Standardized catch rates of Southeast US Atlantic gray triggerfish (*Balistes capriscus*) from headboat logbook data

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Standardized catch rates of Southeast US Atlantic gray triggerfish (*Balistes capriscus*) from headboat logbook data

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Abstract
Standardized catch rates were generated from the Southeast headboat survey trip records (logbooks) for 1995-2011. The analysis included areas from central North Carolina through south Florida. The index is meant to describe population trends of fish in the size/age range of fish landed by headboat vessels. Data filtering and subsetting steps were applied to the data to model trips that were likely to have directed gray triggerfish effort.

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.

Until 1980, there was no category for gray triggerfish on the catch record form for all south Atlantic states. Until 1980, captains had to write in species in blanks provided on the form.

A 12” minimum size limit for gray triggerfish has been in place since 1995 in Florida.

Headboat records were examined to determine if sufficient data exists to develop a standardized index of abundance for south Atlantic gray triggerfish.

Data treatment

Data from 1972-1979 were dropped from the analysis because the data collected included only North Carolina, South Carolina, Georgia and north 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 0.1% of trips. These trips were excluded because they were possibly misreported and likely don't reflect the behavior of headboats in general.

The index working group (IWG) discussed the starting year for this index (Table 2), summarized below:

- Although data were reported throughout the 1980s, the CPUE during that time period was considered unreliable as a measure of abundance. This was due to increases in desirability to keep gray triggerfish throughout the 1980s, and the fact that the headboat logbooks contained no information on discards during that period.
- Many regulatory changes of snapper-grouper species were implemented in 1992, and they may have affected targeting of gray triggerfish. In addition, a 12-inch size limit was implemented in 1995 in state and federal waters off the east coast of Florida. For this reason, the index was computed starting in 1995.

Subsetting trips

Trips to be included in the computation of the index need to be determined based on effort directed at gray triggerfish. Effort can be determined directly for trips which had positive gray triggerfish catches, but some trips likely directed effort at gray triggerfish, but were unsuccessful at landing gray triggerfish. Given that information on directed effort for trips without gray triggerfish harvest is not available, another method must be used to compute total effort.
In order to determine effort that was likely directed at gray triggerfish 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 gray triggerfish 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 gray triggerfish 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-hour and was calculated as the number of gray triggerfish caught divided by the number of anglers multiplied by the number of trip hours.

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 gray triggerfish effort per year and area is provided in Table 1.

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: ≤16 anglers, 16-22 anglers, 23-31 anglers, 32-45 anglers, and >45 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). Jackknife estimates of variance were computed using the 'leave one out' estimator (Dick 2004). 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 gray triggerfish 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. In this case, the stepwise AIC procedure did not remove any predictor variables (Appendix 1). Recognizable patterns were not apparent in the quantile residuals (Figures 6-10).

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, the lognormal distribution outperformed the gamma distribution with lower AIC values when all factors were included and when using only those factors that were selected in the previous step (Appendix 1).

Thus, the lognormal model with all factors 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 6-10) appeared reasonable.

Index

The distribution of CPUE for the index is presented in Figure 9 and the QQ plot of the residuals (Figure 10). The index is presented in Table 3 and in Figure 11.

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Table 1. Number of gray triggerfish headboat trips by area including positive trips prior to subsetting (pos.raw) and positive and zero trips following Stephens & MacCall (SM) method.

	NC				SC				GF				SF				Total.SM			
Year	pos.raw	Pos.SM	0.SM	%	pos.raw	Pos.SM	0.SM	%	pos.raw	Pos.SM	0.SM	%	pos.raw	Pos.SM	0.SM	%	pos.raw	Pos.SM	0.SM	%
1995	417	120	84	59%	763	366	382	49%	1059	564	657	46%	1216	238	937	20%	3455	1288	2060	38%
1996	452	121	82	60%	671	331	384	46%	702	325	562	37%	776	130	543	19%	2601	907	1571	37%
1997	279	103	64	62%	545	299	290	51%	623	351	285	55%	533	86	408	17%	1980	839	1047	44%
1998	451	137	90	60%	740	379	457	45%	1224	767	522	60%	815	155	587	21%	3230	1438	1656	46%
1999	370	135	114	54%	579	353	472	43%	1335	760	536	59%	532	103	310	25%	2816	1351	1432	49%
2000	375	149	106	58%	555	346	563	38%	761	378	679	36%	531	137	290	32%	2222	1010	1638	38%
2001	271	114	125	48%	436	264	558	32%	789	466	612	43%	667	184	418	31%	2163	1028	1713	38%
2002	334	137	65	68%	535	313	460	40%	680	414	582	42%	686	197	261	43%	2235	1061	1368	44%
2003	308	110	78	59%	466	160	379	30%	783	386	499	44%	524	123	226	35%	2081	779	1182	40%
2004	507	214	86	71%	646	290	396	42%	1233	578	259	69%	914	310	341	48%	3300	1392	1082	56%
2005	318	119	116	51%	388	188	363	34%	954	468	305	61%	746	180	361	33%	2406	955	1145	45%
2006	284	115	70	62%	435	220	430	34%	1043	510	319	62%	582	134	261	34%	2344	979	1080	48%
2007	298	103	62	62%	626	313	464	40%	1115	532	307	63%	542	94	201	32%	2581	1042	1034	50%
2008	317	106	81	57%	462	195	395	33%	998	450	437	51%	1622	596	532	53%	3399	1347	1445	48%
2009	245	80	85	48%	507	220	455	33%	1515	691	346	67%	2198	884	614	59%	4465	1875	1500	56%
2010	312	95	88	52%	634	246	404	38%	1556	563	184	75%	2440	903	648	58%	4942	1807	1324	58%
2011	262	88	69	56%	551	193	314	38%	1451	376	124	75%	2385	830	564	60%	4649	1487	1071	58%
total	5800	2046	1465	58%	9539	4676	7166	39%	17821	8579	7215	54%	17709	5284	7502	41%	50869	20585	23348	47%

Table 2. Progression of discussion of subsetting method leading to recommended index for the headboat logbook data.

run	Progression leading to recommended index	Comments
1	1976-2011, Stephens & MacCall	no data from sFL until 1980
		gray triggerfish was not listed to species on the logbook form until 1980
2	1980-2011, Stephens & MacCall	identified shift in desirability from the late 1980's to the early 1990's,
		identified shift in species composition pre- and post 1992
3	1992-2011, Stephens & MacCall	due to 12" minimum size in FL beginning in 1995, group decided to start index in 1995
4	1995-2011, Stephens & MacCall	

Table 3. The relative nominal CPUE, number of trips, standardized index, and CV for the gray triggerfish headboat logbook data in the south Atlantic.

Year	Relative nominal CPUE	N	Proportion N positive	Standardized index	CV (index)
1995	0.81	3264	0.37	0.62	0.04
1996	1.06	2412	0.35	0.64	0.05
1997	1.14	1845	0.44	0.97	0.05
1998	0.95	2994	0.45	0.80	0.04
1999	0.78	2702	0.48	0.72	0.04
2000	0.76	2541	0.36	0.48	0.05
2001	0.64	2644	0.36	0.46	0.05
2002	0.86	2264	0.41	0.57	0.05
2003	0.83	1852	0.38	0.58	0.06
2004	1.26	2278	0.54	1.35	0.04
2005	0.79	1976	0.44	0.81	0.05
2006	0.71	1930	0.46	0.89	0.05
2007	1.01	1974	0.49	1.02	0.05
2008	1.00	2691	0.47	1.11	0.04
2009	1.23	3289	0.55	1.66	0.03
2010	1.65	3041	0.57	1.98	0.03
2011	1.54	2482	0.58	2.35	0.03

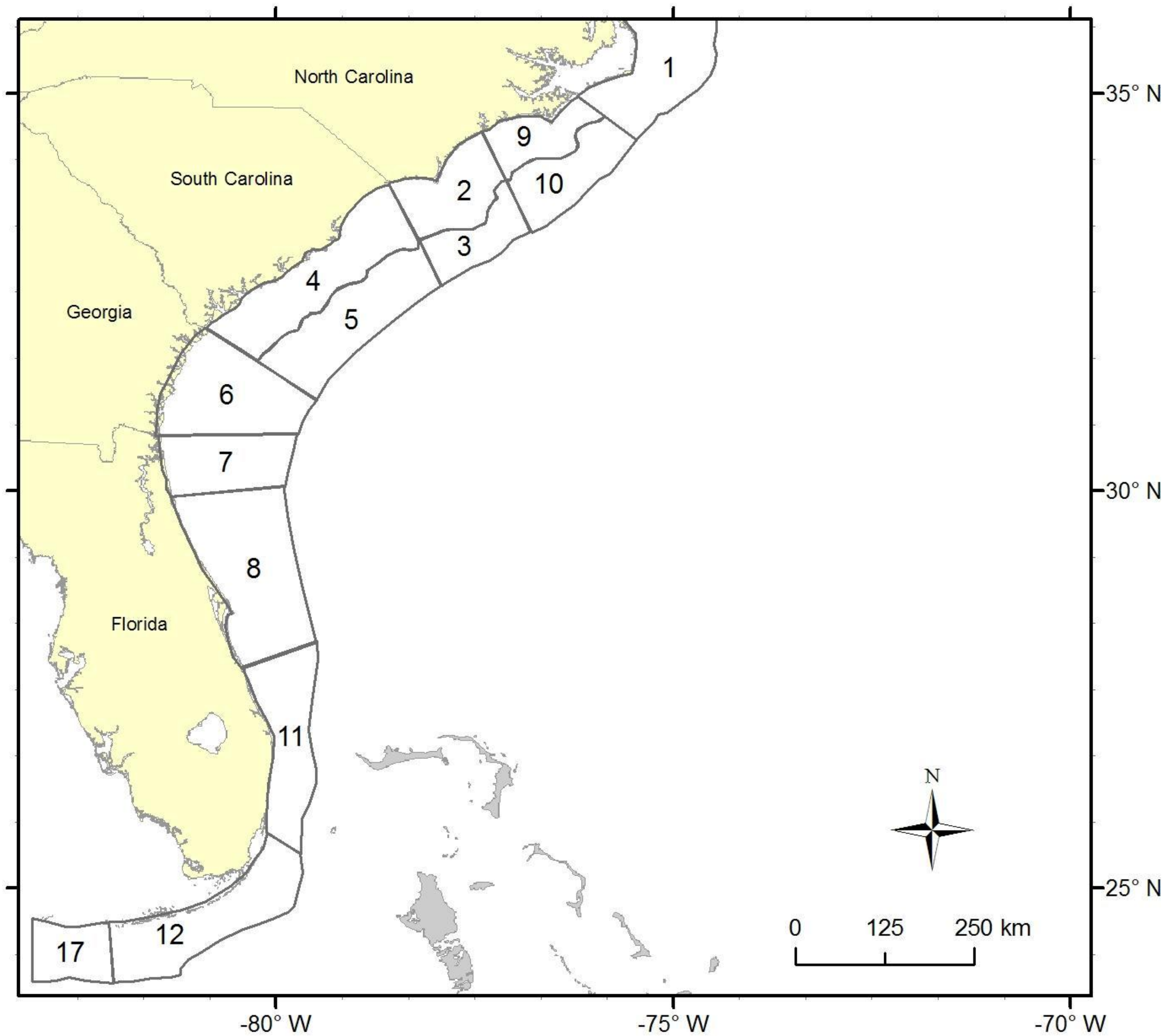


Figure 1. Map of headboat sampling area definition. These areas were pooled into regions of North Carolina (NC=2,3,9,10), South Carolina (SC=4,5), Georgia and North Florida (GNFL=6,7,8), and south Florida (sFL=11,12,17).

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.

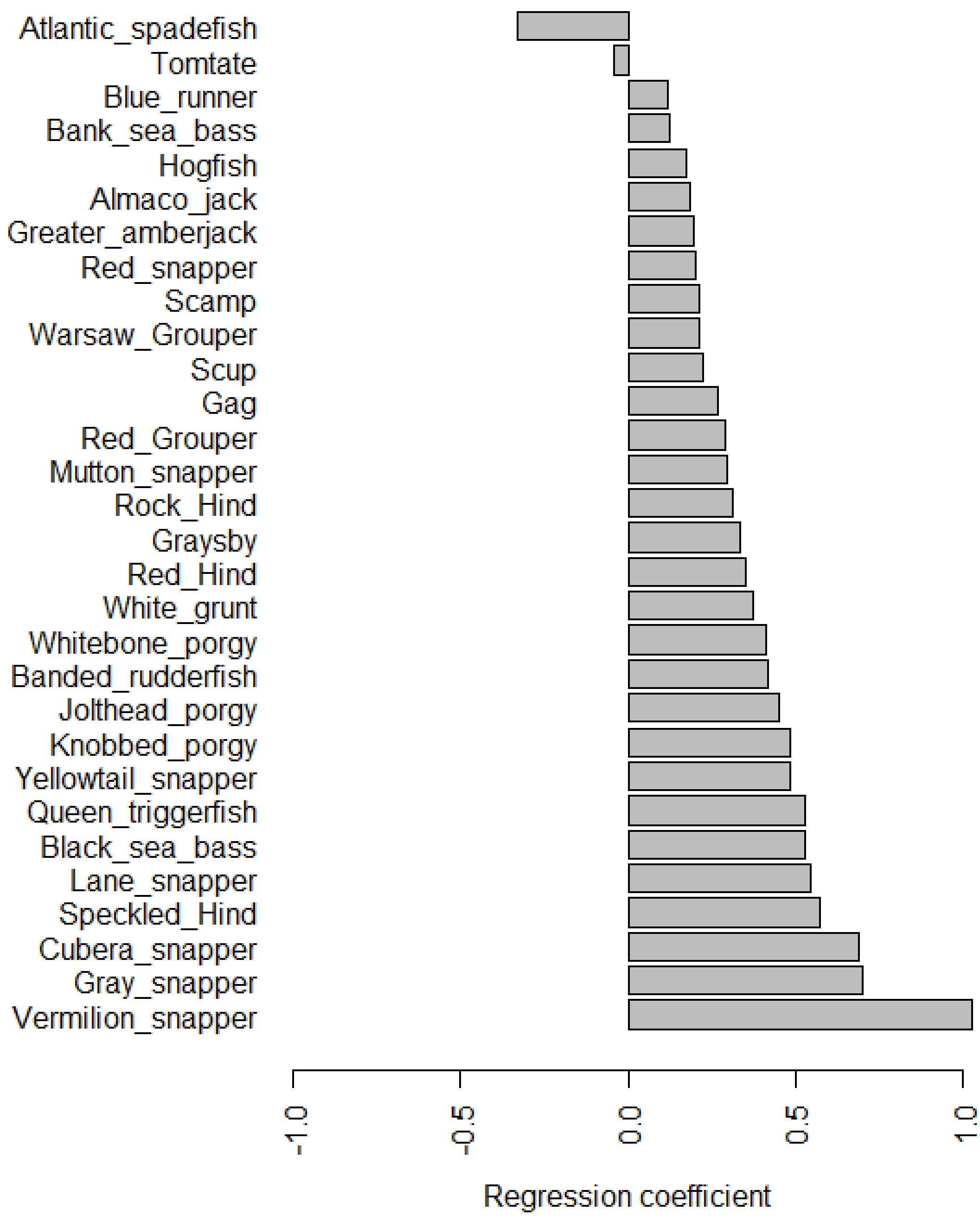


Figure 3. Estimates of species-specific regression coefficients from Stephens and MacCall method applied to headboat data from areas in the southern region (includes areas 11, 12, and 17), as used to estimate each trip's probability of catching the focal species.

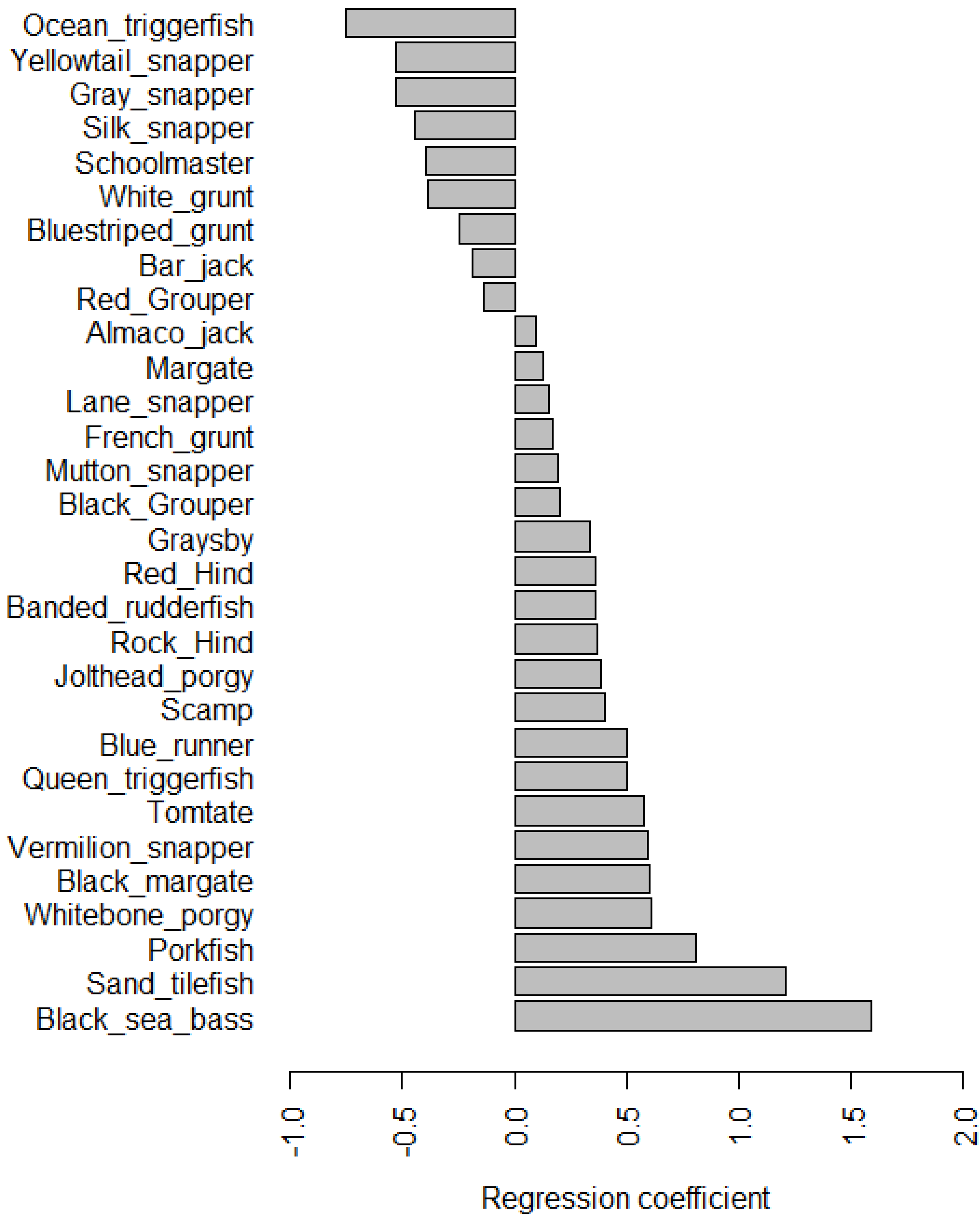


Figure 4. Absolute difference between observed and predicted number of positive trips from Stephens and MacCall method applied to headboat data from the northern region (excludes areas 11, 12, and 17). Left and right panels differ only in the range of probabilities shown.

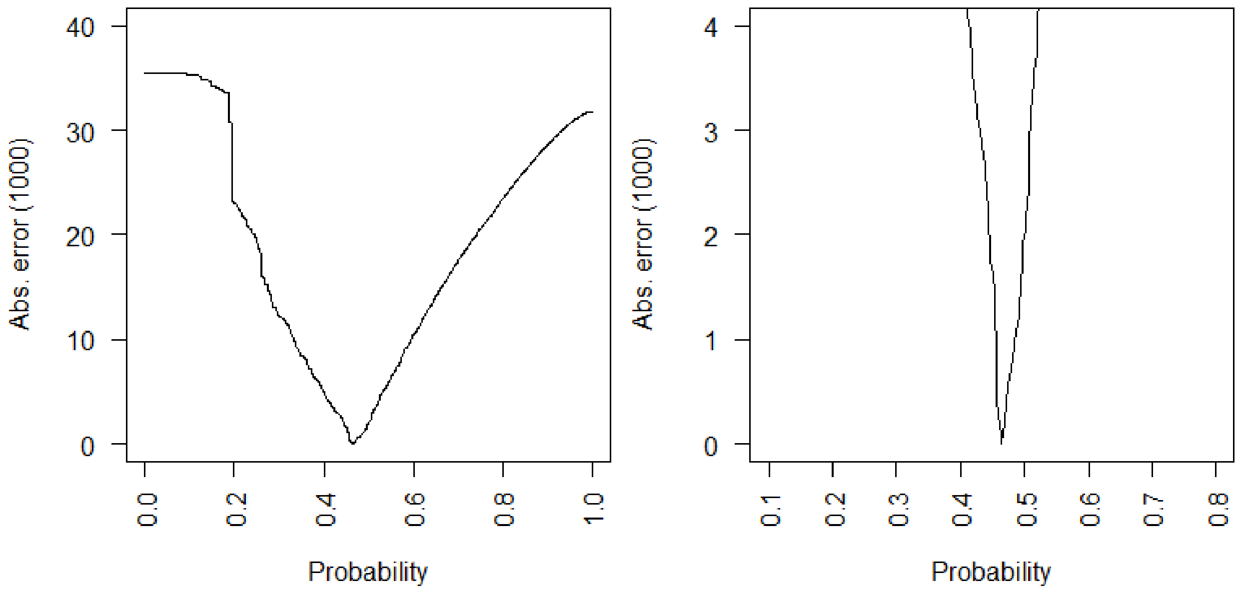


Figure 5. Absolute difference between observed and predicted number of positive trips from Stephens and MacCall method applied to headboat data from the southern region (includes areas 11, 12, and 17). Left and right panels differ only in the range of probabilities shown.

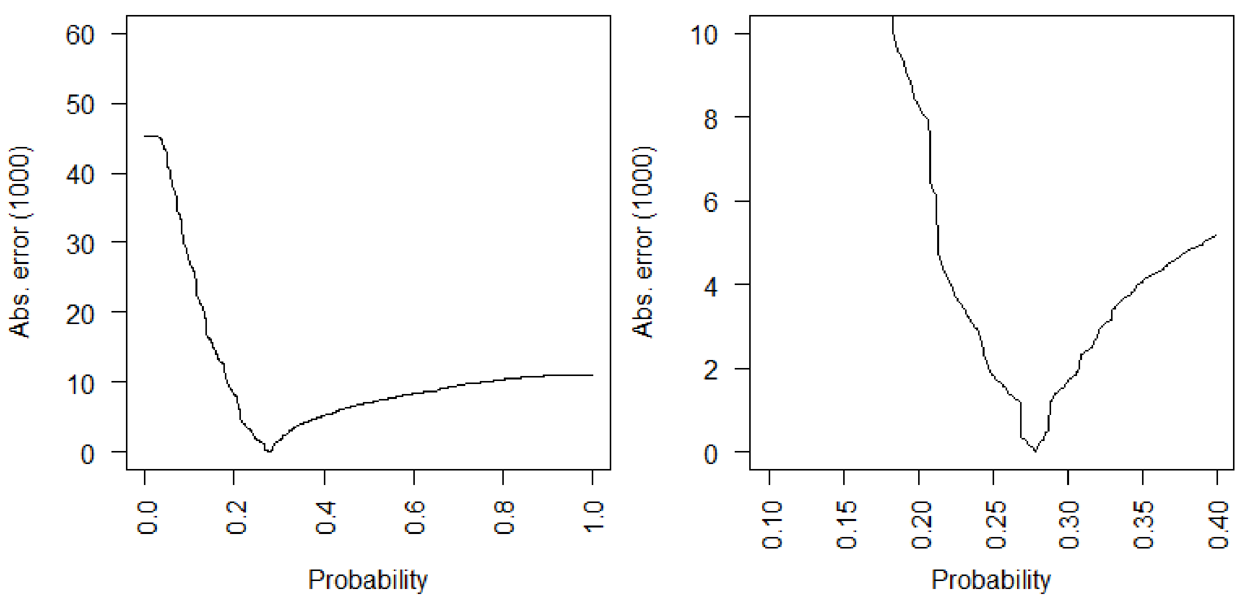


Figure 6. Total effort with gray triggerfish by area.

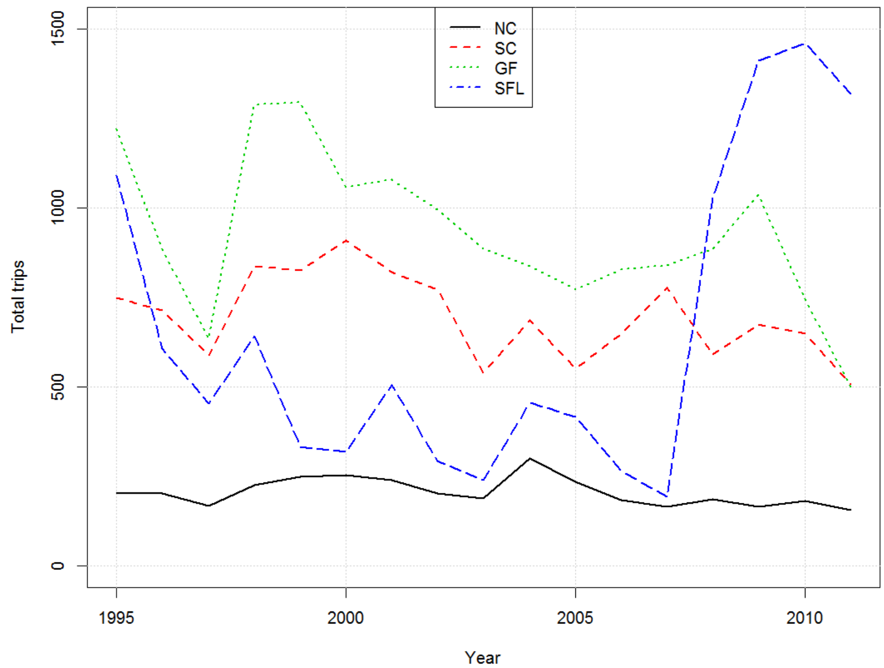


Figure 7. Total effort with gray triggerfish by season.

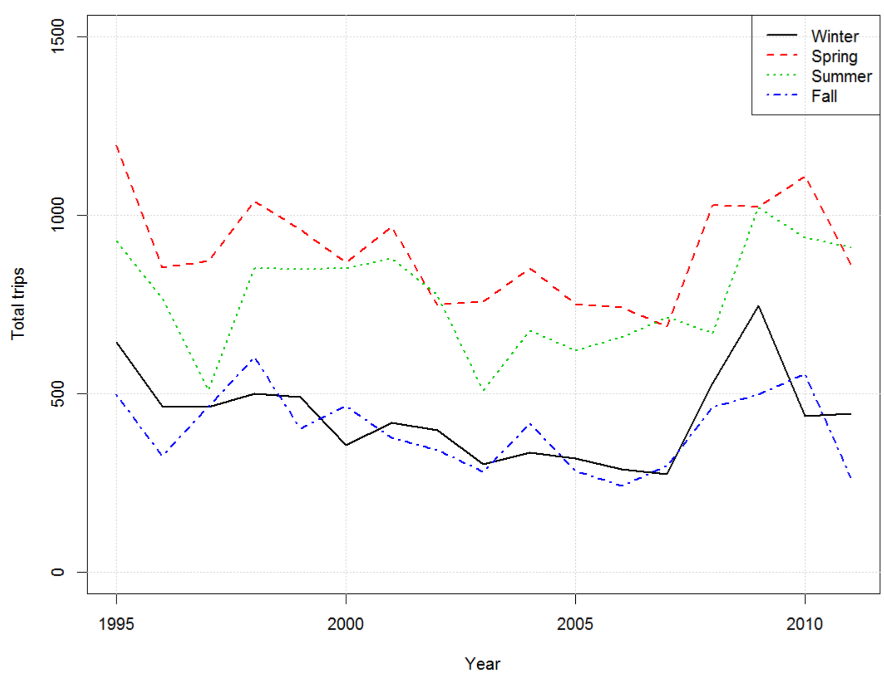
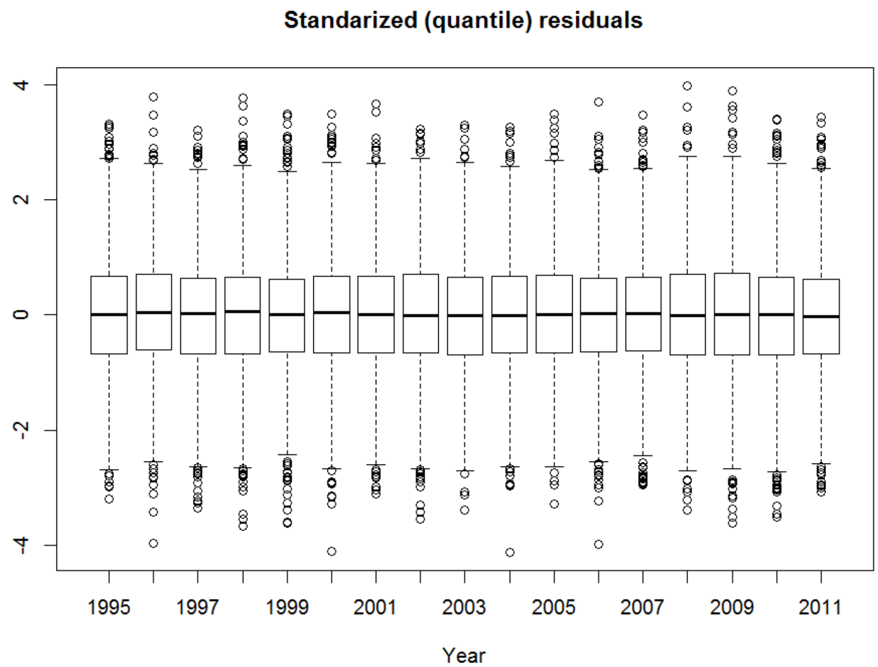


Figure 8. CPUE binomial residuals for year, area, season, trip type and party size.



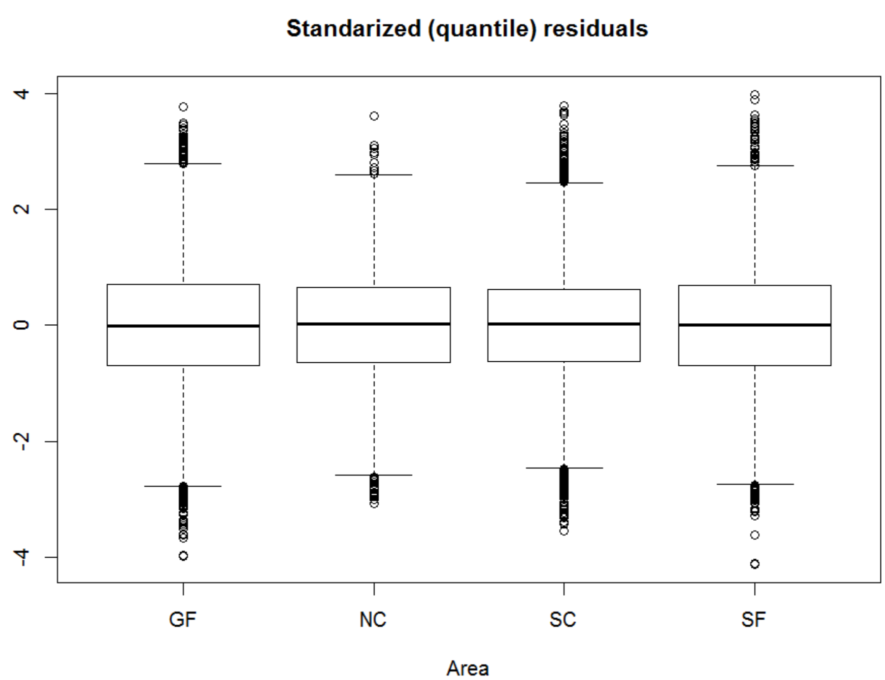
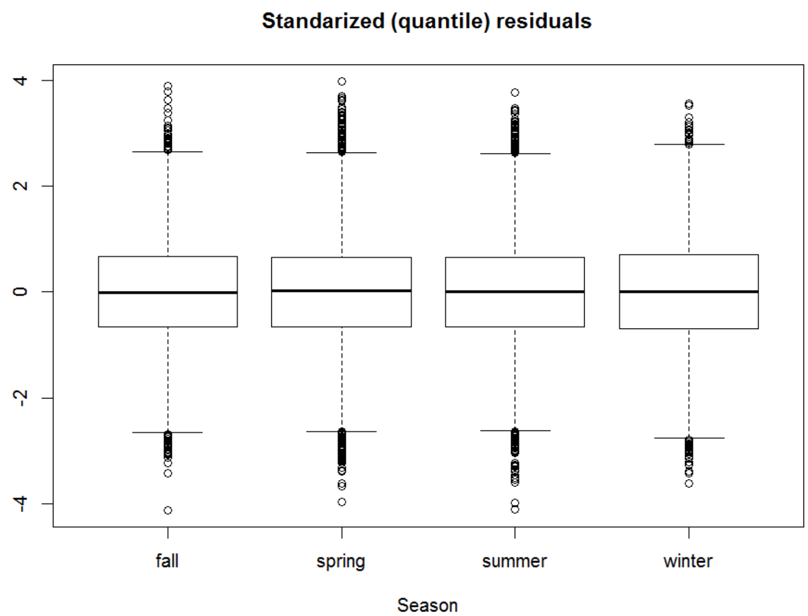


Figure 8. Continued.



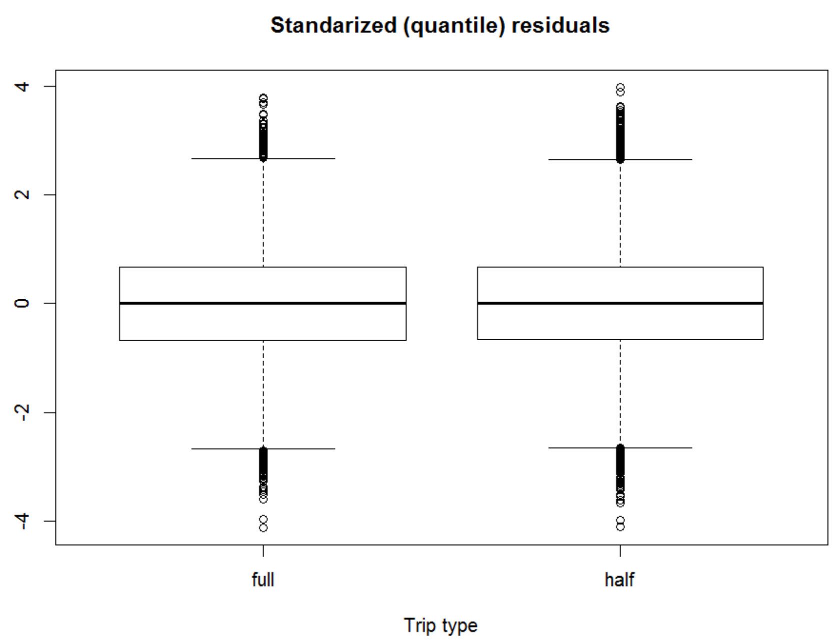


Figure 8. Continued.

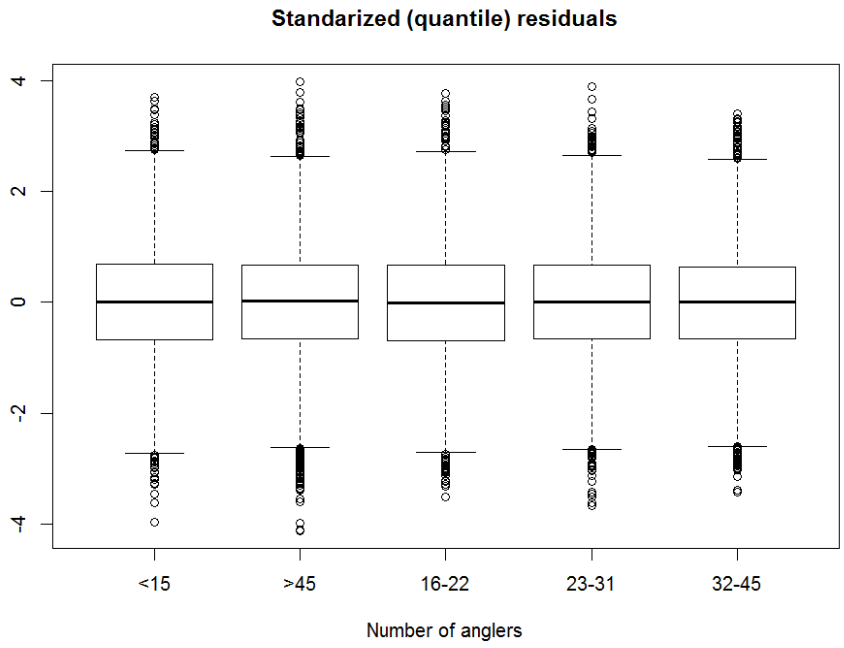


Figure 9. The lognormal distribution of catch for the south Atlantic gray triggerfish headboat logbook during 2005-2011.

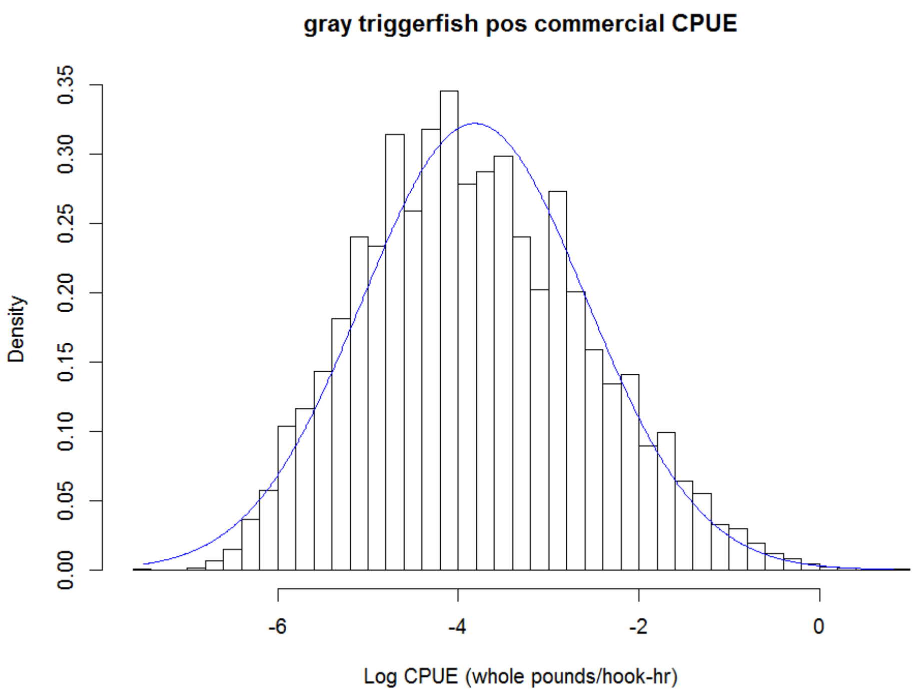


Figure 10. QQ plot residuals for gray triggerfish CPUE.

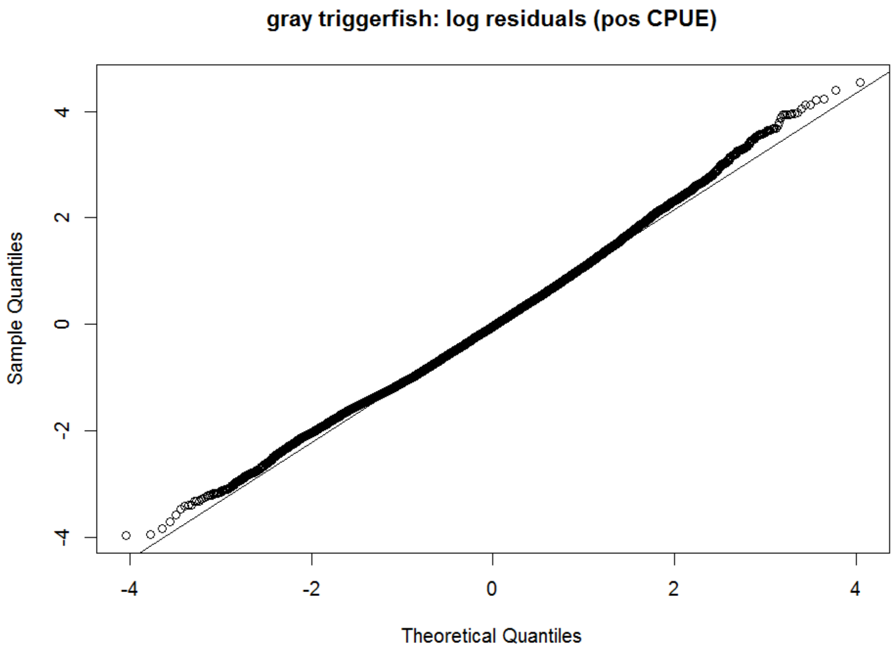
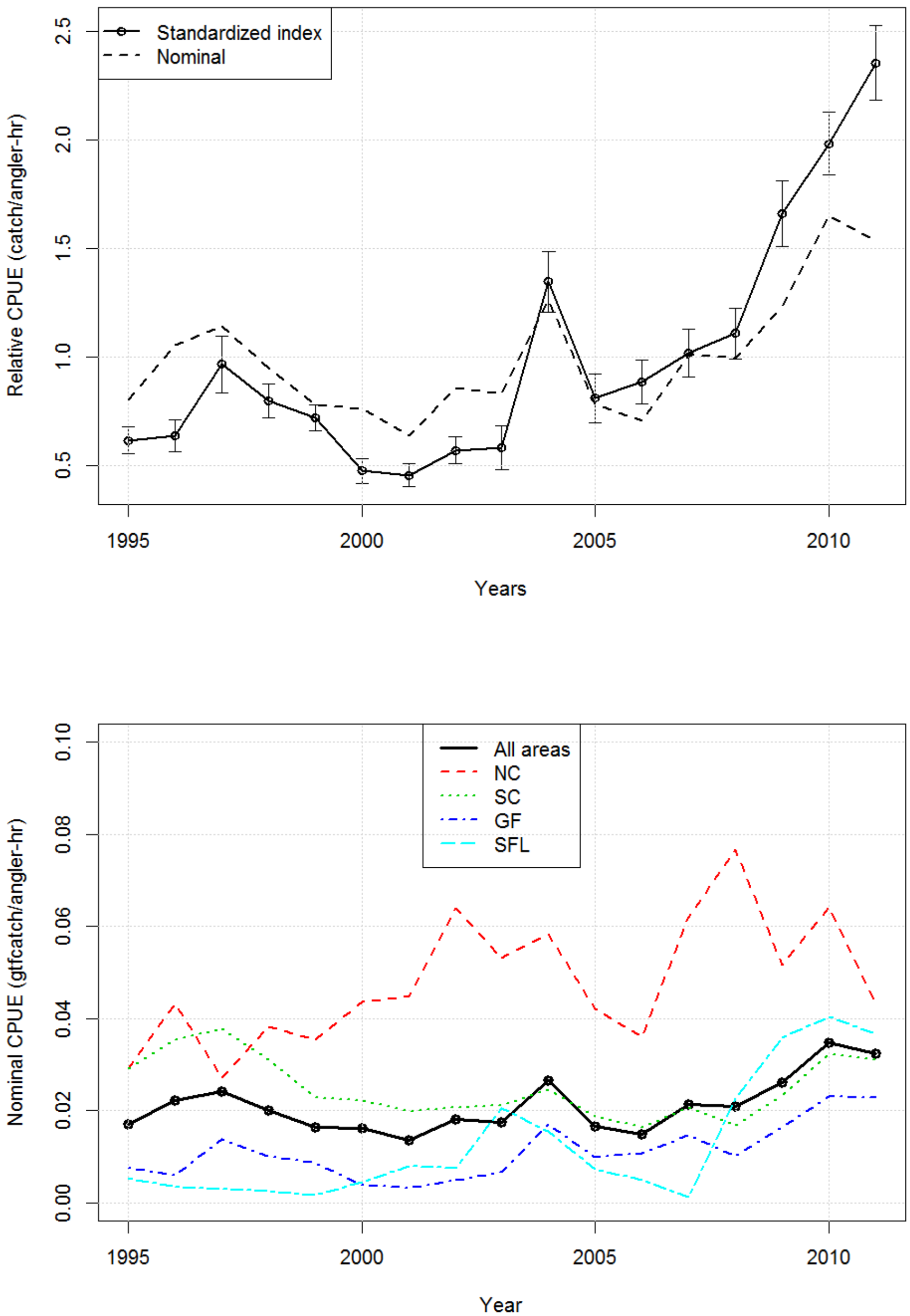


Figure 11. The standardized and nominal CPUE index with error bars at (+/-) 2 standard deviations (nominal by area below) computed for gray triggerfish in the south Atlantic using the headboat logbook data during 2005-2011.



Appendix 1. The stepwise AIC output for the lognormal (a), the gamma (b) distributions, binomial component (c) and the AIC comparison (d).

a)

```
Start:  AIC=58183.47
log(cpue) ~ year + area + anglers + type + season
          Df Deviance   AIC
<none>          23041 58183
- season   3    23334 58421
- type     1    23389 58471
- anglers  4    23865 58853
- year    16    23970 58914
- area     3    26697 61016
```

b)

```
Start:  AIC=-84931.58
cpue ~ year + area + anglers + type + season
          Df Deviance    AIC
<none>          24232 -84932
- type     1    24411 -84861
- season   3    24541 -84812
- year    16    25186 -84576
- anglers  4    25416 -84458
- area     3    28934 -83025
```

c)

```
Start:  AIC=50760.82
cpue ~ year + area + anglers + type + season

          Df Deviance   AIC
<none>          50705 50761
- season   3    50745 50795
- area     3    50824 50874
- anglers  4    51111 51159
- year    16    52986 53010
- type     1    54936 54990
>   bin.fit=glm.step
```

d)

```
AIC comparison
GTF_hb1$aic
                      [,1]
AIC.binomial  5.076082e+04
AIC.gamma    -8.521383e+04
shape.mle     9.263921e-01
> GTF_hb2$aic
                       [,1]
AIC.binomial   50760.821815
AIC.lognormal -89781.179098
sigma.mle          1.093522
```