SCRS/1985/028

Col.Vol.Sci.Pap. ICCAT, 24 : 161-166 (1986)

CPUE ANALYSIS OF THE ATLANTIC BLUEFIN TUNA UP TO 1983

Z. Suzuki
Far Seas Fisheries Research Laboratory
5-7-1 Orido, Shimizu, Shizuoka pref., Japan

SUMMARY

Catch and effort statistics of the Japanese longline fishery were utilized to analyze recent trends in the relative stock size of Atlantic bluefin by the major fishing areas. CPUE, calculated by the Honma method and multiple regression analysis, were compared. The CPUE trends estimated by the two methods showed relatively good accordance in most cases. There were no consistent increasing or decreasing trends in the CPUE from 1970 to 1983 in the stock analyzed.

RESUME

Les statistiques de prise et d'effort de la palangre japonaise sont utilisées pour analyser la tendance récente de la taille relative du stock de thon rouge atlantique par zone de pêche principale. Les CPUE calculées par la méthode de Honma et par l'analyse de régression multiple sont comparées. Les tendances de CPUE estimées par les deux méthodes concordent relativement bien dans la plupart des cas. Aucune tendance cohérente, ascendante ou descendante, n'est observée pour la CPUE de 1970 à 1983 dans les stocks analysés.

RESUMEN

Las estadísticas de captura y esfuerzo de la pesquería japonesa de palangre se utilizaron para analizar las tendencias recientes en el tamaño relativo de la población de atún rojo atlántico, por principales zonas de pesca. Se compara la CPUF calculada por el método Honma y el análisis de regresión múltiple. Las tendencias de la CPUF estimadas por los dos métodos mostraban una concordancia relativamente buena en casi todos los casos. No indicaban tendencias consistentes de la CPUF - tanto en alza como en descenso - en las poblaciones analizadas, de 1970 a 1983.

Introduction

Catch and effort statistics of the Japanese longline fishery have been extensively utilized as an index of apparent relative stock abundance of tunas. The extensive use of this statistics reflects almost entire geographical coverage of the Japanese longline boats over major distribution areas of the Atlantic bluefin with a long historical continuity of the reliable data. Two methods were commonly employed to obtain standardized CPUE series which is more or less independent from areal and seasonal influences of the non-uniform distribution of fishing effort on unadjusted CPUE, and which is assumed to represent annual trend of the Atlantic bluefin stock size. One is Honma method (Honma 1974) and the other, multiple regression analysis (NMFS 1984). Although basic logics are similar in the two methods, treatment of data in practical calculations differ considerably (Conser 1985). The CPUE trends of Atlantic bluefin stock by areas calculated by the two methods were compared and some inferences were given for interpretation of the trends.

Materials and methods

Catch and effort statistics of the Japanese longline fishery were used. They are catch in number of fish by species and number of hooks stratified by months of the year, lat. 5°x long. 5°squares, sizes of boats and kinds of bait used. The statistics from 1970 through 1983, during which period the Japanese longliners shifted fishing effort to bluefin and bigeye were used for calculations (Fisheries Agency of Japan 1972-1982 and ICCAT Secretariate for 1980-1983 statistics).

For Honma method (HM), average relative density by month and 5°squares for five major areas (Fig. 1) were calculated. As fishing seasons in each areas is rather distinctive, months for the calculation were selected for each area (Fig. 1). Monthly CPUE was calculated dividing number of bluefin by number of effective hooks and multiplying 1,000. Mathematical mean of CPUE was calculated over the specified months in each areas. For multiple regression analysis (MRA) a logarithmic (ln) transformation was used to have multiplicative model transformed to additive one. The model used is:

$$CPUE_{ijk} = C + Y_i + M_j + A_k + MA_{jk} + e$$

where $CPUE_{ijk}$: logarithm of unadjusted CPUE (catch in number of bluefin divided by nominal number of hooks and multiplied by 1,000) in year i, month j and area k

C : logarithm of the observed effect of the standard cell

Y_i : logarithm of the effect of year i

M_j : logarithm of the effect of month j

A_k : logarithm of the effect of area k

MA_{jk} : logarithm of the interaction effect of month and area

e : logarithm of the error term

Standard cells in each terms were chosen for earliest year, earliest month and northern-west-most 5° squares in the designated area. Standardized annual CPUE was calculated as CPUE = $e^{(C+Y_i)}$. CPUE used as a dependant variable and year (Y), month (M), 5°squares (A), interaction term between month and area (MA) were used as independent dummy variables. The interaction term (MA) signifies migratory nature of the species. Two sets of calculation, either inclusion or exclusion of the interaction term MA were made using a computer library (BMDT) by Hitachi, Ltd. In either cases, records with no catch were excluded due to logarithmic transformation and records appearing under the same month- 5°squares stratum but different bait or vessel size categories were used as independent records, regarded as repetitions in each month-area stratum.

Result

Annual CPUE series by area calculated by the HM is shown in Table 1 and Figure 2 and that by the MRA in Tables 2 and 3 and Figure 2. As for areas West 1 and West 2 high fishing season usually begins from November of a year to February of the next year, annual CPUE was calculated covering the four months across the neighbouring two years. Although coefficient of determination (R^2) in the MRA is always higher in the cases including the month-area interaction term than those without it (Table 2), general CPUE trends derived from the two models are similar (Table 3). Choice of the year period for areas West 1 and West 2 i.e., inclusion or exclusion of the years after 1981 during which period drastic quota system has been implemented and for Gulf, inclusion or exclusion of the years before 1974 when no directed fishery for the giants started, also showed no significant difference in the resultant CPUE trends. Therefore, CPUE series with higher R and wider year coverage were basically picked up and compared with those calculated by the MH method (Fig 2). Major points to be noted are as follows.

Western Atlantic: Areas Gulf, West 1 and West 2 respectively signify the areas where giant (over 200 cm in folk length), small (below 150 cm) and medium (150-200 cm) fish is mainly caught by the longliners.

Gulf: CPUE increased gradually from 1974 to 1979 in both methods whereas, after 1979 CPUE by the MRA showed sharp decrease in contrast to one by the HM method.

West 1: The trends by the two methods are similar but the annual fluctuation is much higher compared with other areas. Very high CPUE is indicated in 1976. No consistent increasing or decreasing trend during the period of analysis was observed.

West 2: Except observation that the highest CPUE in 1977 by the HM is not indicated by the MRA the trends of two indices are similar with no continuous increasing or decreasing trends.

East Atlantic: Areas Gibraltar and Medit. signify the areas where giant bluefin is dominant in the longline catches.

Gibraltar: CPUE derived from the two methods are in good accordance with stable and small annual fluctuation.

Medit.: Decreasing trends from 1972 to 1981 are common in two CPUE series. However, CPUE in 1982 and 1983 derived from both methods shows recovery.

Discussion and Conclusion

The Japanese longline boats has been changing their fishing grounds and seasons remarkably with little spatio-temporal overlapping in the successive years used for analysis reflecting various socio-economic factors. Bluefin is the highest priced tuna and drastic reduction of quota for this species has accelerated severe competition among the longline boats especially in the west stocks. This inevitably brings about strategic change in the operations and gives classical examples of qualitative discontinuity in the available data series. Given these situations, it seems difficult to obtain CPUE free from spatio-temporal changes in the distribution of fishing effort whatever methods are employed.

This would be represented by generally low values of R ranging from 0.31 to 0.64 obtained from the MRA. Therefore, care should be taken for interpretation of the calculated trends. Almost three fold decline of CPUE in the Gulf of Mexico within two years from 1979 to 1981 will not reflect the change of the stock size, because the giants taken in the areas by the Japan longliners were composed of a number of age groups but no significant change in the size composition was observed during the period (Hisada and Suzuki 1982). Also, it is almost certain that large fluctuation of the CPUE's in West 1 would not reflect as such real annual change in the stock size, at best indicating possibility of appearance of strong year classes (e.g. 1973 year class) during the analysed period. Japanese longline boats operating in the Mediterranean has been under Japanese domestic regulation from 1975. The domestic regulation prohibits the Japanese longliners to capture the giant bluefin in the Mediterranean in the best fishing season, i.e., from late May to the end of June. The operations in the area have become rather erratic after the regulation. Therefore, trends of parent stock size would be better reflected by those in Gibraltar.

To help improve study of this line, it is further necessary to analyze distribution of the fishing effort of longline boats. In this regards, Doubleday (1984) and Honma et. al. (1985) suggested to define specific area and time stratum which is able to best reflect the change in stock sizes of the different segments of the Atlantic bluefin. In conclusion, it is suggested that the Atlantic bluefin stock in the selected areas did not show any consistent increasing or decreasing trends.

References

Conser, R. J. 1985: An examination of the Honma method and its applicability in developing indices of abundance for western Atlantic tuna, ICCAT, CVSP Vol. 22, 107-126 p.

Doubleday, W. G. 1984: The application of sequential population analysis to the assessment of bluefin tuna (Thunnus thynnus thynnus) in the North Atlantic, ICCAT CVSP. Vol. 20, No. 2., 406-419 p.

Fisheries Agency of Japan 1972-1982: Annual report of effort and catch staistics by area on Japanese tuna longline fishery 1970-1980.

Hisada, K. and Z. Suzuki 1982: Catch, fishing effort and length composition of the Atlantic bluefin caught by Japanese longline fishery, ICCAT CVSP. Vol. 17, No. 2., 307-314 p.

Honma, M. 1974: Estimation of overall effective fishing intensity of tuna longline fishery-yellowfin tuna in the Atlantic Ocean as an example of seasonally fluctuating stocks, Bull. Far. Seas Fish. Res. Lab., (10), 63-85 p.

Honma, M., T. Matsumoto and H. Kono 1985: Comparison of two abundance indices based on Japanese catch and effort data by one-degree and five-degree squares for the Atlantic bluefin tuna in the Gulf of Mexico, ICCAT, CVSP Vol. 22, 254-264 p.

NMFS, South-east Fisheries Center 1984: A review of some Atlantic bluefin tuna fisheries data, ICCAT CVSP. Vol. 20, No. 2., 354-373 p.

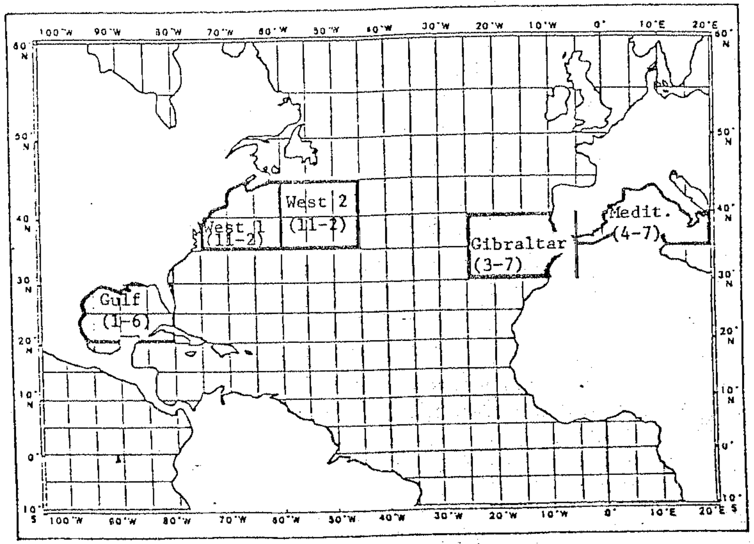

Figure 1. Division of major bluefin fishing grounds used for CPUE analysis basing on the Japanese longline data.

Numerals in the Figure denote months used for calculations.

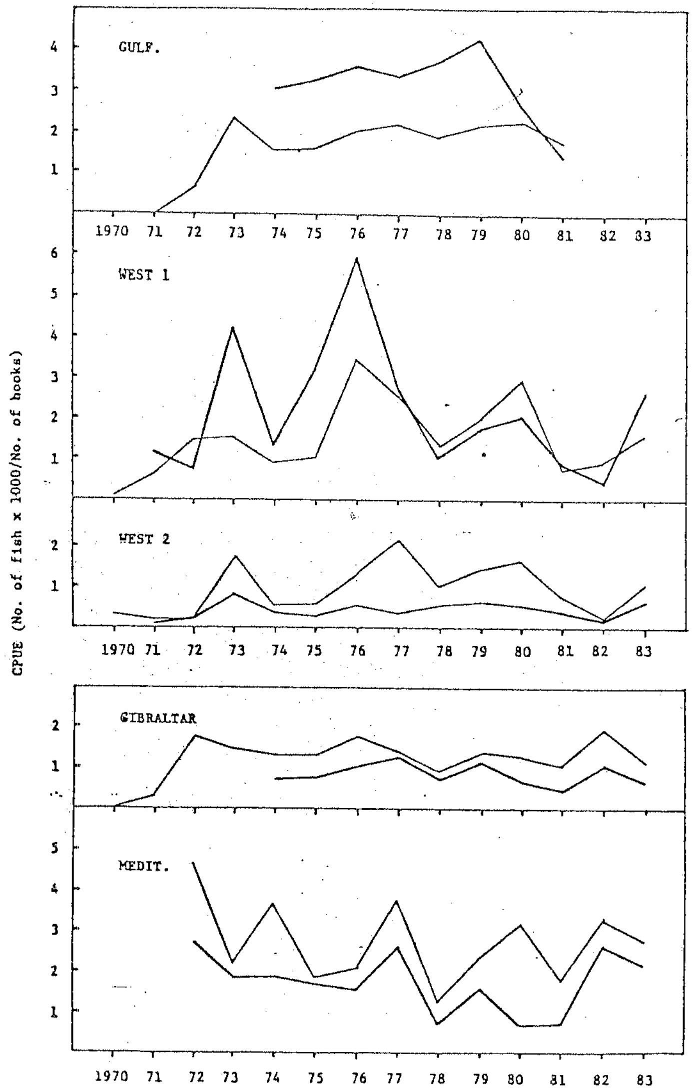

Fig. 2. CPUE series by areas for the Atlantic bluefin caught by the Japanese longliners

—— multiple regression analysis (Shown in Table 2)
—— Honma method

Table 1. Annual trend of cpue for the Atlantic bluefin by areas calculated by Honma method.

unit: 1000 fish / No. of effective hooks

Areas	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
West 1	0.08	0.60	1.46	1.51	0.93	1.08	3.39	2.52	1.30	2.00	2.85	0.79	0.93	1.63
West 2	0.31	0.17	0.20	1.75	0.59	0.61	1.30	2.19	1.03	1.42	1.64	0.78	0.22	1.12
Gulf	0.0	0.0	0.66	2.31	1.52	1.58	2.01	2.18	1.90	2.15	2.27	1.79	-	-
Gibraltar	0.0	0.32	1.77	1.49	1.30	1.32	1.79	1.42	0.93	1.38	1.32	1.08	1.91	1.12
Medit.	-	0.0	4.64	2.17	3.67	1.84	2.07	3.73	1.25	2.31	3.11	1.76	3.24	2.74

- : No fishing effort

Table 2. Summary of the result of multiple regression analysis for the Atlantic bluefin by areas.

Kind of calculations	Area	Year	Factor 1 Y+M+A	Factor 2 Y+M+A+MA	R^2	n
A	West 1	71~81	○		0.57	258
B		71~81		○	0.61	
C		71~83	○		0.55	290
D*		71~83		○	0.59	
E	West 2	71~81	○		0.37	170
F		71~81		○	0.43	
G		71~83	○		0.38	193
H*		71~83		○	0.42	
I	Gulf	71~81	○		0.53	225
J		71~81		○	0.64	
K		74~81	○		0.52	221
L*		74~81		○	0.62	
O	Gibraltar	74~83	○		0.45	472
P*		74~83		○	0.52	
Q	Medit.	72~83	○		0.31	217
R*		72~83		○	0.43	

R^2 : Coefficient of determination
* : Shown in Figure 2
n : Number of data

Table 3. Annual CPUE of the Atlantic bluefin by areas basing on Japanese longline data estimated by multiple regression analysis.

unit 1000 fish/No. of hooks

Areas/Kind of calculation		Year												
		1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
West 1	A	0.211	0.058	0.770	0.287	0.544	1.261	0.596	0.204	0.338	0.396	0.150		
	B	1.498	0.967	5.284	1.764	3.776	7.312	3.558	1.289	2.189	2.532	1.121		
	C	0.225	0.059	0.875	0.297	0.641	1.430	0.680	0.231	0.379	0.450	0.166	0.102	0.696
	D	1.130	0.766	4.265	1.337	3.153	5.953	2.883	1.052	1.764	2.047	0.891	0.428	2.607
West 2	E	0.097	0.197	0.754	0.317	0.275	0.528	0.317	0.404	0.690	0.565	0.377		
	F	0.122	0.216	0.856	0.360	0.300	0.576	0.355	0.553	0.747	0.654	0.428		
	G	0.096	0.183	0.738	0.312	0.269	0.504	0.313	0.395	0.685	0.522	0.348	0.144	0.523
	H	0.119	0.205	0.835	0.353	0.298	0.555	0.348	0.526	0.727	0.581	0.391	0.161	0.610
Gulf	I	0.132	0.039	0.126	0.098	0.130	0.132	*	0.138	0.139	0.082	0.065		
	J	3.187	0.959	4.476	2.812	*	3.449	3.278	3.569	4.072	2.513	1.431		
	K				0.104	0.133	0.137	0.134	0.142	0.145	0.086	0.067		
	L				3.008	3.294	3.602	3.405	3.760	4.292	2.628	1.493		
Gibraltar	O				0.890	0.911	1.198	1.527	0.826	1.506	0.781	0.578	1.376	0.747
	P				0.723	0.787	1.060	1.284	0.726	1.136	0.697	0.475	1.035	0.652
Medit.	Q		3.652	2.806	2.909	2.966	3.110	5.139	1.554	3.006	1.076	1.495	5.218	4.107
	R		2.718	1.802	1.863	1.684	1.556	2.554	0.719	1.571	0.677	0.717	2.593	2.106

As for Areas and kind of calculations, see Figure 1 and Table 2.
* Partical regression coefficient is not significant at 95% confidence interval.