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LARGE BLUEFIN TUNA, *THUNNUS THYNNUS*, INDICES OF ABUNDANCE FROM THE ROD AND REEL AND HANDLINE FISHERY OFF THE NORTHEAST UNITED STATES

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SUMMARY

Large bluefin tuna indices of abundance were derived for the U.S. rod and reel/handline fishery off the northeast U.S. using generalized linear models (GLM) analyses to fit aggregated and disaggregated data. Indices presented vary with respect to aggregation variables and analytical methods.

RESUME

Les indices d'abondance des grands thons rouges ont été calculés pour la pêcherie américaine à la canne/moulinet au large des côtes nord-est des Etats-Unis en utilisant les analyses du modèle linéaire généralisé (GLM) pour ajuster les données regroupées et non regroupées. Les indices présentés varient selon les variables d'aggrégation et les méthodes d'analyse.

RESUMEN

Se obtuvieron índices de abundancia de atunes rojos grandes para la pesquería estadounidense de caña carrete/caña-liña, frente la costa nordeste de Estados Unidos, por medio de análisis de modelos lineales generalizados (GLM) para ajustar datos agregados y disgregados. Los índices presentados varían en lo que se refiere a las variables de agregación y métodos analíticos.

Introduction

The purpose of this paper is to provide standardized CPUE for large bluefin tuna caught off the northeast coast of the United states for possible use by the SCRS in its stock assessments. This is a continuation of earlier work by Brown and Turner (1989 and 1990), Cramer and Brown (1991) and Turner and Cramer (1992); it differs from earlier work in some aspects of the analytical methods.

Although rod and reel and handline fisheries for Large bluefin tuna have existed for many years off the northeast coast of the United States, catch and effort information currently available is from a time interval (1983-1992) when catch rates were very low and regulations limiting catches of bluefin to one or two fish per trip were effect during most of the fishing season. This paper explores the effects of variations in the environment, fishing effort, and regulations on bluefin catch rates.

Materials and Methods

Catch, effort, and size composition from rod and reel and handline fisheries for large bluefin off the northeast United States have been collected since 1982. A detailed description of the agencies involved in data collection, methods of collection and variabilities in data elements recorded in early years can be found in Turner et al. (1992). As noted in the earlier paper, data from 1982 is not currently available. The two years of data (1991 and 1992) which were not available in the 1992 analyses, are similar to data collected in years 1988-1990.

Analyses

Two applications of general linear models (GLM) were used to estimate indices of abundance. The first approach replicated the method applied by Turner et al. (1992), in which the log-transformed daily catch rates from disaggregated data and from data aggregated into observations of 15 trips randomly selected from within the strata are modelled as a function of categorical and continuous variables, and in which a constant (a value of 1) was added to each observation to allow log-transformation of the zero catch rates and inclusion of these data into the modelling. In addition to using a +1 transform, following from Porch and Scott (SCRS/93/75) a constant equal to 10 times the maximum observed CPUE was also added prior to logging the observations. The second approach applied the delta-lognormal approach described by Lo *et.al.* (1992) in which the log-transformed positive catch rates (without any constant added) and the proportion of observations (days fishing) for which there was a positive catch were modelled separately to produce an index as:

$$\hat{I}=\hat{C}*\hat{S}=[\Psi_C e^{\beta_C}]\,[\Psi_S e^{\beta_S}-1],$$

where $\hat{I}$ represents the estimated annual index value, $\hat{C}$, the annual standardized positive catch rate, and $\hat{S}$ the annual standardized proportion of days fished for which there was success in catching bluefin. Following Lo *et.al.* (1992), a value of 1 was added to the observed S values to permit inclusion of 0 values in modelling the log-transformed observations. In the above equation, β_C and β_S, represent the log-scale, standardized GLM estimates of marginal mean (LSMEAN) CPUE and proportion of days fished on which bluefin were caught, and Ψ_C and Ψ_S, the log-transformation bias adjustments for β_C and β_S, respectively. Variance in $\hat{I}$ was estimated via the delta method (Seber 1982). The appropriate equations for estimating this variance and calculating the log-transformation bias adjustment terms are provided in Lo *et.al.* (1992) and are not repeated herein. The log-transform bias adjustment was applied to both the Delta-lognormal and added constant transform methods.

Variables Investigated

Environmental variables included in the analysis were year, month, area, sea surface temperature (SST). The boundaries of the three fishing areas were :NYNJ 39° to 40.67° N and west of 72° W; SONE, outside of NYNJ (north of 40.67° N and west of 72° W) and from 39° to 41.66° N and west of 66° W; and GOMA 41.67° N to 45° N and west of 66° W (Figure 1). SST was assigned to each area from weekly oceanographic charts and was the only continuous variable in the analysis.

Variables relating to effort included boat type(private/charter), gear(troll/chum), fishing method (chum/troll), trip length, and number of lines. Not all variables were recorded in each year.

One variable related to sampling, interview type (phone/dock), was investigated. Since the object of this variable is to compare information collected immediately after a fishing trip (dock) to information which must be recalled (phone), dockside interviews covering trips made before the date when the interview actually took place were grouped with the phone interviews.

One variable related to management of the fishery, trip limit (number of fish that could be legally caught per trip) was also investigated.

Results and Discussion

Single Effects and Their Year Interactions

A GLM (using the +1 transform) was run for each variable to determine the proportion of the total sum of squares (SS) accounted for by that variable and that variables interaction with year. Subsets of the data which included observations of the variable considered in all cells were identified and used in these initial GLMs. Factors which accounted for more than 10% of the total SS were considered for inclusion in the model.

Year was included in all models tested because it would be used in the final index. In a model including all years (1983-1992) the year effect accounted for about 11% of the total sum of squares of the raw data and about 50% for the aggregated analysis.

In the many of the single effects models data from 1983-1986 were excluded in order to create balanced subsets of data and to avoid possible confounding effects of area.

Targeting (analyzed for years 1987-1992 only) was found to have a major influence on catch rates. Target accounted for 4% of the total SS in the disaggregated data and 40% of the total SS of aggregated data. Target-year interactions were less than 1% for disaggregated and 2% for aggregated data. Effort reported for large bluefin had much higher catch rates than effort reported as directed at marlins and tuna.

Area effect, analyzed over years 1987-1992, accounted for 4% of the total SS in the analysis of raw data and 34% in the analysis of aggregated data. GOMA catch rates consistently exceeded catch rates in the southern areas (SONE and NYNJ) during this interval and catch rates in the southern areas were not significantly different. Therefore SONE and NYNJ were combined to make one area referred to as STHN. Year-area interactions accounted for less than 1% of the total SS of raw and 3% of aggregated data.

Number of lines fished accounted for less than 1% of the SS of raw data and 14% of the SS of aggregated data. Line-year interactions were 2% or less. Since tests could not be conducted on the effects of using 1-4 compared to 5 or more lines from both the GOMA and STHN areas, the data were limited to 2-6 lines which excluded about 3% of the effort targeted at large bluefin and about 23% of the marlin/tuna effort; it excluded about 5% of the catch on trips recorded as targeting large bluefin and 4% of the catch on trips recorded as targeting marlin tuna.

The effect of month on catch rates was analyzed for month July through September because insufficient observations were available in the early years to create balanced designs when June and October were included. Month effect accounted for less than 1% and month-year interaction accounted for 2% of the SS of aggregated data.

SST effect analyzed for 1983, and 1987-1992 and its interaction with year accounted for less than 1% of the total SS of unsummarized data for 4% of the SS in the aggregated model. Year-SST interaction for the aggregated model was 4%.

Data from year 1985 and area GOMA in all years were not included in the analyses for gear because handline gear was infrequently reported in GOMA and no identifiable handline effort was reported in 1985. Gear effect accounted for less than 1% of the disaggregated or aggregated SS. Gear-year interaction accounted for 6% of the aggregated SS.

The effects boat type (private/charter), fishing method, and trip limit accounted 2% or less of the total SS from disaggregated or aggregated data. Interview type (phone/dock) and trip length accounted for 5% of the aggregated SS. With the exception of fishing method, all year interactions for these variables accounted for 5% or less of the SS. Year-fishing method interaction accounted for 9% of the aggregated SS.

When the GLMs were rerun using only positive data, year and trip length were the only relevant variables.

Analysis with 3 Primary Variables

From the above analyses on single effects and their interactions with year, it was concluded that the primary influences on large bluefin catch rates were year, area and target. The nominal mean CPUE's by year, year and target, and year and area are plotted in figures 3-5. Further analyses were conducted on these three variables. In the analysis aggregated over year, area and target, area accounted for less than 1% of the total and target about 7%. Therefore area was dropped from the model. The model with year and catch rate was then run with the +10 MAX transformation and used in the proportion positives analysis. A model with year and trip length
was applied to the positive data.

The index of annual abundance estimated using the delta-lognormal method GLMs showed a similar pattern to the added constant transformation GLMs (Figures 2a-2d). The resulting index values from the delta-lognormal method were slightly more precise and the residual patterns generally less skewed than in the case of the +1 or +10 MAX transformation. Tables 2-11 present the results of the GLM fits to the data and a description of the residuals of the fits. Results are summarized in Table 1.

At the 1991 SCRS meeting the bluefin working group elected to exclude the 1983 point from its tuning index. Data were collected in 1982 but most of the data is not currently available for analysis. Table 12 shows a comparison of summarized observations from sampling contract reports (Birdsong 1982,1983); it indicates that 1982 and 1983 catch rates were similar. The same contractor and sampling regime was used in 1984, but no contract report was required.

Literature Cited

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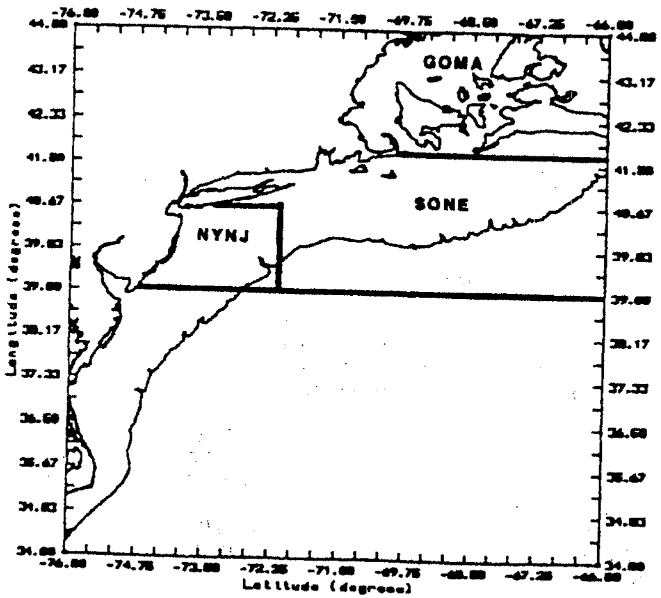


Figure 1. Map of the northeastern coast of the United States showing the 200 meter contour. The boundaries of the three fishing areas used in this analysis are shown.

Table 1: Indices of abundance for large bluefin tuna off the Northeast Coast of the U.S. Abs represents estimated Catch/1000 hooks; Rel represents relative CPUE relative to 1983; CV_I represents the estimated Coefficient of Variation Fits were made using data from 1983-1992.

	DELTA - LOGNORMAL			+ 10XMAX TRANSFORMATION		
YEAR	INDEX	REL	CV_I	INDEX	REL	CV_I
1983	12.06	1.00	0.03	15.16	1.00	0.03
1984	4.05	0.34	0.04	5.80	0.38	0.09
1985	3.44	0.29	0.06	2.50	0.17	0.34
1986	1.05	0.09	0.16	0.94	0.06	1.63
1987	1.66	0.14	0.07	1.87	0.12	0.21
1988	2.31	0.19	0.07	2.45	0.16	0.25
1989	1.91	0.16	0.07	2.12	0.14	0.23
1990	1.58	0.13	0.06	1.83	0.12	0.23
1991	2.08	0.17	0.05	2.71	0.18	0.16
1992	0.55	0.05	0.09	0.83	0.05	0.65

	+ 1 TRANSFORMATION			+ 1 TRANSFORMATION (AGGREGATED)		
YEAR	INDEX	REL	CV_I	INDEX	REL	CV_I
1983	1.66	1.00	0.05	5.59	1.00	0.08
1984	0.47	0.28	0.10	2.01	0.36	0.11
1985	0.40	0.24	0.19	1.56	0.28	0.21
1986	0.10	0.06	1.18	0.93	0.17	0.52
1987	0.16	0.10	0.18	0.82	0.15	0.12
1988	0.27	0.16	0.18	1.13	0.20	0.17
1989	0.18	0.11	0.20	0.80	0.14	0.16
1990	0.15	0.09	0.19	0.75	0.13	0.14
1991	0.20	0.12	0.16	0.92	0.17	0.13
1992	0.05	0.03	0.66	0.26	0.05	0.37

Table 2: GLM on proportion positives

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	71.04454815	7.10445482	97074.42	0.0001
Error	11329	0.82912029	0.00007319		
Corrected Total	11339	71.87366845			

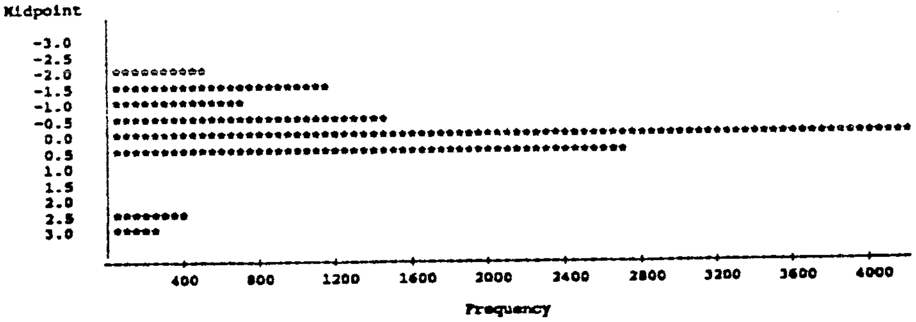
R-Square	C.V.	Root MSE	POS Mean
0.988464	11.14118	0.00855486	0.07678596

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	9	34.42751153	3.82527906	52268.15	0.0001
TARGET	1	7.89046951	7.89046951	99999.99	0.0001

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		0.0453441994 B	162.14	0.0001	0.00027966
YR	83	0.1981077805 B	561.98	0.0001	0.00035251
	84	0.0767776384 B	205.83	0.0001	0.00037302
	85	0.0835142876 B	167.43	0.0001	0.00049880
	86	0.0104471603 B	12.69	0.0001	0.00082346
	87	0.0256196555 B	75.36	0.0001	0.00033999
	88	0.0507520553 B	122.50	0.0001	0.00041430
	89	0.0290759669 B	79.09	0.0001	0.00036763
	90	0.0247525059 B	72.00	0.0001	0.00034379
	91	0.0323915922 B	92.62	0.0001	0.00034974
	92	0.0000000000 B	.	.	.
TARGET	1	-.0653057989 B	-328.35	0.0001	0.00019889
	3	0.0000000000 B	.	.	.

Table 3: Studentized Residuals Proportion Positive

N	11340	Sum Wgts	11340
Mean	4.375E-6	Sum	0.049617
Std Dev	1.000176	Variance	1.000352
Skewness	0.982434	Kurtosis	3.29197



Midpoint	Freq	Freq	Percent	Percent
-3.0	0	0	0.00	0.00
-2.5	0	0	0.00	0.00
-2.0	495	495	4.37	4.37
-1.5	1133	1628	9.99	14.36
-1.0	700	2328	6.17	20.53
-0.5	1458	3786	12.86	33.39
0.0	4220	8006	37.21	70.60
0.5	2684	10690	23.67	94.27
1.0	0	10690	0.00	94.27
1.5	0	10690	0.00	94.27
2.0	0	10690	0.00	94.27
2.5	385	11075	3.40	97.66
3.0	265	11340	2.34	100.00

Table 4: GLM on Positive Catches

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	128.31869014	11.66533547	67.70	0.0001
Error	933	160.77423063	0.17231965		
Corrected Total	944	289.09292077			

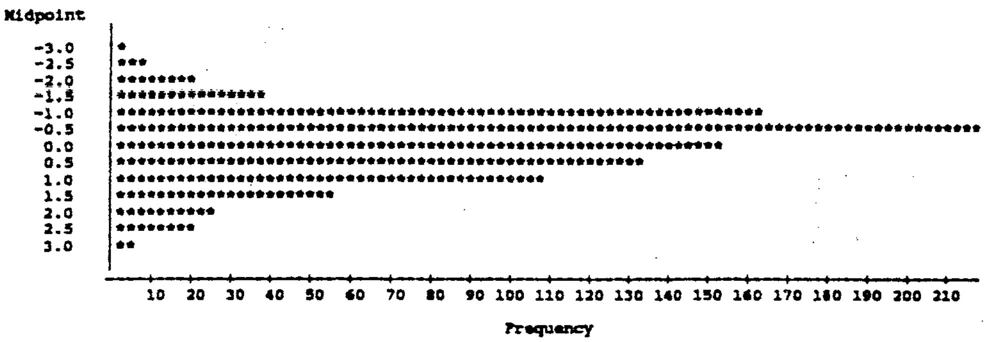
	R-Square	C.V.	Root MSE	LAFCR Mean
	0.443867	10.75595	0.41511402	3.85938890

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	9	14.75061692	1.63895744	9.51	0.0001
TRIPLEN	2	93.00647507	46.50323754	269.87	0.0001

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		3.018871985 B	27.01	0.0001	0.11175541
YR	83	0.177600606 B	1.90	0.0581	0.09361210
	84	0.005699892 B	0.06	0.9532	0.09715743
	85	-0.231445943 B	-2.17	0.0301	0.10654211
	86	0.050454078 B	0.28	0.7820	0.18224867
	87	-0.013145982 B	-0.12	0.9056	0.11082518
	88	-0.198843856 B	-1.78	0.0757	0.11183977
	89	0.043144148 B	0.39	0.6959	0.11033904
	90	-0.036501173 B	-0.34	0.7312	0.10622096
	91	0.047433921 B	0.46	0.6472	0.10360327
	92	0.000000000 B	.	.	.
TRIPLEN	1	1.331645357 B	16.63	0.0001	0.08008670
	2	0.639492169 B	8.46	0.0001	0.07556506
	3	0.000000000 B	.	.	.

Table 5: Studentized Residuals Positive Catches

N	945	Sum Wgts	945
Mean	-0.00001	Sum	-0.01267
Std Dev	1.000021	Variance	1.000043
Skewness	0.316916	Kurtosis	0.385654



Midpoint	Freq	Freq	Percent	Percent
-3.0	2	2	0.21	0.21
-2.5	8	10	0.85	1.06
-2.0	20	30	2.12	3.17
-1.5	38	68	4.02	7.20
-1.0	163	231	17.25	24.44
-0.5	218	449	23.07	47.51
0.0	153	602	16.19	63.70
0.5	133	735	14.07	77.78
1.0	107	842	11.32	89.10
1.5	55	897	5.82	94.92
2.0	24	921	2.54	97.46
2.5	19	940	2.01	99.47
3.0	5	945	0.53	100.00

Table 6: GLM on +10 MAX Transformation

Source	DF	Squares	Square	F Value	Pr > F
Model	10	0.05318667	0.00531867	116.84	0.0001
Error	11329	0.51572695	0.00004552		
Corrected Total	11339	0.56891362			

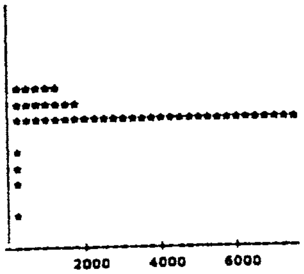
R-Square	C.V.	Root MSE	LMCPUE Mean
0.093488	0.086215	0.006747	7.825865

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	9	0.03179507	0.00353279	77.60	0.0001
TARGET	1	0.00316601	0.00316601	69.55	0.0001

Parameter		Estimate	Parameter=0		Estimate
INTERCEPT		- 7.825030564 B	35477.81	0.0001	0.00022056
YR	83	0.005714054 B	20.55	0.0001	0.00027802
	84	0.001985975 B	6.75	0.0001	0.00029420
	85	0.000669752 B	1.70	0.0887	0.00039340
	86	0.000046345 B	0.07	0.9431	0.00064945
	87	0.000417352 B	1.56	0.1196	0.00026814
	88	0.000648186 B	1.98	0.0473	0.00032675
	89	0.000517107 B	1.78	0.0745	0.00028994
	90	0.000401047 B	1.48	0.1391	0.00027114
	91	0.000781782 B	2.73	0.0064	- 0.00027583
	92	0.000000000 B	.	.	.
TARGET	1	-0.001308147 B	-8.34	0.0001	0.00015686
	3	0.000000000 B	.	.	.

Table 7: Studentised Residuals +10 MAX Transformation

N	11340	Sum Wgts	11340
Mean	-1.17E-7	Sum	-0.00132
Std Dev	0.999964	Variance	0.999929
Skewness	4.691259	Kurtosis	32.48783



SRESID Midpoint	Freq	Cum. Freq	Percent	Cum. Percent
-3.0	0	0	0.00	0.00
-2.5	0	0	0.00	0.00
-2.0	0	0	0.00	0.00
-1.5	0	0	0.00	0.00
-1.0	1151	1151	10.15	10.15
-0.5	1756	2907	15.49	25.63
0.0	7504	10411	66.17	91.81
0.5	53	10464	0.47	92.28
1.0	147	10611	1.30	93.57
1.5	152	10763	1.34	94.91
2.0	127	10890	1.12	96.03
2.5	105	10995	0.93	96.96
3.0	345	11340	3.04	100.00

Table 8: GLM on catches +1

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	1444.92949924	144.49294992	137.61	0.0001
Error	11329	11895.41087561	1.04999655		
Corrected Total	11339	13340.34037485			

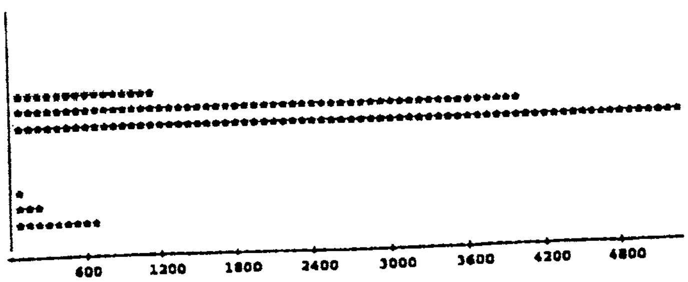
R-Square	C.V.	Root MSE	LNCPUE Mean
0.108313	316.6328	1.02469339	0.32362204

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YR	9	780.57730714	86.73081190	82.60	0.0001
TARGET	1	120.44742395	120.44742395	114.71	0.0001

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		0.1787955202 B	5.34	0.0001	0.03349724
YR	83	0.9259968685 B	21.93	0.0001	0.04222388
	84	0.3351672996 B	7.50	0.0001	0.04468035
	85	0.2830747936 B	4.74	0.0001	0.05974621
	86	0.0355078508 B	0.36	0.7189	0.09863364
	87	0.0974393439 B	2.39	0.0167	0.04072316
	88	0.1842637851 B	3.71	0.0002	0.04962446
	89	0.1134877831 B	2.58	0.0100	0.04403425
	90	0.0923664533 B	2.24	0.0249	0.04117872
	91	0.1317584656 B	3.15	0.0017	0.04189112
	92	0.0000000000 B	.	.	.
TARGET	1	-.2551520616 B	-10.71	0.0001	0.02382288
	3	0.0000000000 B	.	.	.

Table 9: Studentised Residuals catches +1

N	11340	Sum Wgts	11340
Mean	9.518E-8	Sum	0.001079
Std Dev	1.000012	Variance	1.000023
Skewness	2.604516	Kurtosis	6.556306



Midpoint	Freq	Freq	Percent	Percent
-3.0	0	0	0.00	0.00
-2.5	0	0	0.00	0.00
-2.0	0	0	0.00	0.00
-1.5	0	0	0.00	0.00
-1.0	1151	1151	10.15	10.15
-0.5	3990	5141	35.19	45.34
0.0	5254	10395	46.33	91.67
0.5	0	10395	0.00	91.67
1.0	0	10395	0.00	91.67
1.5	11	10406	0.10	91.76
2.0	46	10452	0.41	92.17
2.5	213	10665	1.88	94.05
3.0	675	11340	5.95	100.00

Table 10: GLM on +1 Aggregated

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	10	444.22736884	44.42273688	133.96	0.0001
Error	736	244.06483975	0.33160984		
Corrected Total	746	688.29220859			

R-Square	C.V.	Root MSE	LNCRSUM1 Mean
0.645405	63.32284	0.57585574	0.90939652

Source	DF	Type I SS	Mean Square	F Value	Pr > F
YEAR	9	346.71686891	38.52409655	116.17	0.0001
TARGET	1	97.51049993	97.51049993	294.05	0.0001

Source	DF	Type II SS	Mean Square	F Value	Pr > F
YEAR	9	140.90781483	15.65642387	47.21	0.0001
TARGET	1	97.51049993	97.51049993	294.05	0.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
YEAR	9	140.90781483	15.65642387	47.21	0.0001
TARGET	1	97.51049993	97.51049993	294.05	0.0001

Parameter		Estimate	T for H0: Parameter=0	Pr > |T|	Std Error of Estimate
INTERCEPT		-0.221516860 B	-2.84	0.0046	0.07796701
YEAR	83	1.657049771 B	17.89	0.0001	0.09259931
	84	0.873201796 B	8.93	0.0001	0.09778326
	85	0.706305209 B	5.38	0.0001	0.13137599
	86	0.409406508 B	1.89	0.0590	0.21648943
	87	0.368984832 B	4.12	0.0001	0.08949290
	88	0.527029755 B	4.84	0.0001	0.10896179
	89	0.359126884 B	3.72	0.0002	0.09661848
	90	0.329519564 B	3.65	0.0003	0.09035088
	91	0.425875611 B	4.63	0.0001	0.09202140
	92	0.000000000 B	.	.	.
TARGET	LARGE BF	0.896371026 B	17.15	0.0001	0.05227281
	MARLIN/TUNA	0.000000000 B	.	.	.

Table 11: Studentised Residuals +1 Aggregated

```
          N            747  Sum Wgts        747
          Mean    4.358E-6  Sum        0.003256
          Std Dev 1.001299  Variance   1.002601
          Skewness -0.1444  Kurtosis    0.79334

Midpoint                                    Freq  Freq  Percent  Percent

  -3.0  |                                      1     1     0.13     0.13
  -2.5  |**                                   13    14     1.74     1.87
  -2.0  |*******                              55    69     7.36     9.24
  -1.5  |                                      2    71     0.27     9.50
  -1.0  |*****                                35   106     4.69    14.19
  -0.5  |***************************         197   303    26.37    40.56
   0.0  |************************            174   477    23.29    63.86
   0.5  |*****************                   119   596    15.93    79.79
   1.0  |********                             63   659     8.43    88.22
   1.5  |*******                              52   711     6.96    95.18
   2.0  |****                                 27   738     3.61    98.80
   2.5  |*                                     7   745     0.94    99.73
   3.0  |                                      2   747     0.27   100.00
        |
        ----+----+----+----+----+----+--
           30   60   90  120  150  180

                 Frequency
```

Table 12. Large bluefin tuna CPUE (catch / 1000 line hours) reported by Birdsong in 1982 and 1983.

AREA	YEAR = 1982 LARGE BFT	LINE HRS	CPUE	YEAR = 1983 LARGE BFT	LINE HRS	CPUE
PROVINCETOWN						
HANDLINE	19	3,684	5	69	23,681	3
ROD & REEL	13	3,343	4	29	5,371	13
GLOUCESTER						
HANDLINE	90	11,975	8	141	6,939	7
ROD & REEL	65	8,422	8	135	10,875	13
GALILEE						
COMBINED	47	516	91	125	4,081	31

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FIGURE 2A. Delta-Lognormal
Index of Abundance

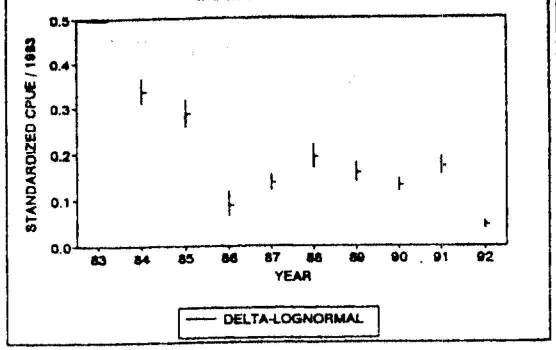


FIGURE 2b. 10xMAX Transformation
Index of Abundance

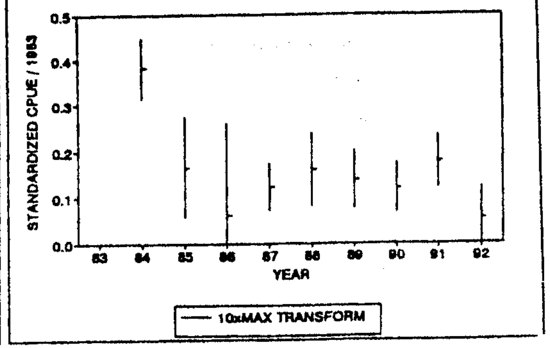


FIGURE 2c. +1 Transformation
Index of Abundance

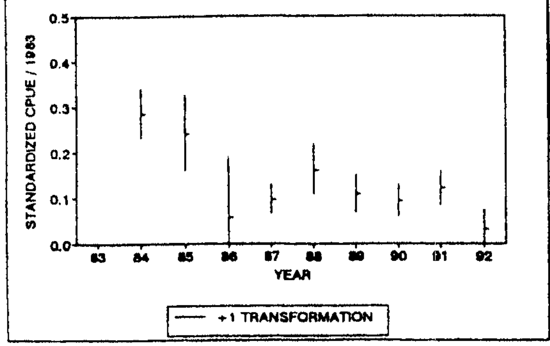
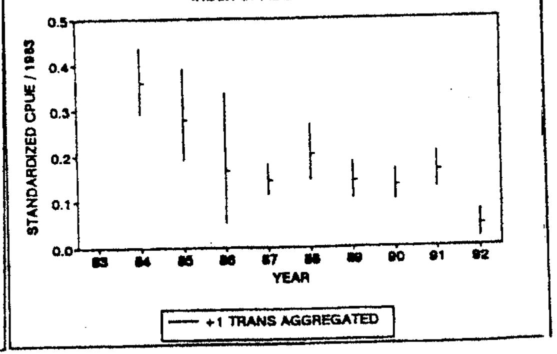


FIGURE 2d. +1 Trans Aggregated
Index of Abundance



* In all graphs 1983 is set equal to one and all other points are relative to 1983.

Fig 3: NOMINAL CPUE BY YEAR

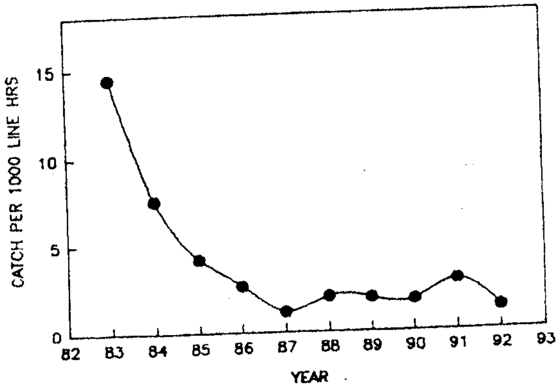


Fig 4: NOMINAL CPUE BY YEAR AND TARGET

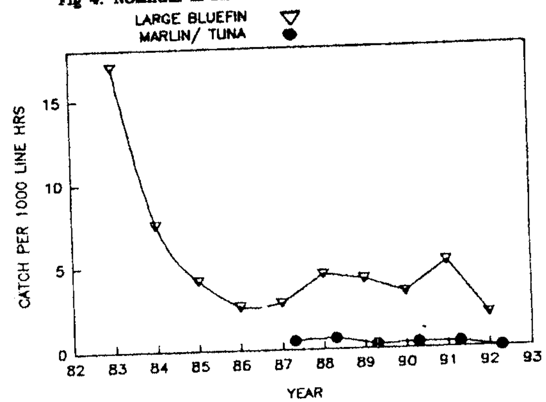


Fig 5: NOMINAL CPUE BY YEAR AND AREA