Standardized catch rates of tilefish (*Lopholatilus chamaeleonticeps*) in the southeast U.S. from commercial logbook data.

Eric Fitzpatrick

SEDAR66-WP03

Received: 12/04/2020

Please cite this document as:

Fitzpatrick, Eric. 2020. Standardized catch rates of tilefish (*Lopholatilus chamaeleonticeps*) in the southeast U.S. from commercial logbook data. SEDAR66-WP03. SEDAR, North Charleston, SC. 27 pp.

Standardized catch rates of tilefish (*Lopholatilus chamaeleonticeps*) in the southeast U.S. from commercial logbook data.

*Sustainable Fisheries Branch**

December 2020

This document describes the the development of the SEDAR 66 commercial logbook longline index for tilefish.

Commercial Fisheries Logbook Program (CFLP) overview

Landings and fishing effort of commercial vessels operating in the southeast U.S. Atlantic have been monitored by the NMFS Southeast Fisheries Science Center through the Coastal Fisheries Logbook Program (CFLP). The program collects information about each fishing trip from all vessels holding federal permits to fish in waters managed by the Gulf of Mexico and South Atlantic Fishery Management Councils. Initiated in the Gulf in 1990, the CFLP began collecting logbooks from Atlantic commercial fishers in 1992, when 20% of Florida vessels were targeted. Beginning in 1993, sampling in Florida was increased to require reports from all vessels permitted in coastal fisheries, and since then has maintained the objective of a complete census of federally permitted vessels in the southeast U.S.

Catch per unit effort (CPUE), defined as whole weight per number of sets by the number of hooks per set, from the logbooks was used to develop an index of abundance for tilefish landed with longline, the dominant gear for this tilefish stock. Thus, the size and age range of fish included in the index is the same as that of landings from this same fleet.

For each fishing trip, the CFLP database included a unique trip identifier, the landing date, fishing gear deployed, areas fished, number of days at sea, number of crew, gear-specific fishing effort, species caught, and weight of the landings. Fishing effort data available for longline gear included number of sets and number of hooks per line.

Background

During SEDAR 25, a CFLP commercial longline index was developed and recommended for use in the assessment. In 2016, this index was updated and included data from 1993 to 2014 and used in the most recent assessment. Since SEDAR 25, several deepwater species (blueline tilefish and snowy grouper) have been reassessed and the longline indices from these assessments were not used. There are several contributing factors that led to the recommendation not to use these indices for snowy grouper and blueline tilefish (increased regulations, closures, targeting hyperstability, etc.). These factors along with others (e.g. limited spatial range) are applicable to the tilefish longline index.

In recent years fishery dependent indices have been scrutinized during the review process which has led to a more detailed analysis to ensure these data are reflecting trends in abundance opposed to reflecting other changes that may be occurring in the fishery (regulations, fleet behavior, etc).

The commercial logbook data for the longline fishery were examined to evaluate the potential utility of this longline index and determine the impact of recent regulations, including: 1. Truncation of the season due to decrease in ACL in 2006 2. Reduction in ACLs in 2006 3. Additional regulations within the deepwater complex.

*Eric Fitzpatrick, National Marine Fisheries Service, Southeast Fisheries Science Center, 101 Pivers Island Rd, Beaufort, NC 28516

An initial attempt was made to replicate the index from SEDAR 25 and the 2016 update including the most recent years (1993-2018) along with exploring splitting the indices to explore the effects of the management regulations (Figure 2). After completing these exploratory runs and noticing the very steep increase in the index following the 2006 management regulations a more thorough examination of this portion of the time series was warranted.

After presenting these findings to the SEDAR 66 DW panel, similar concerns were raised regarding this index followed by a thorough discussion involving multiple panel members and stakeholders.

Summary of SEDAR 66 DW discussion

- Access to tilefish habitat is a shorter run off the coast of Florida compared to other areas (30 miles versus 80-90 miles)
- Management regulations over time forced the fishery from year round to a few months (Figure 1)
  - Forced the fishery to be a derby style fishery where fishermen now have to go out in less than ideal conditions, previously they could choose days with better weather for fishing.
  - Normally fishermen would avoid cold water, strong currents, and bad weather but due to derby fishery these previously avoidable factors are now contributing to decreased catches.
  - The driving force behind an inconsistently hit trip limit now depends on a judgement call based on the last set of the day (cost-benefit related to trip limit). The captain may decide to go in without meeting the trip limit to avoid staying out an additional day. Conversely, he may come in to avoid going over the limit if catches are to high on that last set.
  - Regulations started in 2006 but the impacts from the reduced season didn't begin until 2007
- Coastal logbook data are trip-based, therefore, effort (specifically hours fished) cannot be unambiguouosly apportioned if targeting changed during a trip.
- Fishermen noted that beginning in 2007-2010 larger fish were being targeted due to a shift in market conditions. A shift in the nominal age composition provides some evidence of this shift noted by the fleet. (Figure 3).
- Spatially limited fishery primarily in south Florida (Figures 6-8)

Recommendation:

Upon further inspection of the data and based on the discussion from the SEDAR 66 data workshop, the commercial longline index was truncated with a terminal year of 2006. It is believed that the factors described above, mostly a result of management actions, are likely to decouple the relationship between landings-per-unit effort and population abundance. The index was truncated and only includes the years between 1993 and 2006 when the ACL and management were stable, the effort within the fishery was year around and not shortened due to seasonal closures and the number and coastwide distribution of vessels in the fleet were somewhat consistent.

Data Exclusions

The following decisions reflect the treatment of the data and standardization of the commercial logbook longline index.

1. Outlier removal

Extreme values occur more frequently in self-reported data because there are limited methods for validating data. Recent SEDAR stock assessments have removed values at the extreme upper tail of distribution for cpue and associated fields for self-reported fishery-dependent data. Values falling outside the 99.5 percentile of the data were excluded from the analyses. For trip-level data (crew, days at sea, hours fished, number of lines, and number of hooks per line) all snapper-grouper trips were evaluated. Positive tilefish trips were evaluated for outliers in tilefish cpue (Table 1).

2. Other data exclusions and assumptions (delayed reporting, multiple gears, area reported)

Data were restricted to include only those trips with landings and effort data reported within 45 days of the completion of the trip (some reporting delays were longer than one year). Also excluded were records reporting multiple gears fished, which prevents designating catch and effort to specific gears. Therefore, only trips which reported one gear fished were included in these analyses. For records where more than one area was reported, the first area reported was used to determine the latitude associated with the trip.

3. Starting year

The CFLP began in 1992 with complete coverage beginning in 1993. 1993 was chosen as the starting year.

4.Terminal year - 2006, commercial closures due to tilefish quota

A standardized index was developed during SEDAR 25 for tilefish that filtered the months during years where ACLs were met and the fishery closed. However, the longline fishery started catching the quota sooner in the latter part of this index. The index used in SEDAR 25 attempted to include as much data as possible for the benchmark assessment and following this assessment the update in 2014 required that this index be provided as input in the model. Consequently, the index was just updated to include recent data and lead to an index after 2006 that is tracking the behavior of the fishery (targeting) instead of tracking abundance.

Evaluation of explanatory variables

YEAR – Year was necessarily included, as standardized catch rates by year are the desired outcome. Years modeled were 1993-2005.

SEASON – Season included four levels: Jan-Mar, Apr-Jun, Jul-Sep, Oct-Dec. The density of trips by month with associated season factor is shown in Figure 5.

AREA – Areas reported in the logbook on a one degree grid (Figure 4). The majority of the positive trips and catch for commercial handline is in the Carolinas (Figures 6 and 7). Initially, a regional split at Cape Canaveral was considered but due to the limited samples in the SF region the coast was divided into two areas split at 32 degrees Latitude near Savannah, GA (Figure 5).

DAYS AT SEA – Days at sea (sea days) were pooled into three levels: one day (one), two to four days (twotofour), and five or more days (fiveplus) (Figure 5).

CREW SIZE – Crew size (includes Captain) could influence the total effort during a trip and could be a psuedo-factor for vessel size. The quartile split values (at 25, 50, and 75%) for tilefish crew size fall at 1, 2, and 3 plus crew per trip. Figure 5 shows the density of trips associated with each crew size.

Analytical decisions

1. Subsetting trips - Use Stephens and MacCall(2004) method
2. Species included in Stephens and MacCall approach: limit to snapper-grouper complex and remove species (red porgy for current years) with full-year closures, ID issue, or large shifts in desirability over the index period (prior to truncating the index red porgy, red snapper, vermilion snapper, mutton snapper, snowy grouper, gag, black sea bass, blueline tilefish and yellowtail snapper were removed)
3. Apply Stephens and MacCall to Carolinas (CAR), Georgia-N.Florida (GNF), and S. Florida (SF) with Cape Canaveral, FL separating North and South Florida

Subsetting trips

Effective effort was based on those trips from areas where tilefish were available to be caught. Without fine-scale geographic information on fishing location, trips to be included in the analysis must be inferred, which was done here using the method of Stephens and MacCall (2004). The method uses multiple logistic regression to estimate a probability for each trip that the focal species was caught, given other species caught on that trip. The method was applied separately for the three regions considered due to species composition shifts. A zoogeographic boundary is apparent near Cape Canaveral (Shertzer, Williams, and Taylor 2009) which is the break between GNF and SF areas. Another break between the CAR and GNF areas was included to limit the influence of species at the edge of their range (e.g. scup in the North or yellowtail snapper to the South). To avoid undue influence of rare species on regression estimates, species included in each analysis were limited to those occurring in 1% or more of trips for CAR, 1% or more for GNF and 1% for SF. However, the cutoff values had little influence on the trips selected because the species with the highest probabilities (positive and negative) were always included. Species with management closures were also omitted because the potential for erroneously removing trips likely to have caught tilefish during years of restrictions (red porgy).

A backwards stepwise AIC procedure (Venables and Ripley 1997) was then used to perform further selection among possible species as predictor variables, where the most general model included all listed species as main effects. In this procedure, a generalized linear model with Bernoulli response was used to relate presence/absence of tilefish in each trip to presence/absence of other species. Regression coefficients of included species for all areas are given in Appendix 1 and shown in figure 9. A trip was then included if its associated probability of catching tilefish was higher than a threshold probability (Figure 9). The threshold was designed to be that which resulted in the same number of predicted and observed positive trips, as suggested by Stephens and MacCall(2004). Retention of positive and zero tilefish trips across factors are shown in Figures 10 - 12. A large number of positive trips were retained while a large proportion of zero trips were dropped. The proportion of tilefish relative to the other associated species for each of these regions is much different north and south of Cape Canaveral. This difference can bee seen in the disproportionate removal of zero trips for the SF region. The nominal catch rate before and after the subsetting are fairly similar (Figure 13)

Standardization

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

Bernoulli submodel

The Bernoulli component of the delta-GLM is a logistic regression model that attempts to explain the probability of either catching or not catching tilefish on any given trip. Initially, all explanatory variables were included in the model as main effects, and then stepwise AIC (Venables and Ripley 1997) with a backwards selection algorithm was used to eliminate those variables that did not improve model fit. In this case, the stepwise AIC procedure did not remove any explanatory variables. Diagnostics, based on standardized (quantile) residuals, suggested reasonable fits of the Bernoulli submodel (Figure 14).

Positive CPUE submodel

Two parametric distributions were considered for modeling positive values of CPUE, lognormal and gamma. For both distributions, all explanatory variables were initially included as main effects, and then stepwise AIC (Venables and Ripley 1997) with a backwards selection algorithm was used to eliminate those variables that did not improve model fit. For both distributions, the best model fit included all explanatory variables. The two distributions were compared using AIC. Gamma outperformed lognormal, and was therefore applied in the final delta-GLM. Diagnostics suggested a reasonable fit (Figures 15 and 16).

Results

The standardized index was similar to the nominal index (Figure 17).

Table 1: CFLP Longline cutoff values for outliers (records reporting more (upper),or less (lower) were excluded).

	manual	electric
lines fished (upper)	30	6
hooks per line (upper)	3000	8
days at sea (upper)	13	12
crew (upper)	4	5
hours fished (lower)	1	4
hours fished (upper)	123	130
cpue (upper)	3	3

Table 2: Nominal and standardized CPUE for tilefish 1993-2005 with CVs for stardardized index of abundance.

Year	N	Nominal.CPUE	Relative.nominal	Standardized.CPUE	Proportion.Positive	CV
1993	486	0.32	1.01	0.89	0.97	0.05
1994	392	0.27	0.85	0.85	0.96	0.07
1995	355	0.29	0.91	0.83	0.91	0.07
1996	275	0.18	0.58	0.57	0.91	0.06
1997	237	0.20	0.64	0.81	0.93	0.06
1998	217	0.32	1.00	0.96	0.91	0.07
1999	266	0.40	1.25	1.01	0.87	0.08
2000	337	0.41	1.28	1.16	0.89	0.07
2001	278	0.28	0.89	0.85	0.93	0.06
2002	216	0.26	0.83	0.88	0.92	0.12
2003	190	0.22	0.70	0.71	0.84	0.09
2004	136	0.25	0.79	0.90	0.87	0.09
2005	100	0.55	1.71	1.72	0.87	0.10
2006	135	0.50	1.57	1.86	0.87	0.09

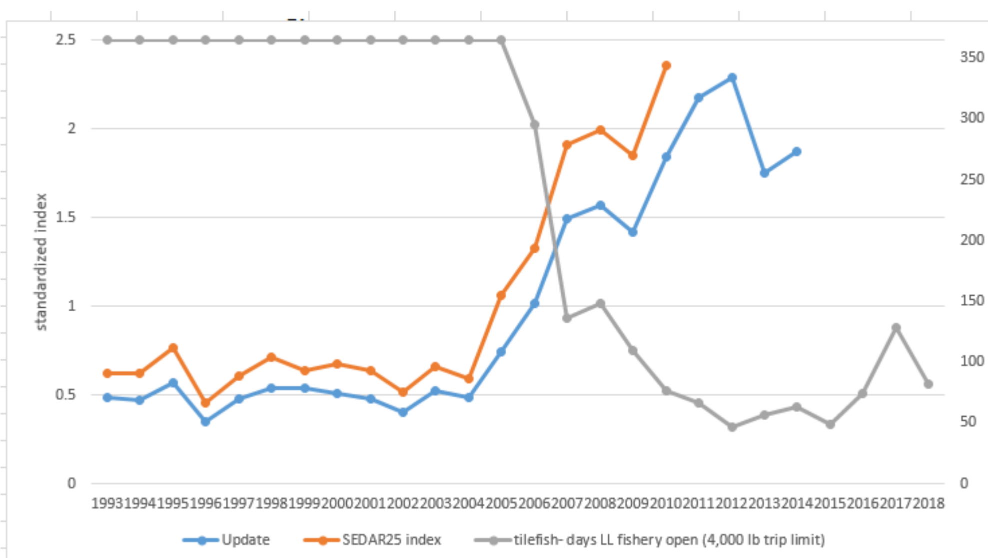


Figure 1: SEDAR 25 and 2014 update indices plotted versus number of days the fishery was open by year.

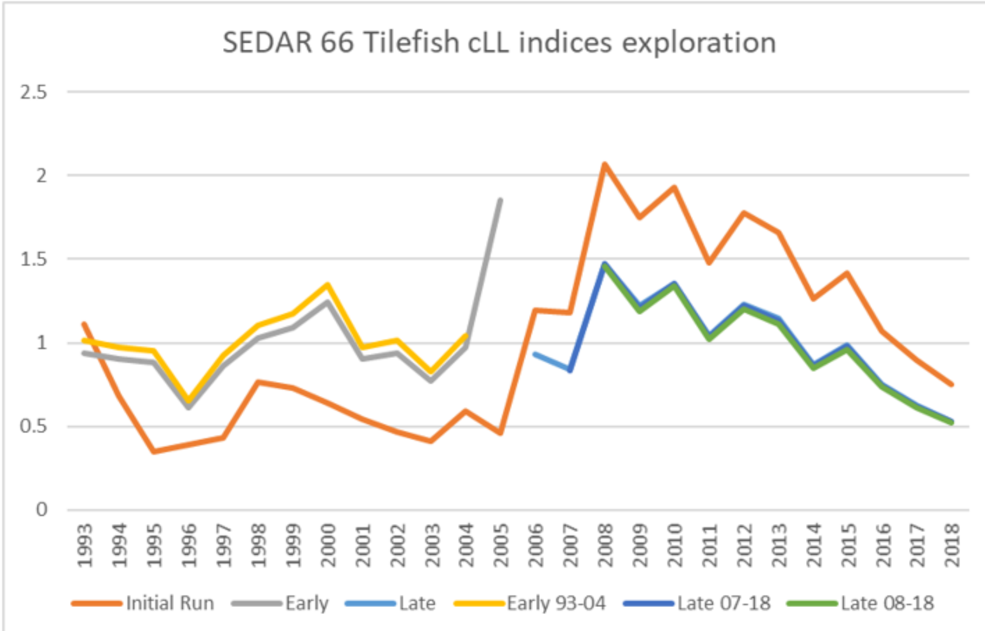


Figure 2: Exploratory indices developed during SEDAR 66.

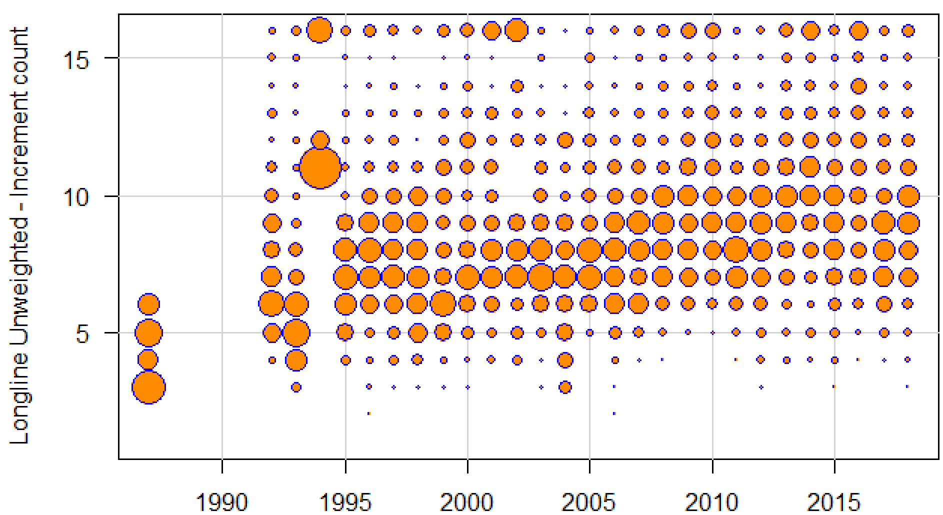


Figure 3: Nominal bubble plot of longline tilefish age composition.

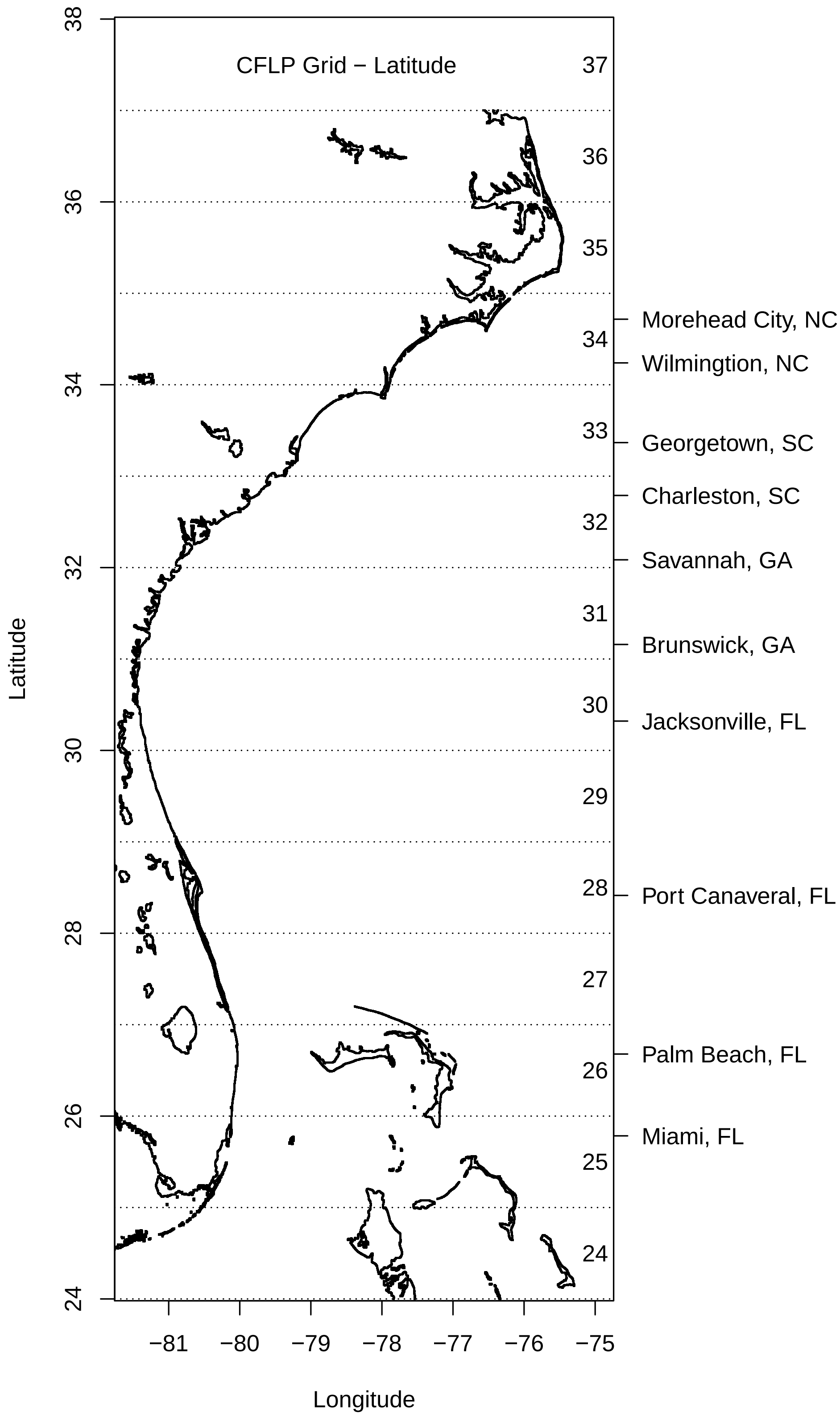


Figure 4: CFLP Latitude Stratification (midpoint of each latitudinal grid is labeled with the floor for the bin).

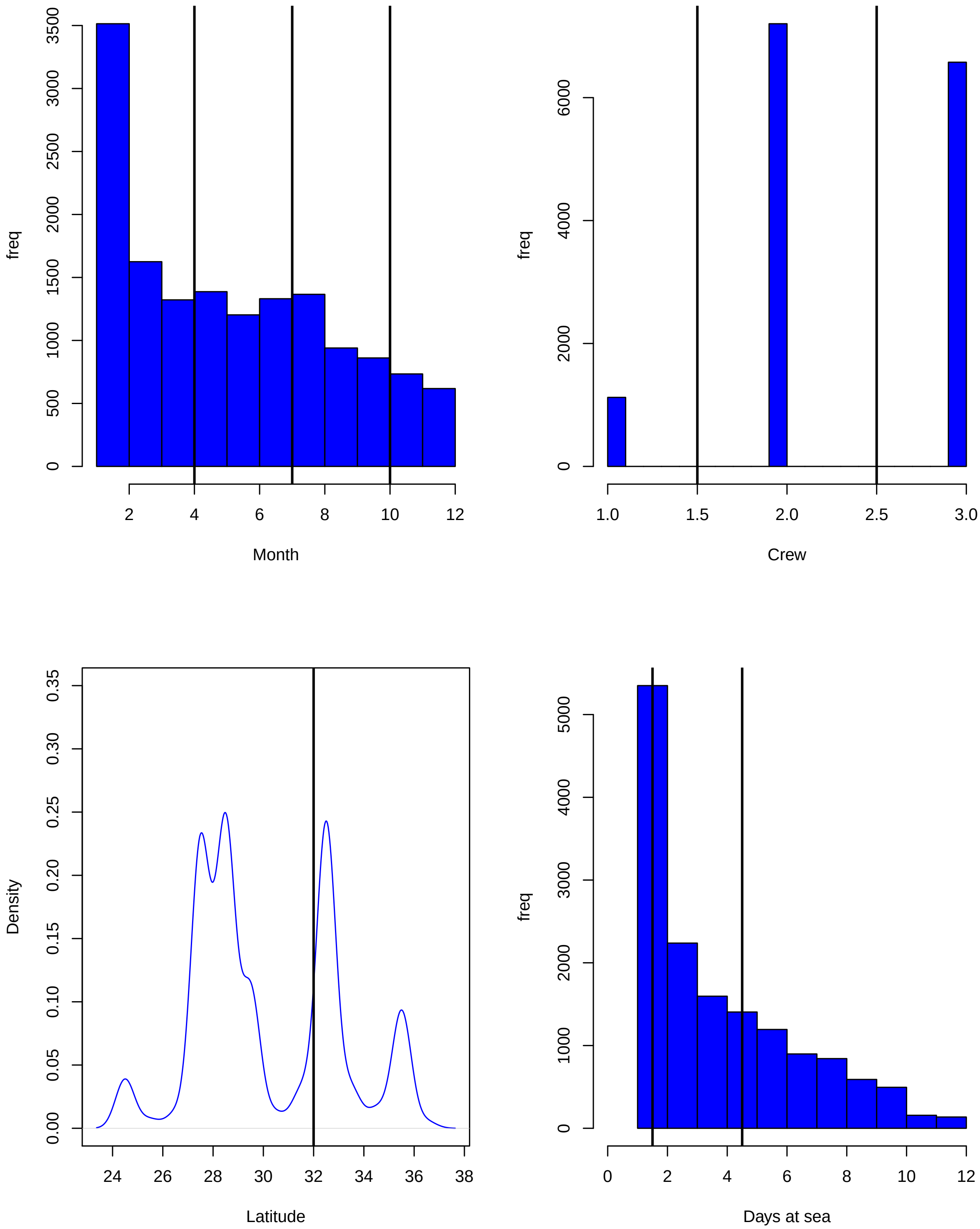


Figure 5: tilefish longline explanatory variable factorization. Vertical lines represent breaks for factors.

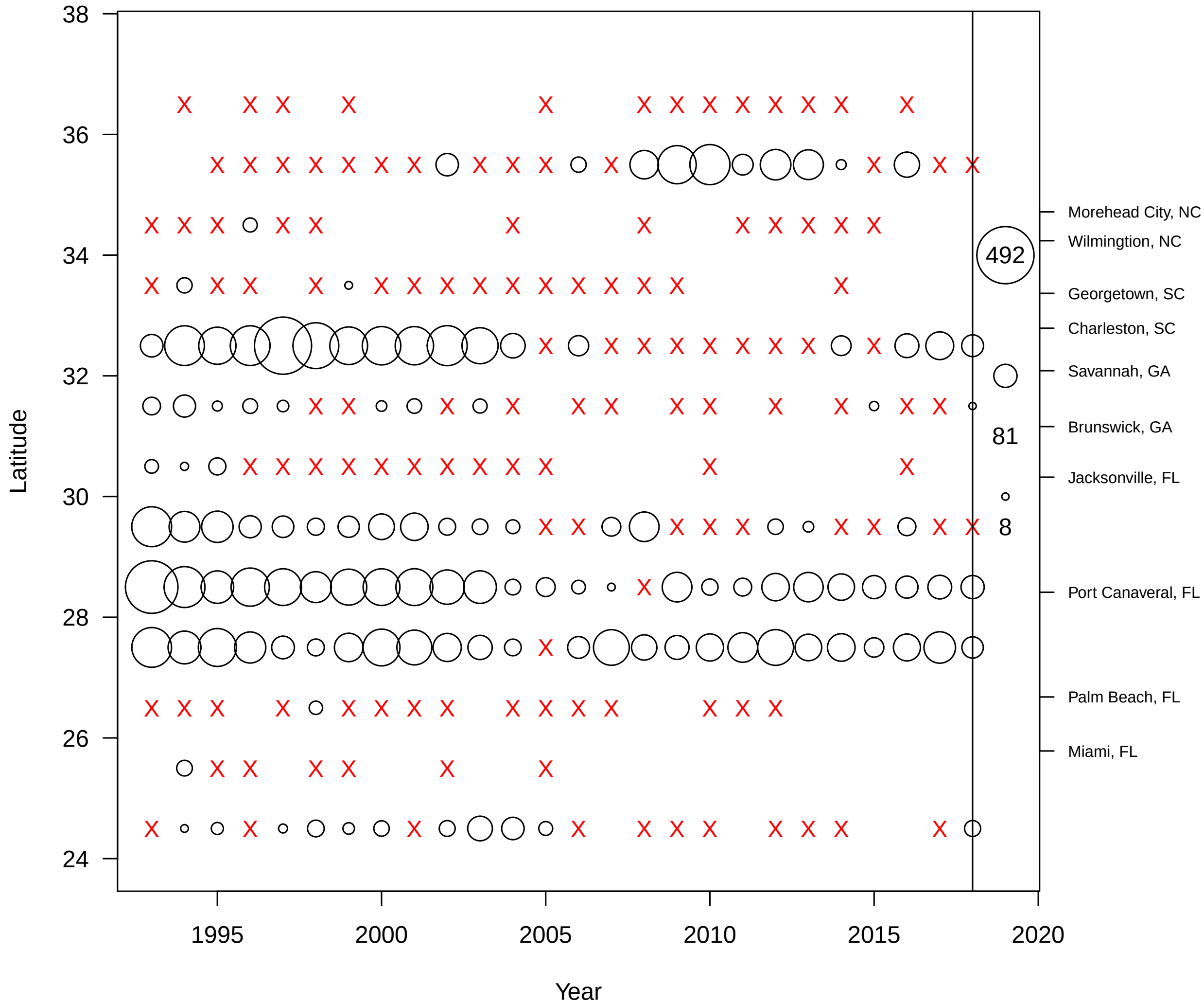


Figure 6: tilefish longline trips by year and latitude. Symbol size relative to number of trips, 'X' signifies confidential data and represents a small percentage of the total trips.

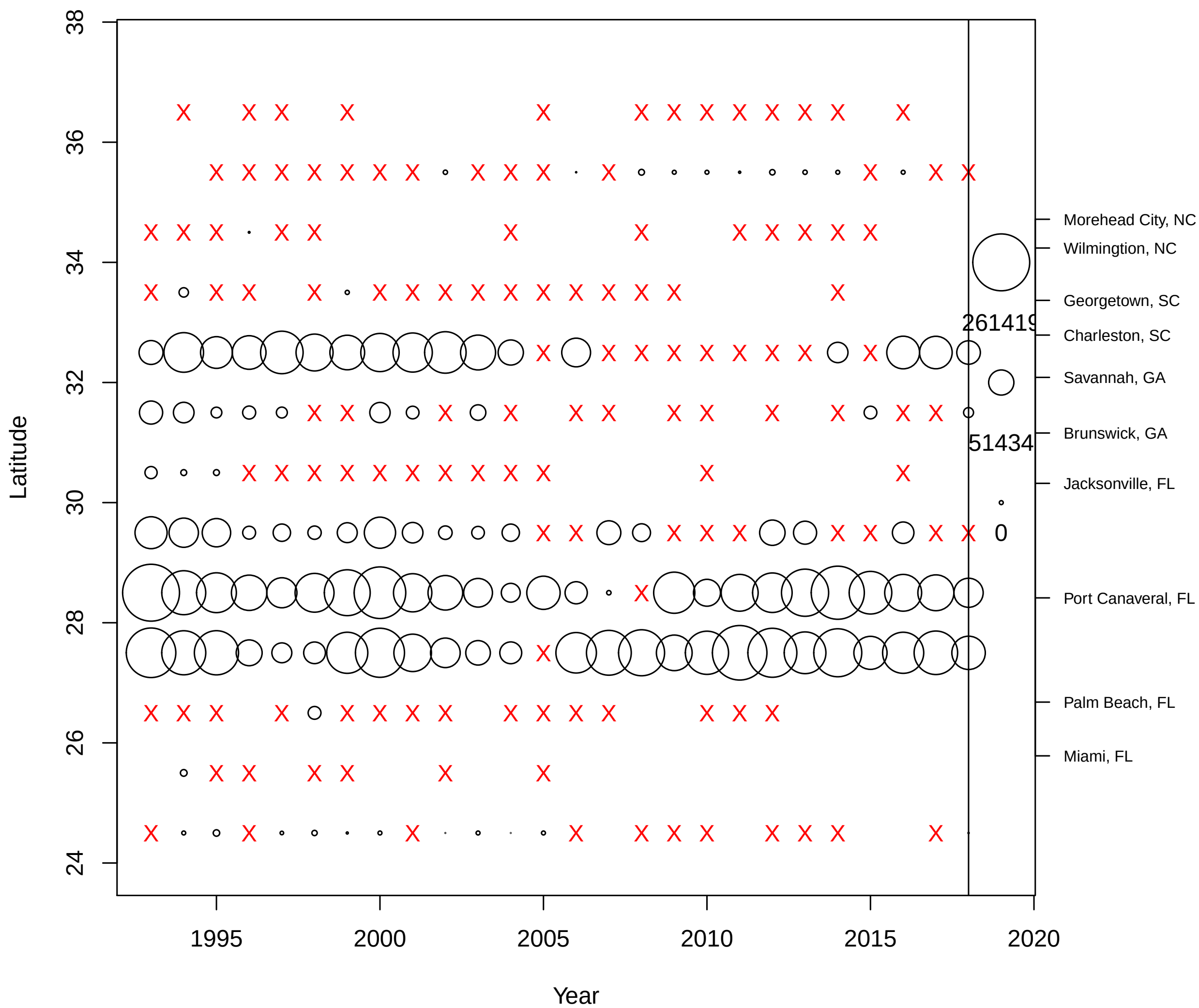


Figure 7: tilefish longline catch (whole pounds) by year and latitude. Symbol size relative to catch, 'X' signifies confidential data and represents a small percentage of the total catch.

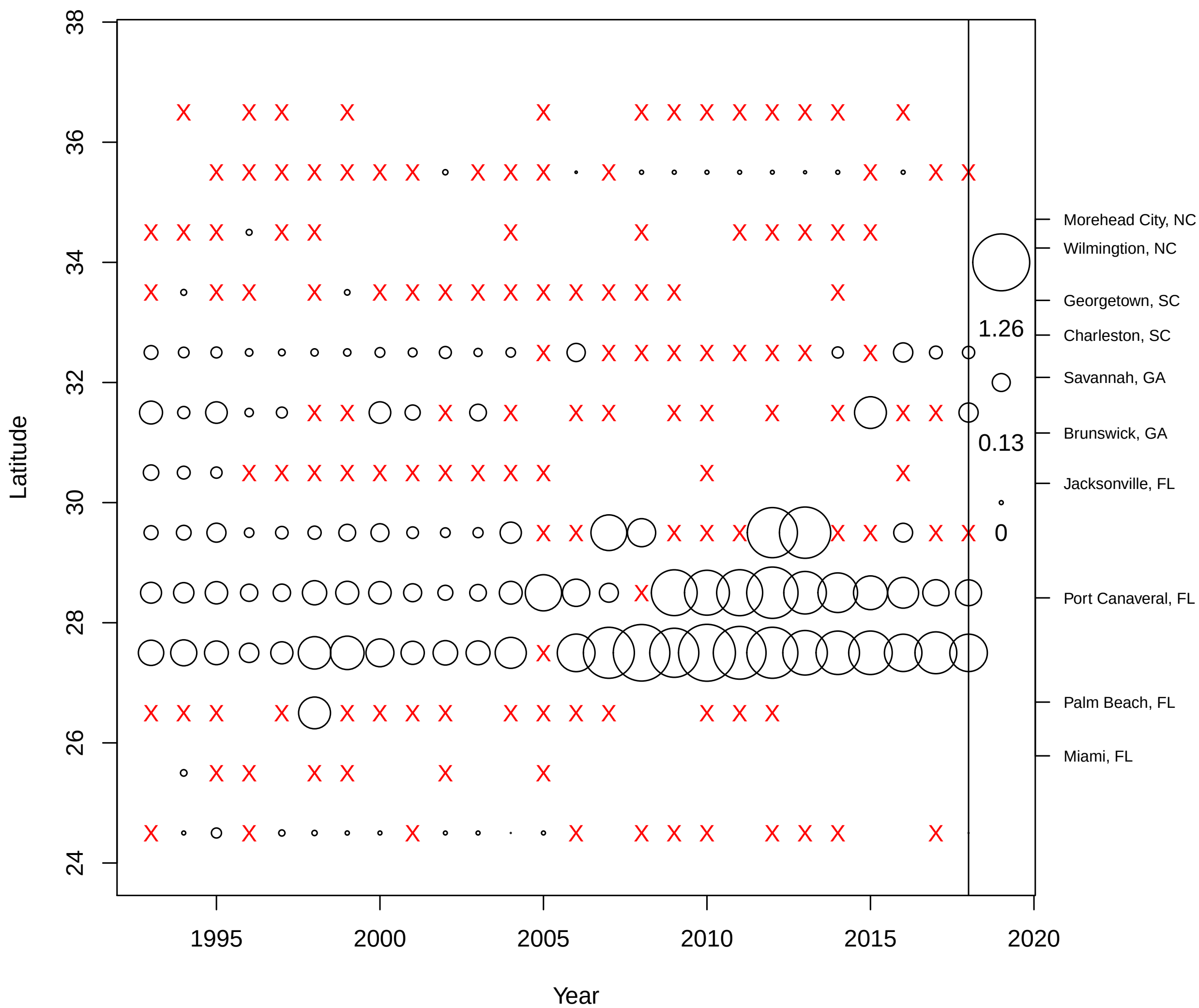


Figure 8: tilefish longline mean cpue (whole pounds/hook-hour) by year and latitude. Symbol size relative to cpue, 'X' signifies confidential data and represents a small percentage of the total records.

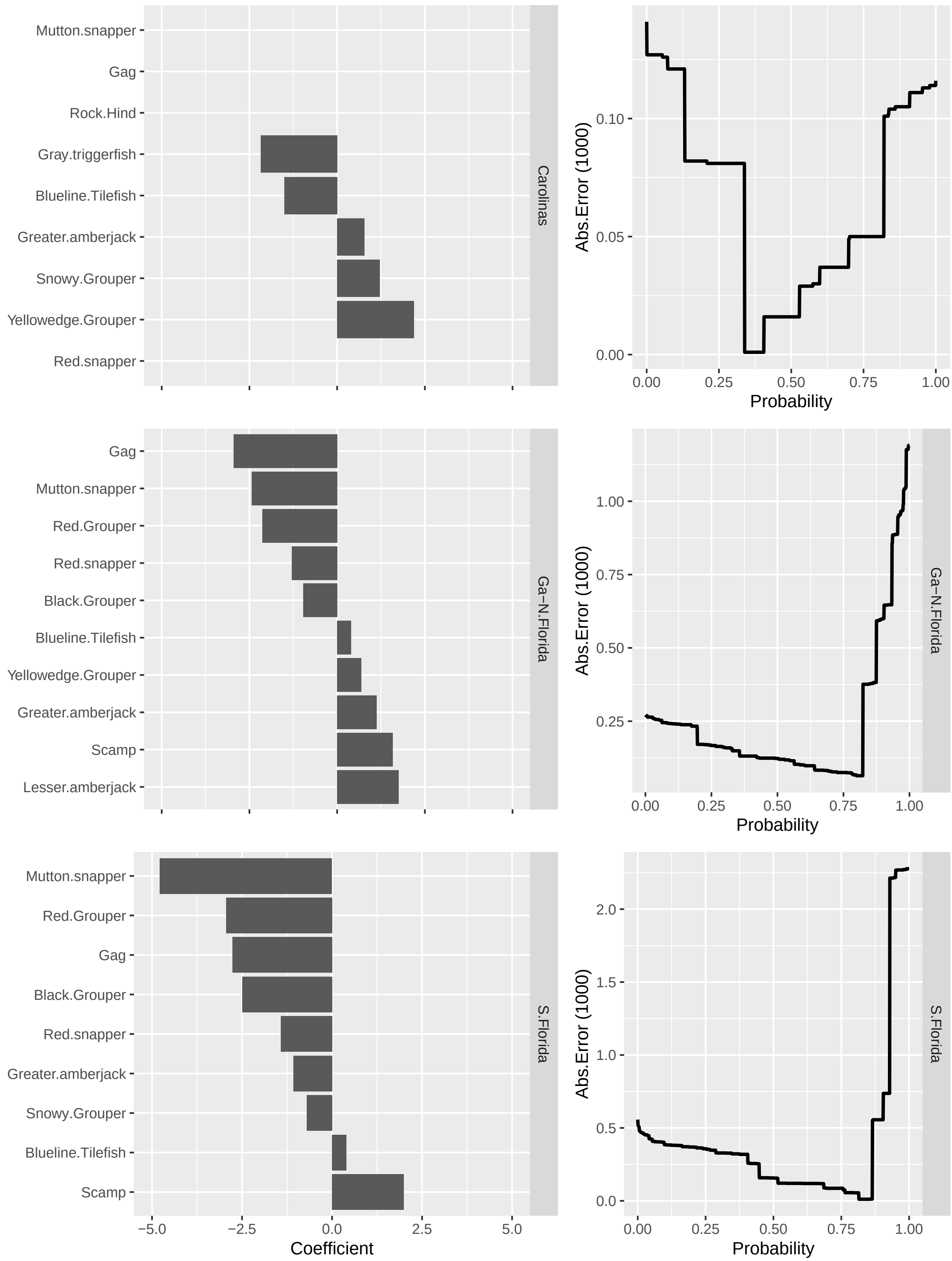


Figure 9: Estimates of species-specific regression coefficients used to predict each trip's probability of catching the focal species on the left panel. The right panel shows the absolute difference between observed and predicted number of positive trips across a range of probability cutoff values.

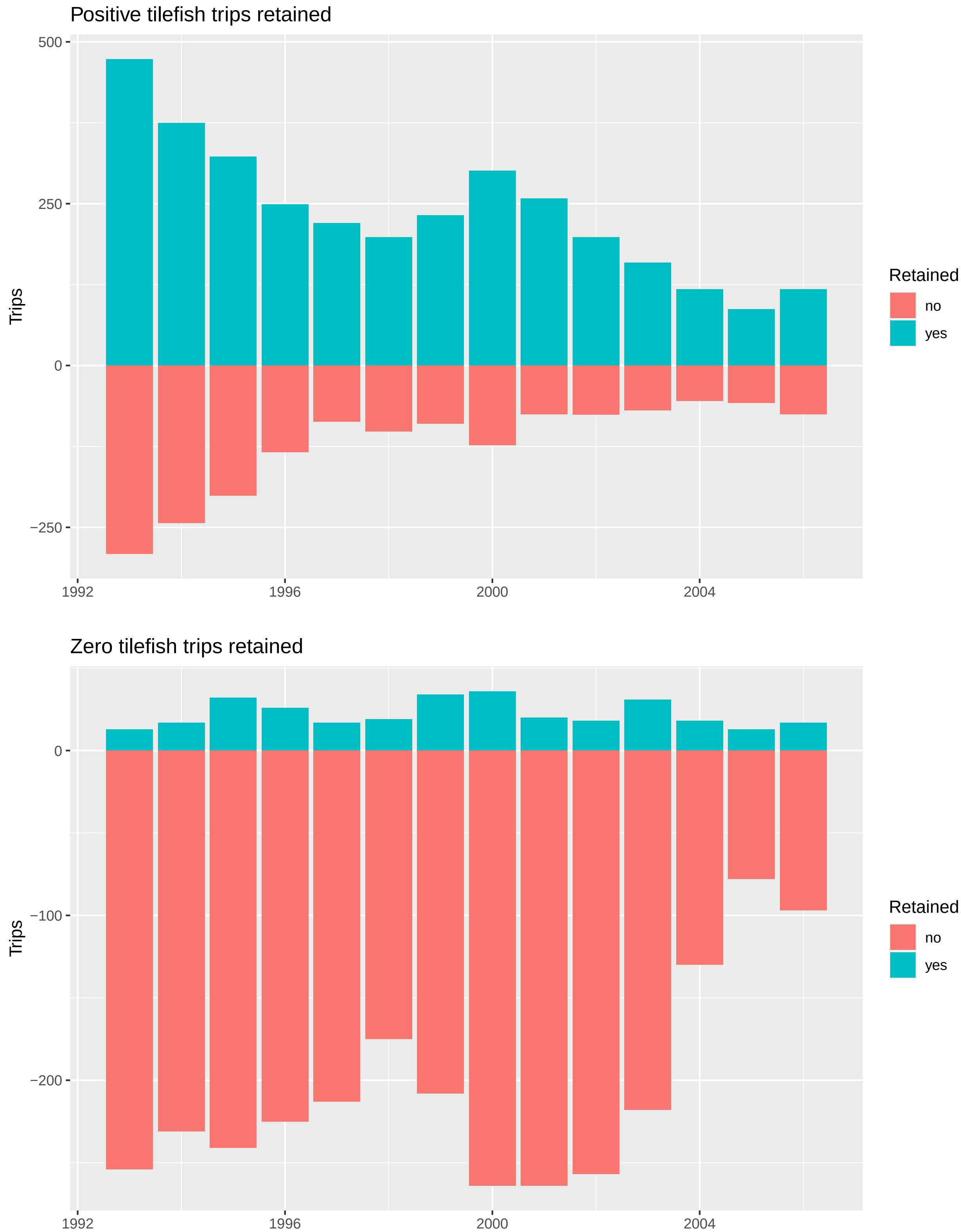


Figure 10: Positive and zero tilefish trips retained after subsetting using Stephens and MacCall approach by year.

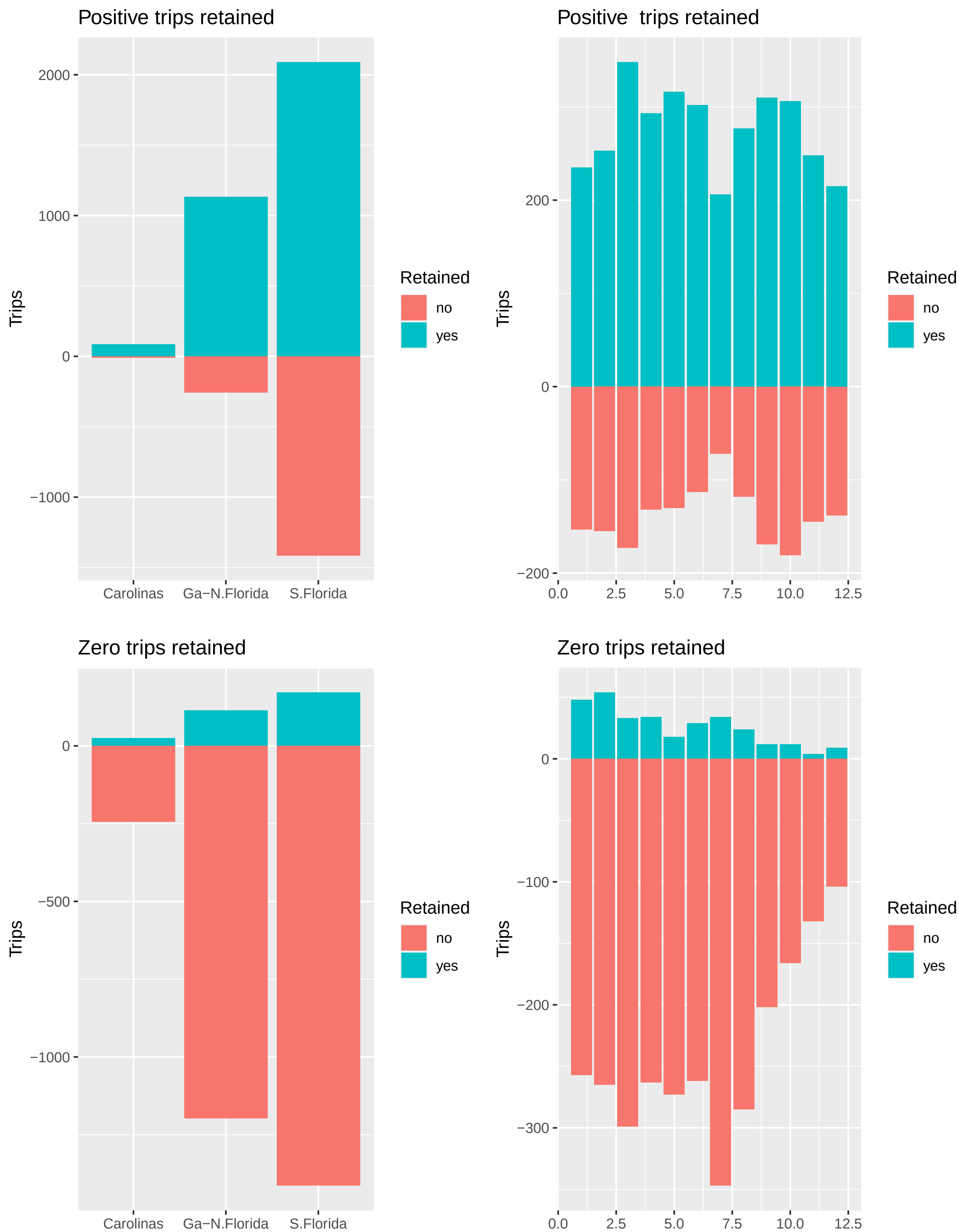


Figure 11: Positive and zero tilefish trips retained after subsetting using Stephens and MacCall approach by area and month (season).

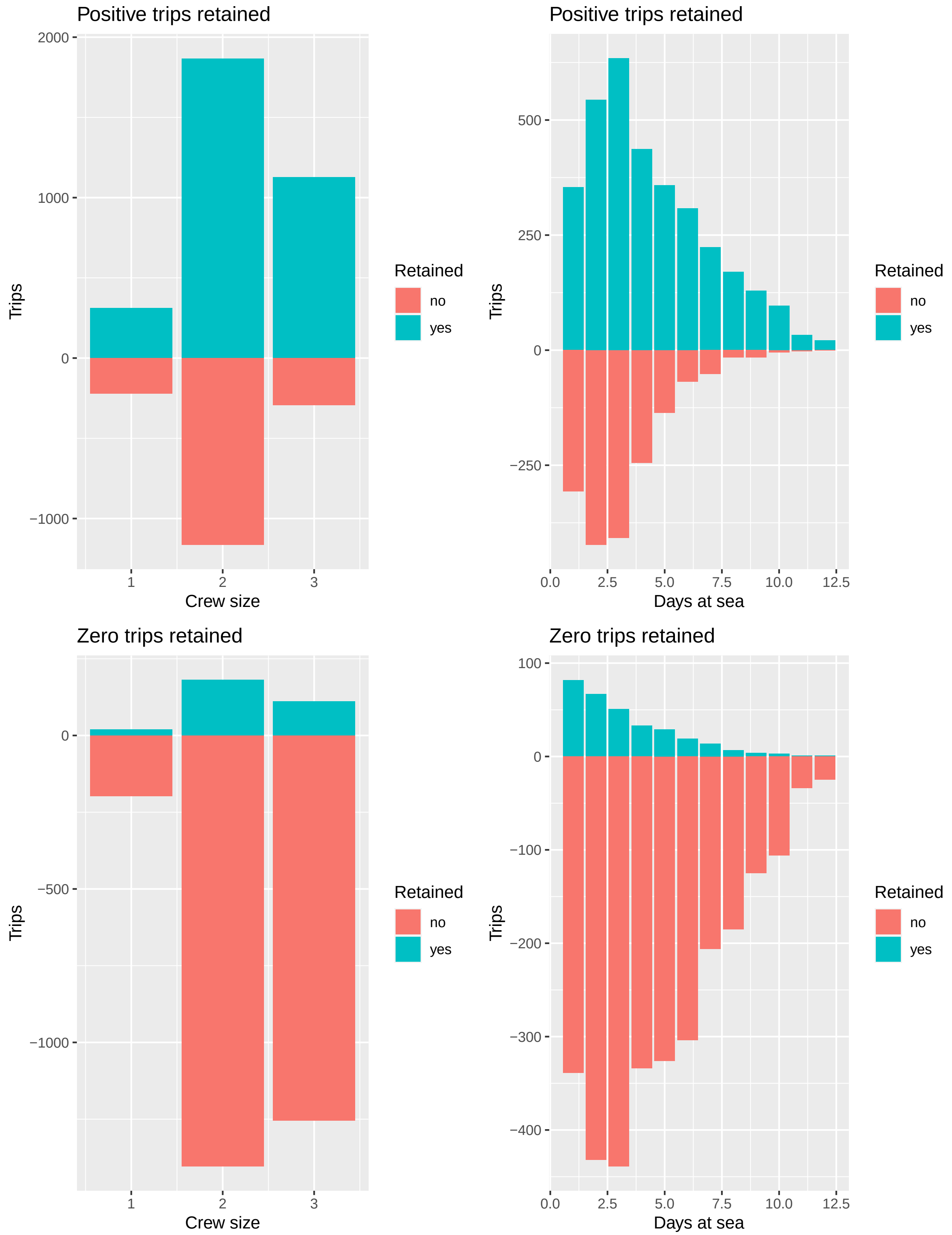


Figure 12: Positive and zero tilefish trips retained after subsetting using Stephens and MacCall approach by factors for crew size and days at sea.

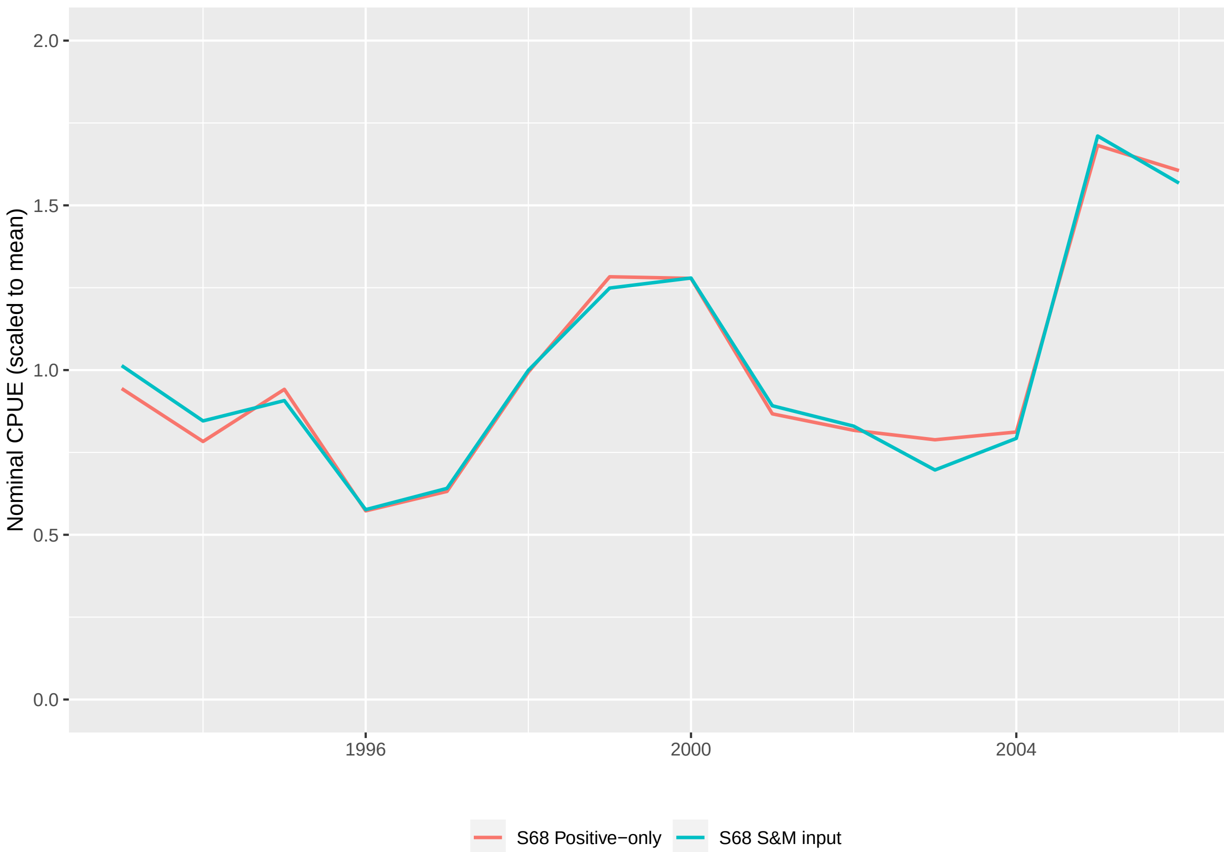


Figure 13: Nominal tilefish cpue for raw data and subsetted trips.

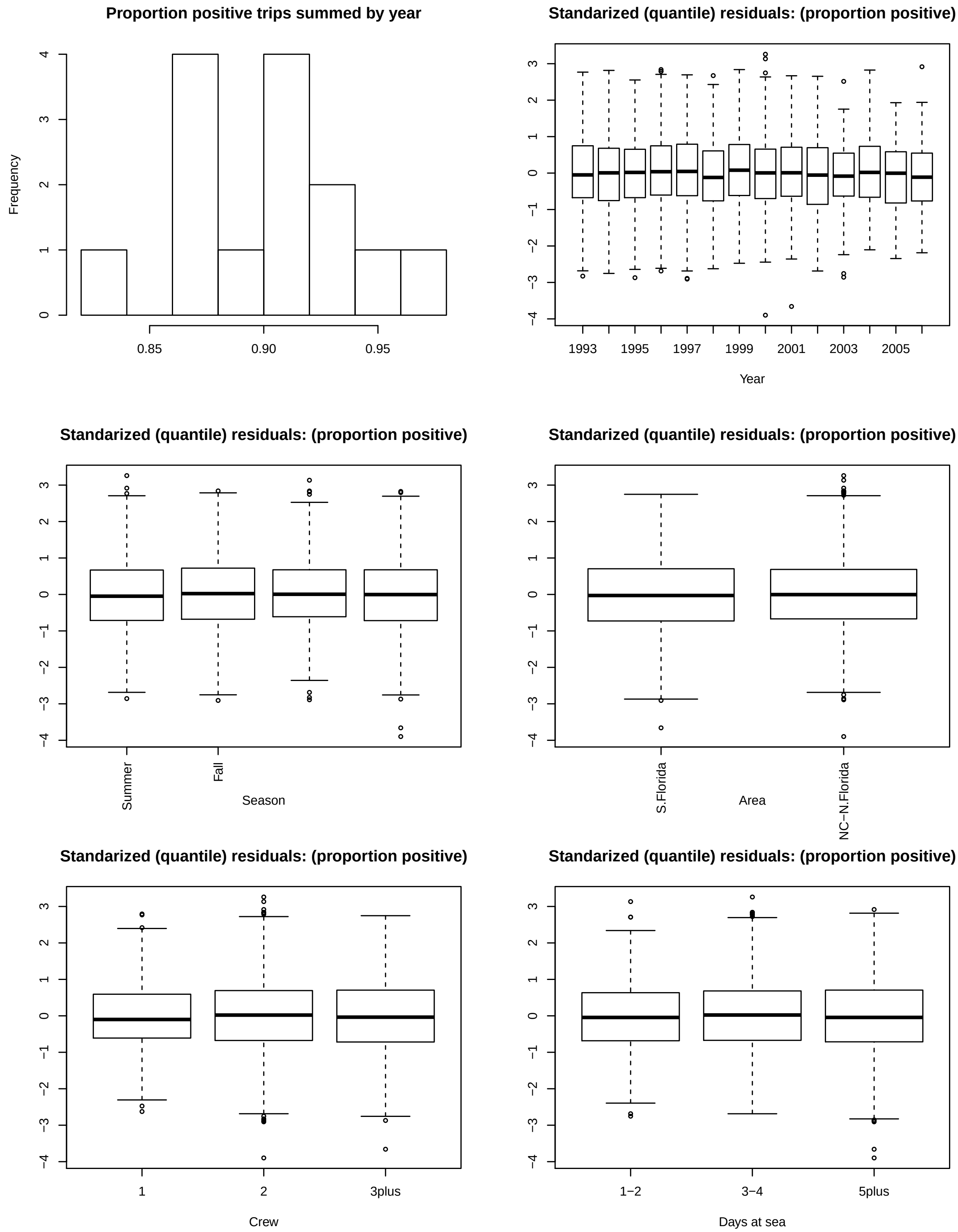


Figure 14: Diagnostics of Bernoulli submodel fits to positive versus zero CPUE data. Box and whisker plots give first, second (median) and third quartiles, as well as limbs that extend to approximately one interquartile range beyond the nearest quartile, and outliers (circles) beyond the limbs. Residuals are standardized (quantile) residuals.

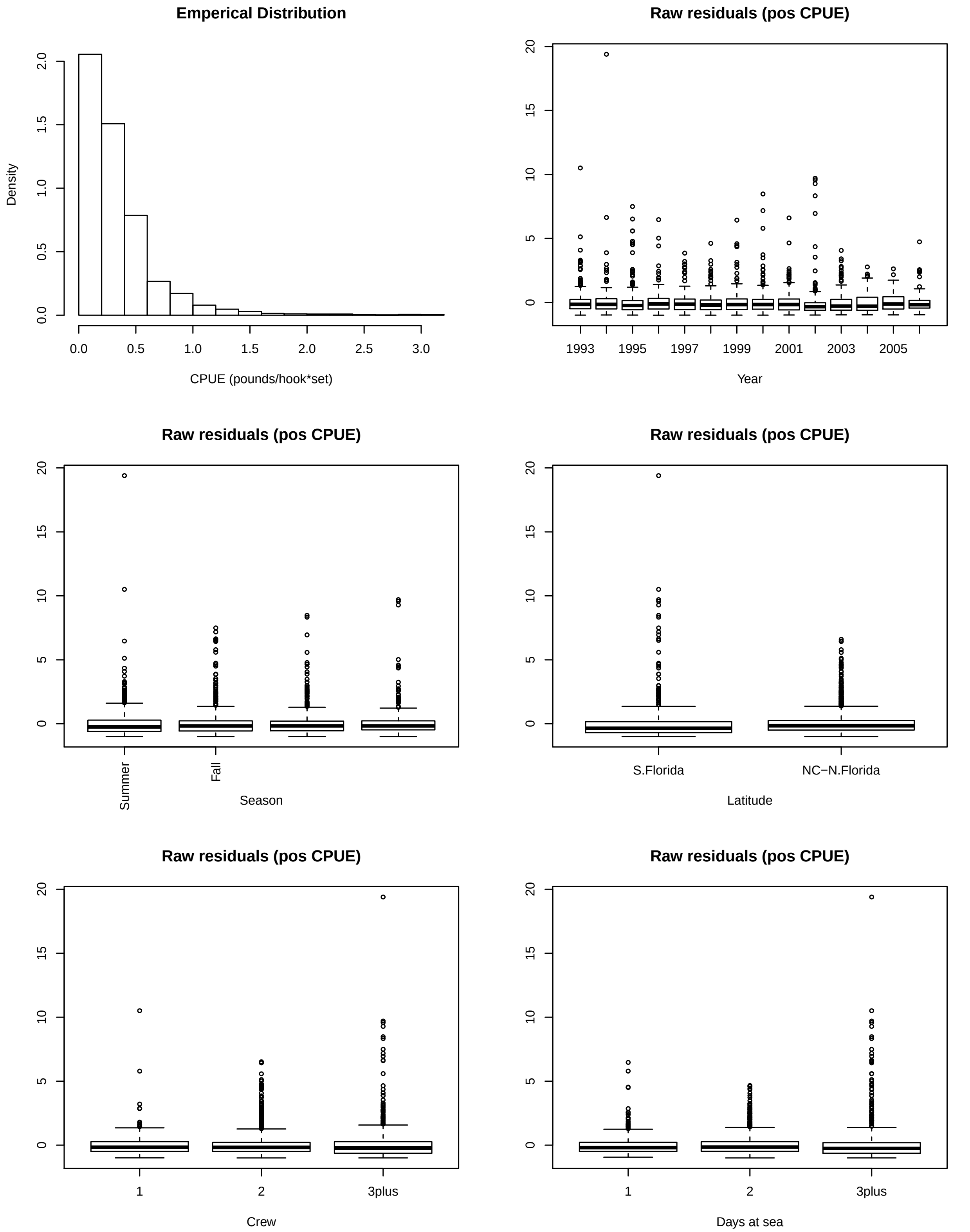
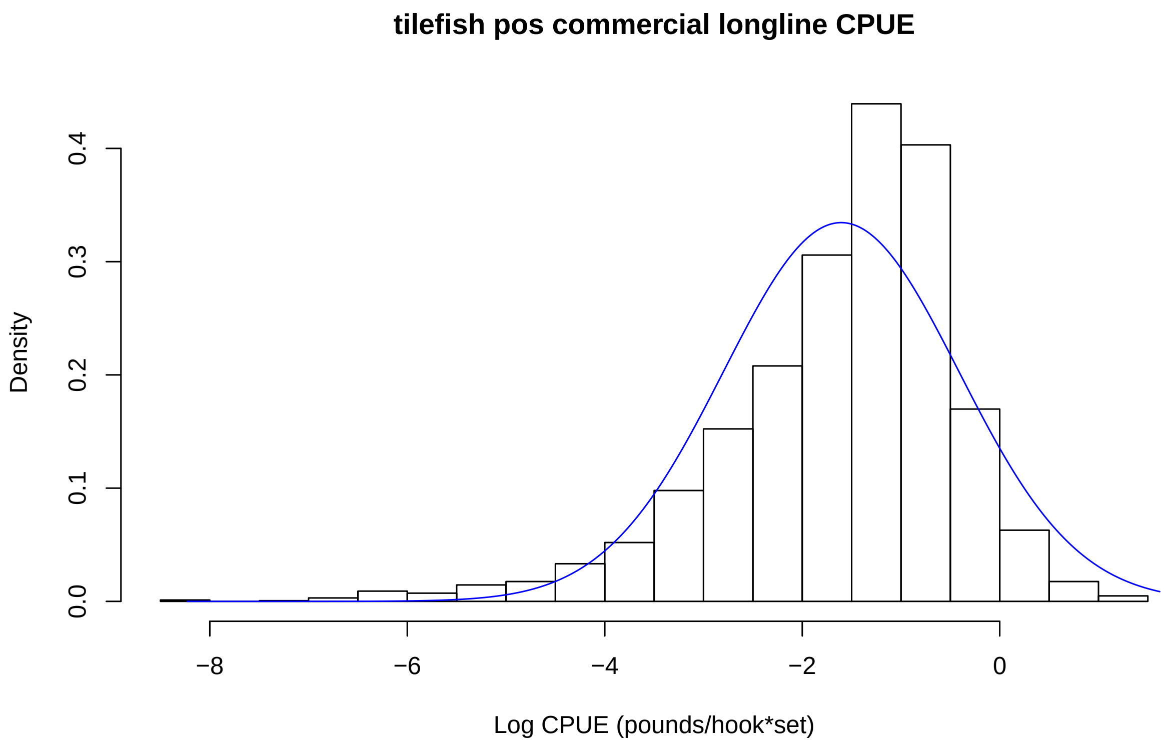


Figure 15: Diagnostics of lognormal submodel fits to positive CPUE data. Top left panel shows the distribution of positive cpue. Box and whisker plots give first, second (median) and third quartiles, as well as limbs that extend to approximately one interquartile range beyond the nearest quartile, and outliers (circles) beyond the limbs. Residuals are raw.



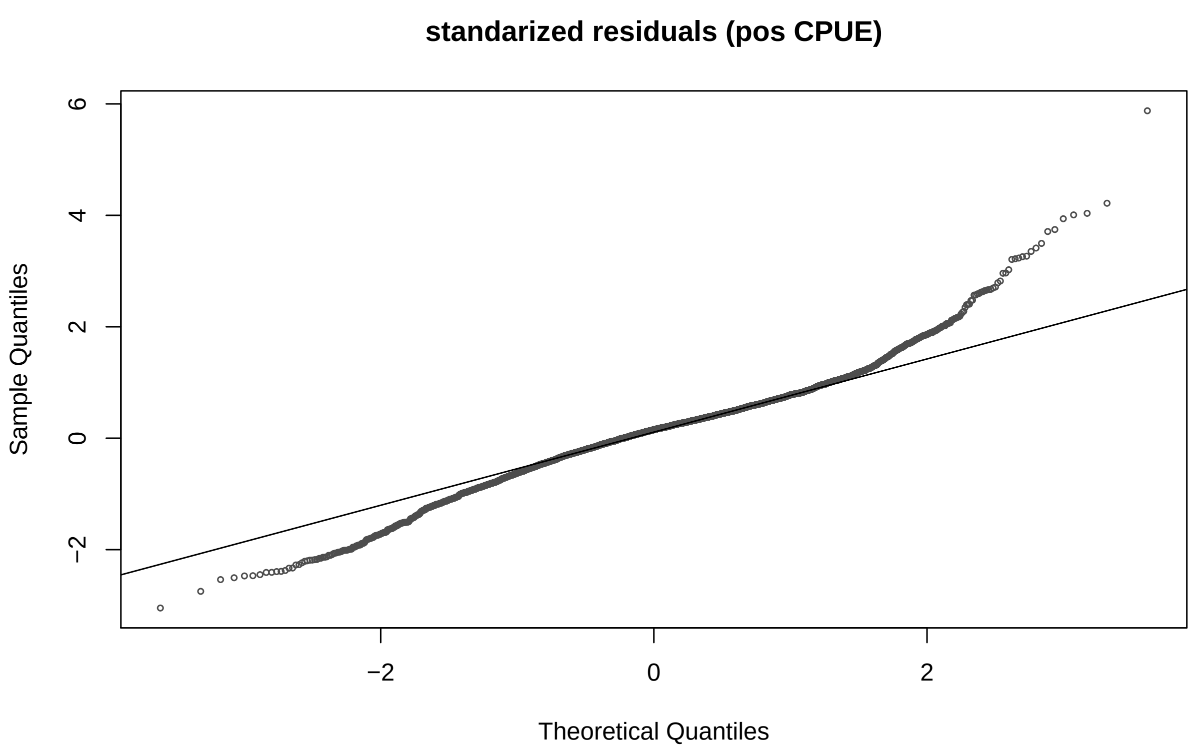


Figure 16: Histogram of empirical log CPUE, with the normal distribution overlaid. Quantile-quantile plot of residuals from the fitted gamma submodel to the positive cpue catch.

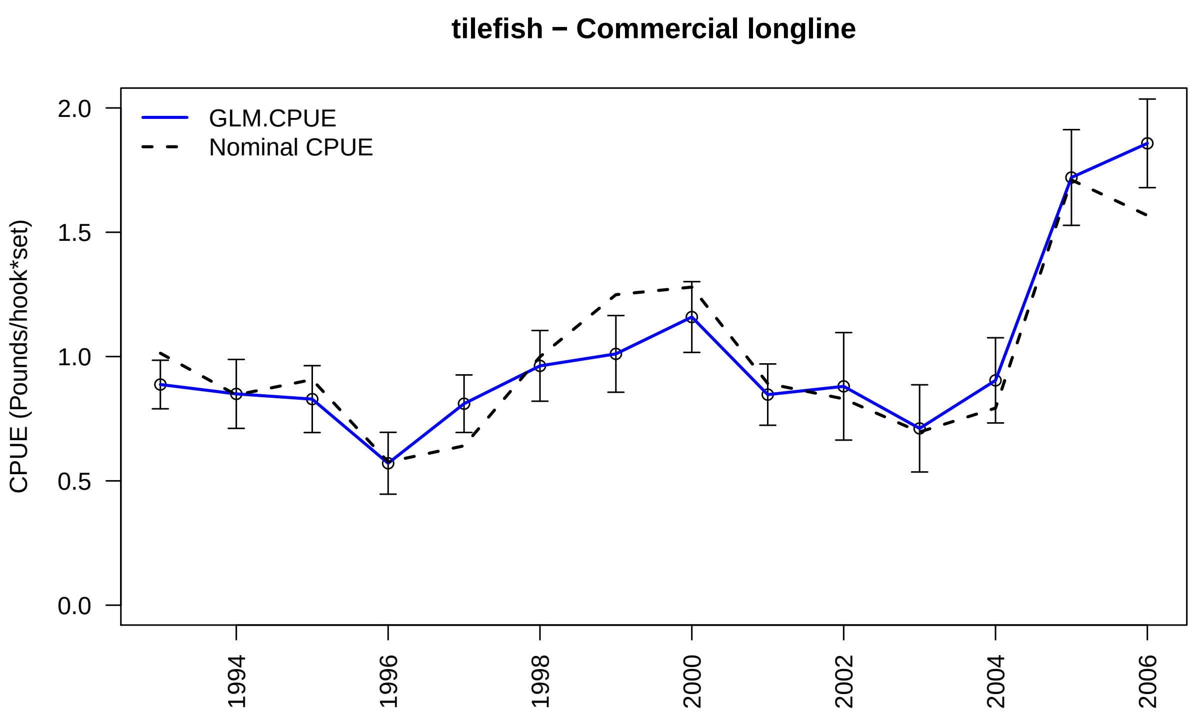


Figure 17: Standardized commercial handline tilefish catch rate (solid) with 95% confidence intervals and nominal catch rate (dashed).

Appendix

Results of generalized linear model with Bernoulli response to select species associations with tilefish for the Carolinas.

Call: glm(formula = Tilefish ~ Blueline.Tilefish + Gag + Gray.triggerfish + Greater.amberjack + Mutton.snapper + Red.snapper + Rock.Hind + Snowy.Grouper + Yellowedge.Grouper, family = "binomial", data = n.mat.cut.df)

Coefficients: (Intercept) Blueline.Tilefish Gag
-0.3811 -1.5099 -33.9488
Gray.triggerfish Greater.amberjack Mutton.snapper
-2.1744 0.7821 -34.6040
Red.snapper Rock.Hind Snowy.Grouper
16.6830 -17.5300 1.2214
Yellowedge.Grouper
2.1899

Degrees of Freedom: 256 Total (i.e. Null); 247 Residual Null Deviance: 353.8 Residual Deviance: 260.5 AIC: 280.5

Results of generalized linear model with Bernoulli response to select species associations with tilefish for the Georgia-N.Florida.

```
##
## Call:  glm(formula = Tilefish ~ Black.Grouper + Blueline.Tilefish +
##     Gag + Greater.amberjack + Lesser.amberjack + Mutton.snapper +
##     Red.Grouper + Red.snapper + Scamp + Yellowedge.Grouper, family = "binomial",
##     data = m.mat.cut.df)
##
## Coefficients:
##        (Intercept)       Black.Grouper   Blueline.Tilefish
##             1.5436             -0.9679              0.3985
##                Gag   Greater.amberjack    Lesser.amberjack
##            -2.9544              1.1230              1.7561
##     Mutton.snapper         Red.Grouper         Red.snapper
##            -2.4405             -2.1325             -1.2895
##              Scamp  Yellowedge.Grouper
##             1.5890              0.6930
##
## Degrees of Freedom: 1461 Total (i.e. Null);  1451 Residual
## Null Deviance:       1402
## Residual Deviance: 1003  AIC: 1025
```

Results of generalized linear model with Bernoulli response to select species associations with tilefish for the S. Florida.

```
##
## Call:  glm(formula = Tilefish ~ Black.Grouper + Blueline.Tilefish +
##     Gag + Greater.amberjack + Mutton.snapper + Red.Grouper +
##     Red.snapper + Scamp + Snowy.Grouper, family = "binomial",
##     data = s.mat.cut.df)
##
## Coefficients:
##       (Intercept)      Black.Grouper  Blueline.Tilefish
##            2.5579            -2.4927             0.3963
##               Gag  Greater.amberjack     Mutton.snapper
##           -2.7667            -1.0799            -4.7819
```

```
##      Red.Grouper       Red.snapper             Scamp
##          -2.9387           -1.4259            1.9927
##    Snowy.Grouper
##          -0.7006
##
## Degrees of Freedom: 2833 Total (i.e. Null);  2824 Residual
## Null Deviance:       2809
## Residual Deviance: 1854  AIC: 1874
```

Results of lognormal glm to determine factors.

```
##
## Call:  glm(formula = cpue ~ year + season + lat + crew + away, family = gaussian(link = "identity"),
##     data = pos.dat)
##
## Coefficients:
## (Intercept)     year1994     year1995     year1996     year1997
##    0.155547    -0.024410     0.001940    -0.090705    -0.011679
##    year1998     year1999     year2000     year2001     year2002
##    0.087913     0.159377     0.153192     0.027238     0.019272
##    year2003     year2004     year2005     year2006      season2
##    0.005188     0.036411     0.333764     0.283830    -0.046713
##     season3      season4         lat2        crew2        crew3
##   -0.011256    -0.014053     0.205491     0.068885     0.047048
##       away2        away3
##   -0.027743    -0.107335
##
## Degrees of Freedom: 3308 Total (i.e. Null);  3287 Residual
## Null Deviance:       387.6
## Residual Deviance: 309.6     AIC: 1597
```

Results of gamma glm to determine factors.

```
##
## Call:  glm(formula = cpue ~ year + season + lat + crew + away, family = Gamma(link = "log"),
##     data = pos.dat)
##
## Coefficients:
## (Intercept)     year1994     year1995     year1996     year1997
##  -1.870e+00   -6.726e-02    3.610e-02   -3.898e-01   -1.984e-01
##    year1998     year1999     year2000     year2001     year2002
##   1.265e-01    3.043e-01    3.590e-01   -7.351e-05    1.667e-01
##    year2003     year2004     year2005     year2006      season2
##  -9.365e-02    2.830e-02    6.879e-01    6.881e-01   -1.380e-01
##     season3      season4         lat2        crew2        crew3
##  -4.022e-02   -2.935e-02    8.611e-01    1.613e-01    1.409e-02
##       away2        away3
##  -4.276e-02   -2.229e-01
##
## Degrees of Freedom: 3308 Total (i.e. Null);  3287 Residual
## Null Deviance:       3405
## Residual Deviance: 2572  AIC: -1604
```

Results of binomial glm to determine factors.

```
##
## Call:  glm(formula = cpue ~ year + season + lat + away, family = "binomial",
```

```
##     data = bin.dat)
##
## Coefficients:
## (Intercept)     year1994     year1995     year1996     year1997
##      1.8666      -0.6044      -1.3646      -1.3955      -1.1606
##    year1998     year1999     year2000     year2001     year2002
##     -1.3666      -1.9836      -1.6506      -1.2747      -1.4431
##    year2003     year2004     year2005     year2006      season2
##     -2.1380      -1.8426      -1.8706      -1.6430       0.4778
##     season3      season4         lat2        away2        away3
##      0.4147       1.4823       0.4315       1.0366       1.7528
##
## Degrees of Freedom: 3619 Total (i.e. Null);  3600 Residual
## Null Deviance:       2121
## Residual Deviance: 1910  AIC: 1950
```

Results of lognormal delta glm to compare models.

```
## $error.distribution
## [1] "Lognormal distribution assumed for positive observations."
##
## $binomial.formula
## [1] "Formula for binomial GLM: cpue ~ year + season + lat + crew + away"
##
## $positive.formula
## [1] "Formula for gaussian GLM: log(cpue) ~ year + season + lat + crew + away"
##
## $deltaGLM.index
##          index jackknife
## 1993 0.2238682        NA
## 1994 0.2143356        NA
## 1995 0.2090691        NA
## 1996 0.1439797        NA
## 1997 0.2044071        NA
## 1998 0.2427912        NA
## 1999 0.2549420        NA
## 2000 0.2923330        NA
## 2001 0.2136346        NA
## 2002 0.2220110        NA
## 2003 0.1793425        NA
## 2004 0.2280729        NA
## 2005 0.4338995        NA
## 2006 0.4685549        NA
##
## $pos.effects
## $pos.effects[[1]]
##         1         2         3         4
## 0.2606387 0.2418524 0.2757192 0.2879053
##
## $pos.effects[[2]]
##         1         2
## 0.1530529 0.4621803
##
## $pos.effects[[3]]
##         1         2         3
```

```
## 0.2542590 0.2941981 0.2515146
##
## $pos.effects[[4]]
##         1         2         3
## 0.3032731 0.2833041 0.2189740
##
##
## $bin.effects
## $bin.effects[[1]]
##         1         2         3         4
## 0.8500973 0.9001463 0.8951234 0.9615407
##
## $bin.effects[[2]]
##         1         2
## 0.8957818 0.9239632
##
## $bin.effects[[3]]
##         1         2         3
## 0.9339236 0.9021846 0.8911630
##
## $bin.effects[[4]]
##         1         2         3
## 0.7946356 0.9203480 0.9597983
##
##
## $data.filter
## [1] "Data filter threshold set at 2 positive observations."
##
## $levels.deleted.by.filter
## $levels.deleted.by.filter$year
## [1] NA
##
## $levels.deleted.by.filter$season
## [1] NA
##
## $levels.deleted.by.filter$lat
## [1] NA
##
## $levels.deleted.by.filter$crew
## [1] NA
##
## $levels.deleted.by.filter$away
## [1] NA
##
##
## $aic
##                        [,1]
## AIC.binomial   1950.072379
## AIC.lognormal -1182.989702
## sigma.mle         1.001153
```

Results of gamma delta glm to compare models.

```
## $error.distribution
## [1] "Gamma distribution assumed for positive observations."
```

```
##
## $binomial.formula
## [1] "Formula for binomial GLM: cpue ~ year + season + lat + crew + away"
##
## $positive.formula
## [1] "Formula for Gamma GLM: cpue ~ year + season + lat + crew + away"
##
## $deltaGLM.index
##          index jackknife
## 1993 0.2126129        NA
## 1994 0.1952538        NA
## 1995 0.2067166        NA
## 1996 0.1347766        NA
## 1997 0.1663879        NA
## 1998 0.2266448        NA
## 1999 0.2522993        NA
## 2000 0.2786985        NA
## 2001 0.2009038        NA
## 2002 0.2339935        NA
## 2003 0.1661256        NA
## 2004 0.1959828        NA
## 2005 0.3781235        NA
## 2006 0.3883622        NA
##
## $pos.effects
## $pos.effects[[1]]
##         1         2         3         4
## 0.2586458 0.2252974 0.2484492 0.2511654
##
## $pos.effects[[2]]
##         1         2
## 0.1596503 0.3777110
##
## $pos.effects[[3]]
##         1         2         3
## 0.2316155 0.2721698 0.2349020
##
## $pos.effects[[4]]
##         1         2         3
## 0.2683052 0.2570742 0.2146874
##
##
## $bin.effects
## $bin.effects[[1]]
##         1         2         3         4
## 0.8500973 0.9001463 0.8951234 0.9615407
##
## $bin.effects[[2]]
##         1         2
## 0.8957818 0.9239632
##
## $bin.effects[[3]]
##         1         2         3
## 0.9339236 0.9021846 0.8911630
```

```
##
## $bin.effects[[4]]
##         1         2         3
## 0.7946356 0.9203480 0.9597983
##
##
## $data.filter
## [1] "Data filter threshold set at 2 positive observations."
##
## $levels.deleted.by.filter
## $levels.deleted.by.filter$year
## [1] NA
##
## $levels.deleted.by.filter$season
## [1] NA
##
## $levels.deleted.by.filter$lat
## [1] NA
##
## $levels.deleted.by.filter$crew
## [1] NA
##
## $levels.deleted.by.filter$away
## [1] NA
##
##
## $aic
##                      [,1]
## AIC.binomial  1950.072379
## AIC.gamma    -1625.724915
## shape.mle        1.430535
```

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