Standardized catch rates of Atlantic king mackerel (*Scomberomorus cavalla*) from the North Carolina Commercial fisheries trip tickets 1994-2013

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Standardized catch rates of Atlantic king mackerel (*Scomberomorus cavalla*) from North Carolina Commercial fisheries trip tickets 1994-2013.

John Walter[1] and Stephanie McInerny[2]

SUMMARY

Standardized indices of abundances were estimated for the Atlantic stock king mackerel from the commercial fisheries off the North Carolina State. The data analyzed included single trip catch information for all commercial fishers from 1994 to spring of 2013 (2012-2013 fishing year) collected by the Trip Ticket Program. Analyses took into account not only trips targeting mackerels, but also other coastal pelagic species likely associated with the catch of mackerels. Standardization procedures used Generalized Linear Models (GLMs) with a delta lognormal approach. In recent years, and particularly in 2010-2012, the standardized index values are low, with 2010 values the lowest of the 19 year time series. The reduction in the index in the recent years is driven by a reduction in the proportion of positive trips in recent years as there is not a substantial decrease in the pounds landed per trip for positive trips. Trip limits (3500 trips) did not have a limiting effect on trips.

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Introduction

Information on the relative abundance of Atlantic mackerel stocks is required for stock assessment models. At the last stock assessment (SEDAR 16) for Atlantic king mackerel, an index of abundance from the commercial fishery in North Carolina derived from the trip ticket program was presented (Bianchi and Ortiz 2007) which represented an updated and revised version of an index constructed in 2003 (Ortiz and Sabo 2003). The index constructed for SEDAR 16 used fishers with a history of 8 or more years of landing king mackerel and used a repeated measures approach to obtain standardized catch rates. We repeat this analysis with catch rate data through 2013 (2012-13 fishing year in the South Atlantic).

Materials and Methods

The North Carolina Trip Ticket Program (http://portal.ncdenr.org/web/mf/46) monitors commericial fishing in North Carolina, for both offshore and inshore fisheries since 1994 (Figure 1). Each observation represents the catch/sell of a single trip by species.

Trip and data selection

Methods followed were similar to that of Bianchi and Ortiz (2007) and used the same waterbody and gear selections. Only North Carolina landings from the ocean using handline gears were selected when determining an index. Handline gears include rod-n-reel and trolling gear types. Data were available from 1994 through June 2013. Using this subset, an analysis of species catch composition was performed to identify trips with a positive likelihood of catching king mackerel following methods defined by Stephens and MacCall (2004). The Stephens and MacCall (2004) method uses a logistic regression of multispecies presence-absence information to predict the probability of king mackerel presence and provide a critical probability value to include or exclude trip observations. Positive regression coefficients indicated king mackerel were positively correlated with species such as little tunny, red hind, red snapper, Spanish mackerel, hog snapper, red porgy, and amberjacks (Table 1; Figure 2). Negative correlations were associated with bluefin tuna, yellowfin tuna, and blueline tilefish among others (Table 1; Figure 2). A critical value of 0.54 was determined and used to subset offshore trips that had a positive likelihood of catching king mackerel (Figure 3).

Index Development

Similar to Bianchi and Ortiz (2007), a repeated measures model was used where individual fishers identified by the Participant Identification Number were selected if they had 8 or more years of landing king mackerel. Based upon a review of a subset of the trip ticket data (Bianchi and Ortiz 2007), between 1994 and 2007 about 315 (17%) of the Participant Identification Number (PIDs) reported catch of king mackerel for at least eight or more years, and they accounted for 76% of the overall catch of king mackerel(Figure 4). This suggests that this subgroup of PIDs are likely to have consistently targeted king mackerel since 1994, and are likely to provide more consistent catch rate information than those the remaining PIDs who only occasionally catch/target king mackerel and are therefore more opportunistic in nature. Therefore, for the catch rate analyses, the data were further restricted to those PIDs with a history of 8 or more years of catch reported for king mackerel.

Catch was reported in total pounds landed by species and trip. Although fishing effort data are currently collected as number of days per trip in the Trip Ticket Program, this information was only available since 1999 (NCDENR). Thus nominal catch rates were estimated as total pounds per trip. Figure 5 shows the frequency distribution of the log-transformed nominal catch rates (CPUE) of the subset data for king mackerel 1994-2012. The explanatory variables considered for the king mackerel index analyses were year and season. Season defined as winter (Jan-Mar), spring (Apr-Jun), summer (Jul-Oct) and fall (Nov-

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Dec). The index was calculated for the fishing year where fishing year (from 1994-2004, from 4/1-3/31 and from 2005 onward from 3/1-2/28-29 for the Atlantic) was assigned as follows. For months 4-12, all trips were assigned to the year that they occurred in. For months 1-3, trips were assigned to the previous year. This aligned the data with the South Atlantic fishing years, consistent with the index construction for SEDAR 16.

To account for correlated variability on catch rates due to fisher or PID, the GLM model for positive observations include PID as a random component, by assuming an alternative covariance matrix structure, auto-regressive (AR1) (Little et al 1996). This covariance structure assumed that the variance within a fisher is similar for consecutive years. Relative indices of abundance were estimated by Generalized Linear Mixed Modeling (GLMM) approach using a delta lognormal model error distribution. The selection of a delta model responded to the significant proportion of trips with zero catch. The analysis used a delta model with 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 used the Generalized Linear Model structures. 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 later case, the identity was the link function in this model.

A step-wise regression procedure was used to determine the set of systematic or fixed factors and interactions that significantly explained the observed variability. The deviance difference between two consecutive modes formulations followed a Chi-square distribution. This statistic was used to test for the significance of an additional factor in the model, where the number of additional parameters minus one corresponded to the number of degrees of freedom in the Chi-square test (McCullagh and Nelder 1989). Deviance tables are presented for the two components of the delta model: the binomial proportion of positives, and the mean catch rate of positive trips. Final selection of explanatory factors was conditional on: a) the relative percent of deviance explained by the added factor in the model, normally factors that explained 5% or more of deviance were retained, b) the Chi-square significant test, and c) the type III test within the final specified model. Once a set of fixed factors was specified, all possible first level interactions were evaluated, in particular interactions that included the year factor. Analyses were done using the GLIMMIX and MIXED procedures for the SAS® statistical computer software (SAS Institute Inc. 1997). Once a set of fixed factors and interactions was selected for each species, all interactions that included the factor *year* were assumed as random interactions. This assumption allowed estimating annual indices, which was the main objective of the standardization process, but also recognized the variability associated with the year-factors interactions that were significant. This process converted the base models into the generalized linear mixed model category. The significance of random interactions was evaluated between nested models by using three criteria: the likelihood ratio test (Pinheiro and Bates 2000), the Akaike's information criteria (AIC), and the Schwarz Bayesian information criteria (BIC) (Little et al 1996). For the AIC and BIC smaller values indicated best model fit.

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). The proportion positive and the logCPUE was tested for correlation and found to be insignificant so Goodman's (1960) exact variance estimator was used for the variance of the product of two random variables.

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Results and Discussion

Deviance analysis tables indicated that season was a main explanatory variable for the proportion of successful trips of king mackerel (Table 2), followed by year. The year*season interaction explained 10.9% of the deviance but when modeled as a random effect did not converge (Table 3) and was not used in the final model. For king catch rate of successful trips, season was explained the greatest amount of deviance (85%) and the interaction with year explained 5.7% of the deviance and resulted in a better fitting model by AIC when included as a random effect (Table 3). Hence the interaction of year*season was included in the positive catch rate model. The final models were:

Proportion Positive: success~ Year Season

Positive Catch: lgcpue**~** Year Season *Year*Season*

Where the interaction between year*season was modeled as a random effect A plot of the raw ln CPUE indicates that there was some substantial divergence from an expected lognormal distribution for the full dataset (Figure 5). Diagnostic plots of the model fit of king mackerel are shown in Figure 6 and Figure 7. The distribution of residuals and cumulative normalized residual plots (qq-plots) illustrated the expected patterns for the positive trips model component. While there is divergence from a lognormal distribution the patterns do not appear extreme.

Table 4 and Figure 8 show the estimated standardized index for king mackerel from the commercial fisheries off North Carolina waters using fishers with 8 or more years of landings history. The index constructed up to 2012 (the 2012-2013 fishing year) shows a similar pattern to the index constructed up through 2006 (Figure 8). Note that the index presented in Bianchi and Ortiz (2007) was not the final index used in the SEDAR 16 base VPA. In recent years, and particularly in 2010-2012, the standardized index values are low, with 2010 values the lowest of the 19 year time series. The reduction in the index in the recent years is driven by a reduction in the proportion of positive trips in recent years (Figure 9) as there is not a substantial decrease in the lbs landed per trip for positive trips.

For sensitivity analyses, indices of abundance were also estimated for the data that included all PIDs, not only those with 8 or more years of king mackerel catch data. Figure 9 shows the estimated index with all PIDs included. The trend was similar to the index with only the 8-year PIDs, except for some divergent years.

An additional exploration of the potential effects of the 3500 lb trip limit was conducted by plotting histograms of the catch per trip of the positive trips by year with the 3500 lb trip limit (which went into place 4/1/1995) overlaid (Figure 11). Similar to an analysis conducted for SEDAR 16 (McCarthy et al. 2007) it appears unlikely that the 3500 lb trip limit had much effect upon limiting overall trip catches in the North Carolina fishery and hence no corrective action was taken.

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.

Cooke, J.G. 1997. (Rev) A procedure for using catch-effort indices in bluefin tuna assessments. ICCAT SCRS Collected Volume of Scientific Papers 46(2):228-232.

Goodman, L. A.1960. On the exact variance of products. Journal of the American Statistical Association. 55(292): 708- 713.

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.

McCarthy, K., S. Cass-Calay, M. Ortiz and J. Walter. 2007. Effects of King Mackerel Fishing Regulations on the Construction of Fisheries Dependent Indices of Abundance SEDAR16-AW-02.

McCullagh, P. and J.A. Nelder. 1989. Generalized Linear Models. 2nd edition. Chapman & Hall.

North Carolina Department of Environment and Natural Resources (NCDENR). Trip Ticket User Manual. A guide to completing trip tickets in accordance with the North Carolina trip ticket program (version 5.0). Division of Marine Fisheries PO Box 769 Morehead City, NC.

Ortiz, M. and L. Sabo. 2003. Standardized catch rates of Spanish and king mackerel (*Scomberomorus maculatus* and *S. cavalla*) from the North Carolina commercial fisheries. MSAP-03. NOAA-NMFS SEFSC Miami. Sustainable Fisheries Division contribution SFD-02/03-005.

Pinheiro, J.C. and D.M. Bates. 2000. Mixed-effects models in S and S-Plus. Statistics and Computing Series. Springer Verlag New York, Inc.

SAS Institute Inc. 1997. SAS/STAT® Software. Changes and enhancements through release 6.12. Cary, NC. SAS Institute Inc., 1997.

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

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Table 1. List of Species Used for Stephens and MacCall (2004) selection method for NC King Mackerel trips with potential effort towards king mackerel. Percent of the total hook and line trips, and estimated multispecies regression coefficients with king mackerel reported catch.

Species	% of Trips	Coefficient
Little tunny	10.6382	1.2784
Red hind	10.6768	0.7838
Red snapper	6.1306	0.5418
Spanish mackerel	2.6931	0.5095
Hog snapper	4.2654	0.3231
Red porgy	21.9520	0.1944
Amberjacks	18.4029	0.0537
Grunts	25.1705	-0.2089
Bluefish	2.6786	-0.3682
Red grouper	20.7607	-0.3702
Vermilion snapper	22.2464	-0.4134
Cobia	3.1343	-0.4798
Dolphin	17.0215	-0.4851
Triggerfishes	19.3632	-0.5417
Wahoo	4.3898	-0.5837
Snowy grouper	6.6665	-0.5883
Spottail pinfish	3.2530	-0.7212
Black sea bass	23.6719	-0.7213
Gag grouper	26.2390	-1.0455
Blueline tilefish	5.5113	-1.4321
Yellowfin tuna	8.7330	-2.1253
Bluefin tuna	3.6645	-6.2510
Jolthead porgy	6.8365	
Scamp	14.7777	
King mackerel	45.3198	

Table 2. Deviance analysis table for the mean catch rate of successful trips and the proportion of positive trips for king mackerel from the North Carolina offshore commercial fisheries Trip ticket data. *p* value refers to the Chi-square test between two consecutive models.

Model factors proportion positives	d.f.	Residual deviance	Change in deviance	% of total deviance	*p*
intercept	1	4314.95			
YEAR	18	3509.85	805.10	18.7%	< 0.001
YEAR season	3	471.23	3038.62	70.4%	< 0.001
YEAR season YEAR*season	54	0.00	471.23	10.9%	< 0.001

Model factors positive catch rates values	d.f.	Residual deviance	Change in deviance	% of total deviance	*p*
intercept	1	57220.6			
YEAR	18	56035.3	1185.3	8.6%	< 0.001
YEAR season	3	44196.8	11838.5	85.7%	< 0.001
YEAR season YEAR*season	54	43406.6	790.2	5.7%	< 0.001

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Table 3. Analysis of delta-lognormal mixed model formulation for king mackerel catch rates from the NC offshore commercial trip ticket data. Likelihood ratio tests the difference of -2 REM log likelihood values between two nested models.

King mackerel Atlantic Model	-2 REM Log likelihood	Akaike's Information Criterion	Corrected Akaike's Information Criterion	Schwartz's Bayesian Criterion	Likelihood Ratio Test	
Proportion Positives						
Year Season	178747.2	178749.2	178749.2	178757.7		
Year Season *Year*Season*			Did not converge			
Positive Catch						
Year Season	91088.4	91092.4	91092.4	91100		
Year Season *Year*Season*	90872	90878	90878	90885	216.4	0.0000

Table 4. Nominal and standard CPUE for king mackerel NC offshore commercial trip ticket data.

Year	N Obs	Nominal	Standardized	Coeff Var	Index	95% LCL	95% UCL	Prop Pos
1994	1997	206.0	201.3	17.3%	0.80	0.57	1.13	77%
1995	2010	187.4	209.2	17.4%	0.83	0.59	1.18	74%
1996	1755	363.9	309.8	17.4%	1.24	0.88	1.74	78%
1997	2074	246.4	290.8	17.3%	1.16	0.82	1.63	80%
1998	2281	321.8	274.5	17.2%	1.09	0.78	1.54	83%
1999	2305	275.0	242.0	17.2%	0.97	0.69	1.36	81%
2000	2339	257.8	261.3	17.2%	1.04	0.74	1.47	85%
2001	2362	283.5	280.9	17.2%	1.12	0.80	1.58	84%
2002	2039	258.9	243.9	17.3%	0.97	0.69	1.37	79%
2003	1787	236.0	219.3	17.4%	0.87	0.62	1.23	80%
2004	2263	351.1	323.5	17.2%	1.29	0.92	1.82	86%
2005	2106	345.0	288.9	17.2%	1.15	0.82	1.62	87%
2006	2218	321.8	256.7	17.3%	1.02	0.73	1.44	86%
2007	2331	285.7	307.8	17.2%	1.23	0.87	1.73	82%
2008	1890	290.0	265.1	17.4%	1.06	0.75	1.49	76%
2009	1755	226.4	220.9	17.4%	0.88	0.62	1.25	73%
2010	981	120.8	156.1	18.1%	0.62	0.43	0.89	59%
2011	1044	281.0	182.7	18.1%	0.73	0.51	1.04	65%
2012	829	182.7	228.9	18.2%	0.91	0.64	1.31	67%

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Figure 1. Map of North Carolina showing area where landings come from.

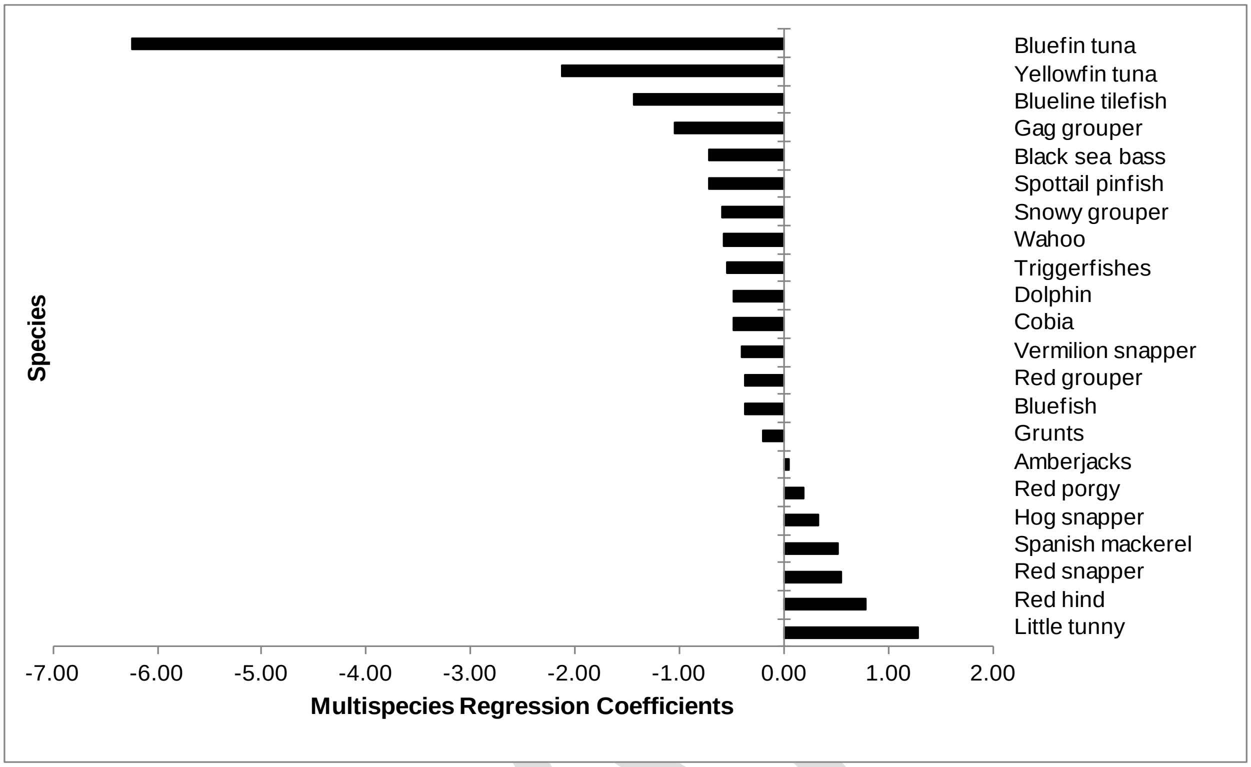

Figure 2. Multispecies correlations of king mackerel catch for offshore commercial fisheries in North Carolina, derived from the trip ticket program data.

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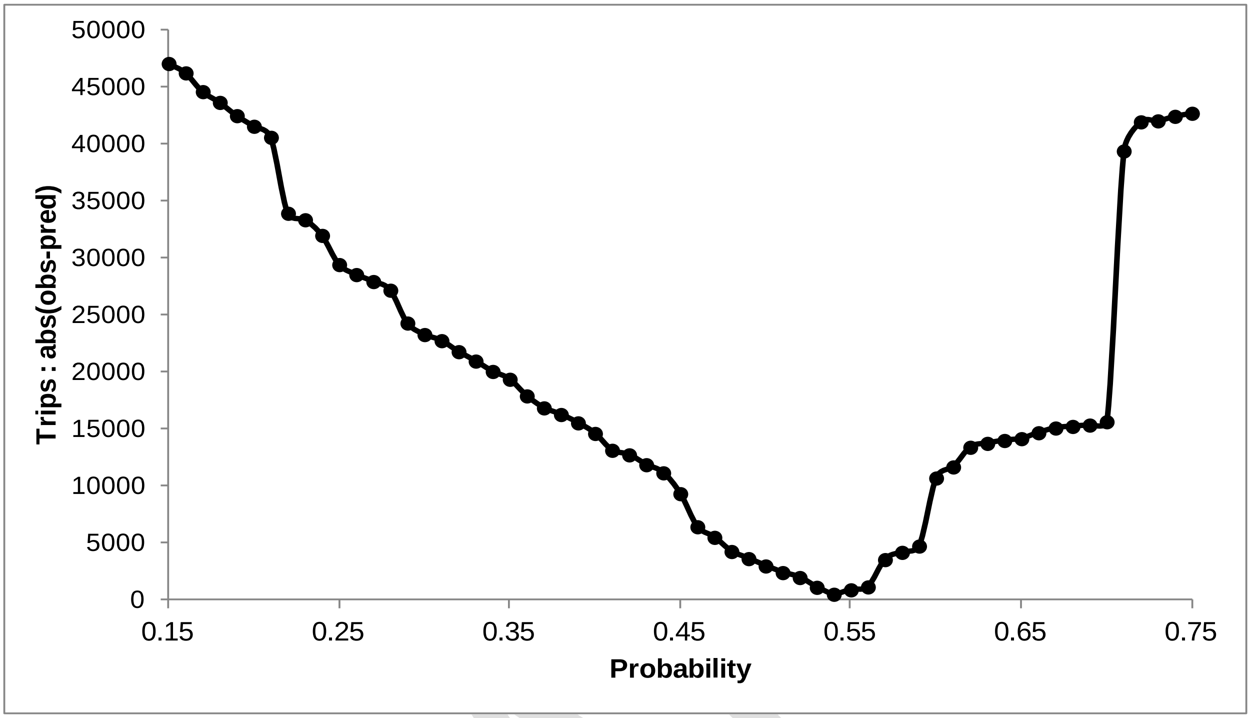

Figure 3. Stephens and MacCall (2004) critical value definition for the association of king mackerel multispecies catch from the commercial trip ticket offshore NC data. The 0.54 value was used as criteria for subsetting trips that have positive likelihood of catching king mackerel.

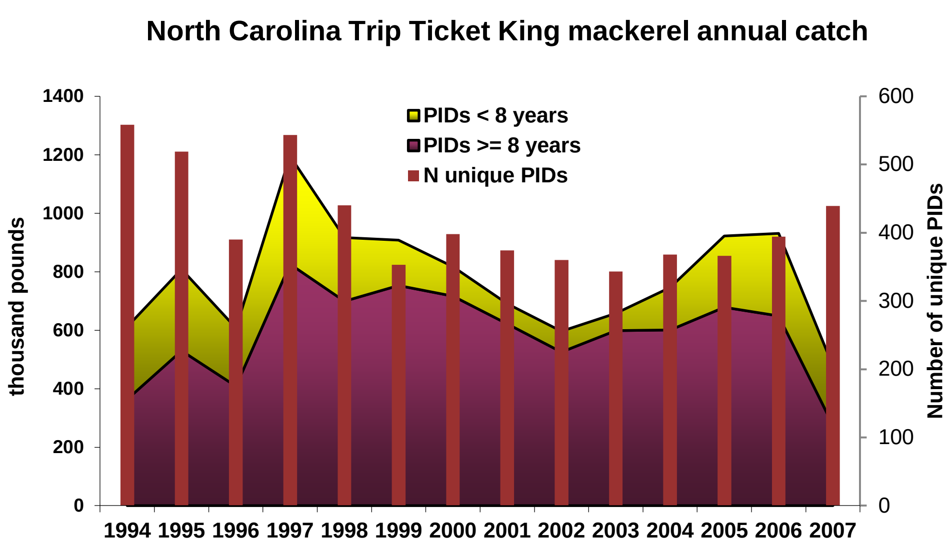

Figure 1. Annual king mackerel catch (area plots) and number of unique PID that reported that catch from the NC trip ticket commercial offshore fishery 1994-2007. Total annual catch is split by the catch from PIDs that have at least 8 or more years of king reporting catches (dark area), and catch by the remained PID. Bars show the unique PID number per year. Note that this figure is not updated from Bianchi and Ortiz 2007.

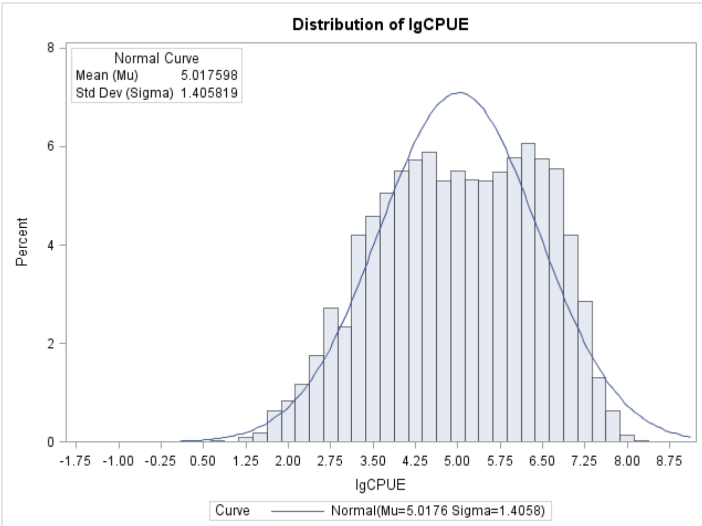

Figure 2. Frequency distribution of log-transformed nominal CPUE for king mackerel from the NC offshore commercial trip ticket data 1994-2012, fishers with at least 8 or more years of king reporting catches.

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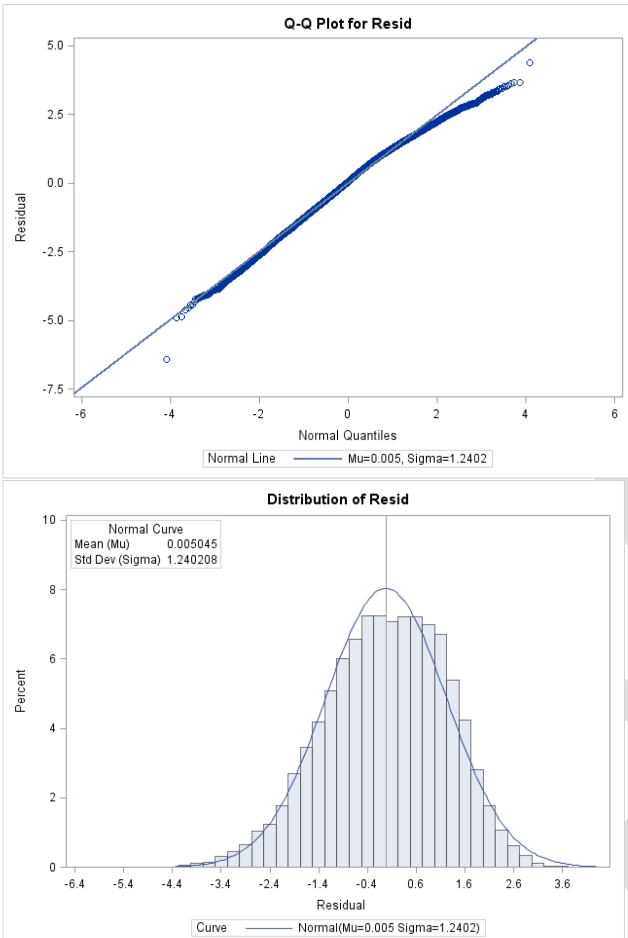

Figure 3. Diagnostic plot for the positive observations delta-lognormal model fit. Top normal cumulative qq-plot residuals of positive CPUE, bottom histogram of residuals.

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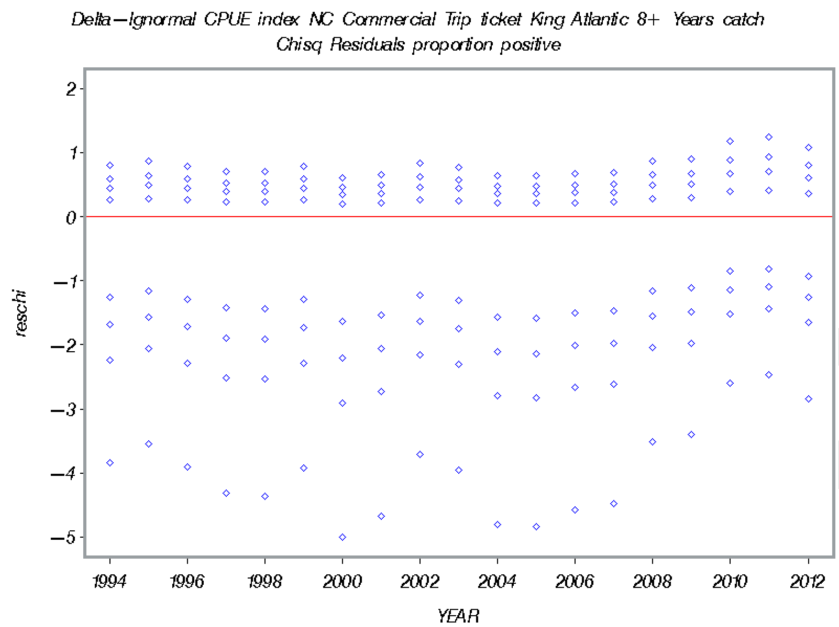

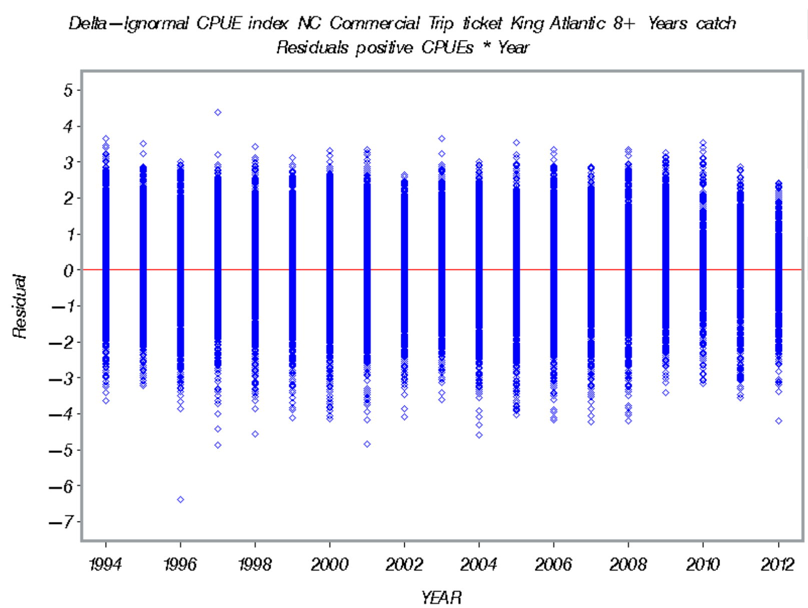

Figure 4. Distribution of residuals a. proportion positive and b. positive observations by year King mackerel CPUE NC trip ticket data.

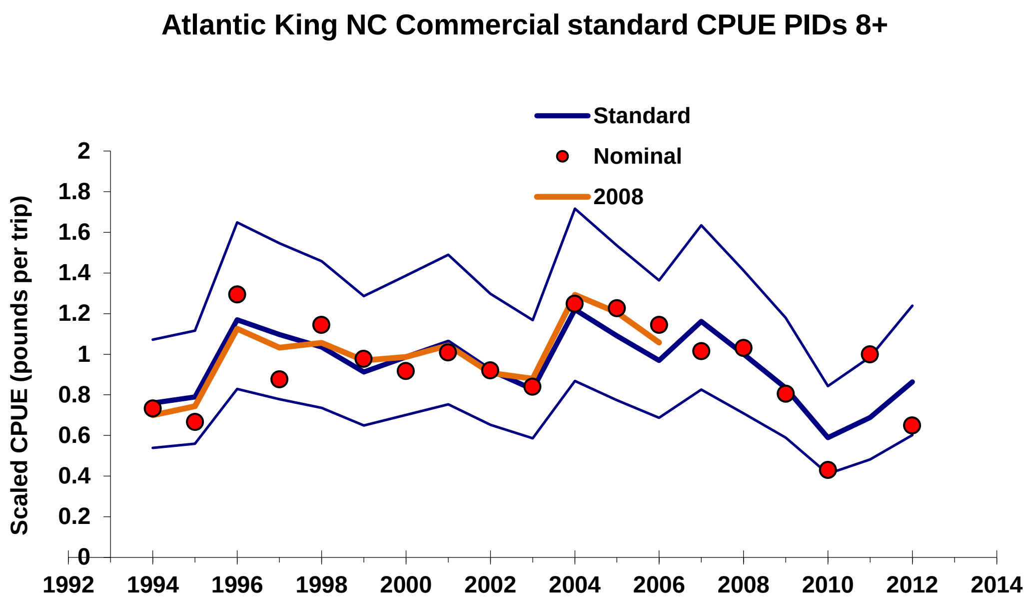

Figure 5. Standard and nominal CPUE index for NC king mackerel commercial fishery with 95% confidence intervals with fishers with at least 8 or more years of king reporting catches. For comparison the same index used for the the 2008 assessment is also shown.

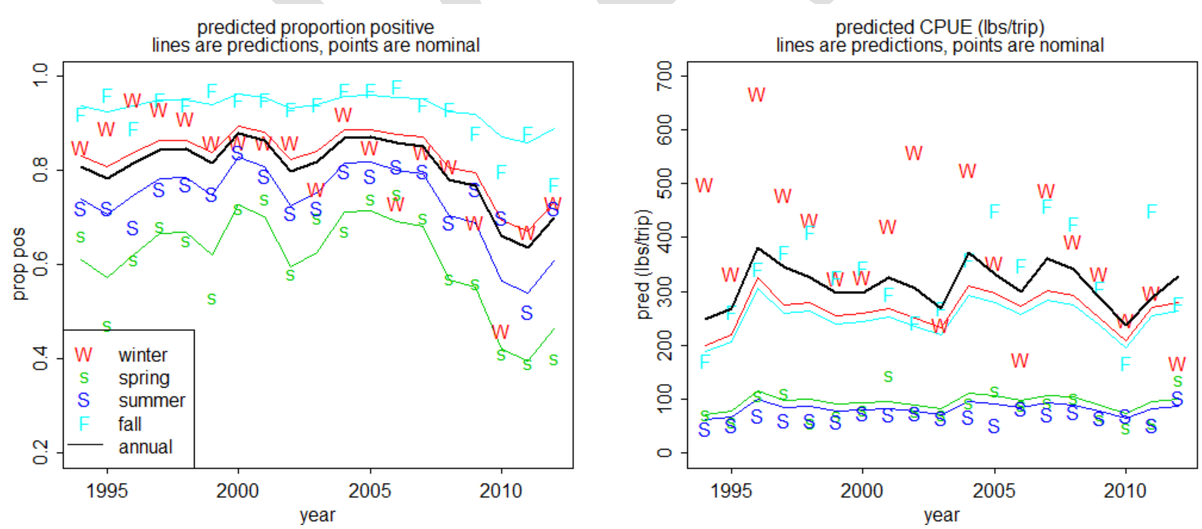

Figure 9. Standardized (lines) and nominal (letters) proportion positive and CPUE (lbs per trip) by year and season for North Carolina Trip ticket fishers with 8-plus years of landings. Estimated annual values are shown as black lines.

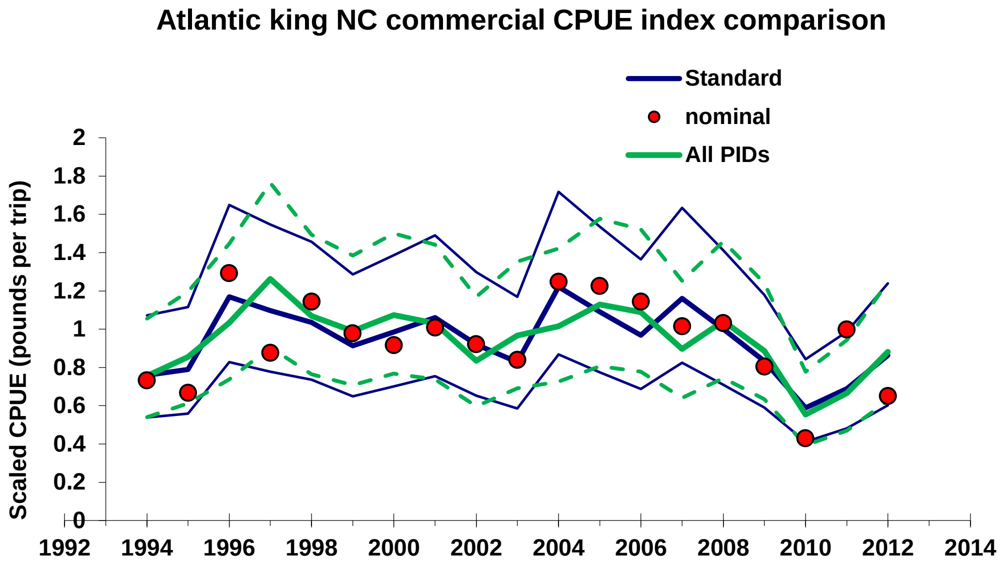

Figure 10. Comparison of standard indices of abundance for king mackerel estimated with all PID-fishers (green lines) or restricting the information to only those PID-fishers that have 8 or more years of reported catch of king mackerel (blue lines).

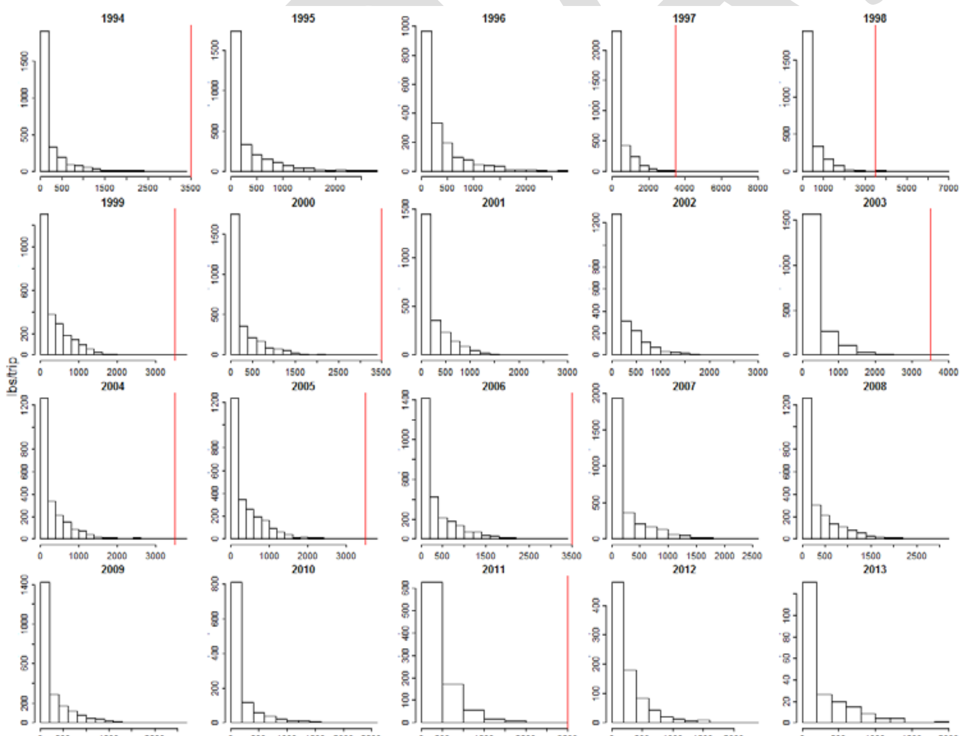

Figure 11. Distribution of CPUE per trip by year with the 3500 trip limit shown, when it fell within the range of each year histogram. In almost all years it appears unlikely that the 3500 lb trip limit had an effect of limiting CPUE.

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