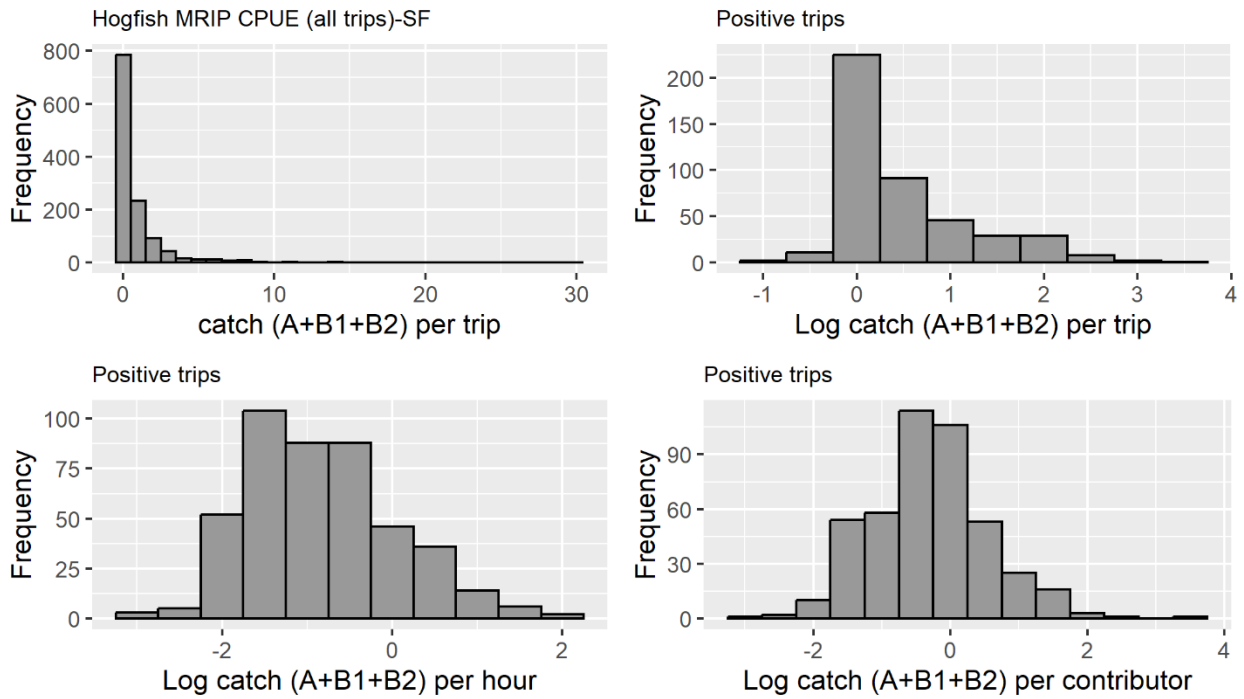

Figure A10. Histograms of hogfish catch per trip within the species cluster including zeros (top left), log(catch per trip) for positive trips (top right), log (catch per median hour fished) for positive trips (bottom left), and a histogram of log(catch per contributor) for positive trips (bottom right) for the Keys-EFL H&L data (shore, charter, and private mode, nearshore and offshore), 1991-2016.

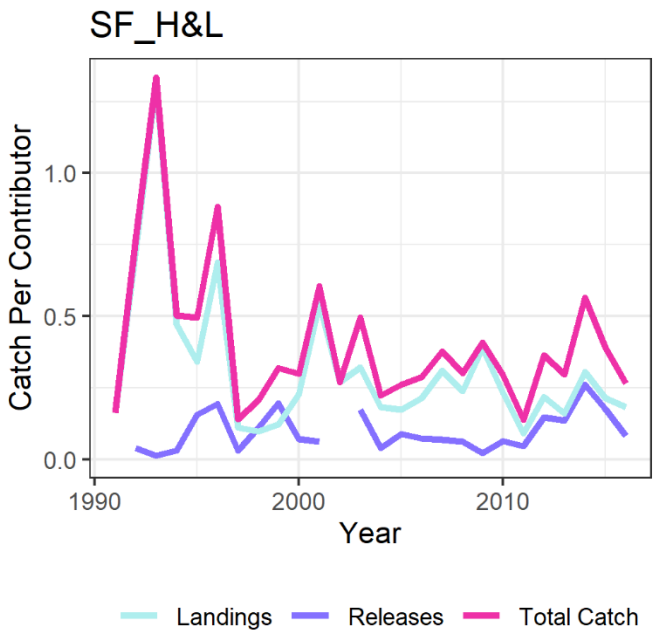

Figure A11. A comparison of mean nominal total catch per contributor (magenta), landings per contributor (light blue), and releases per contributor (dark blue) for the Keys-EFL H&L data (shore, charter, and private mode, nearshore and offshore).

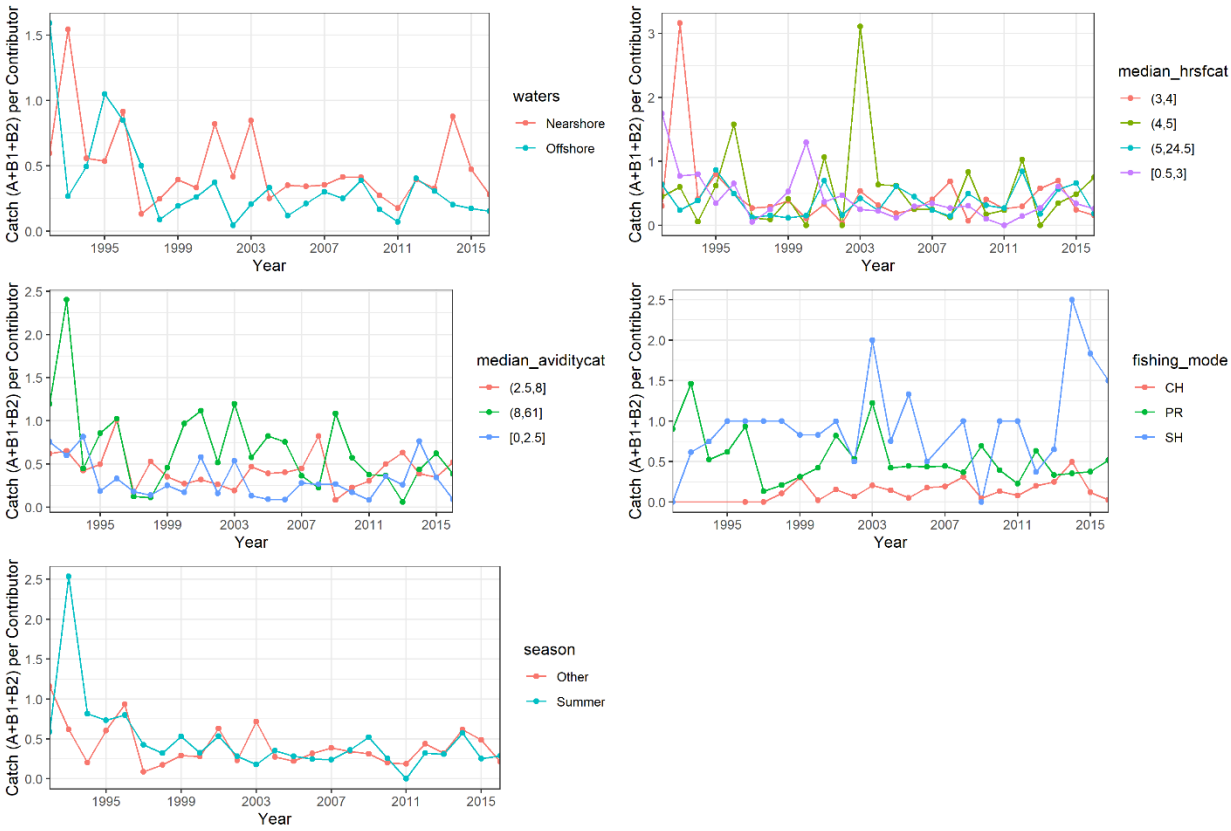

Figure A12. Interaction plots between year and considered covariates for the binomial model using the Keys-EFL H&L data (shore, charter, and private mode, nearshore and offshore) using mean catch per contributor.

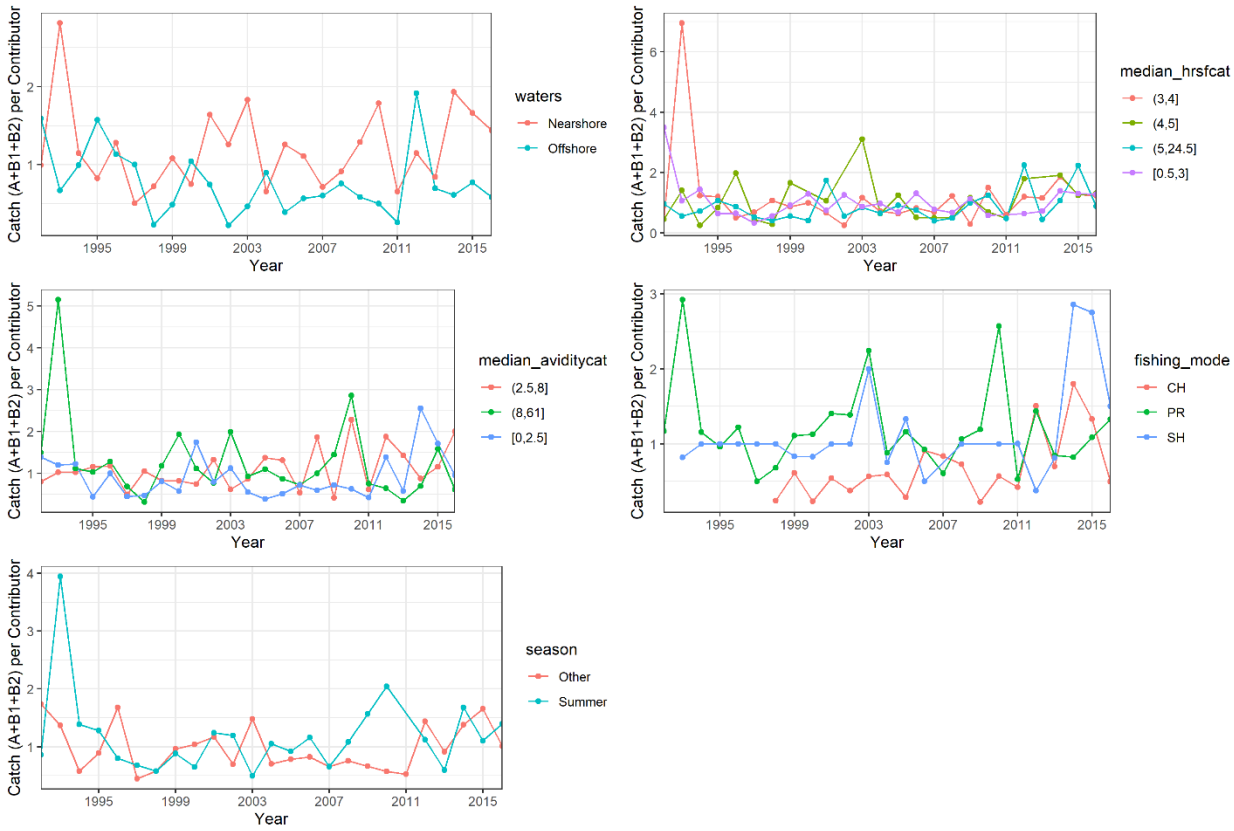

Figure A13. Interaction plots between year and considered covariates for the positive model using the Keys-EFL H&L data (shore, charter, and private mode, nearshore and offshore) using mean catch per contributor.

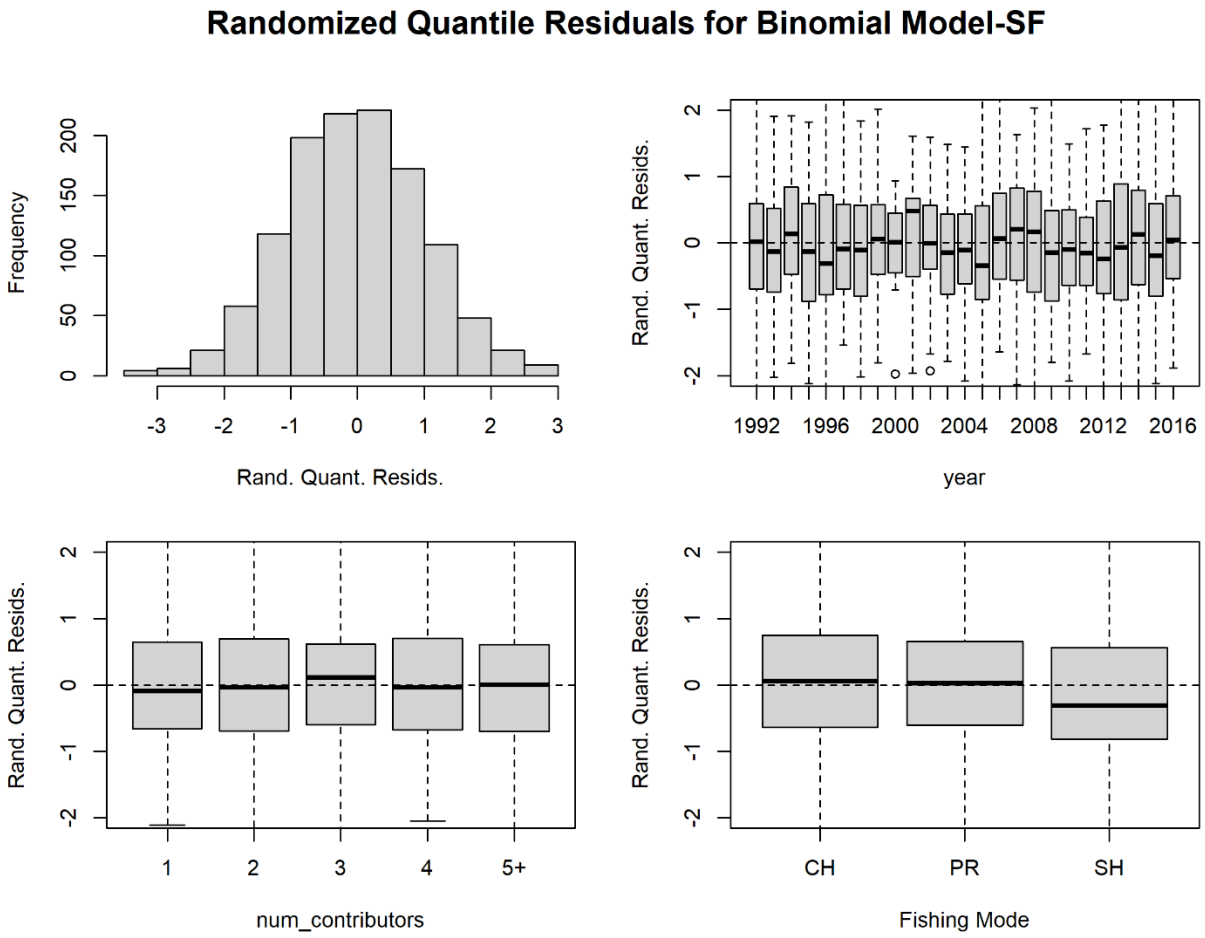

Figure A14. Randomized quantile residuals for the Keys-EFL H&L binomial model.

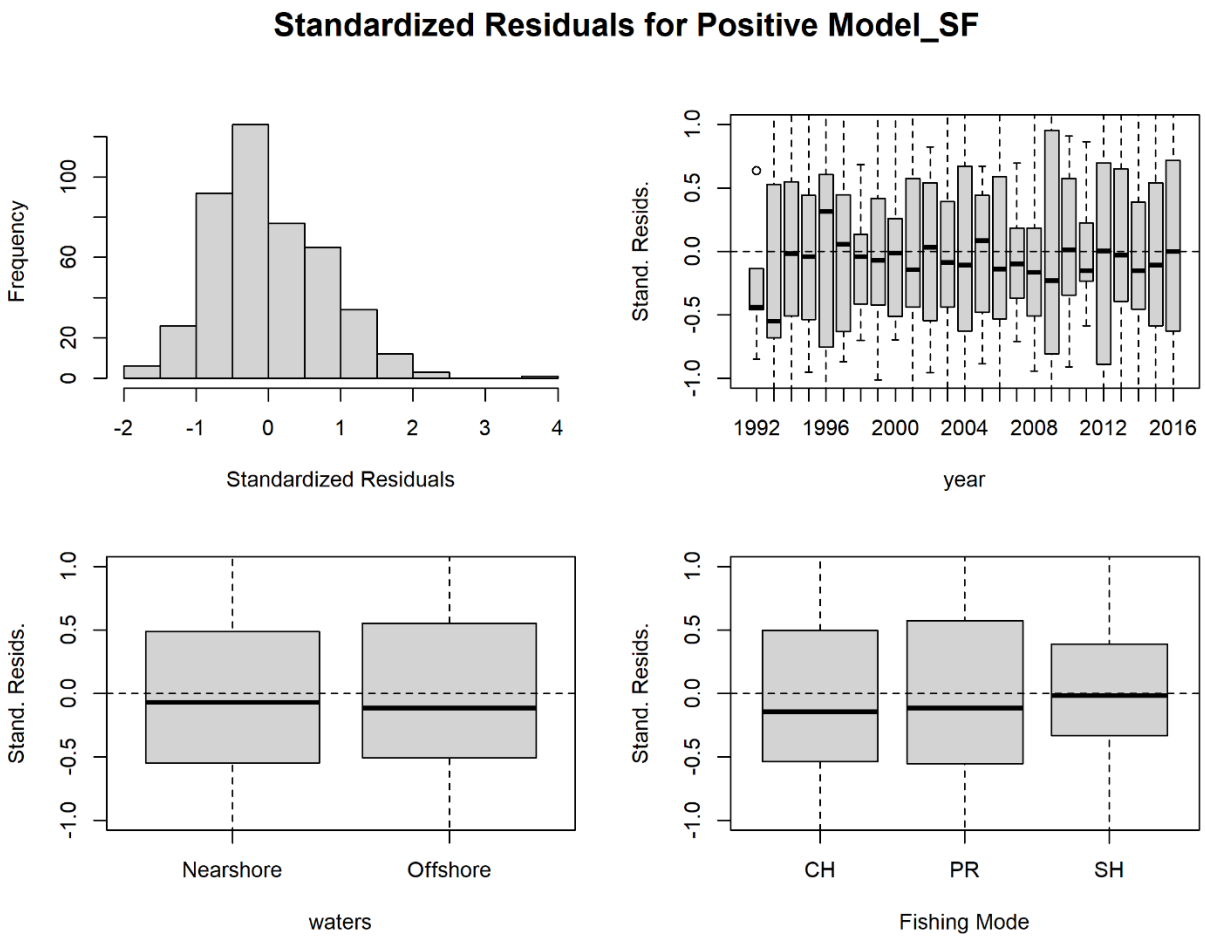

Figure A15. Standardized Pearson residuals for the Keys-EFL H&L positive Model.

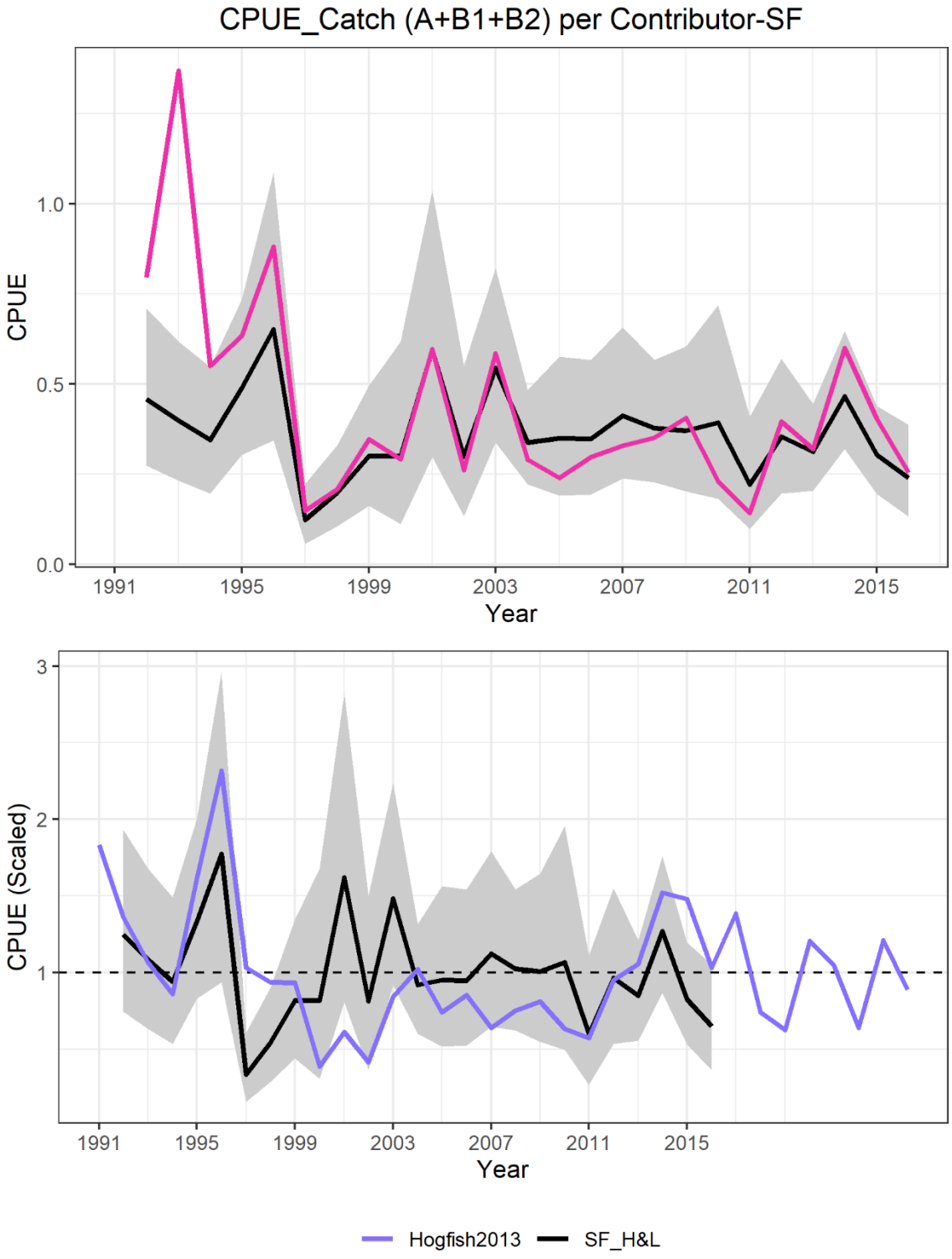

Figure A16. Standardized MRIP catch rate index (black line) of hogfish for the Keys-EFL H&L fishery with 95% confidence intervals (grey ribbon), along with the nominal CPUE (magenta line) and the standardized CPUE from a continuity model based on SEDAR 37 (blue line).