Standardized catch rates of red snapper (*Lutjanus campechanus*) in the southeast U.S. from commercial logbook data

Sustainable Fisheries Branch, National Marine Fisheries Service (contact: Rob Cheshire)

SEDAR41-DW19

Submitted: 24 July 2014

Addendum: 29 August 2014

***Addendum added to reflect changes made during Data Workshop.**

Updated to correct coding error: 30 July 2015

Please cite this document as:

Sustainable Fisheries Branch – National Marine Fisheries Service. 2014. Standardized catch rates of red snapper (*Lutjanus campechanus*) in the southeast U.S. from commercial logbook data. SEDAR41-DW19. SEDAR, North Charleston, SC. 37 pp.

Standardized catch rates of red snapper (Lutjanus campechanus) in the southeast U.S. from commercial logbook data

Sustainable Fisheries Branch, National Marine Fisheries Service
Southeast Fisheries Science center
101 Pivers Island Rd, Beaufort, NC 28516
July 2014
Ammended July 2015
(see Addendum, Tables 4–6, and Figures 18–26)

1.1 Introduction

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 snapper landed with vertical lines (manual handline and electric reel), the dominant gear for this red snapper 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. The time series used for construction of the index spanned 1993 to 2009, when all vessels with federal snapper-grouper permits were required to submit logbooks on each fishing trip. For this southeast U.S. Atlantic stock, areas used in analysis were those between 24 and 37 degrees latitude, inclusive of the boundaries (Figure 1). A red snapper closure was implemented in January, 2010 which prevents the use of the CFLP data as an index for 2010-present.

1.2 Commercial Diving

The CFLP diving data was considered and rejected due to small sample sizes and limited spatial coverage (Tables 1 and 2, Figure 2).

1.3 Commercial Handline

1.3.1 Data filtering

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 (reported fields described in Appendix). Fishing effort data available for vertical line gear included number of lines fished, hours fished, and number of hooks per line.

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). This restriction excluded approximately 24% of the full data set (i.e., the data set with all gears and all areas, including Gulf of Mexico). 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.

Clear outliers in the data used as factors in the model or to calculate cpue were excluded from the analyses. Outliers were defined as values falling outside the 99.5 percentile of the data. 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 instead of the positive red snapper trips as in SEDAR 24 (Table 3). For hours fished, both upper and lower outliers were removed. Outliers related to CPUE for positive red snapper trips were removed (Table 3).

The analysis of data from the CFLP was completed through 2009 in SEDAR 24 for handline gear (electric and manual reels combined). The analysis could not be extended further due to the January 2010 closure of the red snapper fishery. Minimal open seasons that were implemented in recent years are biased due to targeting and could not be used in the development of an index of abundance.

1.3.2 Explanatory variables considered

YEAR - Year was necessarily included, as standardized catch rates by year are the desired outcome. Years modeled were 1993-2009. The total number of red snapper trips by year is provided in table 1 and catch per year is provided in table 2.

SEASON - Season included four levels: winter (JanuaryMarch), spring (AprilJune), summer (JulySeptember), and fall (OctoberDecember). The relative number of trips per month is shown in figure 3. The annual cpue associated with each season is given figure 4.

AREA - Area (latitude) is reported in the logbook on a one degree grid (Figure 1). For SEDAR 41, we propose keeping the data at the level it was collected with the exception of pooling the latitudes at the fringe of the range. Pooling latitudes 24 to 29 to 29 degrees and 34 to 38 to 34 degrees (Figure 3). This pooling gives 2000 to 3000 trips per latitude bin. Other methods for pooling areas were considered including quantiles. However, these methods require assigning latitude bins with large sample size to pooled bins when the geographical boundary (e.g. states) or quartile value falls in the middle of a latitude bin. The annual cpue associated with each latitude is given figure 5.

DAYS AT SEA - 'Days at sea' were pooled into three levels: one to two days, three to four days (twotofour), and five or more days (fiveplus). The relative number of trips per year by days at sea is shown in Figure 3. The annual cpue associated with days at sea is given figure 6.

CREW SIZE - Crew size (crew) could influence the total effort and could be a psuedo–factor for vessel size. The quantile split values (at 25, 50, and 75%) for red snapper crew size fall at 2, 2, and 3 crew per trip. Therefore crew size was pooled more subjectively into three levels: one (one), two (two), and three or more days (threeplus). The relative number of trips in each level is given in figure 3. Trips with one crew member were not pooled even though the relative sample size is small because it is believed there would be a significant difference trip efficiency between a crew size of one and two. The annual cpue associated with crew size is given figure 7.

1.3.3 Response variable (CPUE) data considerations

The distribution of positive red snapper trips generally showed a maximum off NC and SC with a moderate decline to about cape canaveral and then a precipitous decline further South (Figure 8). However, the trend in CPUE the mean nominal CPUE has the opposite spatial pattern with larger values further south (Figure 9). This may partially be explained by much shorter trips in South Florida on average. Fishermen are known to target other species at night on multi–day trips and this effort is counted towards the total effort for the trip.

The response variable, CPUE, was calculated for each trip as,

CPUE = pounds of red snapper/hook-hours

where hook-hours is the product of number of lines fished, number of hooks per line, and total hours fished. Spatio-temporal trends were examined for cpue and each of its components (Figures 10 – 9). The mean cpue increased dramatically from 2006–2009 in GA and North Florida while other areas showed no increase (Figure 9). Mean cpue was examined by latitude with northern latitudes grouped 34 degrees and southern latitudes pooled at 29 degrees (Figure 5). The trends in cpue diverge at approximately 32 degrees (near Savannah, GA) after 2005 with the South showing a dramatic increase in CPUE. Inversely, at the beginning of the series the South has the lowest CPUE values. The recent divergence appears to be driven more by catch than effort (Figures 14 – 16).

1.4 Objectives for SEDAR 41 Data Workshop

- Approve or modify proposed factors and factor definitions
- Discuss other possible factors (fuel price index, lunar phase) if time pemits
- Approve or modify cpue definition
  - Discuss possible issue with correlation between cpue denominator component, hours fished, and days at sea factor (Figure 17)
- Discuss filtering (Stephens and MacCall method)
  - The Stephens and MacCall approach used in SEDAR 24 is problematic for habitats with many correlated species. Trips that have split effort among habitats or modified fishing behavior (hook size or bait size) within a trip excaserbate the problem because species assemblages become nonsense. Vermilion snapper was one of the highest correlated species with red snapper and and although they occur in the same locations as red snapper the typical method to prosecute vermilion snapper is quite different then red snapper in most regions. For these reasons we propose running a GLM on positive red snapper trips for SEDAR 41.
- Run GLM based on DW decisions regarding data and factors
- Estimate uncertainty
- Update working paper and provide text, figures, and research recommendations for the SEDAR 41 DW report

Addendum

1.5 Workgroup decisions and justifications

- The proposed factors and definitions were accepted by the panel.
- Since the 2010 closure of red snapper mini-seasons were established for commercial fishermen in 2012 and 2013. These short openings had a restrictive trip limit of 75 pounds. Commercial fishermen indicated they would target red snapper briefly to catch the limit and move to other habitats. This makes the limited data available for 2012 and 2013 invalid and would be biased toward low CPUE for red snapper.
- Lunar phase and a fuel price index were discussed briefly. Lunar phase can be calculated for each trip and might be of possible use after further investigation but was not recommended for inclusion in SEDAR 41. It was not clear how annual fuel price index would be incorporated and would be currently be absorbed in the year effect.
- The "days at sea" factor correlation with the hours fished which is a component of the CPUE denominator was discussed. The "days at sea" factor was binned into 3 categories. The workgroup did not have a concern that the correlation would influence the model.
- The use of the Stephens and MacCall (2004) approach was discussed and the panel felt, even though there are caveats with the method, it is still the best method to define effective effort. The usual method of determining species association based on presence–absence of both target and predictor species was evaluated. In addition, the species associations were evaluated using presence-absence of the target species and the catch of the predictor species. The species and distribution of species associations were very similar. However, there was some concern that trip limits might influence the regression coefficients when using catch as a predictor. The group also evaluated a positive–only model. The Stephens and MacCall approach was recommended through 2009 as in SEDAR 24 because it is based on effective effort.

1.6 Subsetting

Effective effort was based on those trips from areas where red snapper 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. Because a zoogeographic boundary is apparent near Cape Canaveral (Shertzer et al. 2009), the method was applied separately to data from regions north and south of 29 degrees latitude (near Cape Canaveral). 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 . Red porgy was also omitted because of strict harvest regulations since 1999 (including a temporary moratorium), which creates the potential for erroneously removing trips likely to have caught red snapper during years of red porgy 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 gray triggerfish in each trip to presence/absence of other species. For the northern sampling area (NC, SC, GA, north FL), stepwise AIC eliminated mutton snapper and sand tilefish; for the southern sampling area (south FL), it eliminated black grouper and almaco jack. Regression coefficients of included species for the northern sampling areas are shown in figure 18, and for the southern areas in figure 19. A trip was then included if its associated probability of catching red snapper was higher than a threshold probability (Figures 20, 21). The threshold was defined to be that which resulted in the same number of predicted and observed positive trips, as suggested by Stephens and MacCall (2004). After applying the Stephens and MacCall method, and the constraints described above, the resulting subsetted data set contained 17,255 trips in the northern sampling areas, of which 63% were positive, and 1,724 trips from the southern sampling area, of which 43% were positive.

1.7 Standardization

CPUE was modeled using the delta-GLM approach (Lo et al. 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).

1.8 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 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 (Table 5). Diagnostics, based on randomized quantile residuals (Dunn and Smyth 1996), suggested reasonable fits of the Bernoulli submodel (Figure 22).

1.9 Explanatory variables considered

All explanatory factors considered in the data evaluation were included in the model. Year, season (3–month intervals), latitude (29.5–34.5 degrees pooled at the tails), number of crew including captain (1,2 and 3–plus), and days at sea (1–2,3–4, and 5–plus).

1.10 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 (lognormal shown in Table 5). The two distributions, each with their best set of explanatory variables (all of them), were compared using AIC lognormal(AIC=58) highly outperformed gamma (AIC=2793), and was therefore applied in the final delta–GLM. Diagnostics suggested reasonable fits of the lognormal submodel (Figures 23, 24).

1.11 Results

The Stephens and MacCall (2004) method had the effect of concentrating the higher CPUE values at the center of the population distribution (Figure 25). The standardization process adjusted the CPUE values higher from 2000 to 2006 and lower for 2008 and 2009 (Figure 26 and Table 6). Overall, the SEDAR 41 index developed using the Stephens and MacCall (2004) approach is only slightly different then the alternative approach using the positive red snapper trips (Figure 26).Over the last four years of the index (2006–2009), the pattern has been one of strict increase, culminating in the highest expected value of the full series.

1.12 References

References

Dick, E. 2004. Beyond lognormal versus gamma: discrimination among error distributions for generalized linear models. Fisheries Research **70**:351–366.

Dunn, K. P., and G. K. Smyth. 1996. Randomized quantile residuals. Journal of Computational and Graphical Statistics **5**:236–244.

Efron, B., and R. Tibshirani. 1993. An Introduction to the Bootstrap. Chapman and Hall, London.

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

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

Shertzer, K., E. Williams, and J. Taylor. 2009. Spatial structure and temporal patterns in a large marine ecosystem: Exploited reef fishes of the southeast United States. Fisheries Research **100**:126–133.

Stephens, A., and A. MacCall. 2004. A multispecies approach to subsetting logbook data for purposes of estimating CPUE. Fisheries Research **70**:299–310.

Venables, W. N., and B. D. Ripley. 1997. Modern Applied Statistics with S-Plus, 2nd Edition. Springer-Verlag, New York, New York.

1.13 Tables

Table 1. Commercial logbook red snapper trips by gear.

Year	Diving	Handline	Other
1993	24	1155	24
1994	61	1790	30
1995	60	1624	22
1996	99	1255	15
1997	122	1349	15
1998	85	1221	30
1999	83	1234	14
2000	89	1158	25
2001	122	1764	21
2002	69	1775	13
2003	80	1181	25
2004	48	1032	10
2005	50	980	9
2006	86	729	14
2007	90	824	20
2008	65	1025	26
2009	73	1216	33

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

Year	Diving	Handline	Other
1993	0.64	71.87	1.15
1994	1.71	112.95	0.57
1995	2.61	117.65	1.48
1996	4.40	78.99	0.48
1997	5.63	81.67	0.42
1998	2.77	63.40	1.40
1999	3.40	63.53	0.93
2000	3.18	73.04	1.13
2001	6.45	156.42	1.37
2002	3.02	130.72	0.40
2003	3.40	98.26	1.11
2004	4.25	107.48	0.26
2005	2.89	86.03	0.43
2006	3.27	50.77	0.44
2007	6.12	66.17	0.47
2008	3.34	158.16	1.57
2009	4.89	256.63	0.96

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

Year	s24manual	s24electric	s41manual	s41electric
lines fished (upper)	8	5	6	6
hooks per line (upper)	8	8	8	10
days at sea (upper)	8	11	10	12
crew (upper)	4	5	5	5
hours fished (lower)			4	4
hours fished (upper)			105	143
cpue (upper)			24	24

Table 4. Proportion positive by year and factor (s–season followed by months, l–latitiude, c–crew size, a–days at sea)

Year	s1-3	s4-6	s7-9	s10-12	l29.5	l30.5	l31.5	l32.5	l33.5	l34.5	c1	c2	c3plus	a1-2	a3-4	a5plus
1993	0.69	0.75	0.70	0.61	0.54	0.82	0.83	0.86	0.76	0.66	0.47	0.65	0.81	0.52	0.77	0.85
1994	0.77	0.75	0.64	0.64	0.62	0.85	0.88	0.82	0.63	0.58	0.55	0.66	0.76	0.51	0.73	0.84
1995	0.80	0.66	0.56	0.66	0.72	0.77	0.88	0.78	0.54	0.43	0.61	0.60	0.72	0.49	0.66	0.83
1996	0.61	0.61	0.48	0.60	0.65	0.77	0.85	0.62	0.37	0.35	0.42	0.53	0.63	0.44	0.52	0.72
1997	0.62	0.56	0.48	0.45	0.69	0.64	0.76	0.61	0.36	0.28	0.58	0.51	0.53	0.43	0.52	0.62
1998	0.53	0.56	0.46	0.57	0.55	0.80	0.86	0.59	0.33	0.40	0.34	0.48	0.62	0.42	0.49	0.68
1999	0.50	0.60	0.55	0.57	0.51	0.75	0.94	0.68	0.41	0.40	0.25	0.48	0.64	0.40	0.53	0.73
2000	0.54	0.53	0.53	0.62	0.61	0.83	0.94	0.63	0.26	0.46	0.46	0.51	0.60	0.44	0.54	0.71
2001	0.71	0.72	0.64	0.71	0.71	0.91	0.90	0.70	0.55	0.70	0.55	0.66	0.74	0.55	0.74	0.78
2002	0.77	0.82	0.67	0.68	0.56	0.87	0.95	0.78	0.66	0.70	0.60	0.70	0.77	0.57	0.74	0.84
2003	0.65	0.78	0.56	0.63	0.61	0.94	0.90	0.74	0.53	0.49	0.55	0.60	0.72	0.46	0.63	0.79
2004	0.79	0.70	0.56	0.60	0.69	0.95	0.92	0.75	0.54	0.38	0.39	0.57	0.76	0.41	0.60	0.81
2005	0.67	0.62	0.56	0.59	0.54	0.86	0.84	0.74	0.47	0.40	0.42	0.51	0.70	0.42	0.52	0.77
2006	0.56	0.58	0.39	0.44	0.54	0.88	0.75	0.49	0.37	0.27	0.48	0.43	0.54	0.32	0.45	0.58
2007	0.52	0.43	0.46	0.52	0.62	0.85	0.78	0.45	0.25	0.30	0.40	0.39	0.57	0.38	0.41	0.60
2008	0.61	0.55	0.49	0.63	0.76	0.95	0.75	0.58	0.31	0.38	0.53	0.44	0.66	0.43	0.55	0.66
2009	0.68	0.58	0.59	0.83	0.82	0.93	0.82	0.56	0.31	0.42	0.67	0.50	0.72	0.63	0.54	0.69

Table 5. Model selection results from delta-lognormal model.

Factor	Df	Deviance	AIC
Bernouli submodel			
none		22245	22303
crew	2	22296	22350
season	3	22353	22405
away	2	22742	22796
year	16	22783	22809
lat	5	23564	23612
Lognormal submodel			
none		79760	55197
crew	2	79812	55201
season	3	80059	55235
away	2	81365	55424
lat	5	83285	55687
year	16	84963	55896

Table 6. Standardized index of red snapper from commercial logbook data.).

Year	N	Proportion Positive	Relative nominal	Standardized CPUE	CV
1993	772	0.72	0.571	1.086	0.063
1994	1210	0.7	0.521	0.891	0.051
1995	1400	0.66	0.716	0.891	0.046
1996	1101	0.57	0.525	0.612	0.055
1997	1390	0.53	0.662	0.589	0.054
1998	1222	0.53	0.694	0.659	0.055
1999	1068	0.56	0.507	0.798	0.060
2000	1067	0.55	0.746	0.737	0.056
2001	1282	0.7	0.94	1.274	0.049
2002	1386	0.73	0.903	1.383	0.046
2003	1117	0.66	0.699	1.042	0.053
2004	1030	0.65	0.84	1.423	0.054
2005	1067	0.61	0.786	1.188	0.058
2006	893	0.49	0.44	0.597	0.071
2007	1108	0.48	0.599	0.665	0.064
2008	955	0.56	1.933	1.223	0.066
2009	911	0.63	4.918	1.942	0.073

1.14 Figures

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

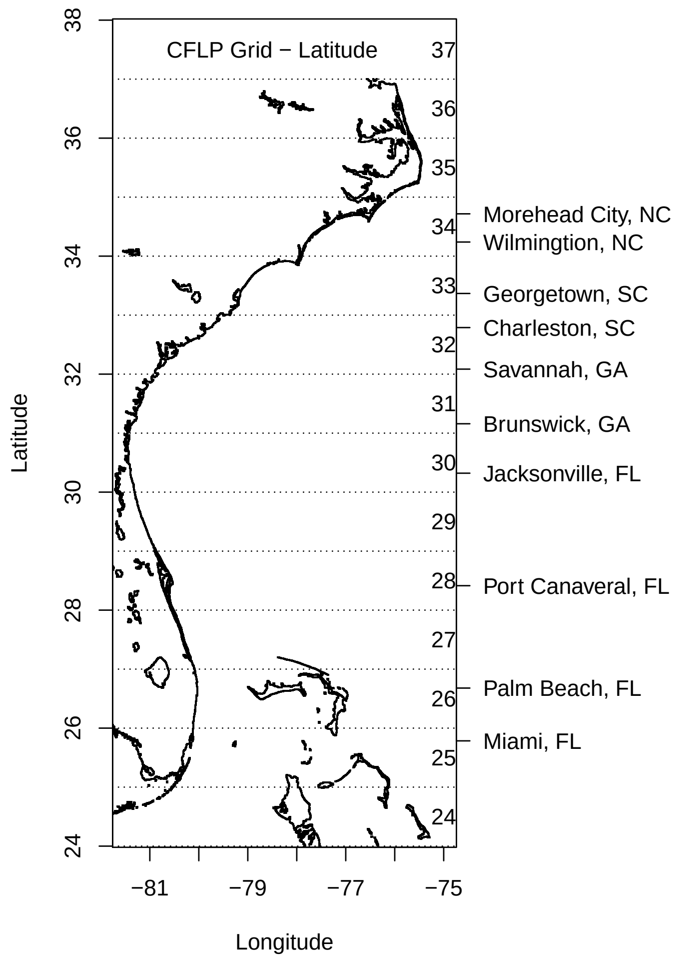


Figure 2. Red snapper diving trips by year and latitude. Symbol size relative to number of trips, 'X' signifies confidential data and represents a small percentage of the total trips.

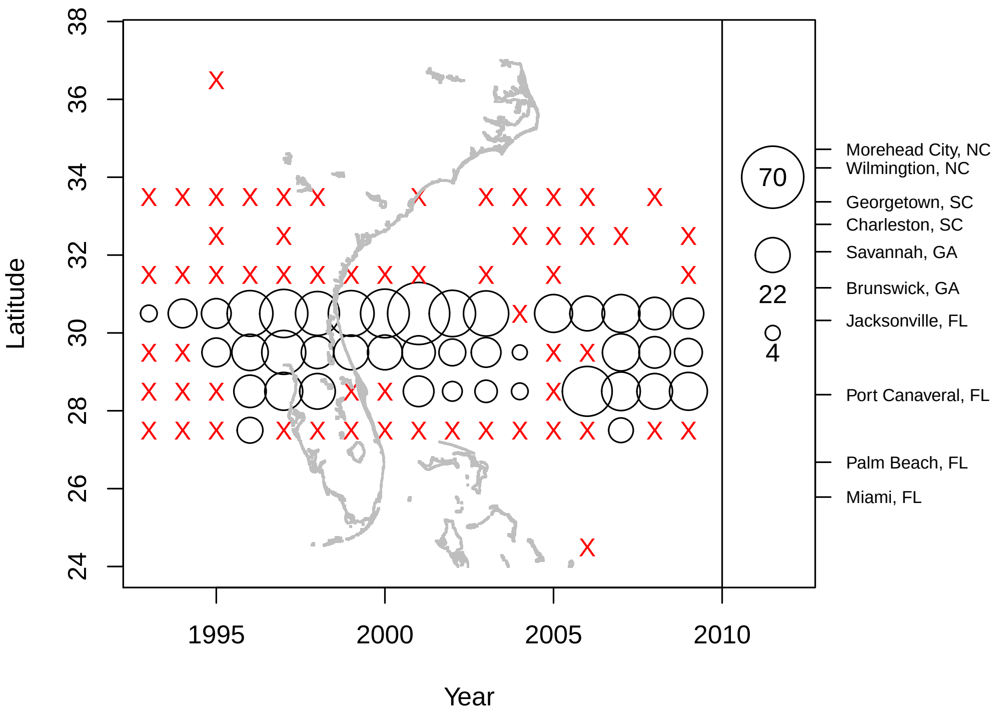


Figure 3. Red snapper handline explanatory variable factor deliniation. Line represents the relative number of trips in each categorical variable. Vertical lines represent proposed breaks for factors).

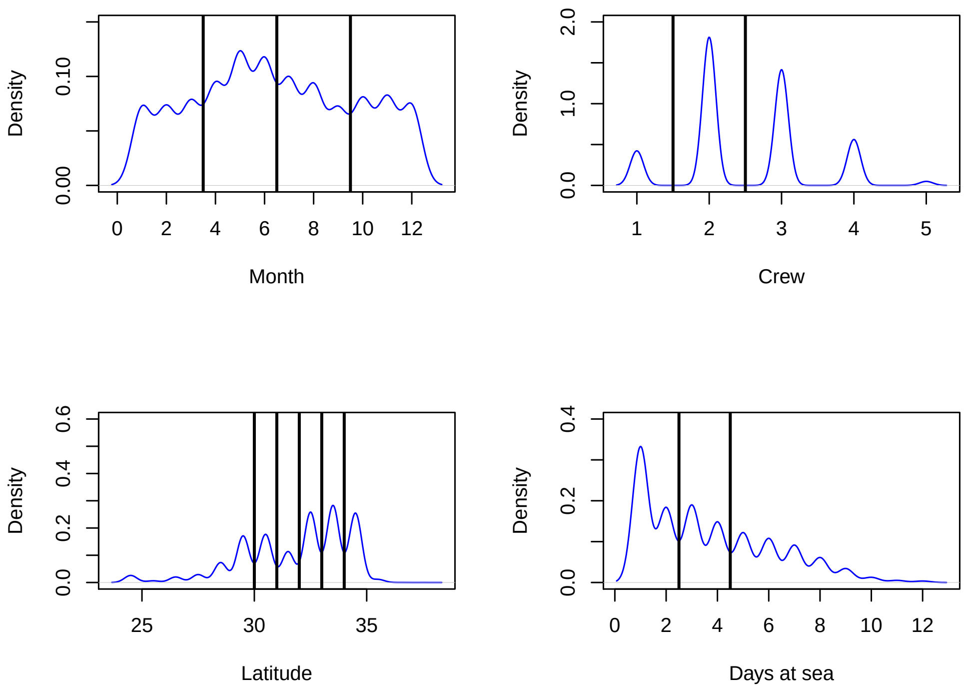


Figure 4. Red snapper handline nominal cpue by year and season.

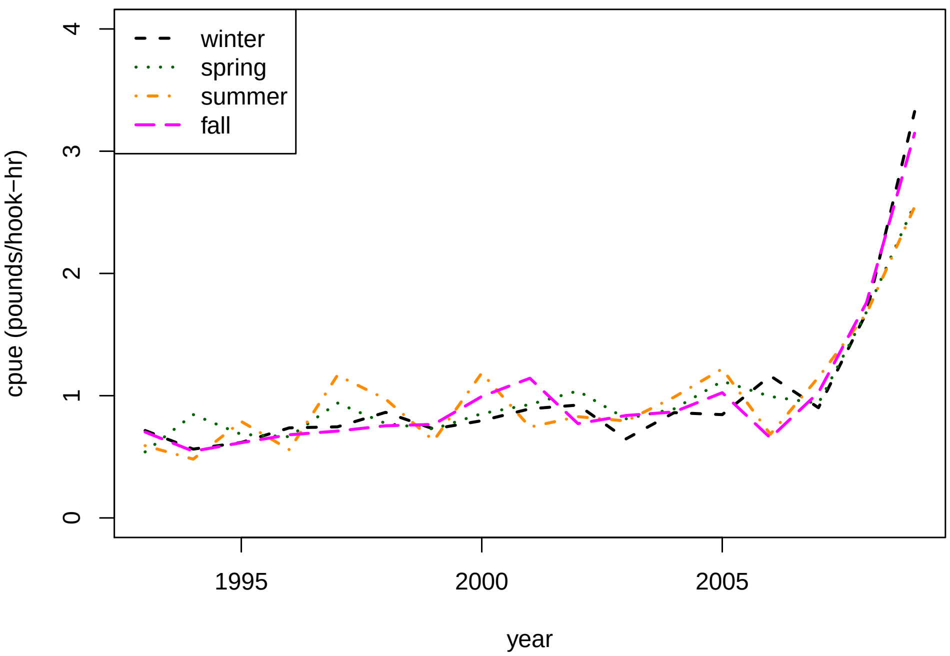


Figure 5. Red snapper handline mean cpue (whole pounds/hook-hour) by year and latitude. Latitudes in the North are pooled at 34 degrees and latitudes in the South are pooled at 29 degrees.

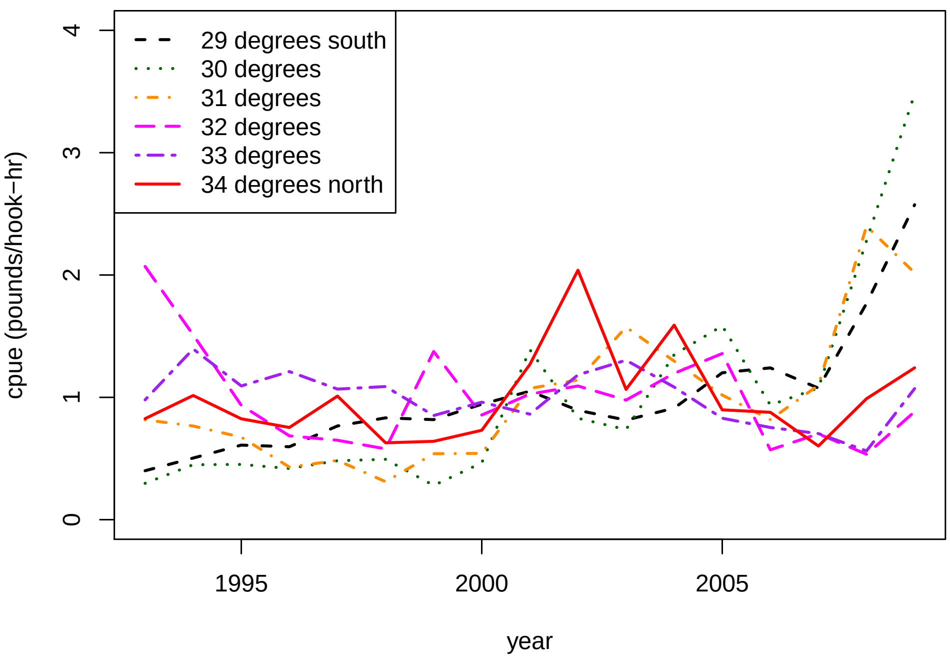


Figure 6. Red snapper handline nominal cpue by year and days at sea.

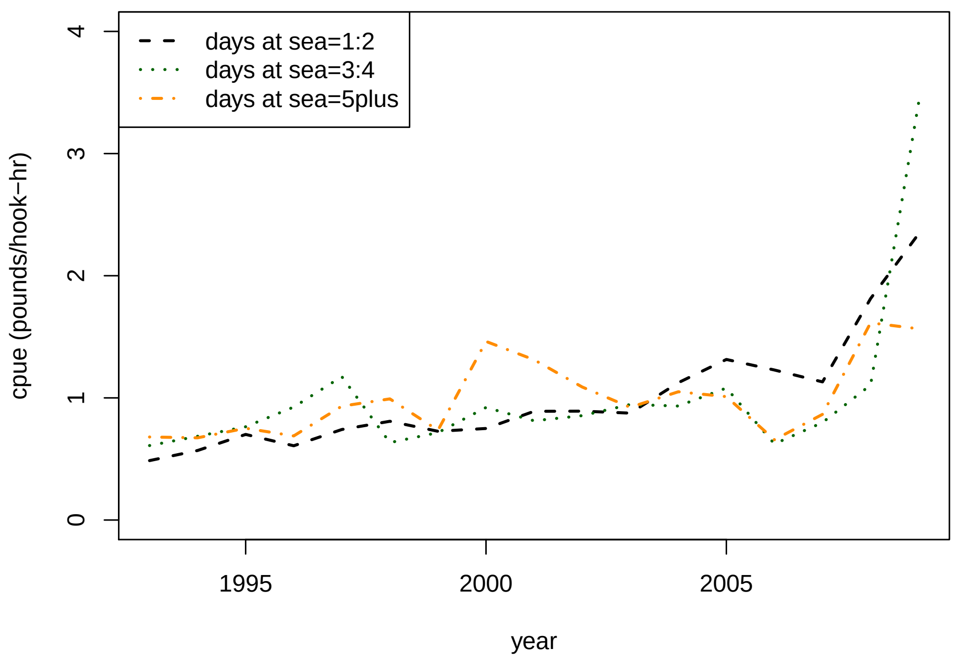


Figure 7. Red snapper handline nominal cpue by year and crew.

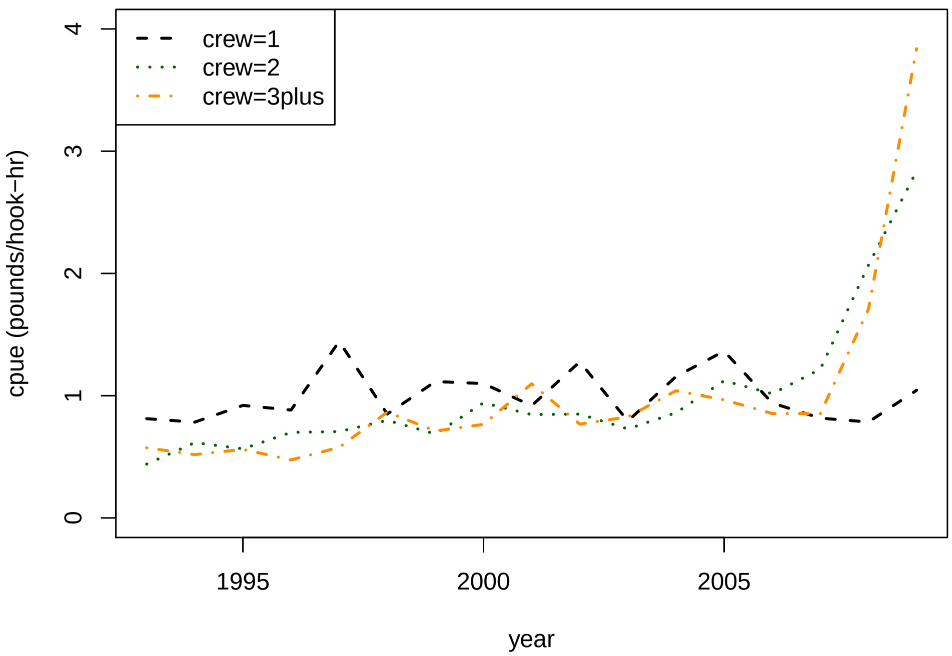


Figure 8. Red snapper handline trips by year and latitude. Symbol size relative to number of trips, 'X' signifies confidential data and represents a small percentage of the total trips.

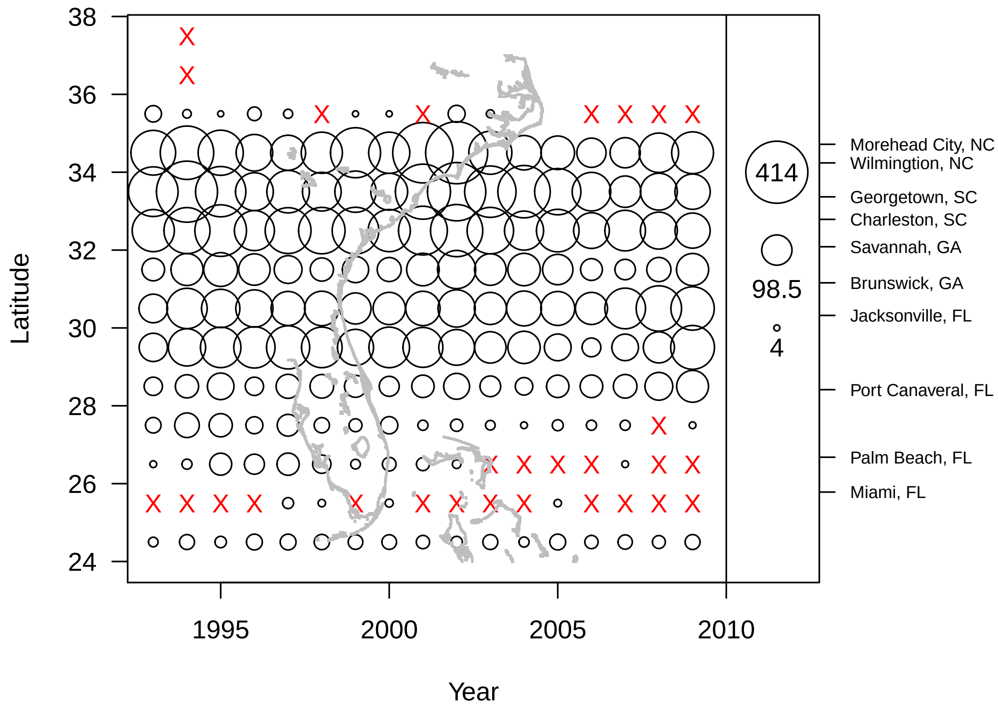


Figure 9. Red snapper handline mean cpue (whole pounds/hook-hour) by year and latitude. Symbol size relative to cpue, X signifies confidential data and represents a small percentage of the total records.

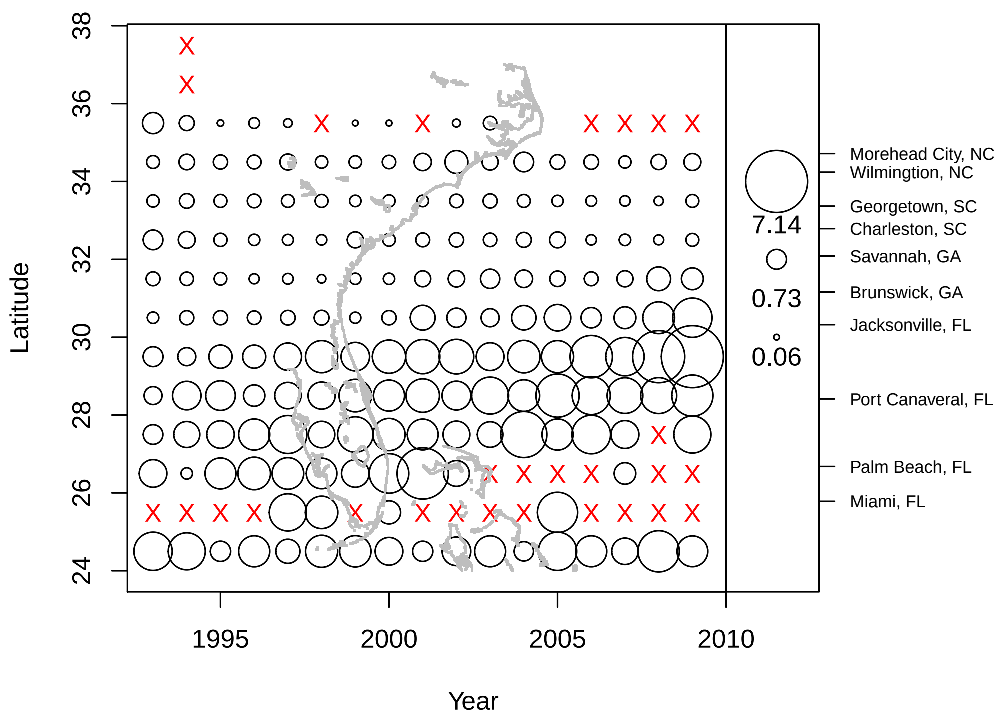


Figure 10. Red snapper handline catch (whole pounds) by year and latitude. Symbol size relative to catch, X signifies confidential data and represents a small percentage of the total catch.

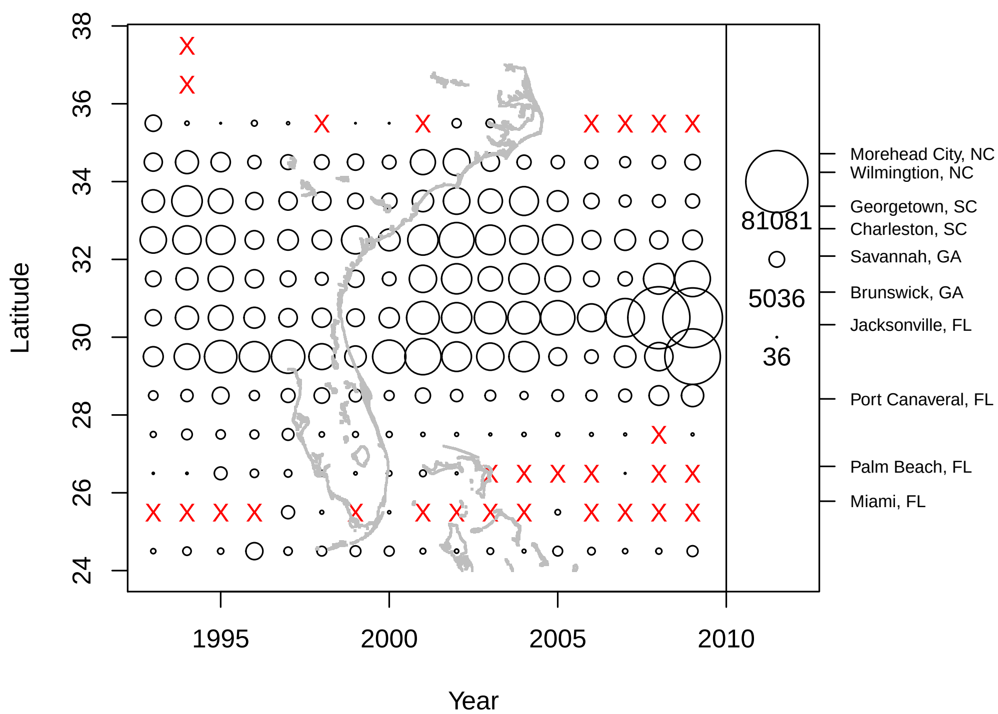


Figure 11. Red snapper handline mean hours fished by year and latitude. Symbol size relative to hours fished, X signifies confidential data and represents a small percentage of the total hours fished.

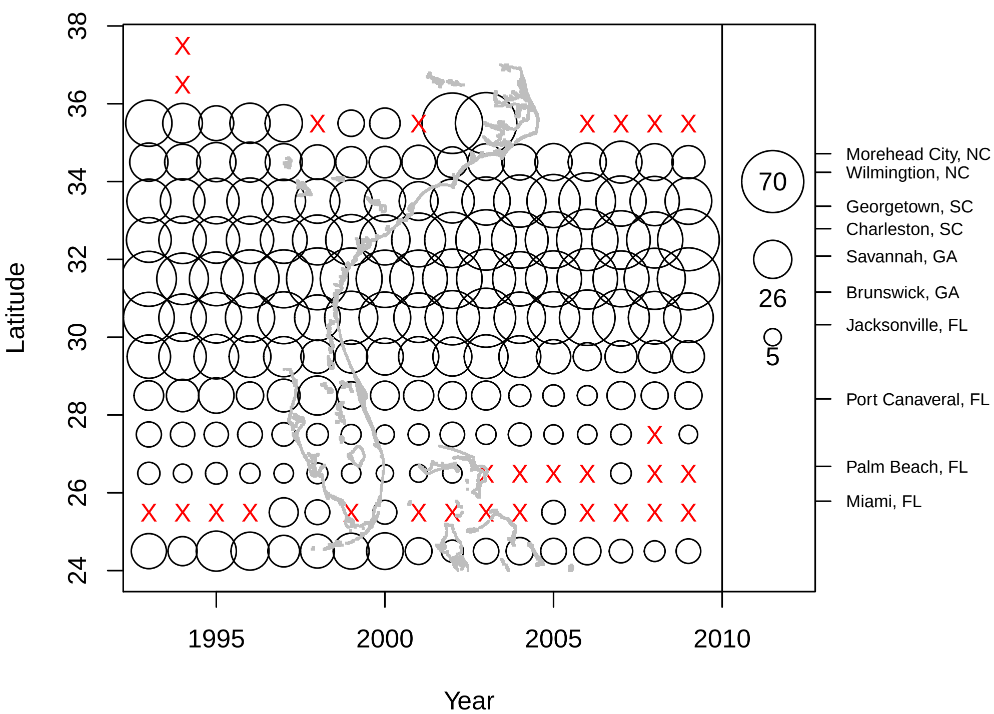


Figure 12. Red snapper handline mean number hooks per line by year and latitude. Symbol size relative to number of hooks, X signifies confidential data and represents a small percentage of the total records.

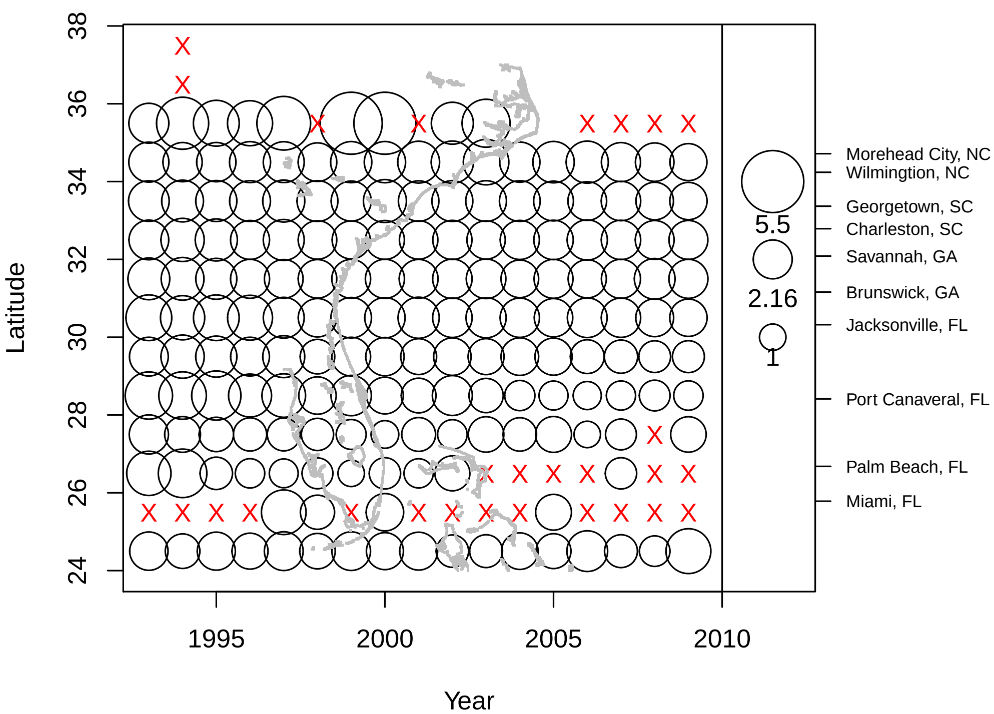


Figure 13. Red snapper handline mean number of lines fished by year and latitude. Symbol size relative to number of lines, X signifies confidential data and represents a small percentage of the total records.

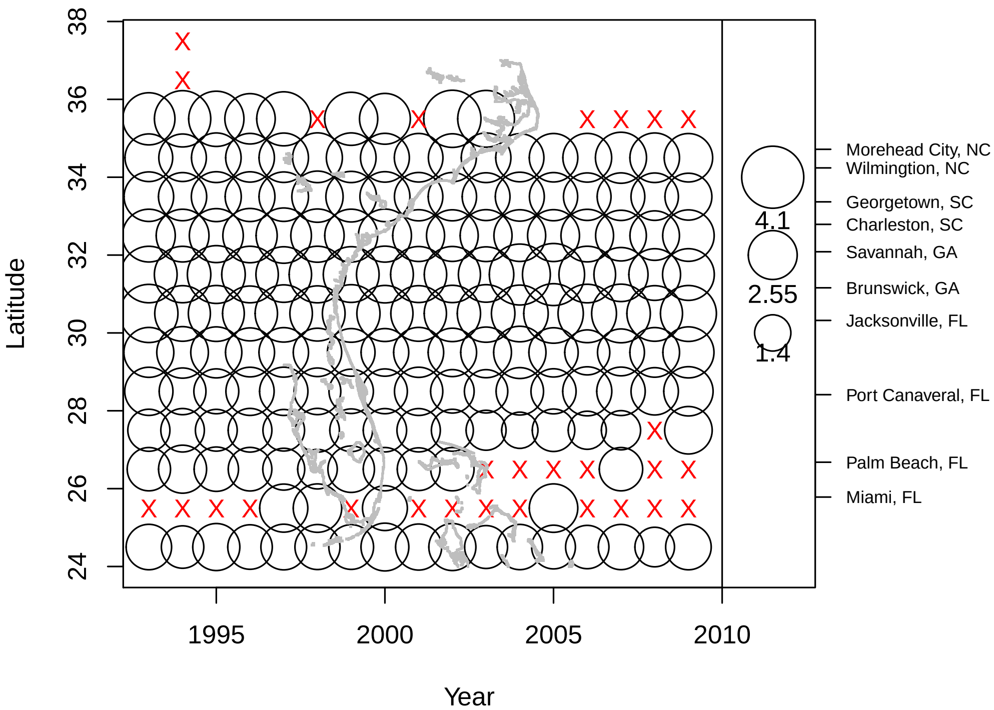


Figure 14. Red snapper handline catch distribution (whole pounds) by year and latitude divided into north of 32 degrees Latitude (orange above 0) and South of 32 degrees Latitude (blue, below 0).

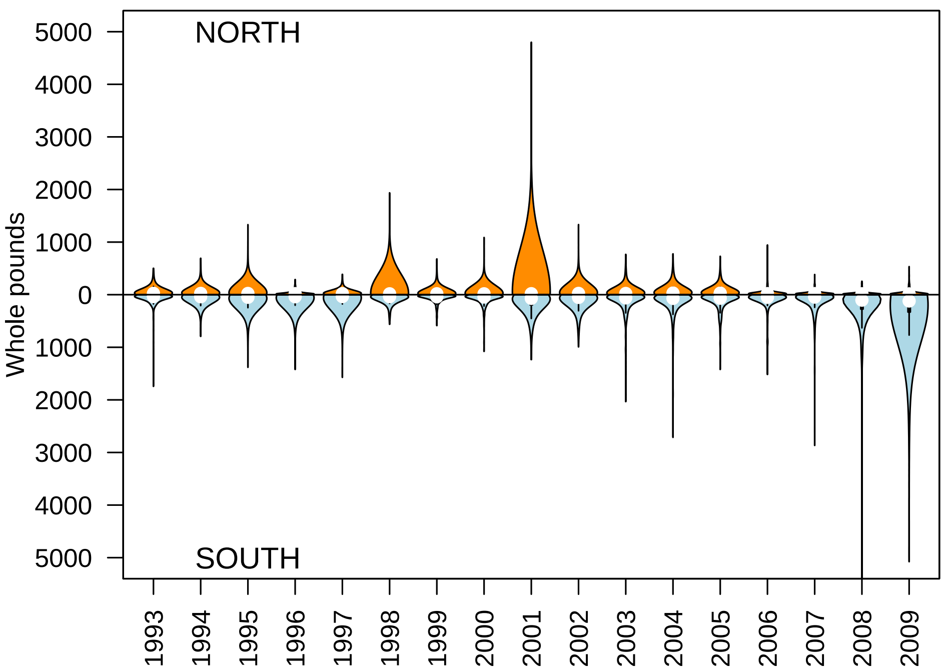


Figure 15. Red snapper handline hook-hours distribution by year and latitude divided into north of 32 degrees Latitude (orange above 0) and South of 32 degrees Latitude (blue, below 0).

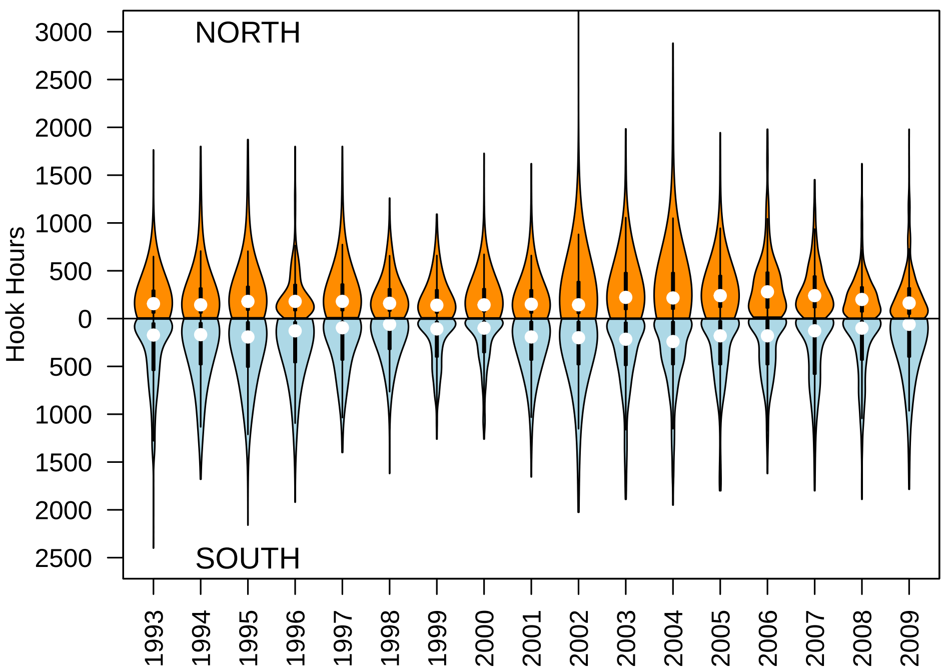


Figure 16. Red snapper handline cpue (whole pounds/hook-hr) distribution by year and latitude divided into north of 32 degrees Latitude (orange above 0) and South of 32 degrees Latitude (blue, below 0).

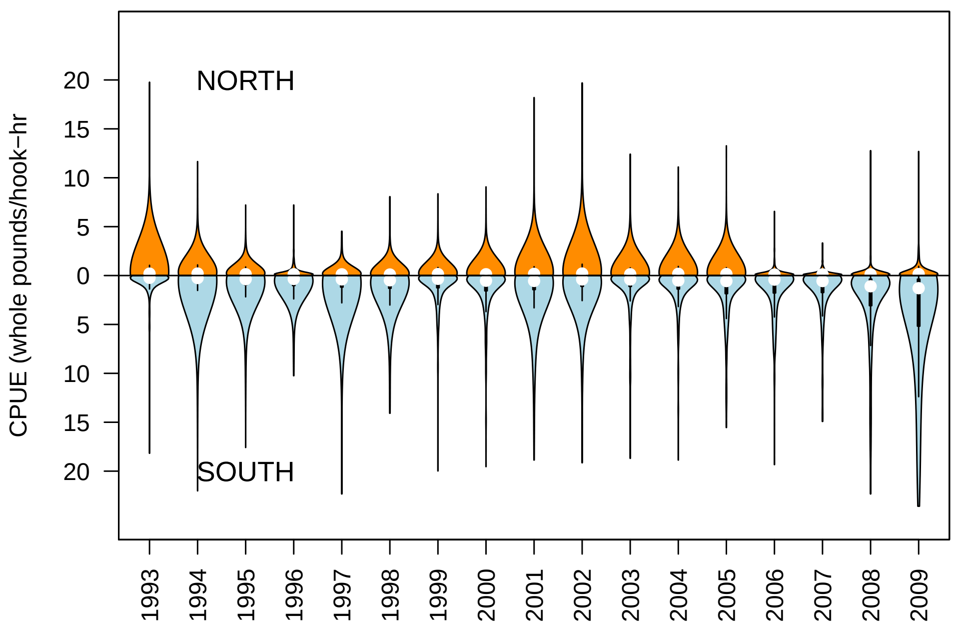


Figure 17. Red snapper handline hours fished by days at sea with correlation coefficient. The mean of approximately 10 hours per day fished applies through approximately 9 days at sea with a pearson correlation coefficient of 0.86.

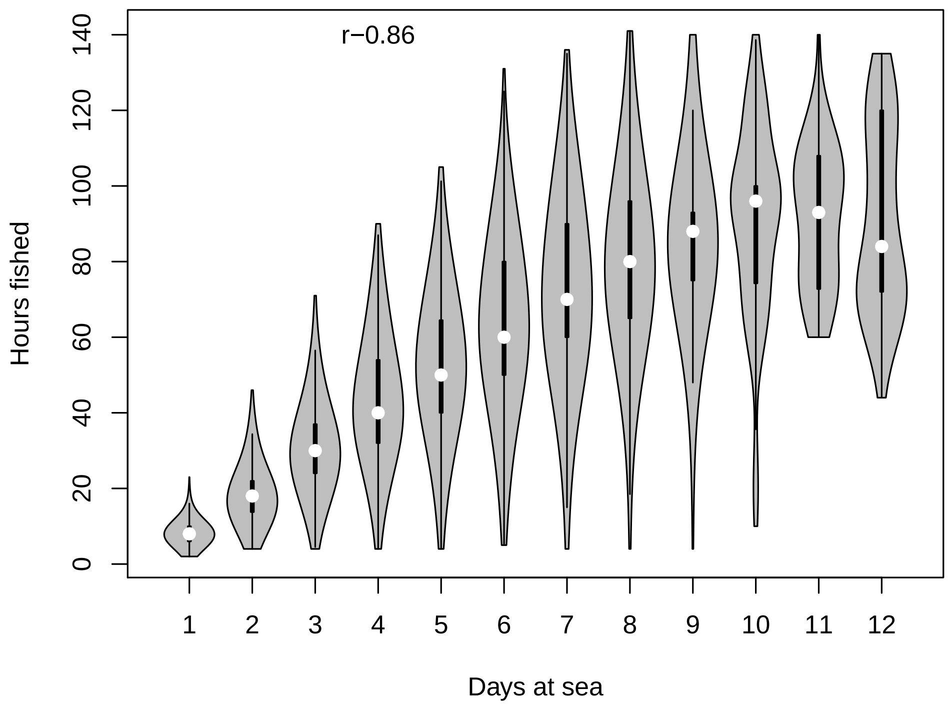


Figure 18. Estimates of species-specific regression coefficients from Stephens and MacCall method applied to logbook data from areas in the northern region (NC, SC, GA, north FL), as used to estimate each trips probability of catching the focal species.

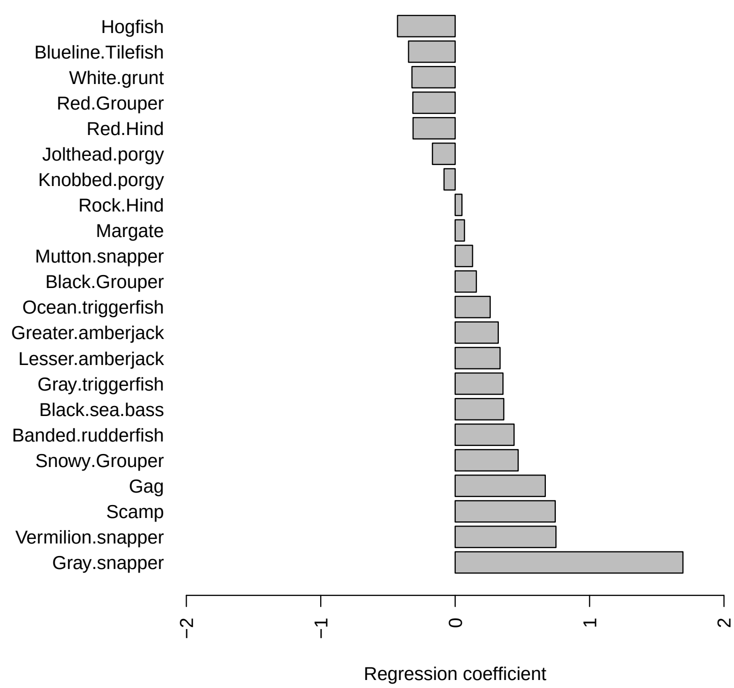


Figure 19. Estimates of species-specific regression coefficients from Stephens and MacCall method applied to logbook data from areas in the southern region (south FL), as used to estimate each trips probability of catching the focal species.

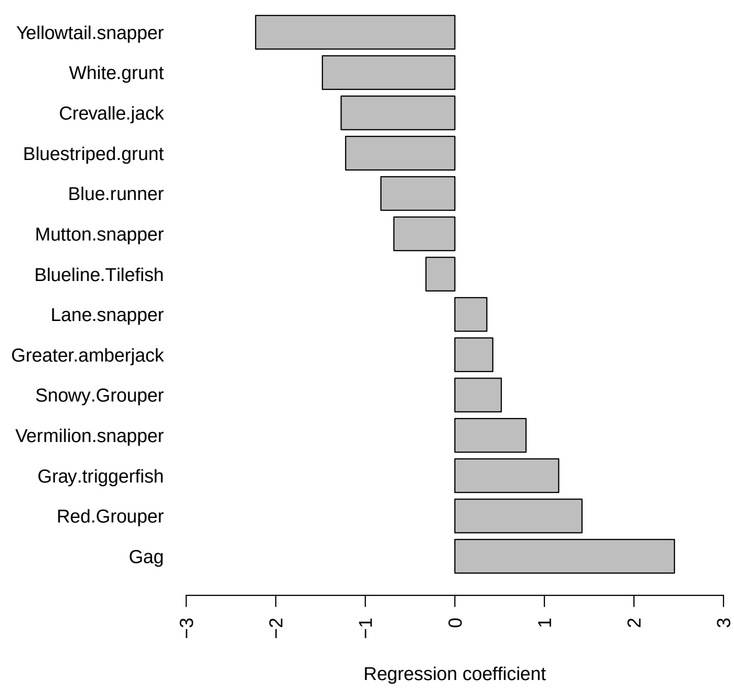


Figure 20. Absolute difference between observed and predicted number of positive trips from Stephens and MacCall method applied to logbook data from the northern region (NC, SC, GA, north FL). Left and right panels differ only in the range of probabilities shown.

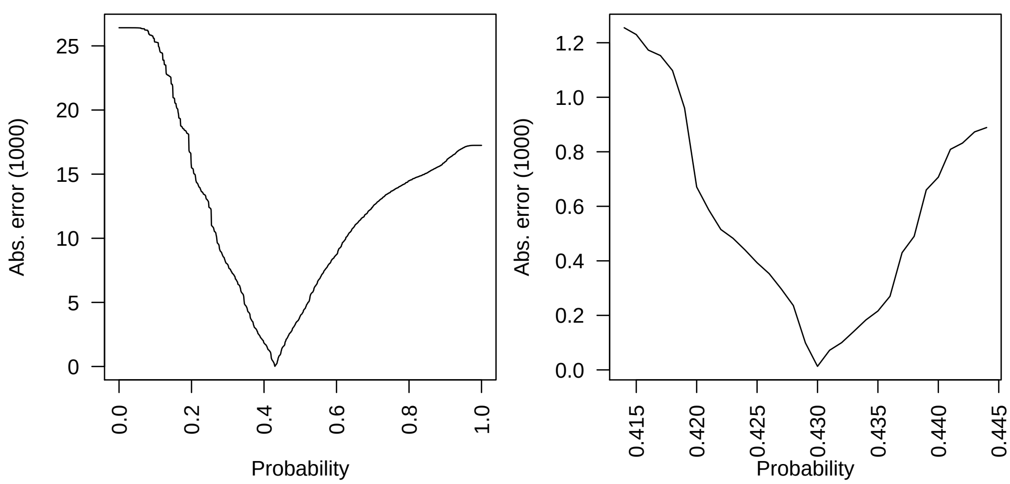


Figure 21. Absolute difference between observed and predicted number of positive trips from Stephens and MacCall method applied to logbook data from the southern region (south FL). Left and right panels differ only in the range of probabilities shown.

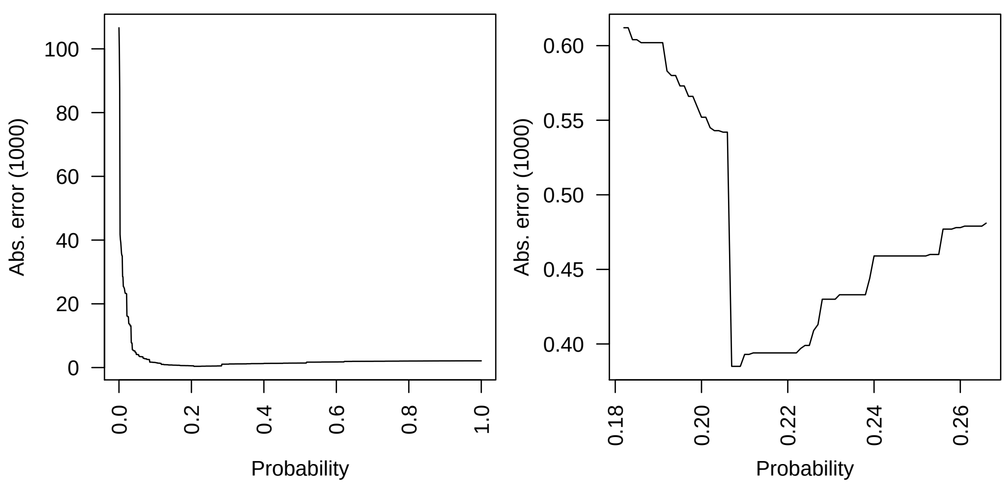


Figure 22. Diagnostics of Bernoulli submodel fits to positive versus zero CPUE data. Box-andwhisker plots give first, second (median), and third quartiles, as well as limbs that extend approximately one interquartile range beyond the nearest quartile, and outliers (circles) beyond the limbs. Residuals are randomized quantile residuals.

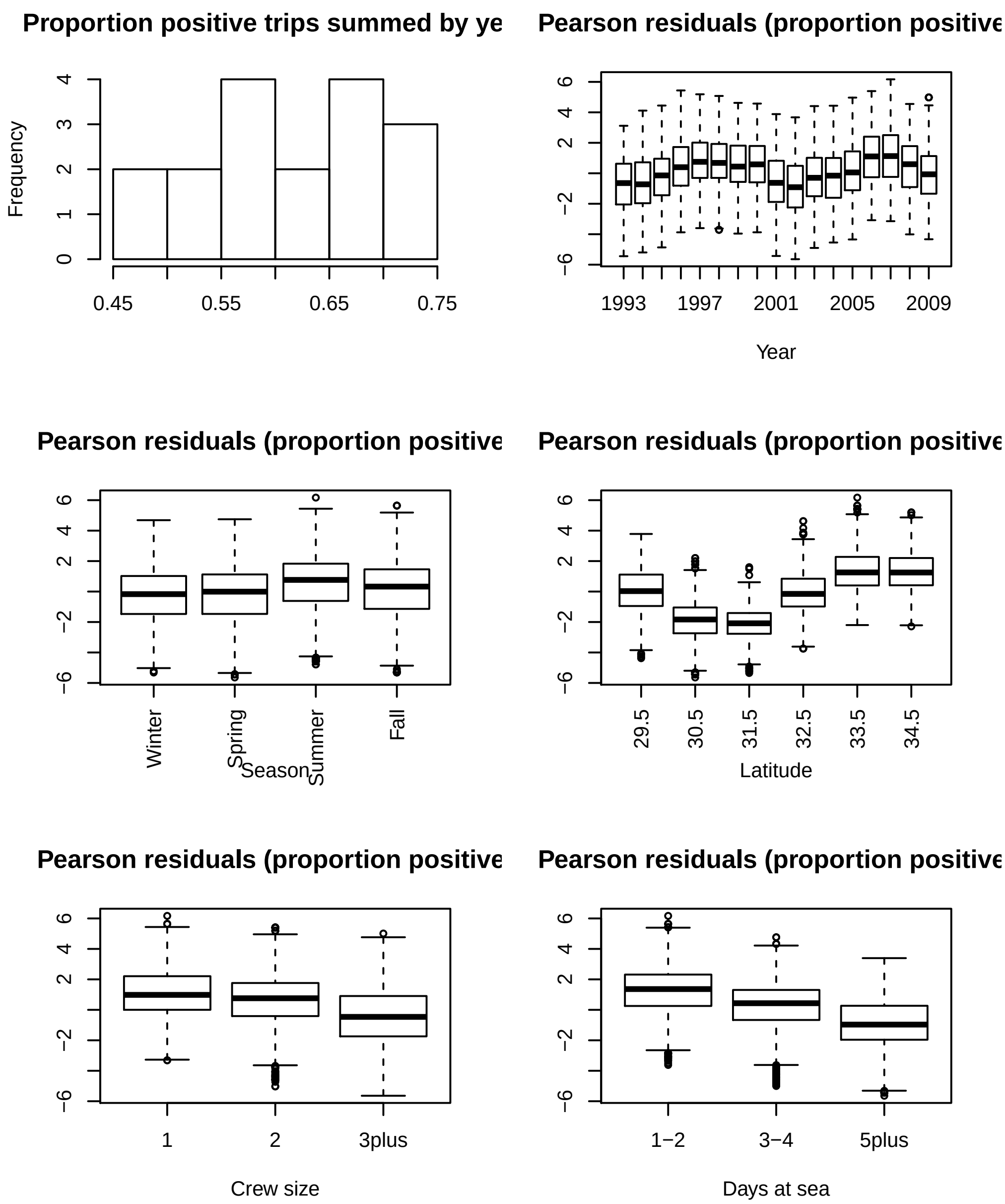


Figure 23. Diagnostics of lognormal submodel fits to positive CPUE data. Top left panel shows the histogram of empirical log CPUE, with the normal distribution (empirical mean and variance) overlaid. Box-and-whisker plots give first, second (median), and third quartiles, as well as limbs that extend approximately one interquartile range beyond the nearest quartile, and outliers (circles) beyond the limbs. Residuals are raw.

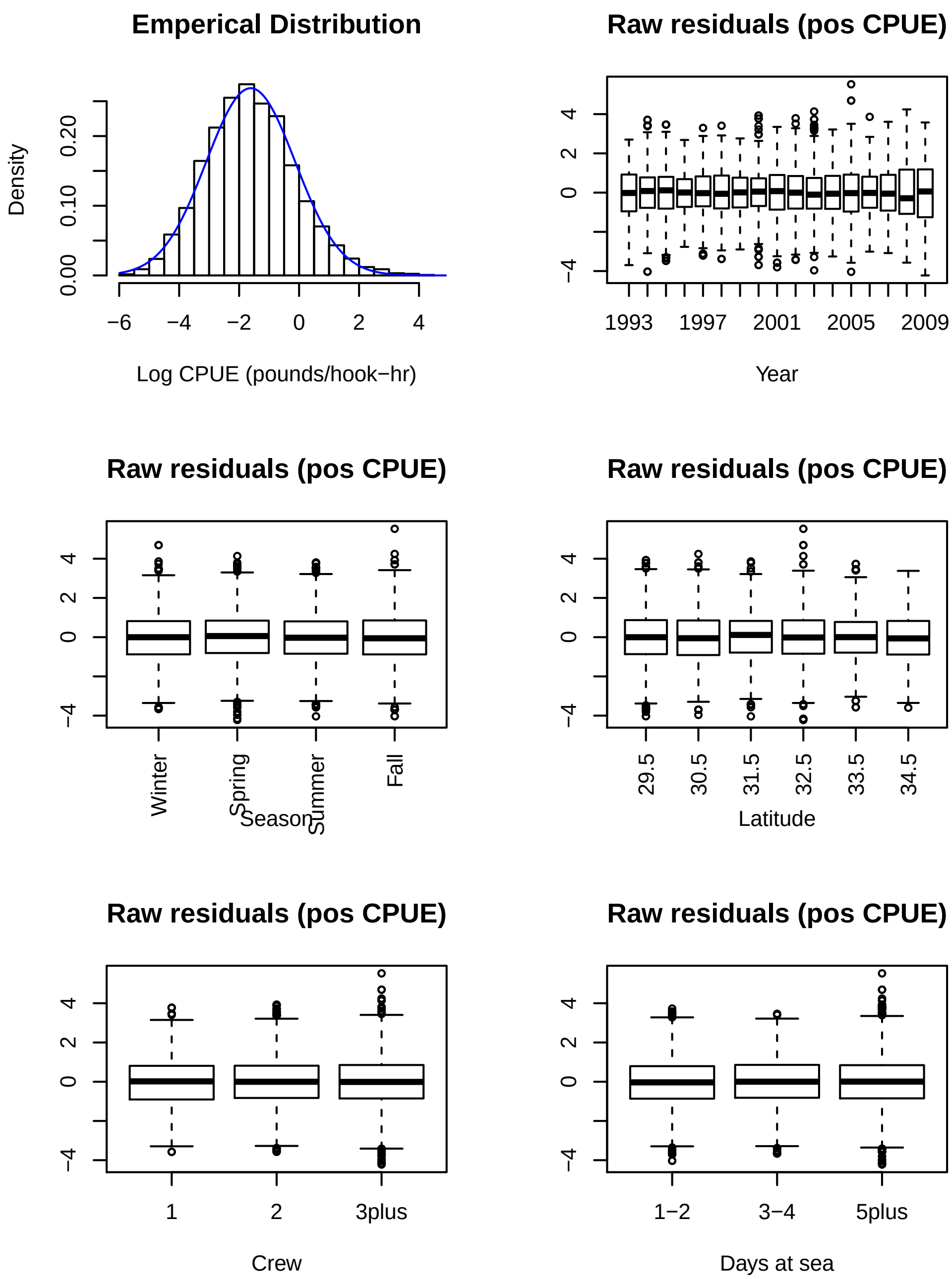


Figure 24. Quantile-quantile plot of residuals from the fitted lognormal submodel to the positive cpue data.

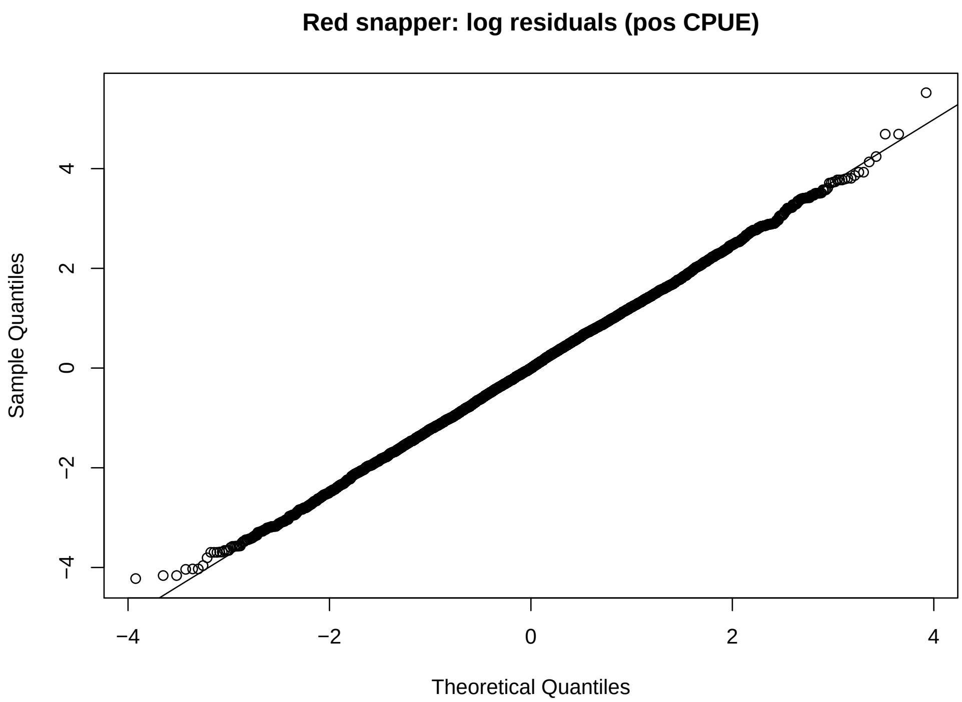


Figure 25. Red snapper handline mean nominal cpue (whole pounds/hook-hour) by year and latitude after applying the Stephens and MacCall method. The symbol size is relative to cpue.

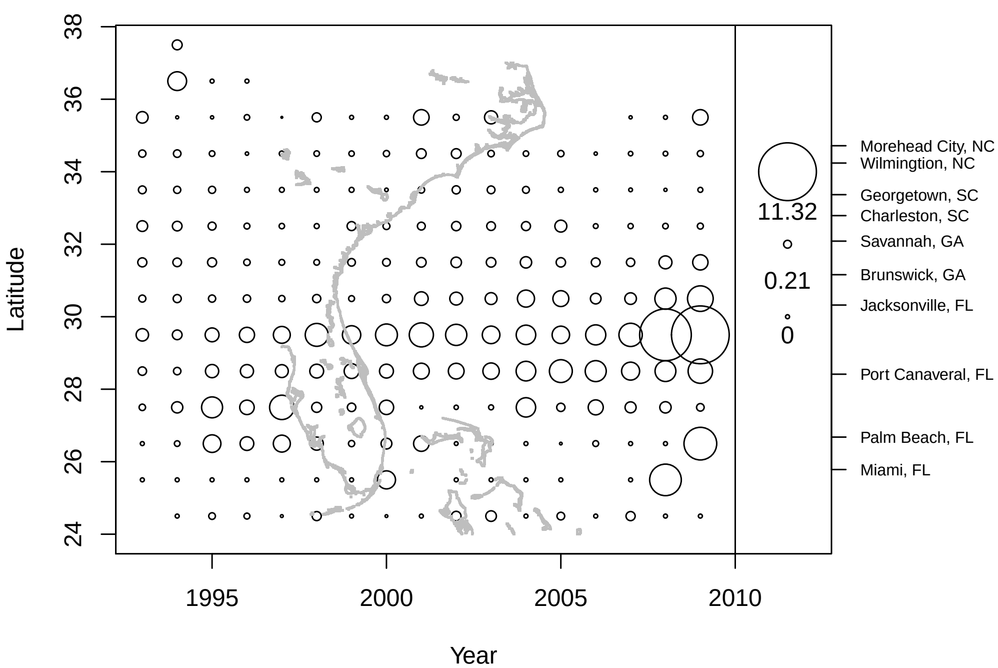
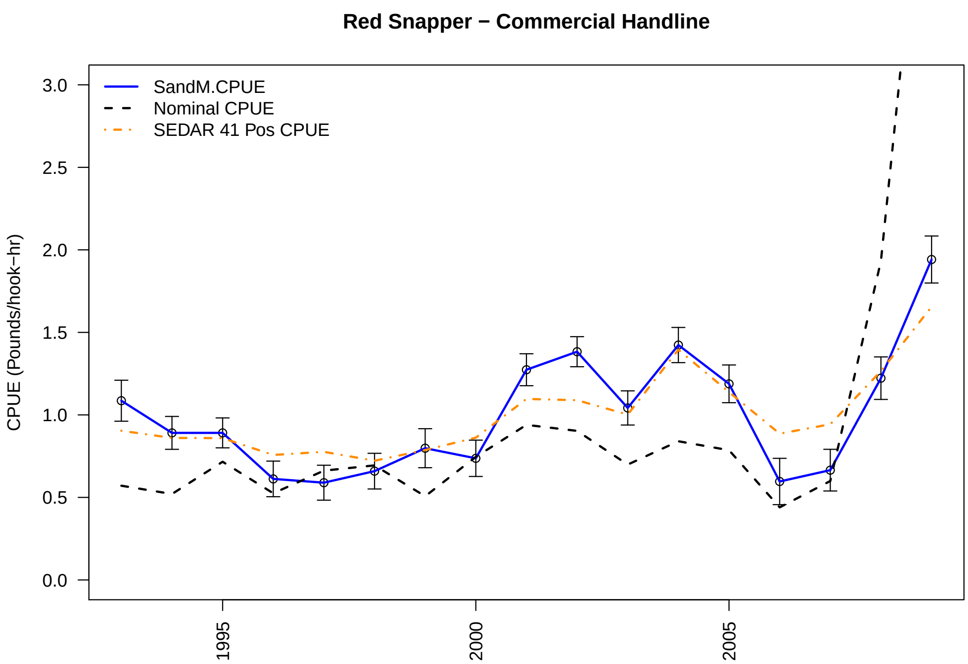


Figure 26. Relative standardized index (solid line, black circles, 95% error bars), relative nominal index (dashed), and alternative positive–only model (dash–dot).



2 Appendix A. The commercial logbook data set contains the following variables (all are numeric unless otherwise noted)

schedule: this is a unique identifier for each fishing trip and is a character variable

species: a character variable to identify species caught.

gear: a character variable, the gear type, multiple gear types may be used in a single trip, L = longline, H = handline, E = electric reels, B = buoy gear, GN = gill net, P = diver using power head gear, S = diver using spear gun, T = trap, TR = trolling

area: area fished, in the south Atlantic these codes have four digits- the first two are degrees of latitude and the second two are the degrees of longitude

totlbs: a derived variable that sums the gutted (with conversion factor) and whole weights, this is the total weight in pounds of the catch for a particular species, trip, gear, and area

length: length of longline (in miles) or gill net (in yards)

numgear: the amount of a gear used, number of lines (handlines, electric reels), number of sets (longlines), number of divers, number of traps, number of gill nets

fished: hours fished on a trip, this is problematic for longline data as discussed later

effort: like numgear, the data contained in this field depends upon gear type; number of hooks/line for handlines, electric reels, and trolling; number of hooks per longline for longlines; number of traps pulled for traps; depth of the net for gill nets, this field is blank for divers

vesid: a character variable, a unique identifier for each vessel

landed: numeric (mmddyy8) variable, date the vessel returned to port

unload: numeric (mmddyy8) variable, date the catch was unloaded

received: numeric (mmddyy8) variable, date the logbook form was received from the fisherman

away: number of days at sea, this value should equal (landed-started+1)

crew: number of crew members, including the captain

state: character variable, the state in which the catch was sold

area1 - area3: areas fished, if the trip included catch from multiple areas, those areas will be listed here