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STANDARDIZED CATCH RATES OF LARGE BLUEFIN TUNA IN THE NEW ENGLAND (U.S.) ROD AND REEL/HANDLINE FISHERY 1982-1986

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SUMMARY

Data obtained during interviews of anglers fishing in the Gulf of Maine and off the south coast of New England were used to develop indices of abundance for bluefin tuna in that fishery for 1982-1986.

Data from interviews having the same date/area/gear were combined; only data representing at least five trips were used. Standardized catch rates wee developed, using a General Linear Model, and were used to develop standardized indices for large bluefin tuna. The error bars (± 2 standard errors) around the standardized estimates were broad, reflecting the low proportion of total variability explained by the final analysis.

RESUME

Les données obtenues lors d'enquêtes auprès des pêcheurs à la ligne dans le golfe du Maine et au large des côtes sud de la Nouvelle-Angleterre sont utilisées pour élaborer des indices de l'abondance pour le thon rouge dans cette pêcherie pour 1982-86.

Les données d'enquêtes comportant les mêmes date/zone/engin ont été combinées; seules les données illustrant au moins 5 marées ont été utilisées. Les taux stardisés de capture ont été élaborés au moyen d'un modèle linéaire généralisé, et ont servi à définier des indices standardisés pour le thon rouge de grande taille. Les marges d'erreur (+/- 2 erreurs standard) étaient amples, ce qui reflète le faible pourcentage de variabilité totale exposé par l'analyse finale.

RESUMEN

Se emplearon los datos obtenidos en entrevistas con pescadores del Golfo de Maine y de la costa sur de Nueva Inglaterra, para desarrollar índices de abundancia de atún rojo en dicha pesquería en el periodo 1982-1986.

Se combinaron los datos que tenían la misma fecha, zona y arte; solo se seleccionaron los datos que representaban al menos 5 viajes. Se desarrollaron tasas estandar de captura por medio del Modelo Lineal Generalizado que se emplearon para hallar índices estandar para atunes rojos grandes. Las franjas de error (errores estandar +/-2) alrededor de las estimaciones estandar eran amplias, reflejando la baja proporción de la variabilidad total que queda aclarada en el análisis final.

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 1982-1987. Fishermen were interviewed as they returned to the dock to determine if the trip was directed at large bluefin tuna, the number of bluefin caught, and the effort expended during the trip.

The large (>200 cm, 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 quota regulations imposed on the fishery during the period of this survey, catch is generally limited to 1 bluefin per vessel per trip. The distribution of CPUE for large bluefin therefore essentially consists of CPUE's of zero or one fish per trip.

The variation in fishing year, area fished, time of year, and environmental factors may make it inappropriate to compare nominal CPUE across years. Standardized abundance indices of small and medium bluefin within the U.S. Fishery Conservation Zone during 1983-1986 have been developed from Japanese longline vessel catch and effort data by Turner (1987) and Davis and Turner (1988) using a General Linear Model approach. The purpose of this paper is to develop standardized indices of abundance for large bluefin tuna in the New England RR/HL fishery using the same approach.

Materials and Methods

Each trip interview record includes data on: date, gear (with the exception of 1982), time fished, number of lines (hooks), landing location, and number and size of each bluefin tuna caught. Bluefin were considered to be large if their size was at least 200 cm in fork length. Effort was evaluated in terms of hook-hours (HKHR). Trips for which all bluefin were not sized were excluded.

The variables chosen to initiate the analyses were year, month, area, gear type and sea surface temperature (SST). Data from 1982 were initially excluded from the analysis because information on gear type was not collected. Only data from months July, August, and September were included in the analyses; data from other months was too scarce to insure a balanced design.

Areas were defined based on landing location. Interviews conducted in Massachusetts, north of Chatham (on Cape Cod), were assigned to the GOMA area. Interviews conducted along the southern coast of Massachusetts, Rhode Island, Connecticut and the Montauk, Long Island region of New York were assigned to the SONE area. Catches of vessels fishing out of western Long Island, New Jersey and other states further south were rare; therefore, interviews obtained in this region were not included in the analyses.

Values of SST were 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 temperature value was assigned to each area for each week based on the SST at a location determined to be the major fishing grounds in each area. The SST values were then incorporated into the CPUE data by matching date and area.

A General Linear Model (Draper and Smith 1966) approach to analysis of variance (ANOVA) was used to examine logged catch rates per 1000 HKHR for differences among the effects of years, months, areas, gear, and SST as well as all possible two-way interactions except these involving year. One (1) was added to the raw catch rates when catch rates of zero were included, but not when only positive catch rates were analyzed. F-tests were conducted on all main effects and interactions, except with years, to determine whether or not each contributed significantly to the model. At the conclusion of each ANOVA, 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 insure that they approximated the normal distribution. The final model was used to develop standardized catch rates for each year.

Results

Plots of the frequency distribution of catch per hook-hour (CPHKHR) by SST (Fig. 1) showed distributions for SST values of 11°C and 12°C which differed from those at higher temperatures. These low SST distributions essentially lack the right-hand tail, present at higher temperatures, which were produced by positive catch rates. Although positive catch rates at 23°C were not present in sufficient numbers to produce a right-hand tail at the scale shown in Figure 1, they appeared more frequently than at 11°C or 12°C. This suggests that catch rates were abnormally low at these lower temperatures. Therefore, data from trips fished when SST was less than 13°C were excluded from the analyses.

Catch and effort data were collected from a fleet operated by the Unification Church out of Boston, MA and represented large portions of the total trips sampled in 1986 and 1987. However, these data were not gathered during individual trip interviews, but rather from daily summaries of the fleet's activities. These vessels fished as a group and reported values for effort reflected the effort expended by the fleet, not that expended by a particular vessel while fishing. These CPUE values were not comparable to values from the other interviews and were excluded from the analyses.

Preliminary investigation indicated that interviews conducted in 1987 were biased towards successful trips. This was evidenced by both the reports from the interviewers and the data itself. In 1987, a substantial proportion of interviews were conducted at dealers. One approach that was frequently employed involved backtracking fish sold to dealers to obtain interviews. The percentage of interviewed trips which were successful increased dramatically in 1987 from previous years. In 1982-1986, the percentages of trips which were successful were 38%, 28% 16%, 14%, and 22% respectively. In 1987, this value jumped to 57%. Data from 1987 could therefore only be used when analyses were restricted to positive trips.

A variety of preparatory treatments were applied to the 1983-1987 data. The data were restricted to successful trips in an effort to include 1987 data. Analyses of: 1) single trip data, 2) data combined by date/area/gear, and 3) data combined by month/day/area/gear and then limited to only those values representing at least 5 trips all produced similar estimates of catch rate trends. However, they differed considerably from the estimated trends of abundance resulting from analyses incorporating unsuccessful trips. Because it was felt that unsuccessful trip effort was reflective of abundance trends, the analyses on successful trips only could not be used and 1987 had to be excluded from all final analyses and results.

The analysis of 1983-1986 single trip data which contained catch rates of zero was examined. The high proportion of zeros resulted in histograms of standardized residuals which were extremely peaked. To retain at least some of the information from unsuccessful trips, trip data were combined by date, area, and gear, with each new record representing data from at least 5 trips. Two data sets were created: one containing all of the catch rate information resulting from this combining procedure; the other including only those combined records on which at least one fish was caught. Both data sets were analyzed using GLM procedures, and the results of both procedures are presented.

Nominal CPUE data for each year, month and area obtained from single trip records and from combined trip records are contrasted in Table 1. Methods for comparing nominal CPUE include: (1) calculating a mean catch rate from the catch rates of individual trips; (2) dividing the total catch in a given year, month, and area by the total amount of corresponding effort, a method which retains effort information from unsuccessful trips; and (3) calculating a mean catch rate from the combined data used in the final GLM procedures. From this table, using the data shown on sample sizes and number of zero catch rates, nominal CPUE values for positive trips can also be derived for each stratum.

The GLM analysis for 1983-1986 combined trip data (zeros included) indicated that gear did not contribute significantly to the model. Since gear information was no longer a concern, 1982 data were added to the data set and a new GLM analysis was generated. The final analysis showed that only year, month and area had significant effect on logged catch rates (Fig. 2). The distributions of the standardized residuals did remain peaked or skewed for some levels of the main effect year (Fig. 3), month (Fig. 4) and area (Fig. 5), but were accepted. The distribution of standardized residuals for the whole model more closely approached the normal, although it remained somewhat peaked and skewed (Fig.6). The standard estimates of abundance increased sharply from 1982-1983 before decreasing again to near the 1982 level for 1984-1986 (Fig. 2).

The GLM analysis for 1983-1986 combined trip data (zeros excluded) also indicated that gear did not contribute significantly to the model. Data from 1982 were added, resulting in a final analysis that showed only the main effects of year, month and area and the month-area interaction having a significant effect on logged catch rates (Fig. 7). The distributions of the standardized residuals for the levels of the main effects year (Fig. 8), month (Fig. 9) and area (Fig. 10) and for the whole model (Fig. 11) did appear to be slightly closer to the normal distribution than were those of the data set retaining zeros. The standard estimates of abundance increased from 1982-1983 and decreased in 1984 before increasing from 1984-1986 (Fig. 7).

Discussion

Both sets of abundance indices suggest that the population size of large (age 10+) bluefin tuna expanded from 1982-1983, declined in 1984 and expanded again in 1985 and 1986 (although only very slightly according to estimates derived using combined trip data which included catch rates of zero). They differ mainly in the magnitudes of the standardized mean catch rates and in the magnitudes of the trends. For the data set retaining zeros, results suggest a sharp population increase from 1982-1983, a steep decline from 1983-1984, and only a very slight increase from 1984-1986. For the data set in which zeros were excluded, results suggest a moderate increase from 1982-1983, a steep decline from 1983-1984, and a moderate increase from 1984-1986. Results from both approaches remain questionable due to the relatively low coefficients of multiple determination (R^2) that were derived for each model (.22 with zeros retained, .26 with zeros excluded).

Arguments may be made for choosing either approach over the other. We feel that, despite the less normal distribution patterns of standardized residuals, the catch rates of zero are valuable information and their inclusion should produce more accurate results.

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Draper, N.R. and H. Smith. 1966. Applied Regression Analysis. John Riley and Sons, Inc., New York, 407 p.

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. 26(2):323-328.

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

			Single Trips						Combined by date/area/gear, representing at least 5 trips each			
YR	MON	AREA	MEAN	SD	N	Catch	Hook -Hrs	No. 0's	MEAN	SD	N	No. 0's
82	7	SONE	9.75	41.89	47	5	695	44	14.97	12.39	7	2
	8	SONE	82.31	183.90	116	56	2919	60	15.45	12.67	20	4
	9	SONE	35.61	67.92	86	36	2495	50	9.27	8.81	13	4
83	7	GOMA	21.05	52.39	47	16	1984	31	14.17	14.49	9	2
	8	SONE	36.51	89.15	191	71	4260	130	19.14	9.46	19	0
		GOMA	11.35	30.24	667	138	27184	537	6.68	6.30	56	9
	9	SONE	24.17	50.66	237	81	5345	171	19.45	13.05	15	1
		GOMA	20.58	34.27	545	210	16974	346	15.09	7.94	48	2
84	7	SONE	28.68	78.47	277	56	4800	221	11.88	11.15	22	4
		GOMA	5.09	19.24	166	15	4553	151	6.66	4.85	5	1
	8	SONE	18.01	59.09	573	97	11852	482	7.83	7.89	28	5
		GOMA	10.06	39.49	478	54	11730	424	3.41	4.39	26	10
	9	SONE	8.82	51.45	34	3	623	33	13.40	18.95	2	1
		GOMA	16.79	49.35	555	104	16673	451	6.77	6.93	39	7
85	7	SONE	0.00	.	5	0	71	5	.	.	.	.
		GOMA	4.16	13.67	134	14	5243	120	3.32	3.80	9	4
	8	SONE	13.89	19.64	2	1	52	1	.	.	.	.
		GOMA	3.40	11.99	201	21	8203	181	3.77	4.80	15	7
	9	GOMA	7.43	12.03	66	20	2945	46	6.16	6.19	5	1
86	7	SONE	54.68	122.33	139	62	2740	82	15.45	12.67	20	4
		GOMA	0.76	4.88	41	1	1233	40	0.00	.	1	1
	8	SONE	21.79	69.84	98	3	180	97	9.27	8.81	13	4
		GOMA	4.85	28.01	85	6	2368	79	0.77	2.04	7	6
	9	GOMA	7.85	23.64	23	4	542	20	7.10	.	1	0
87	7	SONE	35.19	41.52	77	46	1911	31	20.42	10.85	20	0
		GOMA	12.96	26.08	61	15	1426	46	6.68	6.30	56	9
	8	SONE	37.36	28.83	39	30	956	9	21.66	15.42	16	1
		GOMA	23.41	25.73	237	146	7490	91	15.62	8.68	49	2
	9	SONE	12.68	20.69	16	5	466	11	19.77	17.32	3	1
		GOMA	25.97	46.00	85	50	2708	35	14.17	14.45	9	2

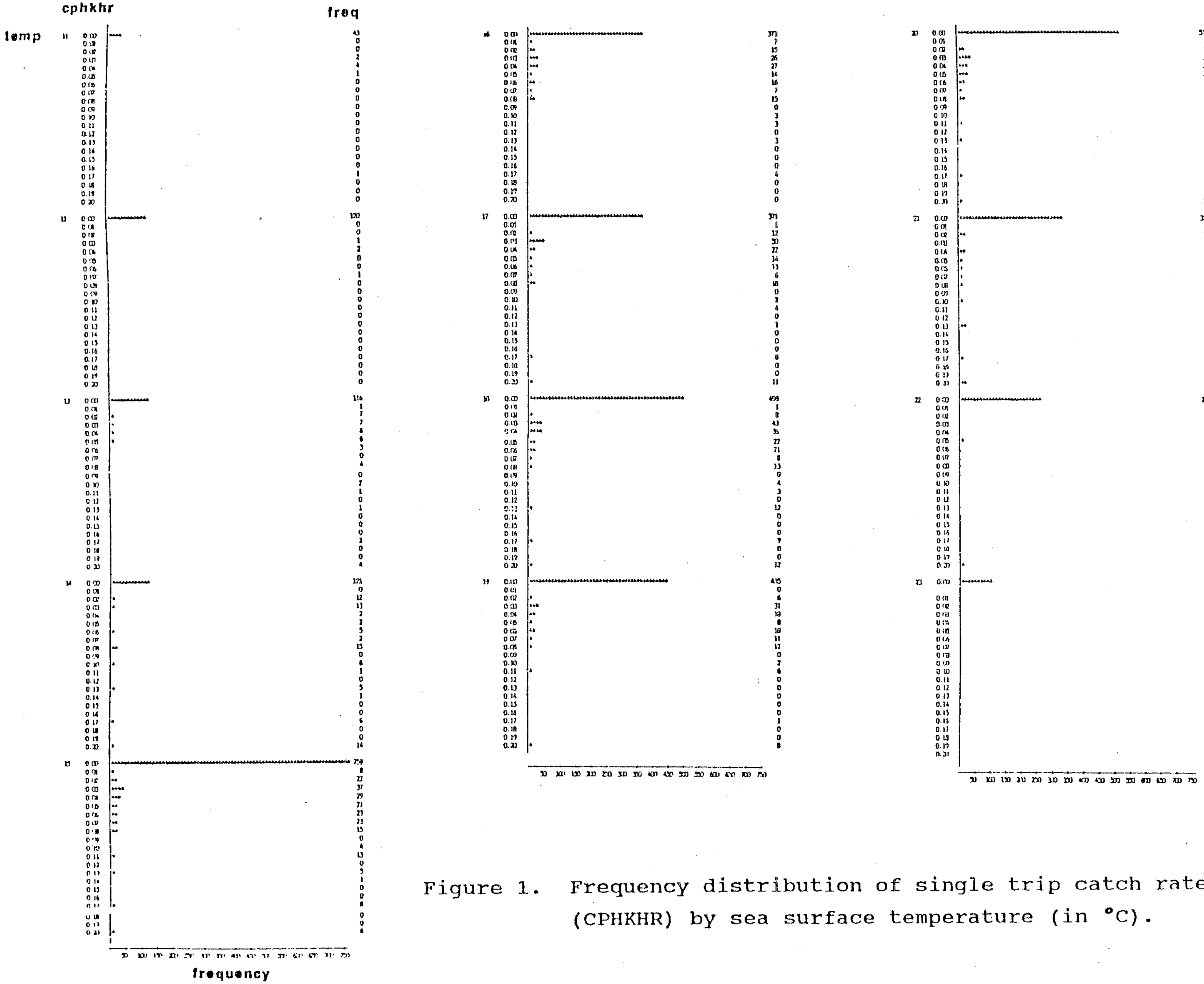

Figure 1. Frequency distribution of single trip catch rates (CPHKHR) by sea surface temperature (in °C).

Final model: ln(1000*(CPHKHR+1)) = Y + M + A
where Y = year
M = month
and A = area

R^2 = 0.2214
Standard error of the estimate = 0.00879
Number of observations = 399

Year	Estimated Catch rate	Est. - 2SE	Est. + 2SE
1982	12.28	8.62	15.92
1983	18.78	15.54	22.02
1984	11.59	8.46	14.73
1985	12.00	7.49	16.52
1986	12.34	9.03	15.67

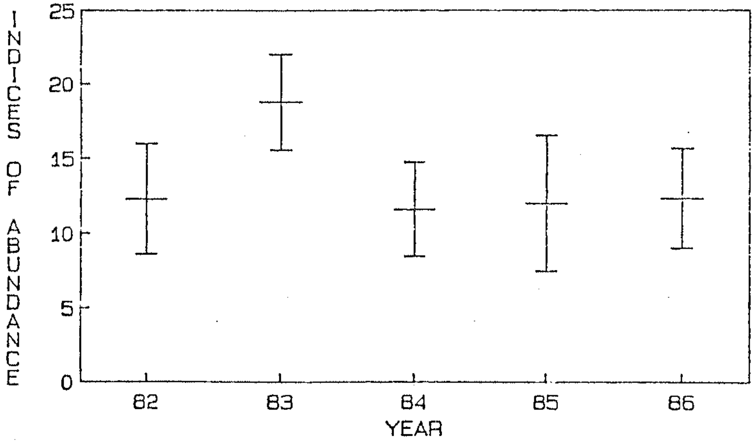

Figure 2. Annual standardized indices of abundance (catch per 1000 hook-hours) with error bars at +/- 2 standard errors (SE) for large bluefin tuna in the New England RR/HL fishery (estimates were derived from the antilog (e^x) of the model estimates using combined trip data, catch rates of zero included.

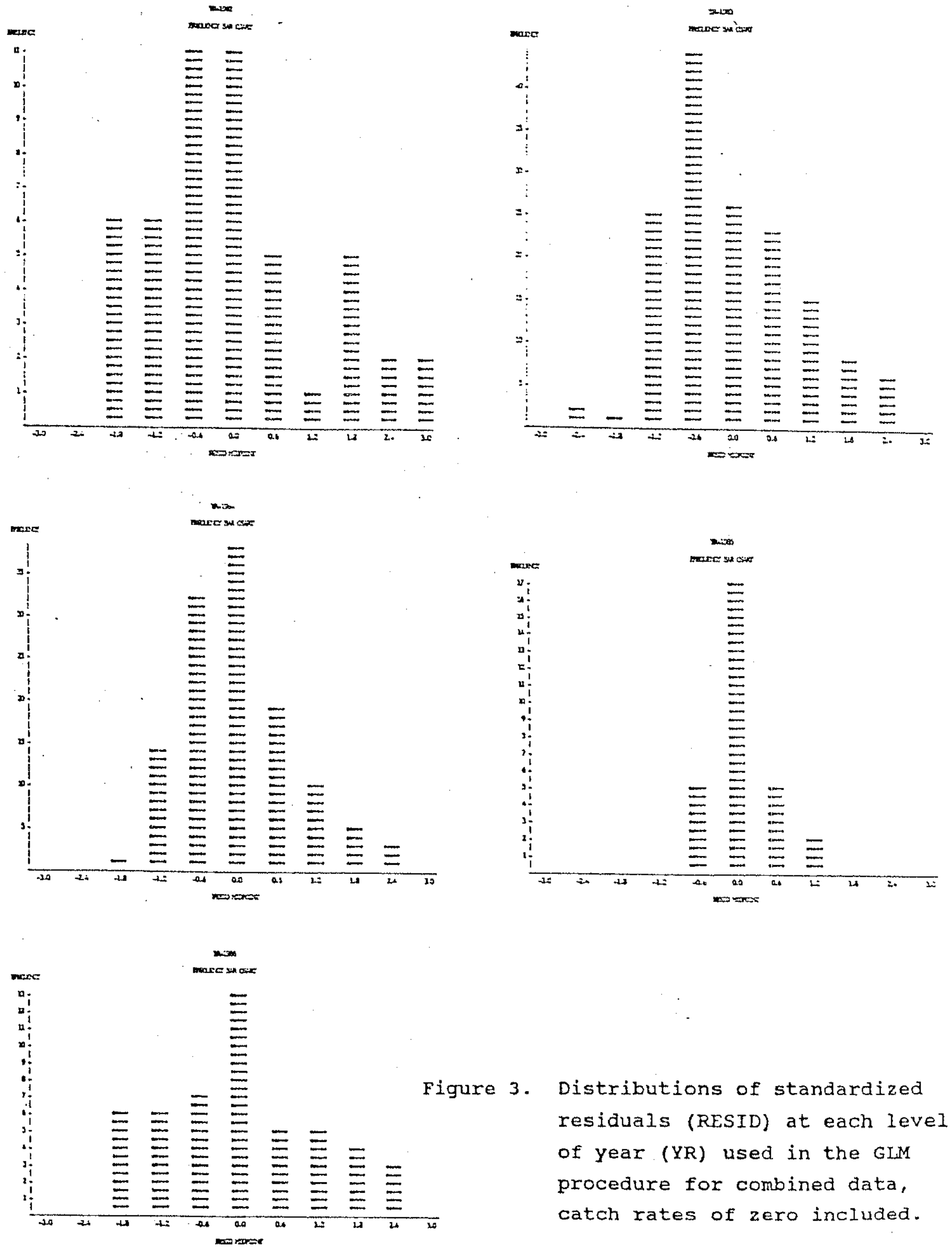

Figure 3. Distributions of standardized residuals (RESID) at each level of year (YR) used in the GLM procedure for combined data, catch rates of zero included.

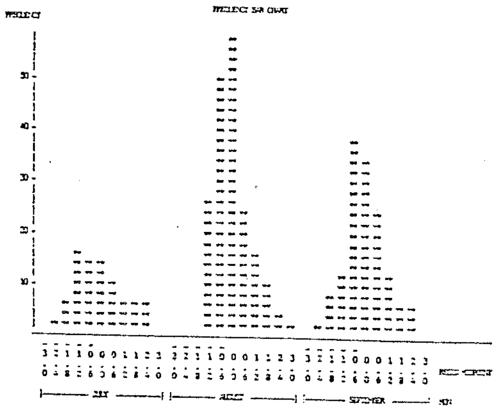

Figure 4. Distributions of standardized residuals (RESID) at each level of month used in the GLM procedure for combined data, catch rates of zero included.

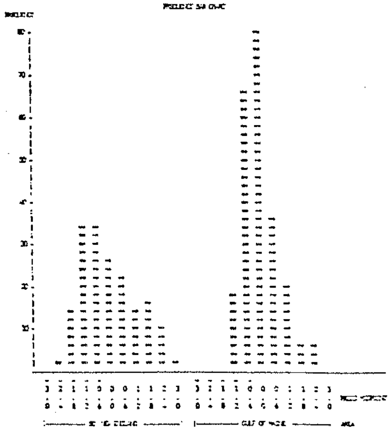

Figure 5. Distributions of standardized residuals (RESID) at each level of area used in the GLM procedure for combined data, catch rates of zero included.

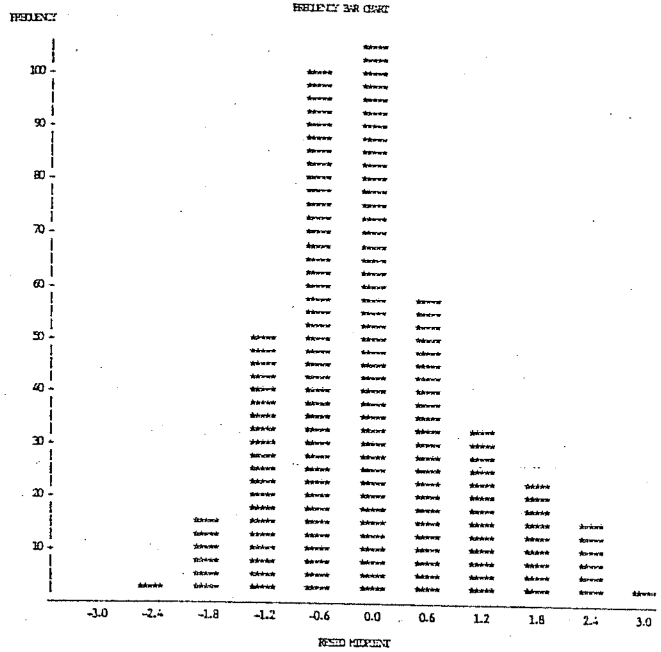

Figure 6. Distributions of standardized residuals (RESID) of the final model for combined data, catch rates of zero included.

Final model: ln(1000*CPHKHR) = Y + M + A + M*A
where Y = year
M = month
A = area
M*A = month-area interaction

R^2 = 0.2628
Standard error of the estimate = 0.7828
Number of observations = 329

Year	Estimated Catch rate	Est. - 2SE	Est. + 2SE
1982	11.59	7.87	17.07
1983	12.89	9.16	18.14
1984	7.14	5.14	9.90
1985	8.14	5.87	11.30
1986	10.67	7.47	15.23

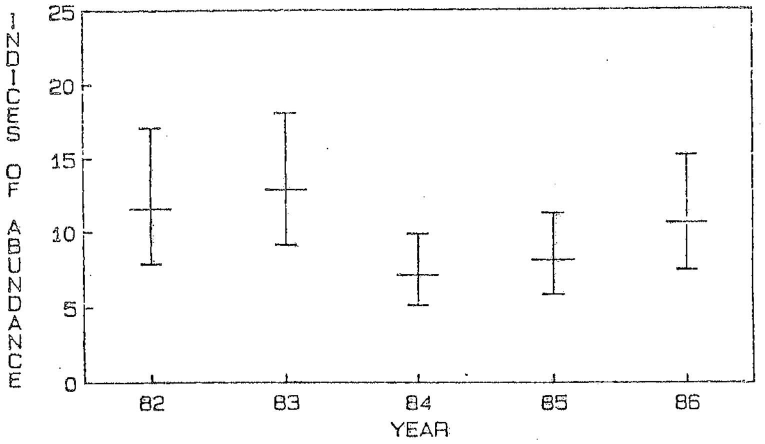

Figure 7. Annual standardized indices of abundance (catch per 1000 hook-hours) with error bars at +/- 2 standard errors (SE) for large bluefin tuna in the New England RR/HL fishery (estimates were derived from the antilog (e^x) of the model estimates using combined trip data, catch rates of zero excluded.

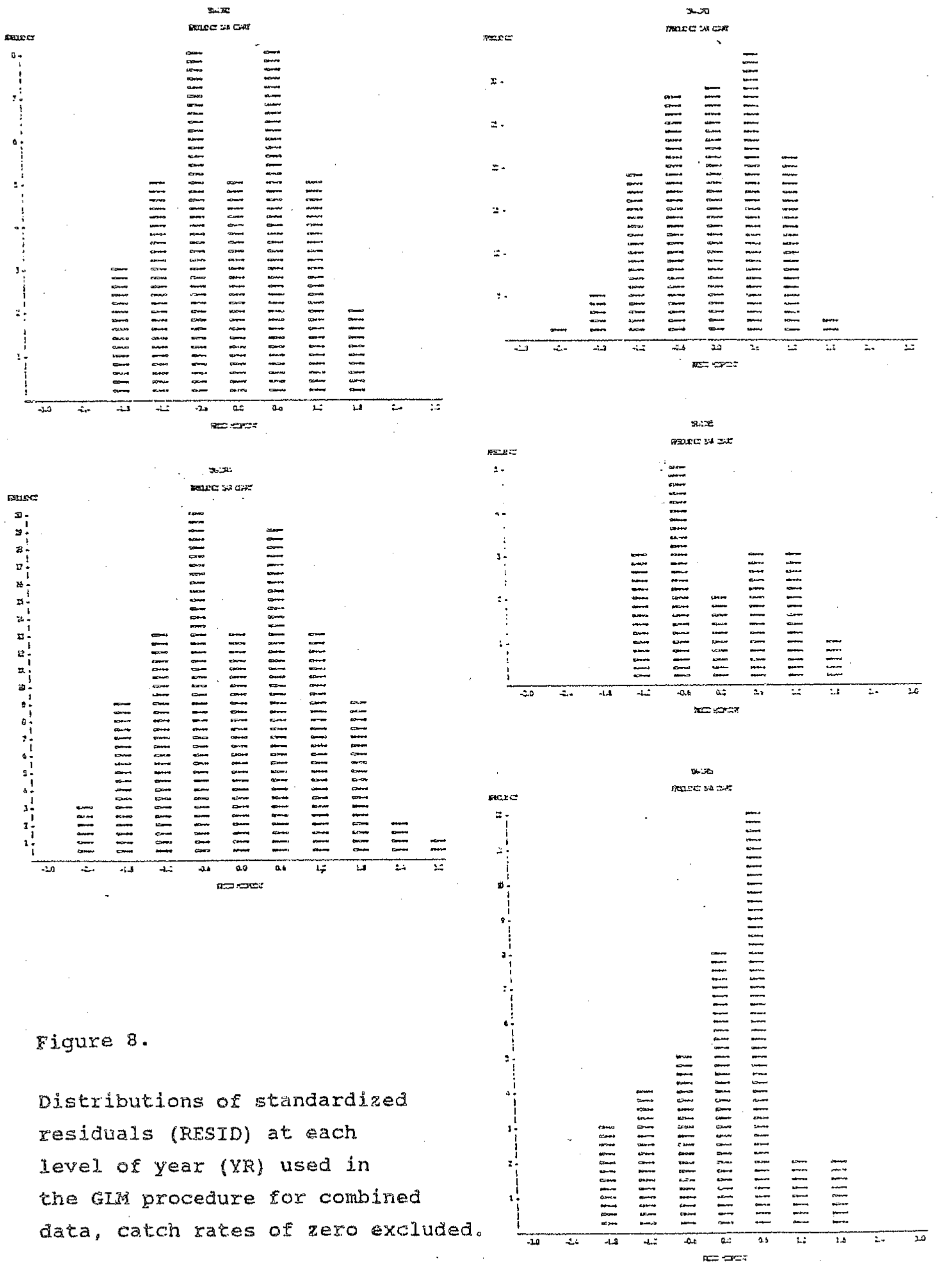

Figure 8.

Distributions of standardized residuals (RESID) at each level of year (YR) used in the GLM procedure for combined data, catch rates of zero excluded.

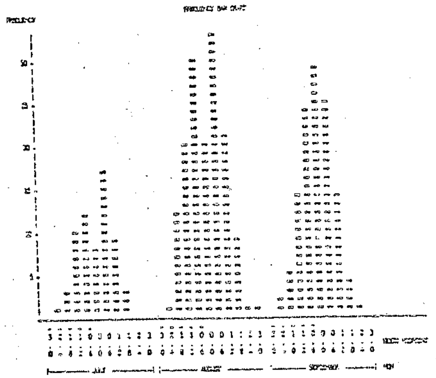

Figure 9. Distributions of standardized residuals (RESID) at each level of month used in the GLM procedure for combined data, catch rates of zero excluded.

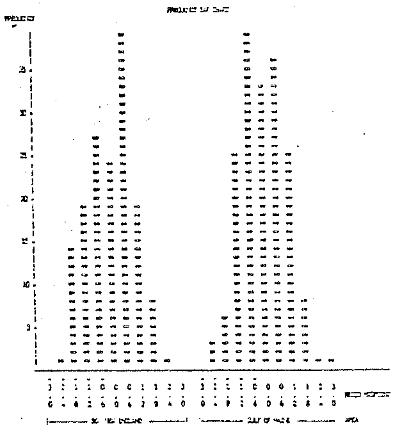

Figure 10. Distributions of standardized residuals (RESID) at each level of area used in the GLM procedure for combined data, catch rates of zero excluded.

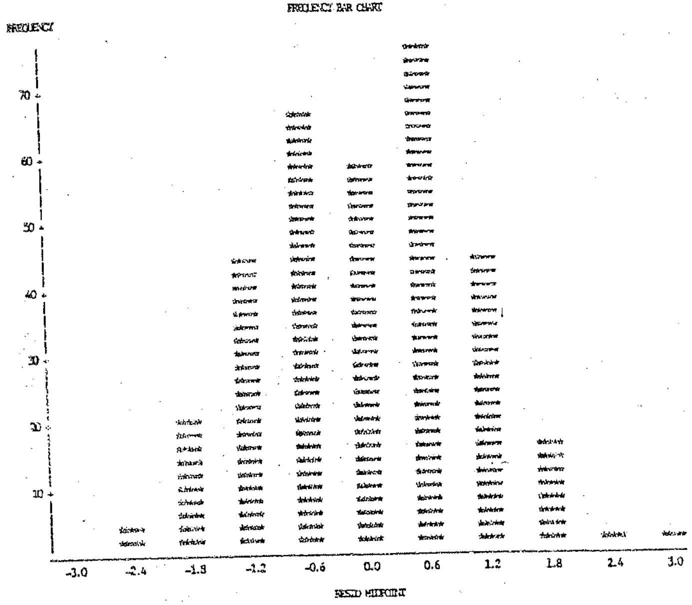

Figure 11. Distributions of standardized residuals (RESID) of the final model for combined data, catch rates of zero excluded.