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ASSESSMENT OF THE SOUTH ATLANTIC ALBACORE RESOURCE BY USING SURPLUS PRODUCTION MODELS, 1967-88

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SUMMARY

Surplus production models were adopted to assess the status of the south Atlantic albacore resource. Abundance indices of the stock are derived from the 1967-1988 catch and effort statistics of Taiwan longline fishery by using Honma's algorithm. The results obtained are as follow: (1) a generalized production model with parameter m equals 1.001 and significant year class k equals 3 appeared to be the best fit of the data set; (2) the MSY of the resource was estimated at about 27,300 MT per year.

The current catch level (around 25.9 thousand MT in 1988) is near the estimated MSY while the current effort level was near the estimated optimum fishing level producing the MSY. Since catch level has been approaching the maximum potential yield of the stock in the mid-1980s, it is hence suggested that a careful monitoring of the fishery be continued.

RESUME

Des modèles de production excédentaire ont été adoptés pour évaluer l'état des ressources en germon sud-atlantique. Des indices d'abondance du stock sont calculés à partir des statistiques 1967-88 de prise et effort de la pêcherie palangrière taiwanaise en utilisant l'algorithme de Honma. Les résultats obtenus sont comme suit: (1) un modèle de production généralisé, avec un paramètre m égal à 1.001 et une classe annuelle significative k égale à 3, semble donner le meilleur ajustement du jeu de données; (2) la PME des ressources a été estimée à environ 27.300 TM par an.

Le niveau actuel des prises (environ 25.9 milliers de TM en 1988) se trouve aux alentours du niveau estimé de la PME, alors que le niveau actuel de l'effort se situe autour du niveau optimal de pêche donnant la PME. Du fait que le niveau des prises était proche au milieu des années quatre-vingt de la production maximale potentielle du stock, on suggère ici de continuer de suivre de près la pêcherie.

RESUMEN

Se emplearon modelos de producción excedente para evaluar la situación de los recursos de atún blanco en el Atlántico sur. Los índices de abundancia del stock se derivan de las estadísticas de captura y esfuerzo de la pesquería palangrera de Taiwan en el periodo 1967-1988, aplicando el algoritmo de Honma. Los resultados obtenidos son los siguientes: (1) el mejor ajuste del conjunto de datos parecía ser un modelo del modelo de producción generalizado con m = 1001 y una importante clase de edad k = 3; (2) el RMS del recurso se estimó en 27300 t anuales.

El nivel actual de captura (unas 25.9 miles de t en 1988) se alcanza cerca del RMS estimado, mientras que el nivel de esfuerzo actual era aproximadamente el nivel óptimo de pesca estimado para obtener el RMS. Dado que el nivel de captura se acercó a mediados de los años 80 al rendimiento potencial máximo del stock, se sugiere continuar una cuidadosa vigilancia de la pesquería.

INTRODUCTION

It has recognized that there are two distinct albacore stocks in the Atlantic Ocean segregated at the 5 degree N latitude (Yang et al. 1969; Yang 1970; Bartoo 1979; Yang & Sun 1983). Southern stock of albacore (Thunnus alalunga) is one of the most abundant and economically important tunas resources in the south Atlantic.

Japanese longliners began in the early 1950s exploiting south Atlantic albacore resouce yet has switched target species to bigeye and bluefin tunas since early 1970s. Taiwanese longliners started early 1960s fishing in the south Atlantic for tunas resources and became targetting on albacore since late 1960s. The longline fishery developed rapidly in the early years yet has remained fairly steady level since mid 1970s. Taiwanese catch of albacore, which composed the majority of harvested albacores in the south Atlantic, ranged from 15 to 38 thousand mt in the past two decades.

Since early 1970s, the south Atlantic albacore resource were essentially fished by Taiwanese longliners except that the emergence of south African bait boat fishery started mid 1980s taking mainly surface juvenile albacores. Catch and effort statistics of Taiwanese longline fishery therefore have become one of the most indispensable data sets to assess the status of the stock. Several studies on the assessment of south Atlantic albacore stock condition have already been carried out based on the data set (Yang & Sun 1983; Liu 1985; Yeh & Liu 1988). Main purpose of this study is thus to assess the stock by using the updated 1967-1988 catch and effort data series.

MATERIALS AND METHODS

ICCAT Statistical Bulletins (1967-1988) are the major souce of data for annual catch and nominal effort statistics of south Atlantic albacore fisheries. Detailed catch and effort data, compiled by five-degree-square-block and by month, of 1967-1988 Taiwanese longline fishery were the major source of data for effective effort analyses in this study.

Because albacore caught by longliners comprised the majority of total albacore landings from the south Atlantic, catch per unit effort derived from longline fishery was thus adopted as the relative abundance index of the resource. Effective longline fishing efforts were derived by using Honma's algorithm (Honma 1973).

Pella and Tomlinson (1969) suggested the generalized form of production model for a single-species system as follow:

$$dP/dt = H\,P(t)^{m} - K\,P(t) - q\,f(t)\,P(t)$$

where P(t) is the population size at time t;
H, K, m are constant parameters and H, K must be positive when m < 1, or H, K must be negative when m > 1;
q is the catchability coeffficient;
f(t) is the fishing effort standardized to be proportional to its fishing mortality rate.

At equilibrium situation; we can get:

$$Y = qf\left(\frac{qf + K}{H}\right)^{1/(m-1)} = f(a+bf)^{1/(m-1)} \qquad (1)$$

$$U = Y/f = q\left(\frac{qf + K}{H}\right)^{1/(m-1)} = (a+bf)^{1/(m-1)} \qquad (2)$$

where Y is the equilibrium yield;
U is the equilibrium catch per unit effort;
a and b are parameters from recombinations of H, K, and q.

Following formulas, which are mathematically obtainable by differentiating equation (1) with respect to f, are particularly useful for the fisheries managerial sector:

$$fopt = \frac{K(1-m)}{mq} = a\left(\frac{1}{m} - 1\right) / b \qquad (3)$$

$$Uopt = \left(\frac{qK}{Hm}\right)^{1/(m-1)} = (a/m)^{1/(m-1)} \qquad (4)$$

$$Ymax = MSY = fopt{*}Uopt = H\left(\frac{K}{mH}\right)^{m/(m-1)} - K\left(\frac{K}{mH}\right)^{1/(m-1)}$$

$$= (m)^{1/(1-m)}\, a^{m/(m-1)} \left(\frac{1}{m} - 1\right)/b \qquad (5)$$

Where fopt is the optimum fishing efffort required to produce the maximum sustainable yield Ymax; and Uopt is catch per unit effort at catch level of Ymax.

For better expressing the concept of equilibrium, a method of averaging fishing effort through a period of years was as follow:

$$\bar{f}_i = (k f_i + (k-1).f_{i-1} + ... + f_{i-k+1}) \;/\; (k + (k-1) + ... + 1)$$

where k is the number of year classes which contributed most significantly to total catch of the i-th year. The number of significant year classes which would have contributions to the present catch was considered to be 3 to 4 (Bartoo & Coan 1983).

RESULTS

Catch and Catch Rate

The catch level of south Atlantic albacore appeared at 25-30 thousand mt per year in the years of 1967 to 1973. The catch trend in the period of 1974-1989 appeared to be fairly stable, i.e., fluctuated between 20 and 25 thousand mt, except that (1) catch level lowered to about 15 thousand mt in the years of 1983-1984; and (2) catch level increase to about 35 thousand mt in the years of 1986-1987. Catch level slided again to about 25 thousand mt per year in the past couple of years (Table 1).

Effective effort rose rapidly from 1968 and reached its high value of about 99 million effective hooks in 1973, and then fluctuated between 60 to 80 million effective hooks in the years of 1974 to 1981, and increased to 110 million effective hooks in 1982. In 1983 and 1984, however, effective hooks droped to about 50 million but rose again to levels of about 110-130 million effective hooks since 1985 (Table 1).

CPUE (number fish/100 effective hooks) trends shown in Figure 1 were derived from 3 different standard years period (1967-1977, 1978-1988, and 1967-1988) as requested by Honma's method. The results indicate that (1) CPUE trends derived from 3 standard years period appeared very similar in tendency; (2) the standard years periods of more fishing area coverages tends to have closer relationship in CPUE trends.

Chosen 1967-1988 period as the standard years, CPUE1 (number of albacore caught/100 effective hooks) and CPUE2 (Kg caught/100 effective hooks) thus obtained can be viewed as a relative abundance indicator of the resource. As shown in Table 1, both CPUE1 and CPUE2 have revealed a similar trend. Relative stock abundance appeared decreasimg rapidly from late 1960s until mid 1970s then stablized at about 3 fishes per 100 effective hooks or 40 Kg per 100 effective hooks upto 1986. Catch rate, however, appeared a decline trend in the past couple of years.

Production Models Analyses

Catch and effective effort statistics of the South Atlantic albacore fisheries (Table 1) were analyzed by using surplus production models. The best fit obtained from these models appeared that when m value equals 1.001 and the significant year class k value set to 3. The surplus curve thus derived is shown in Figure 2. Maximum potential yields of the stock, taking 1967-1988 as the standard years, are estimated about 27,300 mt per year and the correstponding optimum fishing efforts were estimated as 134 million effective hooks per year.

DISCUSSION

It has well acknowledged that surplus production models are among the simplest and most widely used approaches in the assessment of exploited fish populations. Despite that requirements as (a) fishing capabilities remain constant and (b) there is an immediate responsive mechanism of the stock against enviromental stress are generally difficult to verify, it is still the authors' viwepoint that production models will continue for some time to serve as a basis for management of important fish stocks of the world's fisheries. Particularly when information as fisheries biological charcteristcs and fishing activities is still in rather poor situation.

Honma's algorithm in effort standardization has been adopted for many years as one of the standard methods for evaluating tuna stocks in the Atlantic Ocean. Previous studies on the status of south Atlantic albacore resource have all employed the algorithm (Shiohama 1977, 1978, 1979; Bartoo & Coan 1983; Yang & Sun 1984; Liu 1985; Yeh & Liu 1987 and 1988). Honma's algorithm although required certain period as the standard years, the results from this study indicate that the effect of chosen standard years may not adversely affect the output of the production analyses.

The current catch level (25.9 thousand mt in 1988) is slightly less than the lower boundary of predicted equilibrium MSY and the current effort level is close to the optimum fishing effort that producing the equilibrium MSY. The status of the south Atlantic albacore stock, judged by present study, appears that the harvest rate of the stock has approaching MSY level in mid 1980s. It is thus recommended that a closely monitoring on status of the stock should be continued.

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Table 1.Catch and effective effort analyses of the south Atlantic albacore fisheries based on the Taiwanese longline fishery data in the south Atlantic Ocean, 1967-1988.

Year	Taiwan Longline Fishery					All Fisheries	
	Catch in Number (x1000)	Mean Wt./ fish (Kg)	Nominal Effort (x100000 Hooks)	Catch in Number Per 100 Effect. Hooks	Catch in Kg Per 100 Effective Hooks	Catch in Weight x1000 (mt)	Effective Effort (x100000 Hooks)
1967	40.6	14.2	9.54	4.25	60.4	15.90	272.90
1968	722.2	15.1	198.06	3.65	55.1	25.70	395.88
1969	849.8	16.4	266.19	3.19	52.3	28.50	593.42
1970	672.4	16.8	210.13	3.20	53.7	23.65	510.30
1971	1273.6	15.6	366.08	3.48	54.3	25.02	465.55
1972	1209.6	15.0	411.18	2.94	44.1	33.26	948.77
1973	1098.8	14.9	413.59	2.66	39.6	28.23	994.40
1974	973.5	15.6	350.01	2.78	43.4	19.70	620.78
1975	1031.6	13.3	309.55	3.33	44.3	17.53	544.72
1976	919.3	14.8	316.19	2.91	43.0	19.25	678.83
1977	1063.4	14.2	309.45	3.44	48.8	21.59	684.42
1978	1430.4	13.6	401.26	3.57	48.6	23.04	765.83
1979	1049.5	14.7	323.05	3.25	47.8	22.55	774.87
1980	1080.6	15.1	327.02	3.30	49.8	22.49	706.65
1981	1102.3	14.4	391.97	2.81	40.5	23.59	859.54
1982	1310.8	13.7	458.50	2.86	39.2	29.10	1121.66
1983	625.4	14.9	218.96	3.17	47.2	14.36	549.18
1984	531.2	13.9	167.85	2.84	39.5	13.15	431.23
1985	1356.7	13.7	477.65	2.95	40.4	28.40	1121.52
1986	2015.5	14.3	682.22	2.84	40.6	34.60	1253.68
1987	2006.2	14.9	865.30	2.32	34.6	37.50	1677.33
1988	1381.5	14.4	720.68	1.92	27.6	25.90	1385.53

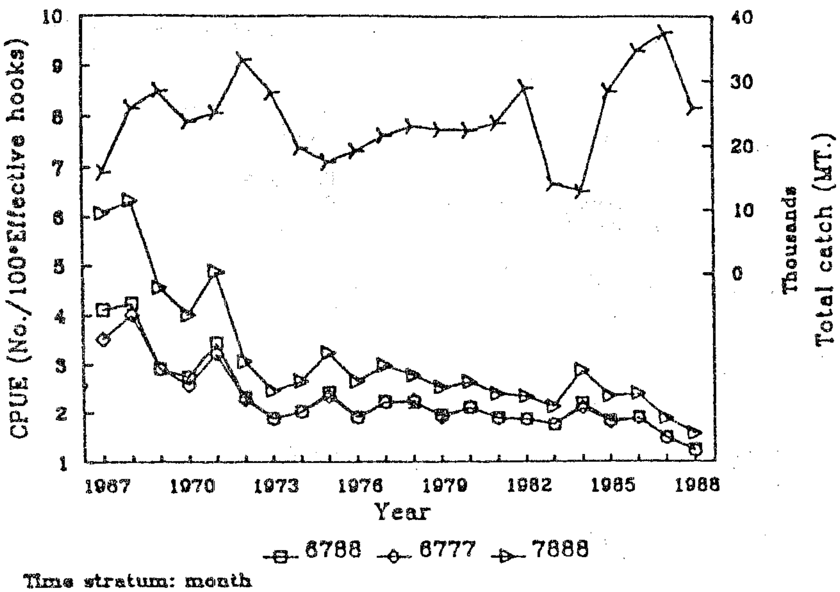

Fig. 1. Trends of annual catch and CPUEs (no. fish caught/100 effective hooks) derived from standard years of 1967-77, 1977-88, and 1967-88.

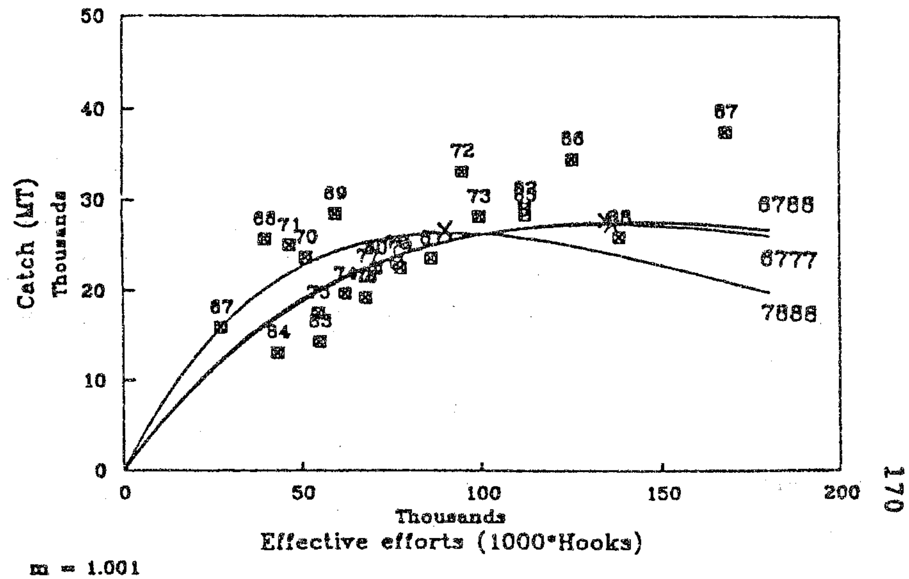

Fig. 2. Equilibrium yield curves derived from standard years of 1967-77, 1977-88, and 1967-88.