Standardized catch rates of U.S. blueline tilefish (Caulolatilus microps) from commercial logbook handline data

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Standardized catch rates of U.S. blueline tilefish (Caulolatilus microps) from commercial logbook handline data

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1. Introduction

Landings and fishing effort of commercial vessels operating in the southeast U.S. Atlantic have been monitored by the NMFS Southeast Fisheries Science Center through the Coastal Fisheries Logbook Program (CFLP). The program collects information about each fishing trip from all vessels holding federal permits to fish in waters managed by the Gulf of Mexico and South Atlantic Fishery Management Councils. Initiated in the Gulf in 1990, the CFLP began collecting logbooks from Atlantic commercial fishers in 1992, when 20% of Florida vessels were targeted. Beginning in 1993, sampling in Florida was increased to require reports from all vessels permitted in coastal fisheries, and since then has maintained the objective of a complete census of federally permitted vessels in the southeast U.S.

Catch per unit effort (CPUE) from the logbooks was used to develop an index of abundance for blueline tilefish landed with vertical lines (manual handline and electric/hydraulic reel). Thus, the size and age range of fish included in the index is the same as that of landings from this same fleet. The time series used for construction of the index spanned 1993−2010, when all vessels with federal snapper-grouper permits were required to submit logbooks on each fishing trip. , A deep-water closure, primary habitat of blueline tilefish, at the end of January, 2011 prevented use of the 2011 information.

2. Data and treatment

2.1 Available Data

For each fishing trip, the CFLP database included a unique trip identifier, the landing date, fishing gear deployed, areas fished, number of days at sea, number of crew, gear-specific fishing effort, species caught, and weight of the landings (reported fields described in Appendix 1). Fishing effort data available for vertical line gear included number of lines fished, hours fished, and number of hooks per line. For this southeast U.S. Atlantic stock, areas used in analysis were those between 24 and 37 degrees latitude, inclusive of the boundaries (Figure 1). However, further investigation and discussion reduced the area considered for this index. A recent trend of increased targeting of blueline tilefish north of Cape Hatteras, NC and fishing patterns associated with Snowy Grouper limits or closures in the area south of Cape Canaveral since the mid-2000’s were the primary reasons for limiting the area considered to just the areas between Cape Hatteras, NC to about Cape Canaveral, FL (28-35 degrees latitude).   The trends in the nominal index prior to the filtering step shows the problematic trends for NC and south FL (Figure 2).

Data were restricted to include only those trips with landings and effort data reported within 45 days of the completion of the trip (some reporting delays were longer than one year). Reporting delays beyond 45 days likely resulted in less reliable effort data (landings data may be reliable even with lengthy reporting delays if trip ticket reports were referenced by the reporting fisher). Also excluded were records reporting multiple areas or gears fished, which prevents designating catch and effort to specific locations or gears. Therefore, only trips which reported one area and one gear fished were included in these analyses.

Clear outliers in the data, e.g. values falling outside the 99.5 percentile of the data, were also excluded from the analyses. These outliers were identified for manual handlines as records reporting more than 20 lines fished, 15 hooks per line fished, 16 days at sea, or 4 crew members, and they were identified for electric reels as records reporting more than 7 lines fished, 13 hooks per line fished, 16 days at sea, or 6 crew members. Records with greater than 4.07 pounds/hook-hr were excluded.

3. Standardization

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

CPUE = pounds of blueline tilefish/hook-hours

where hook-hours is the product of number of lines fished, number of hooks per line, and total hours fished. Explanatory variables, all categorical, are described below. Estimates of variance were based on 1000 bootstrap runs where trips were chosen randomly with replacement from the entire set of trips. All analyses were programmed in R, with much of the code adapted from Dick (2004).

3.1 Explanatory variables considered

YEAR — Year was necessarily included, as standardized catch rates by year are the desired outcome. Years modeled were 1993−2010. The total number of blueline tilefish trips by year is provided in Table 1.

SEASON — Four seasons were considered in the model with the months pooled as Jan-Mar, Apr-Jun, Jul-Sep, and Oct-Nov. However, this factor was excluded based on the results of a backwards selection algorithm used to eliminate those variables that did not improve model fit.

AREA — Three levels of spatial factors were considered ; 1. NC, 2. SC and 3. GA and Northern FL (Ga.NFL) combined. The number of trips is much larger in NC than other regions (Table 3). However, these levels were maintained primarily because of possible differences in the target species for a trip and the distance to blueline tilefish habitat.

CREW SIZE — Crew size (crew) was pooled into two levels: one to two (1-2), and three or more (3plus). The number of trips per year by crew is shown in Table 4.

DAYS AT SEA — Days at sea were pooled into three levels: one or two days (1-2), three or four days (3-4), and five or more days (5plus). The number of trips per year by sea days is shown in Table 5.

3.2 Positive CPUE model
Two parametric distributions were considered for modeling positive values of CPUE, lognormal and gamma. For both distributions, all explanatory variables were initially included as main effects, and then stepwise AIC (Venables and Ripley, 1997) with a backwards selection algorithm was used to eliminate those variables that did not improve model fit. For both lognormal and gamma distributions, the best model fit excluded month as an explanatory variable (lognormal shown in Table 7). The two distributions, each with their best set of explanatory variables, were compared using AIC: lognormal (AIC=-3564) outperformed gamma (AIC=-2918) and was therefore applied in the final GLM. Diagnostics suggested reasonable fits of the lognormal model (Figures 3, 4).

Results

Several models were considered during the SEDAR 32 DW. The sequence of models and brief summary of the SEDAR 32 DW consensus opinion is given in Table 7. The standardized index did not exhibit any major trends from 1993-2010. However four of the highest values of cpue occur in the last five years (Figure 6, Table 1).

Literature cited

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

Shertzer, K.W., E.H. Williams, and J.C. Taylor. 2009. Spatial structure and temporal patterns in a large marine ecosystem: Exploited reef fishes of the southeast United States. Fish. Res. 100:126−133.

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

Table 1. Standardized index of blueline tilefish from commercial logbook data.

Year	N	Relative nominal	Standardized CPUE	CV
1993	65	0.838	1.125	0.170
1994	93	0.991	0.672	0.146
1995	155	1.434	0.638	0.103
1996	117	0.919	0.935	0.125
1997	198	0.937	0.983	0.094
1998	184	0.814	1.163	0.101
1999	167	1.081	0.796	0.111
2000	156	1.014	1.020	0.122
2001	165	0.940	0.910	0.123
2002	196	0.633	0.756	0.101
2003	176	0.571	0.741	0.108
2004	183	1.029	0.875	0.100
2005	214	1.112	1.138	0.100
2006	178	1.112	1.487	0.109
2007	246	0.836	1.182	0.094
2008	200	1.019	1.415	0.102
2009	170	0.901	0.994	0.102
2010	194	1.819	1.169	0.107

Table 3. Number of blueline tilefish trips by region and year.

Year	NC	SC	Ga.NFL
1993	27	15	23
1994	65	8	19
1995	90	21	41
1996	81	21	15
1997	138	24	36
1998	145	12	27
1999	139	8	18
2000	137	7	11
2001	136	16	13
2002	144	26	26
2003	91	58	27
2004	111	56	15
2005	124	55	34
2006	84	68	24
2007	133	83	30
2008	107	75	18
2009	75	70	24
2010	87	62	39

Table 4. Number of blueline tilefish trips by crew size and year.

Year	1-2	3plus
1993	32	33
1994	45	47
1995	79	73
1996	40	77
1997	78	120
1998	68	116
1999	65	100
2000	30	125
2001	49	116
2002	64	132
2003	58	118
2004	81	101
2005	89	124
2006	74	102
2007	83	163
2008	92	108
2009	77	92
2010	91	97

Table 5. Number of blueline tilefish trips by days at sea and year.

Year	1-2	3-4	5plus
1993	20	34	11
1994	25	52	15
1995	39	90	23
1996	33	62	22
1997	83	84	31
1998	69	93	22
1999	71	84	10
2000	79	67	9
2001	59	85	21
2002	57	94	45
2003	42	71	63
2004	29	94	59
2005	42	95	76
2006	24	63	89
2007	46	113	87
2008	41	89	70
2009	25	70	74
2010	46	70	72

Table 6. Model selection results from lognormal model.

Removed	Df	Deviance	AIC
None		568.5	3578
State	2	570.7	3586
Year	17	576.6	3587
Crew	1	579.5	3634
Away	2	581.8	3645

Table 7. Sequence of blueline tilefish index models leading up to the final accepted version.

Model	Consensus
Delta-GLM, Stephens&MacCall, species in at least 1% logbook trips, factors not pooled, all regions, shark catch <500lbs	Crew and away factor levels need to be pooled, examine nominal state-specific cpue, examine pelagic species included as positive association with blueline tilefish (dolphin), remove species of sharks prohibited in recent years, examine recent records with depth recorded to get species list associated with blueline tilefish trips.
Delta-GLM, pool factor levels for crew size and days at sea, prohibited shark species removed, removed trips with >33% shark catch.	Standardized CPUE splits the difference between the increasing trend in NC and decreasing trend in south FL since the mid 2000's. Discussion with fishermen identified targeting issues north of Cape Hatteras. Snowy grouper regulations impacted the incidental catch of blueline tilefish in recent years. Check Stephens&McCall for south FL 1993-2002 and 2005-2010.
Snowy grouper was the only highly positive associated species in the early time(1993-2002) period for Stephens&McCall method. The later period (2005-2010) included many more positively associated species some of which prefer shallower habitat than blueline tilefish.	Exclude area north of Cape Hatteras, NC and south of Cape Canaveral, FL. Greatly reduces sample size but removes known bias. Run on positive only trips. Pool months to 4 seasons. Include regional factor if possible.
GLM on positive only blueline tilefish trips from Cape Hatteras, NC to Cape Canaveral, FL.	Accepted.

Figure 1. Commercial handline trips (left panel) and positive blueline tilefish commercial handline trips (right panel). The green symbols represent the areas that combined signify fifty percent of the total trips, the red and green circles combined represent seventy-five percent of the total trips, the red, green, and yellow symbols combined represent ninety-nine percent of the total trips, and the gray symbols represent one percent of the trips. The area between 28 and 35 degrees latitude were included in this analysis (solid horizontal red lines).

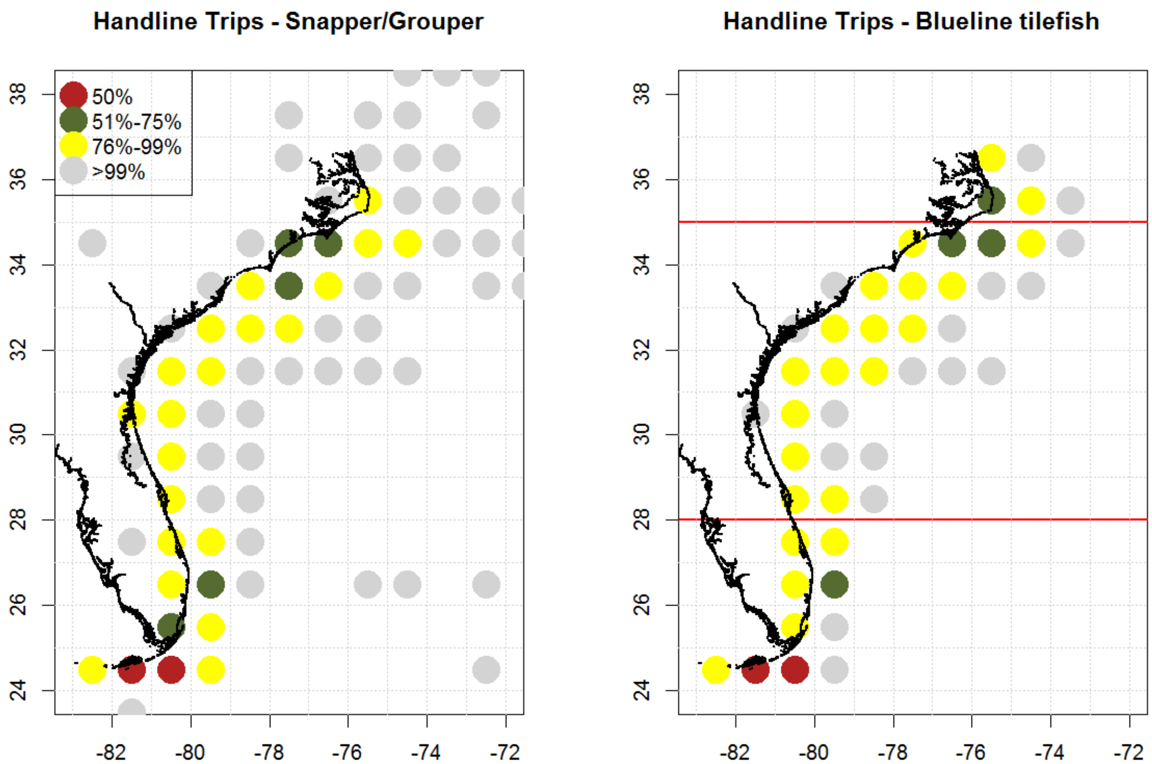


Figure 2. Nominal CPUE by region across all years prior to filtering areas with targeting or management influences. A portion of NC trips (north of Cape Hatteras, NC) were removed as well as the trips from South Florida.

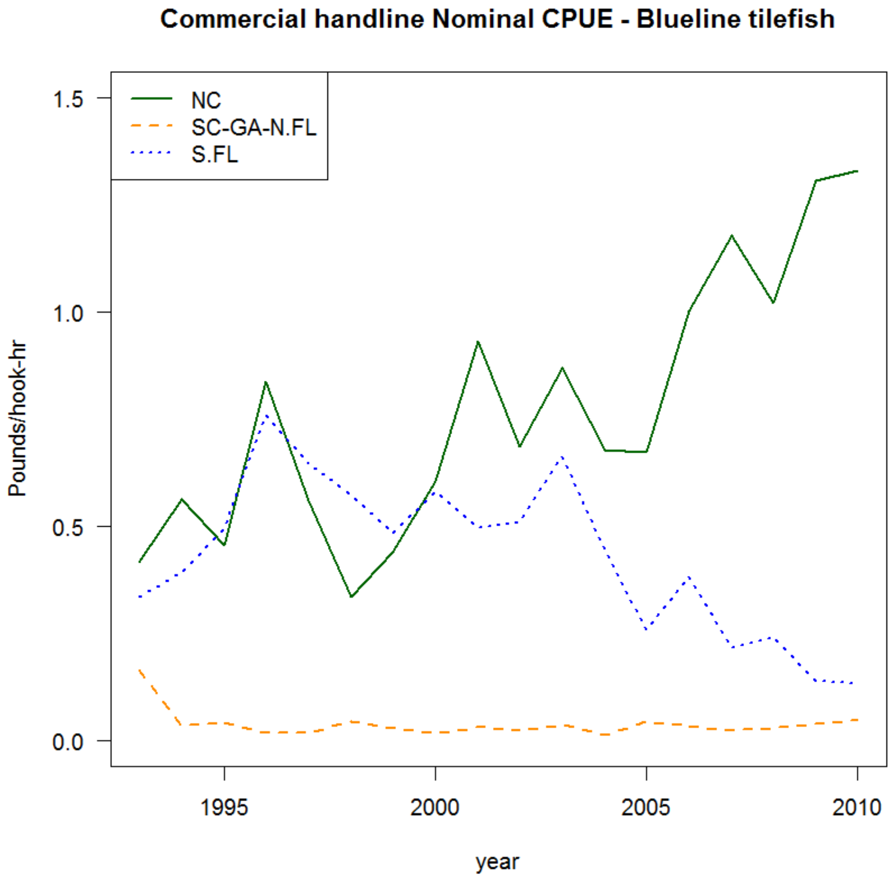
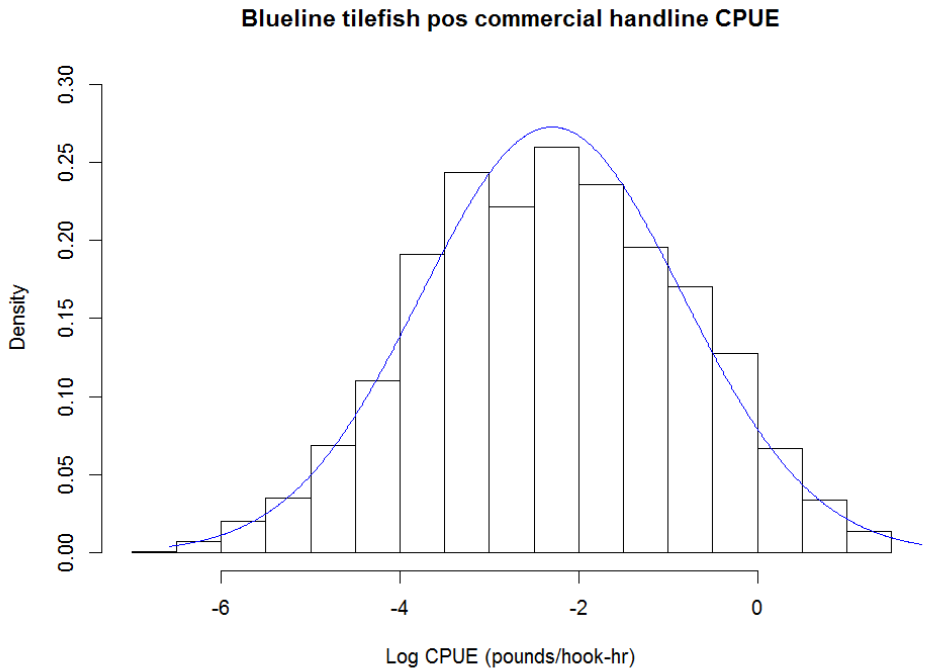


Figure 3. Diagnostics of lognormal model fits to positive CPUE data. Top panel shows the histogram of empirical log CPUE, with the normal distribution (empirical mean and variance) overlaid. Bottom panel shows the quantile-quantile plot of residuals from the fitted model.



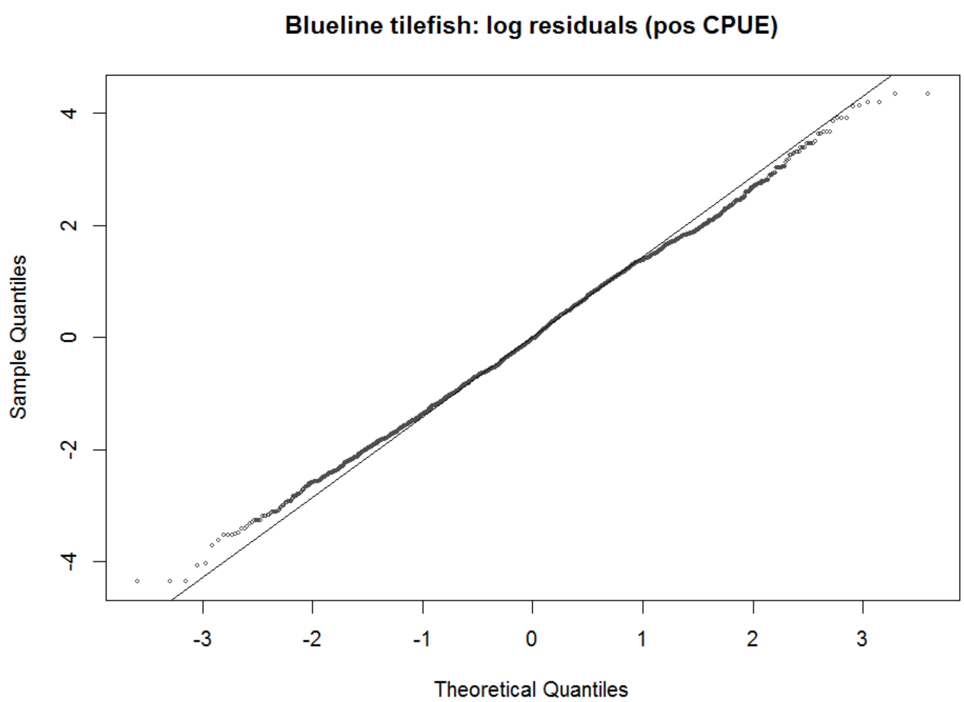


Figure 4. Diagnostics of lognormal model fits to positive CPUE data. Box-and-whisker plots give first, second (median), and third quartiles, as well as limbs that extend approximately one interquartile range beyond the nearest quartile, and outliers (circles) beyond the limbs. Residuals are raw.

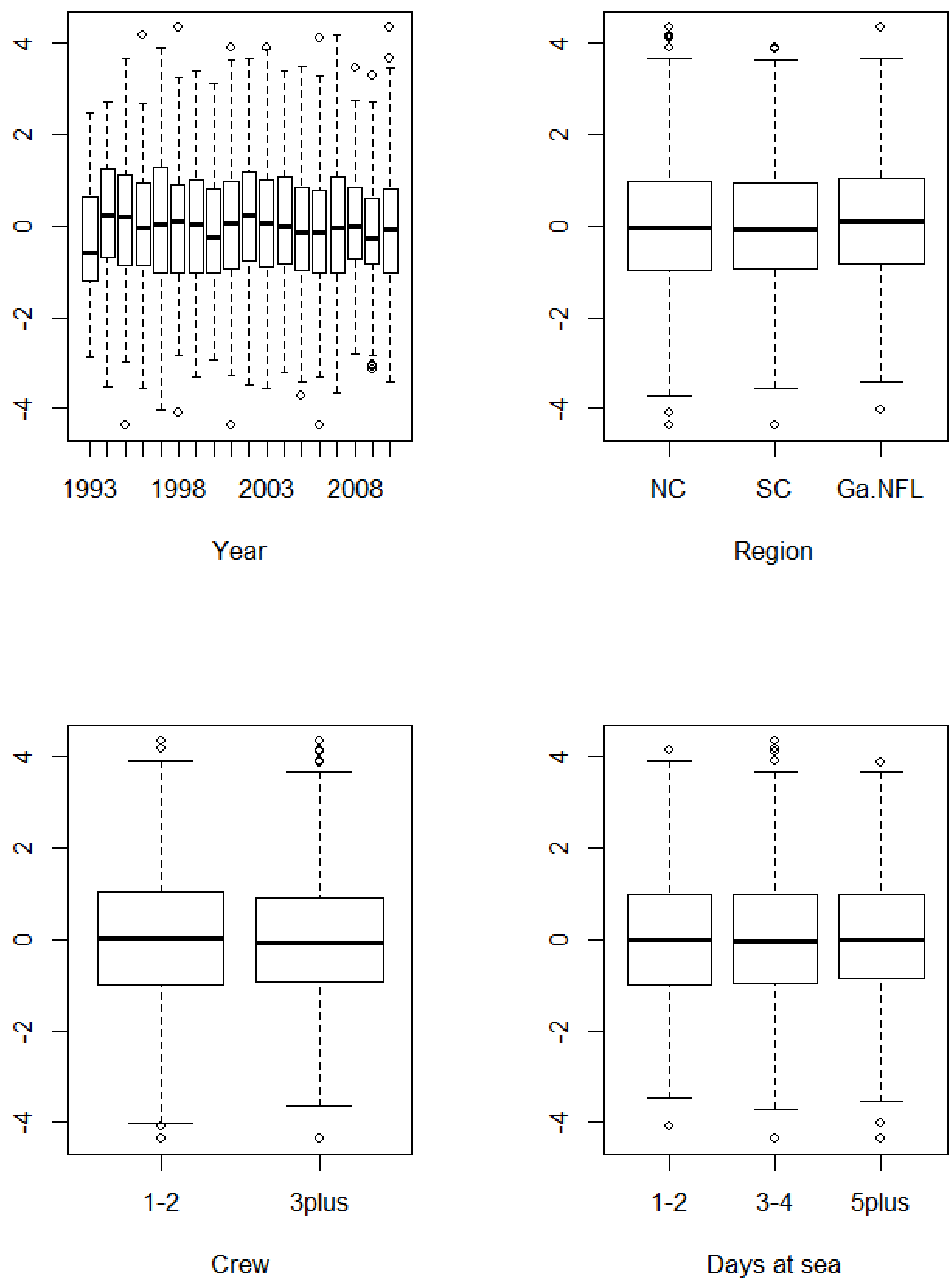


Figure 5. Nominal CPUE by region of trips included in the analysis.

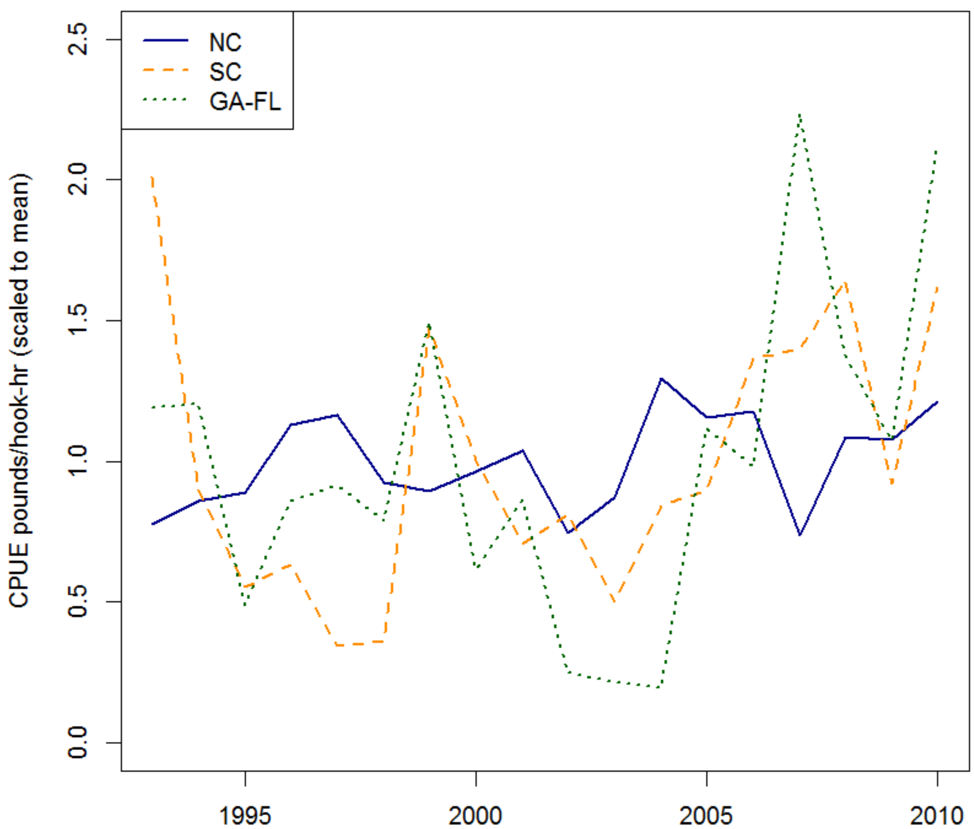


Figure 6. Blueline tilefish standardized CPUE and nominal cpue.