Notice on SEDAR Working Papers

Standardized catch rates of U.S. Atlantic red snapper (*Lutjanus campechanus*) from headboat data

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Background and Data Description

The headboat fishery in the south Atlantic includes for-hire vessels that typically accommodate 11-70 passengers and charge a fee per angler. The fishery uses hook and line gear, generally targets hard bottom reefs as the fishing grounds, and generally targets species in the snapper-grouper complex. This fishery is sampled separately from other fisheries, and the available data were used to generate a fishery dependent index, with the size and age range of fish the same as that of landings from the headboat fishery.

Headboats in the south Atlantic are sampled from North Carolina to the Florida Keys (Figure 1). Data have been collected since 1972, but logbook reporting did not start until 1973. In addition, only North Carolina and South Carolina were included in the earlier years of the data set. In 1976, data were collected from North Carolina, South Carolina, Georgia, and northern Florida, and starting in 1978, data were collected from southern Florida (areas 11, 12, and 17). Variables reported in the data set include year, month, day, area, location, trip type, number of anglers, species, catch, and vessel id. Biological data and discard data were recorded for some trips in some years.

Methods

Headboat records were examined, and the data were explored in order to determine if any confounding factors would have an effect on the ability of the index to reflect relative abundance. Catch-per-unit-effort (CPUE) standardization was then employed, and an index of abundance was computed for 1976-2009.

Data treatment

Data from 1972-1975 were dropped from the analysis because the data collected included only North Carolina and South Carolina. Thus, the data didn't include the primary location of red snapper (i.e., northern Florida). Data from area 1 (Figure 1) were excluded as this area was not recorded during most of the time series. The minimum number of anglers per vessel was set at 6, which excluded the lower 0.5% of trips. These trips were excluded because they were possibly misreported and likely don't reflect the behavior of headboats in general. Finally, outliers defined by the upper 0.5% of red snapper catch data were dropped as they likely represent misreporting.

Possible confounding factors

As part of the analysis, the data were explored in order to identify any factors that could confound inferences about relative abundance. As part of this exploration, two factors were considered: bag limit changes and size limit changes for the fishery.

The changes that have occurred in the past include:

- A 12" minimum size limit in August of 1983
- A 20" minimum size limit in January of 1992
- A bag limit of 10 snapper/person/day with no more than 2 red snapper in January of 1992

Changes in the minimum size limit did not result in changes in the computation of the headboat index because changes in the size limit can be accounted for with selectivity curves in the assessment model.

The bag limit change was explored in order to determine if bag limits impacted the catch of red snapper. In order to determine if change occurred, I examined the percentage of headboat trips where anglers caught 2 or more red snapper and contrasted this percentage before and after the bag limit change. This contrast was done for two regions: north (areas 2-10) and south (11, 12, and 17). Based on this exploration, harvest of red snapper did not change after the bag limit was instituted in 1992 (Table 1). Thus, this exploration suggests that CPUE of red snapper is unlikely to be influenced by bag limit regulations in the south Atlantic.

Subsetting trips

Trips to be included in the computation of the index need to be determined based on effort directed at red snapper. Effort can be determined directly for trips which had positive red snapper catches, but some trips likely directed effort at red snapper, but were unsuccessful at landing red snapper. Given that information on directed effort for trips without red snapper harvest is not available, another method must be used to compute total effort.

In order to determine effort that was likely directed at red snapper and which trips should be used to compute an index, the method of Stephens and MacCall (2004) was applied. The Stephens and MacCall 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. Species compositions differ across the south Atlantic; thus, the method was applied separately for two different regions: north (areas 2-10) and south (areas 11, 12, and 17; Shertzer and Williams 2009). To avoid computation errors, the number of species in each analysis was limited to those species that occurred in 1% or more of trips (Table 2). The most general model therefore included all species in the snapper-grouper complex which occurred in 1% or more of trips as main effects, excluding red porgy. Red porgy was eliminated because of regulation changes, which could erroneously remove trips likely to have caught red snapper in recent years. A backwards stepwise AIC procedure (Venables and Ripley 1997) was then used to perform further selection among possible species as predictor variables. In this procedure, a generalized linear model with Bernoulli response was used to relate presence/absence of red snapper in headboat trips to presence/absence of other species. For the northern area (areas 2-10), stepwise AIC eliminated Atlantic spadefish, bank sea bass, blue runner, and mutton snapper. For the southern area (areas 11, 12, and 17), stepwise AIC eliminated bar jack, black margate, bluestriped grunt, hogfish, jolthead porgy, knobbed porgy, mutton snapper, queen triggerfish, saucereye porgy, and schoolmaster. Regression coefficients for the remaining species were computed for the northern area (Figure 2) and for the southern area (Figure 3).

Finally, a trip was included as effort if the trip's probability of catching red snapper was higher than a threshold probability for the northern region (Figure 4) and for the southern region (Figure 5). The threshold was defined to be that which results in the same number of predicted and observed positive trips, as suggested by Stephens and MacCall (2004). The resulting data set, given the constraints and methods above, contained 46,404 trips in the northern region and 29,548 (64%) of those trips were positive, and 1,662 trips in the southern region and 413 (25%) of those trips were positive.

Response and explanatory variables
CPUE – Catch per unit effort (CPUE) has units of fish/angler-hour and was calculated as the number of red snapper caught divided by the number of anglers times the number of trip hours.

YEAR – A summary of the total number of trips with red snapper effort per year is provided in Table 3, and a summary of the total number of trips with positive red snapper catch per year is provided in Table 4. Following data subsetting, the number of records with positive red snapper effort ranged from 773 in 1997 to 2,091 in 1987, and the number of records with positive red snapper catch ranged from 377 in 1997 to 1,291 in 1985.

AREA – The total number of trips with positive red snapper effort by year and area is provided in Table 3 (Figure 6), and the total number of trips with positive red snapper catches by year and region is provided in Table 4. The proportion of trips with positive red snapper catch by area is provided in Figure 6. Most of the trips with positive red snapper catches occurred in north Florida and Georgia (GF; 80%), followed by South Carolina (SC; 13%), North Carolina (NC; 6%), and south Florida (SFL; 1%).

SEASON – The seasons were defined as winter (January, February, March), spring (April, May, June), summer (July, August, September) and fall (October, November, December). The total number of trips with red snapper effort was greatest in spring and summer, but the proportion of trips catching red snapper was consistent across seasons (Figure 7).

TRIP TYPE – Trips were originally labeled in the dataset according to whether they were half day, three quarters, full day, or multi-day trips. It was assumed that half day trips fished for 5 hours, three quarters day trips fished for 7 hours, full day trips fished for 9 hours, and multi-day trips fished for 12 hours/day. The proportions of three quarters and multi-day trips were relatively low but constant over time (Figure 8). Consistent with previous south Atlantic SEDARs (e.g. SEDAR 2008), multi-day trips were combined with full day trips and three quarters day trips were combined with half day trips as factor variables in the standardization process, while the original number of hours was retained for effort determinations. Based on the subsetted data, there were n=6,464 half/three-quarters day red grouper trips, and n=41,602 full/multi-day trips. Of these, 46% of half day trips and 65% of full day trips caught at least one red snapper.

ANGLERS – Based on subsetted data, most trips had fewer than 60 passengers (mean 35.2, median 33). Nominal CPUE appeared to decrease as a function of the number of anglers (Figure 9). As effort was summarized by angler-hours, the number of anglers was not independent of CPUE, and thus it should not be included directly as an explanatory variable. However, if headboat captain's behavior changes (e.g., fishing locations) as a function of the number of anglers (e.g., revenue to buy fuel, etc.), the number of anglers may be an important variable to consider. Therefore, I considered 2 categories for the number of anglers as factors in the standardization process. In particular, I considered the categories: small (6-30 anglers) and large (31+ anglers). The total number of trips and proportion of trips with positive red snapper catches over time by angler category is provided in Figure 10.

Standardization

I modeled CPUE using the delta-glm approach (cf., Lo et al. 1992; Dick 2004; Maunder and Punt 2004). In particular, I compared fits of lognormal and gamma models for positive CPUE, and examined which combination of predictor variables best explained CPUE patterns (both for positive CPUE and 0/1 CPUE). Jackknife estimates of variance were computed using the 'leave one out' estimator (Dick 2004). All analyses were performed in the R programming language, with much of the code adapted from Dick (2004).

BERNOULLI SUBMODEL

One 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 a particular trip. First, I fit a model with all main effects in order to determine which effects should remain in the binomial component of the delta-GLM. Stepwise AIC (Venables and Ripley1997) with a backwards selection algorithm was then used to eliminate those that did not improve model fit. In this case, the stepwise AIC procedure did not remove any predictor variables (Appendix 1). Recognizable patterns were not apparent in the randomized quantile residuals (Figures 11-16).

POSITIVE CPUE SUBMODEL

Then, to determine predictor variables important for predicting positive CPUE, I started by fitting the positive portion of the model with all main effects using both the lognormal and gamma distributions. Stepwise AIC (Venables and Ripley1997) with a backwards selection algorithm was then used to eliminate those that did not improve model fit. All predictor variables were modeled as fixed effects (and as factors rather than continuous variables). Backwards model selection eliminated only the trip type variable for the lognormal distribution (Appendix 1) and did not eliminate any of the predictor variables for the gamma distribution.

I then fit both components of the model together (with the code adapted from Dick 2004) using the lognormal and gamma distributions and compared them using AIC. With CPUE as the dependent variable, the lognormal distribution outperformed the gamma distribution with lower AIC (ΔAIC >1,000) values when all factors were included and when using only those factors that were selected in the previous step.

Thus, the lognormal model with all factors except trip type was used for computing the positive component of the index, and the binomial with all factors was used for computing the Bernoulli component of the index. Standard model diagnostics (Figures 17-21) appeared reasonable for the positive component of the model using raw residuals (Dunn and Smyth 1996).

Index
The distribution of log CPUE for the index appeared reasonable (Figure 22), as did the QQ plot of the residuals (Figure 23). The nominal CPUE for all areas most closely resembles the nominal CPUE for Georgia and north Florida (Figure 24). The index is presented in Table 5 and visually in Figure 25.

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Table 1. Proportion of trips with positive red snapper catches that had two or more red snapper per angler for both the northern regions (areas 2-10) and the southern region (areas 11, 12, and 17).

Year	North	South
1976	0.099	
1977	0.058	
1978	0.067	0.000
1979	0.055	0.000
1980	0.032	0.000
1981	0.047	0.000
1982	0.012	0.031
1983	0.023	0.011
1984	0.034	0.015
1985	0.026	0.014
1986	0.003	0.014
1987	0.007	0.000
1988	0.011	0.065
1989	0.008	0.045
1990	0.012	0.059
1991	0.006	0.050
1992	0.010	0.000
1993	0.002	0.014
1994	0.007	0.022
1995	0.004	0.000
1996	0.004	0.000
1997	0.002	0.000
1998	0.002	0.056
1999	0.004	0.063
2000	0.005	0.000
2001	0.026	0.040
2002	0.052	0.091
2003	0.010	0.000
2004	0.008	0.000
2005	0.006	0.000
2006	0.009	0.000
2007	0.005	0.000
2008	0.019	0.000
2009	0.013	0.008

Table 2. All species (common names) in the snapper-grouper complex in the south Atlantic, and species retained from the snapper-grouper complex and included in logistic regressions for the Stephens-MacCall method for the northern region (areas 2-10) and southern region (11, 12, and 17). Species were included if they appeared in the catch records of 1% or more of headboat trips (red porgy was removed because of strict regulations).

Full snapper-grouper list		North	South
Almaco jack	Ocean triggerfish	Almaco jack	Almaco jack
Atlantic spadefish	Porkfish	Atlantic spadefish	Bar jack
Banded rudderfish	Puddingwife	Banded rudderfish	Blackfin snapper
Bank sea bass	Queen snapper	Bank sea bass	Black grouper
Bar jack	Queen triggerfish	Black sea bass	Black margate
Black grouper	Red grouper	Blue runner	Black sea bass
Black margate	Red hind	Cubera snapper	Blue runner
Black sea bass	Red porgy	Gag grouper	Bluestriped grunt
Black snapper	Red snapper	Gray snapper	French grunt
Blackfin snapper	Rock hind	Gray triggerfish	Gag grouper
Blue runner	Rock sea bass	Graysby	Graysby
Blueline tilefish	Sailors choice	Greater amberjack	Gray snapper
Bluestriped grunt	Sand tilefish	Jolthead porgy	Gray triggerfish
Coney	Saucereye porgy	Knobbed porgy	Greater amberjack
Cottonwick	Scamp	Lane snapper	Hogfish
Crevalle jack	Schoolmaster	Longspine porgy	Jolthead porgy
Cubera snapper	Scup	Mutton snapper	Knobbed porgy
Dog snapper	Sheepshead	Queen triggerfish	Lane snapper
French grunt	Silk snapper	Red grouper	Margate
Gag grouper	Smallmouth grunt	Red hind	Mutton snapper
Goliath grouper	Snowy grouper	Rock hind	Ocean triggerfish
Grass porgy	Spanish grunt	Scamp	Porkfish
Gray snapper	Speckled hind	Scup	Queen triggerfish
Gray triggerfish	Tiger grouper	Snowy grouper	Red grouper
Graysby	Tilefish	Speckled hind	Red hind
Greater amberjack	Tomtate	Tomtate	Rock hind
Hogfish	Vermilion snapper	Vermilion snapper	Sand tilefish
Jolthead porgy	Warsaw grouper	Warsaw grouper	Saucereye porgy
Knobbed porgy	White grunt	White grunt	Scamp
Lane snapper	Whitebone porgy	Whitebone porgy	Schoolmaster
Lesser amberjack	Wreckfish	Yellowtail snapper	Silk snapper
Longspine porgy	Yellow jack		Tomtate
Mahogany snapper	Yellowedge grouper		Vermilion snapper
Margate	Yellowfin grouper		Whitebone porgy
Misty grouper	Yellowmouth grouper		White grunt
Mutton snapper	Yellowtail snapper		Yellowtail snapper
Nassau grouper			

Table 3. The total number of trips with red snapper effort per year for each region.

Year	NC	SC	GA-NFL	SFL	Total
1976	144	226	440	-	810
1977	62	177	576	-	815
1978	147	236	1041	4	1428
1979	162	77	967	33	1239
1980	115	177	989	57	1338
1981	106	50	821	75	1052
1982	191	217	858	65	1331
1983	175	207	1108	70	1560
1984	84	189	1057	93	1423
1985	79	247	1181	162	1669
1986	97	247	1484	190	2018
1987	116	310	1487	178	2091
1988	119	348	1466	97	2030
1989	49	192	1062	51	1354
1990	66	252	1075	24	1417
1991	142	284	982	12	1420
1992	244	227	1519	67	2057
1993	178	259	1388	59	1884
1994	182	224	1101	59	1566
1995	182	209	1042	25	1458
1996	173	198	697	20	1088
1997	120	113	527	13	773
1998	210	209	1125	6	1550
1999	164	206	1166	5	1541
2000	188	202	982	15	1387
2001	157	274	1051	14	1496
2002	167	274	952	11	1404
2003	123	154	779	17	1073
2004	197	269	898	20	1384
2005	90	182	902	25	1199
2006	98	213	854	30	1195
2007	69	271	988	39	1367
2008	97	170	941	50	1258
2009	105	124	1086	76	1391
Total	4598	7214	34592	1662	48066

Table 4. The total number of trips with positive red snapper catch per year for each region.

Year	NC	SC	GA-NFL	SFL	Total
1976	37	116	417	-	570
1977	32	61	514	-	607
1978	68	96	888	1	1053
1979	79	31	778	3	891
1980	49	104	752	11	916
1981	68	26	738	29	861
1982	110	112	710	6	938
1983	90	107	947	8	1152
1984	37	124	851	21	1033
1985	39	163	1043	46	1291
1986	62	110	953	27	1152
1987	45	149	1012	25	1231
1988	63	192	885	16	1156
1989	21	127	823	4	975
1990	21	168	806	2	997
1991	49	137	670	0	856
1992	75	110	392	17	594
1993	80	208	411	16	715
1994	55	135	569	22	781
1995	56	103	601	6	766
1996	41	59	425	8	533
1997	24	31	319	3	377
1998	32	80	665	1	778
1999	61	137	690	0	888
2000	55	86	643	7	791
2001	103	170	720	3	996
2002	96	205	664	2	967
2003	46	112	534	0	692
2004	42	168	725	2	937
2005	8	83	753	6	850
2006	11	69	606	12	698
2007	2	86	722	31	841
2008	22	65	856	26	969
2009	33	34	990	52	1109
Total	1712	3764	24072	413	29961

Table 5. The relative nominal CPUE, number of trips with positive effort, portion of trips with positive red snapper catches, standardized index, and CV for the headboat fishery in the south Atlantic.

Year	Relative nominal CPUE	N	Proportion N positive	Standardized index	CV (index)
1976	2.333825	810	0.703704	2.301045	0.068914
1977	2.384366	815	0.744785	2.241804	0.066364
1978	2.410424	1428	0.737395	2.113801	0.051756
1979	2.467378	1239	0.719128	2.118015	0.055641
1980	1.443451	1338	0.684604	1.418691	0.052292
1981	2.429863	1052	0.818441	2.87604	0.051011
1982	0.90684	1331	0.704733	1.139134	0.049624
1983	1.274623	1560	0.738462	1.528256	0.047318
1984	1.42886	1423	0.725931	1.308457	0.051759
1985	1.835491	1669	0.773517	1.991512	0.046176
1986	0.536642	2018	0.570862	0.474538	0.052209
1987	0.599761	2091	0.588714	0.559273	0.049132
1988	0.742369	2030	0.569458	0.539267	0.05508
1989	1.052822	1354	0.720089	0.912407	0.054955
1990	0.91514	1417	0.703599	0.836733	0.051824
1991	0.748394	1420	0.602817	0.654579	0.055796
1992	0.142847	2057	0.28877	0.078295	0.073775
1993	0.284973	1884	0.379512	0.150414	0.071758
1994	0.320607	1566	0.498723	0.259337	0.065835
1995	0.357311	1458	0.525377	0.277886	0.063292
1996	0.230882	1088	0.48989	0.253117	0.068558
1997	0.240769	773	0.48771	0.265594	0.08029
1998	0.286379	1550	0.501935	0.235547	0.059401
1999	0.363517	1541	0.576249	0.298236	0.058135
2000	0.4535	1387	0.570296	0.418363	0.060791
2001	0.743353	1496	0.665775	0.803709	0.059722
2002	0.86125	1404	0.688746	0.963951	0.059374
2003	0.53248	1073	0.644921	0.530603	0.065141
2004	0.747897	1384	0.677023	0.829492	0.05305
2005	0.640722	1199	0.708924	0.803434	0.055258
2006	0.550719	1195	0.5841	0.454168	0.062385
2007	0.510477	1367	0.615216	0.462045	0.055522
2008	1.689744	1258	0.77027	1.858984	0.049069
2009	1.532322	1391	0.797268	2.043275	0.045586

Figure 1. Spatial sampling strata from the headboat survey off the southeast Atlantic coast of the U.S. The northern region consisted of areas 2-10, and the southern region consisted of areas 11, 12, and 17.

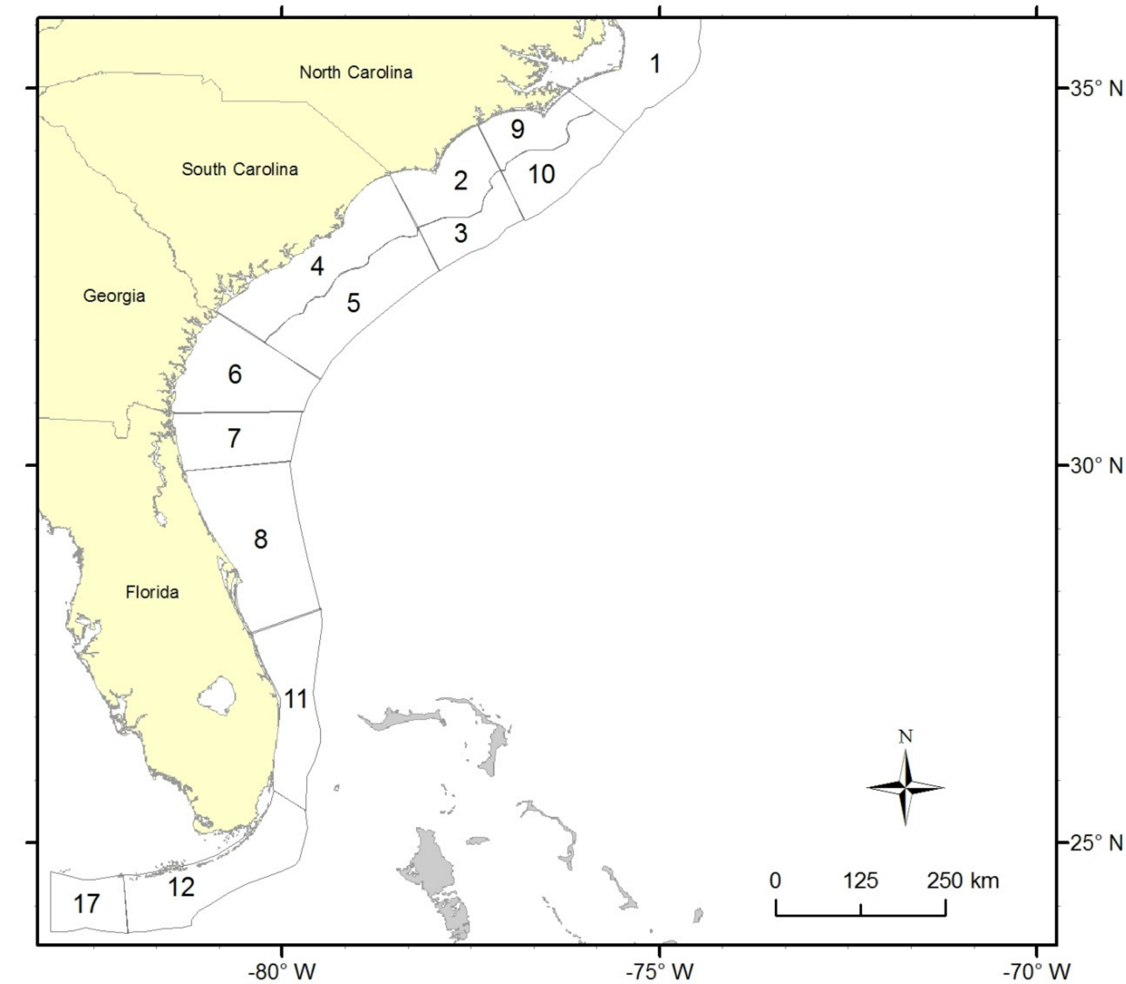


Figure 2. Estimates of species-specific regression coefficients from Stephens and MacCall method applied to headboat data from areas in the northern region (excludes areas 11, 12, and 17), as used to estimate each trip's probability of catching the focal species.

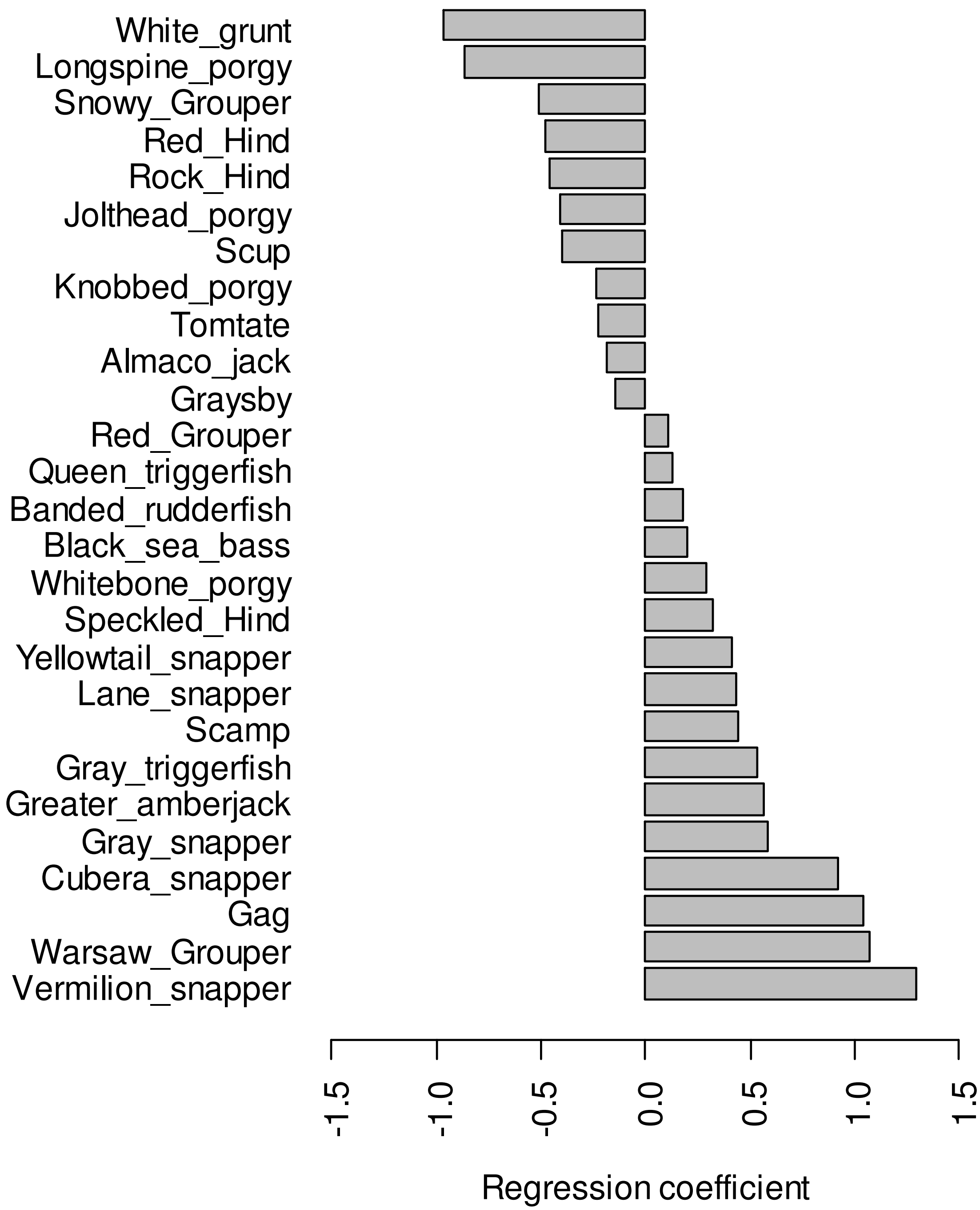


Figure 3. Estimates of species-specific regression coefficients from Stephens and MacCall method applied to headboat data from areas in the southern region (includes areas 11, 12, and 17), as used to estimate each trip's probability of catching the focal species.

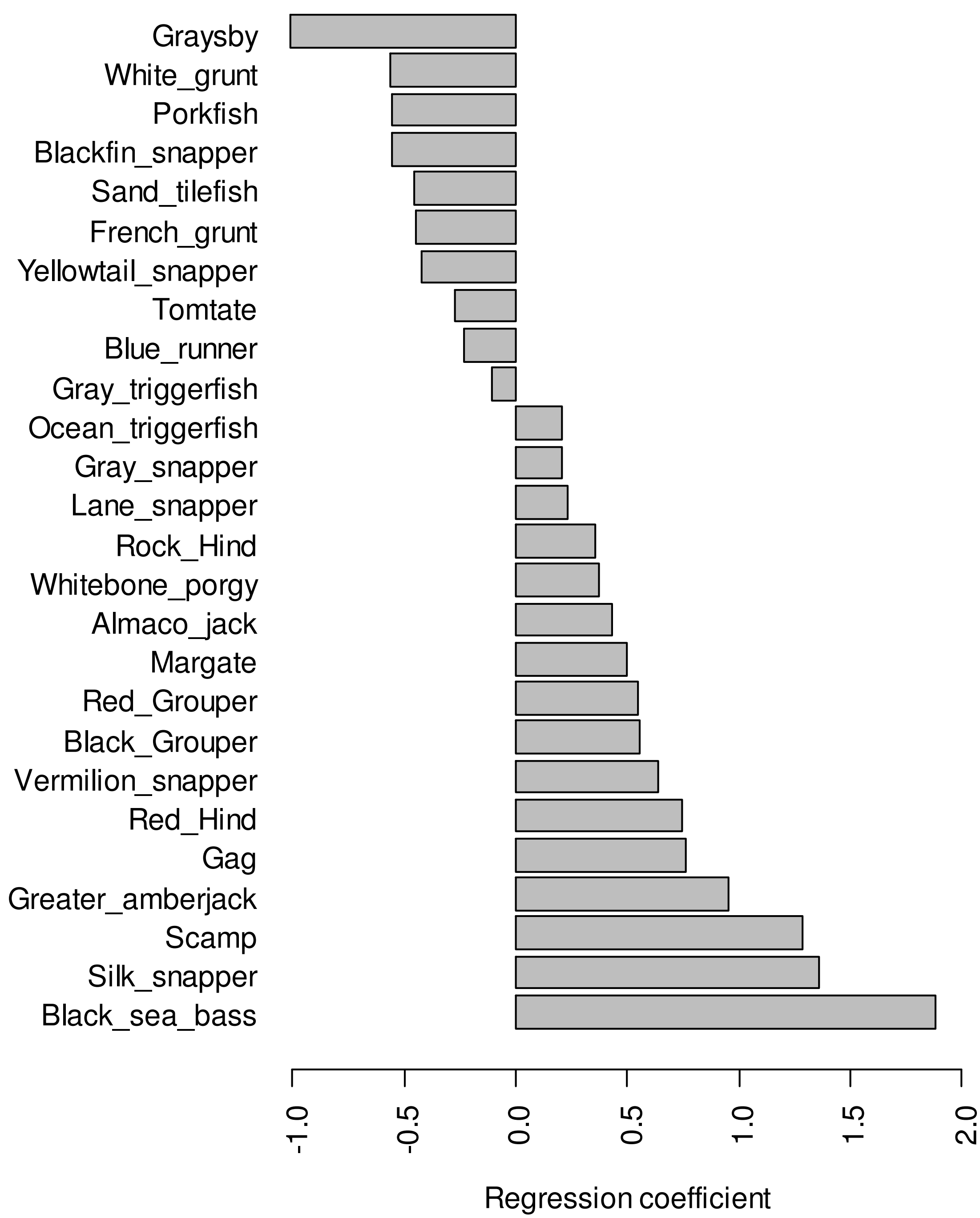


Figure 4. Absolute difference between observed and predicted number of positive trips from Stephens and MacCall method applied to headboat data from the northern region (excludes areas 11, 12, and 17). Left and right panels differ only in the range of probabilities shown.

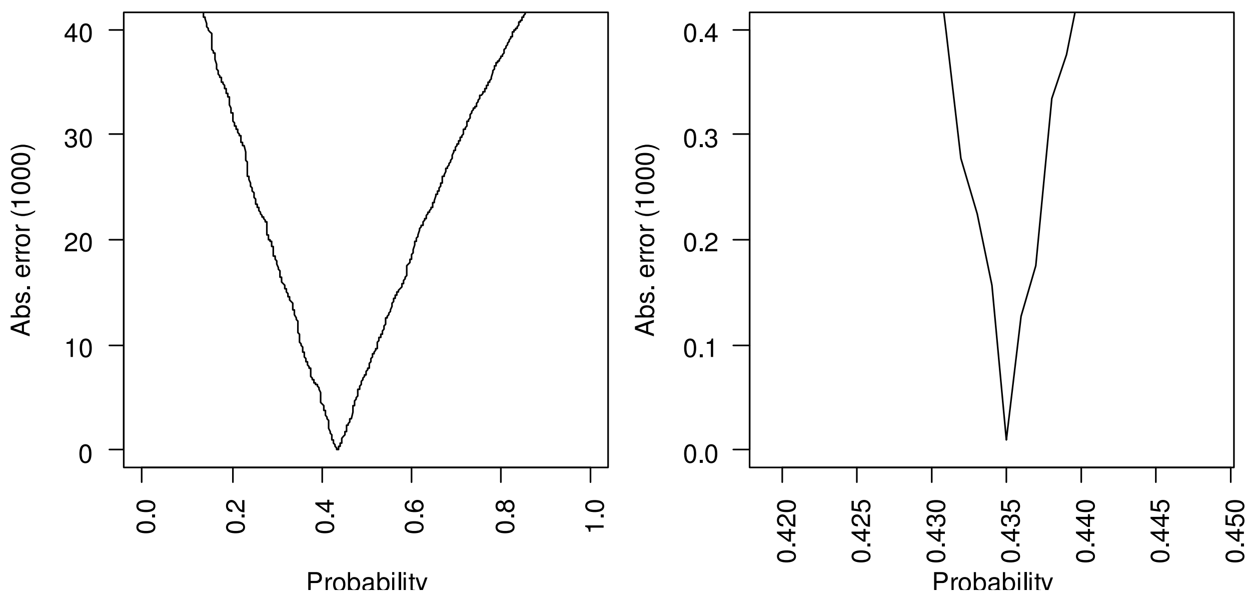


Figure 5. Absolute difference between observed and predicted number of positive trips from Stephens and MacCall method applied to headboat data from the southern region (includes areas 11, 12, and 17). Left and right panels differ only in the range of probabilities shown.

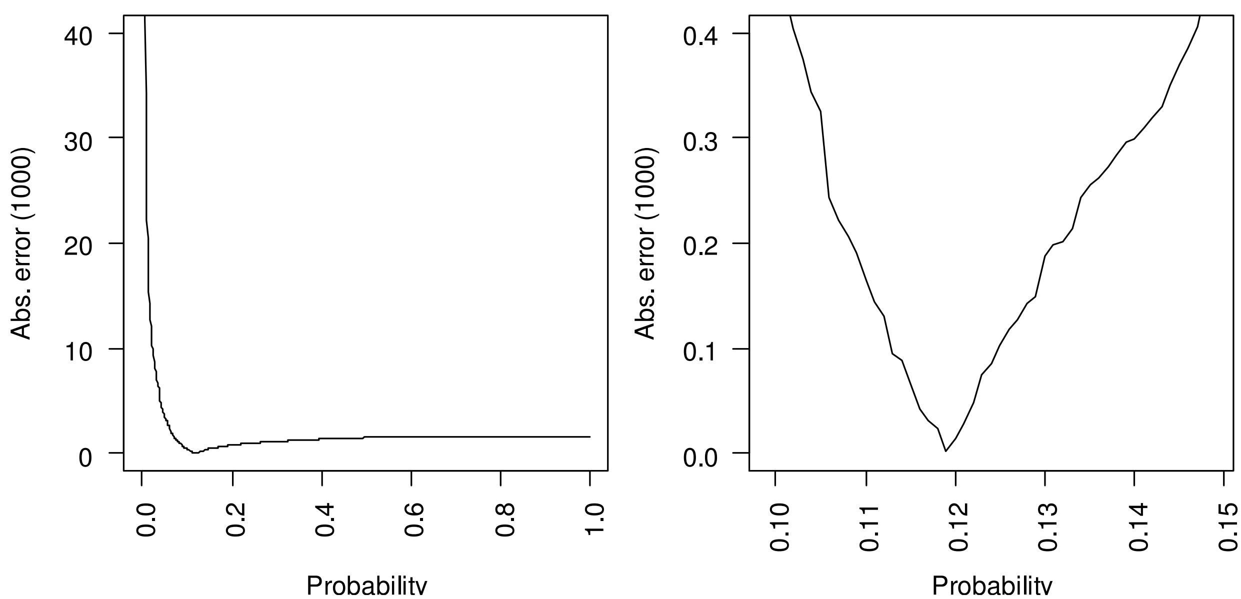


Figure 6. Total number of trips with positive red snapper effort by area (upper panel), and the proportion of trips which had positive red snapper catch by area (lower panel), where NC contains areas 2, 3, 9, and 10; SC contains areas 4 and 5; GF contains areas 6, 7, and 8; and SF contains areas 11, 12, and 17..

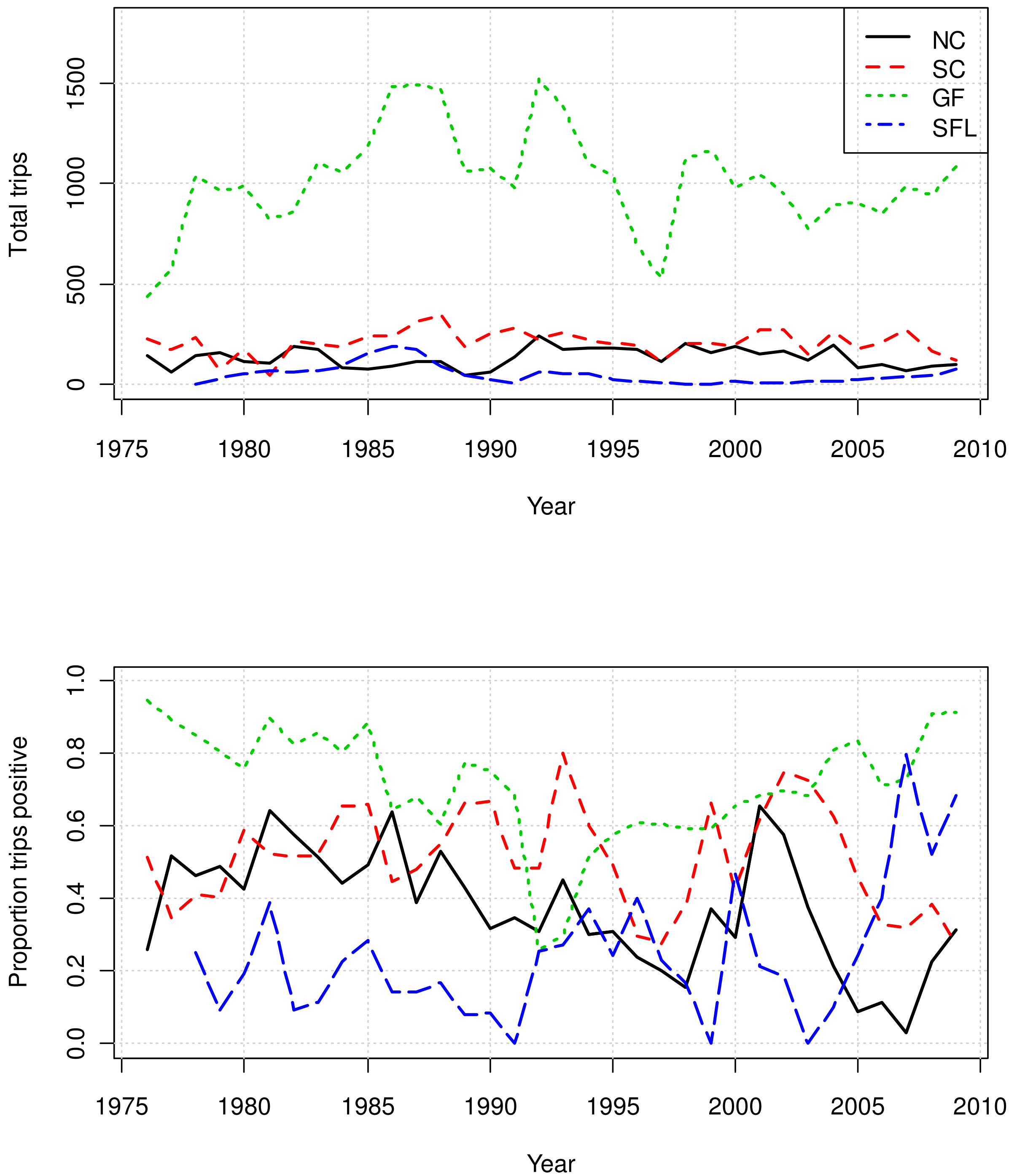


Figure 7. Total number of trips with positive red snapper effort by season (upper panel), and the proportion of trips which had positive red snapper catch by season (lower panel).

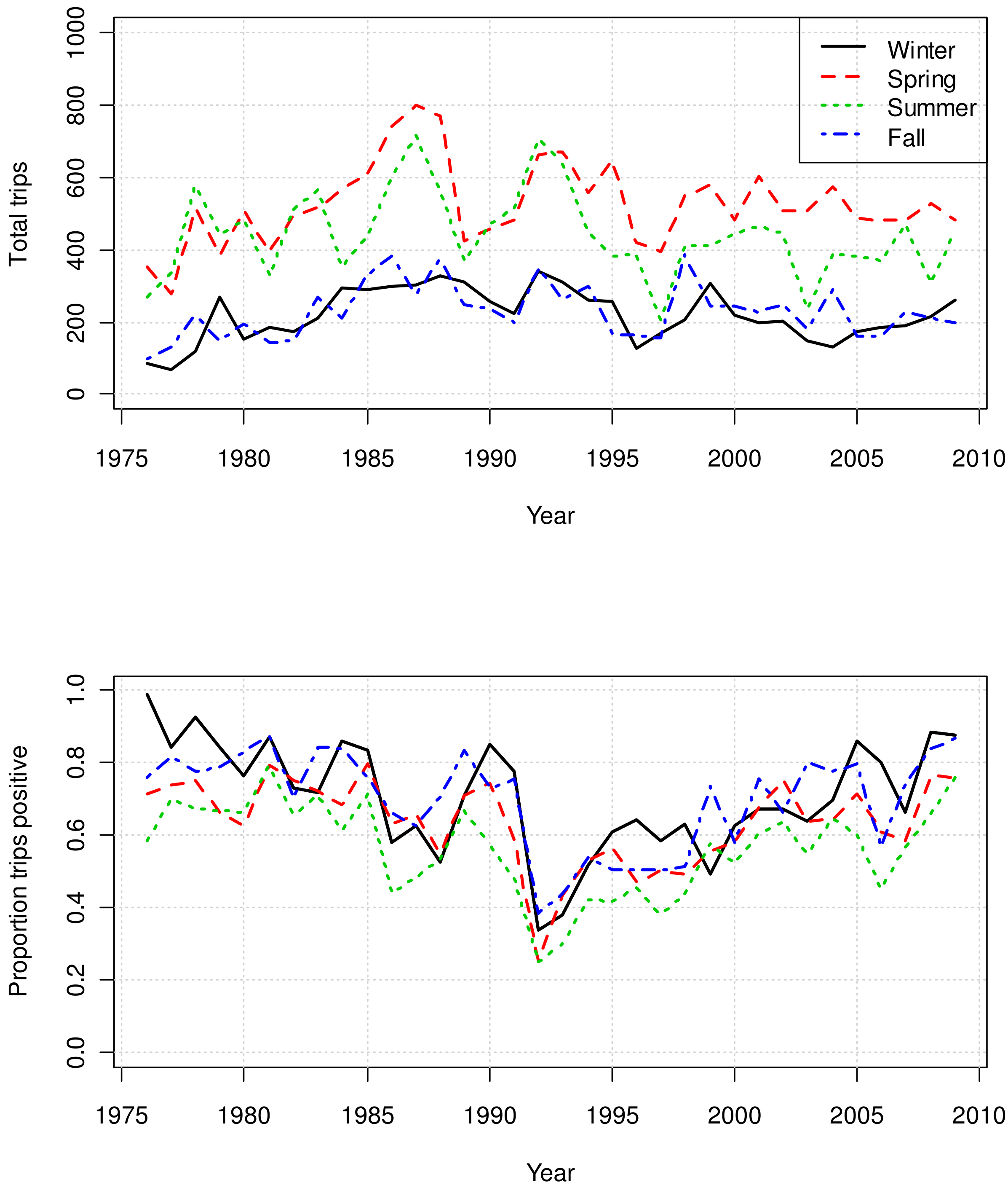


Figure 8. The proportion of full, half, three quarters, and multi-day trips from the entire headboat data set over time.

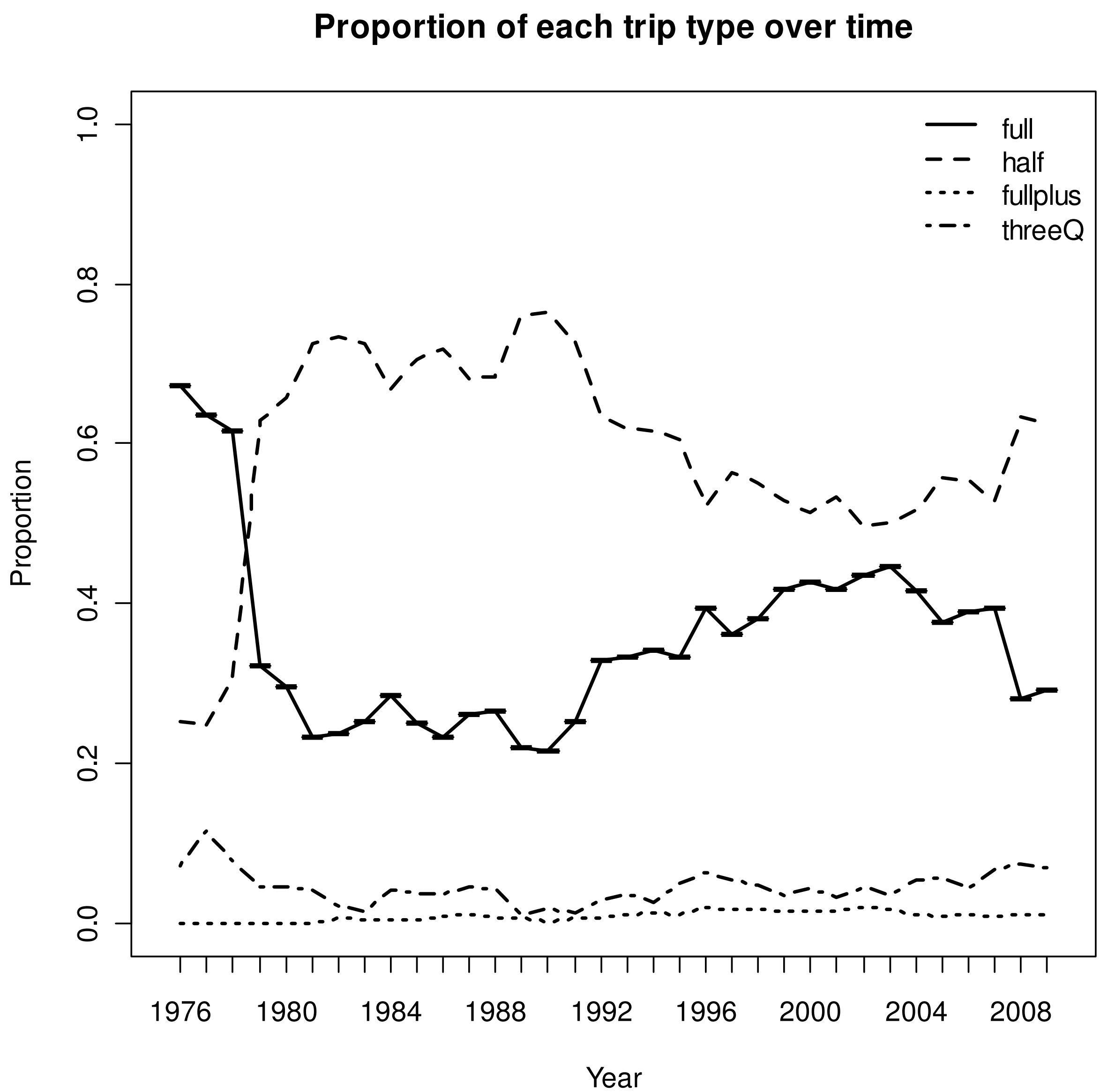


Figure 9. The catch per angler-hour as a function of the number of anglers.

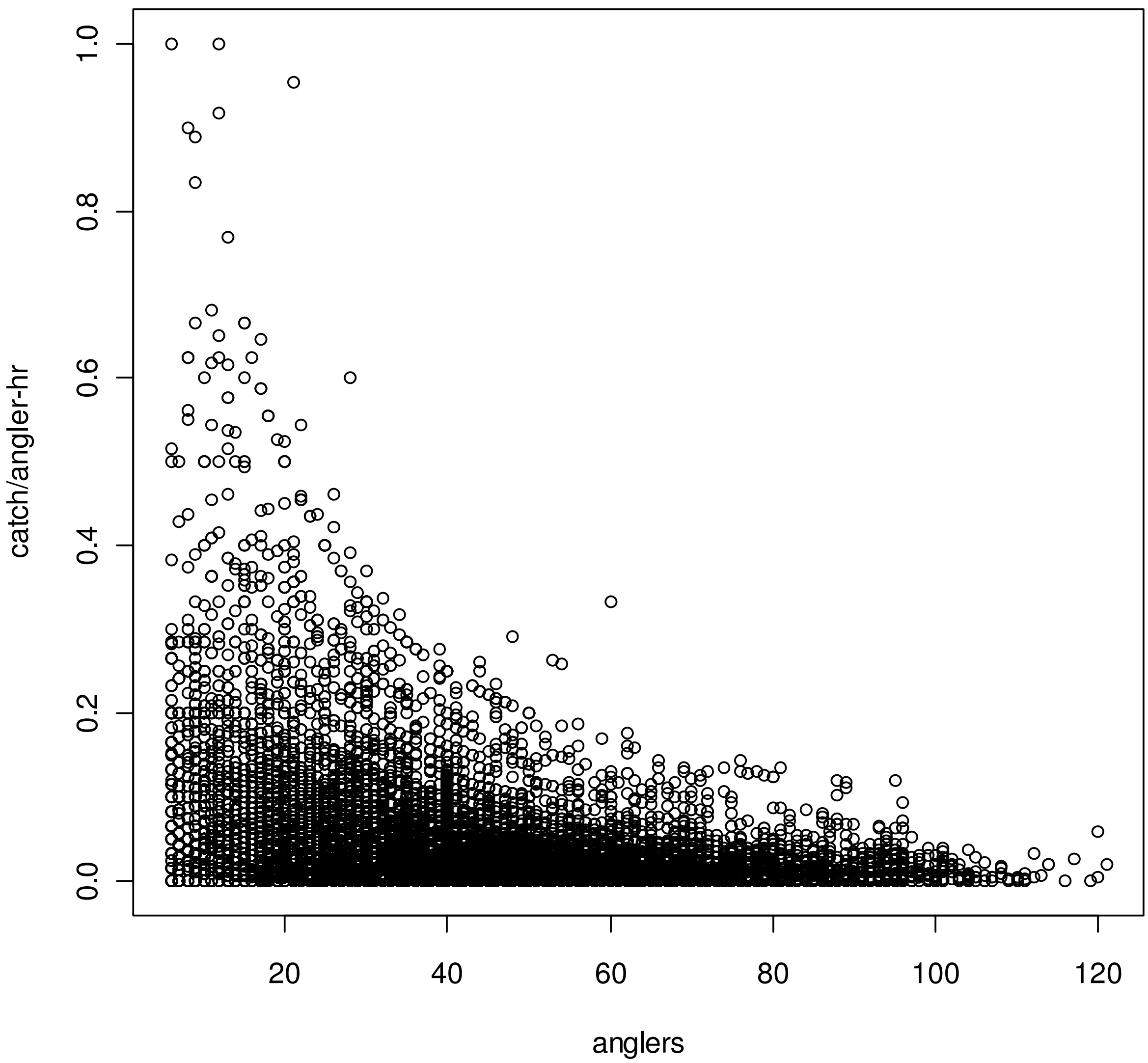


Figure 10. The number of total trips and the proportion of trips positive over time for boats with different levels of anglers (small: 6-30 anglers, and large: 31+ anglers).

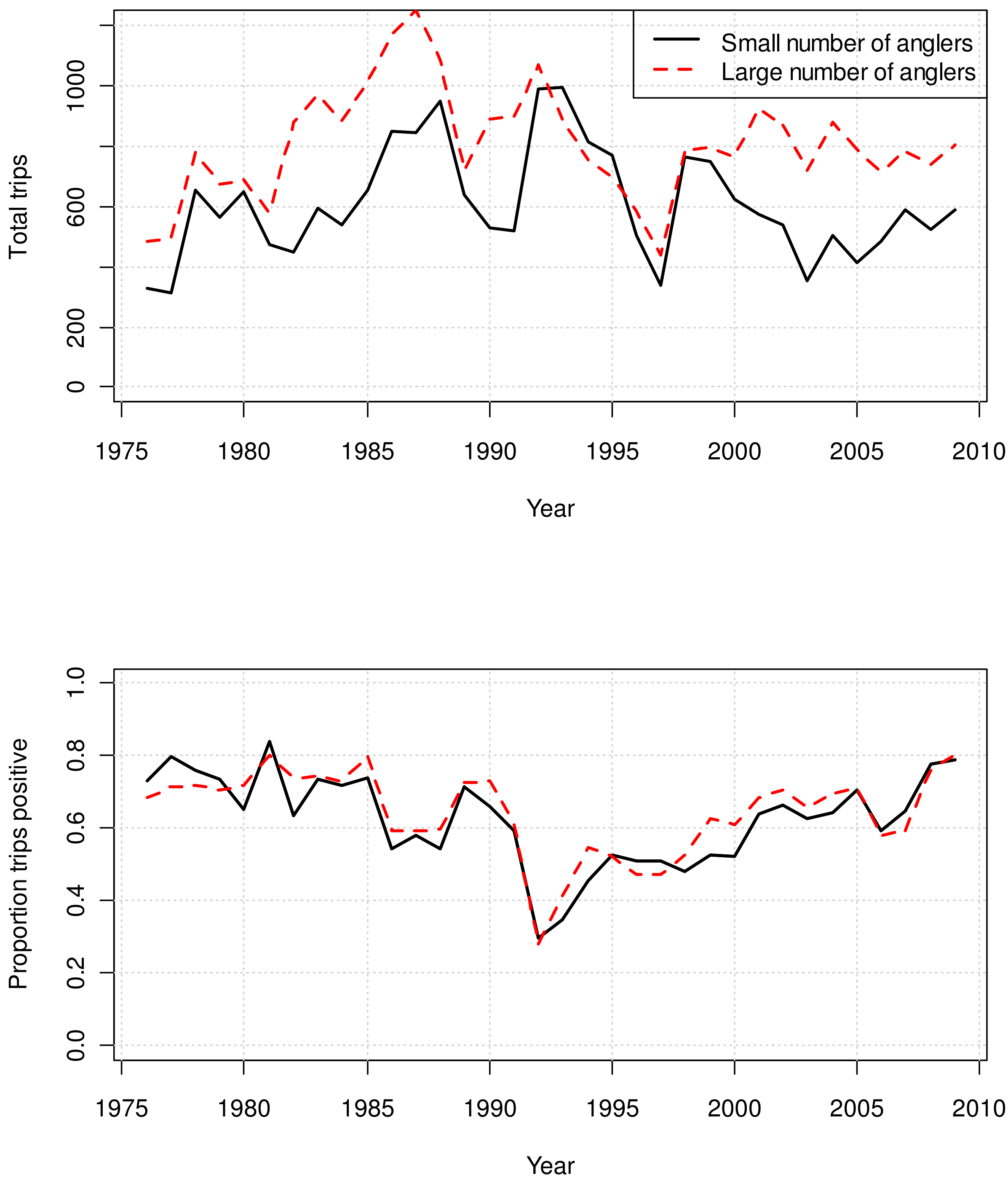


Figure 11. The proportion of trips, which had positive catches of red snapper, summed by year.

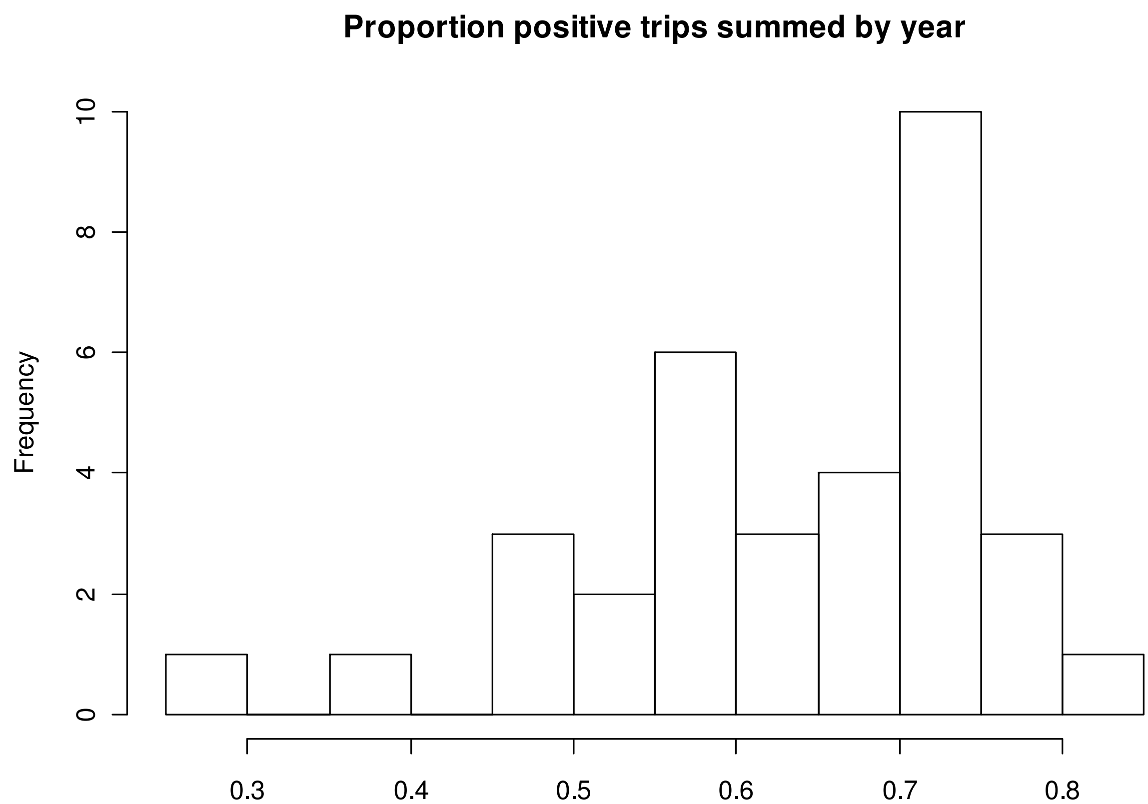


Figure 12. Standardized (quantile) residuals from the binomial portion of the index during 1976-2009.

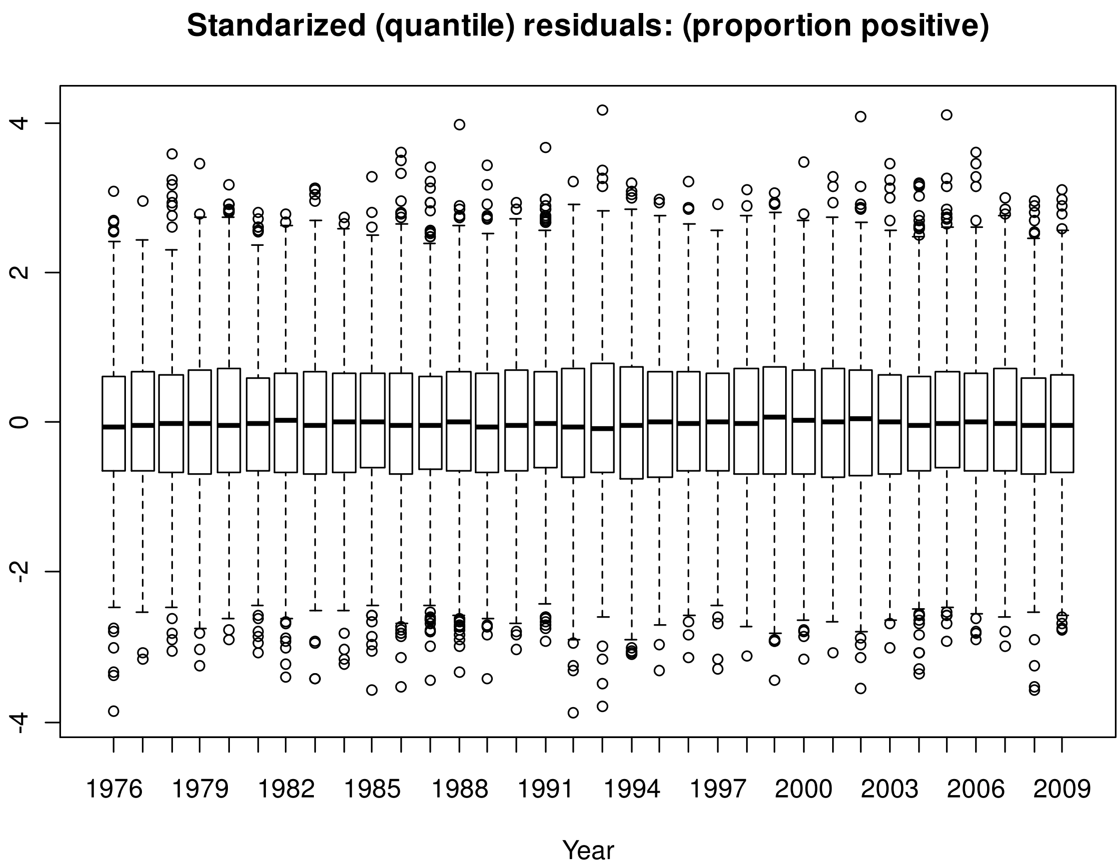


Figure 13. Standardized (quantile) residuals from the binomial portion of the index across the explanatory variable season, where winter is January-March, spring is April-June, summer is July-September, and fall is October-December.

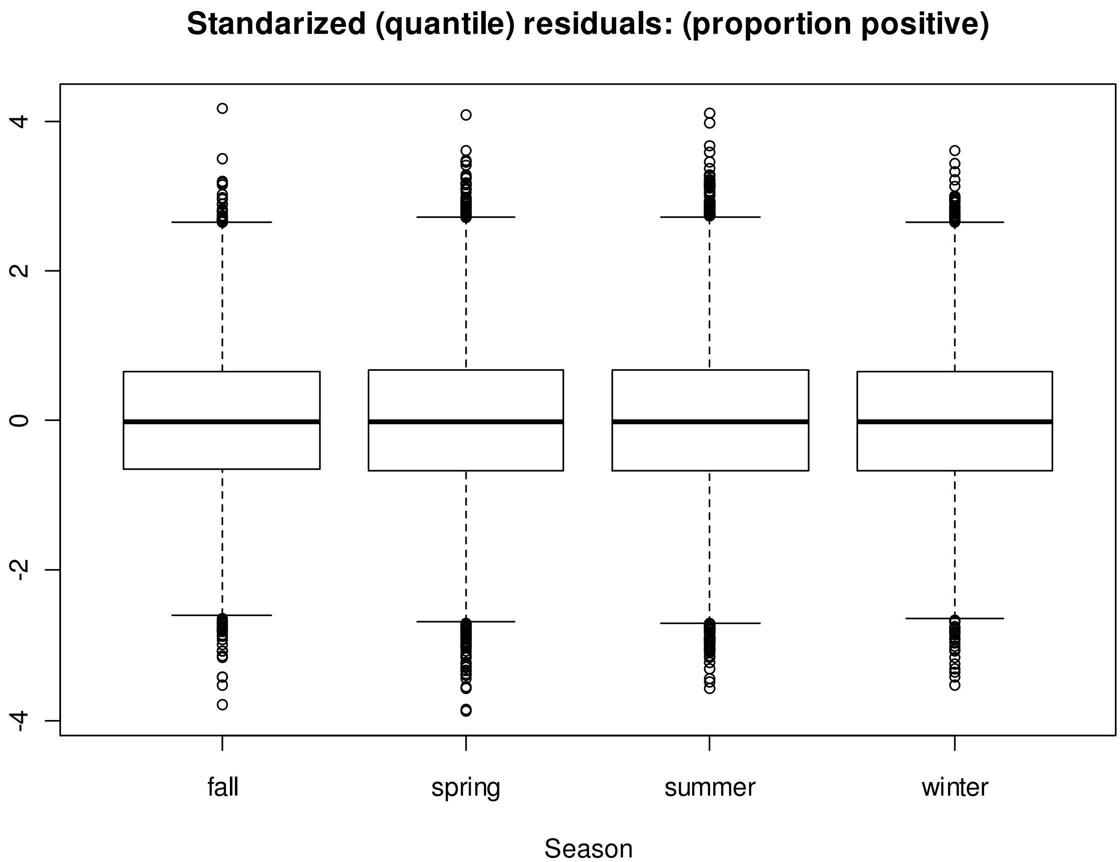


Figure 14. Standardized (quantile) residuals from the binomial portion of the index across the explanatory variable area, where NC contains areas 2, 3, 9, and 10; SC contains areas 4 and 5; GF contains areas 6, 7, and 8; and SF contains areas 11, 12, and 17.

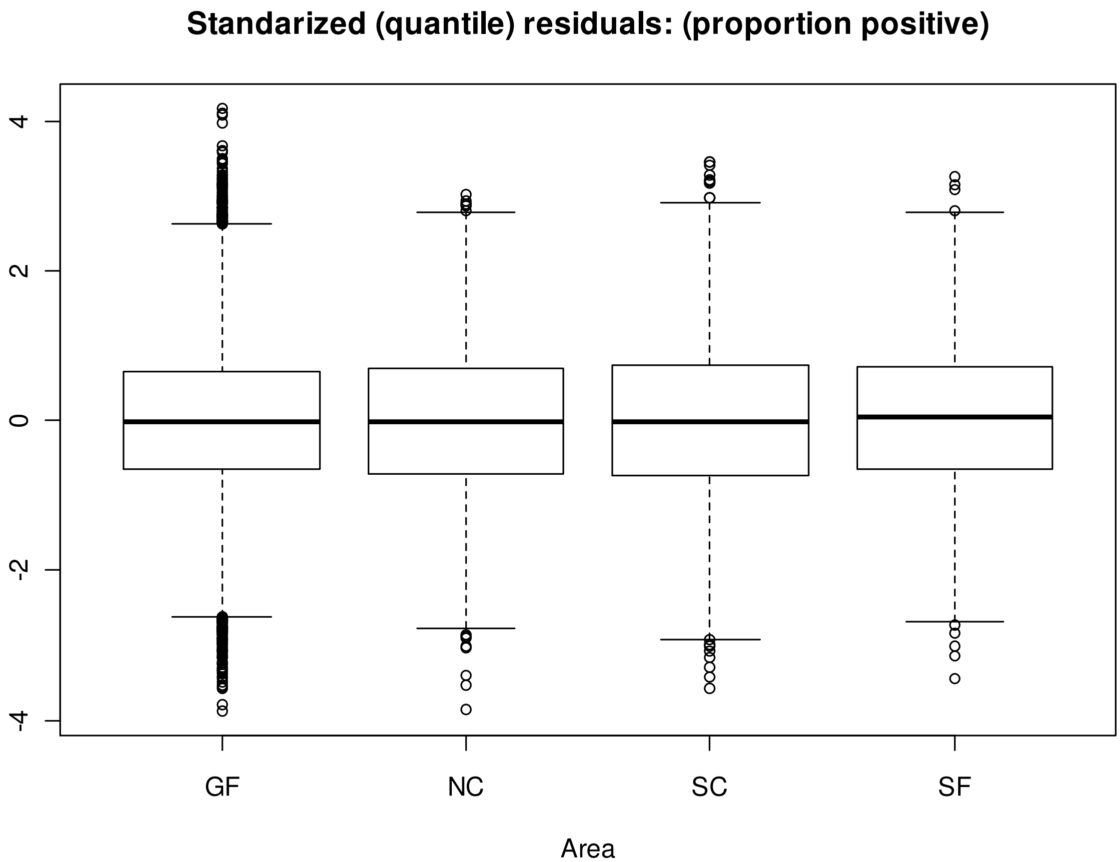


Figure 15. Standardized (quantile) residuals from the binomial portion of the index across the explanatory variable of number of anglers, where small is 6 to 30 anglers and large is 31+ anglers.

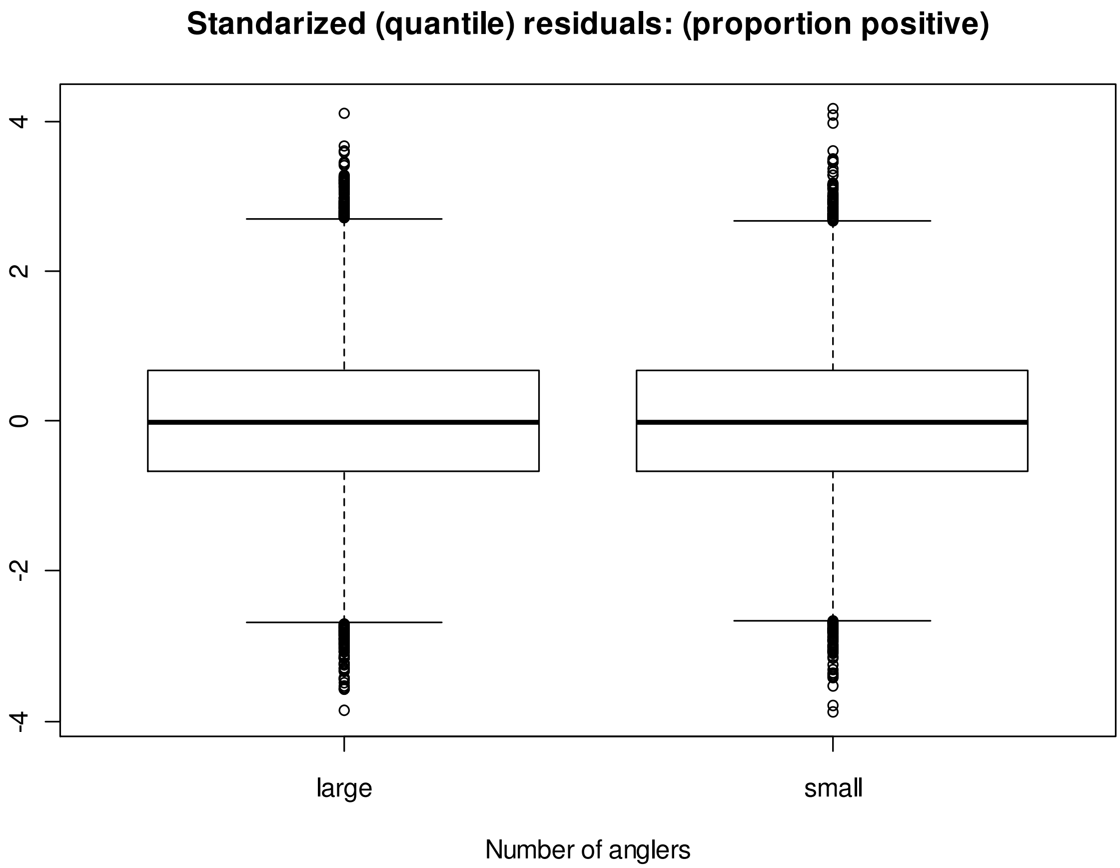


Figure 16. Standardized (quantile) residuals from the binomial portion of the index across the explanatory variable of trip type.

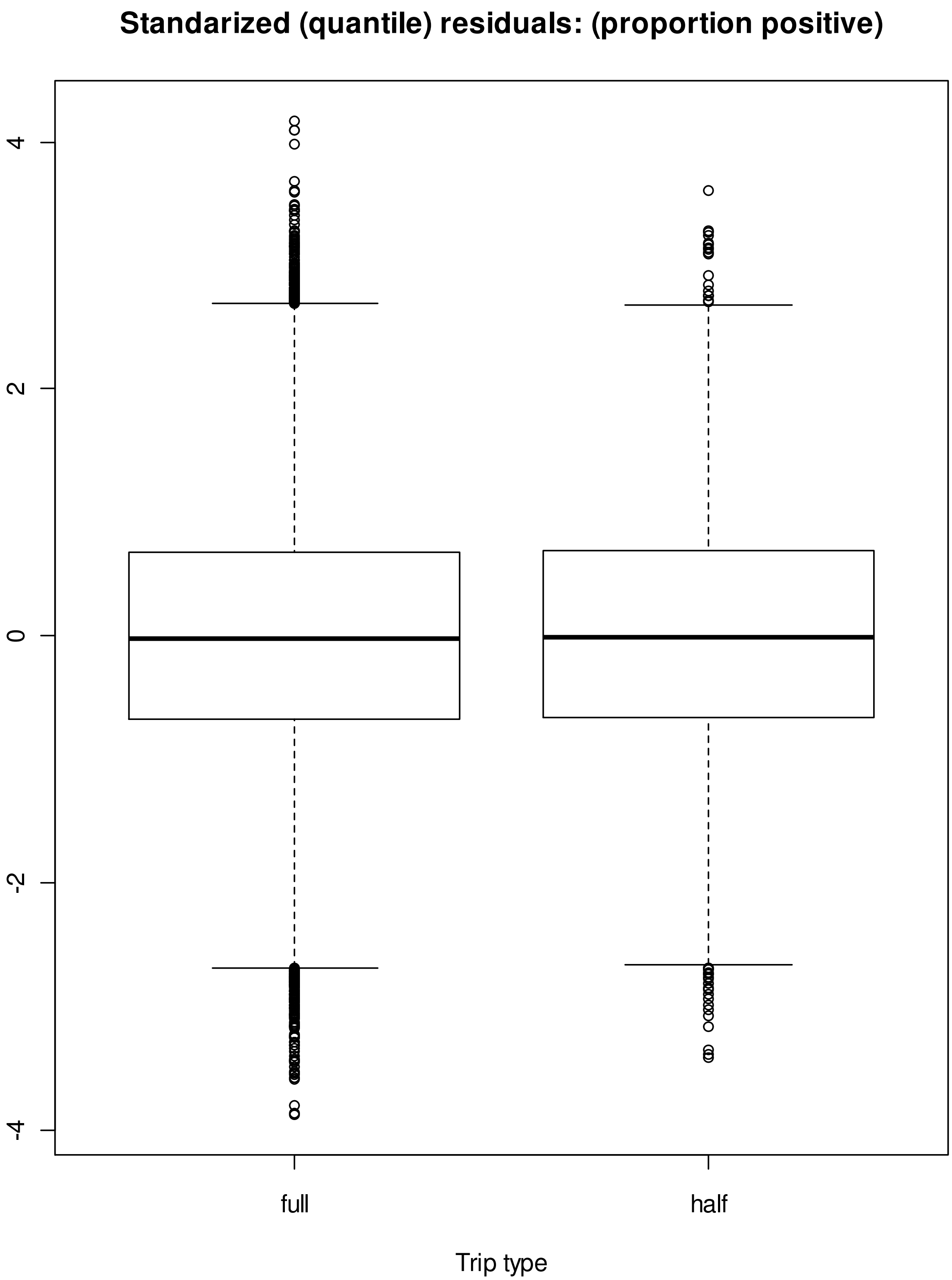


Figure 17. The distribution of CPUE for the positive portion of the headboat index, which was fit with a lognormal distribution.

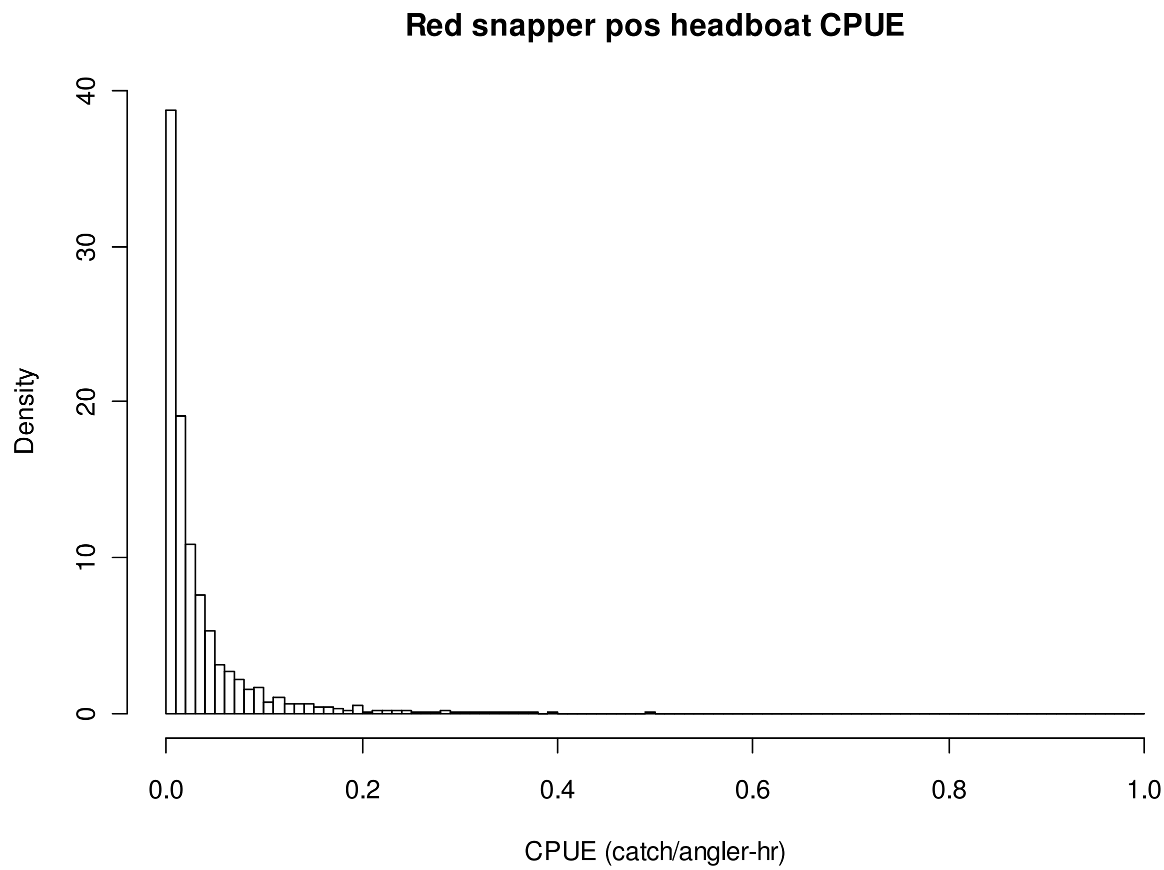


Figure 18. Raw residuals from the positive portion of the index, estimated using a lognormal distribution, across the years 1976-2009.

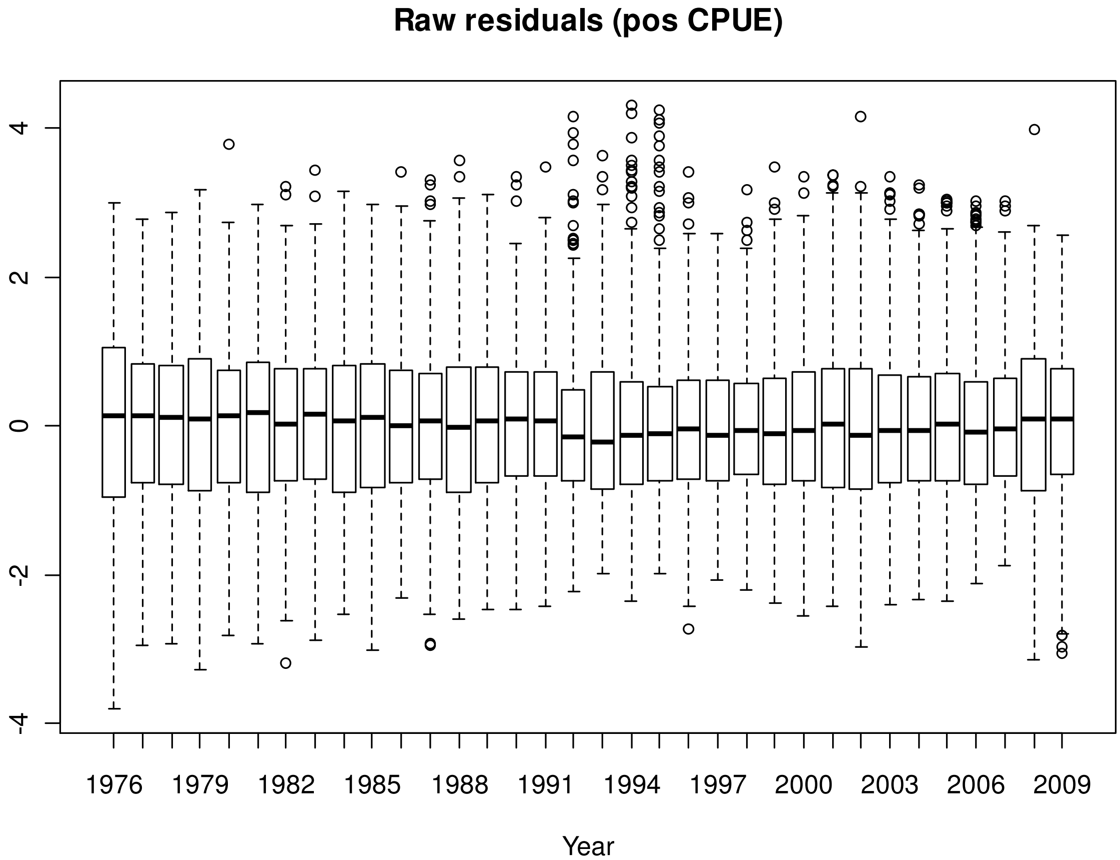


Figure 19. Raw residuals from the positive portion of the index, estimated using a lognormal distribution, across the explanatory variable season, where winter is January-March, spring is April-June, summer is July-September, and fall is October-December.

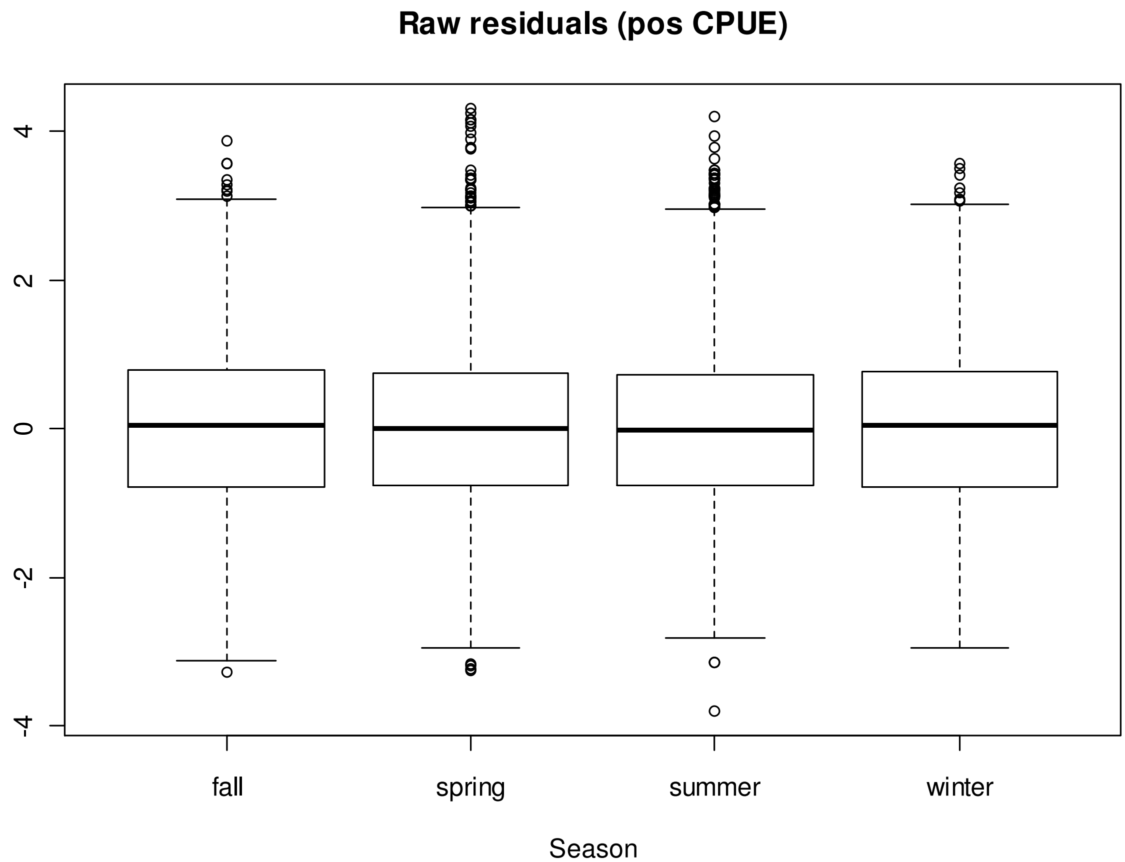


Figure 20. Raw residuals from the positive portion of the index, estimated using a lognormal distribution, across the explanatory variable season, where NC contains areas 2, 3, 9, and 10; SC contains areas 4 and 5; GF contains areas 6, 7, and 8; and SF contains areas 11, 12, and 17.

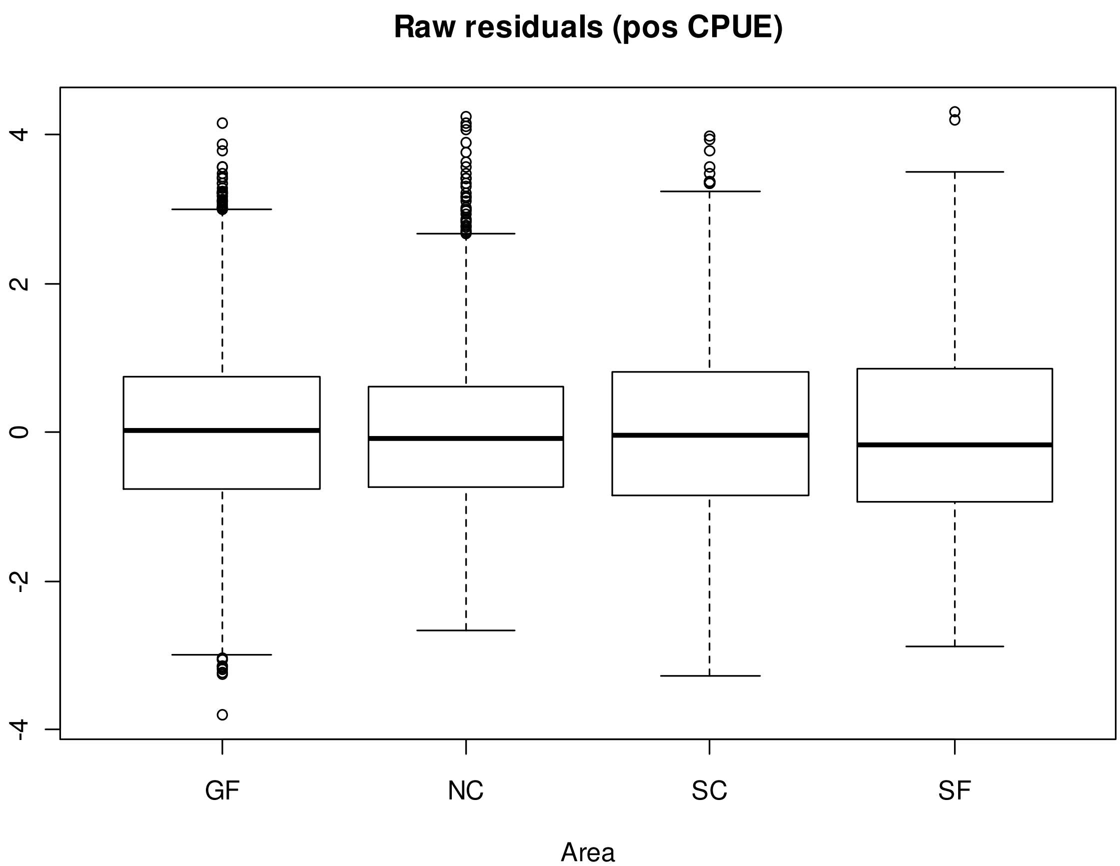


Figure 21. Raw residuals from the positive portion of the index, estimated using a lognormal distribution, across the explanatory variable season, where small is 6 to 30 anglers and large is 31+ anglers.

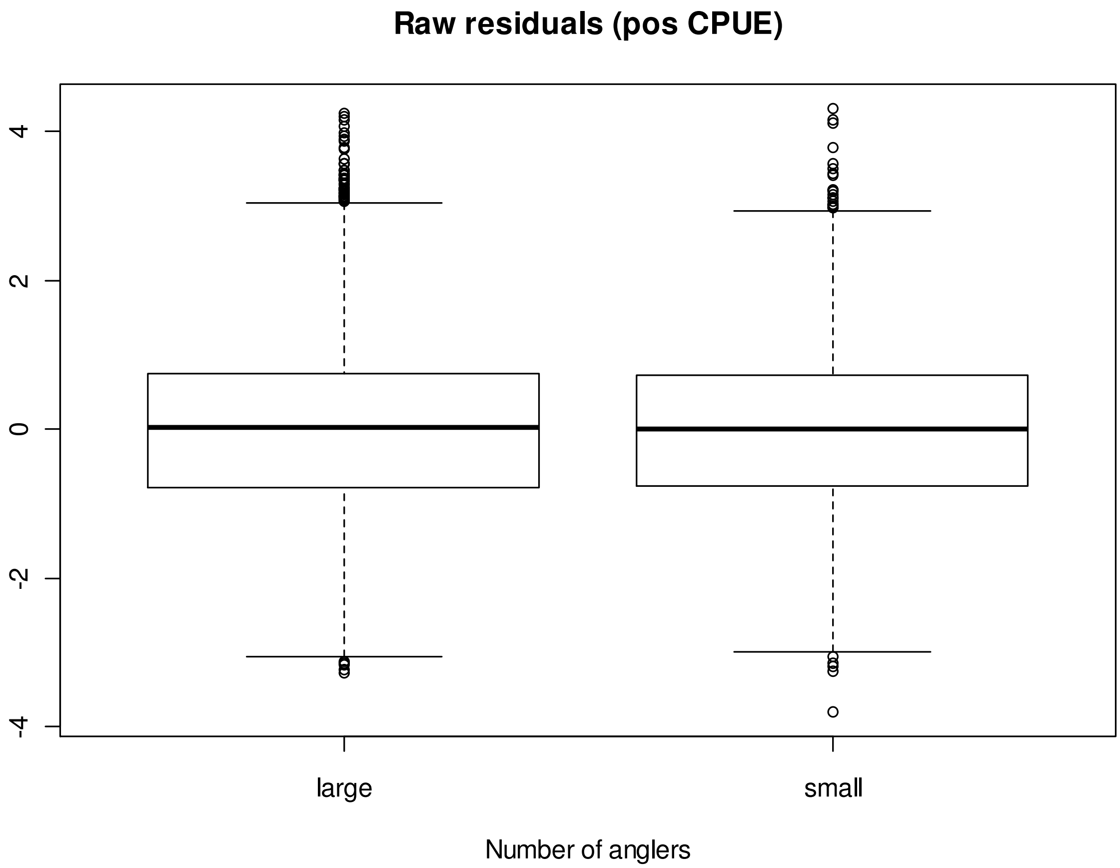


Figure 22. The distribution of log CPUE for the south Atlantic red snapper headboat fishery during 1976-2009, with the normal distribution (empirical mean and variance) overlaid.

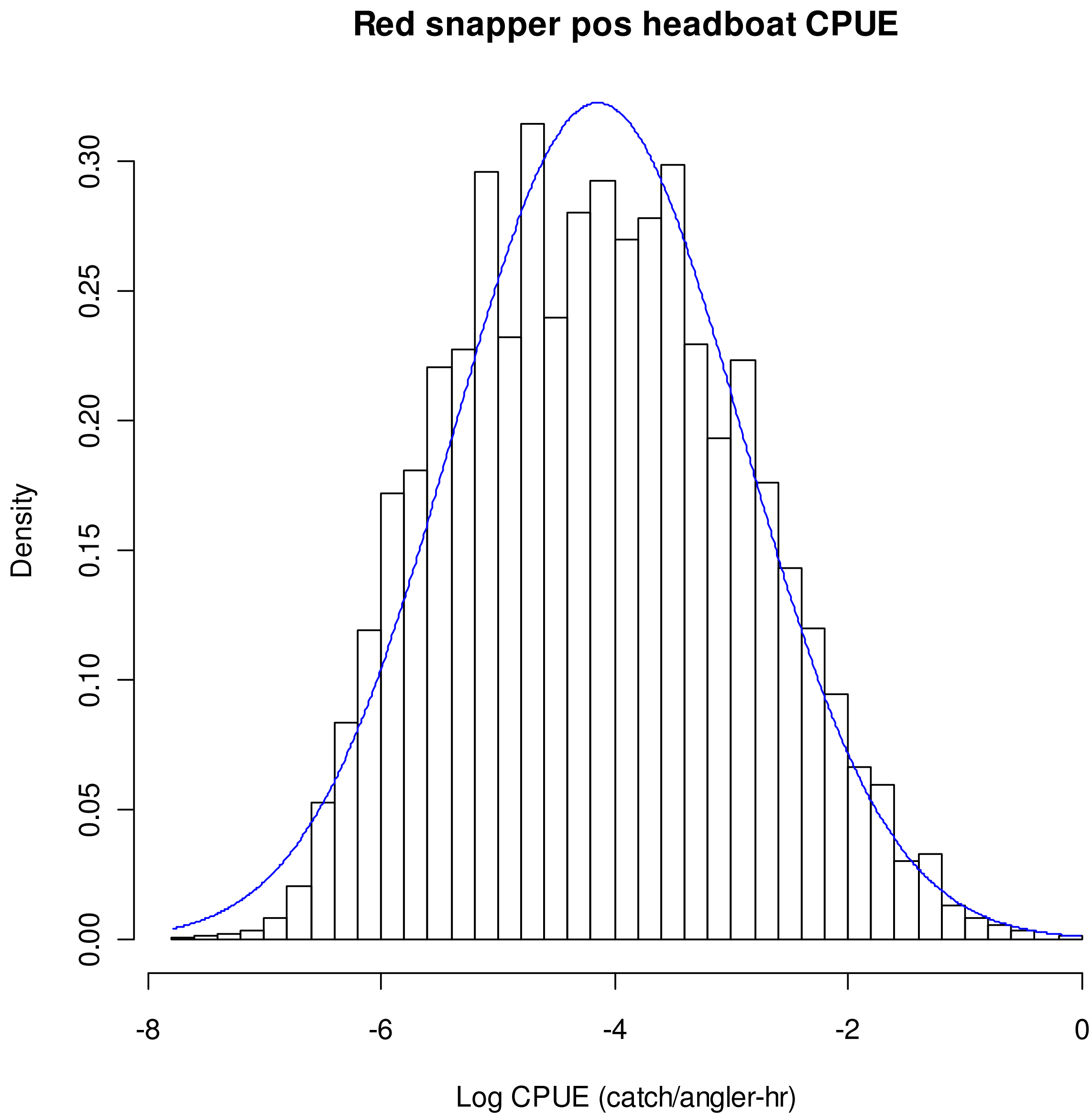


Figure 23. Q-Q plot of the log residuals of the positive CPUE.

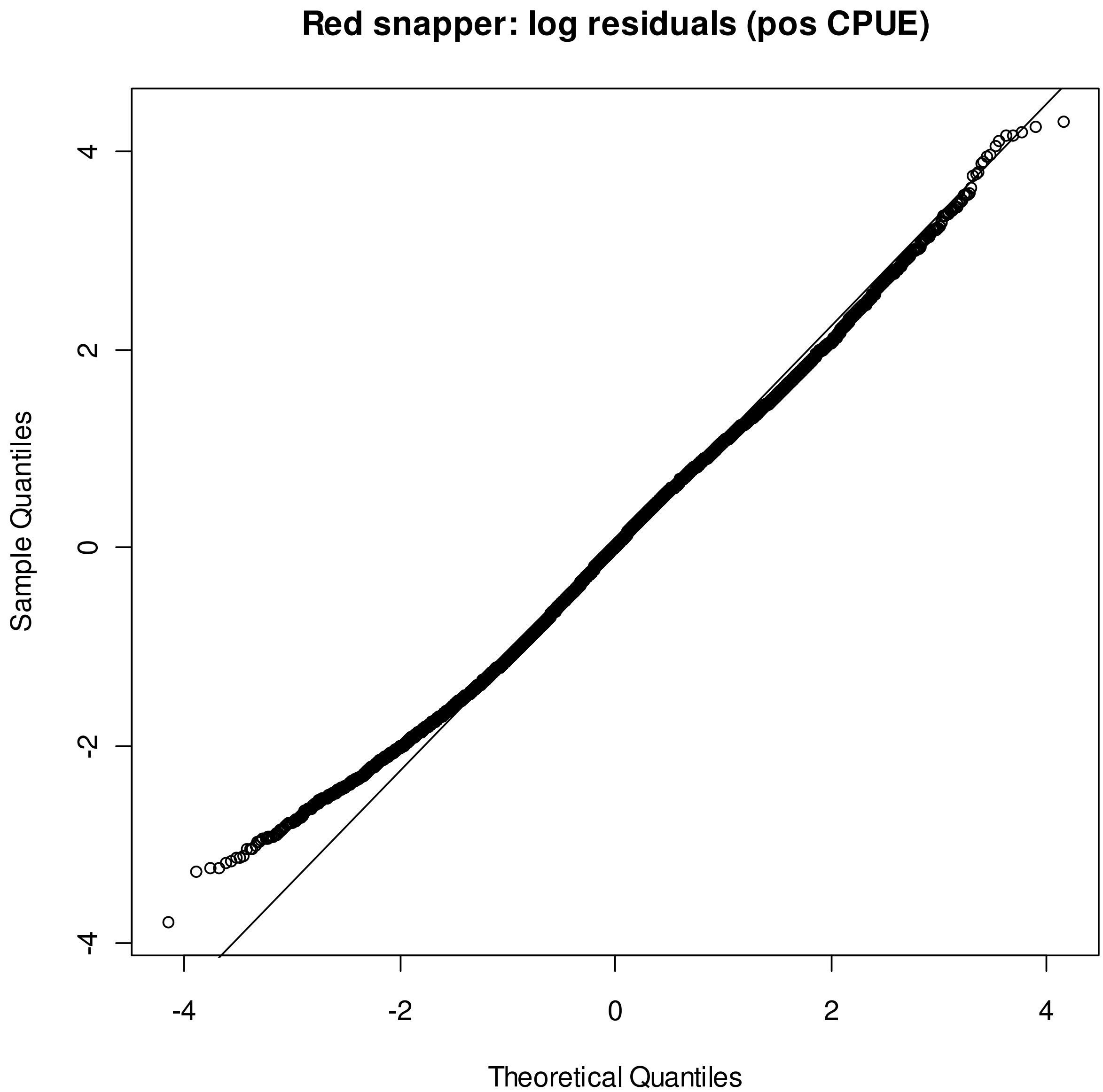


Figure 24. The nominal CPUE over time for each area.

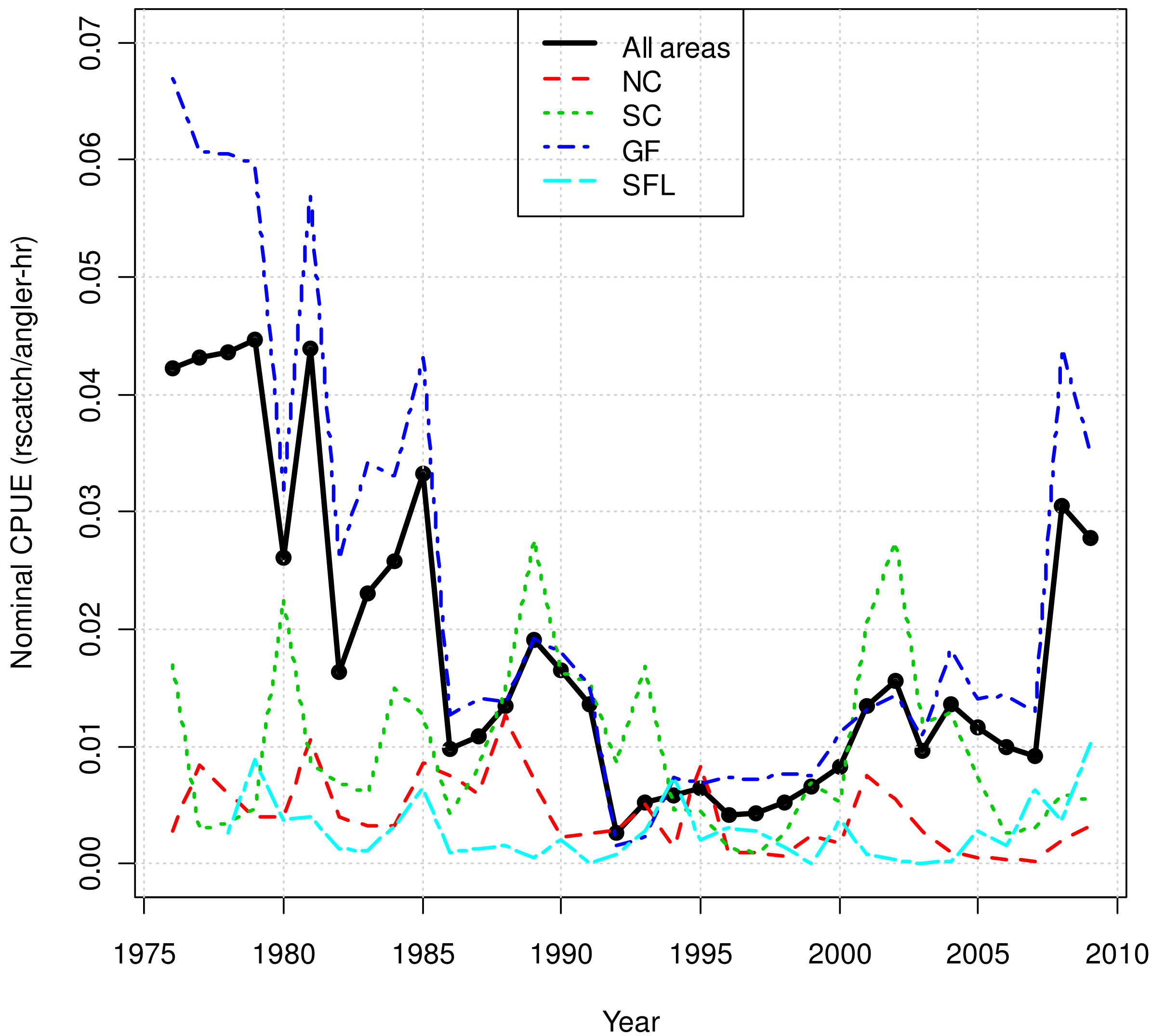
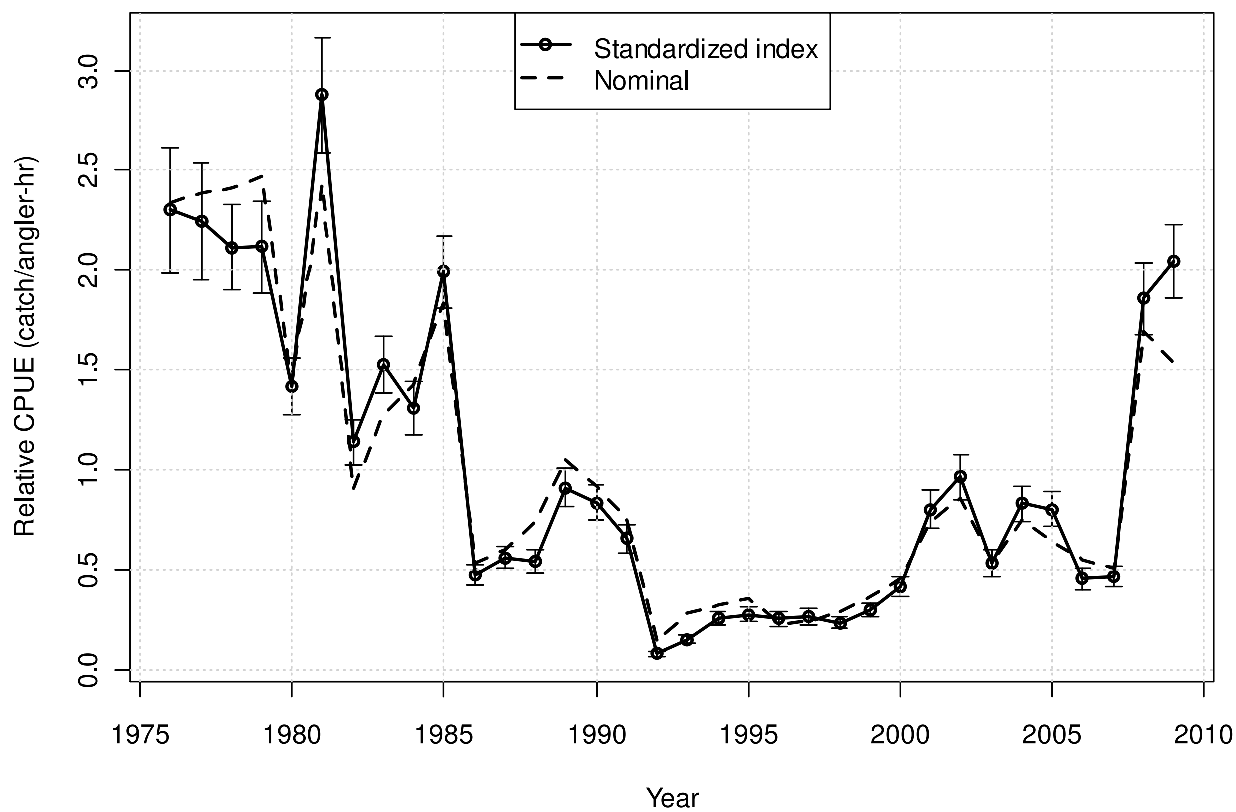


Figure 25. The standardized and nominal headboat index computed for red snapper in the south Atlantic during 1976-2009.



APPENDIX 1

Model selection steps for choosing factors independently for each of the model components. For the positive component using the lognormal, all factors were retained except type which is trip type:

Start: AIC=88554.04
log(cpue) ~ year + area + anglers + type + season

	Df	Deviance	AIC
type	1	33609	88552
none		33609	88554
season	3	34755	89553
anglers	1	35259	89988
area	3	35337	90050
year	33	40407	94007

Step: AIC=88552.24
log(cpue) ~ year + area + anglers + season

	Df	Deviance	AIC
none>		33609	88552
season	3	34756	89551
anglers	1	35261	89988
area	3	35339	90050
year	33	40421	94015

For the positive component using the gamma distribution, all factors were retained:
Start: AIC=-154522.6
cpue ~ year + area + anglers + type + season

	Df	Deviance	AIC
none		33434	-154523
type	1	33438	-154522
area	3	34267	-154096
season	3	34768	-153836
anglers	1	34821	-153804
year	33	40885	-150722

For the Bernoulli component using the binominal distribution, all factors were retained:
Start: AIC=54950.82
cpue ~ year + area + anglers + type + season

	Df	Deviance	AIC
none		54867	54951
anglers	1	55014	55096
season	3	55406	55484
type	1	56295	56377
year	33	58597	58615
area	3	58715	58793