Standardized catch rates of red grouper (*Epinephelus morio*) from the Southeast U.S. from commercial logbook data

Sustainable Fisheries Branch – NMFS (contact: Rob Cheshire)

SEDAR53-WP03

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Standardized catch rates of red grouper (Epinephelus morio) in the southeast U.S. from commercial logbook data

Sustainable Fisheries Branch[*]

August 2016

This document describes the the development of the SEDAR 53 commercial logbook handline index for red grouper.

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) from the logbooks was used to develop an index of abundance for red grouper landed with vertical lines (manual handline and electric reel), the dominant gear for this red grouper stock (Tables 1 and 2). 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 vertical line gear (manual and electric) included number of lines fished, hours fished, and number of hooks per line.

Data Exclusions

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. Outliers in the data used as factors in the model or to calculate cpue. 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 red grouper trips were evaluated for outliers in red grouper cpue (Table 3).

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). Reporting delays beyond 45

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

days likely resulted in less reliable effort data (landings data may be reliable even with lengthy reporting delays if trip ticket reports were referenced by the reporting fisher). 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 - spawning closure, commercial closures due to gag quota

The shallow-water grouper closure (Jan-Apr) took effect in 2010. Comparisons of the median cpue by region for all months and May-Dec shows little difference in median cpue across regions (Figure 2). Removing trips from these months allows us to extend the headboat logbook index until the terminal year of the assessment (2015). In 2012 commercial red grouper closed due to gag meeting quotas temporarily in October(21-31), then re-opened on November 1st and closed for the remainder of the year on November 22nd, 2012. The terminal year was set to 2015 with the removal of all trips from January to April across all years. In addition, all trips in 2012 during the red grouper closure associated with the gag quota were removed. There were approximately 10 days of trips removed in October and November and all of December in 2012.

Evaluation of explanatory variables

YEAR – Year was necessarily included, as standardized catch rates by year are the desired. Years modeled were 1993-2015. The total number of red grouper trips by year is provided in table 1 and reported catch per year is provided in table 2.

SEASON – Season included two levels: summer (May - August) and fall (September-December). The density of trips by month with associated season factor is shown in Figure 3.

AREA – Areas reported in the logbook on a one degree grid (Figure 1). The majority of the positive trips and catch for commercial handline is in the Carolinas (Figures 4 and 5). The coast was divided into two areas split at 29 degrees Latitude near Cape Canaveral, FL (Figure 3).

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 3

CREW SIZE – Crew size (includes Captain) could influence the total effort during and could be a psuedo-factor for vessel size. The quartile split values (at 25, 50, and 75%) for red grouper crew size fall at 2, 2, and 3 crew per trip. Crew size factor was fixed at three levels: one (one), two (two), and three or more crew (threeplus). Figure 3 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 with full-year closures, ID issue, or large shifts in desirability over the index period
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 red grouper 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 5% or more of trips for CAR and GNF and 2% for SF. SF had too few species at a cutoff of 5% (6 species). 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 red grouper during years of restrictions.

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 red grouper in each trip to presence/absence of other species. For the CAR area, stepwise AIC eliminated banded rudderfish, bluestripped grunt, and lesser amberjack; for the GNF sampling area, it eliminated greater amberjack, jolthead porgy, and knobbed porgy; for the SF sampling area, it eliminated gray snapper. Regression coefficients of included species for all areas are given in Appendix 1 and shown in figure 7. A trip was then included if its associated probability of catching red grouper was higher than a threshold probability (Figure 7). The threshold was designed to be that which resulted in the same number of predicted and observed positive trips, as suggested by Stephens and MacCall (2004).

Standardization

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

Bernoulli submodel

The Bernoulli component of the delta-GLM is a logistic regression model that attempts to explain the probability of either catching or not catching red snapper on any given trip. Initially, all explanatory variables were included in the model as main eiiects, 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 8).

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 lognormal and gamma distributions, the best model fit included all explanatory variables. The two distributions, each with their best set of explanatory variables (all of them), were compared using AIC. Lognormal outperformed gamma, and was therefore applied in the final delta-GLM. Diagnostics suggested reasonable fits of the lognormal submodel (Figures 9 and 10).

Results

The standardized index was similar to the nominal index with the exception of a few years associated with peaks in the catch rate (Figure 11). The increase in the error since 2010 may be due to the lower proportion of positive catches.

Table 1: Commercial logbook red grouper trips by gear.

	Diving	Handline	Other
1993	62	797	9
1994	92	1413	25
1995	94	1664	46
1996	91	1763	16
1997	228	2448	38
1998	259	2760	86
1999	172	2441	66
2000	164	2155	55
2001	213	2185	44
2002	227	2202	61
2003	151	1984	70
2004	166	1888	33
2005	161	1790	26
2006	96	1781	40
2007	142	2168	26
2008	108	2012	11
2009	76	1554	3
2010	75	994	2
2011	89	887	3
2012	114	676	11
2013	149	610	7
2014	151	580	16
2015	140	437	11

Table 2: Commercial logbook red grouper landings by gear (Thousand pounds).

	Diving	Handline	Other
1993	1.63	49.48	0.23
1994	2.43	74.76	10.80
1995	3.92	134.36	17.59
1996	1.56	115.83	2.84
1997	5.96	185.64	1.21
1998	6.77	236.55	9.78
1999	5.96	276.91	5.21
2000	4.38	242.73	20.06
2001	5.25	217.27	13.57
2002	7.02	215.29	3.22
2003	4.24	214.59	3.98
2004	4.48	175.88	9.91
2005	3.70	142.60	1.67
2006	1.80	240.00	1.06
2007	3.81	435.21	0.75
2008	3.81	454.13	0.29
2009	1.83	259.77	0.05
2010	3.08	225.62	0.03
2011	3.24	135.61	0.08
2012	3.64	82.06	6.45
2013	8.48	59.98	4.93
2014	5.41	49.59	20.50
2015	5.68	38.39	10.07

Table 3: CFLP Handline cutoff values for outliers (records reporting more (upper),or less (lower) were excluded).

	manual	electric
lines fished (upper)	6	6
hooks per line (upper)	8	8
days at sea (upper)	10	12
crew (upper)	5	5
hours fished (lower)	4	4
hours fished (upper)	100	135
cpue (upper)	24	24

Table 4: Nominal and standardized CPUE for red grouper 1980-2015 with CVs for stardardized index of abundance.

Year	N	Nominal.CPUE	Relative.nominal	Standardized.CPUE	CV
1993	588	0.36	0.31	0.35	0.10
1994	915	0.37	0.32	0.26	0.09
1995	997	0.60	0.52	0.46	0.08
1996	954	0.49	0.42	0.57	0.07
1997	1277	0.64	0.55	0.62	0.07
1998	1281	1.12	0.96	1.13	0.06
1999	1076	1.27	1.10	1.51	0.06
2000	1033	1.20	1.04	1.01	0.07
2001	1179	1.17	1.01	0.87	0.07
2002	1355	1.15	0.99	0.74	0.07
2003	1216	1.22	1.05	0.97	0.07
2004	1039	1.09	0.94	0.79	0.07
2005	967	1.01	0.87	0.85	0.07
2006	947	1.54	1.33	1.31	0.07
2007	1260	2.67	2.30	2.23	0.06
2008	1109	2.56	2.21	2.64	0.06
2009	894	1.53	1.32	1.46	0.07
2010	873	1.83	1.58	1.71	0.07
2011	675	1.60	1.38	1.14	0.09
2012	558	1.10	0.95	0.88	0.10
2013	518	0.81	0.70	0.62	0.11
2014	389	0.77	0.66	0.57	0.11
2015	430	0.56	0.49	0.34	0.13

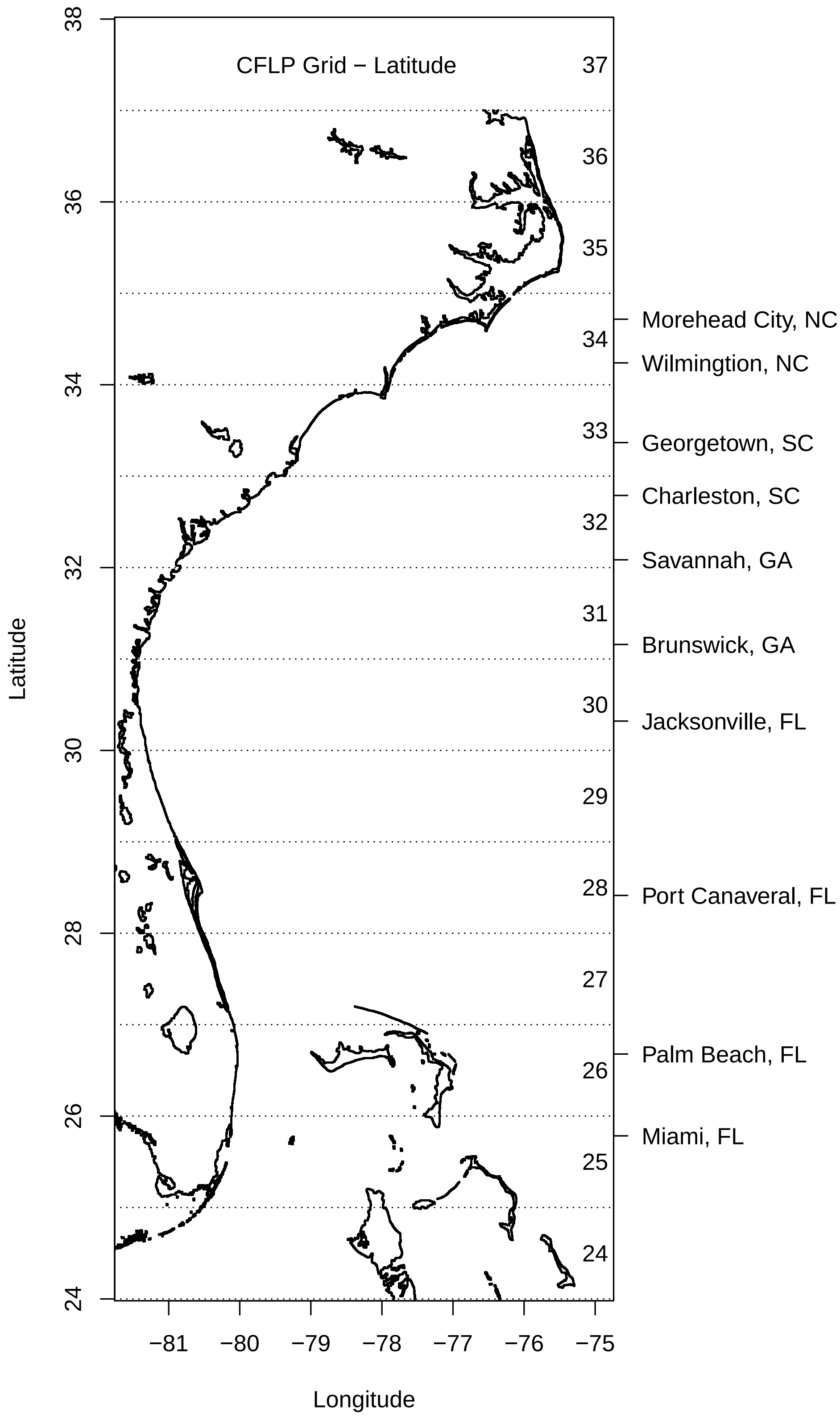


Figure 1: CFLP Latitude Stratification (midpoint of each latitudinal grid is labeled with the floor for the bin).

Figure 2: Nominal CPUE for positve red grouper trips with and without the Jan-Apr spawning closure beginning in 2010).

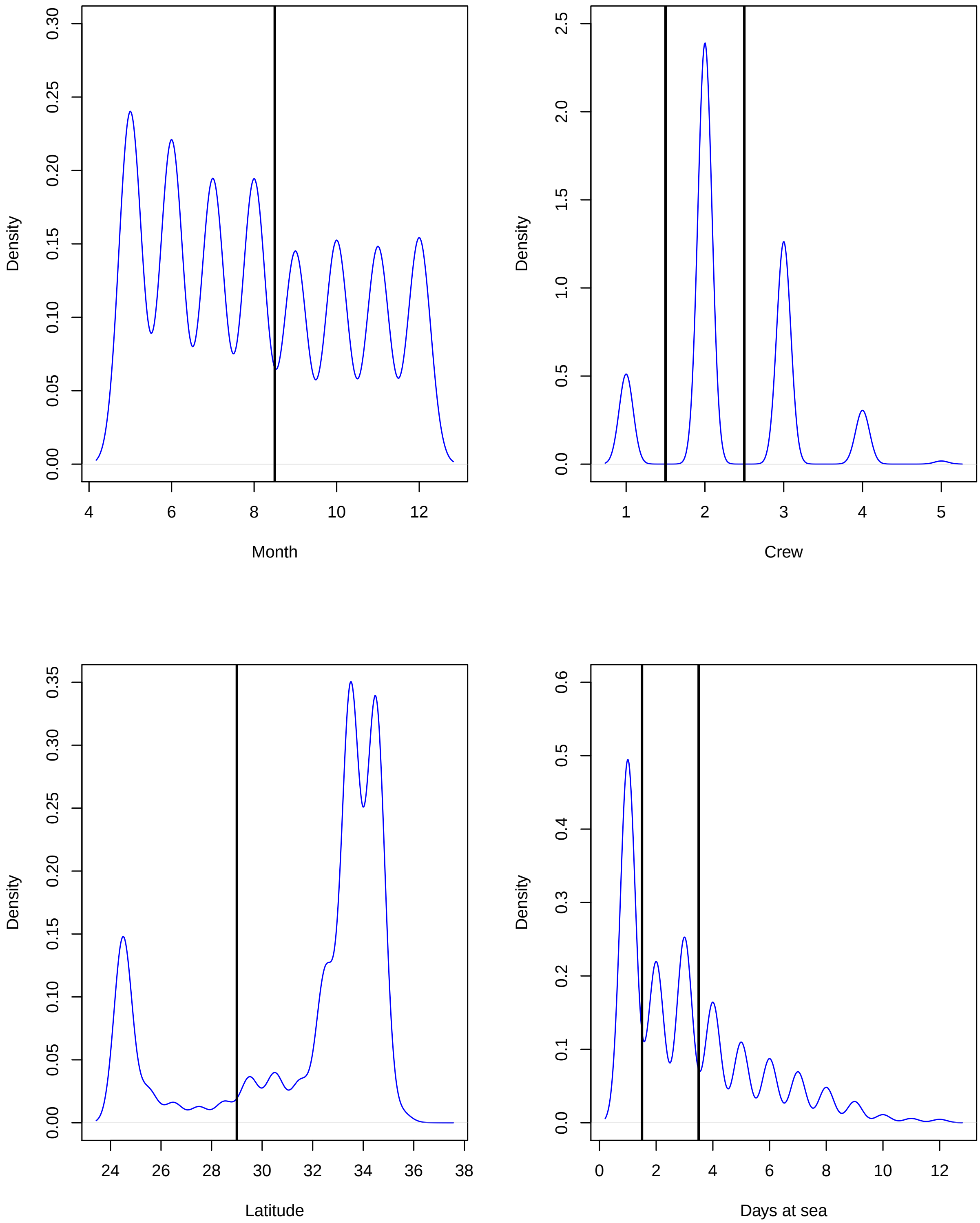


Figure 3: Red grouper handline explanatory variable factorization. Vertical lines represent breaks for factors.

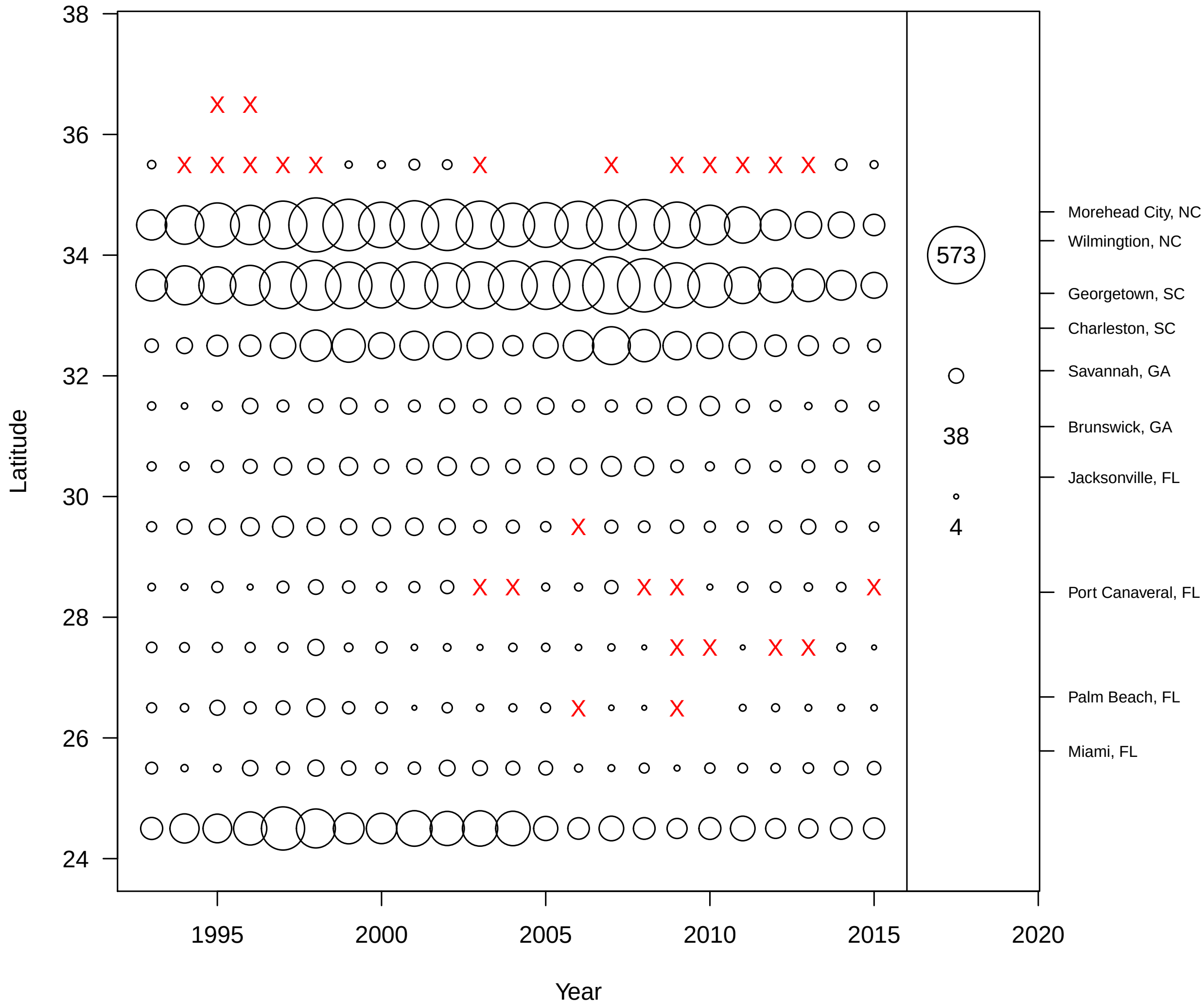


Figure 4: Red grouper handline trips by year and latitude. Symbol size relative to number of trips, 'X' signifies confidential data and represents a small percentage of the total trips.

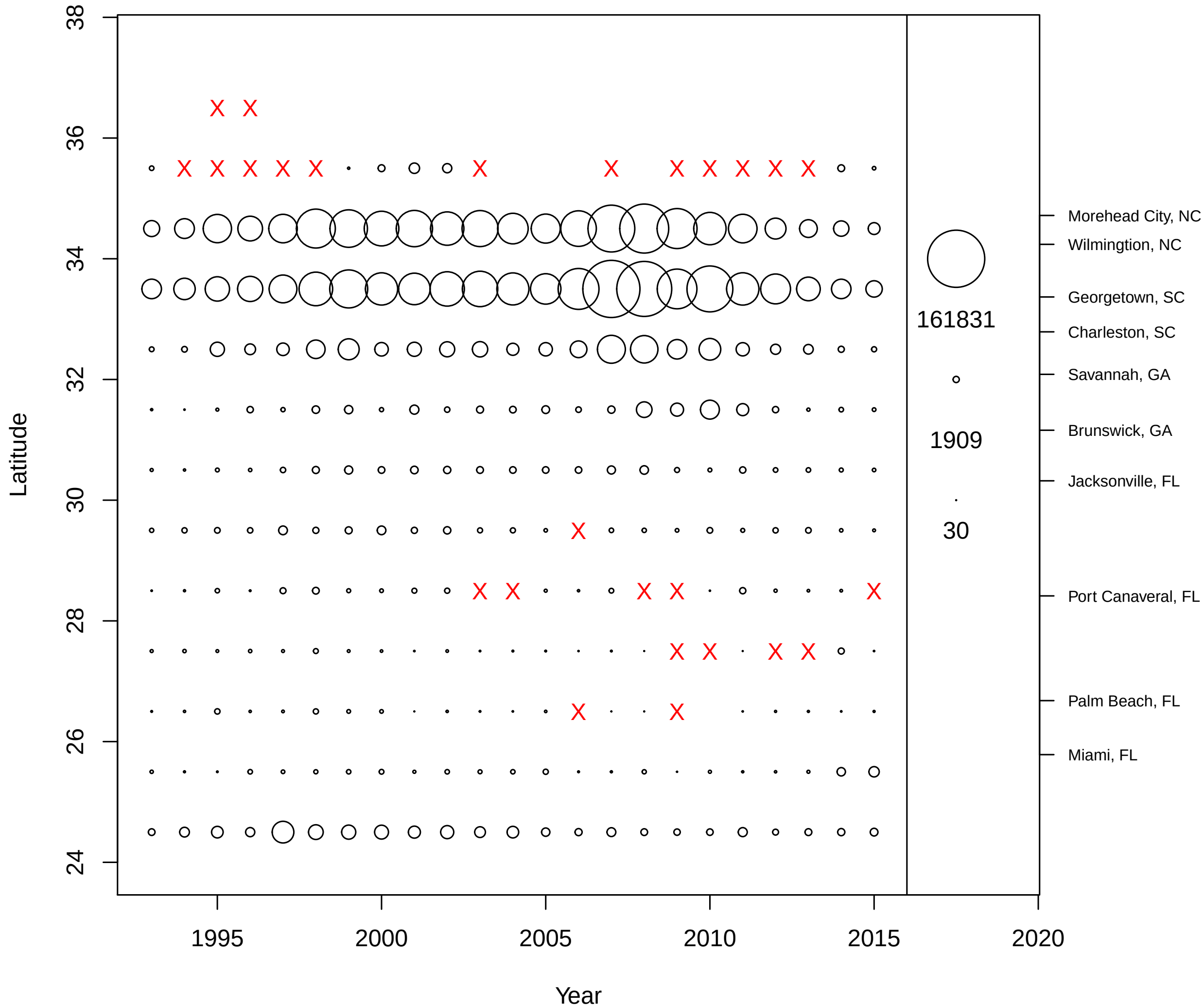


Figure 5: Red grouper handline catch (whole pounds) by year and latitude. Symbol size relative to catch, 'X' signifies confidential data and represents a small percentage of the total catch.

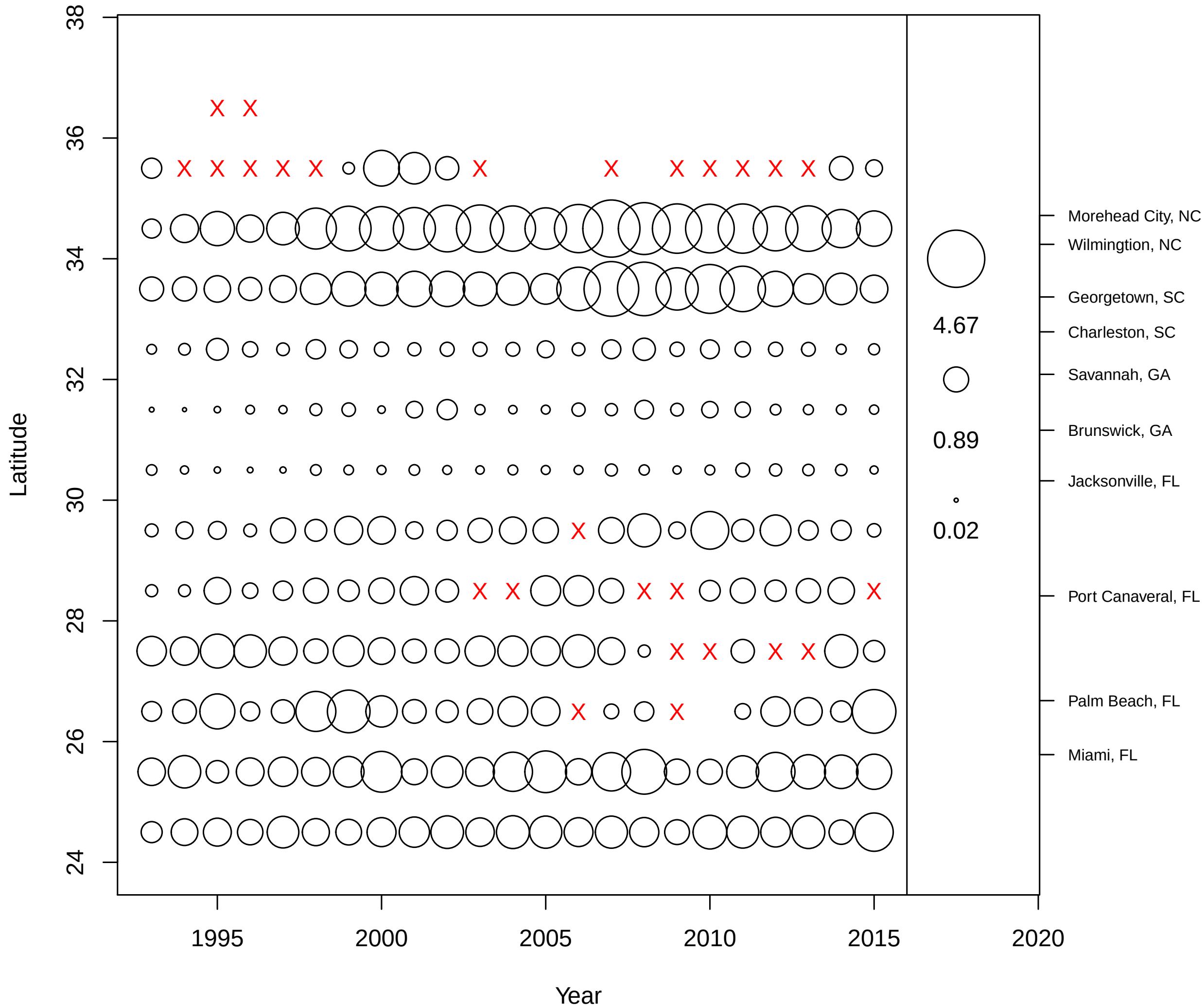


Figure 6: Red snapper handline mean cpue (whole pounds/hook-hour) by year and latitude. Symbol size relative to cpue, 'X' signifies confidential data and represents a small percentage of the total records.

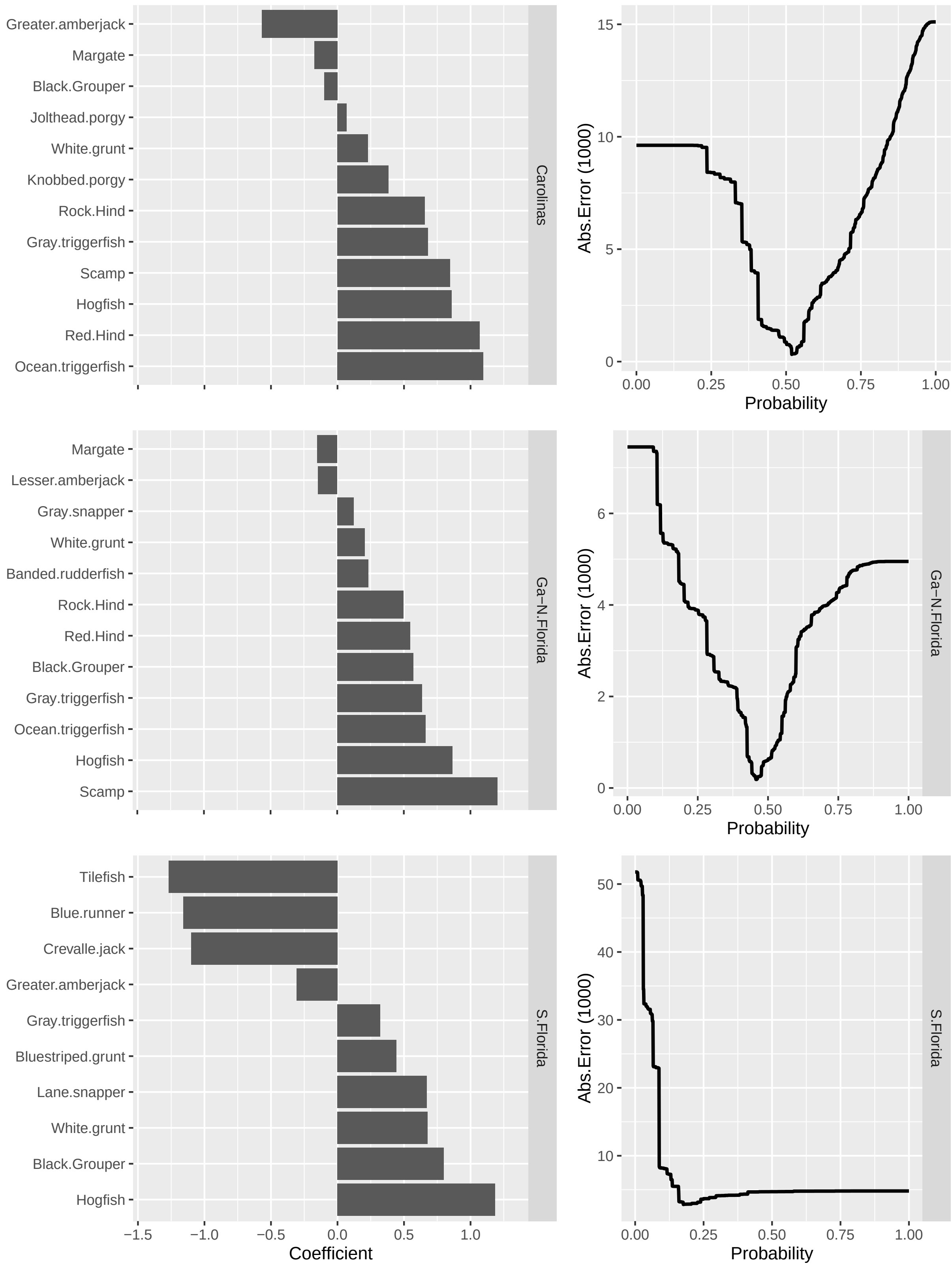


Figure 7: Estimates of species-specific regression coefficients used to predict each trip's probability of catching the focal species on the left panel. The right panel shows the absolute difference between observed and predicted number of positive trips across a range of probability cutoff values.

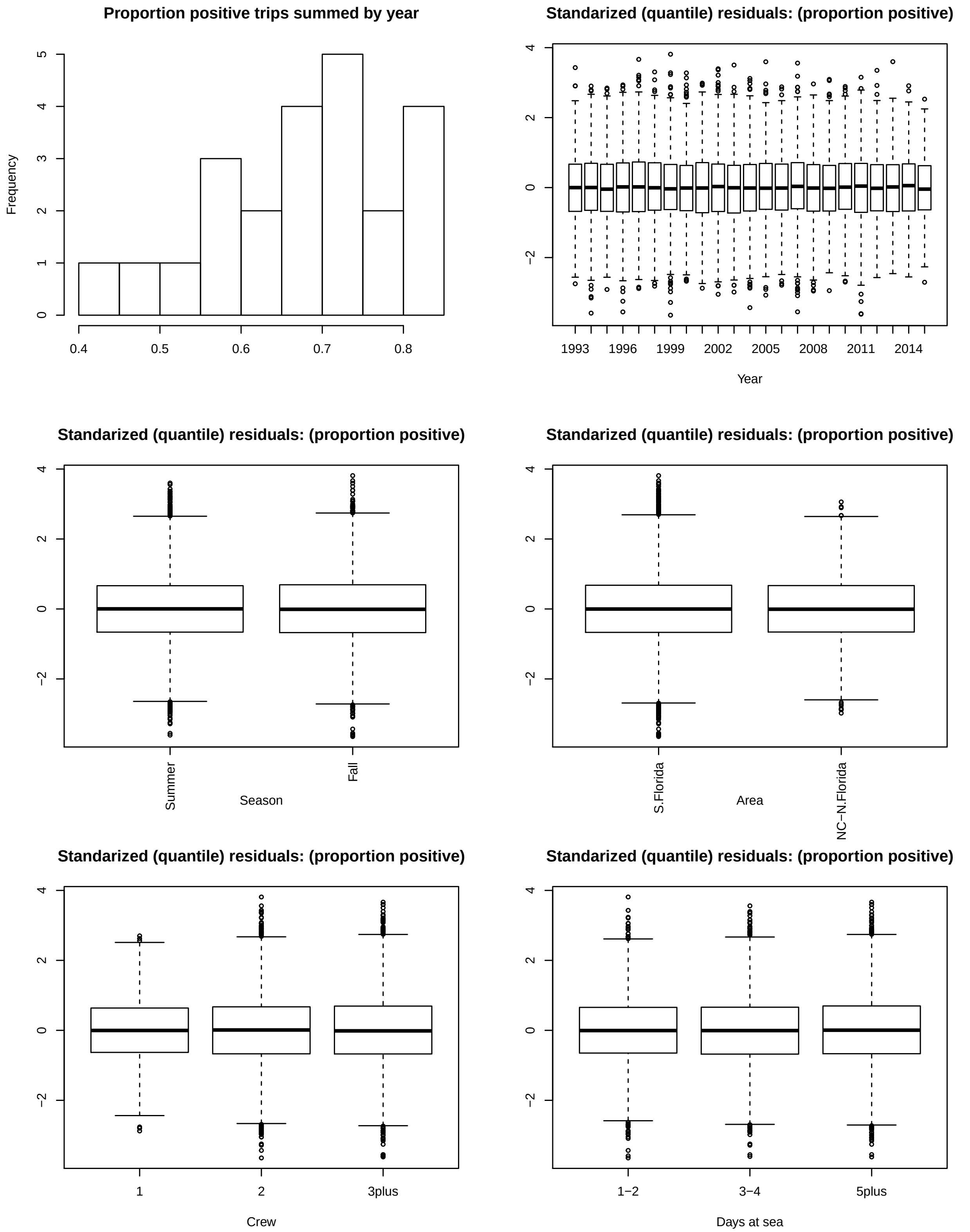


Figure 8: Diagnostics of Bernoulli submodel fits to positive versus zero CPUE data. Box and whisker plots give first, second (median) and third quartiles, as well as limbs that extend to approximately one interquartile range beyond the nearest quartile, and outliers (circles) beyond the limbs. Residuals are standardized (quantile) residuals.

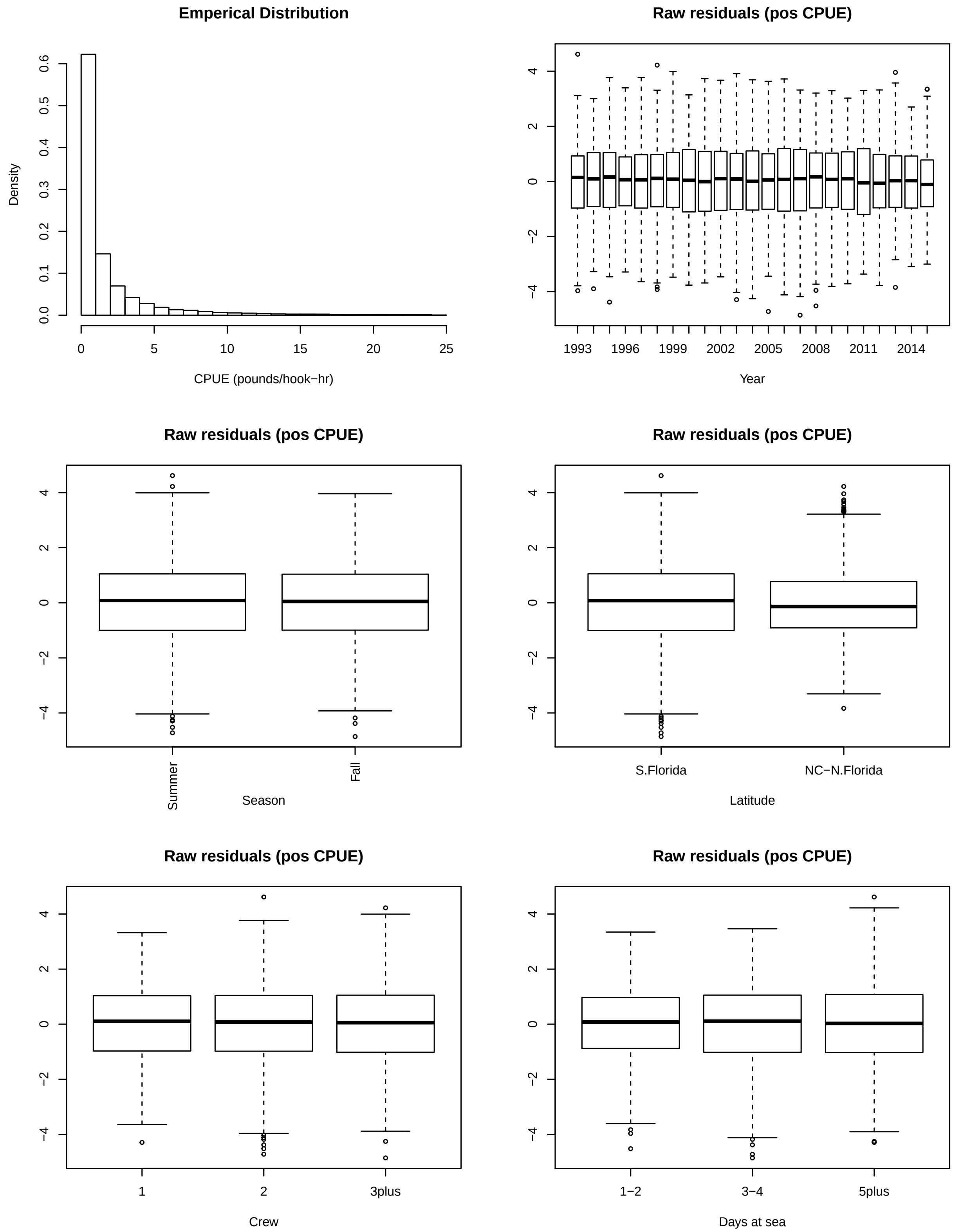
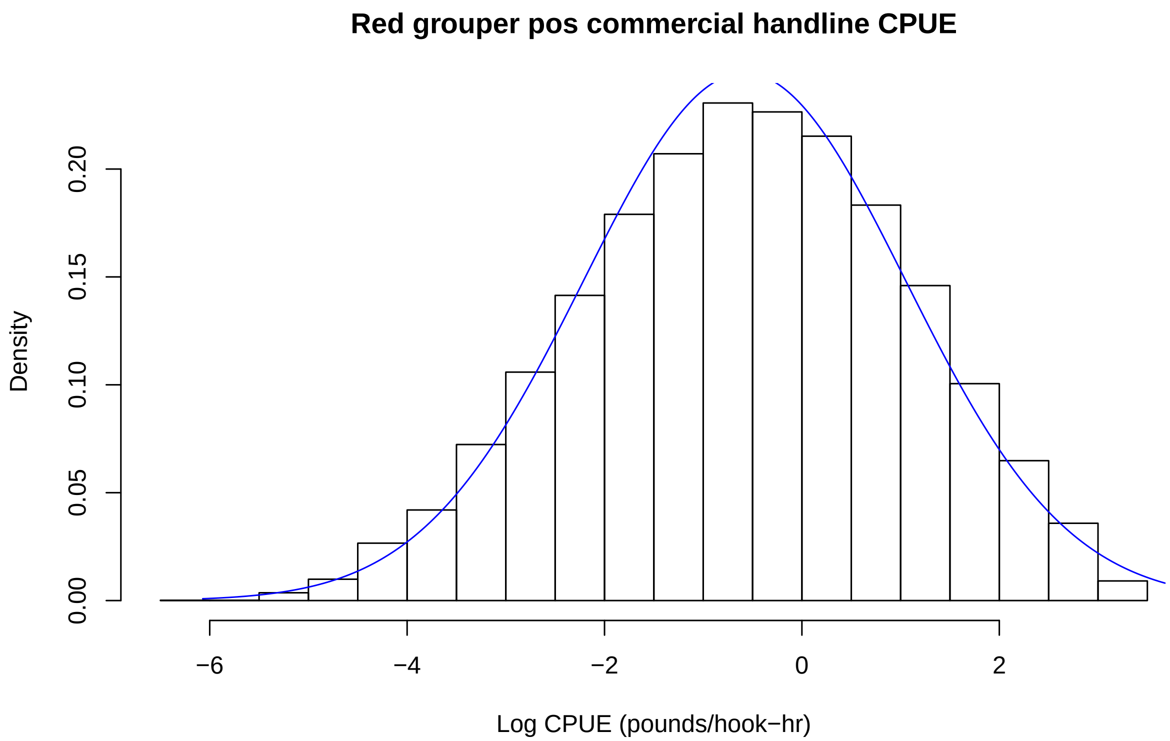


Figure 9: Diagnostics of lognormal submodel fits to positive CPUE data. Top left panel shows the distribution of positive cpue. Box and whisker plots give first, second (median) and third quartiles, as well as limbs that extend to approximately one interquartile range beyond the nearest quartile, and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



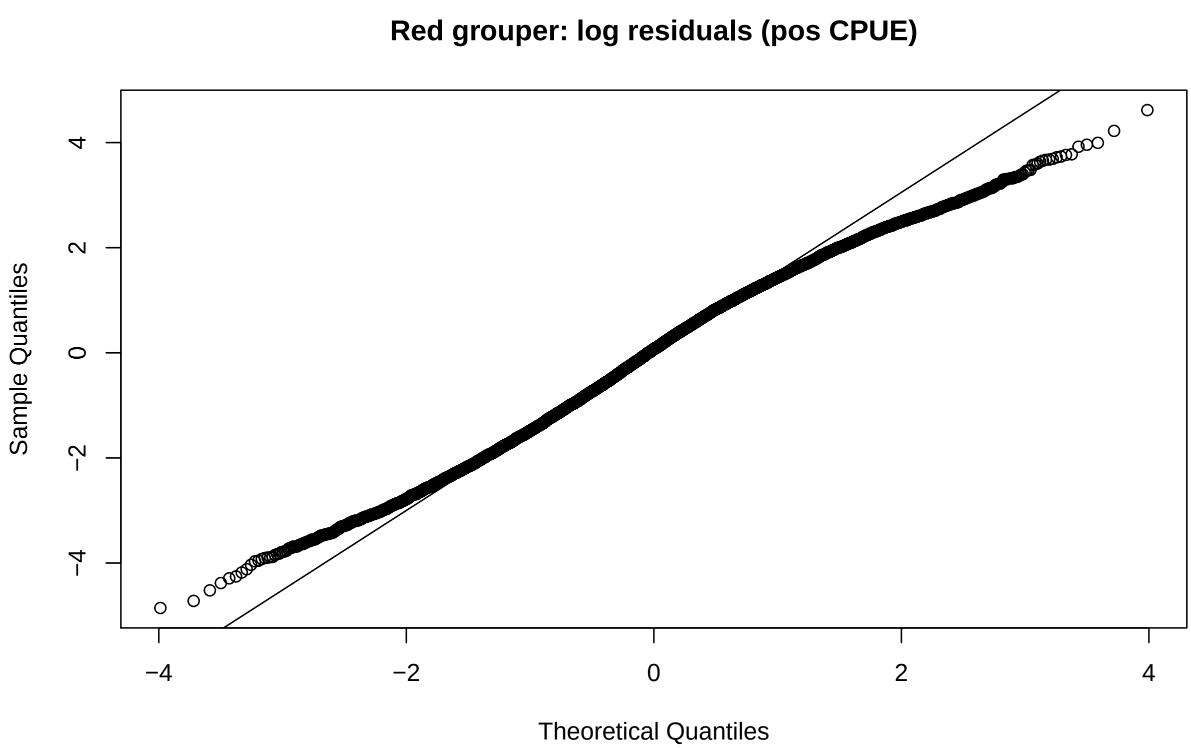


Figure 10: Histogram of empirical log CPUE, with the normal distribution (empirical mean and variance) overlaid. Quantile-quantile plot of residuals from the fitted lognormal submodel to the positive cpue cata.

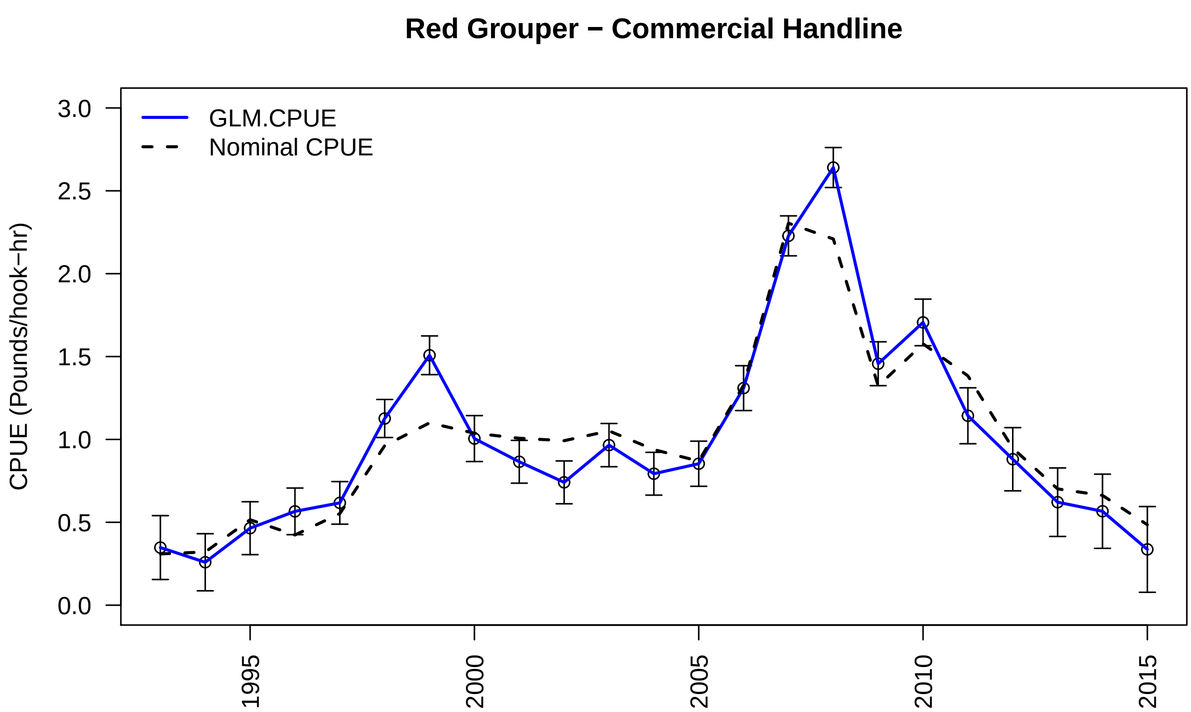


Figure 11: Standardized commercial handline red grouper catch rate (solid) with 95% confidence intervals and nominal catch rate (dashed).

Appendix

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

```
##
## Call:  glm(formula = Red.Grouper ~ Black.Grouper + Gray.triggerfish +
##     Greater.amberjack + Hogfish + Jolthead.porgy + Knobbed.porgy +
##     Margate + Ocean.triggerfish + Red.Hind + Rock.Hind + Scamp +
##     White.grunt, family = "binomial", data = n.mat.cut.df)
##
## Coefficients:
##       (Intercept)      Black.Grouper   Gray.triggerfish
##          -0.60643           -0.09822            0.68097
## Greater.amberjack            Hogfish     Jolthead.porgy
##          -0.56974            0.85668            0.06974
##     Knobbed.porgy            Margate  Ocean.triggerfish
##           0.38409           -0.17394            1.09542
##          Red.Hind          Rock.Hind              Scamp
##           1.06809            0.65504            0.84641
##       White.grunt
##           0.23002
##
## Degrees of Freedom: 24727 Total (i.e. Null);  24715 Residual
## Null Deviance:       33050
## Residual Deviance: 27530     AIC: 27560
```

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

```
##
## Call:  glm(formula = Red.Grouper ~ Banded.rudderfish + Black.Grouper +
##     Gray.snapper + Gray.triggerfish + Hogfish + Lesser.amberjack +
##     Margate + Ocean.triggerfish + Red.Hind + Rock.Hind + Scamp +
##     White.grunt, family = "binomial", data = m.mat.cut.df)
##
## Coefficients:
##       (Intercept)  Banded.rudderfish      Black.Grouper
##           -2.1352             0.2340             0.5710
##      Gray.snapper   Gray.triggerfish            Hogfish
##            0.1230             0.6351             0.8639
##  Lesser.amberjack            Margate  Ocean.triggerfish
##           -0.1436            -0.1484             0.6623
##          Red.Hind          Rock.Hind              Scamp
##            0.5461             0.4979             1.2007
##       White.grunt
##            0.2063
##
## Degrees of Freedom: 12403 Total (i.e. Null);  12391 Residual
## Null Deviance:       16690
## Residual Deviance: 14340     AIC: 14360
```

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

```
##
## Call:  glm(formula = Red.Grouper ~ Black.Grouper + Blue.runner + Bluestriped.grunt +
##     Crevalle.jack + Gray.triggerfish + Greater.amberjack + Hogfish +
##     Lane.snapper + Tilefish + White.grunt, family = "binomial",
##     data = s.mat.cut.df)
##
## Coefficients:
##       (Intercept)      Black.Grouper        Blue.runner
##           -2.3426             0.7986            -1.1596
## Bluestriped.grunt      Crevalle.jack   Gray.triggerfish
##            0.4427            -1.0983             0.3213
## Greater.amberjack            Hogfish       Lane.snapper
##           -0.3084             1.1851             0.6718
##          Tilefish        White.grunt
##           -1.2692             0.6773
##
## Degrees of Freedom: 56588 Total (i.e. Null);  56578 Residual
## Null Deviance:       32910
## Residual Deviance: 30120     AIC: 30140
```

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
##     3.14200      0.09202      0.37049      0.33975      0.43921
##    year1998     year1999     year2000     year2001     year2002
##     0.92161      1.06436      0.91307      1.02661      1.12443
##    year2003     year2004     year2005     year2006     year2007
##     1.05701      0.91157      0.87189      1.34432      2.56302
##    year2008     year2009     year2010     year2011     year2012
##     2.45509      1.36681      2.02211      1.79271      0.96225
##    year2013     year2014     year2015      season2         lat2
##     0.81486      0.53857      0.50981     -0.56284     -1.48720
##       crew2        crew3        away2        away3
##     0.11104     -0.84829     -1.69943     -2.90691
##
## Degrees of Freedom: 14959 Total (i.e. Null);  14931 Residual
## Null Deviance:       144000
## Residual Deviance: 114200    AIC: 72930
```

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
##     0.79339     -0.10640      0.23132      0.04777      0.10470
```

```
##    year1998    year1999    year2000    year2001    year2002
##     0.58996     0.69984     0.58912     0.56530     0.52677
##    year2003    year2004    year2005    year2006    year2007
##     0.65522     0.46289     0.49589     0.76837     1.27284
##    year2008    year2009    year2010    year2011    year2012
##     1.28033     0.79685     1.10563     0.94245     0.65152
##    year2013    year2014    year2015     season2        lat2
##     0.49112     0.27172     0.26675    -0.25826    -0.12314
##       crew2       crew3       away2       away3
##     0.03700    -0.64388    -0.51032    -1.38586
##
## Degrees of Freedom: 14959 Total (i.e. Null);  14931 Residual
## Null Deviance:       34230
## Residual Deviance: 24780     AIC: 36560
```

Results of binomial glm to determine factors.

```
##
## Call:  glm(formula = cpue ~ year + season + lat + crew + away, family = "binomial",
##     data = bin.dat)
##
## Coefficients:
## (Intercept)    year1994    year1995    year1996    year1997
##    -0.61881    -0.28300     0.04339     0.55399     0.71601
##    year1998    year1999    year2000    year2001    year2002
##     1.13687     1.64083     1.02629     0.74803     0.50754
##    year2003    year2004    year2005    year2006    year2007
##     0.82480     0.94732     0.97848     1.41497     1.55006
##    year2008    year2009    year2010    year2011    year2012
##     1.58578     1.16529     0.85765     0.73461     0.44527
##    year2013    year2014    year2015     season2        lat2
##     0.16302     0.15025    -0.41389    -0.15055    -1.34112
##       crew2       crew3       away2       away3
##     0.46752     0.26232     0.78294     0.63964
##
## Degrees of Freedom: 21529 Total (i.e. Null);  21501 Residual
## Null Deviance:       26490
## Residual Deviance: 23660     AIC: 23720
```

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 0.2931407        NA
```

```
## 1994 0.2183759        NA
## 1995 0.3918440        NA
## 1996 0.4774069        NA
## 1997 0.5206039        NA
## 1998 0.9500073        NA
## 1999 1.2717878        NA
## 2000 0.8478272        NA
## 2001 0.7297614        NA
## 2002 0.6250133        NA
## 2003 0.8145675        NA
## 2004 0.6689123        NA
## 2005 0.7198253        NA
## 2006 1.1045716        NA
## 2007 1.8795804        NA
## 2008 2.2272704        NA
## 2009 1.2287284        NA
## 2010 1.4389809        NA
## 2011 0.9639446        NA
## 2012 0.7427271        NA
## 2013 0.5240218        NA
## 2014 0.4779282        NA
## 2015 0.2837131        NA
##
## $pos.effects
## $pos.effects[[1]]
##        1        2
## 1.603677 1.294884
##
## $pos.effects[[2]]
##       1       2
## 1.79063 1.15969
##
## $pos.effects[[3]]
##         1         2         3
## 1.7153190 1.8568839 0.9394897
##
## $pos.effects[[4]]
##         1         2         3
## 3.2690434 1.5708409 0.5827319
##
##
## $bin.effects
## $bin.effects[[1]]
##         1         2
## 0.5362383 0.4986654
##
## $bin.effects[[2]]
##         1         2
## 0.6771039 0.3542007
##
## $bin.effects[[3]]
##         1         2         3
## 0.4567722 0.5730181 0.5222285
##
```

```
## $bin.effects[[4]]
##         1         2         3
## 0.4002899 0.5935542 0.5585757
##
##
## $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  23721.105554
## AIC.lognormal 34851.782358
## sigma.mle         1.383668
```

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 0.2725693        NA
## 1994 0.2017431        NA
## 1995 0.3533591        NA
## 1996 0.3966431        NA
## 1997 0.4555324        NA
## 1998 0.8871995        NA
## 1999 1.1655631        NA
## 2000 0.8487484        NA
## 2001 0.7331876        NA
## 2002 0.6248219        NA
```

```
## 2003 0.8313403        NA
## 2004 0.7239247        NA
## 2005 0.7581083        NA
## 2006 1.1682600        NA
## 2007 2.0154747        NA
## 2008 2.0513996        NA
## 2009 1.1028657        NA
## 2010 1.3238329        NA
## 2011 1.0622632        NA
## 2012 0.6843224        NA
## 2013 0.4942140        NA
## 2014 0.3937233        NA
## 2015 0.2662874        NA
##
## $pos.effects
## $pos.effects[[1]]
##        1        2
## 1.568430 1.211447
##
## $pos.effects[[2]]
##        1        2
## 1.465967 1.296120
##
## $pos.effects[[3]]
##         1         2         3
## 1.6874866 1.7510929 0.8863492
##
## $pos.effects[[4]]
##         1         2         3
## 2.5934903 1.5568818 0.6486555
##
##
## $bin.effects
## $bin.effects[[1]]
##         1         2
## 0.5362383 0.4986654
##
## $bin.effects[[2]]
##         1         2
## 0.6771039 0.3542007
##
## $bin.effects[[3]]
##         1         2         3
## 0.4567722 0.5730181 0.5222285
##
## $bin.effects[[4]]
##         1         2         3
## 0.4002899 0.5935542 0.5585757
##
##
## $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 2.372111e+04
## AIC.gamma    3.622940e+04
## shape.mle    7.261419e-01
```

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