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STANDARDIZED CATCH RATES OF LARGE BLUEFIN TUNA IN THE NEW ENGLAND (U.S.) ROD AND REEL/HANDLINE FISHERY

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SUMMARY

Data obtained during interviews of anglers targeting large bluefin tuna in the Gulf of Maine and off the south coast of New England were used to develop indices of abundance for large bluefin in that fishery for 1983-1988.

Data from interviews having the same year/month/area/sea surface temperature were combined into groups of 15 trips. Standardized catch rates were developed, using a general linear model, and were used to derive standardized indices for large bluefin tuna.

RESUME

Les données obtenues lors des entretiens avec les pêcheurs qui capturent des gros thons rouges dans le Golfe du Maine et au large de la côte sud de la Nouvelle Angleterre, ont été utilisées pour développer des indices d'abondance pour les grands thons rouges de cette pêcherie pour la période 1983-1988.

Les données provenant de ces entretiens, avec la même année/mois/zone/température de surface de la mer, ont été combinées en groupes de 15 voyages. Des taux standards de prise ont été développés en utilisant un modèle linéaire généralisé et ont été utilisés pour obtenir des indices standardisés pour les grands thons rouges.

RESUMEN

Los datos obtenidos durante las entrevistas con pescadores que perseguían grandes ejemplares de atún rojo en el Golfo de Maine y frente a la costa Sur de Nueva Inglaterra, se utilizaron para desarrollar índices de abundancia para grandes atunes rojos en esa pesquería para 1983-1988.

Los datos obtenidos de las entrevistas por año/mes/área, que presentan la misma temperatura superficial del mar, se combinaron en grupos de 15 viajes. Se desarrollaron tasas de captura estandarizadas, utilizando un modelo lineal generalizado, que se emplearon para deducir índices estandarizados para grandes ejemplares de atún rojo.

Introduction

Catch per unit effort data on rod and reel (RR) and handline (HL) effort directed at large bluefin tuna off the coast of New England in the United States have been collected in dockside surveys from 1982-1988. Fishermen were interviewed as they returned to the dock to determine if the trip was directed at large bluefin tuna, the number and sizes of bluefin caught, and the effort expended during the trip.

The large [>200 cm straight fork length (SFL), age 10+ years] bluefin tuna RR/HL fishery off the northeastern U.S. is generally restricted to the waters just south of New England (SONE) and in the Gulf of Maine (GOMA). Because of regulations imposed on the fishery during the period of this survey, catch is generally limited to one large bluefin per vessel per trip. The distribution of CPUE for large bluefin tuna essentially consists of CPUE's of zero or one fish per trip, with unsuccessful trips predominating.

The variation in area fished, time of year, and environmental factors make it inappropriate to compare nominal CPUE across years. Standardized abundance indices of small and medium bluefin within the U.S. Exclusive Economic Zone (EEZ) during 1983-1986 have been developed from Japanese longline CPUE data by Turner (1987) and Davis and Turner (1988) using a general linear model (GLM) approach. Age specific indices have been developed for 3 to 7 year old bluefin within the EEZ during 1984-1989 (Davis 1989). Standardized abundance indices were also developed for large bluefin in the New England RR and HL fishery during 1982-1986 by Brown and Turner (1988) using a GLM procedure. Standardized indices of abundance for large bluefin tuna in the New England RR/HL fishery during 1983-1988 are developed in this paper using the same approach.

Materials and Methods

Each trip interview record includes data on: target species, date, gear, time fished (hours), number of lines, fishing location (except in 1984, when no fishing location was recorded), landing location, and number of each bluefin tuna caught. Size information was frequently recorded. Catch was determined from the number of bluefin of at least 200 cm SFL; effort was evaluated in terms of line-hrs (LHR). The data were restricted to only those trips which targeted large bluefin.

For cases in which size information was absent, records were cross referenced to a size data base derived from mandatory sales reports of all medium and large bluefin. If sizes could not be found, the fish were regarded as small. This assumes that non-compliance with the mandatory reporting, if it occurs, does not vary significantly from year to year. Released fish were also regarded as small. The release of large bluefin is rare; during 1988, only one fish was released out of a sample of 233 large bluefin.

The variables chosen to initiate the analysis were year, month, area, and sea surface temperature (SST). Gear type was not included as a factor in the analysis as a previous study (Brown and Turner 1988) had indicated that gear (HL or RR) had no significant effect on catch rates.

The two areas studied (GOMA and SONE) were defined based on fishing location. An exception was data from 1984, when only landing location was available. The GOMA was defined by the bounds of 41° 20'N, 43°N and 69°W. For 1984, interviews conducted in Massachusetts from Chatham north were also assigned to this area. The SONE area was bounded by 40° 40'N, 41° 20'N, 69°W and 72°W. For 1984, this area included interviews conducted along the southern coast of Massachusetts, Rhode Island, Connecticut and the Montauk, Long Island region. The relative scarcity of trips targeting large bluefin prevented the inclusion of vessels fishing out of western Long Island (New York), New Jersey and states further south.

Values of SST were crudely incorporated by examination of the weekly oceanographic analysis charts modified by the National Marine Fisheries Service, Northeast Fisheries Center, Narragansett Laboratory, Marine Climatology Investigation Division. A weekly temperature for each area was assigned based on the SST at a location determined to be the major fishing grounds. These values generally reflected the temperature throughout each area.

The high proportion of unsuccessful trips (80%, 88%, 89%, 86%, and 93% for 1983-1986 and 1988, respectively) prevented the analysis of single trip observations. Trip records were randomly drawn from within each year/month/area/temperature stratum to create summary catch and effort observations, each representing exactly 15 trips. Summary observations were created within each stratum until less than 15 interviews remained; these remaining interviews were excluded to ensure that each summary observation represented an identical number of interviews. Summation across 15 trips was sufficient to reduce the proportion of zero valued observations to a more manageable level (0%, 26%, 30%, 38% and 33% for 1983-1986 and 1988, respectively).

Data from 1982 were excluded from the analysis as there were too few observations to insure a balanced design; only data from months July, August, and September were included in the analysis for similar reasons. Interviewer reports from 1987 suggested that a bias existed toward interviews of successful trips (Brown and Turner 1988). Data from 1987 were therefore excluded from the analysis.

Beginning in 1986, catch and effort data were collected from a fleet operated by the Unification Church out of Gloucester, MA. These vessels fished as a group and the catch and effort data was recorded in a manner which reflected the group's activities, not that of individual vessels. These CPUE values could not be compared to data from other interviews; therefore, all data obtained from this fleet was excluded from the analysis and were not included in the summary observations.

A GLM (Draper and Smith 1966) approach to analysis of variance was used to examine logged catch rates per 1000 LHR for differences among the effects of year, month, area and SST as well as all possible two-way interactions except those involving year. The square of SST (SST*SST) was also tested to determine if a nonlinear relationship between SST and logged catch rates existed. The value of catch for each summary observation was increased by 1 to permit all catch rate values, including nominal catch rates of 0, to be logged. F-tests were conducted on all main effects and interactions to determine whether or not each contributed significantly to the model. At the conclusion of each GLM run, the least significant effect was removed and the new model was tested again. This process was repeated until all remaining effects contributed significantly to the model. The frequency distribution of standardized residuals [(observed - predicted)/standard error of the estimate] were examined at each level of the main effects and for the whole model to ensure that they approximated the normal distribution. The final model was used to develop standardized catch rates for each year.

Results

Previous analysis (Brown and Turner 1988) had suggested that catch rates were abnormally low at SST values of less than 13°C and that data from trips fished when SST was below 13°C should be excluded from any analyses. This was not a factor in the current study. Summation restricted the SST range to 14°-23°C. Records containing more extreme SST values were too sparse to create any summary observations. Examination of the frequency distributions of catch per line-hour (CPLHR) by SST indicated that no abnormally low catch rates occurred within the temperature range of the data set.

Nominal CPUE data for each year, month, and area obtained from single trip records and from summary observations are contrasted in Table 1. The mean catch rates shown were obtained by averaging the catch rates of the observations within each cell. Total catch (in numbers of fish) and effort (in trips and line-hours) is shown for each cell. The comparison of these values between the single trip data and the summary observations indicates that little information was lost during the summation process, despite the elimination of all remaining trip data within each cell when there were fewer than 15 trips.

The yearly mean nominal CPUE, derived from summary observations, is plotted in Figure 1. Confidence intervals are not shown as the values were not normally distributed. Instead, the range of values is illustrated.

The final GLM analysis showed that the main effects of year, month, area and SST all had a significant effect on logged catch rates, as did the month-area interaction (Fig. 2). The distributions of the standardized residuals did remain somewhat peaked or skewed for some levels of the main class effects of year (Fig. 3), month (Fig. 4) and area (Fig. 5). This occurred because catch rates of zero remained the mode, even for summary observations. The residual patterns at each level were accepted. The distribution of standardized residuals for the whole model approached the normal distribution (Fig. 6), although it also was slightly peaked and skewed as a result of the remaining catch rates of zero. The standardized indices of abundance decreased from 1983-84 and remained about level for 1984-1988 (Fig. 2).

Discussion

The nominal catch rates of large bluefin fluctuated significantly during 1983-1988 (Fig. 1). Declining from nearly 13 fish per 1000 LHR in 1983 to less than 3 fish per 1000 LHR in 1985, the nominal catch rate jumped to over 9 fish per 1000 LHR in 1986. This level dropped to a mean of about 2.3 fish per 1000 LHR in the final year (1988). By standardizing the catch rates, however, it is clear that the trends are much smoother.

The only continuous variable in the model was SST. Since SST (but not SST*SST) had a significant effect on logged catch rates, the model indicates that a linear relationship exists between SST and logged catch rates within the SST range found in the data. The parameter estimate for SST was negative, signifying that the logged catch rate would be expected to decrease as SST increases within the range of 14°-23°C.

The standardization of the catch rates using a GLM approach permits comparisons across years. The confidence intervals (+/-2 standard errors) shown in Figure 2 reflect uncertainty in this year effect. These yearly indices were derived from the parameter estimates of each year effect in the model. Each parameter estimate was added to the intercept estimate before transformation back to the catch per 1000 LHR scale. This intercept estimate (23.25) was, by definition, equal to the index for the standard year (1988). The confidence interval (CI) shown for 1988 (Fig. 2) is the CI for the intercept and includes uncertainty introduced by all levels of the model. The true CI for the 1988 yearly estimate is likely to be much smaller. The uncertainty (CI) around the intercept estimate would serve to increase or decrease each yearly estimate equally, therefore (for 1984-1986) only the CIs around the yearly estimates are shown to permit comparisons between years.

The scale of the abundance indices is larger than the scale of the nominal catch rates. The effect of the continuous variable SST was not removed. Standardization of indices to a temperature would only rescale all indices by a constant value. The present disparity of scales does not affect the abundance trends.

These abundance indices suggest that the population size of large (age 10+) bluefin tuna declined from 1983-1984 and then fluctuated only slightly from 1984-1988. The CIs around each estimate result from a relatively moderate coefficient of multiple determination (R^2) that was derived for the model (0.41). Despite the less than normal distribution patterns of the standardized residuals, we feel that the catch rates of zero are valuable information and should be included in any model.

Literature Cited

Brown, C.A. and S.C. Turner. 1988. Standardized catch rates of large bluefin tuna in the New England (U.S.) rod and reel/handline fishery 1982-1986. Int. Comm. Conserv. Atl. Tunas, Col. Vol. Sci. Pap. 30(2):302-310.

Davis, K.S. 1989. Standardized catch rates of bluefin tuna from the Japanese longline fishery in the Exclusive Economic Zone of the United States. ICCAT Working Document, SCRS/89/75.

Davis, K.S. and S.C. Turner. 1988. Standardized catch rates of bluefin tuna in the United States Fishery Conservation Zone for 1983-1986. Int. Comm. Conserv. Atl. Tunas, Col. Vol. Sci. Pap. 30(2):311-317.

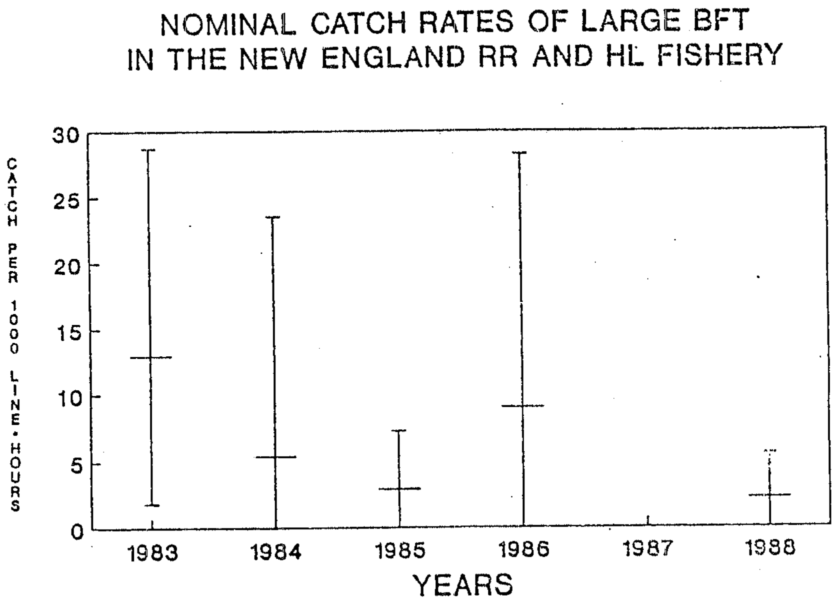
Turner, S.C. 1987. Catch rates of bluefin tuna in the Japanese longline fishery recorded by United States observers. Int. Comm. Conserv. Atl. Tunas, Col. Vol. Sci. Pap. 26(2):323-328.

Table 1. Nominal CPUE (in catch per 1000 line-hours) by year, month and area.

			Single Trips						Observations summarized by year/month/area/SST, representing 15 trips each					
YR	MON	AREA	MEAN	SD	N	Catch	Line -Hrs	No. 0's	MEAN	SD	N	Catch	Line -Hrs	No. 0's
83	7	SONE	62.50	176.78	8	1	318	7	.	.	.	.	.	.
	8	SONE	25.79	60.70	123	34	2836	94	16.89	9.51	7	30	2112	0
		GOMA	0.00	.	1	0	63	1	.	.	.		.	.
	9	SONE	13.82	37.02	162	25	3584	137	10.20	7.71	10	25	3201	0
		GOMA	125.00	.	1	1	8	0	.	.	.	.	.	.
84	7	SONE	21.43	66.58	313	48	5379	265	10.60	6.42	20	47	4876	1
		GOMA	3.82	13.19	61	5	1490	56	3.16	2.79	4	4	1470	1
	8	SONE	10.85	45.42	616	60	12705	556	4.91	5.47	38	49	11739	14
		GOMA	6.94	32.78	501	35	12387	466	2.85	3.31	32	31	11559	13
	9	SONE	0.00	0.00	38	0	701	38	0.00	0.00	2	0	519	2
		GOMA	13.13	41.88	565	95	18951	490	5.89	5.32	37	89	17592	4
85	7	SONE	0.00	.	1	0	18	1	.	.	.	.	.	.
		GOMA	3.10	12.46	123	9	4664	114	2.44	1.84	7	9	3611	2
	8	SONE	0.00	.	1	0	35	1	.	.	.	.	.	.
		GOMA	[illegible].99	11.33	215	19	8447	196	2.41	2.43	13	18	7367	[illegible]
	9	GOMA	6.39	11.49	73	19	3069	54	6.52	0.68	3	12	1854	0
86	7	SONE	39.93	111.93	152	49	3134	104	16.40	9.14	8	40	2528	1
		GOMA	0.00	0.00	26	0	797	26	.	.	.	.	.	.
	8	SONE	4.05	33.25	104	3	2882	101	1.73	2.30	5	3	1903	3
		GOMA	4.78	28.60	81	5	2204	76	1.42	2.46	3	2	1123	2
	9	SONE	0.00	0.00	6	0	172	6	.	.	.	.	.	.
		GOMA	5.68	15.77	23	3	542	20	.	.	.	.	.	.
88	7	SONE	0.00	0.00	23	0	556	23	0.00	.	1	0	290	1
		GOMA	2.66	8.54	74	7	2508	67	2.74	2.65	3	3	1328	1
	8	SONE	0.00	0.00	20	0	496	20	.	.	.	.	.	.
		GOMA	2.77	9.01	143	14	5124	129	2.38	2.00	8	10	4139	2
	9	SONE	0.00	0.00	5	0	124	5	.	.	.	.	.	.
		GOMA	0.00	0.00	2	0	36	2	.	.	.	.	.	.

Figure 1. Mean annual nominal CPUE (catch per 1000 line-hours). Error bars indicate the range of values within each year.

Year	Mean CPUE	Min. observed CPUE	Max. observed CPUE
1983	12.95	1.85	28.71
1984	5.42	0.00	23.53
1985	2.96	0.00	7.27
1986	9.01	0.00	28.23
1988	2.27	0.00	5.59



Final model: ln(1000*(CPLHR+1)) = Y + M + A + T + M*A

where Y = year
M = month
A = area
and T = SST

R^2= 0.4118
Standard error of the estimate = 0.00002561
Number of observations = 201

Year	Abundance Index	Est. - 2SE	Est. + 2SE
1983	37.81	32.68	42.94
1984	26.79	23.25	30.33
1985	25.34	21.59	29.09
1986	26.15	21.87	30.43
1988	23.25	13.74	32.76

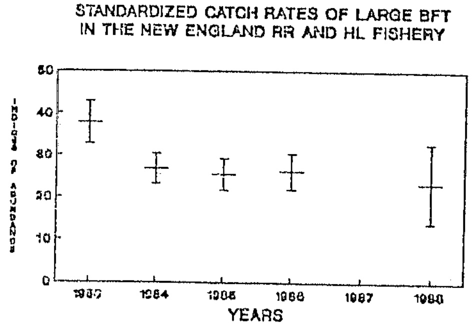
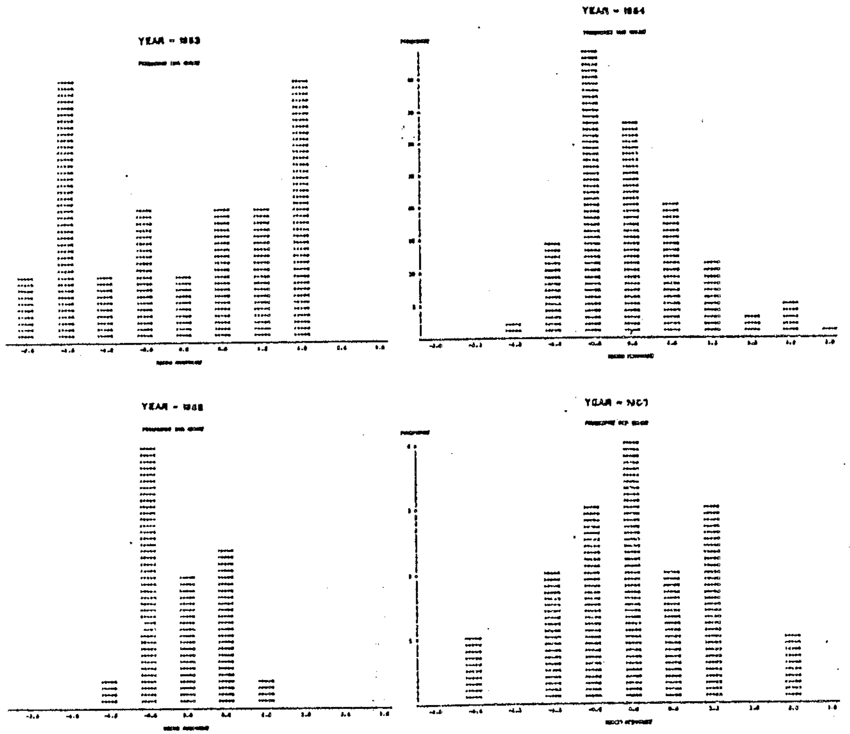


Figure 2. Annual standardized indices of abundance (catch per 1000 line-hours) with error bars at +/- 2 standard errors (SE) for large bluefin tuna in the New England RR/HL fishery. (Indices were derived from the antilog (e^x) of the model parameter estimates using summary observations. The indices are larger than the nominal catch rates as the effect of the continuous variable temperature, which was linearly related to CPLHR, was not removed. Standardization of indices to a temperature would only rescale all indices by a constant value. The error bars for 1988 were determined from the the standard error of the intercept estimate.)



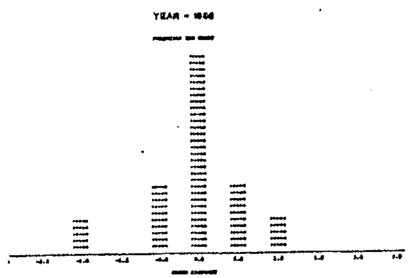


Figure 3. Distributions of standardized residuals (RESID) at each level of year tested in the GLM procedure.

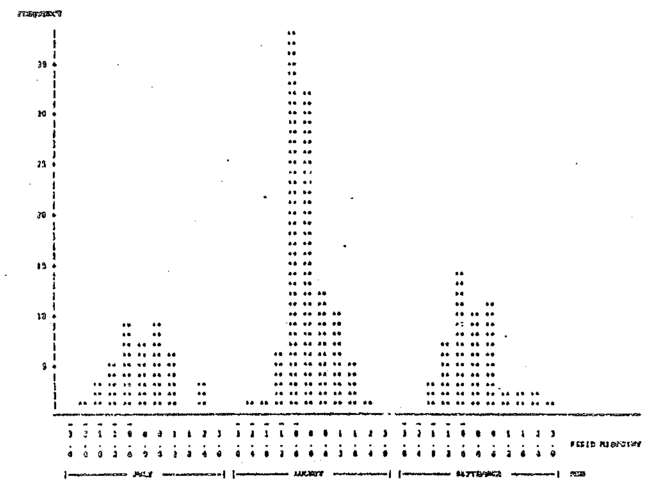


Figure 4. Distributions of standardized residuals (RESID) at each level of month tested in the GLM procedure.

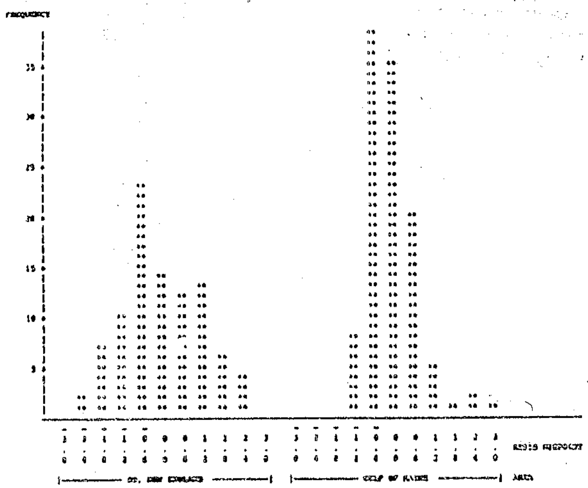


Figure 5. Distributions of standardized residuals (RESID) at each level of area tested in the GLM procedure.

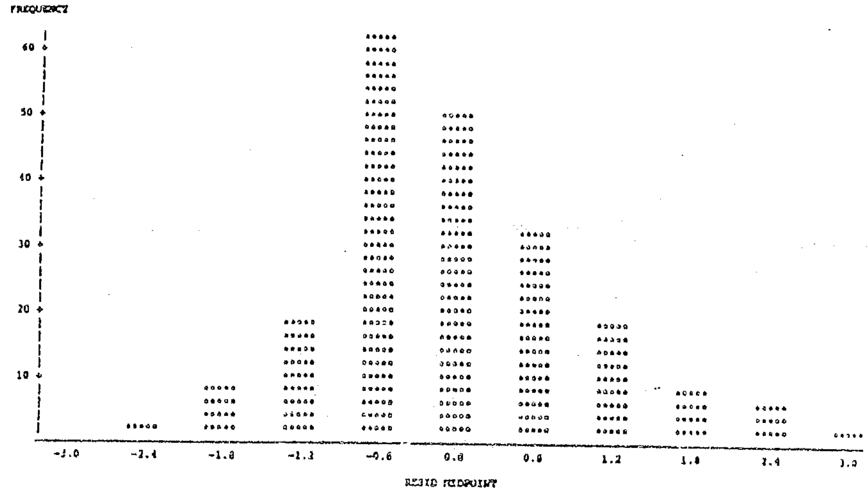


Figure 6. Distributions of standardized residuals (RESID) of the final model determined using the GLM procedure.