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STOCK ASSESSMENT OF SOUTH ATLANTIC ALBACORE BY USING PRODUCTION MODEL ANALYSIS, 1967-1987

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SUMMARY

This paper deals with stock assessment of the south Atlantic albacore resource by using surplus yield models to analyze 1967-1987 catch and effort statistics. Effective effort analyses were primarily based on the Taiwanese longline fishery data and assumed that the rest of the albacore caught can be expressed in terms of the equivalent Taiwanese longline effort. The results obtained are as follow: (1) a generalized production model where parameter m = 2.00 and significant year class k = 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 25,650 - 28,500 MT per year.

The current catch level (about 25,600 MT in 1986) is in the lower bound of the estimated MSY while the current effort level was about 10 percent higher than the estimated maximum level of producing the MSY. It is suggested that the stock has been reaching its maximum yield phase since early 1980's and hence carefully monitoring of the fishery should be continued.

RESUME

Ce document traite de l'évaluation du stock de germon de l'Atlantique sud en utilisant les modèles de rendement excédentaires pour analyser les statistiques de prises et effort de 1967-1987. Les analyses de l'effort effectif sont principalement basées sur les données de la pêcherie palangrière taiwanaise et il est supposé que le reste des prises de germon capturées peut être exprimé en terme de l'équivalence de l'effort palangrier taiwanais. Les résultats obtenus sont les suivants: (1) un modèle de production généralisé avec un paramètre m = 2.00 et une classe d'âge significative k = 4 semble le meilleur ajustement du jeu de données; (2) la PME de la production est estimée se situer dans la gamme de 25.650 - 28.500 TM par an.

Le niveau actuel des prises (environ 25.600 TM en 1986) se situe dans la limite inférieure de la PME estimée alors que le niveau actuel de l'effort représente environ 10% de plus que le niveau maximum estimé produisant la PME. Il est suggéré que le stock a atteint son state maximum de production depuis le début des années 80 et que, par conséquent, un suivi de la pêcherie devrait se poursuivre.

RESUMEN

Este documento trata sobre la evaluación del stock de atún blanco del Atlántico Sur, utilizando modelos de producción excedente para analizar las estadísticas de captura y esfuerzo 1967-1987. Los análisis de esfuerzo efectivo se basaron principalmente en los datos de la pesquería de palangre de Taiwan, asumiendo que el resto de atún blanco capturado puede expresarse en términos del esfuerzo equivalente de palangre de Taiwan. Los resultados obtenidos son: (1) un modelo de producción generalizado con el parámetro m igual a 2.00 y una importante clase de edad k igual a 4 pareció ser el mejor ajuste del conjunto de datos; (2), se estimó que el RMS del recurso se hallaba en el rango de 25.650 - 28.500 t/año.

El nivel actual de captura (unas 25.600 t en 1986) se encuentra en el límite inferior del RMS estimado, mientras que el nivel de esfuerzo actual se halla un 10% por encima del nivel máximo estimado de producción del RMS. Se sugiere que el stock ha estado alcanzando su fase de rendimiento máximo desde principios de los años 80, y por ello se debería continuar un cuidadoso seguimiento de la pesquería.

INTRODUCTION

Albacore (Thunnus alalunga) is one of the most abundant and economically important tuna species in Atlantic Ocean. In early 1950s, the resource began under industrial exploitation pioneered by Japanese longliners. Since early 1970s, however, Japanese fleet gradually switching their target species from albacore to bigeye and bluefin tunas. Taiwanese longliners ventured tunas fishing since mid 1960s and have developed the major longline fleet targetting on the albacore resource. In 1986, e.g., the albacore harvested by Taiwanese fleet comprised 85% of the total albacore caught in the Atlantic. In recent years, however, the bait boat and the purseiner fisheries developed in Atlantic Ocean have also taken sizable amount of smaller albacore in the surface layer.

Albacore resource in Atlantic Ocean is believed to be two distinct and separate stocks by the 5°N latitude (Yang et al. 1969; Yang 1970; Bartoo 1979; Yang & Sun 1983). The southern stock was since early 1970s being primarily utilized by Taiwanese longliners (Liu 1985; Yeh & Liu 1987). Fisheries scientists of the Standing Committee on Research and Statistics (SCRS) of the International Commission for the Conservation of Atlantic Tunas (ICCAT) have expressed concerns about the ability of Atlantic tuna stocks to sustain the high catch level since mid 1970s. The south albacore stock is one of the stocks they are concerned and hence have led to previous analyses on stock status of the south Atlantic albacore resource (Shiohama 1977, 1978, 1979; Bartoo & Coan 1983; Yang & Sun 1983; Liu 1985; Liu & Yeh 1987).

Main purpose of this study is thus to assess current status of the south Atlantic albacore resource by adopting the surplus yield analyses on the updated 1967-1987 catch and standardized fishing effort data.

MATERIAL AND METHOD

ICCAT Statistical Bulletins (1967-1987) are the major souce of data on annual catch and nominal effort statistics of south Atlantic albacore fisheries. Detailed catch and effort data, compiled by locality and by month, of (1) 1967-1987 Taiwanese longline fishery and (2) 1967-1985 Japanese and Korea longline fisheries, provided by the ICCAT secretariate, were the major source of data for effective effort analyses in this study.

Regarding that albacore caught by longliners always comprised a 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 expressed as effective hooks were derived based on the Taiwanese 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 coefficient;
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.

Equations (1) and (2) are usually referred as asymptotic model when m equals 0, as Gompertz model or exponential model when m approaches 1 but not equals 1 (Fox 1970), and as logistic model when m equals 2 (Schaefer 1954, 1957).

For better expressing the concept of equilibrium, a method of averaging fishing effort through a period of years was proposed by Gulland (1961, 1969) as follow:

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

where k is the number of year classes which contributed most significantly to total catch of the i-th year.

Three forms of production models, i.e., when m=0.0, 1.001 and 2.0, was adopted to fit the catch and effort data of the south Atlantic albacore fisheries. The number of significant year class which would have contributions to the present catch was set set to be 3 and 4 (Bartoo & Coan 1983).

RESULTS

Catch and Catch Rate

CPU1 (no. of albacore caught/100 effective hooks) and CPU2 (Kg caught/100 effective hooks) can be viewed as a relative abundance indicator of the resource. As shown in Fig. 1, both CPU1 and CPU2 have revealed a similar trend in the studied period. The stock abundance seemed to decrease quite rapidly from late 1960s until mid 1970s then stablized at about 30 Kg per 100 effective hooks upto present; although a slightly decreasing trend was shown in very recent couple of years. Annual catch of albacore from south Atlantic fluctuated between 13,310 mt and 33,200 mt during the years 1967 to 1973. It become fairly stable between 17,540 mt and 23,590 mt during the period 1974 to 1981. Catch increased to 28,980 mt in 1982 and after two years of low catch level (13,300 - 14,400 mt) and increased again in 1985 to a high level of 28,050 mt and remained the same high level of 25,600 mt in 1986 (Table 1).

Effective effort rose rapidly from 1968 and reached its high value of about 90.2 million effective hooks in 1973, and then fluctuated between 50 to 70 million effective hooks in the years of 1974 to 1980, and increased to 94.6 million effective hooks in 1982. In 1983 and 1984, however, effective hooks droped to about 56.7 million but rose again to a level of about 90 million effective hooks since 1985 (Table 1).

Production Models Analyses

Catch and effective effort data for the South Atlantic albacore fisheries (Table 1) were fitted into production models for parameter estimation. The best fit of applying surplus models on the catch and effective fishing effort data set appears at when m value approaches 2.0 and the significant year class k value set to 3 or 4. The surplus curve thus obtained is shown in Figure 2. The range of maximum potential yield estimated for the stock appeared to be from 25,500 - 28,500 mt per year and the correstponding optimum fishing effort will be at about 80.0 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 the fact that some common theoretical requirements such as: (a) the population is either an unit stock or an isolated population; (b) an equilibrium condition can be achieved; (c) the constitutions (selectivity, catchability and temporal distribution pattern) of the fishery have remained constant; and (d) there is no time lag in the population response to its equilibrium mechanism; are generally not easy to meet in reality (Pella & Tomlinson 1969, Fox 1974). It is also believed by the authors that production models will continue for some time to serve as a basis for management of important fish stocks of the world's fisheries.

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).

The value of MSY estimated by this present study are lower than those of Yang and Sun (1984) but slightly higher than the previous year results (Yeh & Liu 1987). In last year's analyses, Japanese longline data was included in effective effort analyses while Japaese fleet evidently are not targetting on albacore since mid 1970s; although some incidental catch do happen. The inclusion of Japanese data lacking an appropriate adjustment may result in a lower estimation of MSY.

The current catch level (25,600 mt in 1986) is slightly over the lower boundary of predicted equilibrium MSY but the current effort is about 1.10 times of that needed to produce the equilibrium MSY. The status of the South Atlantic albacore stock, judged by present study, appears that the stock has been fully exploited beyond MSY level since 1981. 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, 1967-1987.

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 (mt) x1000	Effective Effort 5 (x10 Hooks)
1967	11.6	15.0	2.47	4.13	48.7	19.80	319.99
1968	196.5	14.2	4.52	5.07	72.1	27.84	386.19
1969	261.7	15.7	69.11	3.52	55.4	34.56	623.75
1970	536.0	15.0	72.73	3.17	47.5	23.65	244.38
1971	1268.2	15.2	312.79	4.05	61.5	25.02	406.67
1972	1209.6	14.7	375.68	2.51	36.9	33.20	900.66
1973	1032.0	13.8	376.07	2.27	31.3	28.23	902.19
1974	1052.3	13.7	334.49	2.46	33.6	19.70	520.26
1975	1029.3	14.6	289.85	2.79	40.8	17.53	429.50
1976	1500.5	12.8	418.39	2.78	35.6	19.25	600.57
1977	1491.1	14.4	414.64	2.69	38.7	21.37	595.57
1978	1740.5	13.6	487.96	2.52	34.2	23.05	707.05
1979	1076.0	13.6	331.53	2.27	30.8	22.50	733.02
1980	1113.0	14.7	339.54	2.48	36.4	22.54	619.70
1981	1119.1	15.0	398.72	2.24	33.7	23.59	700.23
1982	1320.0	14.4	476.61	2.14	30.6	28.98	946.11
1983	634.6	13.7	223.90	1.85	25.4	14.40	566.71
1984	535.8	14.9	168.61	2.60	38.6	13.31	345.20
1985	1365.5	13.9	481.75	2.12	29.4	28.05	955.17
1986	1532.0	13.5	499.07	2.17	29.1	* 25.61	878.33
1987	1128.7	13.9	464.05	1.61	22.3	**15.71	703.35

*: Japanese data is not included.
**: Only Taiwanese data is used.

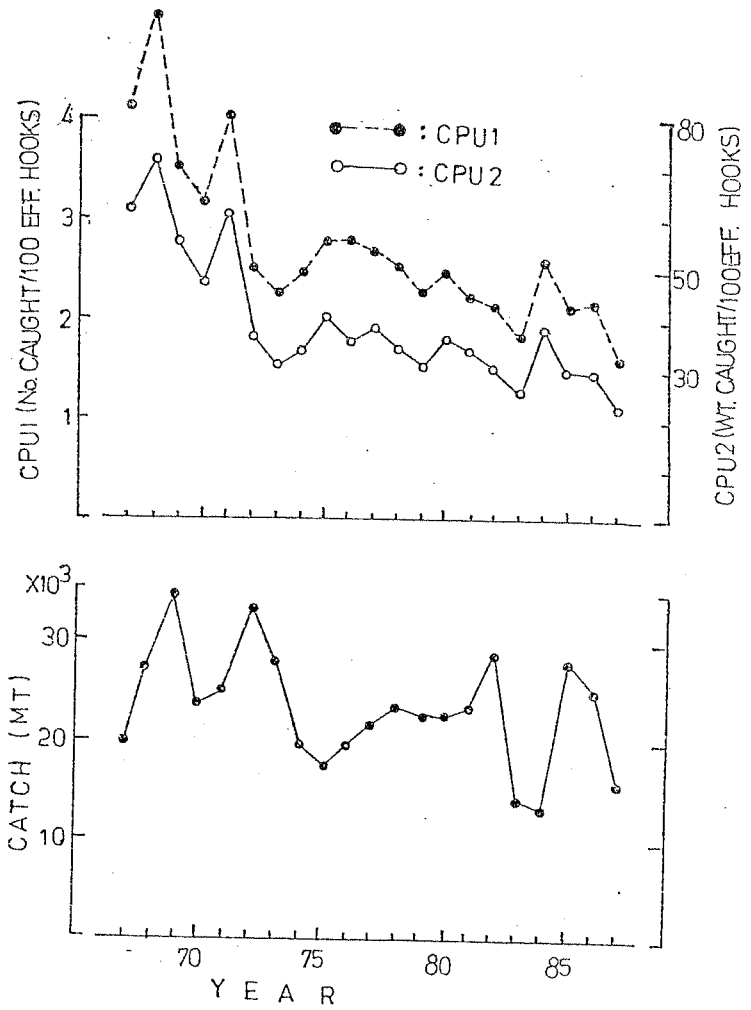

Fig. 1. Trends of annual CPU1 (in no. fish caught/100 effective hooks) and CPU2 (in weight caught/100 effective hooks) and total catch of south Atlantic albacore in 1967-1987.

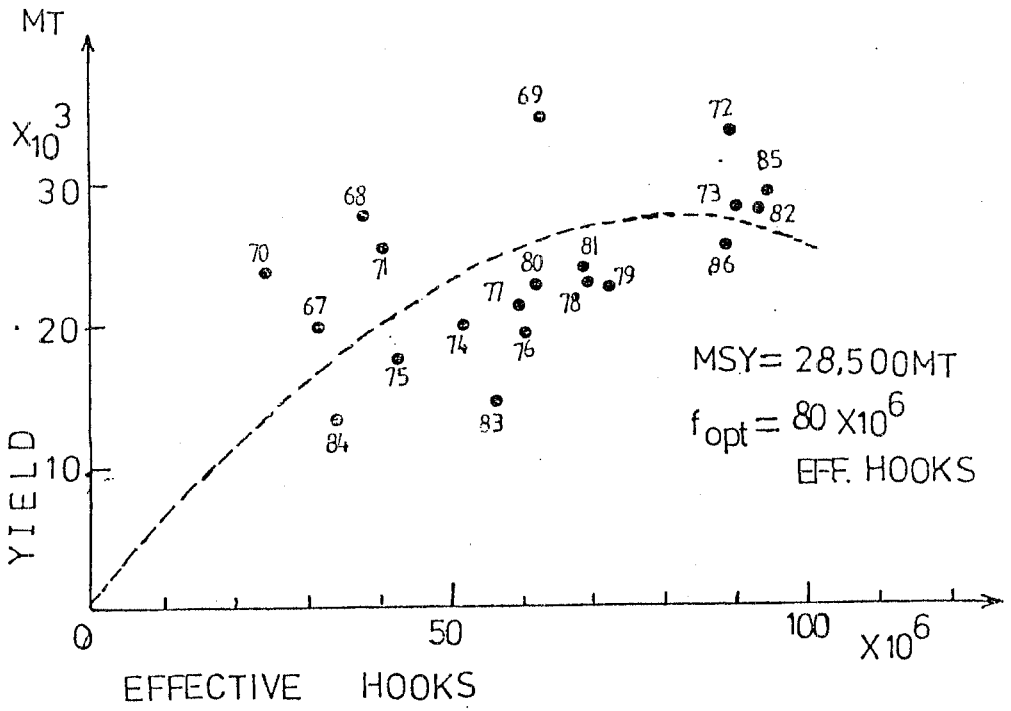

Fig. 2. Equilibrium yield curve and the observed data for south Atlantic albacore fisheries, 1967-1987.