APPROXIMATE ESTIMATION OF POPULATION PARAMETERS UTILIZING EFFORT AND CATCH DATA OF THE SOUTH ATLANTIC ALBACORE STOCK

by

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SUMMARY

Utilizing catch and effort data of the longline fishery from 1956 to 1967 and yearly age compositions of the Japanese longline catches from 1962 to 1967, the population parameters of the South Atlantic albacore stock were approximated. From a linear relationship between fishing effort and reciprocals of CPUE in an equilibrium state, and the ratio of the actual catch to an expected equilibrium catch, approximations of R, M and q were obtained as 1,901,000, 0.475 and 1.335 by iteration, respectively. However, more close examination is needed on these values.

RESUME

Les paramètres de population du stock de germon de l'Atlantique Sud sont estimés par approximation à partir de données palangrières de capture et d'effort de 1956 à 1967 et de la structure démographique annuelle de la prise palangrière japonaise de 1962 à 1967. Une relation linéaire entre l'effort et les valeurs réciproques du CPUE en conditions d'équilibre, ainsi que la proportion entre la prise actuelle et la prise équilibrée escomptée, ont permis d'obtenir par itération des valeurs approximatives de R (1.901.000), M (0,475) et q (1,335). Ces valeurs doivent cependant faire l'objet d'une étude plus approfondie.

RESUMEN

Presenta un cálculo aproximado de los parámetros de población del stock de atún blanco en el Atlántico Sur, basado en los datos de captura y esfuerzo de la pesquería palangrera (1956-1967) y en composiciones por edad, anuales, de las capturas palangreras de Japón (1962-1967). Partiendo de una relación lineal entre esfuerzo y valores recíprocos de la CPUE en condiciones de equilibrio, y de la proporción de captura real en relación con la captura equilibrada en perspectiva, se obtienen, por iteración, las aproximaciones siguientes: R = 1.901.000; M = 0,475; q = 1,335. Sin embargo, es necesario profundizar en el estudio de estos valores.

1 Method

The southern stock of albacore in the Atlantic Ocean has been mainly utilized by Taiwanese, Korean and Japanese longline fishery. Since the late 1960's, the albacore catch by the Japanese fleet has declined gradually and the Taiwanese and Korean catches have increased rapidly. Utilizing the catch and effort data from the Japanese fishery before 1967 when the Taiwanese and Korean fleets did not operate yet so actively, approximate estimates of population parameters on the South Atlantic albacore were obtained.

These parameters were estimated using the Suda's method[1/] summarized as follows;

$$\bar{C} = \frac{F}{Z} R$$

$$\frac{1}{\bar{C}} = \frac{Z}{FR} = \frac{qf+qm}{qfR}$$

$$\frac{f}{\bar{C}} = \frac{f}{R} + \frac{m}{R}$$

R : recruitment at the first capture
$\bar{C}$: equilibrium catch
F : fishing mortality coefficient
Z : total mortality coefficient
q : catchability
q × m = M : natural mortality coefficient

This means that a linear relationship is expected between fishing effort and reciprocals of CPUE in an equilibrium state.

So,

$$\frac{f}{\bar{C}} = A + Bf \quad \text{----------(1)}$$

where, $\frac{m}{R} = A$ and $\frac{1}{R} = B$

If the catch and effort data are available, A and B, as well as R and m (=M/q) could be obtained. And then, if there is another information on a relationship between q and M, either one of their approximate values would be obtained.

On the other hand, the ratio of the actual catch (C_t) to an expected equilibrium catch ($\bar{C}_t$) under effort (f_t) in t-th year is given as following equation.

$$\frac{\bar{C}_t}{C_t} = \frac{\frac{qf_tR}{Z_t}}{\frac{qf_tR}{Z_t}(1-e^{-Z_t})\left[1+e^{-Z_{t-1}}+e^{-(Z_{t-1}+Z_{t-2})}+e^{-(Z_{t-1}+Z_{t-2}+Z_{t-3})}+\text{-----}\right]}$$

$$= \frac{1}{(1-e^{-Z_t})\left[1+e^{-Z_{t-1}} + e^{-(Z_{t-1}+Z_{t-2})} + e^{-(Z_{t-1}+Z_{t-2}+Z_{t-3})} + \cdots\right]} \quad \cdots\cdots(2)$$

Calculating procedure is as follows ;

i) Using the equation-(1), R and m are estimated from the regression of C_t and f_t.

ii) First approximations of q and M are estimated from m, if a relationship between q and M is known from other sources.

iii) Z_t is calculated from f_t, q and M, and $\bar{C}_t/C_t$ is estimated by equation-(2).

iv) $\bar{C}_t/C_t$ multiplied by C_t makes first approximation of $\bar{C}_t$.

v) Second approximations of R and m are obtained from first approximater values of $\bar{C}_t$ and f_t by the same procedure as that for the first one.

vi) Iteration is continued until the last approximations of R, M and q get close enough to those of the preceding approximations.

2 Basic data

Considering to Morita's ms[2/] otherwise written, Shiohama (unpublished) estimated the Japanese longline catches and effective efforts for the adult albacore stock and whole one in the South Atlantic Ocean on a quarterly basis. These annual estimates are shown in Tables 1 and 2. Based on the Morita's result[2/], the age frequencies were estimated as shown in Table 1.

3 Relation between q and M

An average total mortality coefficient was given from the data on catch by age and effort from 1962 through 1967, when the albacore stock was considered to be in an almost steady state.

$$S = \frac{\sum_{i=2}^{6}\sum_{n=8}^{11} \frac{C_{in}}{f_i}}{\sum_{i=1}^{5}\sum_{n=7}^{\omega} \frac{C_{in}}{f_i}}$$

S : average survival rate

C_{in} : catch of n year old fish in i-th year from 1962 to 1967

$$= e^{-Z} = 0.447$$

$$Z = 0.805$$

On the other hand,

$$\bar{f} = \frac{1}{6}\sum_{i=1}^{6} f_i = 2{,}469 \times 10^4$$

Then, the following relationship was obtained.

$$0.805 = 0.247\ q + M \quad \text{---------- (3)}$$

(q : per 10^8 hooks)

4 First approximations

From Table 2, the regression of f_t/C_t on f_t from 1958 through 1967, during which the southern Atlantic albacore was harvested solely by the Japanese fishery, was calculated as follows ;

$$\frac{f}{C} = 0.399\ f + 0.1926 \quad \text{-------- (see Fig. 1)}$$

(f : 10^8 hooks, C : 10^6 fish)

viz. A = 0.1926, B = 0.399

Then, R = 2.505 ($\times 10^6$)

$$n = M/q = 0.4825 \quad \text{---------- (4)}$$

From equations-(3) and -(4), q = 1.1035, M = 0.532.

Using these values of q and M, $\overline{C}_t/C_t$ are obtained by equation-(2), and first approximation of $\overline{C}_t$ was estimated by multiplying C_t to $\overline{C}_t/C_t$.

5 Results of iteration

By iterating the same procedure as that for the first approximation, successive approximate estimates of R, q and M were obtained. After the fifth approximation, R, M and q reached almost same values as given in Table 3. Fig. 2 shows reciprocals of the sixth approximation of CPUE plotted against f. The resultant estimates for albacore in the South Atlantic Ocean are 1,901,000 fish, 0.475 and 1,335 per 10^8 hooks for R, M and q, respectively. Fig. 3 shows sustainable catch curve calculated from final estimates of R, M and q, and actual status of yearly fishery.

6 Some considerations

This method holds under the assumption that R and M are constant. However, it seems that more close examination is needed since there are some suggestions on the fluctuation of year classes and age dependent M[3]. Especially, the first approximation of Z estimated here was that from data on albacore older than 6 years, so it seems that value of M is slightly overestimate as an average value for fish including younger ages.

References

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

2) Morita, S. : Estimated age compositions of albacore harvests by Japanese and Taiwanese longline fisheries in the Atlantic Ocean. MS SCRS/ICCAT (1976).

3) Suda, A. : Recent status of resources of tuna exploited by longline fishery in the Indian Ocean. Far Seas Fish. Res. Lab., Bull. 10, 27-62. (1974).

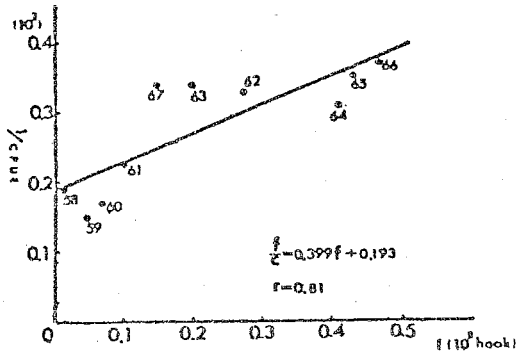

Figure 1 Reciprocal of CPUE plotted against number of effective hooks for the South Atlatic albacore.

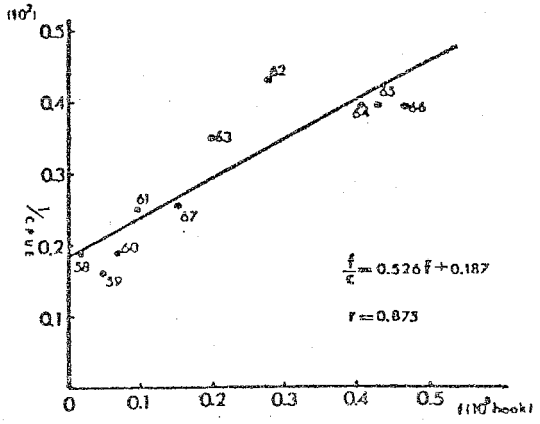

Figure 2 Reciprocal fifthly corrected CPUE plotted against number of effective hooks for the South Atlantic albacore.

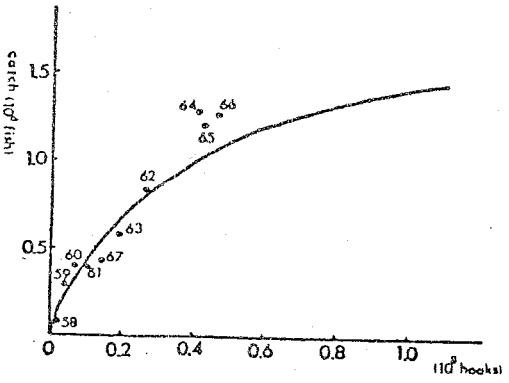

Figure 3 Sustainable catch curve calculated employing the estimates of R, M and q for the South Atlantic albacore and plotted actual yearly catches.

Table 1 ; Annual catch by age and effective effort for albacore in the provided area that adult fish distribute mostly in the South Atlantic Ocean. (from Shiohama and from Morita)

Year	Catch in number by age (10^3)										Effective effort (10^4)
	4	5	6	7	8	9	10	11	12-	Total	
1962	1.0	34.6	185.5	284.1	178.2	68.8	16.9	3.1	1.4	773.6	3110.2
1963	0.6	23.1	123.0	185.5	121.4	46.8	11.5	2.1	1.0	518.0	2132.2
1964	1.3	44.4	238.4	364.9	225.0	86.9	21.3	4.0	1.8	988.0	3928.0
1965	0.9	25.1	137.2	209.5	114.1	34.2	10.9	2.2	0.9	535.0	2682.4
1966	0.5	16.5	88.2	135.0	84.1	32.5	8.0	1.5	0.7	367.0	2103.8
1967	0.2	7.1	38.4	58.7	34.2	13.2	3.3	0.6	0.3	156.0	856.7

Table 2

Numbers of effective hooks, albacore catch and reciprocal of CPUE for the Japanese longline fishery in the South Atlantic Ocean from 1956 to 1967.

(from Shiohama -unpublished-)

Year	Effective effort (10^4)	Catch (10^3)	$\frac{1}{\text{cpue}}$ (10^2)
1956	3.4	1.0	0.35
1957	57.5	26.6	0.22
1958	101.5	52.3	0.19
1959	454.6	297.5	0.15
1960	678.0	400.2	0.17
1961	943.9	413.0	0.23
1962	2733.8	827.0	0.33
1963	1987.4	589.2	0.34
1964	4087.8	1297.9	0.31
1965	4285.3	1214.1	0.35
1966	4637.9	1267.7	0.37
1967	1487.5	436.7	0.34

Table 3 Estimations of R, M and q of the South Atlantic albacore stock.

Operation No.	R (10^6)	M	q
1	2.505	0.5325	1.1037
2	1.973	0.4815	1.3103
3	1.908	0.4760	1.3326
4	1.902	0.4755	1.3347
5	1.901	0.4754	1.3348
6	1.901	0.4754	1.3349