RECENT STATUS OF BIGEYE TUNA IN THE ATLANTIC OCEAN

by

S. Kume

SUMMARY

Bigeye tuna resources in the Atlantic Ocean have been increasingly exploited, and the recent catch is considered to be reaching the level of maximum sustainable yield.

This report presents (1) analyses of the recent status of the stock through the re-examination of population parameters, (2) estimation of the change in amount of catch through Y/R model analysis amoung three types of gears -longline, pole-and-line and purse seine, and (3) respective evaluation of the stock status in case of the possible separation into two stocks in the northern and southern Atlantic.

RESUME

Les ressources en thon obèse dans l'Atlantique sont exploitées de façon croissante, et les prises récentes sont considérées être proches du niveau de production maximale soutenue.

Le présent rapport fait état (1) des analyses de l'état récent des stocks au moyen d'un nouvel examen des paramètres de population, (2) des estimations concernant les changements de répartition du volume de la prise entre trois types d'engin, palangre, canne et senne, au moyen de l'analyse de rendement par recrue, et (3) de l'évaluation des stocks respectifs dans le cas de l'existence éventuelle de deux stocks séparés dans le nord et le sud atlantiques.

RESUMEN

La explotación de los recursos de patudo en el Océano Atlántico ha aumentado progresivamente, y se estima que la captura se está acercando al nivel de producción máxima sostenible. Este documento presenta: 1) análisis del estado actual del stock por medio de una revisión de los parámetros de población; 2) estimación, por análisis del modelo Y/R, del cambio en la distribución del volumen de captura entre tres tipos de arte: palangre, caña liña y cerco; 3) evaluación del estado de cada uno de los stocks, en la hipótesis de una división, al Norte y Sur del Atlántico.

Recent catch of bigeye tuna in the Atlantic has been increasing gradually and 1974 annual catch reached to 53 thousand tons. Until 1970, more than 90% of the total bigeye catch was made by longline fishery, but since then surface catch has increased rather remarkably and also contributed to the recent uprise of the total catch (Fig. 1).

The latest stock assessments on Atlantic bigeye stock, based on the catch and effort data up to 1973, suggested that the bigeye fishery was near the level of maximum sustainable yield (Kume 1976 and Sakagawa 1976). If there exist two stocks in the north and south Atlantic separately, it was supposed that a southern group was harvested heavier than a northern one (Sakagawa 1976). In 1974 and 1975, as annual catch has increased furthermore, especially in surface catch, it is a pressing need to make an assessment on current status of the stock and to evaluate its possible change in the future.

This report presents results on reexamination of population parameters based on revised statistics, Y/R model analyses including the effect among three different type of fisheries and stock assessment for north and south groups.

Data processing

Data on catch in number and weight and effort of longline fishery in terms of standardized hooks on bigeye tuna were already summarized by Kume ms, in which Taiwanese catch and effort statistics were incorporated as basic data for the first time. All available size data obtained from Japanese longline fishery since 1965 are processed following the procedure as explained by Kume 1976 and the catch in number by age and north-south separation is shown in Table 1.

Reestimation of population parameters

To estimate some of population parameters, the relationship between effort and reciprocal of catch per unit of effort (cpue) was again utilized, since it seemed that the revised catch and effort statistics would give better estimates than the previous ones (Kume 1976). The technique for the estimation was explained by Suda (1970). The data adopted in this study are shown in Table 2. The data on cpue prior to 1960 were excluded from the analysis because catch records of bigeye tuna by fishermen were incomplete due to by-product nature of the species in earlier stage of Japanese longline fishery. To obtain total mortality coefficient, one of the imputs for the analysis, crude survival rates were calculated by dividing 5 age and older by 4 age and older from the average age composition, and then they were converted to crude total martality coefficient (Z'). At the same time, corresponding average fishing effort ($\bar{f}$) was calculated from Table 2. It is assumed for this analysis that longline catch and effort data alone are representative because surface catch had been small until recently and recent increase of surface catch does not affect much the recent longline catch and effort relation judging from the difference of the age composition between longline and surface catches (Kume ms). The resultant Z' and $\bar{f}$ were 0.600 and 0.663×10^{8} hooks for the years 1966-1970 and 0.611 and 0.829×10^{8} for the years 1968-1970, respectively. Other imputs for the computation were: 14 pairs of catch and effort data, 1961-1974, five years' sole effort data, 1956-1970, and 9 years interval for computing the correction factor.

The results of computation for two sets of Z' and f are summarized as follows;

	$Z'=0.600$, $f=0.633\times10^{8}$	$Z'=0.611$, $f=0.829\times10^{8}$
R(amount of recruitment)	154×10^{4}	152×10^{4}
q(catchability coefficient)	0.223×10^{-8}	0.216×10^{-8}
M(natural mortality coefficient)	0.452	0.432

Y/R model analysis

Y/R calculation (program by Honma 1973) was carried out under the following conditions, some of which are the results of the above section;

$M=0.45$

$W_t=192.7(1-0.98e^{-0.21t})^3$: Growth equation in terms of weight converted from that of Pacific bigeye obtained by Yukinawa and Yabuta (1963) which was corrobrated by Champagnat and Pianet (1973) to be similar to that of Atlantic bigeye,

$t_c=3.0$: Average age at first capture estimated from average age composition for the years 1971-1974,

$R_1=$ in the range of $400\text{-}600\times10^4$: Recruitment in number of fish at age 1 estimated from cohort analysis (Kume 1976).

The resultant yield curves were indicated in Fig. 2. In addition, observed annual longline catches against corresponding efforts and F's (fishing mortality coefficients calculated with $q=0.220\times10^{-8}$ /hook) are plotted in Fig. 2.

As far as the above analysis is concerned, the recent longline fishery for bigeye in the Atlantic would be at the level above which marginal increment of catch could be expected by increased effort. This might be supported by the fact that recent overall cpue's of bigeye longline fishery have remained on the relatively high level, being 2/3 of those in earlier years with highest (Kume ms). However, it should be taken into account that surface catch of bigeye tuna has been increasing recently, especially since 1974. Such change in the constitution of bigeye fishery will result in the different phase of the process of production of the stock than that hitherto.

Size composition of surface catch of bigeye tuna is composed of mainly small sized fish (Kume and Morita ms): approximately 1-3 age for pole-and-line fishery and 1-5 age for purse seine fishery. Compared with the constituent of the longline catch, that is 3 age and older, surface fisheries are apparently taking bigeye before they enter the longline fishable stock. Therefore, the effect of the increasing catch of small sized fish would be revealed in the Y/R relation of the longline fishery in the near future.

Change in Y/R of bigeye among different types of fisheries

Taking into account of recent status of bigeye fisheries, the following three types of fisheries are postulated;

	Catch	F*	Range of age in the catch
Type-1 (longline)	35,000 tons	0.40	3.0-
Type-2 (pole-and-line)	13,000 tons	0.16	1.0-4.0
Type-3 (purse seine)	2,000 tons	0.03	1.0-6.0

* Type-1's F is assumed to be 0.40, and F's for Type-2 and Type-3 are assigned by prorating according to the catch ratio of each Type.

When one of above three fisheries varies its effort (F), changes in Y/R of respective fishery wore computed. Natural mortality coefficient was assumed to be 0.45. The results are illustrated in Fig. 3.

In both cases of Type-2 and Type-3 variable, Y/R of Type-1 decreases rapidly with the increase of F, and at the same time total Y/R is lowering. On the other hand, the increase in F of Type-1, total Y/R grows larger with a little decline of Y/R's of other two fisheries. This instance is based on several assumptions, but it is indicative enough that enlargement of surface fisheries taking small sized fish would result in the decrease of longline catch and concurrently of total Y/R.

Stock assessment for north-south separated stocks

It might be the case that bigeye resources in the Atlantic would be separated to two stocks in northern and southern hemispheres, respectively (Kume and Morita ms). Sakagawa (1976) reported that close attention was necessary on the southern stock due to the heavier harvest than the northern stock. The relationship between catch and effort based on elaborated treatment for north-south separation of the statistics was presented in separate report (Kume ms) and is reproduced here in Fig. 3. The results are substantially the same as those demonstrated by Sakagawa (1976).

With the reservation on the uncertainty of two separate stocks, northern stock seems to be larger in stock size than southern one and to be able to produce more catch than the current one by more effort. However, as already indicated above, the effect of recent increasing trend of surface catch on longline fishery should be carefully monitored.

References

Champagnat, C. and R. Pianet 1974: Growth of bigeye (Thunnus obesus) in the regions of Dakar and Pointe-Noire. ICCAT Col. Vol. Sci. Papers, Vol.II, 141-144.

Honma, M. 1973: Calculation of yield-per-recruit and relative stock fecundity for fish population with age-dependent natural mortality. Bull. Far Seas Fish. Res. Lab., (9), 177-199.

Kume, S. 1976: Present status of the bigeye tuna in the Atlantic Ocean. ICCAT Col. Vol. Sci. Papers, Vol.V(1), 172-175.

Kume, S. ms: Overall fishing intensity of Atlantic longline fishery for bigeye tuna, 1956-1974. SCRS/76/

Kume, S. and Y. Morita ms: On the stock structure of bigeye tuna in the Atlantic Ocean. SCRS/76/ .

Sakagawa, G.T. 1976: Status of bigeye tuna stocks of the Atlantic Ocean, 1957-73. from production model analysis. ICCAT Col. Vol. Sci. Papers, Vol.V(1), 176-184.

Suda, A. 1970: Approximate estimation of parameters in dynamics of fish population utilizing effort and catch statistics with little informations on biological features. Bull. Far Seas Fish. Res. Lab., (3), 1-14.

Yukinawa, M. and Y. Yabuta 1963: Age and growth of bigeye tuna, Parathunnus mebachi (KISHINOUYE). Rept. Nankai Reg. Fish. Res. Lab., (19), 103-118.

Table 1. Age composition of Atlantic bigeye tuna in terms of catch in number caught by Japanese longline fleet, 1965-1974.

NORTH ATLANTIC (ICCAT area 1-4)

Year \ Age	1	2	3	4	5	6	7	8	9
1965	1,211	21,662	78,902	96,026	67,195	49,916	19,906	1,853	1,158
1966	1,123	17,151	26,235	39,730	28,687	6,677	2,126	219	74
1967	151	8,069	23,981	24,057	17,118	1,508	452	75	-
1968	1,419	11,026	22,186	23,059	17,180	8,275	2,655	432	185
1969	178	6,913	11,660	21,073	15,050	7,261	2,347	417	178
1970	4,850	5,866	31,088	31,361	24,124	6,014	1,093	-	-
1971	14,947	39,256	50,182	82,217	48,383	17,537	4,036	548	464
1972	11,991	62,097	67,177	27,388	32,447	17,394	5,359	1,493	207
1973	7,270	52,646	83,281	45,851	20,785	7,186	2,078	164	82
1974	1,825	16,602	75,572	113,437	69,320	49,054	39,070	19,256	4,416

SOUTH ATLANTIC (ICCAT area 5-8)

Year \ Age	1	2	3	4	5	6	7	8	9
1965	8,170	38,290	57,782	86,560	68,906	35,863	9,960	2,621	191
1966	2,004	6,119	24,761	32,937	25,663	13,261	4,716	744	57
1967	232	11,823	21,628	22,935	19,038	19,277	9,634	828	295
1968	979	13,572	29,739	36,785	21,383	10,933	3,829	679	148
1969	3,068	56,079	51,311	37,633	24,847	15,451	7,847	1,644	198
1970	113	10,668	26,404	18,593	15,588	7,740	3,358	896	84
1971	5,369	28,375	29,989	25,949	24,994	12,318	5,463	3,056	793
1972	777	24,012	30,844	22,392	19,578	12,523	5,408	1,417	582
1973	6,625	21,701	42,236	39,666	28,629	18,704	9,602	3,720	514
1974	749	12,548	29,970	11,191	5,452	4,771	2,514	777	358

TOTAL

Year \ Age	1	2	3	4	5	6	7	8	9
1965	9,381	59,952	136,684	182,586	136,101	85,779	29,866	4,474	1,349
1966	3,127	23,270	50,996	72,667	54,350	19,938	6,842	963	131
1967	383	19,892	45,609	46,992	36,156	20,785	10,086	903	295
1968	2,398	24,598	51,925	59,844	38,563	19,208	6,484	1,111	333
1969	3,246	62,992	62,971	58,706	39,897	22,712	10,194	2,061	376
1970	4,963	16,534	57,492	49,954	39,712	13,754	4,451	896	84
1971	20,316	67,631	80,171	108,166	73,377	29,855	9,499	3,604	1,257
1972	12,768	86,109	98,021	49,780	52,025	29,917	10,767	2,910	789
1973	13,895	74,347	125,517	85,517	49,414	25,890	11,680	3,884	596
1974	2,574	29,150	105,542	124,628	74,772	53,825	41,584	20,033	4,774

Table 2. Effort and reciprocal of catch per unit of effort (cpue) of bigeye tuna caught by whole Atlantic longline fleet, being utilized for estimating population parameters.

Year	Effective effort (number of hooks $\times 10^{-8}$)	1/cpue
1956	0.0007	-
1957	0.0257	-
1958	0.0569	-
1959	0.1107	-
1960	0.1556	-
1961	0.2957	1.1905
1962	0.5231	1.4085
1963	0.4668	1.6129
1964	0.5971	1.7241
1965	1.1545	1.7544
1966	0.4908	1.9608
1967	0.3392	1.6949
1968	0.6627	1.7857
1969	0.8241	1.6129
1970	0.9987	1.9231
1971	1.7239	2.3256
1972	1.5048	2.5641
1973	1.6625	1.9231
1974	1.5806	1.9231

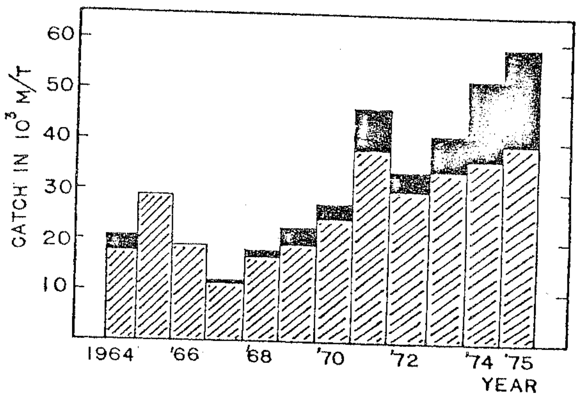

Fig. 1. Annual catch of bigeye tuna in the Atlantic Ocean, 1965-1975. (1975 figure is preliminary)

striated: longline catch
shaded : surface catch

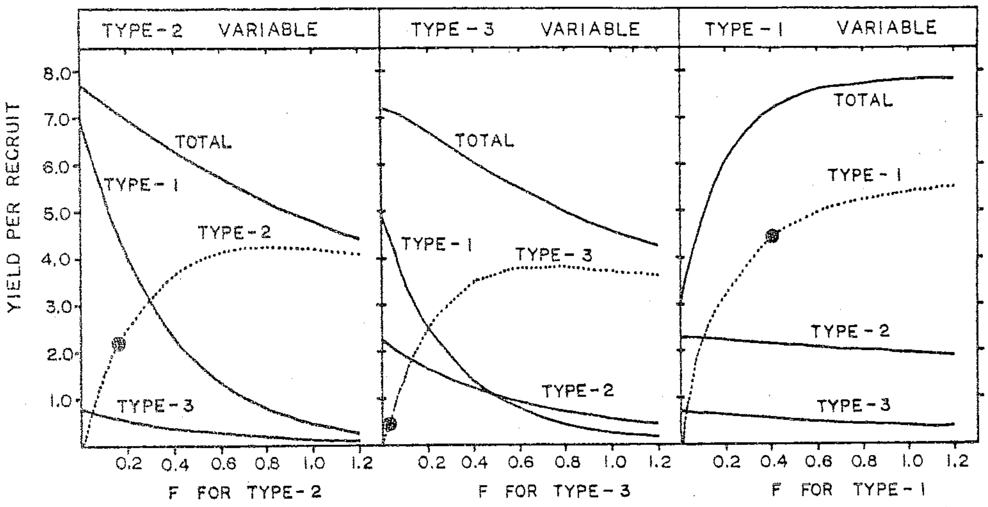

Fig. 3. Change of Y/R among three types of fisheries when one of them varies its effort(F). Shaded circles in each panel show the position of the supposed fishery.

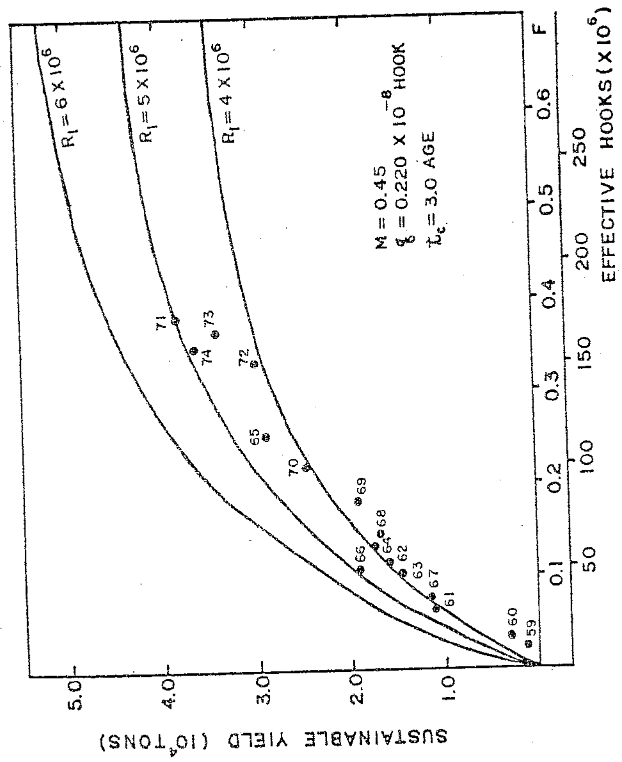

Fig. 2. Yield curves for Atlantic bigeye tuna estimated by Y/R model analysis. Observed annual catches and efforts were incorporated for 1959-1974.

R_1 = recruitment in number of fish at age 1.

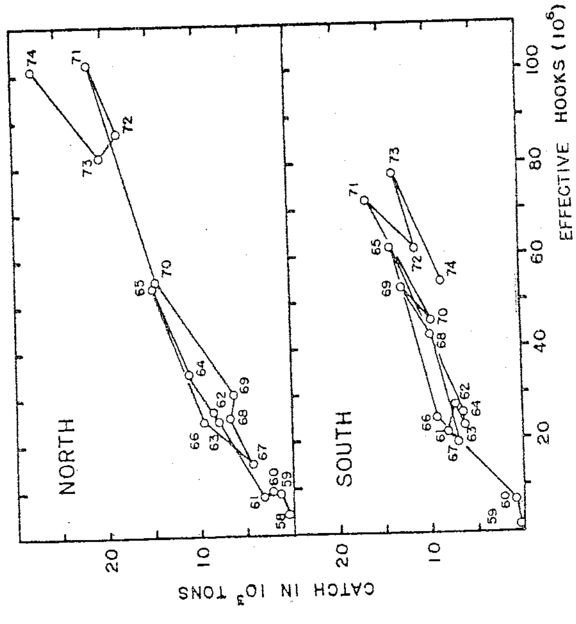

Fig. 4. Relationship between catch and effective hooks on bigeye tuna in north and south Atlantic.