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STANDARDIZED CATCH RATES FOR LARGE BLUEFIN TUNA, *THUNNUS THYNNUS,* FROM THE U.S. PELAGIC LONGLINE FISHERY IN THE GULF OF MEXICO AND OFF THE FLORIDA EAST COAST

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SUMMARY

Indices of abundance of large bluefin tuna from the pelagic longline fishery in the Gulf of Mexico and off the Florida East Coast were derived from a selected subset of 11 vessels which consistently caught bluefin between 1987 and 1997.

RÉSUMÉ

Les indices d'abondance du gros thon rouge de la pêcherie palangrière pélagique opérant dans le golfe du Mexique et au large de la côte est de la Floride ont été dérivés d'un sous-ensemble sélectionné de 11 bateaux qui ont capturé de manière constante du thon rouge entre 1987 et 1997.

RESUMEN

Los índices de abundancia de grandes atunes rojos de la pesquería de palangre pelágica en el Golfo de México y en las aguas a la altura de la costa este de Florida se derivaron de un subgrupo seleccionado de 11 barcos que capturaron atún rojo de manera constante entre 1987 y 1997.

KEY WORDS

Catch/effort, multivariate analysis, long lining

1. INTRODUCTION

Large bluefin tuna are caught in the Gulf of Mexico (GOM) and off the Florida East Coast (FEC) as bycatch by longline vessels fishing for other species of tuna or for swordfish primarily between January first and the end of May. Although bluefin are considered to be bycatch in this fishery, examination of the data, in previous studies, indicated that some vessels have consistently caught bluefin. Data for these analyses were limited by time, area and vessel.

2. MATERIALS AND METHODS

U.S. Atlantic fishing vessels which land swordfish have been required to provide daily records of effort and catch since October 1986. Fifteen complete years of data (1987 to 2001) are now available (2001 data are preliminary). Since swordfish landings are made by a variety of gear types over a wide geographical area, it was necessary to exclude effort not relevant to catch of bluefin. This was accomplished by defining a subset of times (January first and the end of May), areas (GOM and FEC) and vessels most likely to catch bluefin. Twenty one vessels which reported catching at least one bluefin in the GOM and the FEC between January first and the end of May in at least 6 years (from 1987 to 1997) have been used in earlier analyses. Review of vessel records through 2001 indicated that 10 of these 21

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vessels have not reported fishing in the GOM and the FEC between January first and the end of May in the last four years. Therefore these analyses are based on the remaining 11 vessels.

3. ANALYSES

Relative abundance of bluefin tuna was estimated by a delta lognormal model approach of catch rates from the longline fishery in the Gulf of Mexico from 1987 through 2001. Delta models estimates are the product of two independent components; the estimated probability of catching a fish times the estimated mean-catch rate if at least one fish is caught. For the delta model in this analysis, sets are classified as binary information, either success or no success in catching bluefin tuna.

The present analyses used a delta distribution with a binomial distribution assumption for the proportion of positive sets, and a lognormal assumed error distribution for the mean density of successful sets. Parameterization of the model used the general linear model structure: for the proportion of positives, the estimated proportion is a function of a set of systematic fixed factors, including year, area, month, vessel. The logit function was used to link the binomial error distribution and the linearized prediction model component. Similarly, the estimated log of catch rate observed on positive sets is a function of the systematic factors year, month, area, and vessel, assuming a normal distribution of the log (lognormal) catch rate observed. These analyses are an update of the previous years analysis (Cramer and Ortiz, 2000).

Year effect least square means (LSMs) from the binomial and lognormal component were multiplied to generate the overall index, standard errors of the LSMs and confidence intervals for the index were estimated as the product of the respective binomial and lognormal component (**Tables 3 and 4)**. For the lognormal component, a bias correction for back-transformed estimates was done using the equations and algorithms of Lo *et al.* (1992).

4. VARIABLES INVESTIGATED

As in the earlier analysis, bluefin caught included fish both reported kept and discarded. This was done to decrease the possible effects of U.S. regulatory changes which restricted longline landing of bluefin tuna during open season to two fish per trip from 1987 to 1991 and one fish per trip in 1992. Effective Dec. 31, 1991, in addition to the 1 bluefin per trip restriction, vessels were required to have at least 1,134 kg (2500 lbs) of other species on board before a landing a bluefin. Effective Apr. 16, 1994, vessels were required to have 1500 lbs of other species on board between January and the end of April and 3500 lbs of other species on board from May through December. At this time the N-S line was moved from 36 to 34 deg latitude.

Variables included in the analyses and thought to significantly influence catch of bluefin were year (year), month, area (zone), and vessel (id). Other variables examined were less important in explaining the patterns in the data. Bluefin fishing season was not considered as a variable in this analysis since there have been no closed seasons in this area since 1993.

Four zones were defined based on nominal catch distributions. Bluefin catch rates were consistently lower off the coast of Florida and in the southern Gulf of Mexico than in the northwestern Gulf of Mexico or North of the Bahamas.

5. RESULTS AND DISCUSSION

The fixed effects models accounted for 30 % of the variability of the portion positives and 50% of the variability of the positive sets **(Tables 1 and 2)**. Plots of residuals against predicted proportion positive values and the positive catch rate values, for the fixed effects model are shown in **Figures 1 and 3**. The QQ-residual plot from positive catch rates portion of the delta lognormal model suggests a reasonably good fit **(Figure 2)**. Abundance indices, 95% confidence intervals, and coefficients of variation can be found in **Tables 3 and 4**. These values are also plotted in **Figures 4 and 5**. Both the fixed effects and random effects composite indices indicate an upward trend in model predicted mean CPUEs in recent years. There were no consistent differences in predicted mean CPUEs from the two models **(Figures 4 and 5)**. Appendix 1 contains model descriptions from both the delta lognormal model and mixed (random effects model).

REFERENCES CITED

CRAMER, J., Mauricio Ortiz. 2000. Standardized catch rates for large bluefin tuna, *Thunnus thynnus*, from the U.S. pelagic longline fishery in the Gulf of Mexico and off the Florida East Coast. SCRS/100/102.

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Table 1. Model equation, summary of fit, deviance table, type III test for factors and residual plots for the base model selected for the positive catch rates (CPUE) for BLT in the Gulf of Mexico longline fishery 1987-2001. The model assumes a lognormal error distribution and a linear systematic component of fixed factors; year and idn.

lbftcr = YEAR IDN
Response Distribution: Normal
Link Function: Identity

Nominal Variable Information		
Level	YEAR	IDN
1	87	2
2	88	3
3	89	7
4	90	8
5	91	9
6	92	12
7	93	16
8	94	18
9	95	19
10	96	20
11	97	21
12	98	
13	99	
14	100	
15	101	

Summary of Fit			
Mean of Response	0.7169	R-Square	0.4998
Root MSE	0.4435	Adj R-Sq	0.4687

Analysis of Variance					
Source	DF	Sum of Squares	Mean Square	F Stat	Pr > F
Model	24	75.8853	3.1619	16.07	<.0001
Error	386	75.9363	0.1967		
C Total	410	151.8216			

Type III Tests					
Source	DF	Sum of Squares	Mean Square	F Stat	Pr > F
YEAR	14	18.8308	1.3451	6.84	<.0001
IDN	10	26.5273	2.6527	13.48	<.0001

Table 2. Model equation, summary of fit, deviance table, type III test for factors and residual plots for the base model selected for the proportion positive catch for BLT in the Gulf of Mexico longline fishery 1987-2001. The model assumes a binomial error distribution and a linear systematic component of fixed factors; year, idn, and zone. The logit is the link function between the linear predictor and the assumed error distribution.

positv / total = YEAR MONTH IDN ZONE	
Response Distribution:	Binomial
Link Function:	Logit

Nominal Variable Information				
Level	YEAR	MONTH	ZONE	IDN
1	87	1	1	2
2	88	2	2	3
3	89	3	3	7
4	90	4	4	8
5	91	5		9
6	92			12
7	93			16
8	94			18
9	95			19
10	96			20
11	97			21
12	98			
13	99			
14	100			
15	101			

Summary of Fit					
Mean of Response	0.1129	Deviance	852.3665	Pearson ChiSq	1123.853
SCALE	1.0000	Deviance / DF	1.2895	Pearson ChiSq / DF	1.7002
		Scaled Dev	852.3665	Scaled ChiSq	1123.853

Analysis of Deviance					
Source	DF	Deviance	Deviance / DF	Scaled Dev	Pr > Scaled Dev
Model	31	368.5805	11.8897	368.5805	<.0001
Error	661	852.3665	1.2895	852.3665	
C Total	692	1220.9470			

Type III (Wald) Tests			
Source	DF	ChiSq	Pr > ChiSq
YEAR	14	104.6329	<.0001
MONTH	4	65.4423	<.0001
IDN	10	60.0466	<.0001
ZONE	3	58.9761	<.0001

Table 3. Relative abundance indices, 95% confidence intervals, Model delta lognormal/binomial with fixed factors.

YEAR	INDEX	LOWER	UPPER	CV
87	0.65278	0.39753	1.07192	0.25184
88	0.23818	0.08425	0.67335	0.55674
89	0.31454	0.1541	0.64201	0.36841
90	1	0.61317	1.63087	0.24826
91	0.87609	0.5574	1.37699	0.22901
92	0.22493	0.10045	0.50364	0.41998
93	0.21714	0.09142	0.51574	0.45358
94	0.10691	0.03335	0.34273	0.63554
95	0.13032	0.05125	0.33136	0.49322
96	0.13438	0.04643	0.38895	0.5712
97	0.19586	0.08547	0.44881	0.43308
98	0.24342	0.10288	0.57595	0.45136
99	0.31809	0.16664	0.60717	0.33188
00	0.19874	0.08686	0.45473	0.43221
01	0.29712	0.12694	0.69546	0.44517

Table 4. Relative abundance indices, 95% confidence intervals, Model delta lognormal/binomial with random factors.

YEAR	INDEX	LOWER	UPPER	CV
87	0.78776	0.42015	1.47703	0.32222
88	0.2049	0.06258	0.67088	0.64921
89	0.33537	0.14681	0.76612	0.43131
90	1	0.53311	1.87577	0.32245
91	0.91062	0.50828	1.63146	0.29786
92	0.20779	0.07532	0.57325	0.54187
93	0.24351	0.08957	0.66206	0.53305
94	0.10125	0.02539	0.40373	0.78311
95	0.12553	0.03824	0.41207	0.65088
96	0.15132	0.04744	0.48268	0.63234
97	0.20658	0.07953	0.5366	0.50581
98	0.25978	0.08865	0.76127	0.57886
99	0.26219	0.10902	0.63059	0.46078
00	0.19471	0.06555	0.57838	0.58729
01	0.25825	0.08317	0.80192	0.6152

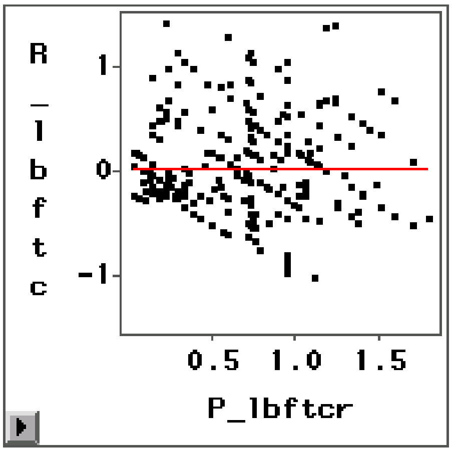

Figure 1. Plot of residuals (R_lbftcr) against predicted positive catch rate values.

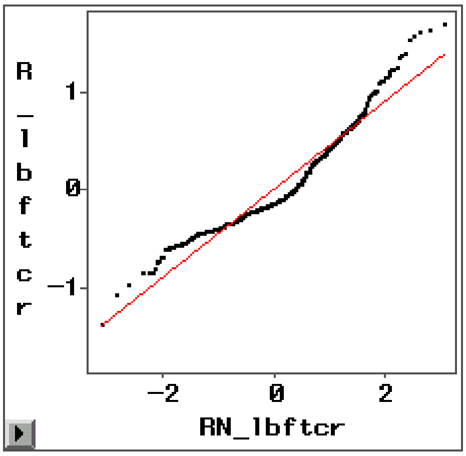

Figure 2. QQ-residual plots from lognormal model of positive catch rates.

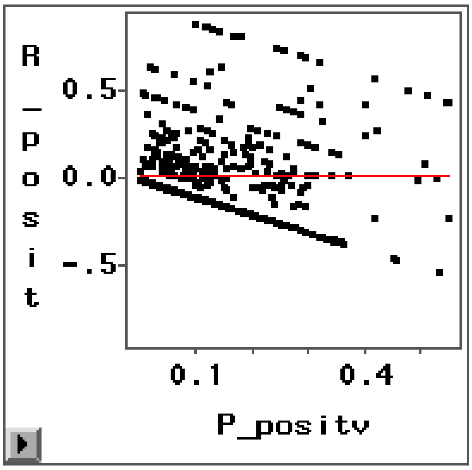

Figure 3. Plot of residuals (R_positiv) against the predicted proportion positive value.

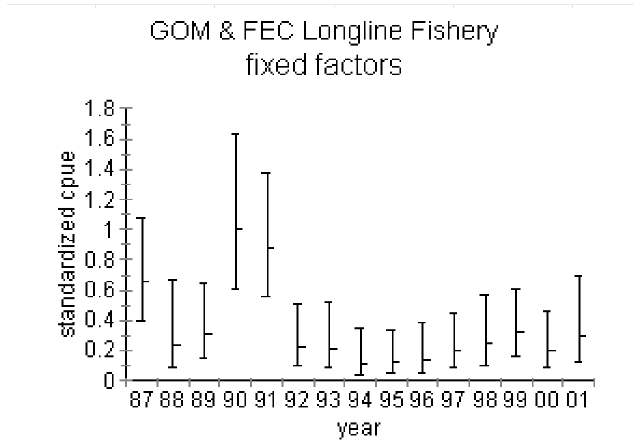

Figure 4. Relative abundance indices, 95% confidence intervals, Model delta lognormal/binomial with fixed factors

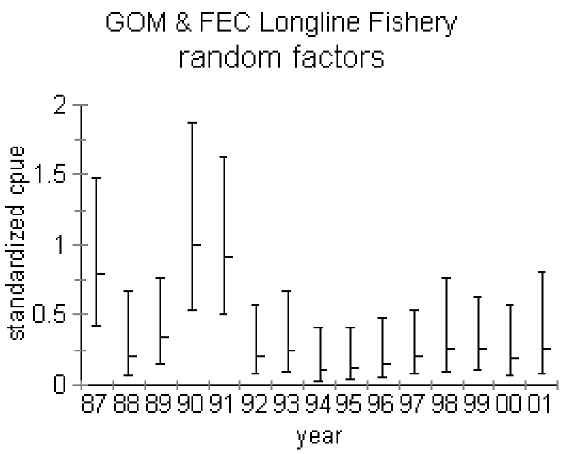

Figure 5. Relative abundance indices, 95% confidence intervals. Model delta lognormal/binomial with random factors

Appendix I

Model and variable descriptions.
Delta lognormal models:
Proportion Positive:
Logit (bft / total number of sets) = year month id zone

Positive sets:
ln(bftcr) = year id

Delta lognormal mixed models:
Proportion Positive:
Logit (bft / total number of sets) = year month id zone (year*id *zone random effects)

Positive sets:
ln(bftcr) = year id (year*id random effects)

Variable descriptions:
dependent variables:
bftcr = bluefin tuna catch rate (bluefin/1000 hooks)
bft = bluefin tuna caught

class variables:
year = year
month = month
id = vessel
zone = area