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ASSESSMENT OF THE SOUTH ATLANTIC ALBACORE RESOURCE BY USING SURPLUS PRODUCTION MODELS, 1967-1988

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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 1967-1988 catch and effort statistics of the Taiwan longline fishery by using Honma's algorithm. The results obtained are as follow: (1) a generalized production model where parameter m equals 1.021 and significant year class k equals 4 appeared to be the best fit of the data set; (2) the MSY of the resource was estimated to be in the range of 27-31,000 MT per year.

The current catch level (about 24,000 MT in 1987) is within the lower bound of the estimated MSY while the current effort level was about the estimated optimum fishing level of producing the MSY. Since the catch level has approached the maximum potential yield of the stock in the mid-1980's, it is hence suggested that a careful monitoring of the fishery should be continued.

RESUME

Des modèles de production excédentaire ont été adoptés pour évaluer l'état des ressources en germon de l'Atlantique sud. Les indices d'abondance du stock sont calculés au moyen de l'algorithme de Honma à partir des statistiques 1967-88 de prise et effort de la pêcherie palangrière taiwanaise. Les résultats obtenus sont comme suit: (1) un modèle de production généralisé dans lequel le paramètre m = 1.021 et la classe annuelle significative k = 4 semble être le meilleur ajustement du jeu de données; (2) la PME de la ressource a été estimée se situer dans la gamme des 27-31.000 TM/an.

Le niveau actuel des prises (environ 24.000 TM en 1987) est de l'ordre de la limite inférieure de la PME estimée, alors que le niveau actuel d'effort se situe aux alentours du niveau optimum estimé de pêche qui donne la PME. Le niveau des prises s'étant rapproché au milieu des années quatre-vingt de la production potentielle maximale du stock, il est suggéré de continuer à suivre de près la pêcherie.

RESUMEN

Se adoptaron modelos de producción excedente para evaluar la condición del atún blanco del Atlántico Sur. Los índices de abundancia del stock se derivan de las estadísticas de captura y esfuerzo de la pesquería de palangre de Taiwan en el periodo 1967-88, por medio del algoritmo de Honma. Los resultados obtenidos son: (1) el mejor ajuste del conjunto de datos era un modelo de producción generalizado con el parámetro m = 1.021 y una importante clase anual k = 4; (2) el RMS del recurso se estimó entre 27.000 y 31.000 t por año.

El nivel actual de captura (unas 24.000 t en 1987) se encuentra en el nivel inferior del RMS estimado, mientras que el esfuerzo se encuentra cerca del nivel de pesca óptimo estimado para obtener el RMS. Dado que el nivel de captura se acercaba al rendimiento máximo potencial del stock a mediados de la decada de los años 80, se sugiere que se continúe vigilando atentamente la pesquería.

INTRODUCTION

It has believed that there are two distinct albacore stocks in the Atlantic seperated by 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 tuna species in the south Atlantic. Japanese longliners began exploiting the resouce since early 1950s. The fleet, however, switched targetting bigeye and bluefin since early 1970s. Taiwanese longliners started fishing for tunas in south Atlantic since early 1960s and became targetting albacore since late 1960s. The fishery developed rapidly in the early years and remained fairly steady since mid 1970s. Taiwanese catch, which composed the majority of the total albacore caught in south Atlantic, of albacore ranged from 15 to 25 thousand mt in the past two decades.

Since early 1970s, the south Atlantic albacore was essentially fished by the Taiwanese longliners except south African bait boat fishery started exploiting surface albacore since mid 1980s. Catch and effort statistics of Taiwan longline fishery therefore are one of the most important data sets to assess the status of the stock. Several studies (Yang & Sun 1983; Liu 1985; Yeh & Liu 1987; Yeh & Liu 1988) have been already carried out based on the data set. Main purpose of this study is thus to assess the stock condition by analyzing the updated 1967-1988 catch and effort data series.

MATERIAL AND METHOD

ICCAT Statistical Bulletins (1967-1987) 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 always comprised the majority of total albacore landings from the south Atlantic albacore fisheries, catch per unit effort derived from longline fishery was thus used as the relative abundance index of the resource. Effective longline fishing effort was derived, based on the Taiwan longline fishery data, 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:

$$dP/dt = HP^{m}(t) - KP(t) - qf(t)P(t)$$

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 then have:

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

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

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

Formulas having fishery management interest are, obtainable by differentiating equation (1) with respect to f, as follow:

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

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

$$Ymax = MSY = fopt.Uopt = H\left(\frac{K}{mH}\right)^{m/(m-1)} - K\left(\frac{K}{mH}\right)^{1/(m-1)}$$
$$= (m)^{1/(1-m)}\, a^{m/(m-1)} \left(\frac{1}{m} - 1\right)/b \quad (5)$$

where fopt is the optimum fishing efffort required to produce the maximum sustainable yield Ymax;
Uopt is catch per unit effort at point Ymax.

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

$$\bar{f}i = (kfi + (k-1).fi-1 + \ldots + fi-k+1) / (k + (k-1) + \ldots + 1)$$

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 class which would have contributions to the present catch was set to be 3 and 4 (Bartoo & Coan 1983).

RESULTS

Catch and Catch Rate

Annual catch of albacore from south Atlantic fluctuated between 20 thousand mt and 34 thousand mt during the years 1967 to 1973. It become fairly stable between 18 thousand mt and 28 thousand mt during the period 1974 to 1986, except catch of 1983 and 1984 were about 14 thousand mt. Catch slightly decreased to about 24 thousand mt in 1987 (Table 1).

Effective effort rose rapidly from 1968 and reached its high value of about 87 million effective hooks in 1972, and then fluctuated between 50 to 70 million effective hooks in the years of 1974 to 1981, and increased to 91 million effective hooks in 1982. In 1983 and 1984, however, effective hooks droped to about 50 million but rose again to a level of about 90-100 million effective hooks since 1985 (Table 1).

CPUE1 (no. 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 Fig. 1, both CPUE1 and CPUE2 have revealed a similar trend. The stock abundance appeared decreasimg rapidly from late 1960s until mid 1970s then stablized at about 35 Kg per 100 effective hooks upto present; although it appeared a slightly decreasing 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 were that when m value equals 1.021 and the significant year class k value set to 4. The surplus curve thus derived is shown in Figure 2. The estimated maximum potential yield of the stock were 27-31,000 mt per year and the correstponding optimum fishing efforts were about 100 million effective hooks per year.

DISCUSSION

It has well aknowledged that 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.

The SCRS of ICCAT also considered production model analysis to be 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 production models (Shiohama 1977, 1978, 1979; Bartoo & Coan 1983; Yang & Sun 1984; Liu 1985; Yeh & Liu 1987 and 1988).

The current catch level (24 thousand mt in 1987) 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 al fisheries based on the Taiwanese longline fishery data in th 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)	Effecti Effort (x1000 Hooks
1967	11.6	11.8	2.47	4.06	62.4	19.80	317.19
1968	196.5	14.2	4.52	4.94	78.6	27.84	354.27
1969	261.5	15.7	69.11	3.45	55.6	34.56	621.59
1970	245.7	15.7	72.73	3.10	45.9	23.65	515.39
1971	1266.0	15.2	312.79	3.95	58.0	25.06	431.88
1972	1209.1	14.7	375.68	2.46	38.2	33.20	870.32
1973	1092.0	13.8	376.07	2.24	33.7	28.23	837.14
1974	934.2	14.5	334.49	2.41	37.8	19.70	520.92
1975	1029.3	14.6	289.85	2.74	41.7	17.53	420.39
1976	1500.5	12.8	418.39	2.74	37.9	19.25	508.60
1977	1491.1	14.4	414.64	2.65	40.9	21.57	527.85
1978	1779.9	13.8	487.96	2.48	37.4	23.05	616.56
1979	1076.0	13.6	331.53	2.25	34.1	22.51	660.41
1980	1092.2	14.7	339.54	2.43	37.4	22.49	602.17
1981	1119.1	15.0	396.72	2.21	34.0	23.59	694.01
1982	1320.0	14.4	476.61	2.10	32.0	28.96	905.14
1983	634.6	13.7	223.90	1.82	26.9	14.40	535.24
1984	535.8	14.9	168.61	2.60	36.6	13.15	359.73
1985	1365.5	13.9	481.75	2.08	30.0	28.40	946.10
1986	1532.0	13.5	499.07	2.12	31.0	28.13	906.63
1987	1128.7	13.9	464.05	1.57	23.3	23.97	1028.05
1988	1415.1	13.8	757.08	1.37	21.3	*21.06	986.93

*: Only Taiwanese data is used.

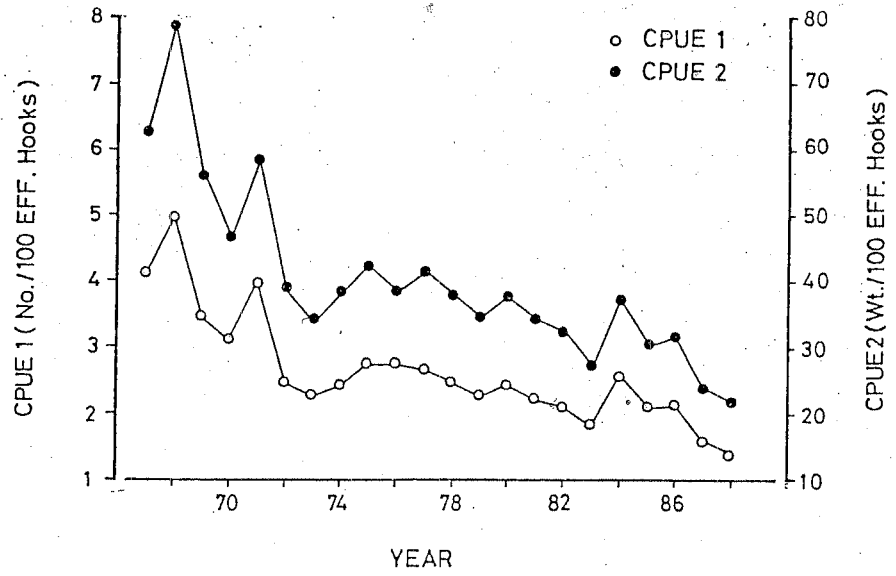

Fig. 1. Trends of annual CPU1 (in no. fish caught/100 effective hooks) and CPU2 (in weight caught/100 effective hooks) of south Atlantic albacore in 1967-1988.

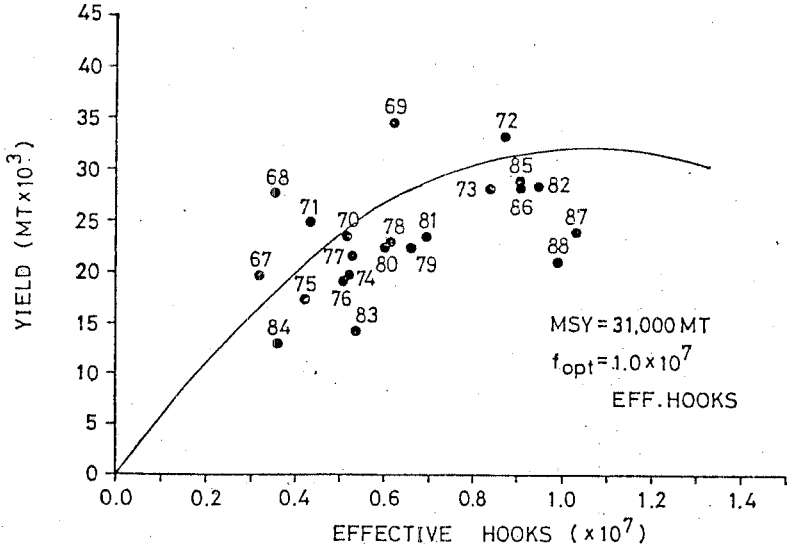

Fig. 2. Equilibrium yield curve and the observed data for south Atlantic albacore fisheries, 1967-1988.