Standardized catch rates of greater amberjack (*Seriola dumerili*) in the southeast U.S. from commercial logbook data

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*Sustainable Fisheries Branch**

November 2018

This document describes the the development of the SEDAR 59 commercial logbook handline index for greater amberjack.

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 greater amberjack landed with vertical lines (manual handline and electric reel), the dominant gear for this greater amberjack 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 greater amberjack trips were evaluated for outliers in greater amberjack 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 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

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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 -

Seasonal closures occurred in 2016 and 2017 while a 1 fish trip limit in April has remained the same. Comparisons of the median cpue by region for all months and May-Sept shows little difference in median cpue across regions (Figure 2). Removing trips from these months allows us to extend the commercial logbook index until the terminal year of the assessment (2017). In 2016 and 2017 commercial greater amberjack closed due to greater amberjack meeting quotas temporarily in October. The terminal year was set to 2017 with the removal of all trips from October to April across all years.

Evaluation of explanatory variables

YEAR – Year was necessarily included, as standardized catch rates by year are the desired. Years modeled were 1993-2017. The total number of greater amberjack 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 - June) and fall (July-September). 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 Florida Keys (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 greater amberjack crew size fall at 1, 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 greater amberjack 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 0.5% for SF. SF had too few species at a cutoff of 2%. 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 greater amberjack 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 greater amberjack 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 7. A trip was then included if its associated probability of catching greater amberjack 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 greater amberjack 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 and the index used in SEDAR 15 with the exception of a few years associated with peaks in the catch rate (Figure 11).

Table 1: Commercial logbook greater amberjack trips by gear.

	Diving	Handline	Other
1993	125	1866	131
1994	216	2466	188
1995	201	2600	171
1996	237	2793	122
1997	215	2766	113
1998	191	2071	239
1999	138	1685	208
2000	163	1774	275
2001	136	2029	220
2002	118	1976	169
2003	121	1843	247
2004	66	1834	141
2005	57	1678	81
2006	40	1382	71
2007	64	1675	136
2008	93	1784	134
2009	89	2046	164
2010	137	1974	114
2011	125	1965	105
2012	119	1708	114
2013	91	1748	57
2014	146	2032	94
2015	137	1918	96
2016	81	1708	54
2017	89	1489	52

Table 2: Commercial logbook greater amberjack landings by gear (Thousand pounds).

	Diving	Handline	Other
1993	55.90	902.90	23.32
1994	98.23	1181.65	33.74
1995	76.69	1075.38	36.46
1996	74.21	1040.35	16.46
1997	67.90	962.89	10.14
1998	29.11	794.56	46.47
1999	28.62	575.05	28.40
2000	55.67	496.32	33.48
2001	27.69	584.38	33.02
2002	32.20	606.08	26.94
2003	32.25	557.67	19.90
2004	20.74	725.60	11.81
2005	18.18	742.83	6.81
2006	13.53	519.71	5.04
2007	19.60	572.04	19.46
2008	32.36	609.90	16.30
2009	18.14	741.97	16.97
2010	36.63	877.79	17.07
2011	28.13	840.55	18.66
2012	37.08	830.82	32.65
2013	32.34	738.13	11.27
2014	47.12	795.22	37.08
2015	39.53	726.38	12.00
2016	23.63	712.96	9.28
2017	24.77	714.73	6.18

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	130
cpue (upper)	172	172

Table 4: Nominal and standardized CPUE for greater amberjack 1993-2017 with CVs for stardardized index of abundance.

Year	N	Nominal.CPUE	Relative.nominal	Standardized.CPUE	CV
1993	880	10.65	0.72	0.66	0.08
1994	984	12.90	0.88	0.80	0.07
1995	1149	12.80	0.87	0.85	0.06
1996	1046	13.57	0.92	0.85	0.07
1997	1143	11.26	0.77	0.82	0.07
1998	922	11.78	0.80	0.79	0.08
1999	762	9.62	0.65	0.47	0.08
2000	820	9.32	0.63	0.61	0.08
2001	944	10.97	0.75	0.75	0.06
2002	912	8.10	0.55	0.79	0.07
2003	927	12.62	0.86	0.84	0.07
2004	779	17.49	1.19	1.12	0.07
2005	792	16.48	1.12	1.10	0.07
2006	728	19.63	1.33	1.08	0.07
2007	762	11.71	0.80	0.72	0.07
2008	756	13.97	0.95	0.81	0.08
2009	890	12.15	0.83	0.94	0.07
2010	850	19.88	1.35	1.41	0.06
2011	949	22.76	1.55	1.38	0.05
2012	952	20.88	1.42	1.23	0.06
2013	934	20.06	1.36	1.28	0.05
2014	1015	11.87	0.81	1.22	0.06
2015	979	12.82	0.87	1.24	0.06
2016	995	19.03	1.29	1.52	0.05
2017	897	25.34	1.72	1.73	0.06

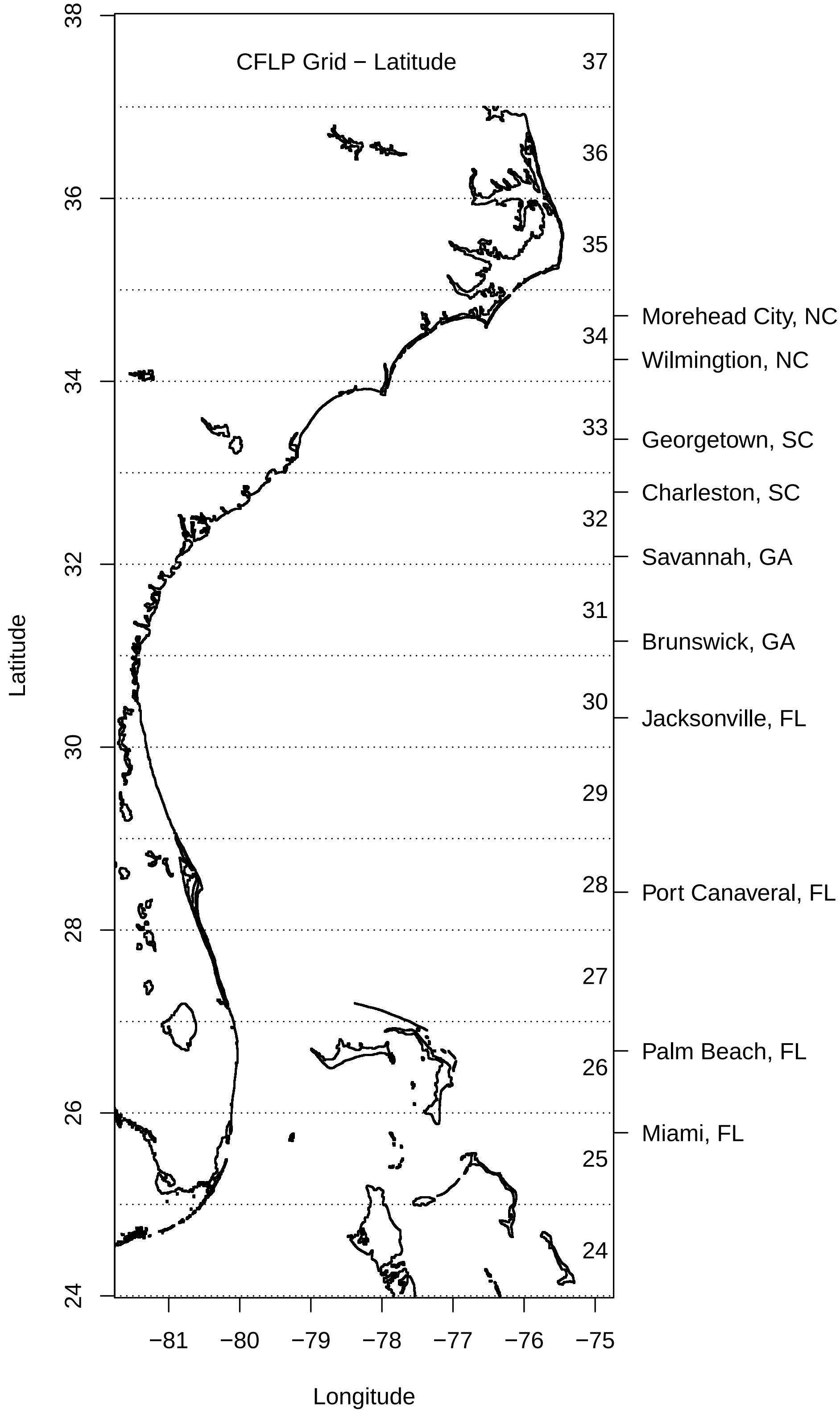


Figure 1: CFLP Latitude Stratification (midpoint of each latitudinal grid is labeled with the floor for the bin).

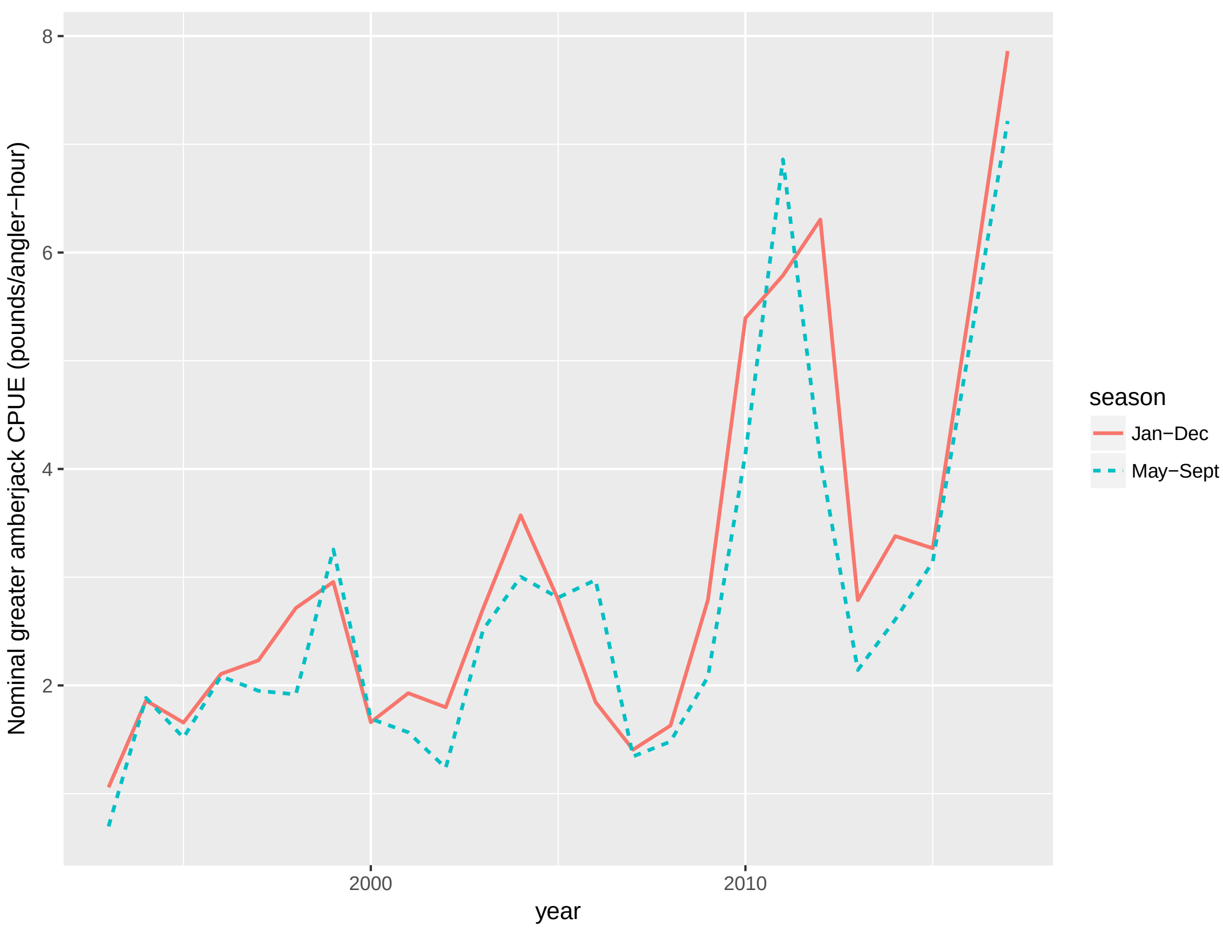


Figure 2: Nominal CPUE for positve greater amberjack trips with and without the Jan-Apr spawning closure beginning in 2010).

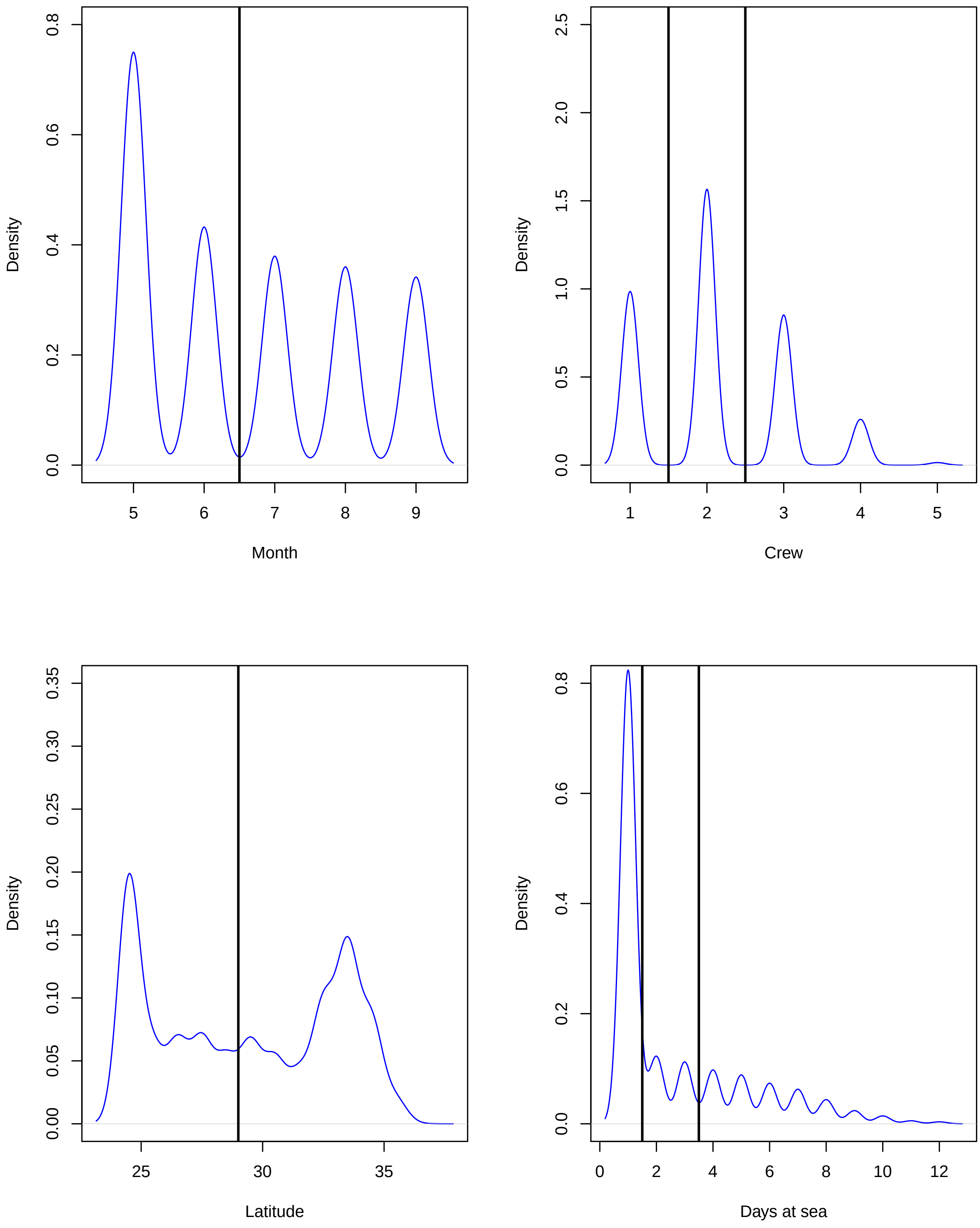


Figure 3: Greater amberjack handline explanatory variable factorization. Vertical lines represent breaks for factors.

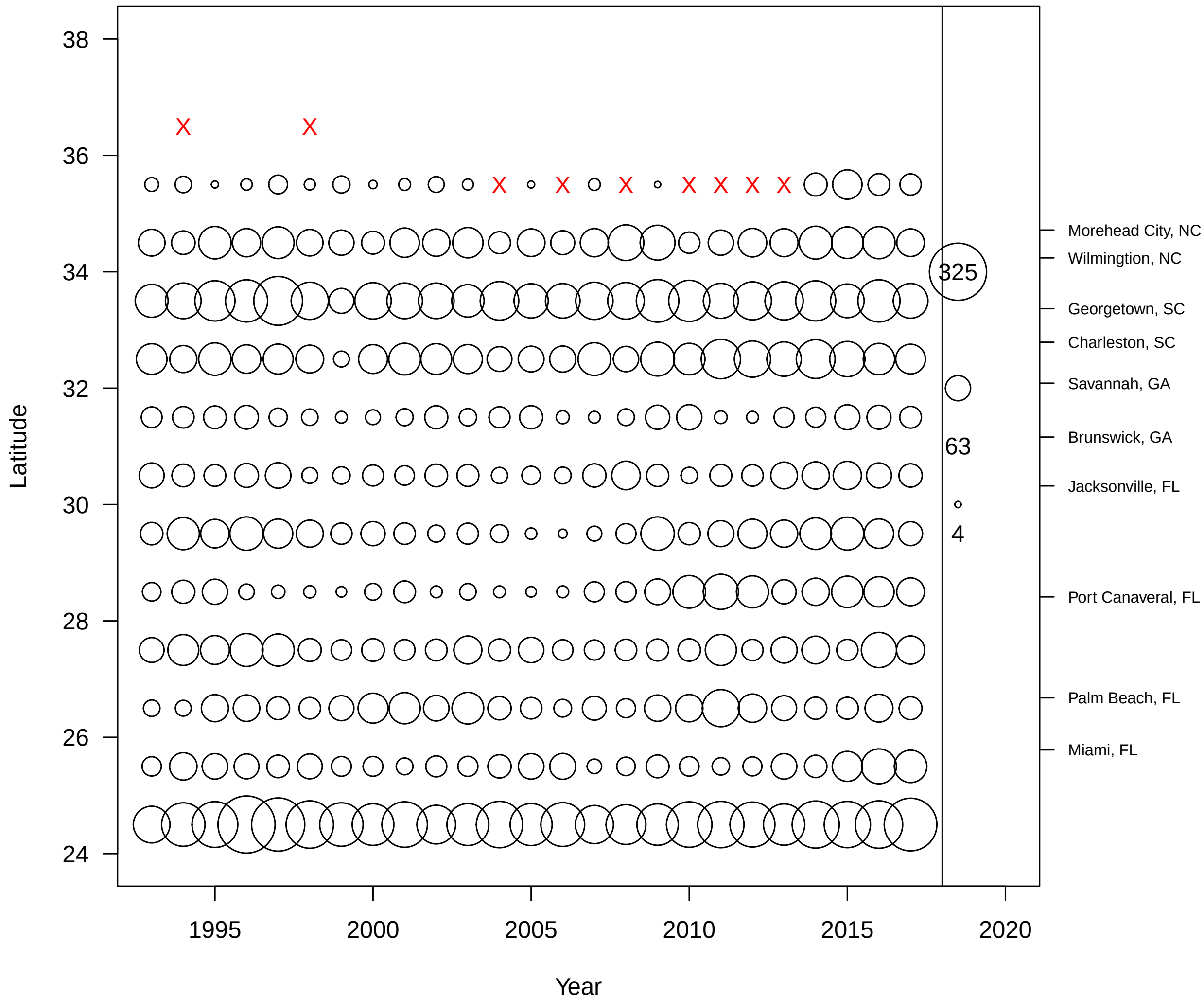


Figure 4: Greater amberjack handline trips by year and latitude. Symbol size relative to number of trips, 'X' signifies confidential data and represents a small percentage of the total trips.

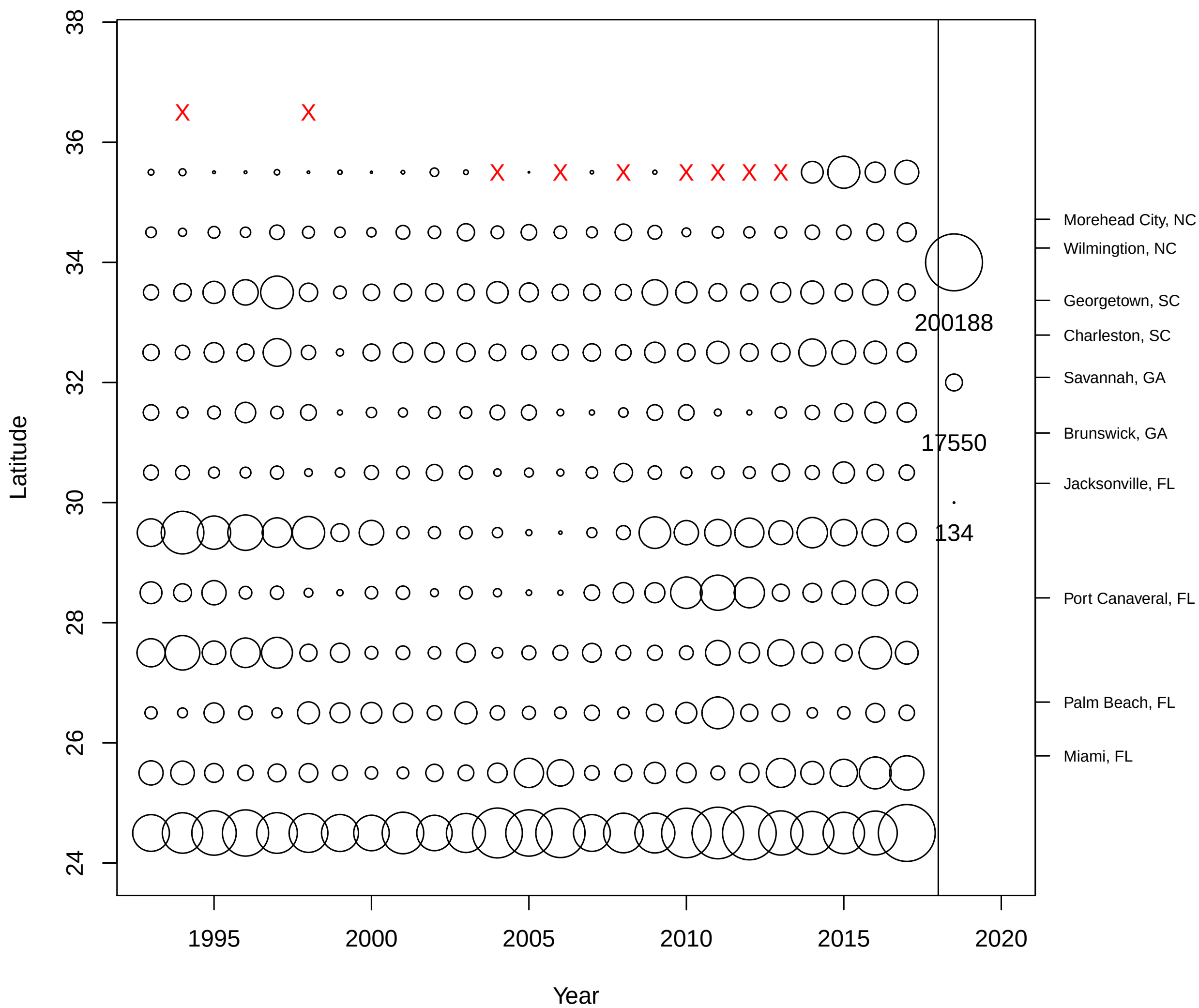


Figure 5: Greater amberjack handline catch (whole pounds) by year and latitude. Symbol size relative to catch, 'X' signifies confidential data and represents a small percentage of the total catch.

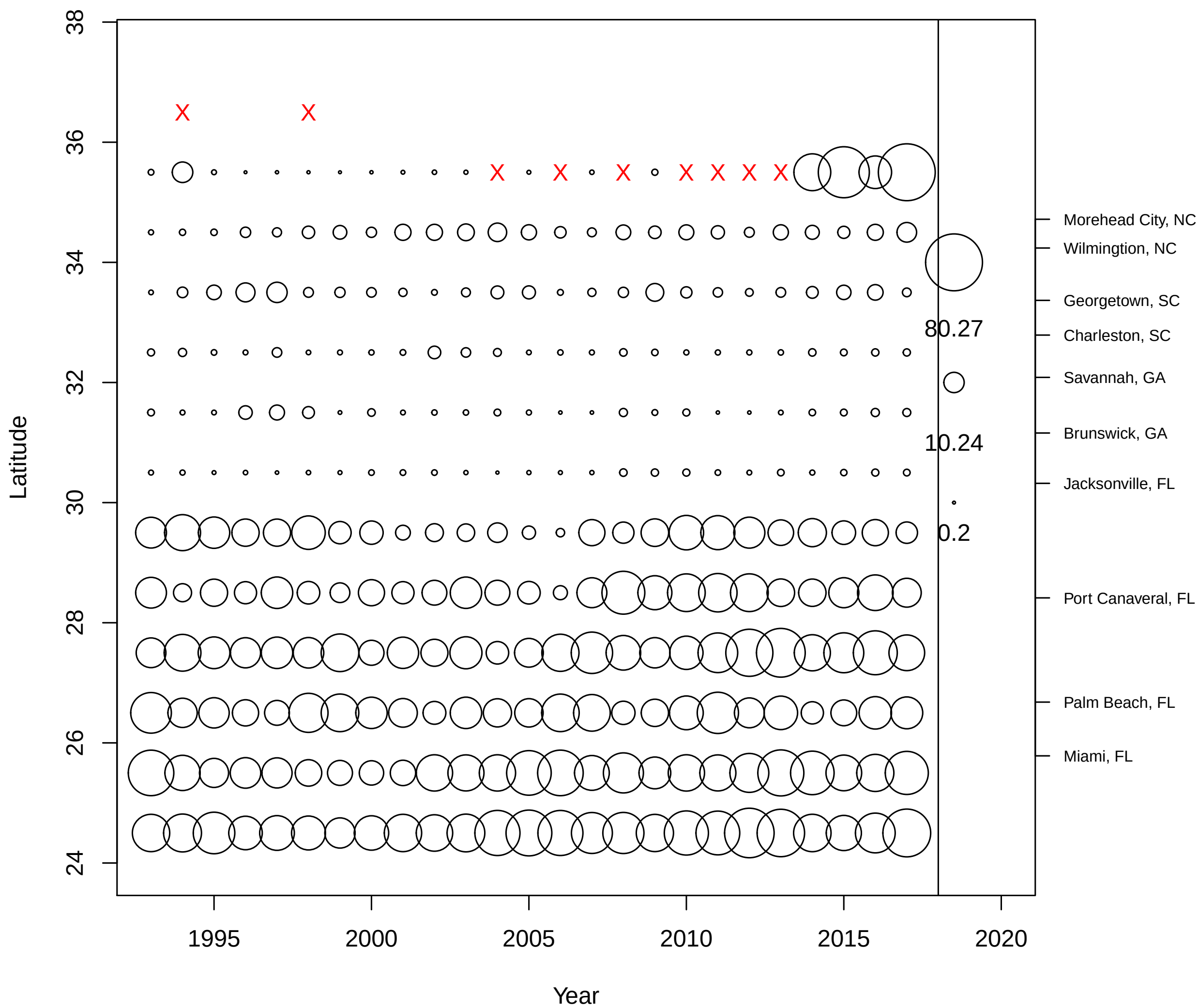


Figure 6: Greater amberjack handline mean cpue (whole pounds/hook-hour) by year and latitude. Symbol size relative to cpue, 'X' signifies confidential data and represents a small percentage of the total records.

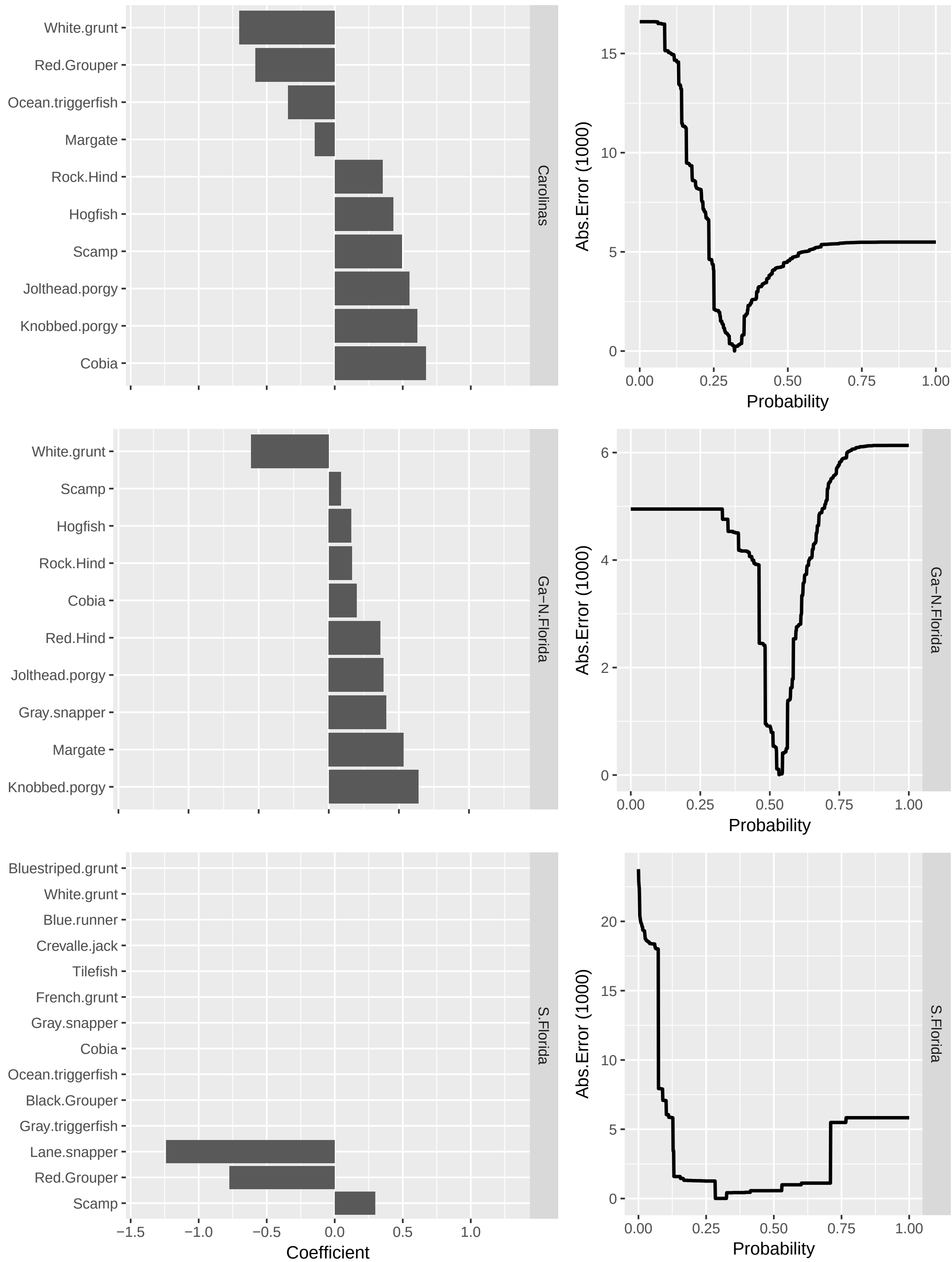


Figure 7: Estimates of species-specific regression coefficients used to predict each trip's probability of catching the focal species on the left panel. The right panel shows the absolute difference between observed and predicted number of positive trips across a range of probability cutoff values.

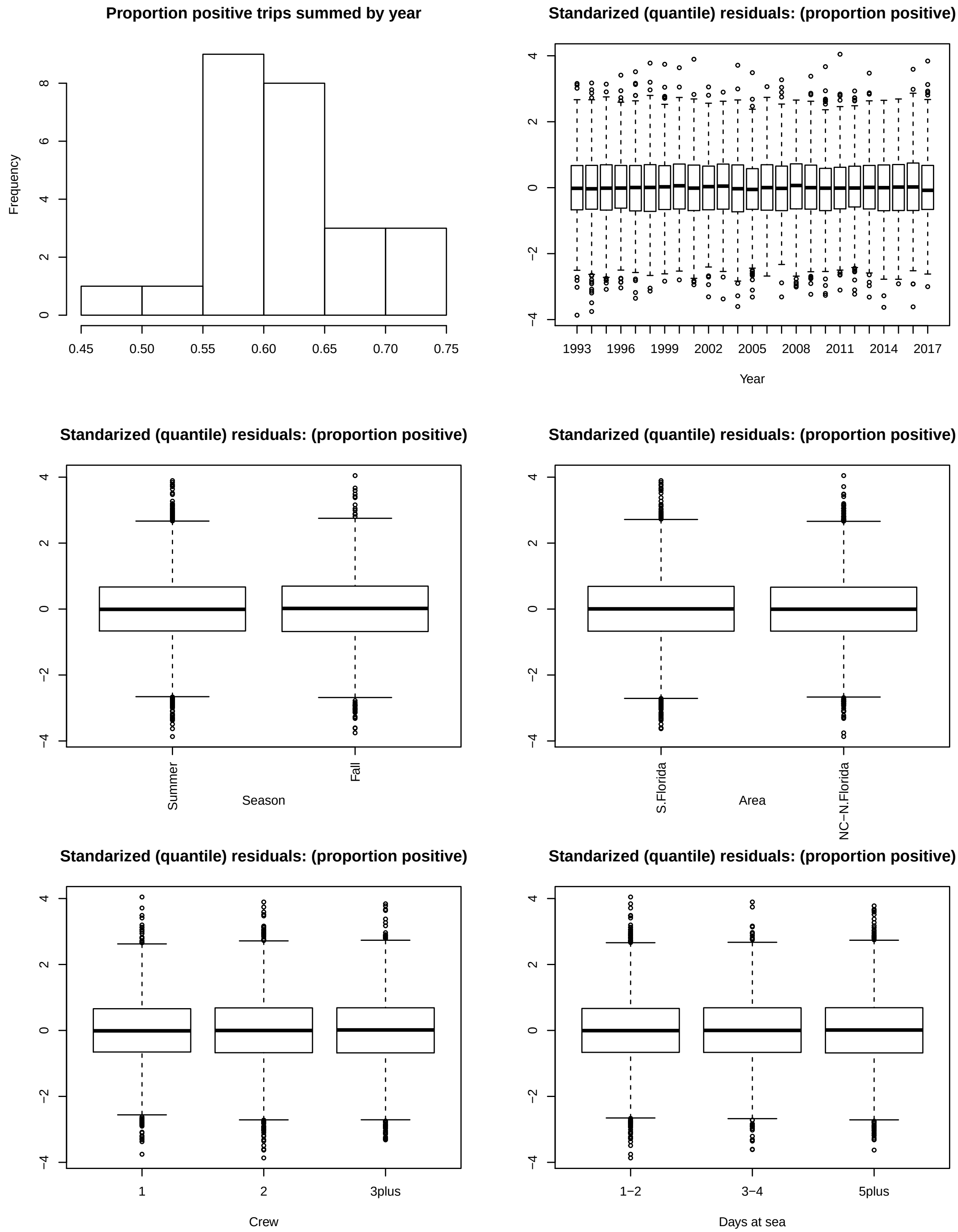


Figure 8: Diagnostics of Bernoulli submodel fits to positive versus zero CPUE data. Box and whisker plots give first, second (median) and third quartiles, as well as limbs that extend to approximately one interquartile range beyond the nearest quartile, and outliers (circles) beyond the limbs. Residuals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

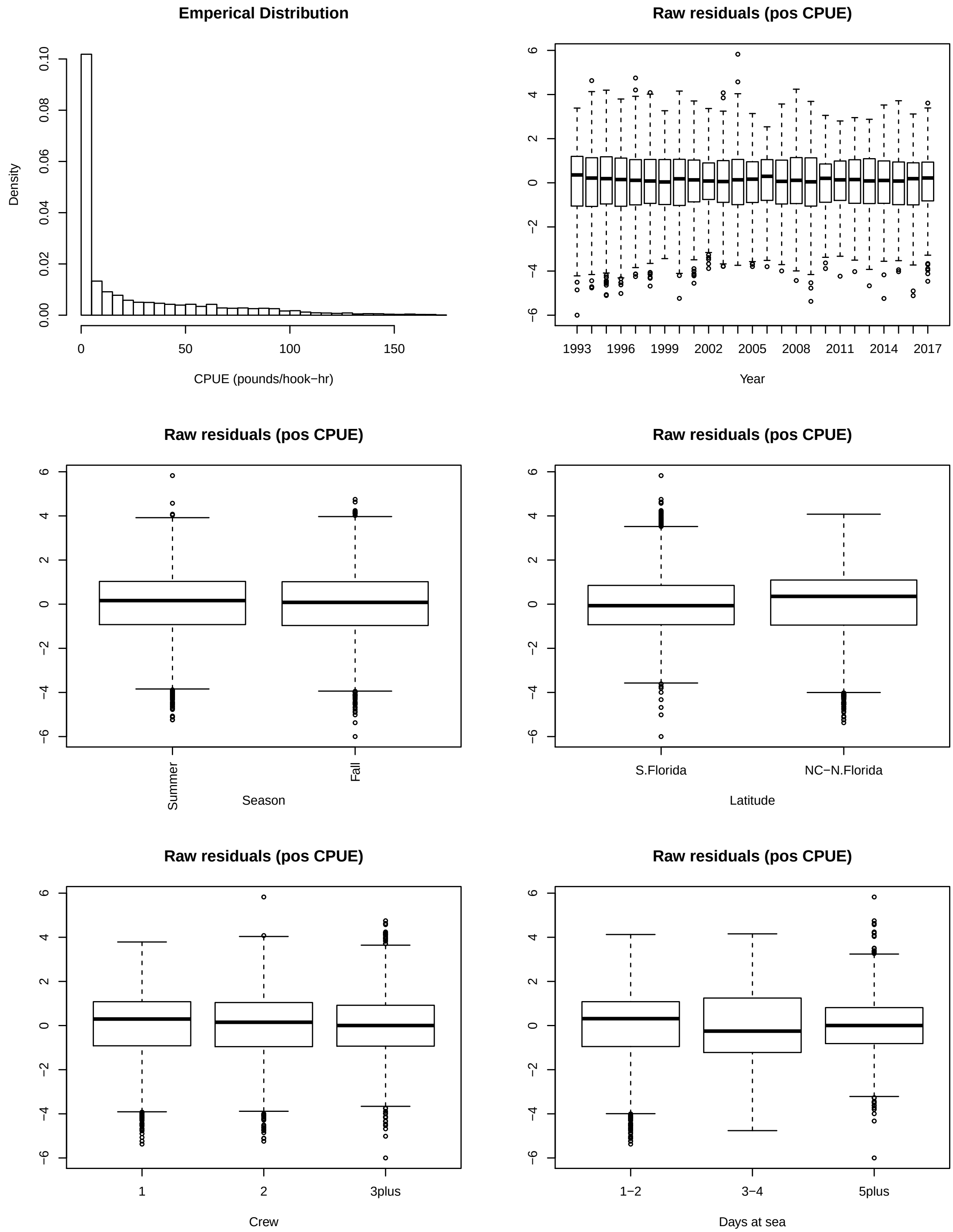
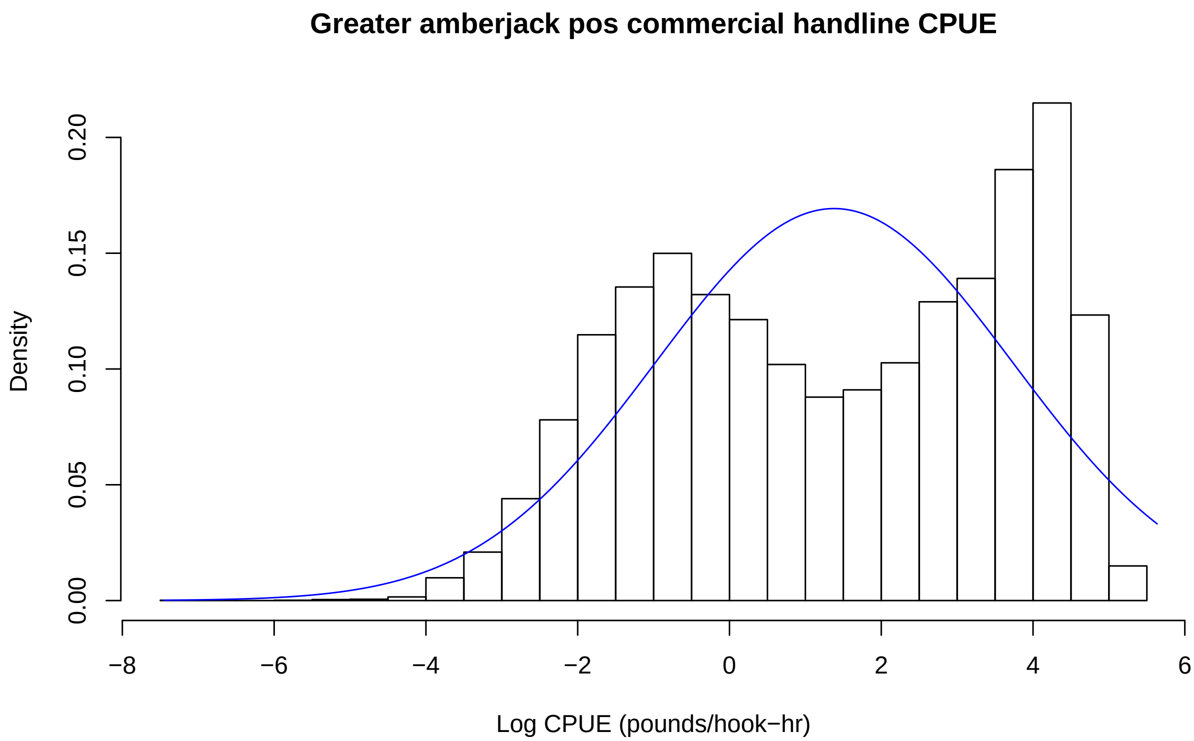


Figure 9: Diagnostics of lognormal submodel fits to positive CPUE data. Top left panel shows the distribution of positive cpue. Box and whisker plots give first, second (median) and third quartiles, as well as limbs that extend to approximately one interquartile range beyond the nearest quartile, and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



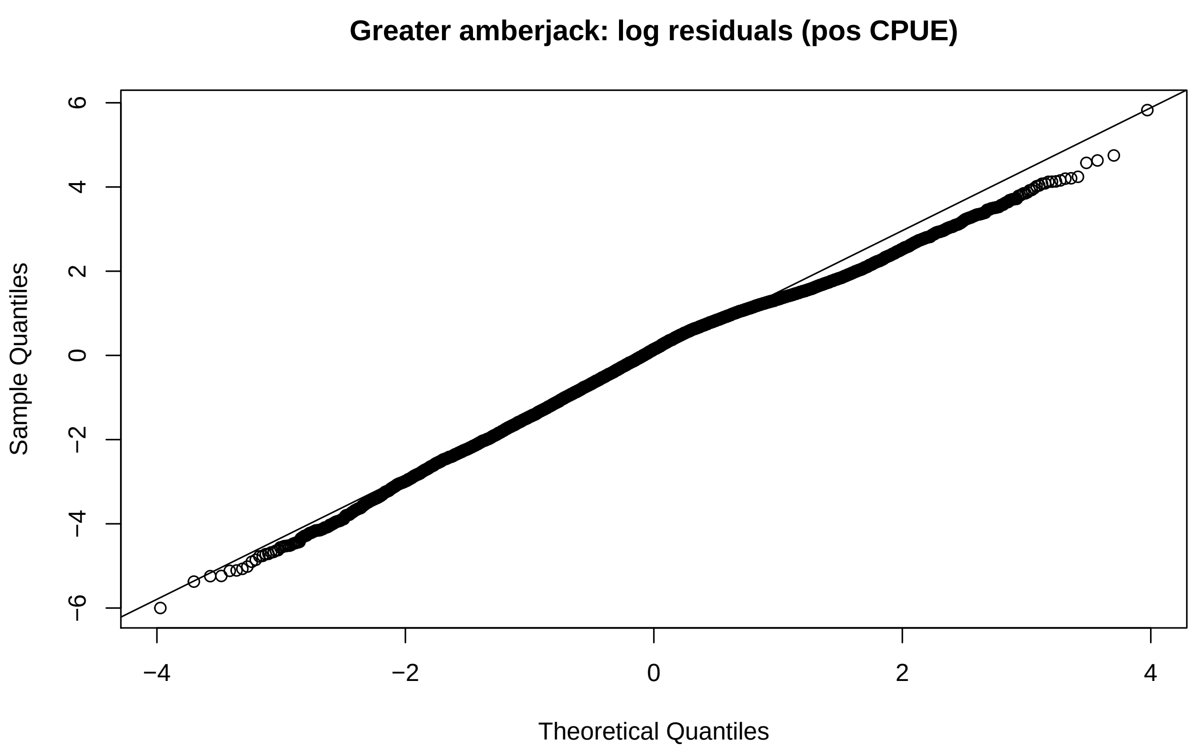


Figure 10: Histogram of empirical log CPUE, with the normal distribution (empirical mean and variance) overlaid. Quantile-quantile plot of residuals from the fitted lognormal submodel to the positive cpue cata.

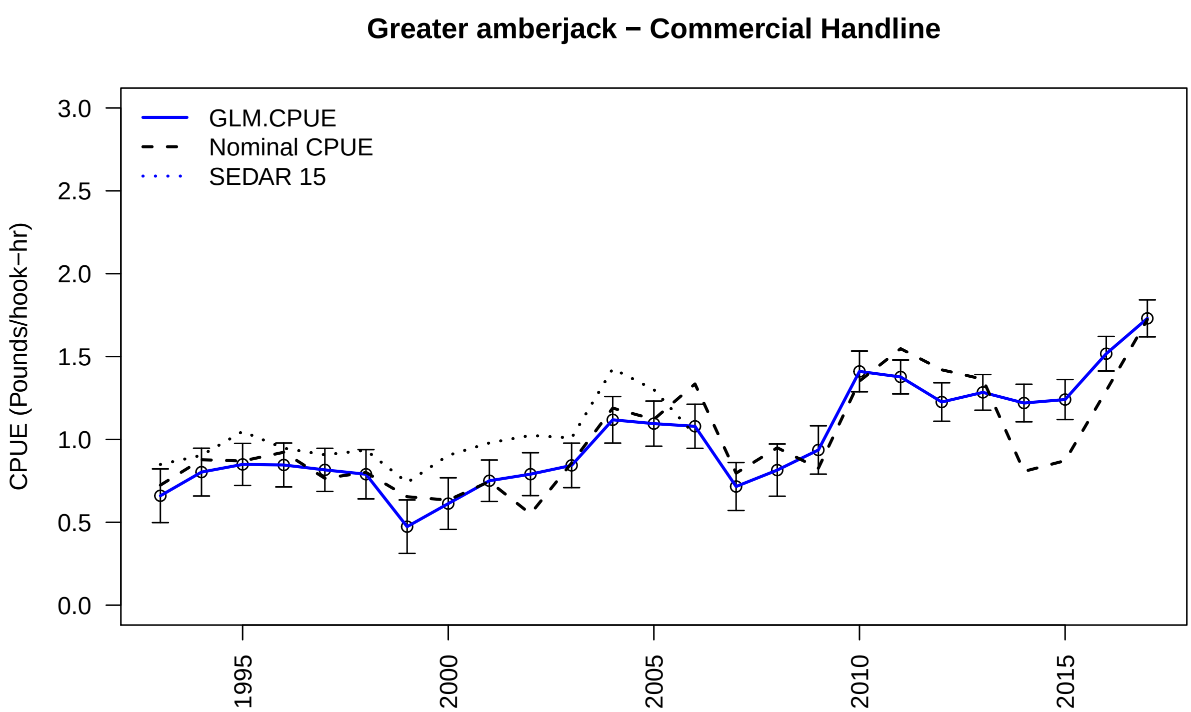


Figure 11: Standardized commercial handline greater amberjack catch rate (solid) with 95% confidence intervals and nominal catch rate (dashed).

Appendix

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

```
##
## Call:  glm(formula = Greater.amberjack ~ Black.Grouper + Cobia + Gray.triggerfish +
##     Hogfish + Jolthead.porgy + Knobbed.porgy + Margate + Ocean.triggerfish +
##     Red.Grouper + Rock.Hind + Scamp + White.grunt, family = "binomial",
##     data = n.mat.cut.df)
##
## Coefficients:
##       (Intercept)      Black.Grouper              Cobia
##          -0.90318           -0.09784            0.63683
##  Gray.triggerfish            Hogfish     Jolthead.porgy
##          -0.08499            0.46712            0.53880
##     Knobbed.porgy            Margate  Ocean.triggerfish
##           0.59686           -0.13874           -0.41608
##       Red.Grouper          Rock.Hind              Scamp
##          -0.61934            0.35976            0.41990
##       White.grunt
##          -0.76041
##
## Degrees of Freedom: 23187 Total (i.e. Null);  23175 Residual
## Null Deviance:       26450
## Residual Deviance: 24750     AIC: 24780
```

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

```
##
## Call:  glm(formula = Greater.amberjack ~ Cobia + Gray.snapper + Hogfish +
##     Jolthead.porgy + Knobbed.porgy + Margate + Red.Hind + Rock.Hind +
##     Scamp + White.grunt, family = "binomial", data = m.mat.cut.df)
##
## Coefficients:
##    (Intercept)           Cobia    Gray.snapper         Hogfish
##       -0.15427         0.19913         0.41003         0.16117
## Jolthead.porgy   Knobbed.porgy         Margate        Red.Hind
##        0.39066         0.63891         0.53394         0.36857
##      Rock.Hind           Scamp     White.grunt
##        0.16503         0.08667        -0.55506
##
## Degrees of Freedom: 11081 Total (i.e. Null);  11071 Residual
## Null Deviance:       15240
## Residual Deviance: 14760     AIC: 14780
```

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

```
##
## Call:  glm(formula = Greater.amberjack ~ Black.Grouper + Blue.runner +
##     Bluestriped.grunt + Cobia + Crevalle.jack + French.grunt +
##     Gray.snapper + Gray.triggerfish + Hogfish + Jolthead.porgy +
##     Lane.snapper + Ocean.triggerfish + Red.Grouper + Scamp +
##     Tilefish + White.grunt + Yellowedge.Grouper, family = "binomial",
```

```
##     data = s.mat.cut.df)
##
## Coefficients:
##       (Intercept)       Black.Grouper         Blue.runner
##            0.9615             -2.0268             -3.4920
##  Bluestriped.grunt              Cobia       Crevalle.jack
##           -3.6752             -2.7383             -3.0708
##       French.grunt       Gray.snapper    Gray.triggerfish
##           -2.9065             -3.6420             -1.6837
##           Hogfish      Jolthead.porgy        Lane.snapper
##           -1.9284             -0.7463             -1.7280
##  Ocean.triggerfish        Red.Grouper               Scamp
##           -2.0750             -1.0156              0.5491
##          Tilefish         White.grunt  Yellowedge.Grouper
##           -2.8432             -3.1629             -2.0557
##
## Degrees of Freedom: 58172 Total (i.e. Null);  58155 Residual
## Null Deviance:       56020
## Residual Deviance: 35710     AIC: 35750
```

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
##     23.7883      -2.9761      -2.2965      -4.9009      -4.8309
##    year1998     year1999     year2000     year2001     year2002
##     -3.6842      -9.7392      -7.9101      -5.4442      -5.4780
##    year2003     year2004     year2005     year2006     year2007
##     -3.4382       1.4536       5.3529       7.2056      -0.1856
##    year2008     year2009     year2010     year2011     year2012
##     -0.9207      -2.7334       3.2162       3.9809       6.8693
##    year2013     year2014     year2015     year2016     year2017
##      5.6299      -1.5885      -1.3852       1.0406       8.1661
##     season2         lat2        crew2        crew3        away2
##     -5.8889      20.4334      -4.3368      -7.4040     -10.5320
##       away3
##    -14.1644
##
## Degrees of Freedom: 14045 Total (i.e. Null);  14015 Residual
## Null Deviance:       16830000
## Residual Deviance: 11510000  AIC: 134200
```

Results of gamma glm to determine factors.

```
##
## Call:  glm(formula = cpue ~ year + lat + crew + away, family = Gamma(link = "log"),
##     data = pos.dat)
##
## Coefficients:
## (Intercept)     year1994     year1995     year1996     year1997
##     2.32258      0.09910      0.01772     -0.05273      0.08091
##    year1998     year1999     year2000     year2001     year2002
```

```
##     0.06085     -0.35915     -0.28024     -0.22056     -0.20078
##    year2003     year2004     year2005     year2006     year2007
##     0.05280      0.53394      0.16313      0.05769     -0.23517
##    year2008     year2009     year2010     year2011     year2012
##     0.05170      0.07323      0.18933      0.05337      0.10914
##    year2013     year2014     year2015     year2016     year2017
##     0.05953     -0.02320      0.15540      0.17030      0.34551
##        lat2        crew2        crew3        away2        away3
##     1.46612     -0.09764     -0.18916     -1.01641     -2.57778
##
## Degrees of Freedom: 14045 Total (i.e. Null);  14016 Residual
## Null Deviance:       50270
## Residual Deviance: 23080     AIC: 89250
```

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
##     -0.7735       0.4159       0.4600       0.5577       0.3153
##    year1998     year1999     year2000     year2001     year2002
##      0.1486      -0.2515       0.2614       0.3673       0.2353
##    year2003     year2004     year2005     year2006     year2007
##      0.1963       0.4934       0.2819       0.2474       0.1717
##    year2008     year2009     year2010     year2011     year2012
##      0.1653       0.4730       0.6891       0.8298       0.5312
##    year2013     year2014     year2015     year2016     year2017
##      0.8923       0.8445       0.8446       1.0420       1.0319
##     season2         lat2        crew2        crew3        away2
##     -0.1610       1.5539      -0.2929       0.3046      -0.2208
##       away3
##      0.7109
##
## Degrees of Freedom: 22766 Total (i.e. Null);  22736 Residual
## Null Deviance:       30300
## Residual Deviance: 27540     AIC: 27600
```

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 2.708975        NA
## 1994 3.294557        NA
## 1995 3.485111        NA
```

```
## 1996 3.471389        NA
## 1997 3.350055        NA
## 1998 3.241603        NA
## 1999 1.943867        NA
## 2000 2.514919        NA
## 2001 3.081028        NA
## 2002 3.243255        NA
## 2003 3.460799        NA
## 2004 4.589672        NA
## 2005 4.494921        NA
## 2006 4.429161        NA
## 2007 2.937887        NA
## 2008 3.344400        NA
## 2009 3.842759        NA
## 2010 5.787616        NA
## 2011 5.650644        NA
## 2012 5.029825        NA
## 2013 5.269223        NA
## 2014 5.005105        NA
## 2015 5.091468        NA
## 2016 6.225712        NA
## 2017 7.100817        NA
##
## $pos.effects
## $pos.effects[[1]]
##        1        2
## 6.862639 5.737364
##
## $pos.effects[[2]]
##         1         2
##  2.541275 15.493580
##
## $pos.effects[[3]]
##        1        2        3
## 7.061986 6.280403 5.570458
##
## $pos.effects[[4]]
##         1         2         3
## 20.121424  5.370423  2.286326
##
##
## $bin.effects
## $bin.effects[[1]]
##         1         2
## 0.6503188 0.6128806
##
## $bin.effects[[2]]
##         1         2
## 0.4410265 0.7886613
##
## $bin.effects[[3]]
##         1         2         3
## 0.6308892 0.5604857 0.6986020
##
```

```
## $bin.effects[[4]]
##         1         2         3
## 0.5930473 0.5388685 0.7479014
##
##
## $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  27597.769727
## AIC.lognormal 88060.509385
## sigma.mle         1.397511
```

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 3.649858        NA
## 1994 4.983334        NA
## 1995 4.556541        NA
## 1996 4.119824        NA
## 1997 4.420074        NA
## 1998 4.120676        NA
## 1999 2.382815        NA
## 2000 3.135919        NA
## 2001 3.477281        NA
## 2002 3.414076        NA
## 2003 5.231154        NA
```

```
## 2004 7.677354        NA
## 2005 5.729683        NA
## 2006 4.363233        NA
## 2007 3.192193        NA
## 2008 4.339694        NA
## 2009 4.958517        NA
## 2010 6.102821        NA
## 2011 5.474792        NA
## 2012 5.136833        NA
## 2013 5.474356        NA
## 2014 4.953911        NA
## 2015 5.704926        NA
## 2016 6.277404        NA
## 2017 7.233884        NA
##
## $pos.effects
## $pos.effects[[1]]
##        1        2
## 7.812941 7.068789
##
## $pos.effects[[2]]
##         1         2
##  2.612695 21.138342
##
## $pos.effects[[3]]
##        1        2        3
## 8.154238 7.466145 6.741547
##
## $pos.effects[[4]]
##         1         2         3
## 14.838330 12.885646  2.146585
##
##
## $bin.effects
## $bin.effects[[1]]
##         1         2
## 0.6503188 0.6128806
##
## $bin.effects[[2]]
##         1         2
## 0.4410265 0.7886613
##
## $bin.effects[[3]]
##         1         2         3
## 0.6308892 0.5604857 0.6986020
##
## $bin.effects[[4]]
##         1         2         3
## 0.5930473 0.5388685 0.7479014
##
##
## $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 2.759777e+04
## AIC.gamma    9.008606e+04
## shape.mle    6.890727e-01
```

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