

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

by

<sup>1</sup> Shean-Ya Yeh, <sup>1</sup> Tien-Shui Tsou and <sup>1</sup> Hsi-Chiang Liu

ABSTRACT

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 about 27,300 mt per year.

The current catch level (about 25.9 thousand mt in 1988) is reached about the estimated MSY while the current effort level was about the estimated optimum fishing level of producing the MSY. Since catch level has approaching maximum potential yield of the stock in mid 1980s, it is hence suggested that a carefully monitoring of the fishery should be continued.

1. Institute of Oceanography, National Taiwan University, Taipei, Taiwan, ROC.

## 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 resource 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 source 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:

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

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 coefficient;  
 $\bar{f}(t)$  is the fishing effort standardized to be proportional  
to its fishing mortality rate.

At equilibrium situation; we can get:

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

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

where  $Y$  is the equilibrium yield;  
 $U$  is the equilibrium catch per unit effort;  
 $a$  and  $b$  are parameters 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:

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

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

$$Y_{max} = MSY = f_{opt} * U_{opt} = H \left( \frac{K}{mH} \right)^{m/(m-1)} - K \left( \frac{1}{mH} \right)^{1/(m-1)}$$

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

Where  $f_{opt}$  is the optimum fishing effort required to produce the maximum sustainable yield  $Y_{max}$ ; and  $U_{opt}$  is catch per unit effort at catch level of  $Y_{max}$ .

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

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

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 slid 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 dropped 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 decreasing rapidly from late 1960s until mid 1970s then stabilized 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 corresponding 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 environmental stress are generally difficult to verify, it is still the authors' viewpoint 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 characteristics 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.

## ACKNOWLEDGEMENTS

We would like to express our thanks to ROC Agricultural Council for the financial supports of this study and to Mr. Ying-Chou Lee, Institute of Oceanography, National Taiwan University, for his assistance with this work.

## REFERENCES CITED

- Bartoo, N.W., (1979). The status of the north Atlantic albacore (Thunnus alalunga) stock. ICCAT/SCRS/78/76, Vol. Sci. Papers 8(2):290-303.
- Bartoo, N.W. and A.L. Coan, (1983). Production model analysis of the south Atlantic albacore stock and efforts of data accuracy. ICCAT/SCRS/82/52, Coll. Vol. Sci. Papers 18(2):421-433.

- Fox, W. W. and W. H. Lenarz, (1974). A production model analysis of the status of Atlantic yellowfin tuna. ICCAT/SCRS/73/61, Coll. Vol. Sci. Papers 2: 78-92.
- Honma, M., (1973). Estimation of overall effective fishing intensity of tuna longone fishery. Bull. Far Seas Fish. Res. Lab. No. 10. pp.63-85.
- Pella, J.J. and P.K. Timlinson, (1969). A generalized stock production model. Ibid., 13(3): 419-496.
- Schaefer, M.B., (1954). Some aspects of the dynamics of populaions important to the management of commercial marine fishers. Inter-Amer. Trop Tuna comm .Bull. 1(2): 26-56.
- Shiohama, T., (1977). Stock assessment of Atlantic albacore by production Atlantic albacore by production model analysis. ICCAT/SCRS/76/31, Coll. Vol. Sci. Papers 6(2): 233-236.
- Shiohama, T., (1978). Overall fishing intensity and yield by the Atlantic longline fishery for albacore, 1956-1975. ICCAT/SCRS/77/84, Coll, Vol. Sci. Papers 7(2): 217-224.
- Shiohama, T., (1979). Production model analysis on albacore stock in the south Atlantic, 1956-76. ICCAT/SCRS/78/89, Coll. Vol. Sci. papers 8(1): 403-307.
- Shiohama, T., (1980). Estimation of overall fishing intensity of Atlantic longline albacore. 1956-1977. ICCAT/SCRS/79/53, Coll. Vol. Sci. Papers 9(2): 376-378.
- Yang, R. T., Y. Nose and Y. Hiyama, (1969). Morphometric studies on Atlantic albacore and yellowfin tuna. Bull. Far Seas Fish. Res. Lab. 2: 23-64.
- Yang, R. T. and C. L. Sun, (1983). Distribution, yield and overall fishing intensity of Atlantic albacore caught by longline fishery, 1967-1981. Acta Oceanographica Taiwanica. 14:100-118.
- Yang, R. T. & C. L. Sun, (1984). Stock assessment of South Atlantic albacore by production model analysis, 1967-1982. Acta Oceanographica Taiwanica. 15:130-140.
- Yeh, S.Y. & H.C. Liu, (1987). Stock assessment of south Atlantic albacore by using production models, 1967-1986. ICCAT/SCRS/87/81.
- Yeh, S.Y. & H.C. Liu, (1988). Stock assessment of south Atlantic albacore by using production models, 1967-1987. ICCAT/SCRS/88/60.

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

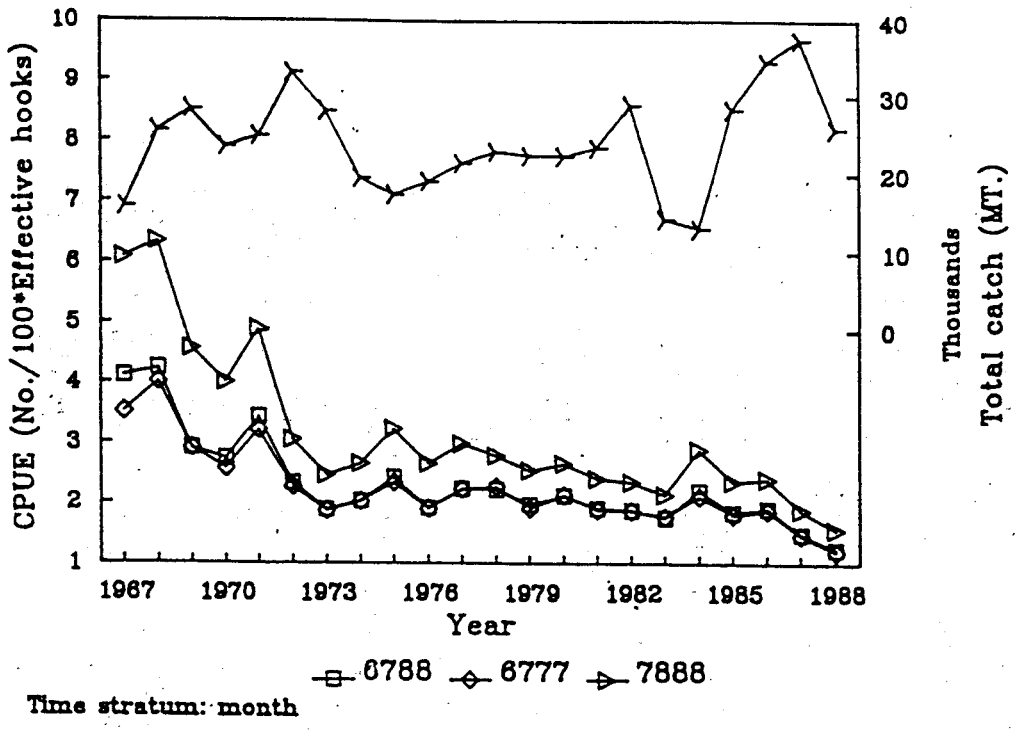


Fig. 1. Trends of annual catch and CPUEs (no. fish caught/100 effective hooks) derived from standard years of 1967-77, 1977-88, and 1967-88.

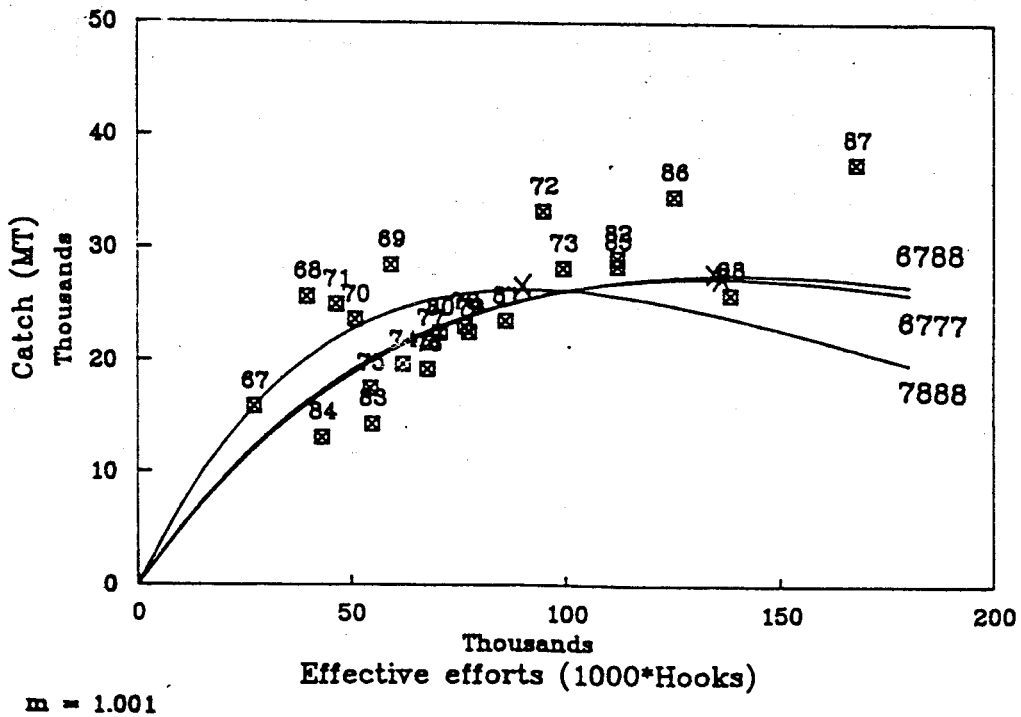


Fig. 2. Equilibrium yield curves derived from standard years of 1967-77, 1977-88, and 1967-88

台灣省水產試驗所圖書室



C001321