Preliminary standardized catch rates of Southeast US Atlantic red snapper (*Lutjanus campechanus*) from headboat logbook data

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SEDAR41-DW12

Submitted: 23 July 2014
Addendum: 20 August 2014
Updated Working Paper & Addendum: 17 August 2015

***Addendum added to reflect changes made during Data Workshops.**
Final index is found in the addendum.

Please cite this document as:

Sustainable Fisheries Branch – National Marine Fisheries Service. 2015. Preliminary standardized catch rates of Southeast US Atlantic red snapper (*Lutjanus campechanus*) from headboat logbook data. SEDAR41-DW12. SEDAR, North Charleston, SC. 30 pp.

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Preliminary standardized catch rates of Southeast US Atlantic red snapper (*Lutjanus campechanus*) from headboat logbook data

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July 22 2014

*__Addendum at end of document reflecting changes made at Data Workshop__

Abstract
Standardized catch rates were generated from the Southeast headboat survey trip records (logbooks) from 1976-2009. The analysis included areas from central North Carolina through south Florida. Data filtering and subsetting steps were applied to the data to model trips that were likely to have directed red snapper effort. The preliminary decisions made prior to the data workshop are presented here. The final results of the headboat index will be presented in the SEDAR 41 Data Workshop Report.

Background

The headboat fishery in the south Atlantic includes for-hire vessels. The fishery uses hook and line gear, generally targets hard bottom reefs as the fishing grounds, and generally targets multiple species in the snapper-grouper complex. One of the key characteristics defining a headboat from other recreational fishing such as charter boats is the number of anglers. Prior to 2000 headboats were defined as vessels carrying 15 or more recreational anglers. This criteria changed to 7 or more passengers in 2000 in the Atlantic (Ken Brennan, pers. comm. Dec. 2011).

Headboats in the south Atlantic are sampled from North Carolina to the Florida Keys.
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 1-17, Figure 1).

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.

A 20” TL minimum size limit for red snapper has been in place since 1992. A 2 fish bag limit began in 1992. The red snapper fishery closed in 2010.

The headboat logbook index was used for SEDAR 24. Additional headboat records from 2010 to 2013 were examined to determine if sufficient data exists to extend this standardized index of abundance for south Atlantic red snapper. Due to the closure and potential effect on the index, these data were not considered.

Data treatment

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 0.1% of trips. These trips were excluded because they were possibly misreported and likely don't reflect the behavior of headboats in general.

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 *et al.* 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. 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 removed 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 (Figure 2 – Figure 5).

Model Input

Response and explanatory variables

CPUE – catch per unit effort (CPUE) has units of fish/angler and was calculated as the number of red snapper caught divided by the number of anglers.

Year – Because year is the explanatory variable of interest, it was necessarily included in the analysis. A summary of the total number of trips with red snapper effort per year and area is provided in Table 1 and 2.

Area – Areas were pooled into regions of North Carolina (NC=2,3,9,10), South Carolina (SC=4,5), Georgia and North Florida (GNFL=6,7,8), and south Florida (sFL=11,12,17).

Season – The seasons were defined as winter (January, February, March), spring (April, May, June), summer (July, August, September) and fall (October, November, December).

Party – Five categories for the number of anglers on a boat were considered in the standardization process. The categories included: ≤20 anglers, 20-40 anglers, 40-60 anglers, 60-80 anglers, and >80 anglers. 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.

Trip Type – Trip types of half and full day trips were included in the analysis. Three-quarter day trips were pooled with half-day trips (<10%). Multi-day trips were removed because most were in Florida and likely targeting deepwater species for some portion of the trip. The codes for first and second half-day trips designation for day and night trips were combined.

Standardization

CPUE was modeled using the delta-glm approach (Lo et al. 1992; Dick 2004; Maunder and Punt 2004). In particular, fits of lognormal and gamma models were compared for positive CPUE. Also, the combination of predictor variables was examined to best explain CPUE patterns (both for positive CPUE and or positive CPUE). All analysis 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, a model was fit 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.

POSITIVE CPUE SUBMODEL
Then, to determine predictor variables important for predicting positive CPUE, the positive portion of the model was fitted 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).

Both components of the model were then fit 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.

Preliminary model diagnostics are presented in Figures 6-7.

It should be noted that the Stephens and MacCall method is most appropriate for species which have strong species associations. In other words, if a species is ubiquitous in the catch, or does not have well-defined effort, Stephens and MacCall may not work well to identify directed effort.

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Dick, E.J. 2004. Beyond 'lognormal versus gamma': discrimination among error distributions for generalized linear models. Fish. Res. 70:351-366.

Lo, N.C., Jacobson, L.D., Squire, J.L. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49:2515-2526.

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Table 1. Proportion positive trips of red snapper in the south Atlantic Headboat fishery.

Year	pos.RS.trips	HB.all.trips	% pos
1973	298	688	43%
1974	366	1182	31%
1975	421	1913	22%
1976	1033	3002	34%
1977	1228	3559	35%
1978	1803	4891	37%
1979	1460	8173	18%
1980	1577	11378	14%
1981	1416	11324	13%
1982	1283	12256	10%
1983	1642	12125	14%
1984	1493	11190	13%
1985	1908	11157	17%
1986	1605	13854	12%
1987	1758	13966	13%
1988	1683	11996	14%
1989	1411	10933	13%
1990	1335	11365	12%
1991	1070	10740	10%
1992	938	15007	6%
1993	1295	13894	9%
1994	1411	12575	11%
1995	1506	12275	12%
1996	1154	9060	13%
1997	649	6284	10%
1998	1250	9123	14%
1999	1386	7618	18%
2000	1430	7645	19%
2001	1602	6820	23%
2002	1516	5590	27%
2003	1225	5542	22%
2004	1558	6278	25%
2005	1379	5695	24%
2006	1177	5909	20%
2007	1326	6381	21%
2008	1770	9215	19%
2009	2134	10250	21%
Total	49750	366756	14%

Table 2. Number of red snapper headboat trips by area, positive and zero trips following Stephens & MacCall (SM) method.

	Total Trips					Positive Trips					Proportion Positive				
Year	GF	NC	SC	SF	Total	GF	NC	SC	SF	Total	GF	NC	SC	SF	Total
1976	464	142	229		835	441	37	118		596	0.95	0.26	0.52		0.71
1977	608	57	208		873	542	30	69		641	0.89	0.53	0.33		0.73
1978	1132	144	249	3	1528	953	67	99	1	1120	0.84	0.47	0.40	0.33	0.73
1979	1028	163	78	28	1297	821	78	30	3	932	0.80	0.48	0.38	0.11	0.72
1980	1032	118	176	48	1374	787	50	104	10	951	0.76	0.42	0.59	0.21	0.69
1981	871	107	52	63	1093	772	69	27	28	896	0.89	0.64	0.52	0.44	0.82
1982	911	189	211	49	1360	733	108	110	4	955	0.80	0.57	0.52	0.08	0.70
1983	1212	173	208	54	1647	1005	91	109	7	1212	0.83	0.53	0.52	0.13	0.74
1984	1160	84	194	86	1524	915	37	130	21	1103	0.79	0.44	0.67	0.24	0.72
1985	1258	72	255	147	1732	1105	40	169	46	1360	0.88	0.56	0.66	0.31	0.79
1986	1591	98	264	184	2137	995	64	118	26	1203	0.63	0.65	0.45	0.14	0.56
1987	1564	106	306	171	2147	1048	44	149	23	1264	0.67	0.42	0.49	0.13	0.59
1988	1529	112	346	87	2074	902	64	196	15	1177	0.59	0.57	0.57	0.17	0.57
1989	1142	46	196	43	1427	855	19	128	6	1008	0.75	0.41	0.65	0.14	0.71
1990	1135	65	242	16	1458	828	19	161	1	1009	0.73	0.29	0.67	0.06	0.69
1991	1043	135	284	11	1473	695	45	138	1	879	0.67	0.33	0.49	0.09	0.60
1992	1612	245	231	62	2150	406	72	110	16	604	0.25	0.29	0.48	0.26	0.28
1993	1451	175	274	66	1966	420	81	217	17	735	0.29	0.46	0.79	0.26	0.37
1994	1167	181	233	44	1625	605	57	138	16	816	0.52	0.31	0.59	0.36	0.50
1995	1108	186	209	19	1522	620	57	103	5	785	0.56	0.31	0.49	0.26	0.52
1996	746	177	207	14	1144	445	42	66	6	559	0.60	0.24	0.32	0.43	0.49
1997	560	115	116	8	799	331	24	32	2	389	0.59	0.21	0.28	0.25	0.49
1998	1209	207	213	4	1633	692	30	80	1	803	0.57	0.14	0.38	0.25	0.49
1999	1301	177	208	1	1687	729	61	137		927	0.56	0.34	0.66	0.00	0.55
2000	1026	192	206	13	1437	672	59	86	7	824	0.65	0.31	0.42	0.54	0.57
2001	1079	162	285	11	1537	732	106	175	2	1015	0.68	0.65	0.61	0.18	0.66
2002	991	179	276	7	1453	687	100	205	1	993	0.69	0.56	0.74	0.14	0.68
2003	825	134	155	15	1129	558	49	111		718	0.68	0.37	0.72	0.00	0.64
2004	1059	219	288	30	1596	818	43	173	4	1038	0.77	0.20	0.60	0.13	0.65
2005	949	103	184	35	1271	776	7	87	8	878	0.82	0.07	0.47	0.23	0.69
2006	993	133	222	43	1391	687	14	70	13	784	0.69	0.11	0.32	0.30	0.56
2007	1085	94	280	40	1499	767	3	89	31	890	0.71	0.03	0.32	0.78	0.59
2008	1116	130	174	113	1533	985	23	68	31	1107	0.88	0.18	0.39	0.27	0.72
2009	1389	123	149	255	1916	1256	33	43	78	1410	0.90	0.27	0.29	0.31	0.74
Grand Tot	37346	4743	7408	1770	51267	25583	1723	3845	430	31581	0.69	0.36	0.52	0.24	0.62

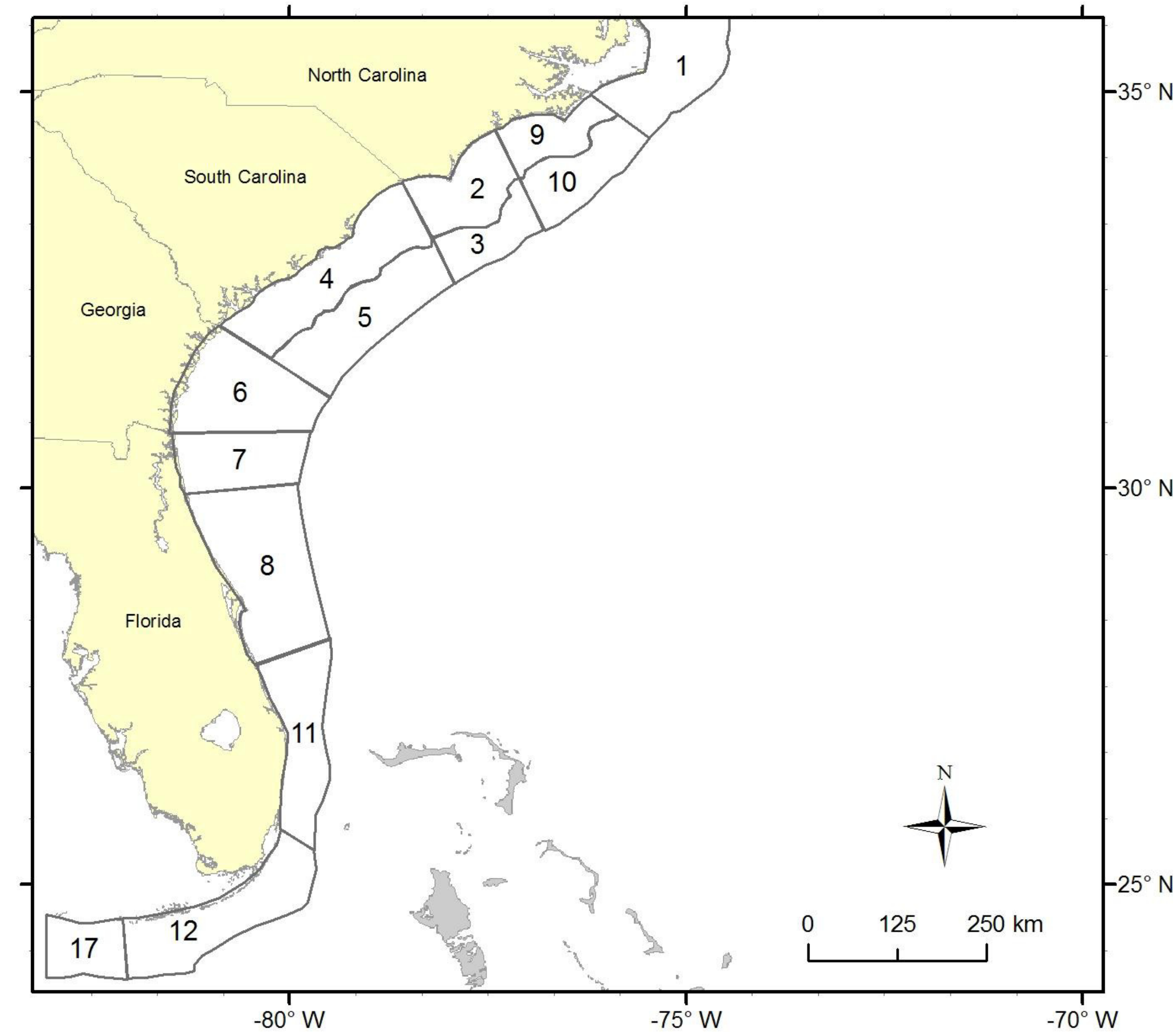


Figure 1. Map of headboat sampling area definition. These areas were pooled into regions of North Carolina (NC=2,3,9,10), South Carolina (SC=4,5), Georgia and North Florida (GNFL=6,7,8), and south Florida (sFL=11,12,17).

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.

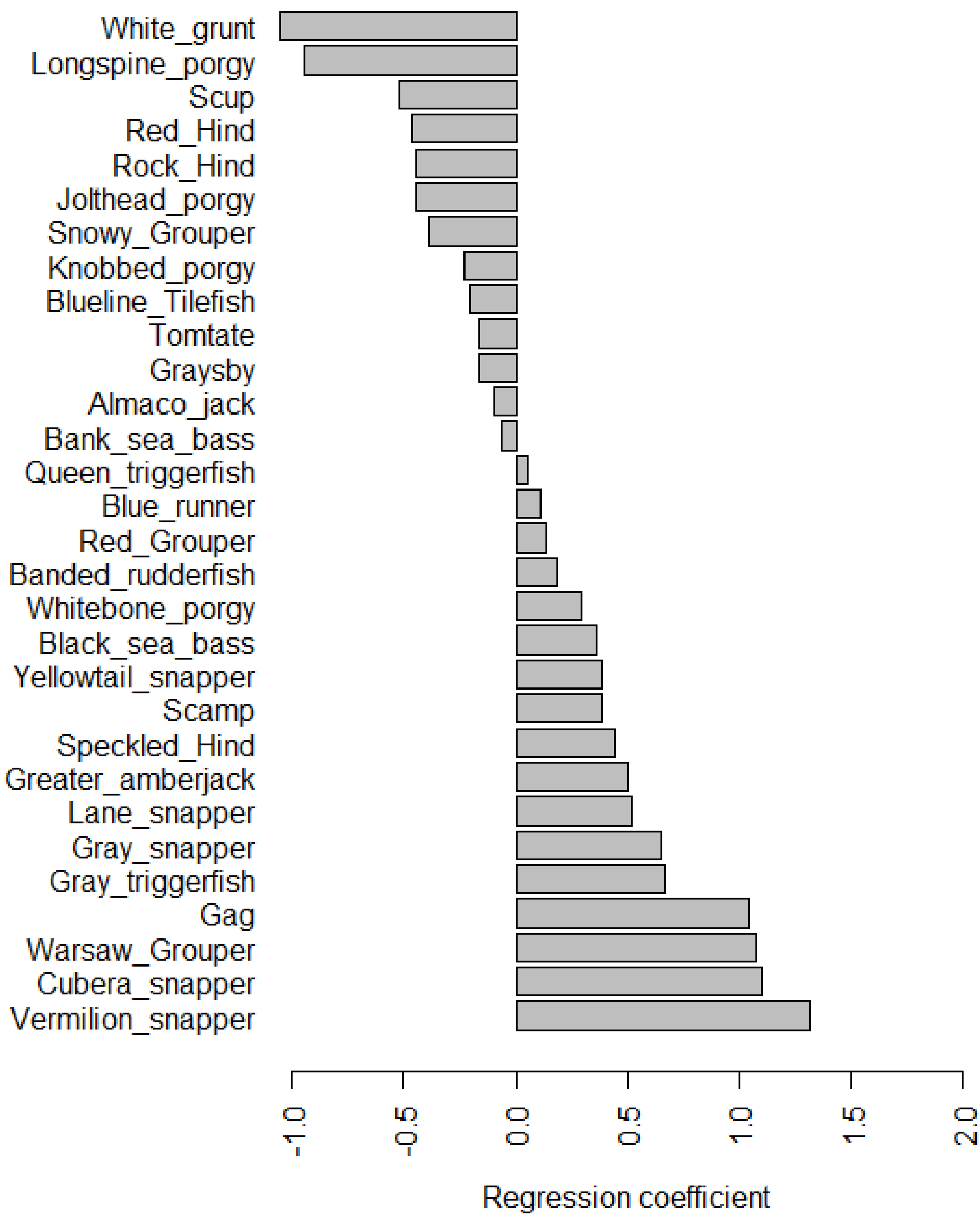


Figure 3. Estimates of species-specific regression coefficients from Stephens and MacCall method applied to headboat data from areas in the southern region (includes areas 11, 12, and 17), as used to estimate each trip's probability of catching the focal species.

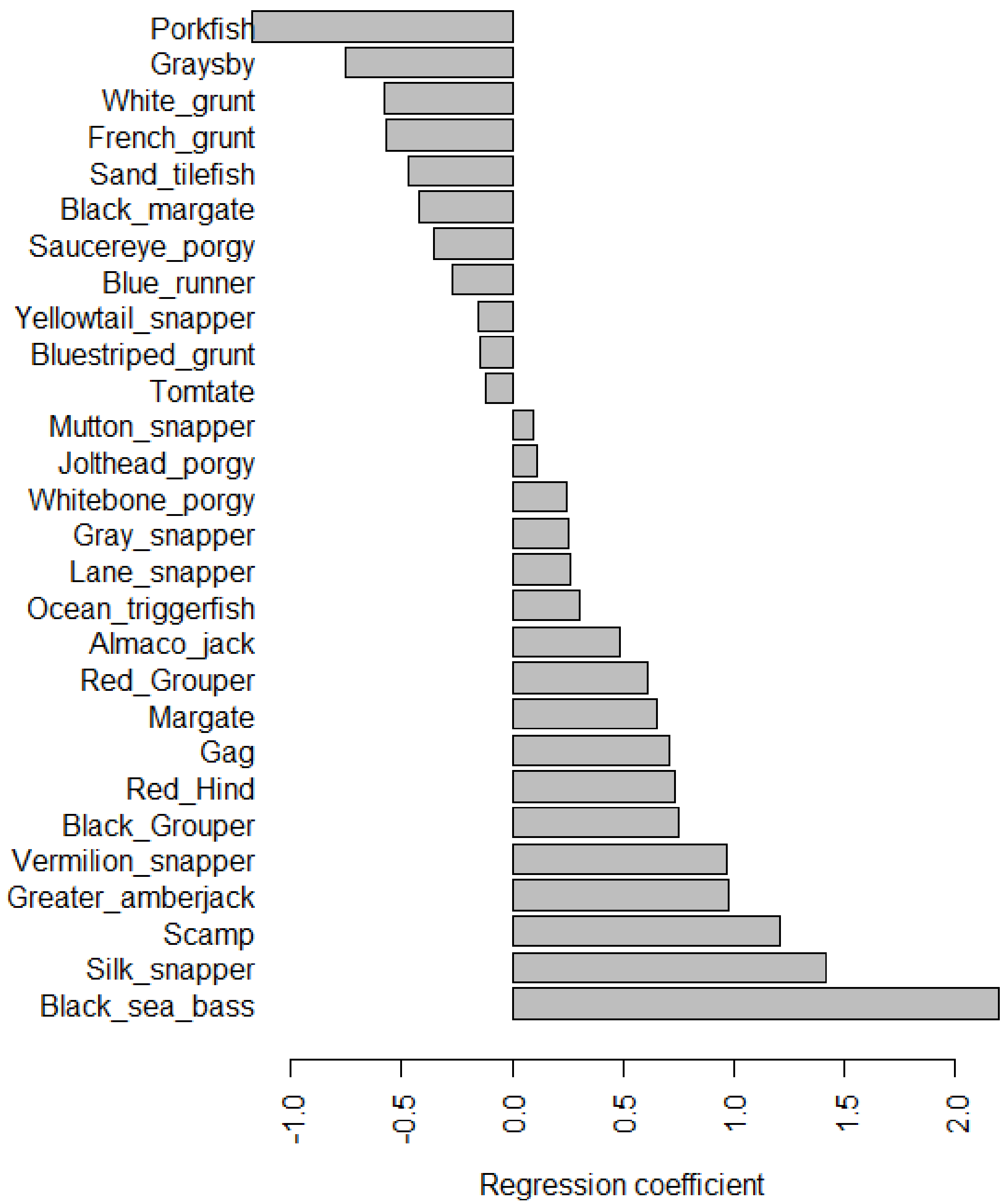


Figure 4. Absolute difference between observed and predicted number of positive trips from Stephens and MacCall method applied to headboat data from the northern region (excludes areas 11, 12, and 17). Left and right panels differ only in the range of probabilities shown.

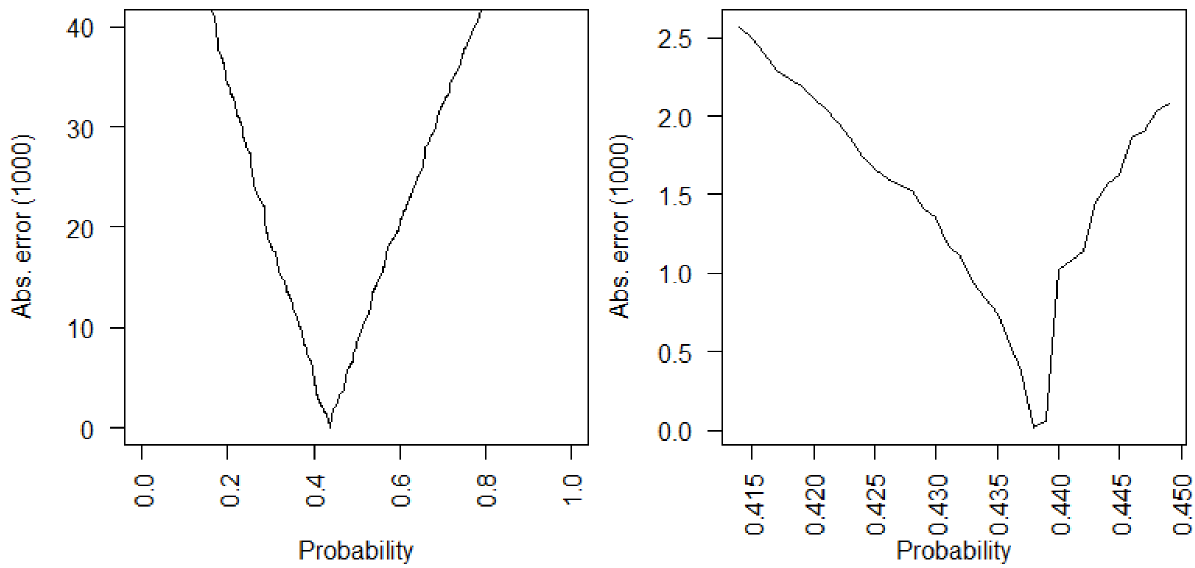


Figure 5. Absolute difference between observed and predicted number of positive trips from Stephens and MacCall method applied to headboat data from the southern region (includes areas 11, 12, and 17). Left and right panels differ only in the range of probabilities shown.

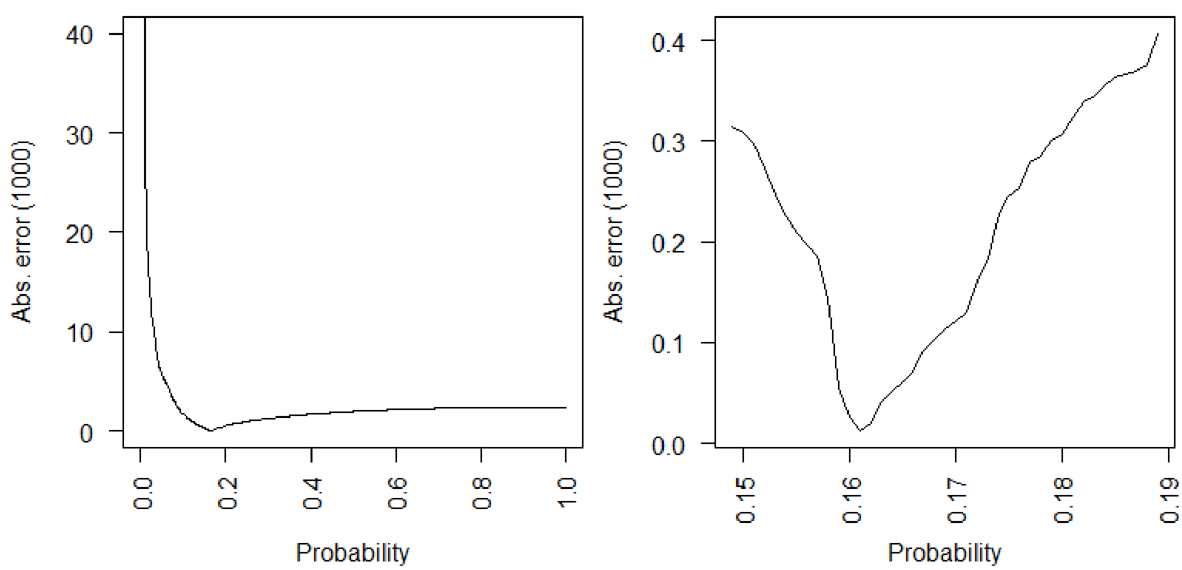
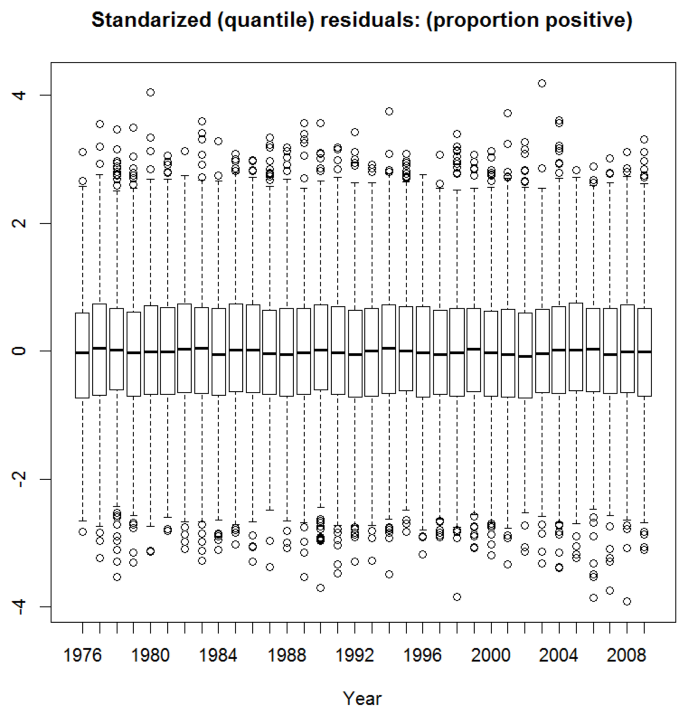


Figure 6. CPUE binomial residuals for year, area, season, trip type and party size.



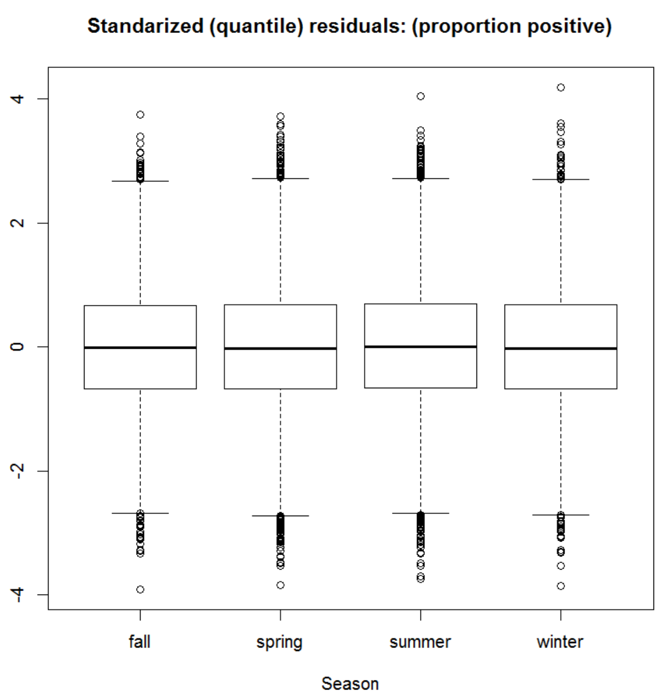
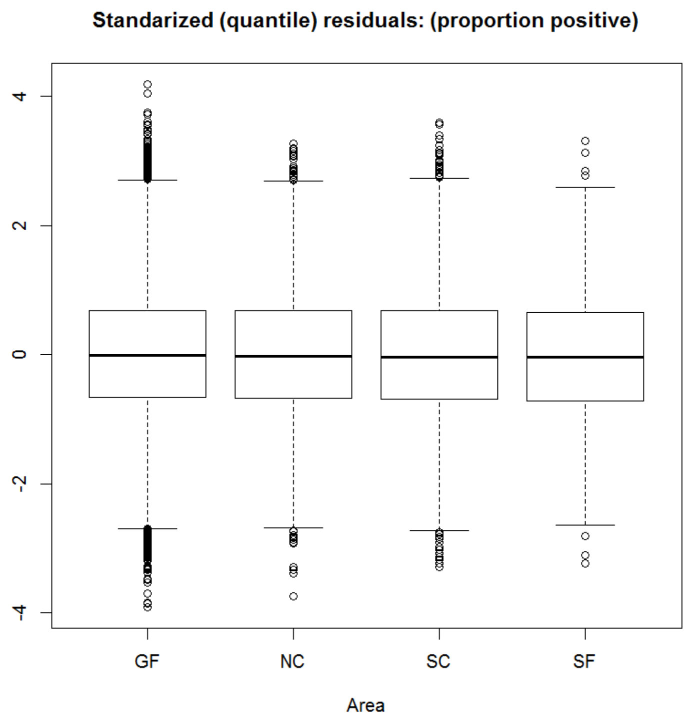


Figure 6. Continued.



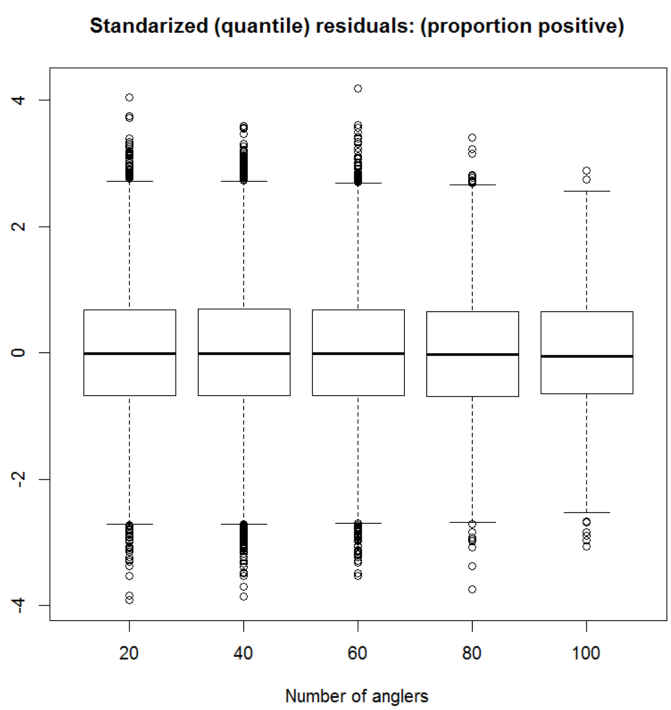
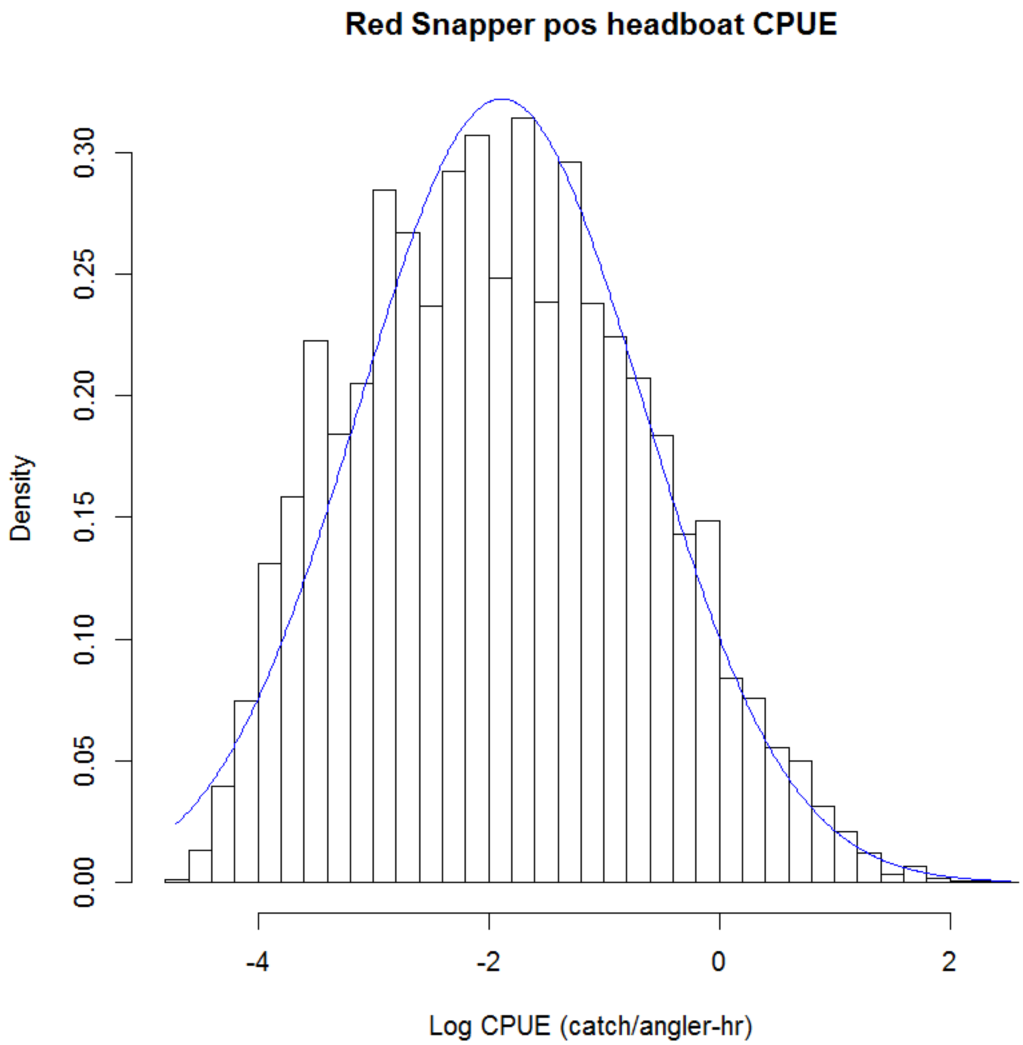


Figure 7. The lognormal distribution of catch for the south Atlantic red snapper headboat logbook during 1976-2009.



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ADDENDUM

Standardized catch rates of Southeast US Atlantic red snapper (*Lutjanus campechanus*) from headboat logbook data

Sustainable Fisheries Branch, National Marine Fisheries Service,
Southeast Fisheries Science Center,
101 Pivers Island Rd, Beaufort, NC 28516
August 2015

Abstract
Standardized catch rates were generated from the Southeast headboat survey trip records (logbooks) from 1976-2009. The analysis included areas from central North Carolina through south Florida. Data filtering and subsetting steps were applied to the data to model trips that were likely to have directed red snapper effort.

SEDAR 41 Index Working Group Review

The SEDAR 41 index working group (IWG) reviewed the methods used to develop an index of abundance for red snapper from headboat logbook data. The following topics were discussed at the data workshop and include the final decisions and justification.

Headboat data evaluation

The SEDAR41 DW (August 2014) recommended the headboat index for use in the assessment. As part of that recommendation, the index was split in 1992. The justification for that split was a possible shift in angler behavior following implementation of the 20” minimum size limit.

SEDAR 41 DW2 Scoping Calls recommended that the headboat index be reconsidered following the headboat data evaluation (SEDAR 41 DW46). As a result, several new data filters were applied (95% of these trips/vessels were filtered previously), and the data were examined for evidence to support splitting the index in 1992.

The headboat data evaluation showed that the number of red snapper landed versus the number sampled by year and region were highly correlated, particularly in the area off of Georgia-north Florida (Figure 8). Figure 9 illustrates the dockside sampling catch rate (red= red snapper >20” TL, green= red snapper between 12” & 20” TL, blue = red snapper < 12”) plotted with the headboat logbook index (black line). These two figures illustrate that headboats landed legal size red snapper following the regulations in 1984 and 1992, but did not avoid red snapper. Before and after 1992, the species associated with red snapper were very similar (Figure 10 & 11). In addition, general species associations in landings off Georgia-north Florida did not demonstrate any clear break in 1992 (Figure 12 & 13). Figure 14 illustrate a hypothetical example of distinct clusters. The dockside sampling and additional analysis suggest a shift in selectivity in 1992, but not necessarily an abrupt change in catchability.

Recommendations from IWG (August 4-6 2015)

- Do not split the index. Rerun headboat logbook index 1976-2009 with recommended filters (SEDAR41-DW46)

Considerations for Assessment workshop

- Allow selectivity to change with time blocks of size limit regulations
- Consider modeling any perceived changes in catchability within the assessment model

Start year
The index includes data from 1976 to 2009.

End year
SEDAR 41 IWG participants along with fisherman present at the meeting discussed the red snapper closure in 2010 and its potential impact on the red snapper headboat logbook index in 2010-2014. Because of this shift in behavior (avoidance), the IWG recommended to end the red snapper headboat logbook index in 2009.

Subsetting technique- Stephens & MacCall

A run using a 5% cutoff was explored. Red snapper in the southern region did not meet this upper cutoff so the 1% was used in the final model run.

The following information represents the final dGLM results for the red snapper headboat logbook index (Table 3 & Figures 15-17).

Model Input

Response and explanatory variables

CPUE – catch per unit effort (CPUE) has units of fish/angler and was calculated as the number of red snapper caught divided by the number of anglers.

Year –1976-2009

Area – Areas were pooled into regions of North Carolina (NC=2,3,9,10), South Carolina (SC=4,5), Georgia and North Florida (GNFL=6,7,8), and south Florida (sFL=11,12,17).

Season – The seasons were defined as winter (January, February, March), spring (April, May, June), summer (July, August, September) and fall (October, November, December).

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Standardization

CPUE was modeled using the delta-glm approach (Lo et al. 1992; Dick 2004; Maunder and Punt 2004). In particular, fits of lognormal and gamma models were compared for positive CPUE. Also, the combination of predictor variables was examined to best explain CPUE patterns (both for positive CPUE and or positive CPUE). All analysis were performed in the R programming language, with much of the code adapted from Dick (2004).

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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, a model was fit 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.

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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).

Both components of the model were then fit 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 was the preferred model.

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Dick, E.J. 2004. Beyond 'lognormal versus gamma': discrimination among error distributions for generalized linear models. Fish. Res. 70:351-366.

Lo, N.C., Jacobson, L.D., Squire, J.L. 1992. Indices of relative abundance from fish spotter data based on delta-lognormal models. Can. J. Fish. Aquat. Sci. 49:2515-2526.

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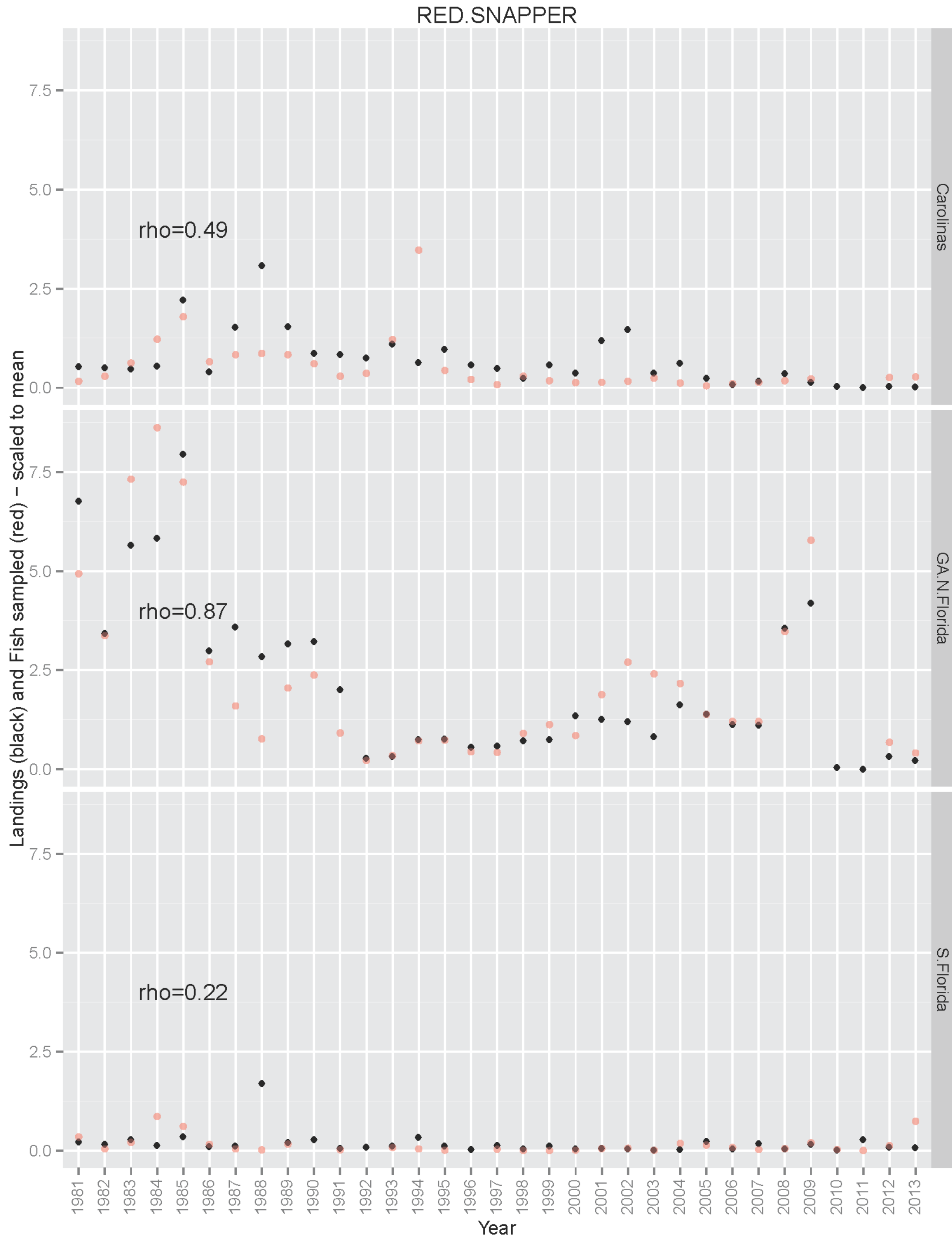


Figure 8. The number of Red Snapper landed versus the number sampled by year and region. The landings and fish sampled are scaled to their means to make them comparable, and the Spearman rank correlation coefficient ρ values are provided in each region panel.

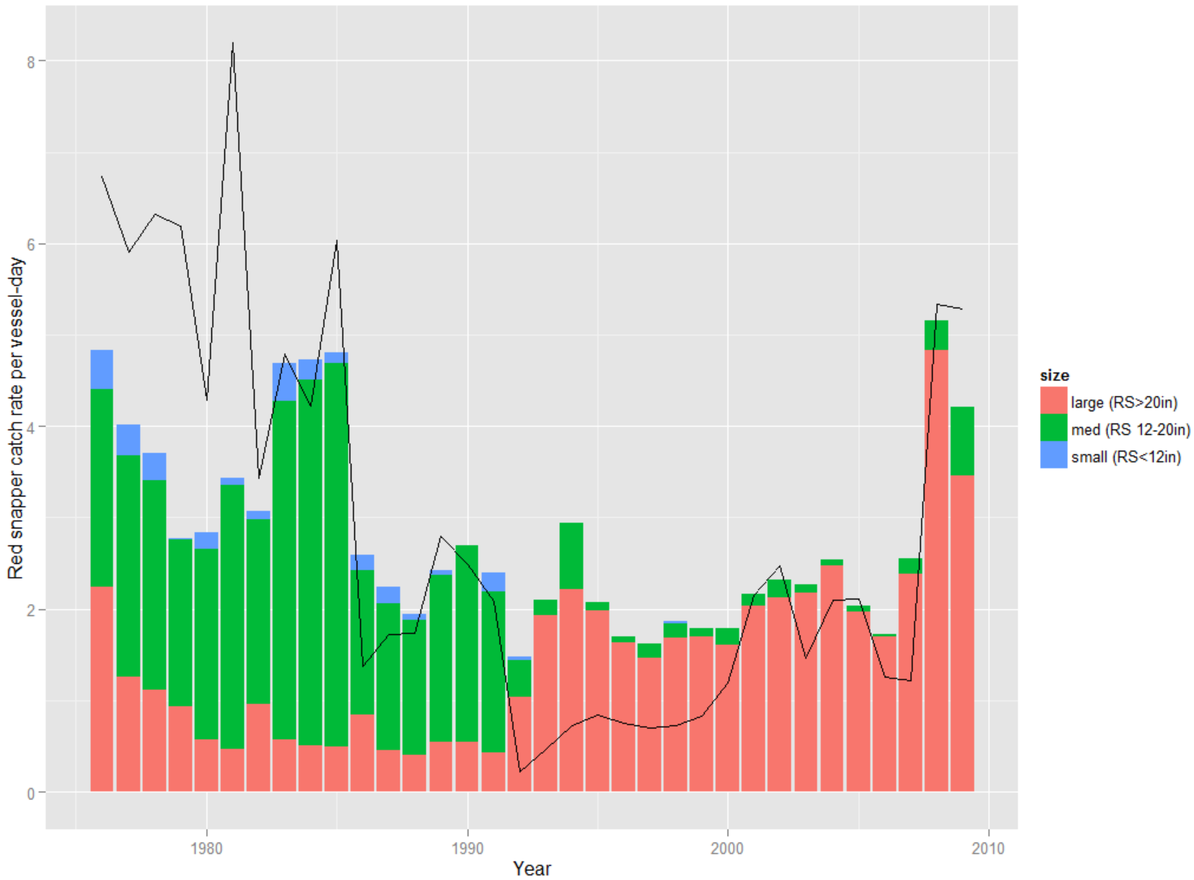


Figure 9. Biological profile (dockside sampling) catch rate (red= red snapper >20" TL max, green= red snapper between 12" & 20" TL max, blue = red snapper < 12") plotted with the headboat logbook index (black line) scaled to the mean catch rate from the sampled fish.

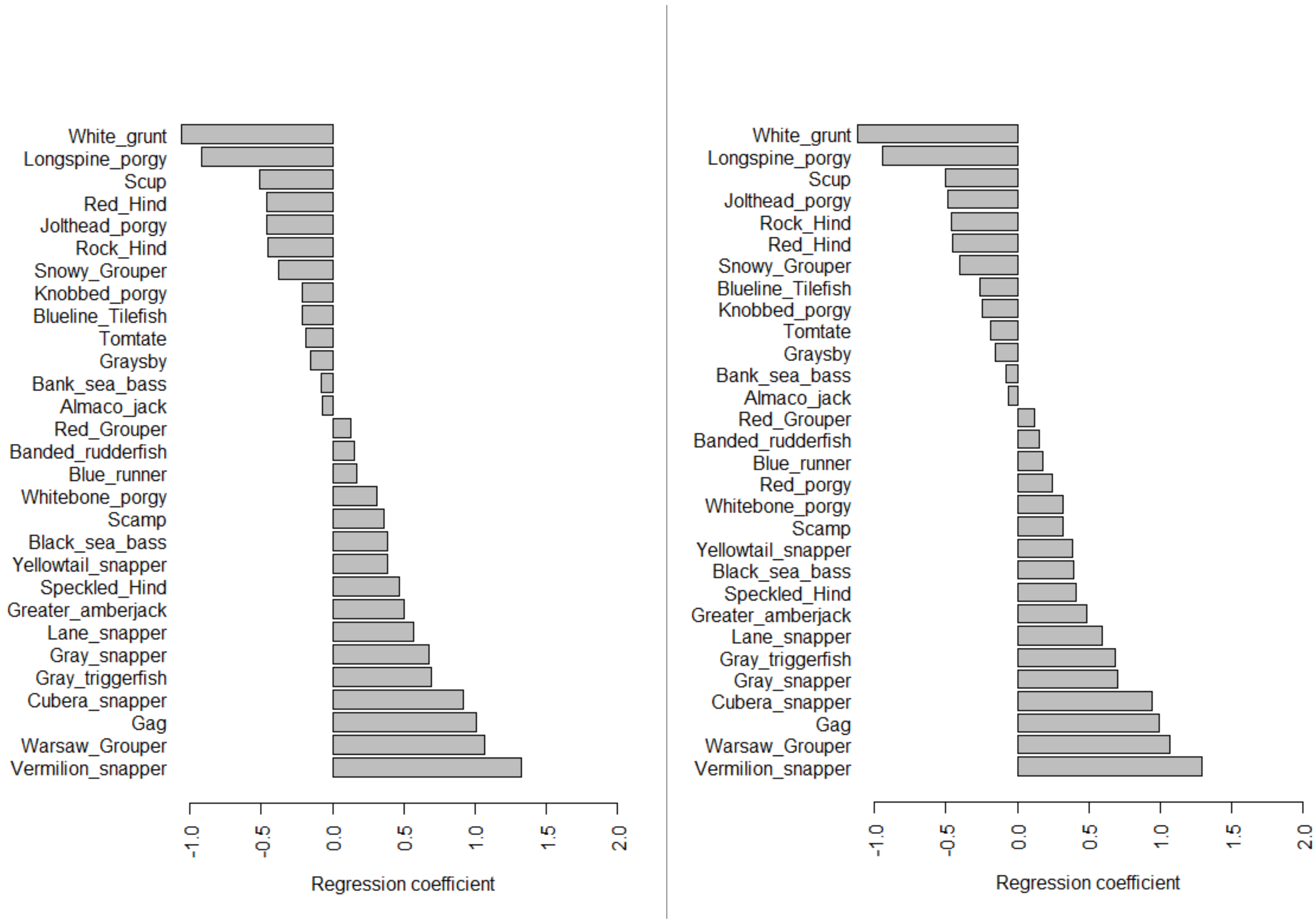


Figure 10. Estimates of species-specific regression coefficients from Stephens and MacCall method applied to headboat data from areas in the northern region. Left panel is from 1976-1991 data; right panel is from 1992-2009 data.

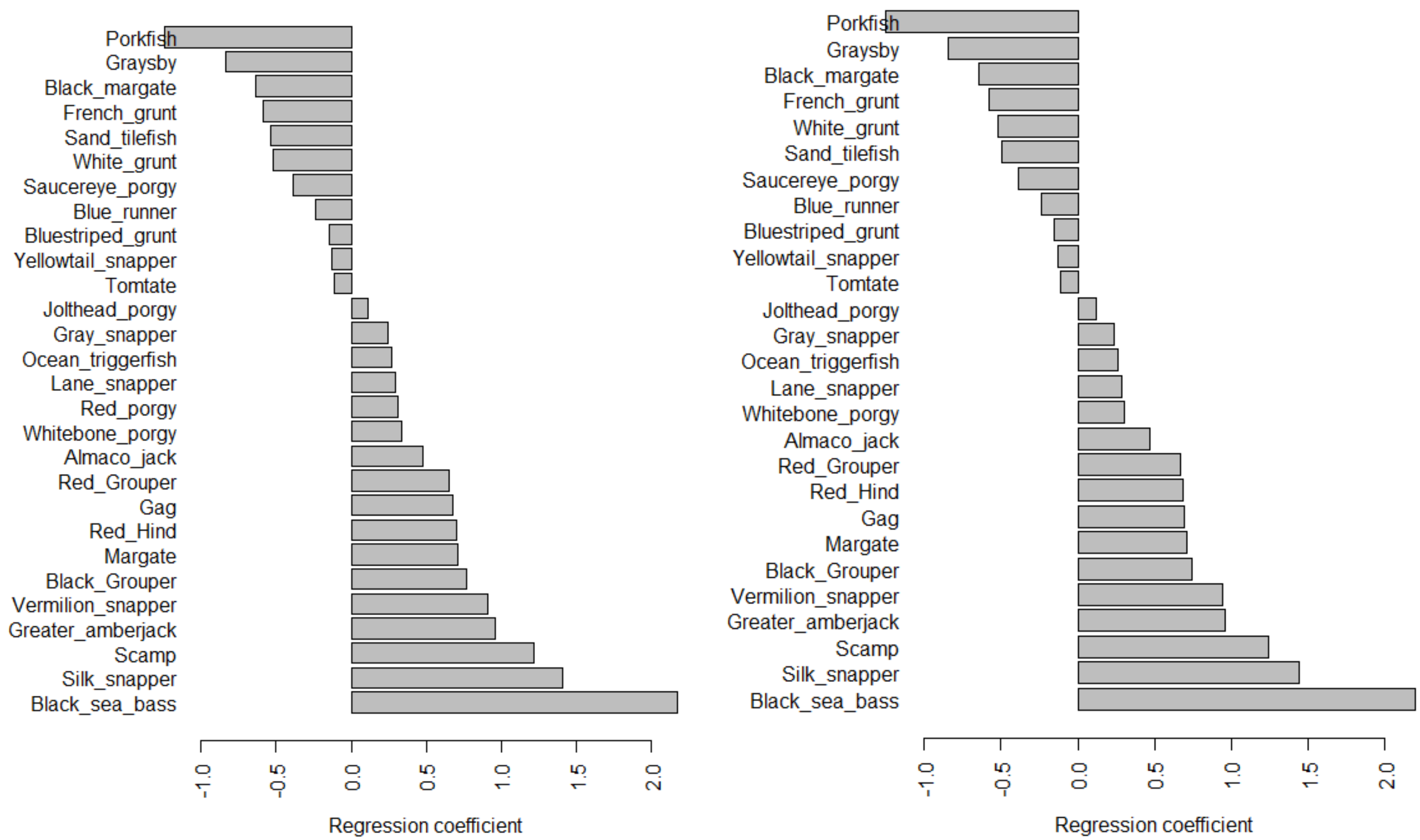


Figure 11. Estimates of species-specific regression coefficients from Stephens and MacCall method applied to headboat data from areas in the southern region. Left panel is from 1976-1991 data; right panel is from 1992-2009 data.

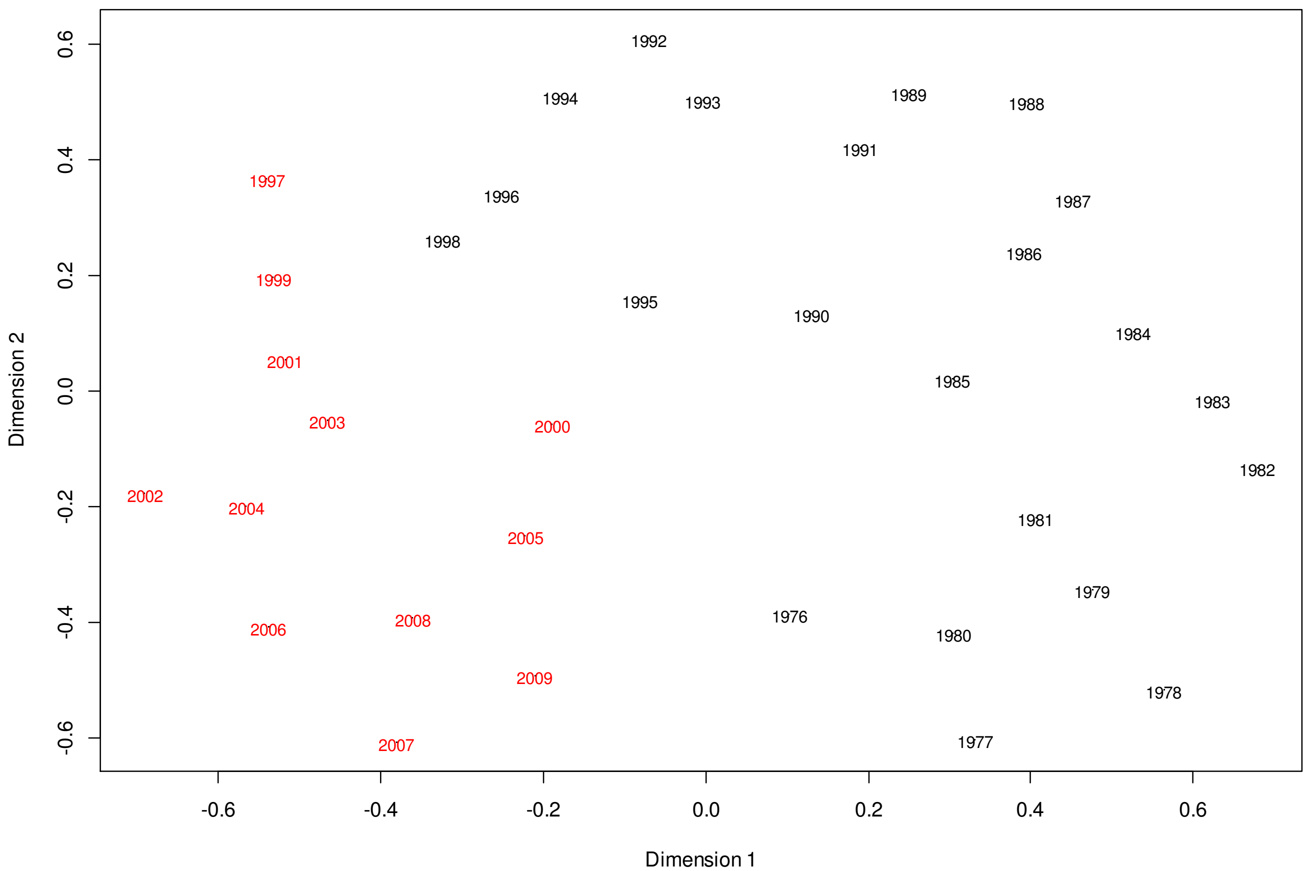
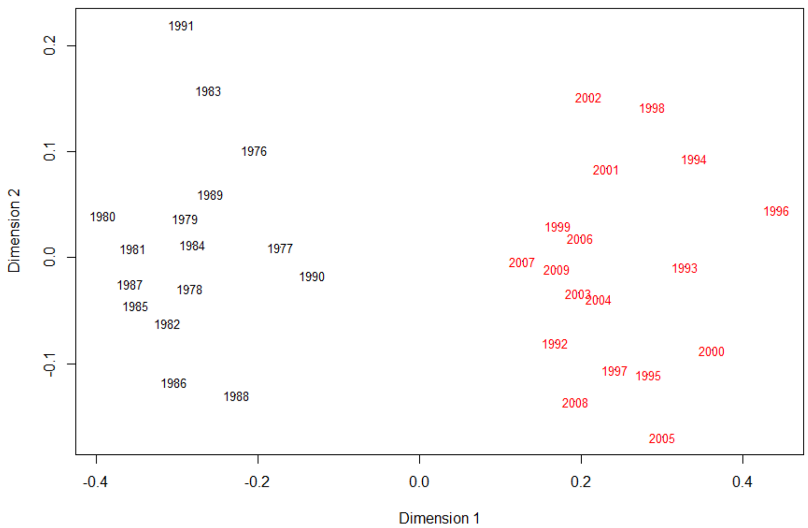
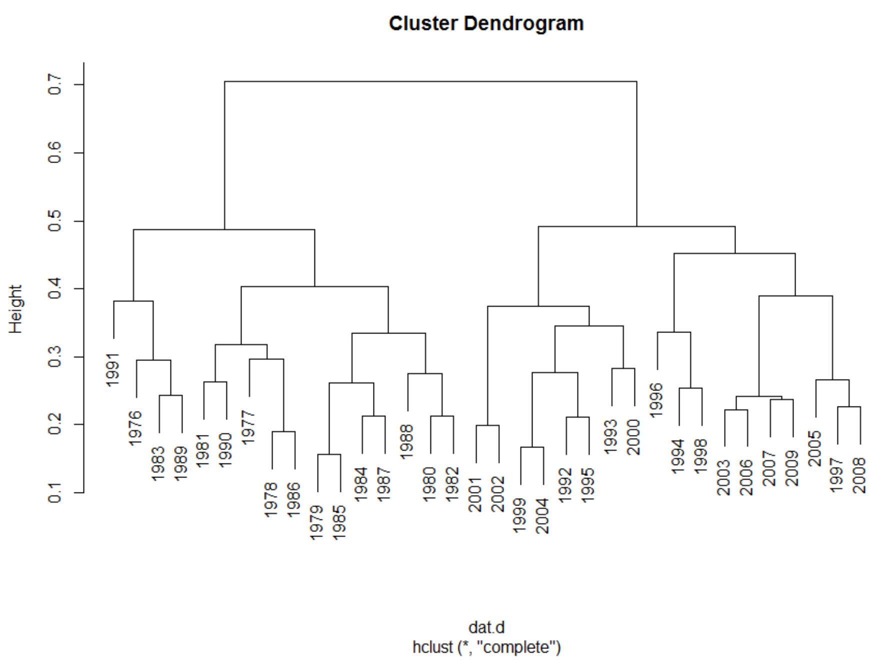


Figure 12. Non metric multidimensional scaling (NMDS) results. Annual shift in species assemblage from analysis using CPUE of the top snapper grouper species. The two colors represent the default number of medoids (clusters) used prior to final NMDS analysis (k=2).

Figure 13. Hierarchical cluster analysis results from CPUE of the top snapper grouper species from vessels north of Cape Canaveral, Florida.

Figure 14. Hypothetical example of distinct clustering with NMDS.





Updated Results for Red Snapper Headboat Logbook Index (1976-2009)

Table 3. The relative nominal CPUE, number of trips, standardized index, and CV for the red snapper headboat logbook data in the south Atlantic from 1976-2009.

Year	N	Nominal CPUE	Relative nominal	Standardized CPUE	CV
1976	876	0.5523	2.6159	2.3652	0.0525
1977	900	0.4672	2.2129	2.1644	0.0800
1978	1576	0.4780	2.2640	2.1293	0.0295
1979	1293	0.4647	2.2009	2.2279	0.0503
1980	1409	0.3053	1.4458	1.4517	0.0461
1981	1092	0.5072	2.4023	2.9481	0.0427
1982	1347	0.2043	0.9676	1.2042	0.0519
1983	1579	0.3103	1.4695	1.6414	0.0536
1984	1477	0.3368	1.5953	1.4202	0.0285
1985	1741	0.3518	1.6661	2.0710	0.0477
1986	2185	0.1130	0.5351	0.4773	0.0660
1987	2199	0.1363	0.6453	0.5782	0.0462
1988	2061	0.1552	0.7349	0.5616	0.0575
1989	1438	0.1984	0.9396	0.9001	0.0457
1990	1468	0.1638	0.7758	0.8680	0.0557
1991	1463	0.1370	0.6488	0.6937	0.0444
1992	2156	0.0316	0.1497	0.0776	0.0950
1993	1981	0.0575	0.2721	0.1622	0.0830
1994	1633	0.0889	0.4210	0.2586	0.0450
1995	1523	0.0760	0.3600	0.2778	0.0638
1996	1130	0.0655	0.3103	0.2477	0.0646
1997	790	0.0641	0.3038	0.2662	0.0927
1998	1647	0.0626	0.2963	0.2427	0.0756
1999	1706	0.0779	0.3689	0.2891	0.0484
2000	1442	0.1026	0.4859	0.4120	0.0535
2001	1553	0.1712	0.8110	0.7569	0.0675
2002	1466	0.2278	1.0788	0.8778	0.0497
2003	1150	0.1249	0.5917	0.5154	0.0454
2004	1606	0.1631	0.7722	0.7641	0.0374
2005	1290	0.1447	0.6854	0.7582	0.0430
2006	1406	0.1124	0.5325	0.4330	0.0513
2007	1505	0.1089	0.5158	0.4369	0.0823
2008	1551	0.3209	1.5200	1.7092	0.0517
2009	1917	0.2966	1.4047	1.8121	0.0276

Figure 15. CPUE binomial residuals for year, area, season, trip type and party size 1976-2009.

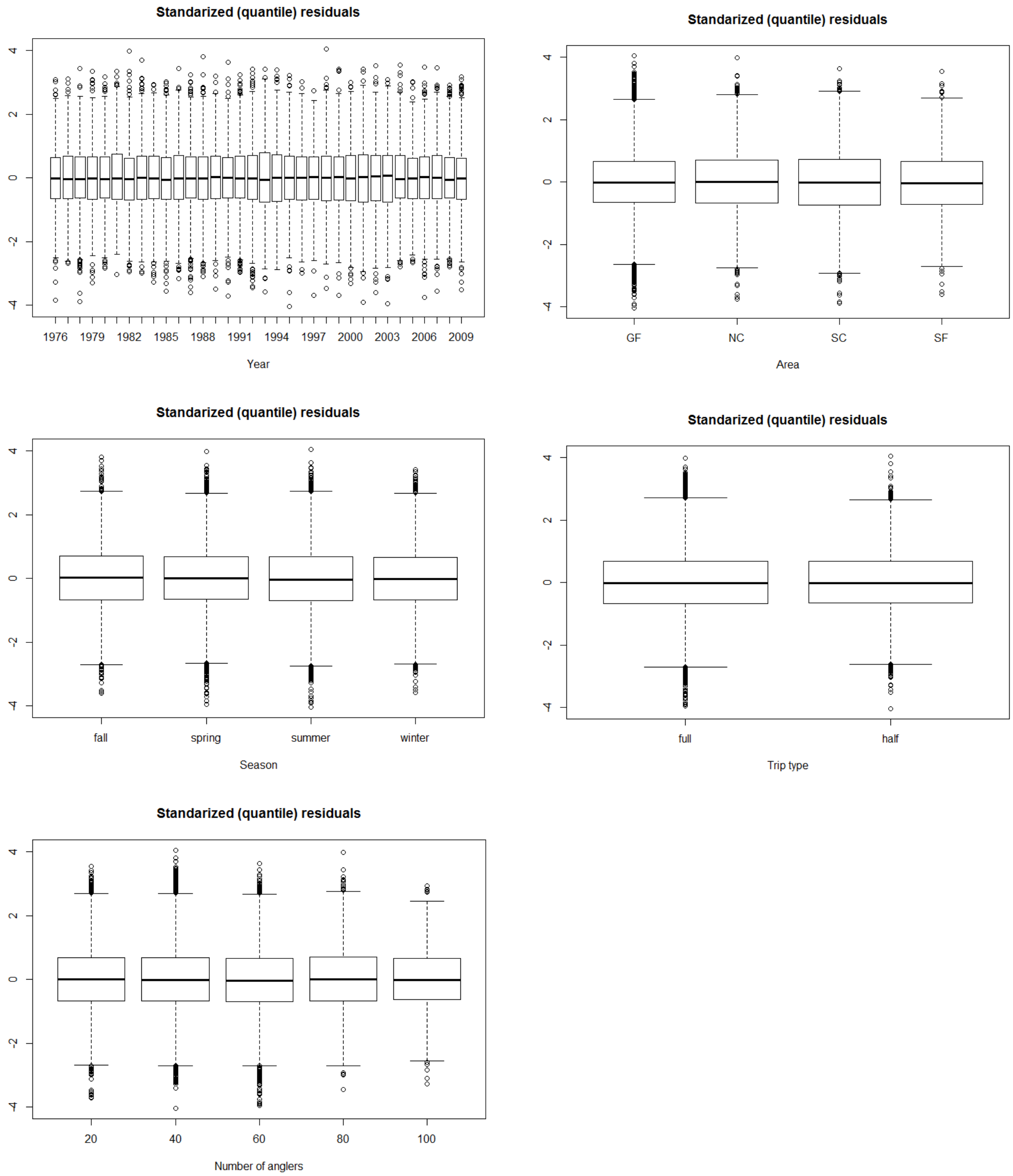


Figure 16. The lognormal distribution and qq plot of catch for the south Atlantic red snapper headboat logbook during1976-2009.

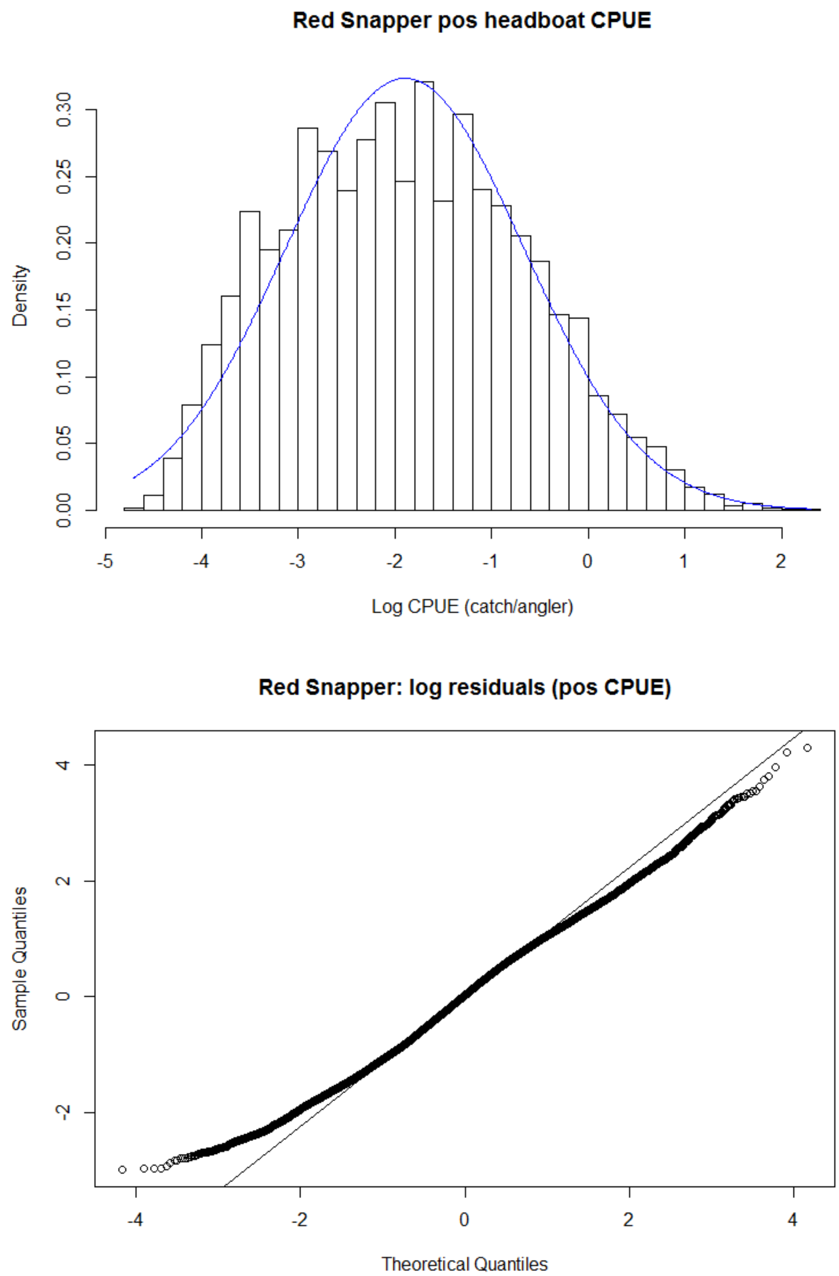


Figure 17 The standardized and nominal CPUE index with error bars at (+/-) 2 standard deviations (nominal by area below) computed for red snapper in the south Atlantic using the headboat logbook data during 1976-2009.