Standardized catch rates of Atlantic red grouper (*Epinephelus morio*) from the North Carolina Commercial Fisheries Trip Ticket Program.

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Introduction

Information on relative abundance of fish stocks is required to tune stock assessment models. Data collected from several commercial and recreational fisheries as well fishery independent surveys have been previously used to develop standardized catch per unit of effort (CPUE) indices of abundance. This report documents the analytical methods applied to the available commercial data for North Carolina, and presents standardized catch rates for red grouper.

Methods and Index Development

Methods followed were similar to that of Bianchi and Ortiz (2007) including a preliminary analysis of trip ticket data from 1994 to 2008 to determine waterbody and gear selection for commercially caught red grouper in North Carolina. This analysis determined that all red grouper were caught in ocean waters and were typically harvested using rod & reel gears. Therefore, only offshore trips utilizing rod & reel gear were selected when determining an index. Using this subset, an analysis of species catch composition was performed to identify trips with a positive likelihood of catching red grouper following methods defined by Stephens and MacCall (2004). Briefly, the multispecies composition was used to infer if fishing effort occurred in a habitat where the target species, red grouper, was likely to be present. The Stephens and MacCall (2004) method used a logistic regression of multispecies presence-absence information to predict the probability of red grouper presence and provide a critical probability value to include or exclude trip observations. Positive regression coefficients indicated red grouper were positively correlated with species such as scamp, red hind, red porgy, grunts, gag grouper, triggerfish, vermilion snapper, hogfish, red snapper, jolt head porgy, and amberjacks (Figure 1). Negative correlations were associated with grey tile, king mackerel, snowy grouper, spottail pinfish, and black seabass (Figure 1). A critical value was determined and used to subset offshore trips that had a positive likelihood of catching red grouper (Figure 2).

Catch was reported in total pounds landed by species and trip. Thus, nominal catch rates were estimated as total pounds per trip. The explanatory variables considered for the red grouper index analyses were year and month. To account for correlated variability on catch rates due to vessel or PID (participant identification number), the General Linear Model (GLM) for positive observations included PID as a random component, by assuming an alternative covariance matrix structure, auto-regressive (AR1) (Littell et al. 1996). This covariance structure assumed that the variance within a vessel is similar for consecutive years. Relative indices of abundance were estimated using a Generalized Linear Mixed Modeling (GLMM) approach that utilized a delta lognormal model error distribution. The selection of a delta model responded to the significant proportion of trips with zero catch. The delta model used a binomial error distribution for modeling the proportion of positive trips, and a lognormal assumed error distribution for modeling the mean density or catch rate of successful trips. Parameterization of the model followed Generalized Linear Model structures.

[1]Thus, the proportion of successful trips per stratum was assumed to follow a binomial distribution where the estimated probability was a linear function of a set of fixed factors and interactions. The logit function was used as a link between the linear factor component and the binomial error assumed. For the successful trips, estimated catch rates were assumed to follow a lognormal distribution, also as a linear function of a set of fixed factors and interactions. In the latter case, the identity was the link function in this model.

Relative indices of abundance were estimated for each species as the product of the year effect least square means (LSmeans) from the binomial and the lognormal model components. In the positive observations component, the LSmeans estimates were weighted proportional to the observed margins in the input data, taking into account the characteristic unbalanced distribution of the input data. For the lognormal LSmeans, a log back-transformation bias correction was also applied (Lo et al 1992).

Results and Conclusions

Index development indicated that year and month were the main explanatory variables for the proportion of successful red grouper trips (Table 1) and for the corresponding catch rates of red grouper from successful trips (Table 2). Diagnostic plots of the model fit for red grouper are shown in Figures 3 – 6. The distribution of residuals and cumulative normalized residual plots (qq-plots) illustrated the expected patterns for both the proportion positive model and the positive trips model. Finally, Table 3 and Figure 7 show the estimated standardized index for red grouper from the commercial fisheries off North Carolina waters. For red grouper, there was an increase in catch rates in the early years of the times series through 1999; however, from 2000 through 2005, there was a relatively stable period. Finally, there was an increase in catch rates after 2005, with the highest catch rate registering in 2007.

Literature Cited

Bianchi, A and M. Ortiz. 2007. Standardized catch rates of Atlantic king mackerel (*Scomberomorus cavalla*) from the North Carolina Commercial fisheries trip ticket. SEDAR16-DW-11.

Littell, R.C., G.A. Milliken, W.W. Stroup, and R.D. Wolfinger. 1996. SAS® System for Mixed models. Cary NC. SAS Institute Inc., 1996. 633 pp.

Lo, N.C., L.D. Jacobson, and J.L. Squire. 1992. Indices of relative abundance from fish spotter data based on delta lognormal models. Can. J. Fish. Aquat. Sci. 49:2512-2526.

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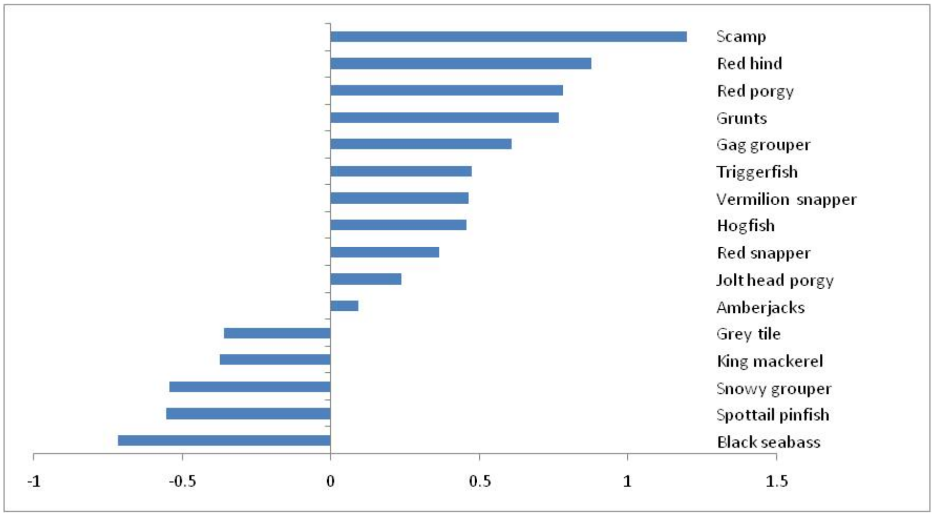

Figure 1. Multispecies correlations of red grouper catch for offshore commercial fisheries in North Carolina, derived from the trip ticket program data.

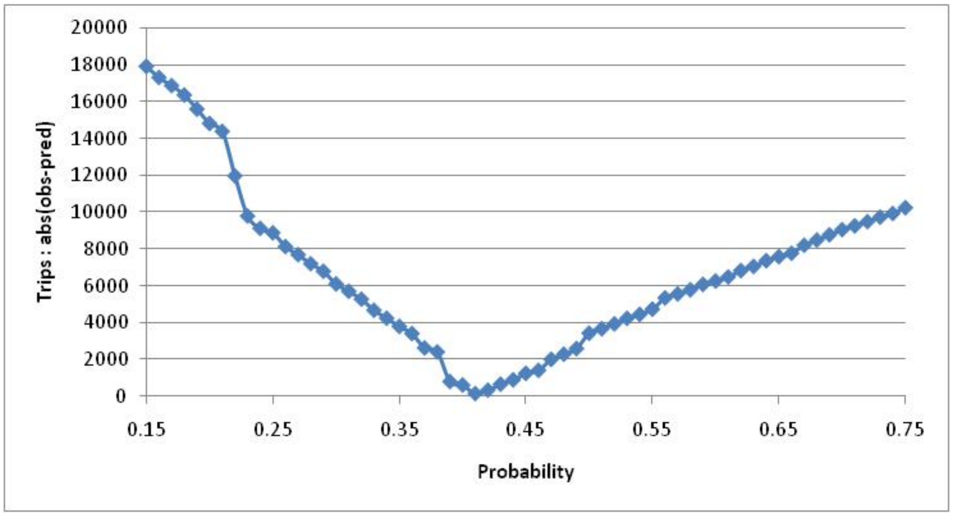

Figure 2. Stephens and MacCall (2004) critical value definition for the association of red grouper multispecies catch from the commercial trip ticket offshore NC data. The 0.41 value was used as criteria for subsetting trips that have positive likelihood of catching red grouper.

Table 1. For Binomial Sub-model: *Type 3 Tests of Fixed Effects*, AIC = 43378.5

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
YEAR	14	9517	553.51	39.54	<.0001	<.0001
Month	11	9213	47.88	4.35	<.0001	<.0001

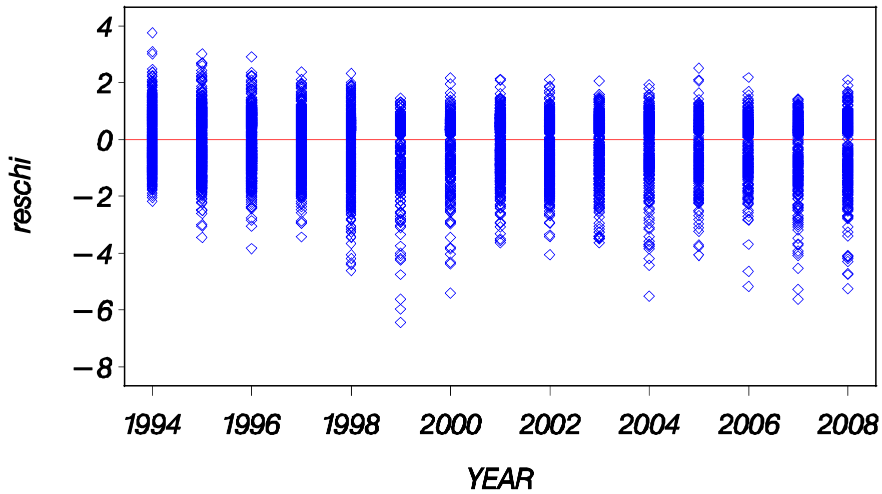

Figure 3. Chi-squared residuals for proportion positive catch rates by year.

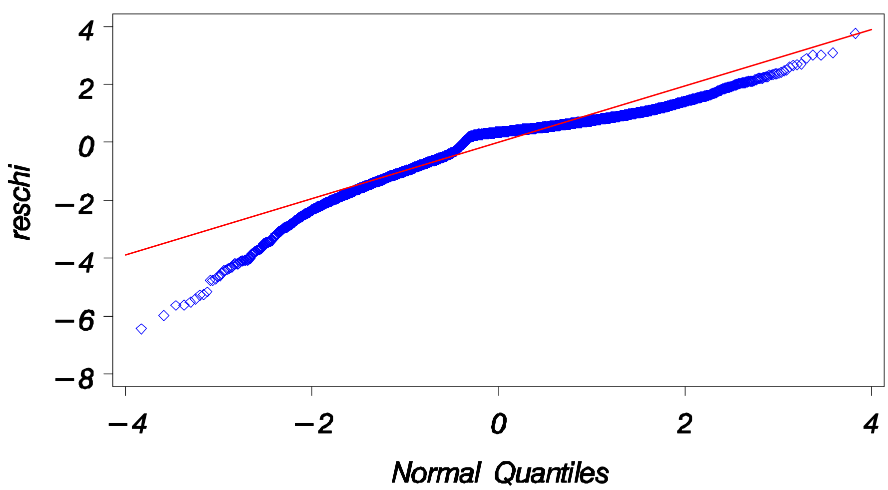

Figure 4. QQ-plot of residuals for proportion positive catch rates.

Table 2. For Lognormal Sub-model: *Type 3 Tests of Fixed Effects*, AIC = 47946.2

Effect	*Num DF*	*Den DF*	*Chi-Square*	*F Value*	*Pr > ChiSq*	*Pr > F*
YEAR	14	16E3	1399.66	99.98	<.0001	<.0001
Month	11	16E3	232.19	21.11	<.0001	<.0001

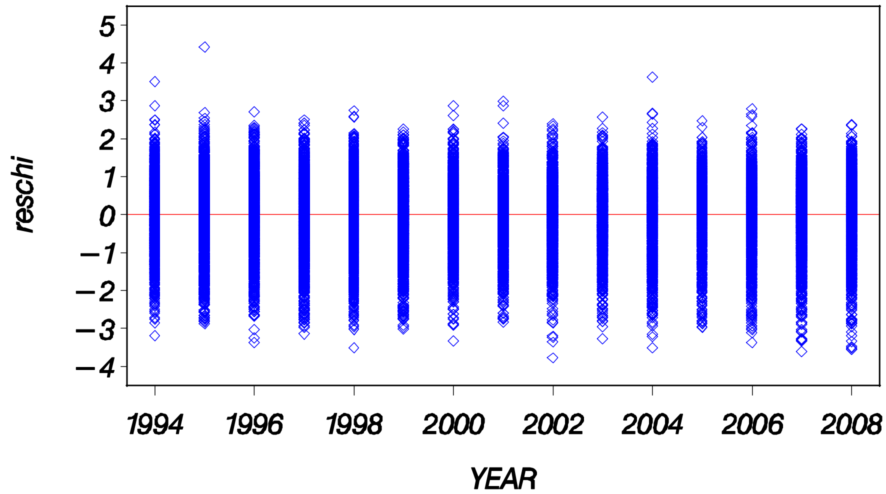

Figure 5. Chi-squared residuals for positive catch rates by year.

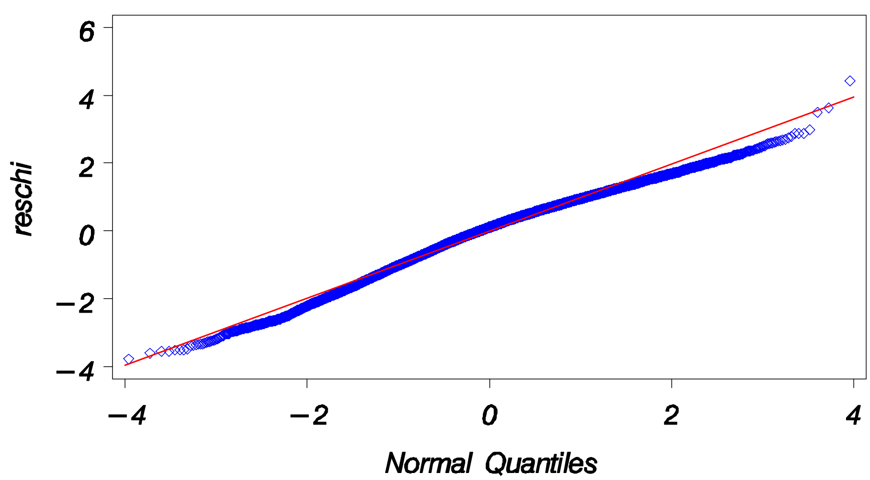

Figure 6. QQ-plot of residuals for positive catch rates.

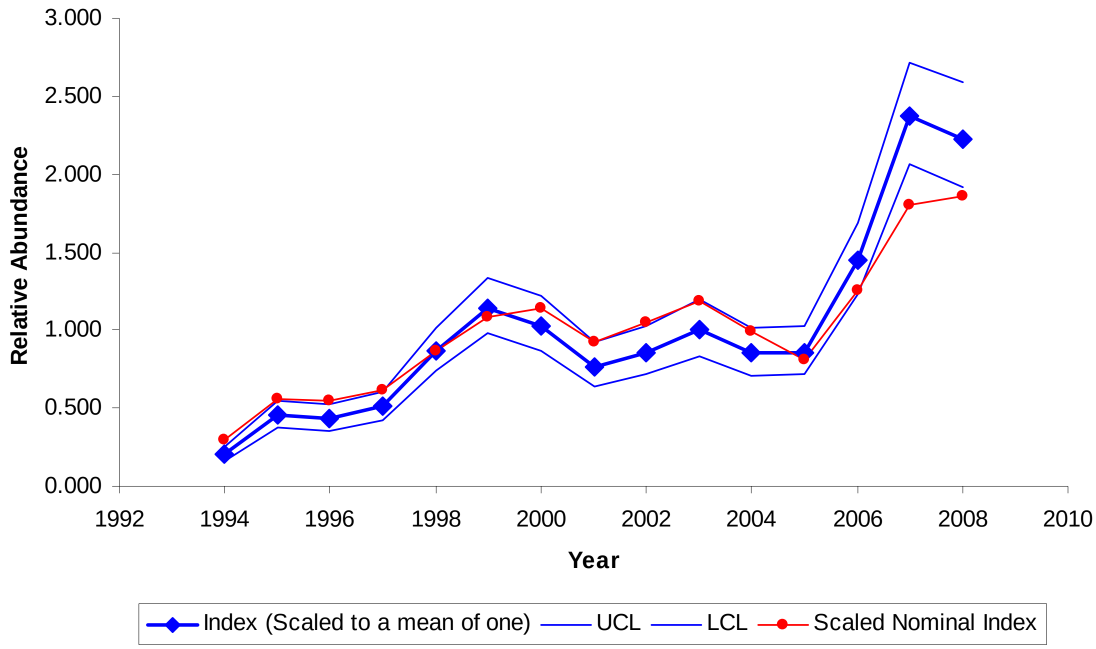

Figure 7. Estimated standardized index for red grouper from the commercial fisheries off North Carolina waters.

Table 3. Estimated standardized index for red grouper from the commercial fisheries off North Carolina waters

Year	*N*	*Nominal Frequency of Occurrence*	*Index (lbs. per trip)*	*Index (Scaled to a mean of one)*	*CV*	*LCL*	*UCL*	*Scaled Nominal Index*
1994	2308	0.488	9.871	0.200	0.104	0.163	0.246	0.301
1995	1901	0.609	22.362	0.454	0.094	0.376	0.548	0.555
1996	1574	0.634	21.203	0.431	0.097	0.355	0.523	0.545
1997	1675	0.693	25.004	0.508	0.092	0.423	0.610	0.620
1998	1739	0.800	42.533	0.864	0.080	0.736	1.013	0.866
1999	1313	0.886	56.220	1.142	0.077	0.980	1.330	1.088
2000	1137	0.843	50.403	1.024	0.086	0.861	1.216	1.142
2001	1308	0.769	37.762	0.767	0.093	0.637	0.924	0.921
2002	1428	0.775	42.289	0.859	0.089	0.720	1.025	1.054
2003	1164	0.800	49.365	1.003	0.091	0.836	1.203	1.185
2004	1085	0.794	41.847	0.850	0.091	0.709	1.019	0.990
2005	1118	0.802	42.370	0.860	0.088	0.722	1.026	0.816
2006	1202	0.855	71.094	1.444	0.077	1.238	1.684	1.251
2007	1565	0.870	116.570	2.367	0.069	2.063	2.716	1.803
2008	1573	0.840	109.731	2.228	0.075	1.919	2.588	1.864