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PRESENT STATUS OF THE BIGEYE TUNA IN THE ATLANTIC OCEAN

by

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SUMMARY

The recent relatively high level of catch and effort of Atlantic bigeye tuna has caused some concern on the status of the stock. In this report, an analytical study was made to assess the recent stock condition of Atlantic bigeye on the basis of a single stock.

The amount of recruitment at age of first capture (R) and natural mortality coefficient (M) were estimated by Mr. Suda's method (1970) which utilized mainly catch and effort data with some additional biological information. Two sets of R and M were obtained: 130 x 10 fish, 0.44 and 145 x 10 fish, 0.65, respectively. From the age composition, age at first capture was estimated: 3.8 for 1966-68 and 2.9 for 1971-73. Using these estimates, Y/R model approach was attempted. In addition, catch and effort data of longline fishery were applied to the generalized production model (Fox 1975).

RESUME

Les niveaux relativement élevés atteints récemment en ce qui concerne les prises et l'effort portant sur le thon obèse de l'Atlantique ont provoqué certaines inquiétudes au sujet de l'état des stocks. Le présent rapport analyse l'état récent des stocks de cette espèce dans l'Atlantique sur la base d'un stock unique.

Le volume de recrutement à l'âge à la première capture (R) et le coefficient de mortalité naturelle (M) ont été estimés par la méthode de Suda (1970) qui utilise principalement des données de capture et d'effort avec quelques données biologiques supplémentaires. Deux jeux de R et M ont été obtenus: 130 x 10 spécimens, 0,44 et 145 x 10 spécimens, 0,65, respectivement. L'âge à la première capture a été estimé à partir de la composition par âge: 3,8 pour 1966-68 et 2,9 pour 1971-73. Une étude de production par recrue a été tentée à partir de ces estimations. Des données palangrières de capture et d'effort ont en outre été appliquées au modèle de production généralisée (Fox 1975).

RESUMEN

El reciente y relativamente alto nivel del esfuerzo y captura del patudo en el Atlántico, ha provocado cierta inquietud sobre el estado de los stocks. En este informe se analiza la situación de los stocks de patudo del Atlántico sobre la base de un stock único.

El volumen de reclutamiento por edad a la primera captura (R) y el coeficiente de mortalidad natural (M) fueron estimados por el método Suda (1970), que utilizaba principalmente datos de esfuerzo y captura, con alguna información biológica adicional. Se obtuvieron dos juegos de R y M: 130 x 10 pez (individuo), 0,44 y 145 x 10 pez (individuo), 0,65, respectivamente. De la composición por edades se calculó: 3,8 para 1966-68 y 2,9 para 1971-73. Empleando estos cálculos se intentó un estudio de Y/R (producción por recluta). Además, los datos de esfuerzo y captura de la pesca de palangre se aplicaron al modelo de producción generalizado (Fox 1975).

Tables 1 - 3 reproduced in Data Record Vol. 7.

Tableaux 1 à 3 reproduits dans le Vol. 7. du Recueil de Donnees.

Cuadros 1 - 3 reproducidos en Vol. 7 de la Colección de Datos Estadísticos.

Bigeye tuna in the Atlantic Ocean are distributed in the wide range from tropical to temperate waters, and recent annual catch (1971-73) amounted to the level of about 40,000 tons. Principal fishery capturing bigeye has been longline gear, by which more than 80 % of the catch is accounted for even in recent years. From the relationship between catch and effort of longline fishery, it was surmised roughly that recent stock condition is approaching to the level of maximum sustainable yield (Kume ms). Further analytical stock assessment was attempted in this study.

Hayasi et al. (1970) stated on the population structure that Atlantic bigeye may consist of either one stock in the whole ocean or two stocks in the north and south Atlantic separately. More biological information has not been available to identify the above standpoint on the population unit. This paper deals with the case of a single stock in the whole Atlantic.

Data processing

1) Catch and effort

Basic data on catch in number of fish and effort in number of hooks of longline fishery were taken from a series of data publication, Annual report of effort and catch statistics by area on Japanese longline fishery up to 1973 edition, and Catch staticitics of Taiwan's tuna longline fishery for the years 1968, 1969 and 1971-73. Catch in weight was based on ICCAT Statistical Bulletin Vol. 5. Catch, effective effort and fishing intensity on longline fishery were already summarized up to 1973 by Kume (ms).

2) Age composition

Size data of Atlantic bigeye caught by longline fishery are available since 1965. Annual catch in number by age was estimated by the following procedure:

i) Champagnat and Pianet (1973) estimated the growth of bigeye from the catch of surface fishery and noted the result was fairly similar to the growth of Pacific bigeye obtained by Yukinawa and Yabuta (1963). Utilizing the latter equation, $L_t=215(1-e^{-0.2066t-0.0249})$, size data were converted to age data by the age-length key.

ii) Atalntic Ocean was divided into 8 sub-areas (Fig.1), considering the characteristics of the geographical distribution and size composition by area. All available catch and size data were summarized by sub-area, with which catch by age of longline catch in the whole Atlantic was obtained by summing up those by sub-area and then by extrapolating the resultant composition to the total number of catch to compensate the data of sub-area in which no data were available.

iii) Catch in number by age for whole longline fishery was estimated by prorating in terms of weight between annual catch of sampled and total estimated.

Stock assessment

1) Estimation of parameters

Some of population parameters were estimated from an expected linear relationship between reciprocal of cpue and effort, technical treatment of which was explained by Suda (1970). The basic data used for this analysis are shown in Table 2. The data prior to 1960 were excluded from the analysis because catch records of bigeye by fishermen were often insufficient due to by-product nature of the species in earlier stage of Atlantic Japanese longline fishery. Other than the catch and effort data, crude survival rate (S) was estimated from the average age composition of 1966-1968, during which period the effort and catch were rather stable and the Japanese longline fishery, by which size data were sampled, expanded almost overall Atlantic. Two survival rates were calculated: 0.41 and 0.55 for 6 age and older/5 age and older (5+), and 5+/4+, respectively. The results of the analysis on the amount of recruitment (R), natural mortality coefficient (M) and catchability coefficient (q) were as follows:

for $S=0.41$; $R=145\times10^4$, $M=0.65$ and $q=0.457\times10^{-8}$ (per hook)

and for $S=0.55$; $R=130\times10^4$, $M=0.44$ and $q=0.314\times10^{-8}$

Supposing that real S was in between the above two's, the two kinds of resultant estimates were averaged tentatively for further analysis: $R=138\times10^4$, $M=0.55$ and $q=0.386\times10^{-8}$. The averaged M is higher than that for Pacific bigeye, 0.361 (Suda and Kume 1967), and the lower M=0.45 (≒0.44) was also considered in this study for a supplemental information.

Cohort analysis with M=0.55 was attempted by Murphy's method (1965; program by Tomlinson 1970) for a cohort from 1 age of 1965 to 9 age of 1973 (1965-1~1973-9). For the back calculation, initial F's were chosen as 0.05, 0.1 0.2 and 0.3 (Fig. 2). While it was difficult to ascertain assuring detailed age-specific F owing to no information on any real F, recruitment at age 1 (R_1) ranged between 605×10^4 and 408×10^4 for initial F's of 0.05-0.3. By the calculation on two cohorts, 1966-1~1973-8 and 1967-1~1973-7, with initial F's of 0.3 and 0.5, two estimates of R_1 resulted in 609×10^4 and 550×10^4 for the former and 700×10^4 and 602×10^4 for the latter. R_1 during the years 1965-67 might have been 400×10^4 ~ 700×10^4. The average R already estimated earlier becomes 639×10^4 as R_1 when the average age at first capture (t_c) was assumed to be 3.8.

An approximate computation of t_c was made for two average age compositions, 1966-68 and 1971-73. The resultant t_c's were 3.8 and 2.9 respectively. Lower t_c in recent years was reflected by the shift of main Japanese longline fishing ground from lower latitudes to higher latitudes, in the latter of which small- and medium-sized fish are predominated.

2) Calculation of sustainable yield with Y/R model

Y/R calculation was attempted with M=0.55 and the growth equation of Pacific bigeye (program by Honma 1973). Supposing R_1 is $600x10^4$, three yield curves for t_c=2.0, 3.0, 4.0 are shown in the upper panel of Fig. 3. In addition, with a combination of M=0.45 and R_1=$450x10^4$ (estimated from R=$130x10^4$), the same curves are drawn in the lower panel of Fig. 3. Observed annual catches and F's (calculated with estimated q's) are plotted in Fig. 3, which are not fitted well to the expected yield curves. This could be related with many factors: 1) reliability of catch statistics , 2) the accuracy of estimated population parameters, 3) the change in t_c, etc. It is difficult at this stage to recognize which of the above is main factor, and it is necessary to put further effort in solving this problem.

So far as the above analysis is concerned, the recent level of longline fishery for bigeye appears to be approaching to the MSY level. It is also suggested that the lowering of t_c will result in the reduction of average sustainable catch with more increment of effort (Fig. 3). It should be mentioned that the recent overall cpue of bigeye longline fishery has still remained on the relatively high level, 2/3 of earlier years with the highest. This might be indicative of the possible increase in catch with further effort increase.

3) An application to the production model

The catch and effort data on longline fishery (Table 3) were fitted to the generalized production model (Fox 1975: program "PRODFIT" by Fox, personal comm.). The data of early years were excluded as explained already and the number of year classes was taken as 4. The calculated sustainable yield curve is shown in Fig. 4. The calculated MSY was $34x10^3$ tons with the fishing intensity of $1,040x10^3/5°$ square.

In applying the model, it should be considered that bigeye fishery in the Atlantic has been changing gradually, so that the necessary assumptions of the model have turned out heterogeneous in quality. For example, recent longline fishery has been capturing more smaller fish than before (Table 1) and the catch by surface fishery has been increasing little by little by which catch of small-sized fish of 1 and 2 ages (Champagnat and Pianet 1973) is on the increase. Thus the constitution of recent change of bigeye fishery and resultant influence of the time lag in the process of production of the stock have been generating some problems on the validity of the production model.

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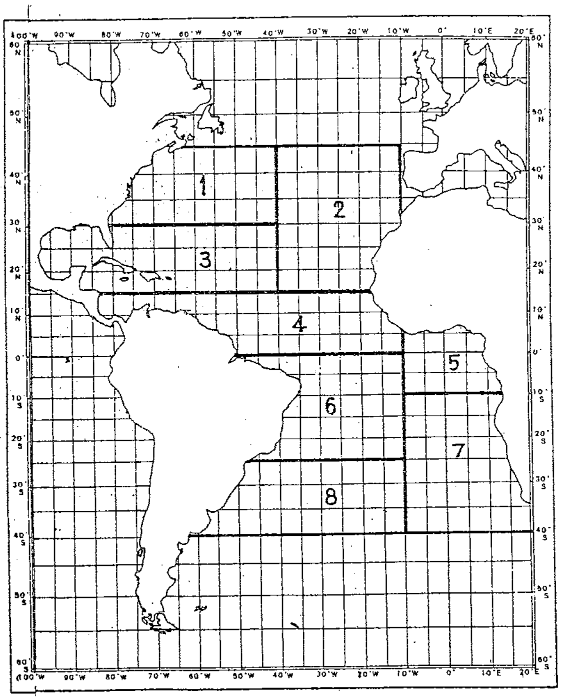

Fig. 1. Areal division for Atlantic bigeye tuna.

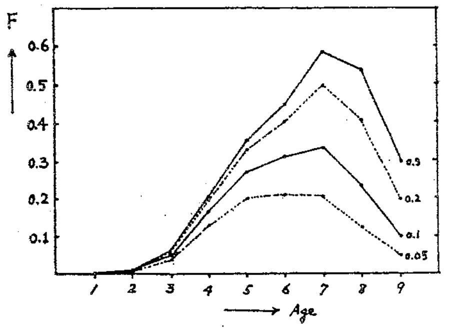

Fig. 2. Calculated age specific F for 1965-1 age to 1973-9 age cohort of Atlantic bigeye with different level of initial F.

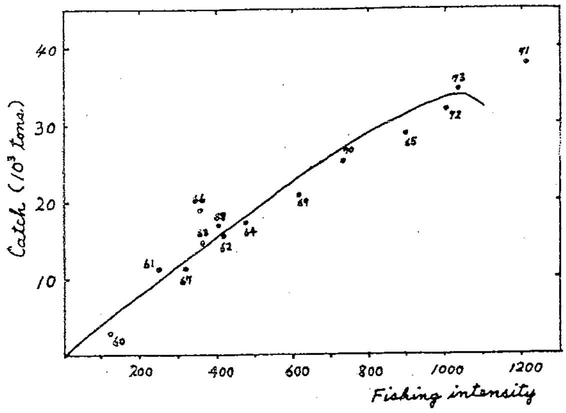

Fig. 4. Fitting of the generalized stock production model ("PRODFIT" by Fox 1975) for Atlantic longline bigeye tuna: data from Table 3.

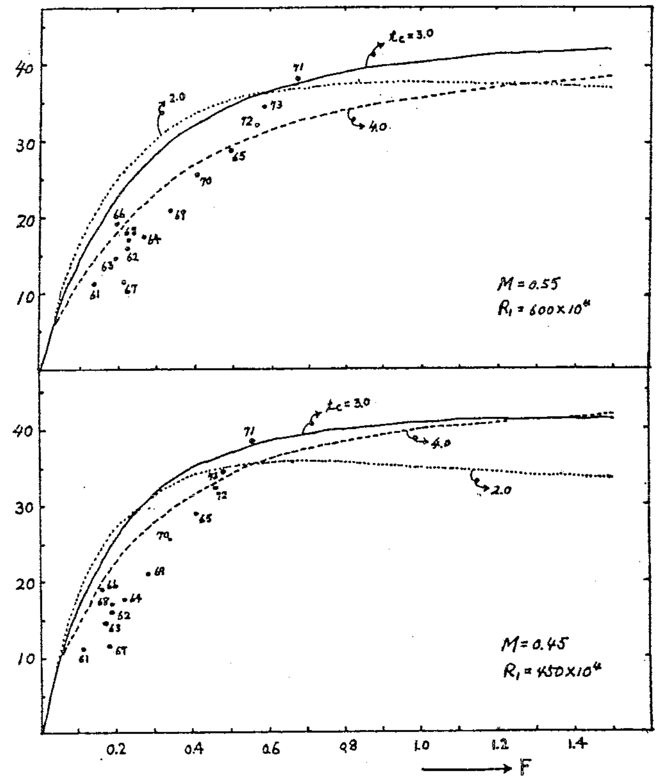

Fig. 3. Yield curves for Atlantic bigeye tuna estimated by Y/R model. Observed annual catches and efforts were interpolated for 1961-73.