Standardized catch rates of Southeast US Atlantic snowy grouper (*Epinephelus niveatus*) from headboat logbook data

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Standardized catch rates of Southeast US Atlantic snowy grouper (*Epinephelus niveatus*) from headboat logbook data

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June 14, 2013

Abstract
Standardized catch rates were generated from the Southeast headboat survey trip records (logbooks) for 1978-2010. 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 snowy grouper 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.

Exploratory Data Analysis

Snowy grouper represent a small fraction of the overall catch in the south Atlantic headboat fishery (~1%). Data filtering steps were applied to the data to identify trips that likely had directed snowy grouper effort. Table 1 summarizes positive snowy grouper trips in the south Atlantic by year and area (North Carolina (NC), South Carolina (SC), Georgia-north Florida (GNFL), and south Florida (sFL).

Data Filtering Techniques

While exploring headboat data to develop a standardized index for snowy grouper in the south Atlantic, multiple subsetting methods were investigated.

Stephens & MacCall
Applying methods described by Stephens & MacCall (2004) to snowy grouper resulted in a reduction in positive snowy grouper trips. A large reduction in positive snowy grouper trips and an inflation of zero snowy grouper trips was anticipated due to the infrequency of snowy grouper in the headboat fishery, therefore a more appropriate method was pursued.

Core Vessels
To identify headboat trips that best characterize the snowy grouper fishery, vessels that consistently caught snowy grouper were investigated. A subset identifying data from 25 headboats representing 90% of snowy grouper effort and landings was selected. This method proved problematic due to regional shifts in effort through time.

Jaccard Method
This method is an alternative to Stephens and MacCall (2004) for identifying trips that fished in snowy grouper habitat (deepwater) but did not catch snowy grouper. In essence, species that are more associated in the catch with the focal species (snowy grouper) would have a higher Jaccard statistic than those that are less associated (equation below, Appendix 2). This method has not been fully developed in any previous SEDAR workshop and, for snowy grouper, likely suffers from the same problem as Stephens and MacCall; it was therefore not further pursued for this standard assessment.

$$S_j = \frac{a}{a+b+c}$$

Where: a = # trips where triggerfish AND species j were caught
b = # trips where triggerfish was caught but NOT species j
c = # trips where species j was caught but NOT triggerfish

Positive Trips
Headboat trips that caught snowy grouper were investigated. This method underestimates the amount of effort directed at snowy grouper in the headboat fishery by disregarding trips that were unsuccessful at catching snowy grouper. This was the method used in SEDAR 4 for snowy grouper, in SEDAR 32 for blueline tilefish, and it has been replicated here for SEDAR 36.

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 snowy grouper caught divided by the number of anglers multiplied by the number of trip hours.

Year- A summary of the total number of trips with snowy grouper effort per year and trips with positive snowy grouper catch is provided in Table 1. Positive snowy grouper trips after 2010

were not included in the analysis due to management regulation (1 snowy grouper per vessel). Year included in the analysis were 1978-2010.

Area – These areas were pooled into two regions of North Carolina/South Carolina (NCSC=2,3,4,5,9,10) and Georgia/Florida (GNFL=6,7,8,11,12,17).
The total effort by year and area for snowy grouper catch are provided in Figure 2.

Season – Due to low samples sizes by month the seasons were defined as season1 (January, February, March,April, May, June) and season2 (July, August, September, October, November, December). Season was not retained as a factor.

Standardization

CPUE was modeled using the glm approach (Dick 2004). In particular, fits of lognormal and gamma models were compared. Also, the combination of predictor variables was examined to best explain CPUE patterns. 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).

POSITIVE CPUE SUBMODEL
To determine predictor variables important for predicting positive CPUE, 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).

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 year and area was used for computing the index. Standard model diagnostics (Figures 3-5) appeared reasonable.

Index

The distribution of CPUE for the index appeared reasonable (Figure 4), as did the QQ plot of the residuals (Figure 5). The index is presented in Table 2 and visually in Figure 6.

LITERATURE CITED

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

Stephens, A., and A. MacCall. 2004. A multispecies approach to subsetting logbook data for purposes of estimating CPUE. Fish. Res. 70:299-310.

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

Table 1. Positive snowy grouper trips and snowy grouper caught in the south Atlantic by year and zone (North Carolina/South Carolina (NC_SC), Georgia-Florida (Ga_FL).

N.Trips							
Year	NC	SC	GA_nFL	sFL	NC_SC	GA_FL	Total
1973	1	33	0	0	34	0	34
1974	4	51	0	0	55	0	55
1975	4	67	0	0	71	0	71
1976	34	63	2	0	97	2	99
1977	9	27	0	0	36	0	36
1978	10	54	2	5	64	7	71
1979	25	43	0	15	68	15	83
1980	11	92	10	37	103	47	150
1981	14	36	18	62	50	80	130
1982	23	74	10	57	97	67	164
1983	19	121	2	68	140	70	210
1984	14	40	4	26	54	30	84
1985	3	69	5	68	72	73	145
1986	13	102	6	46	115	52	167
1987	5	81	8	40	86	48	134
1988	5	87	4	24	92	28	120
1989	1	78	0	18	79	18	97
1990	3	45	4	16	48	20	68
1991	2	33	1	22	35	23	58
1992	20	21	7	18	41	25	66
1993	19	67	1	18	86	19	105
1994	15	63	2	10	78	12	90
1995	15	38	5	17	53	22	75
1996	16	41	2	16	57	18	75
1997	11	21	3	7	32	10	42
1998	15	11	5	19	26	24	50
1999	2	10	7	7	12	14	26
2000	9	4	8	8	13	16	29
2001	22	25	6	7	47	13	60
2002	11	6	5	2	17	7	24
2003	7	12	2	1	19	3	22
2004	20	0	10	9	20	19	39
2005	8	5	19	11	13	30	43
2006	11	0	7	3	11	10	21
2007	18	6	1	12	24	13	37
2008	9	6	2	11	15	13	28
2009	3	3	2	15	6	17	23
2010	4	0	4	9	4	13	17
2011	2	0	1	17	2	18	20
2012	1	0	0	12	1	12	13
Total	438	1535	175	733	1973	908	2881

N.Fish							
Year	NC	SC	GA_nFL	sFL	NC_SC	GA_FL	Total
1973	1	393	0	0	394	0	394
1974	4	1474	0	0	1478	0	1478
1975	73	858	0	0	931	0	931
1976	213	1693	4	0	1906	4	1910
1977	211	691	0	0	902	0	902
1978	51	705	3	13	756	16	772
1979	473	463	0	24	936	24	960
1980	148	2318	177	132	2466	309	2775
1981	196	967	368	221	1163	589	1752
1982	111	1077	36	109	1188	145	1333
1983	62	1820	27	149	1882	176	2058
1984	71	281	4	52	352	56	408
1985	7	677	5	128	684	133	817
1986	53	760	9	112	813	121	934
1987	12	928	8	71	940	79	1019
1988	9	841	5	57	850	62	912
1989	30	645	0	52	675	52	727
1990	7	417	4	44	424	48	472
1991	6	196	1	55	202	56	258
1992	53	99	7	31	152	38	190
1993	54	192	1	28	246	29	275
1994	43	290	2	19	333	21	354
1995	59	216	6	59	275	65	340
1996	50	486	2	30	536	32	568
1997	36	241	5	20	277	25	302
1998	57	19	6	47	76	53	129
1999	6	25	9	20	31	29	60
2000	37	11	9	20	48	29	77
2001	109	215	9	22	324	31	355
2002	34	109	6	8	143	14	157
2003	30	114	3	1	144	4	148
2004	45	0	12	25	45	37	82
2005	12	27	41	32	39	73	112
2006	78	0	7	4	78	11	89
2007	40	65	1	30	105	31	136
2008	23	6	2	15	29	17	46
2009	12	11	2	18	23	20	43
2010	9	0	4	21	9	25	34
2011	19	0	1	34	19	35	54
2012	3	0	0	16	3	16	19
Total	2547	19330	786	1719	21877	2505	24382

Table 2. The relative nominal CPUE, number of trips, standardized index, and CV for the snowy grouper headboat fishery in the south Atlantic.

Year	Nominal index	N	Standardized index	CV
1978	2.03	71	1.58	14%
1979	1.97	83	1.22	15%
1980	3.38	150	2.38	13%
1981	3.42	130	2.18	15%
1982	1.49	164	0.97	11%
1983	1.85	210	1.26	9%
1984	0.82	84	0.85	12%
1985	1.27	145	0.84	10%
1986	0.99	167	0.87	10%
1987	1.23	134	1.17	11%
1988	1.10	120	1.11	12%
1989	1.14	97	1.39	10%
1990	1.27	68	0.93	15%
1991	0.80	58	1.02	14%
1992	0.45	66	0.68	14%
1993	0.35	105	0.49	12%
1994	0.49	90	0.57	11%
1995	0.64	75	0.77	16%
1996	0.94	75	0.96	14%
1997	0.89	42	0.75	23%
1998	0.37	50	0.72	17%
1999	0.41	26	0.80	21%
2000	0.50	29	0.75	17%
2001	0.71	60	0.92	17%
2002	0.86	24	1.08	34%
2003	0.92	22	1.36	35%
2004	0.37	39	0.54	13%
2005	0.44	43	0.64	17%
2006	0.74	21	0.96	31%
2007	0.37	37	0.91	22%
2008	0.26	28	0.54	18%
2009	0.32	23	0.94	16%
2010	0.22	17	0.85	25%

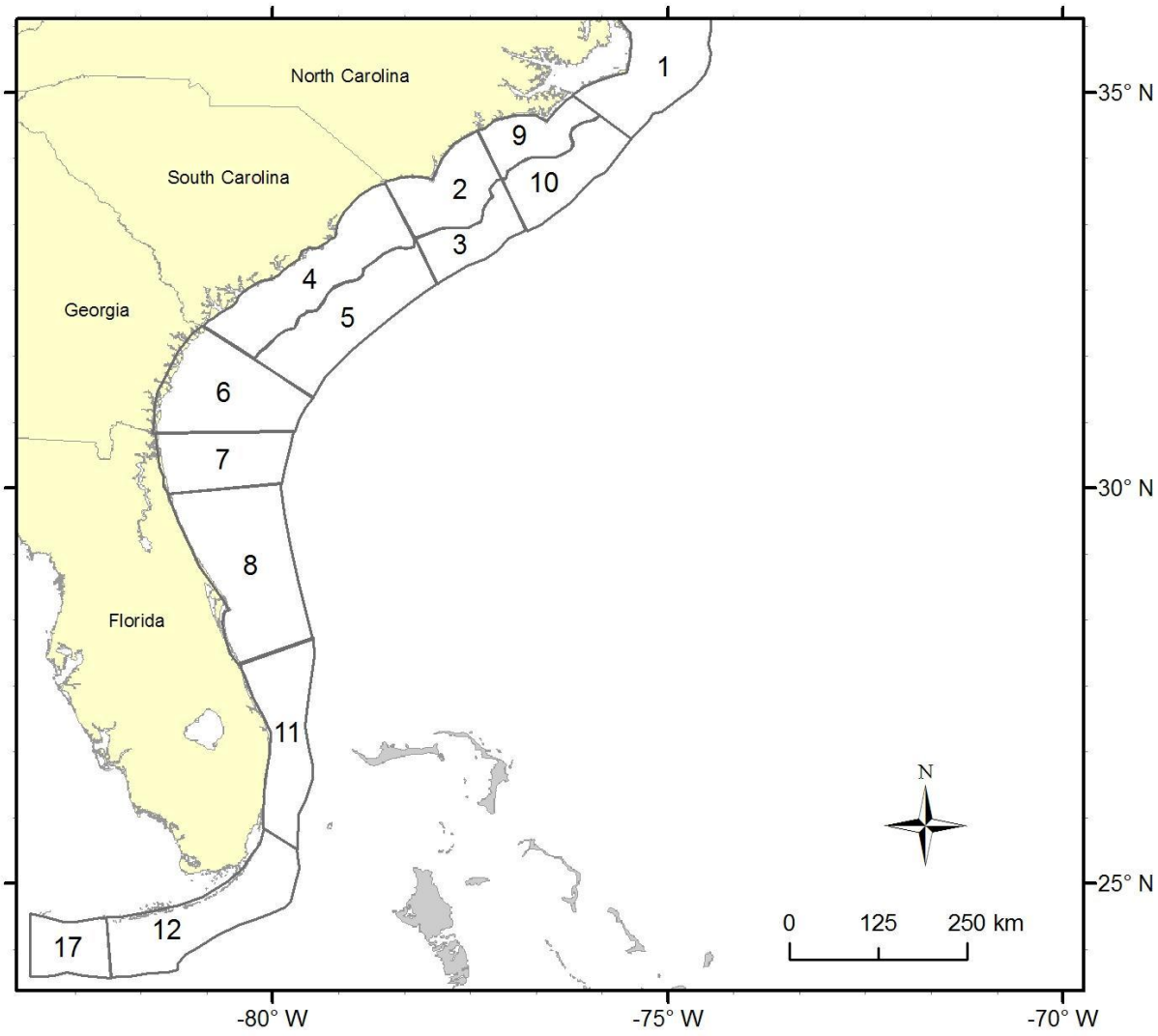


Figure 1. Map of headboat sampling area definition.

Figure 2. Total effort with snowy grouper by area.

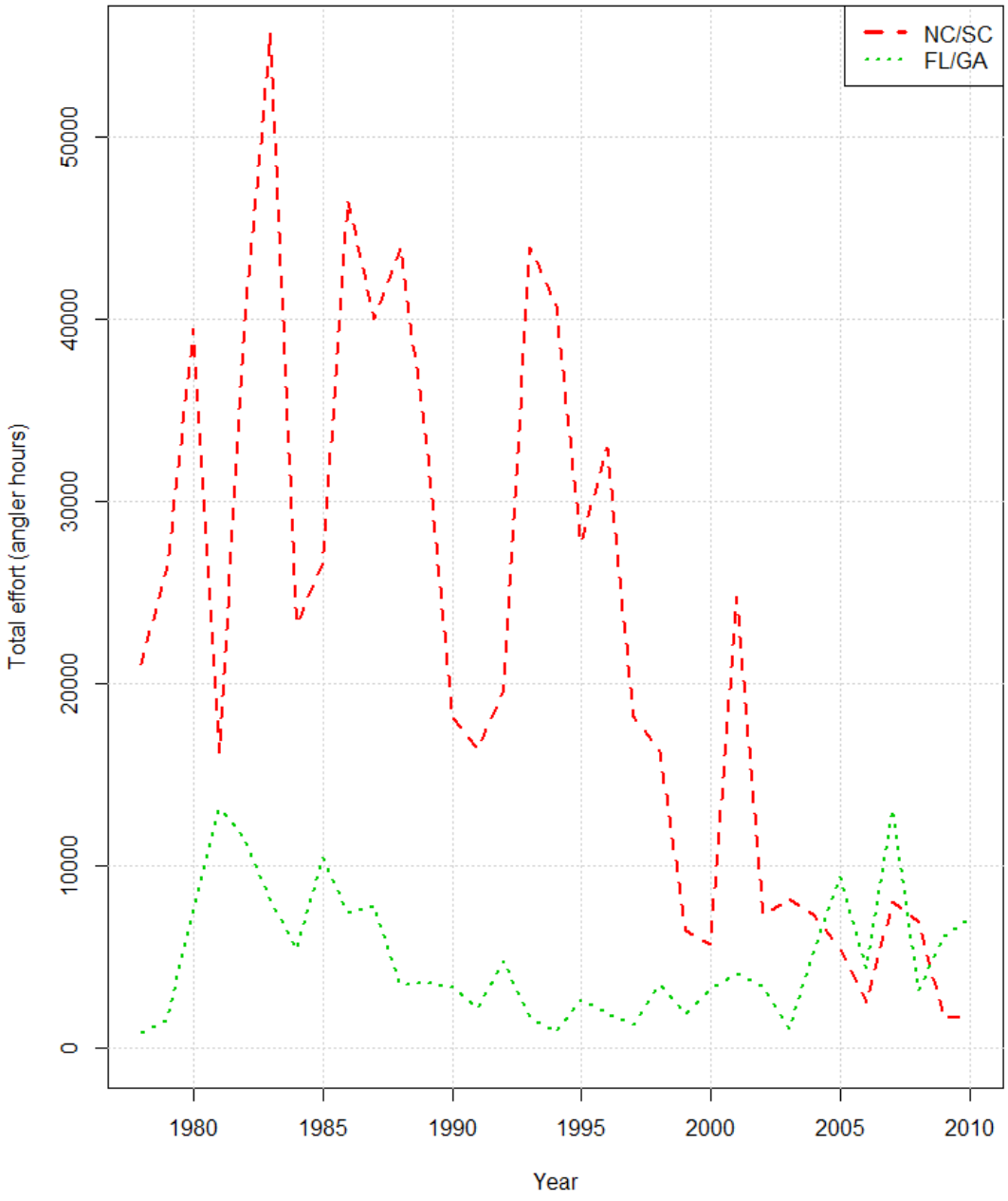
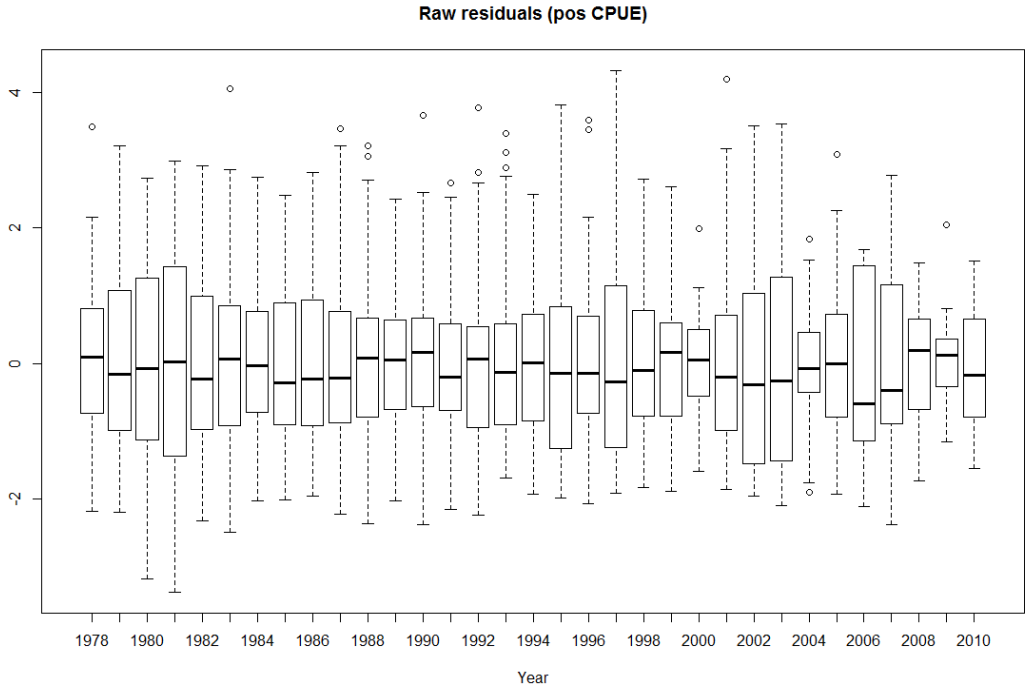


Figure 3. CPUE binomial residuals for year and area.



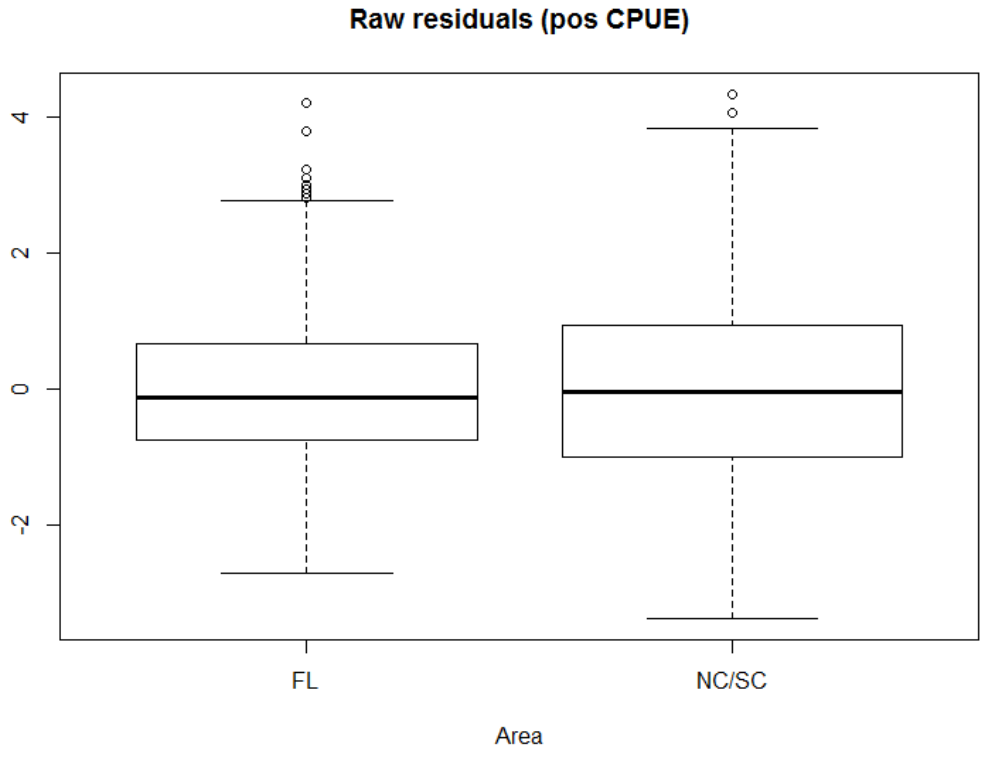


Figure 4. The distribution of catch for the south Atlantic snowy grouper headboat logbook.

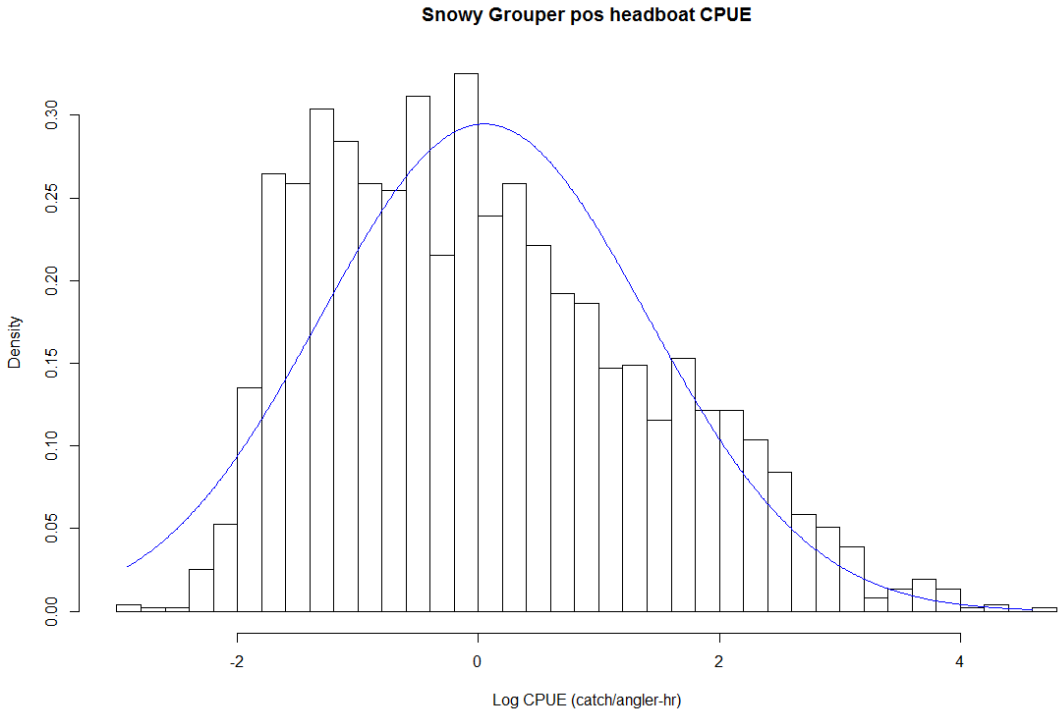


Figure 5. QQ plot residuals for CPUE.

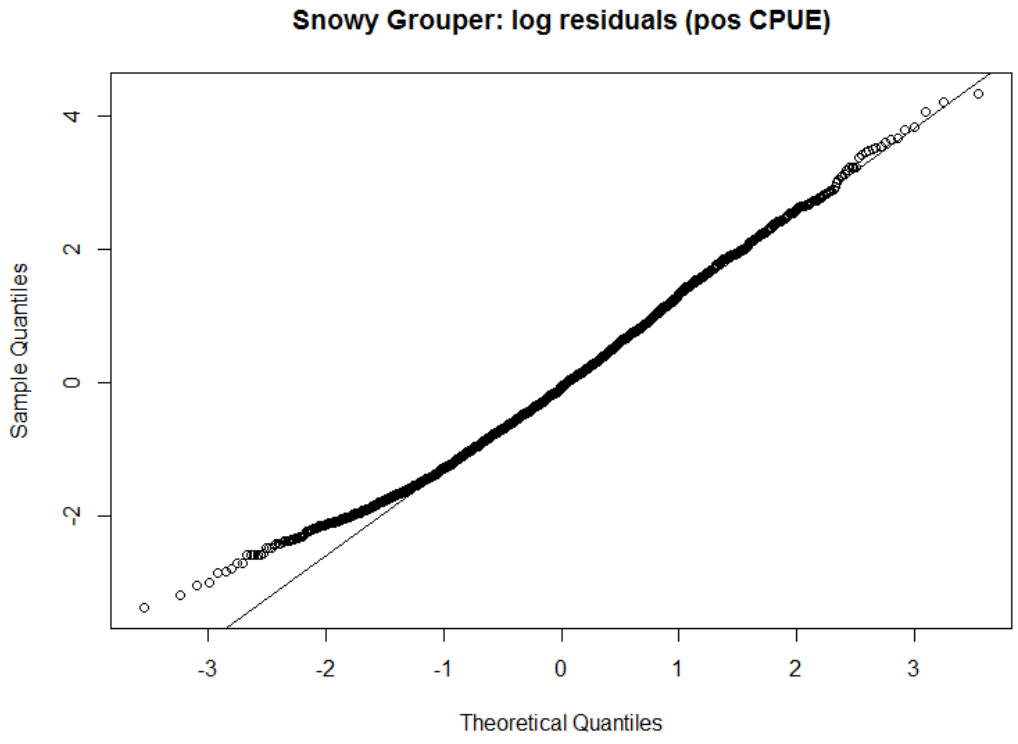
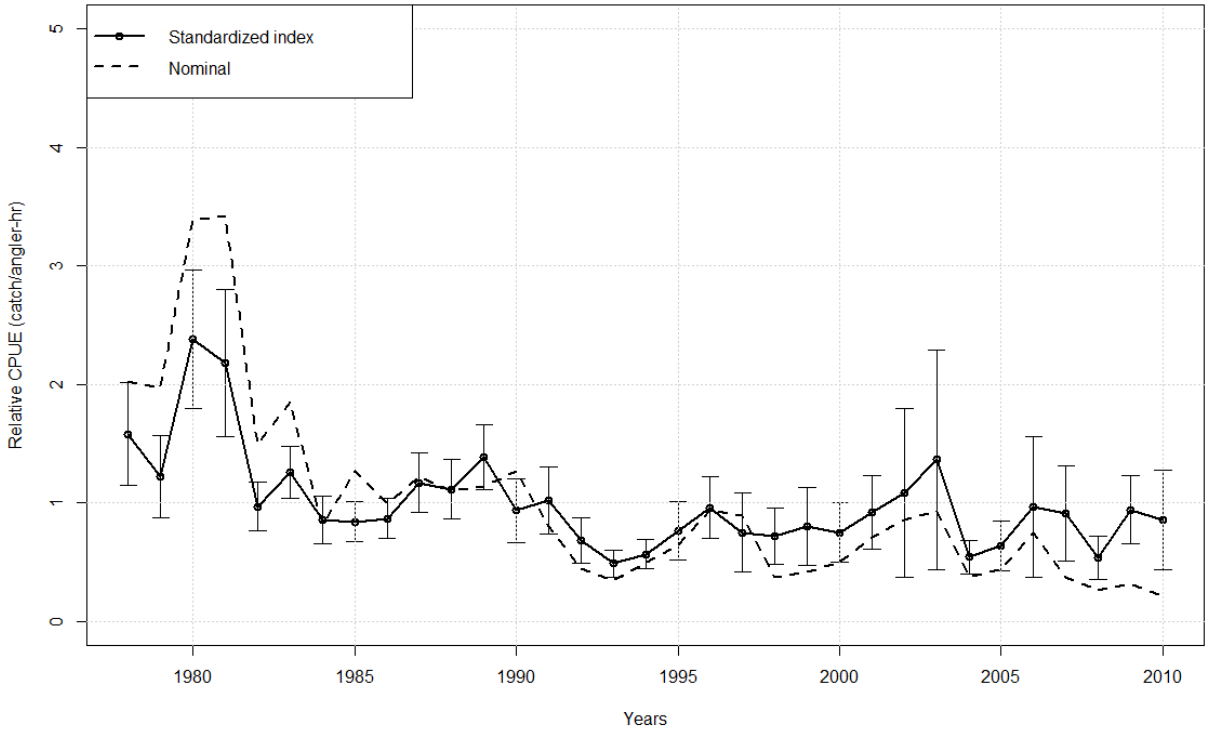


Figure 6. The standardized and nominal CPUE index with error bars at (+/-) 2 standard deviations (nominal by area below) computed for snowy grouper in the south Atlantic using the headboat logbook data during 1978-2010.



Appendix 1. The stepwise AIC output for the lognormal distribution (a), the gamma distribution (b), and AIC comparison (c).

a

```
Start:  AIC=8403.14
log(cpue) ~ year + area

       Df Deviance    AIC
<none>       3909.7 8403.1
- year 32   4304.0 8584.5
- area  1   4258.6 8619.4
```

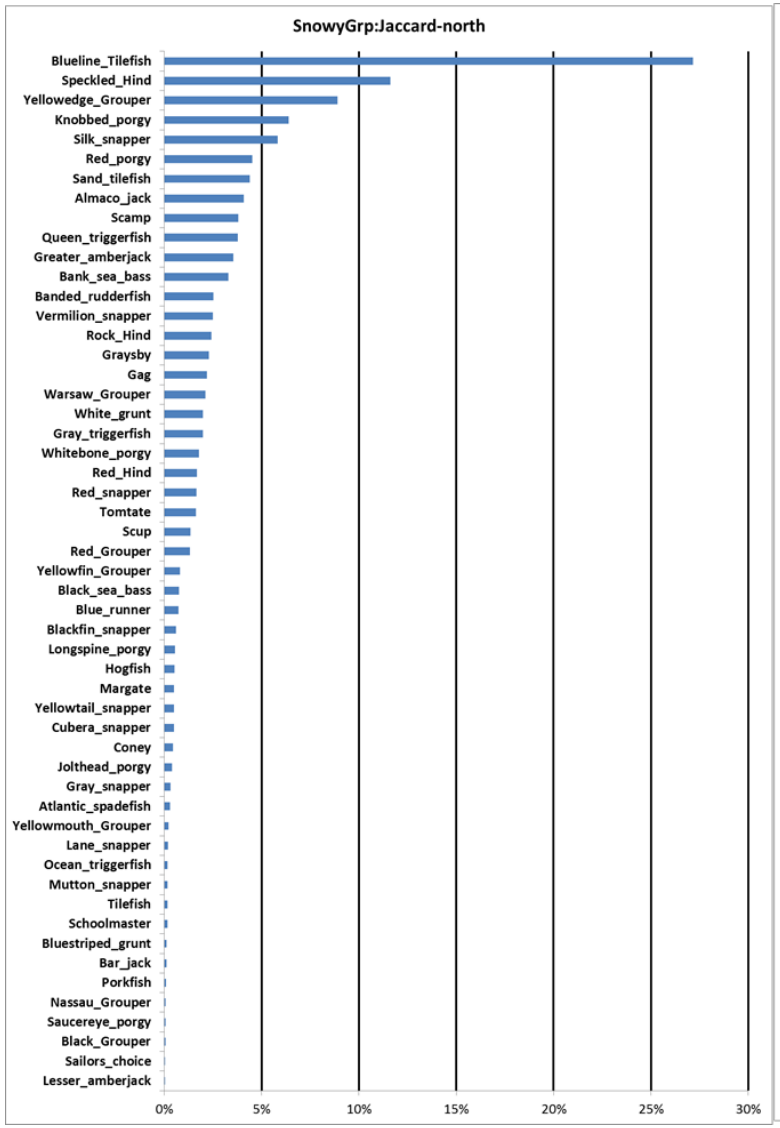
b.

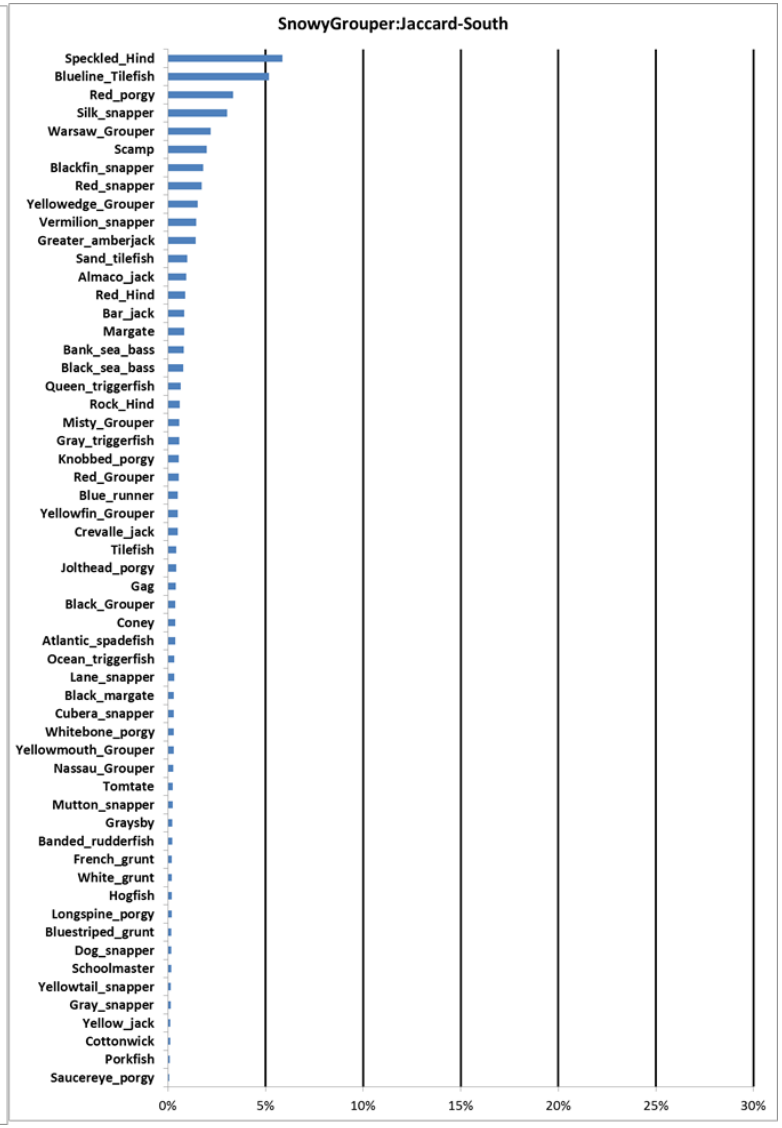
```
cpue ~ year + area

       Df Deviance    AIC
<none>       4057.6 9385.4
- area  1   4531.9 9539.9
- year 32   4729.9 9543.2
```

c.

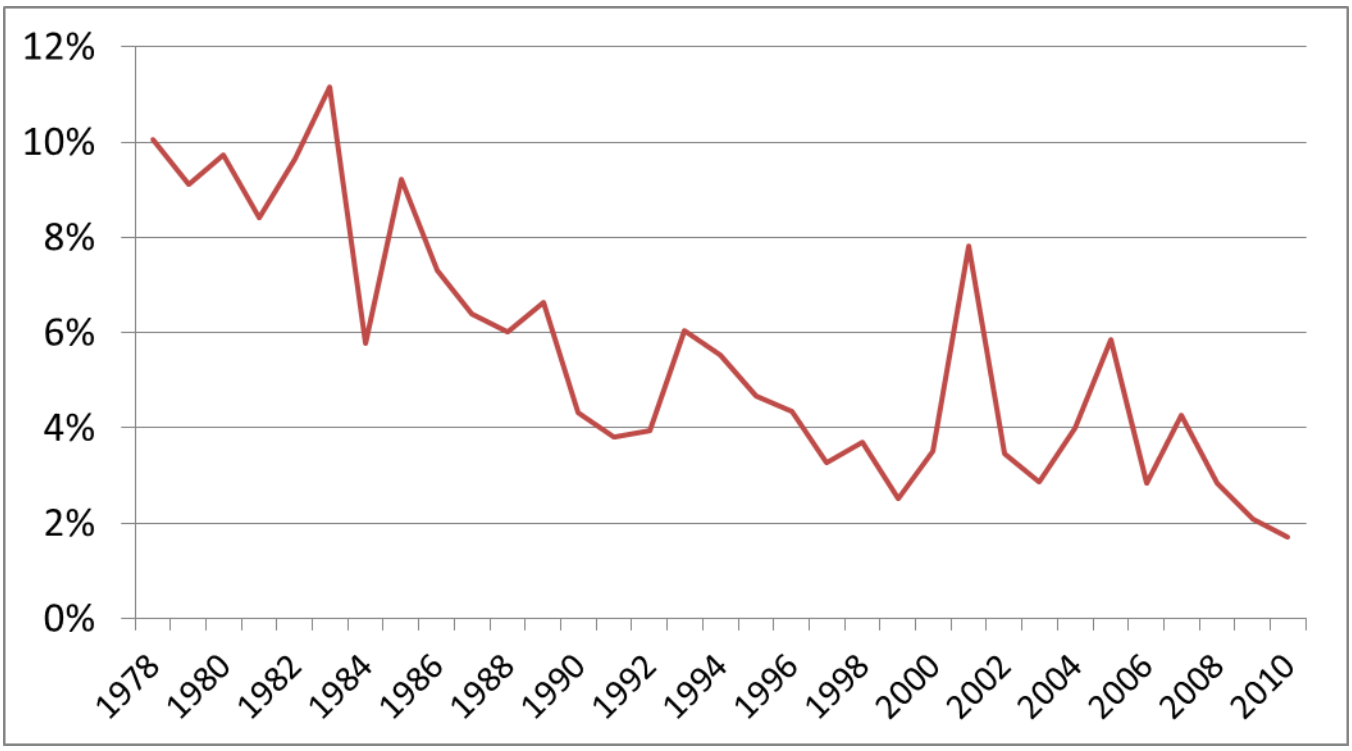
```
GTF_hb1$aic
                  [,1]
AIC.binomial   68.0000000
AIC.gamma    9332.1036684
shape.mle       0.7529177

 GTF_hb2$aic
                  [,1]
AIC.binomial    68.000000
AIC.lognormal 8652.958452
sigma.mle        1.237496
```

Appendix 2. Investigation of the Jaccard species association method to identify headboat trips that fished in deepwater (snowy grouper) habitat but were unsuccessful at landing snowy grouper.





year	pos.trips	tot.trips	% pos
1978	71	706	10%
1979	83	911	9%
1980	150	1540	10%
1981	130	1544	8%
1982	164	1701	10%
1983	210	1884	11%
1984	84	1453	6%
1985	145	1571	9%
1986	167	2284	7%
1987	134	2094	6%
1988	120	1990	6%
1989	97	1464	7%
1990	68	1574	4%
1991	58	1526	4%
1992	66	1670	4%
1993	105	1734	6%
1994	90	1626	6%
1995	75	1609	5%
1996	75	1729	4%
1997	42	1281	3%
1998	50	1347	4%
1999	26	1034	3%
2000	29	823	4%
2001	60	768	8%
2002	24	696	3%
2003	22	764	3%
2004	39	976	4%
2005	43	734	6%
2006	21	741	3%
2007	37	867	4%
2008	28	985	3%
2009	23	1104	2%
2010	17	999	2%


12%
10%
8%
6%
4%
2%
0%
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010