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

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Standardized catch rates of U.S. blueline tilefish (Caulolatilus microps) from commercial logbook longline 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 bottom longlines. 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 1993−2004, when all vessels with federal snapper-grouper permits were required to submit logbooks on each fishing trip. The trips from 2005-2011 were excluded due to shift in effort to almost entirely north of Cape Hatteras, NC and decreased effort in all other areas. Additionally, 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 longline gear included number of lines fished and number of hooks per line. The number of hours fished is inconsistenly reported for longline gear and not recommended for use in effort calcualtions. 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 areas between Cape Hatteras, NC to about Cape Canaveral, FL (28-35 degrees latitude). The number of trips reporting blueline tilefish drops rapidly after 2004 in

areas south of Cape Hatteras and increased significantly north of Cape Hatteras in approximately 2006.

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 commercial longline as records reporting more than 40 lines fished, 4000 hooks per line fished, 16 days at sea, or 7 crew members. Trips with a cpue of greater than 0.8 pounds/hook were excluded.

3. Standardization

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

CPUE = pounds of blueline tilefish/hook

where hook is the product of number of lines fished and the number of hooks per line. Explanatory variables, all categorical, are described below. Estimates of variance were based on 1000 bootstrap runs where trips were chosen randomly with replacement. The samples chosen for the bootstrap runs were equal to the number of trips each year (e.g. If the sample size for 1997 was 83 trips, 83 samples were drawn with replacement from the 1994 subset of the data). All analyses were programmed in R 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 1993−2004. 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 the selection algorithm used to eliminate those variables that did not improve model fit.

REGION — Two regions, NC and SC-FL, were considered as an explanatory variable. However, this factor was excluded based on the results of the selection algorithm used to eliminate those variables that did not improve model fit.

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 2.

DAYS AT SEA — Days at sea (sea days) were pooled into four levels: one or three days (1-3), four to six days (4-6), seven to nine days (7-9), and ten or more days (10plus). The number of trips per year by sea days is shown in Table 3.

3.2 Positive CPUE model

Two parametric distributions were considered for modeling positive values of CPUE, lognormal and gamma. The gamma model did not converge. For the lognormal distribution, all explanatory variables were initially included as main effects, and then stepwise AIC (Venables and Ripley, 1997) with both a forward and backward selection algorithm was used to eliminate those variables that did not improve model fit. The best model (lognormal) fit excluded some explanatory variables (Table 4). Diagnostics suggested reasonable model fit (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 5. The standardized index depicts a decrease in cpue from 1993 to 1996 and remained fairly constant from 1998 through 2004. There is significant uncertainty in the estimated index due to the small sample size. (Figure 5, 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	72	2.052	2.254	0.171
1994	89	1.188	1.024	0.177
1995	65	1.485	0.974	0.199
1996	41	0.605	0.711	0.234
1997	83	1.075	1.530	0.145
1998	45	0.734	1.032	0.235
1999	52	1.181	0.709	0.232
2000	61	0.790	0.501	0.202
2001	61	0.826	0.766	0.204
2002	50	0.900	1.025	0.204
2003	50	0.549	0.891	0.205
2004	42	0.614	0.584	0.201

Table 2. Number of blueline tilefish trips by crew size and year.

Year	1-2	3plus
1993	45	27
1994	20	69
1995	7	58
1996	14	27
1997	26	57
1998	4	41
1999	16	36
2000	18	43
2001	17	44
2002	4	46
2003	7	43
2004	8	34

Table 3. Number of blueline tilefish trips by days at sea and year.

Year	1-3	4-6	7-9	10plus
1993	20	34	16	2
1994	10	35	32	12
1995	9	25	22	9
1996	5	26	7	3
1997	7	27	36	13
1998	3	16	19	7
1999	2	18	24	8
2000	4	16	29	12
2001	4	15	28	14
2002	1	10	25	14
2003		12	19	19
2004	1	6	25	10

Table 4. Model selection results from lognormal model.

Removed	Df	Deviance	AIC
None		1.708	-2237
Crew	1	1.714	-2236
Days at sea	3	1.732	-2233
Year	11	1.814	-2215

Table 5. Sequence of blueline tilefish index models leading up to the final accepted version.

Model	Consensus
Delta-GLM, Stephens&MacCall, 1993-2010, species in at least 1% logbook trips, factors not pooled, all regions, shark catch <500lbs.	Crew and "days at sea" factor levels need to be pooled, examine nominal state-specific cpue, remove species of sharks prohibited in recent years, remove shark trips identified in the shark bottom longline survey(mid 2005-2010), remove trips with shark catch greater than 33% of total catch, limit to 1993-2006 due to switch in effort from SC to north of Cape Hatteras in 2007 and correction of bimodal log(cpue).
Delta-GLM, pool factor levels for crew size and days at sea, prohibited shark species removed, removed trips with >33% shark catch, removed trips identified as shark trips in the shark bottom longline survey, limit to 1993-2006.	Run on positive only trips. Pool months to 4 seasons. Include regional factor if possible. Remove trips in areas greater than 37 degrees due to inconsistent reporting.
GLM on positive only blueline tilefish trips with season and 2 spatial regions.	Poor cpue prediction for 2005-06 due to very low sample sizes (18 and 30 respectively. Exclude area north of Cape Hatteras, NC and south of Cape Canaveral, FL as in commercial handline. Slightly reduces sample size but removes known bias. Season and region factors determined to be insignificant.
GLM on positive only blueline tilefish trips from Cape Hatteras, NC to Cape Canaveral, FL 1993-2004. Factors retained are Year, Crew Size, and Days at sea. (Season and region factors determined to be insignificant .)	Accepted

Figure 1. Commercial longline trips (left panel) and positive blueline tilefish commercial longline 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).

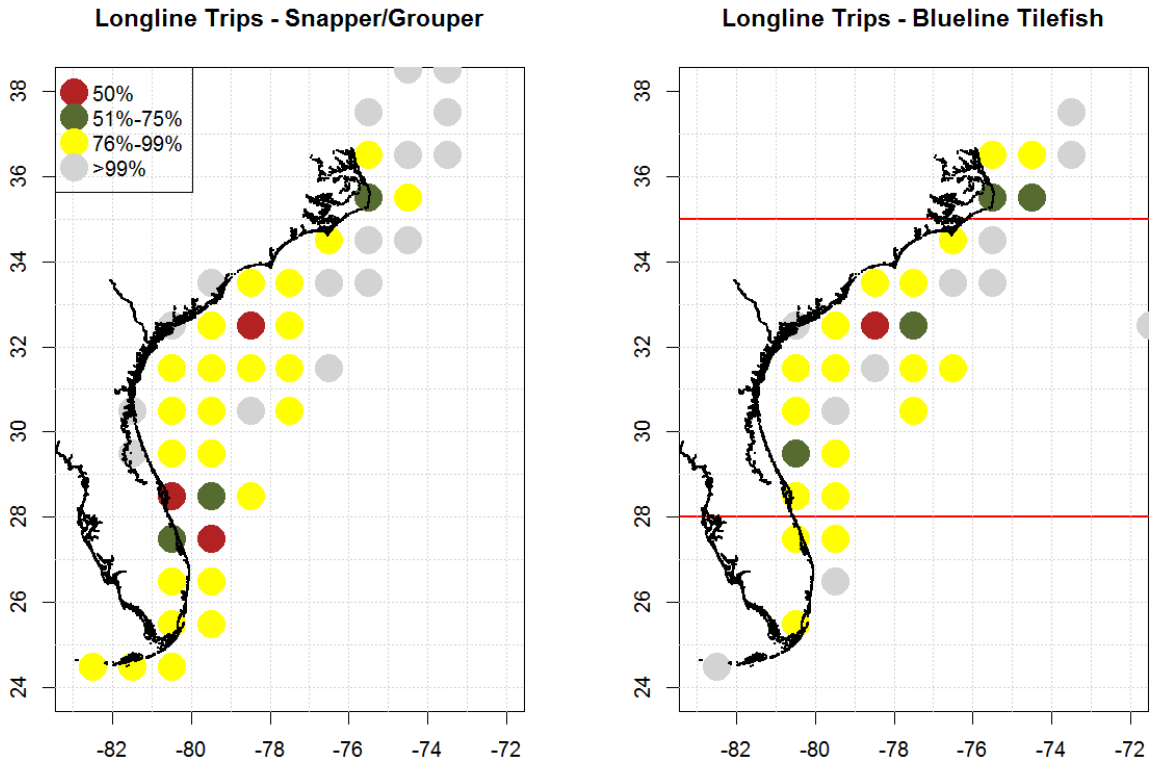
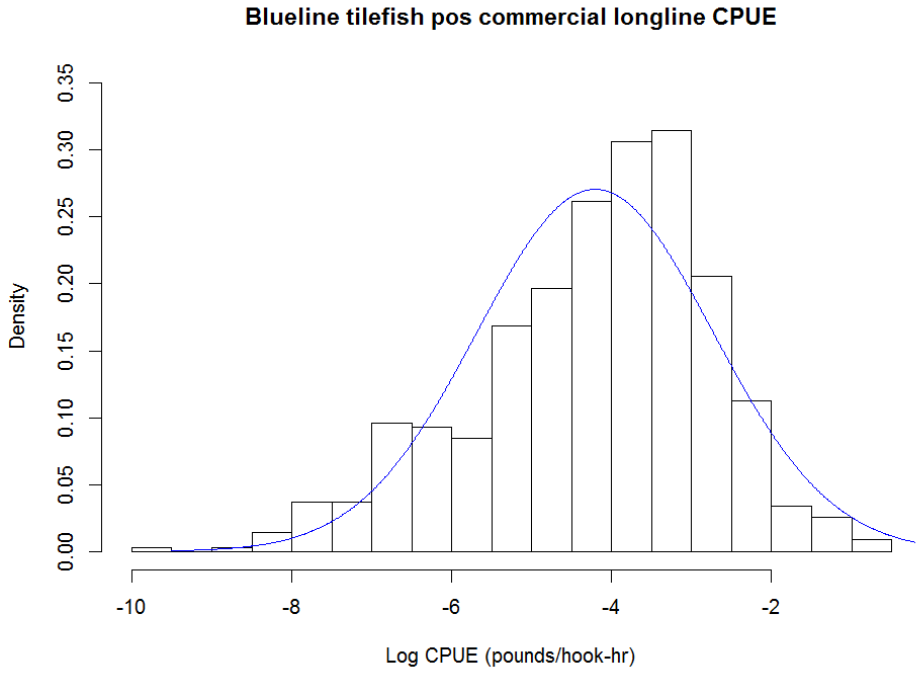


Figure 3. Diagnostics of lognormal model fits to positive CPUE data. Top panel shows the histogram of empirical log CPUE, with the normal distribution (empirical mean and variance) overlaid. Bottom panel shows the quantile-quantile plot of residuals from the fitted model.



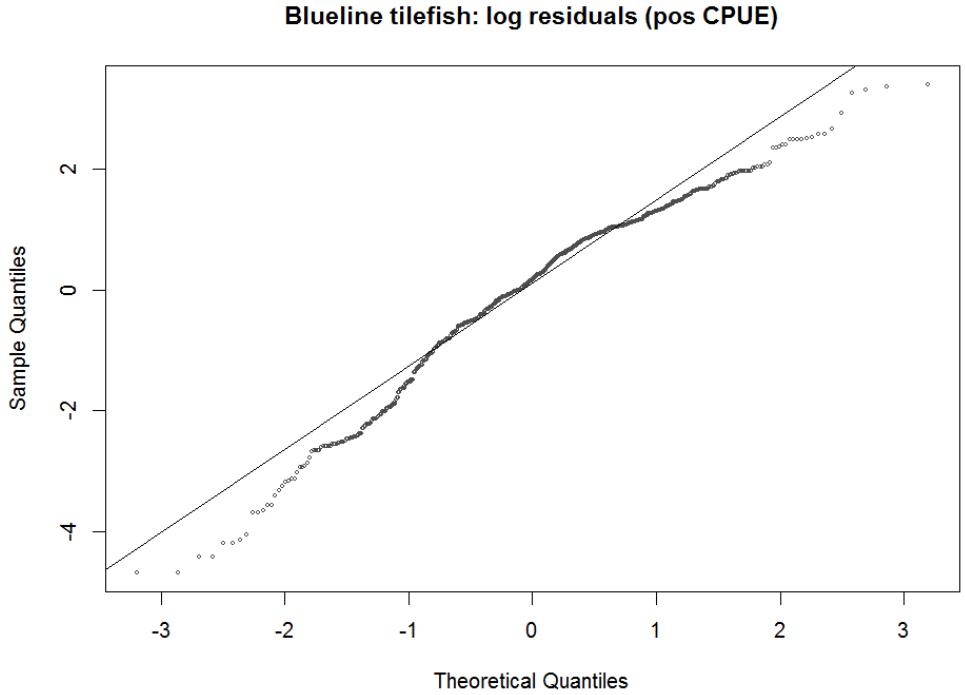
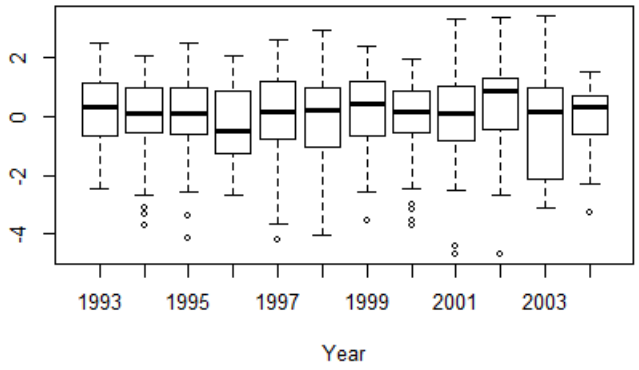
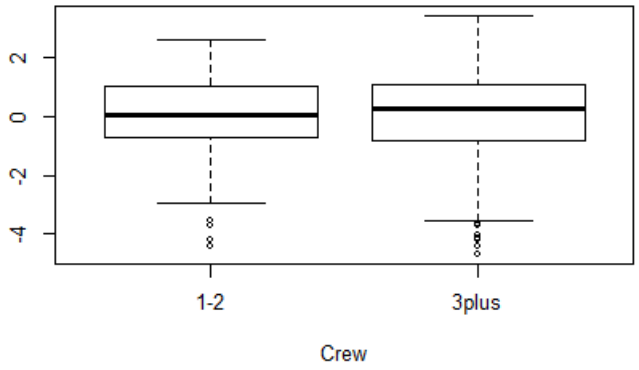


Figure 4. Diagnostics of lognormal model fits to positive CPUE data. Box-and-whisker plots give first, second (median), and third quartiles, as well as limbs that extend approximately one interquartile range beyond the nearest quartile, and outliers (circles) beyond the limbs. Residuals are raw.





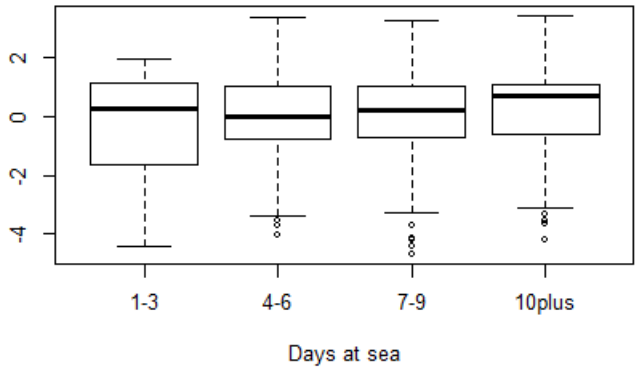


Figure 6. Blueline tilefish standardized CPUE and nominal cpue.