Col.Vol.Sci.Pap. ICCAT, 23 (2): 242-247 (1985)

PRODUCTION MODEL APPROACH TO EVALUATE THE STOCK STATUS OF ATLANTIC BIGEYE TUNA

S. Kume
Far Seas Fisheries Research Laboratory

SUMMARY

Using the updated catch data up to 1982 and revised effort data adjusted for deep longline, the generalized production model (PRODFIT) was conducted. The conclusion was similar to those reached in the past that bigeye tuna in the total Atlantic has been utilized at a level close to or at the estimated MSY level. A test of robustness of the input data in the model (PRODSIM) indicated that an error in catch data would effect the estimation of yield more than would an error in effort data.

RESUME

Le modèle global (PRODFIT) est utilisé avec les données actualisées de capture jusqu'en 1982 et les données d'effort révisées pour la palangre de profondeur. Il en est conclu, comme auparavant, que l'exploitation récente du thon obèse dans l'Atlantique entier est proche de ou égale au niveau estimé de la PME. Les tests de la robustesse des données d'entrée du modèle (PRODSIM) indiquent que l'estimation de la production serait plus affectée par une erreur dans les données de capture que dans les données d'effort.

RESUMEN

Se llevó a cabo el modelo de producción generalizado (PRODFIT), utilizando los datos actualizados de captura hasta 1982 y datos de esfuerzo revisados para operaciones de palangre profundo. Se llegó a la misma conclusión que anteriormente, es decir, que la captura de patudo en el total del Atlántico había estado cerca o al nivel estimado del RMS. Un test de resistencia de los datos de entrada en el modelo (PRODSIM) demostró que un error en los datos de captura tendría mayor influencia en la estimación del rendimiento que en los datos de esfuerzo.

1. Introduction

An appraisal of the status of the stock of the Atlantic bigeye tuna has been continuously done by production model analysis among various assessment techniques. The 1983 Standing Committee on Research and Statistics (SCRS) of the International Commission for the Conservation of Atlantic Tunas evaluated that the stock status has been recently exploited close to or at the level of the maximum sustainable yield (MSY) estimated by the model, but still never being exceeded beyond the MSY level (ICCAT 1984 a). The analysis has been conducted using the catch and effort data, as basic data base, of Japanese longline fishery which is a principal bigeye fishery in the Atlantic and accounting for the major portion of the bigeye catch .

In this report, the analysis is updated using the data up to 1982, and the points revised or different from the past analysis are (1) effort standardization for deep longline operation, which exploits bigeye tuna more efficiently (Kume 1984 a) and (2) an evaluation on accuracy of the input catch and effort data by simulated production model (Bartoo and Coan 1983).

2. Material and method

1) Catch data : Statistical Bulletin (ICCAT 1983) was referred to including separation for north and south Atlantic at around the equator, up to 1982.

2) Effort data : Basic effort data are obtained from Japanese longline fishery and cited from Kume (1984 a), in which effort of deep longline operation was adjusted and additional standardization was made to obtain overall effective effort on bigeye tuna.

3) Cpue in terms of weight : To obtain cpue data in terms of weight from that in number of fish , average weight of the longline catch was used (values up to 1981 were referred to Kume 1984 b). The resultant input catch and effort data, 1961-82, into the model are shown in Table 1.

4) Production model : Employed is the generalized production model "PRODFIT" by Fox (1975). The number of dominant year classes in the catch (parameter k) was selected as 4, and shape parameters in the model were m=0, 1, 2 and variable. Parameters in the calculation were adopted following Fox's suggestion.

5) Stock units: On the stock structure, the SCRS has been using a working hypothesis: a single stock in the whole Atlantic or two stocks in the northern and southern hemispheres respectively.

6) Testing an accuracy of the input data : "PRODSIM" model, being developed with the use of Monte Carlo technique by Bartoo and Coan (1983), was applied to the data which indicated the best fit index of the generalized production model results.

3. The results of the generalized production model

The results of the computation of the fitting the data to the model are summarized in Table 2 and Figs. 1 - 3.

Whole Atlantic

The input data fitted best to the model in the cases of M=0 and variable (Table 1). Corresponding maximum sustainable yields (MSY or Y-max), 124,000 MT, are about 5-10 % higher than the previous results (Kume 1984 b and Pereira

1984). The increase may be ascribed to the higher cpue in 1982, even after the effort was adjusted as to efficiency of deep longline operation. Estimated MSY's for M=1 and 2, the degrees of fitness of which are not so much different from the above two cases, are 64,500 and 58,100 MT, respectively, being higher than those of the previous results by a little less than 10 %. It is still uncertain which yield curve among 4 cases considered above the stock will follow. However, if the stock behaves for the cases m=1 or 2, recent catch level of 60,000 MT (1980-82 average) was in the range of the estimated MSY and the corresponding level of effort was fairly close to the MSY level. As far as the production model is concerned, it may be concluded that the recent utilization of the bigeye tuna in the Atlantic has been close to or at the MSY level. This conclusion is nearly the same as that derived by the previous analyses.

North and south Atlantic

At the meeting of the Working Group of the Juvenile Tropical Tunas held at Brest in July 1984, the Group considered from no indication of juvenile concentration other than in the Gulf of Guinea that a single stock hypothesis would be likely to hold more reality than north-south separated stocks (ICCAT 1984 b). If indeed the Atlantic bigeye tuna is composed of the two stocks, it might be noted that the present analysis did not change substantially the previous results (Kume 1984 b). In the case of northern stock, the recent catch level was below the estimated MSY's and the stock would respond to the fishery by marginal increase in catch with increasing effort in equilibrium sense. The 1982 catch in the south Atlantic was beyond the MSY estimates of the model for the cases of M=1 and 2, though corresponding effort was still below the estimated MSY level. The fishery seems to be operating nearing the MSY level. It is expected that the 1982 catch level would be lowered with the corresponding level of the effort.

4. Test of the behavior of the data in the model

To investigate the behavior of the input data in the production model analysis, "PRODSIM" (Bartoo and Coan 1983) runs were conducted using the same parameters and data of a best fit model (m=variable) for the case of whole Atlantic. The PRODSIM was applied to nine cases: 3 error levels (+ 5, 10 and 15 %) were given to catch, effort and a combination of catch and effort. For each case, the computation was made on 500 generated new sets of data. An example of the results is shown in Fig. 4.

The values of m in all runs converged at 0, which implies MSY is attained at infinite effort level. In this analysis, the range of estimated yield at the effort of 300 million hooks was examined. This effort level was arbitrarily chosen but corresponding to the recent level. As shown in Table 3, the range of expected yield increases with the increase of error level in all cases. To compare the contribution of each element to the variation, the percentage of the range was calculated in terms of the ratio of half of the range to mean yield (Table 3). The result indicates that error in the catch data will give more effect on the estimation of yield than that in the effort data.

References

Bartoo, N. and A. Coan 1983: Production model analysis of the south Atlantic albacore stock and effects of data accuracy. Col. Vol. Sci. Pap., Vol. XVIII(2), 421-432.

Fox, W. 1975: Fitting generalized stock production model by least-squares and equilibrium approximation. Fish. Bull., 73(1), 23-26.

ICCAT 1983: Statistical Bulletin, Vol. 13-1982 (Final).

ICCAT 1984 a: 1983 SCRS Report "A". Col. Vol. Sci. Pap., Vol. XX(3), 558-561.

ICCAT 1984 b: Report of the Working Group on Juvenile Tropical Tunas. Col. Vol. Sci. Pap., Vol. XXI(1).

Kume, S. 1984 a: An analysis on the stock abundance of Atlantic bigeye tuna caught by Japanese longline fishery. (MS, SCRS/84/60)

Kume, S. 1984 b: On the stock status of Atlantic bigeye tuna, evaluated by production model analysis. Col. Vol. Sci. Pap., Vol. XX(1), 192-200.

Pereira, J. 1984: Etat des stocks du patudo de l'Atlantique par analyse des cohortes, analyse de production par recrue et par le modele global. Col. Vol. Sci. Pap., Vol. XXI(2), 155-183.

Table 1. Input fishery data in the production model analyses for Atlantic bigeye tuna, 1961-82. Deep longline effort was adjusted for 1980-82.

WHOLE ATLANTIC

YEAR	HOOK RATE (NO/100 HOOKS)	MEAN WEIGHT (KG)	HOOK RATE (KG/100 HOOKS)	TOTAL CATCH (1000 MT)	TOTAL EFFORT (MILLION)
1961	0.818	45	36.8	17.0	46.2
1962	0.681	43	29.3	23.1	78.8
1963	0.602	51	30.7	26.0	84.7
1964	0.564	50	28.2	23.5	83.3
1965	0.550	50	27.5	39.2	142.5
1966	0.481	48	23.1	25.0	108.2
1967	0.576	50	28.8	24.7	85.8
1968	0.654	48	31.4	23.0	73.2
1969	0.691	44	30.4	33.6	110.5
1970	0.559	49	27.4	39.2	143.1
1971	0.462	47	21.7	52.1	240.1
1972	0.434	44	19.1	42.8	224.1
1973	0.508	40	20.3	53.9	265.5
1974	0.664	47	31.2	59.8	191.7
1975	0.396	50	19.8	56.5	285.4
1976	0.338	47	15.9	38.8	244.0
1977	0.520	49	25.5	46.4	182.0
1978	0.429	45	19.3	45.3	234.7
1979	0.420	44	18.5	40.7	220.0
1980	0.453	45	20.4	58.8	288.2
1981	0.373	45	16.8	57.6	342.9
1982	0.460	47	21.6	65.6	303.7

NORTH ATLANTIC

YEAR	HOOK RATE (NO/100 HOOKS)	MEAN WEIGHT (KG)	HOOK RATE (KG/100 HOOKS)	TOTAL CATCH (1000 MT)	TOTAL EFFORT (MILLION)
1961	0.741	46	34.1	8.9	26.1
1962	0.684	43	29.4	15.6	53.1
1963	0.635	51	32.4	19.3	59.6
1964	0.586	50	29.3	16.6	56.7
1965	0.602	53	31.9	24.4	76.5
1966	0.486	43	20.9	14.4	68.9
1967	0.507	43	21.8	15.1	69.3
1968	0.646	48	31.0	9.2	29.7
1969	0.504	50	25.2	15.0	59.5
1970	0.602	47	28.3	22.6	79.9
1971	0.431	45	19.4	29.0	149.5
1972	0.400	41	16.4	22.1	134.8
1973	0.592	36	21.3	30.0	140.8
1974	0.721	48	34.6	40.3	116.5
1975	0.385	52	20.0	38.8	194.0
1976	0.307	46	14.1	22.6	160.3
1977	0.496	49	24.3	28.1	115.6
1978	0.439	46	20.2	26.8	132.7
1979	0.413	40	16.5	20.3	123.0
1980	0.517	41	21.2	30.3	142.9
1981	0.354	41	14.5	29.7	204.8
1982	0.484	43	20.8	28.9	138.9

SOUTH ATLANTIC

YEAR	HOOK RATE (NO/100 HOOKS)	MEAN WEIGHT (KG)	HOOK RATE (KG/100 HOOKS)	TOTAL CATCH (1000 MT)	TOTAL EFFORT (MILLION)
1961	0.833	46	38.3	8.1	21.1
1962	0.628	43	27.0	7.5	27.8
1963	0.520	51	26.5	6.7	25.3
1964	0.498	51	25.4	6.9	27.2
1965	0.502	48	24.1	14.8	61.4
1966	0.479	53	25.4	10.6	41.7
1967	0.609	54	32.9	9.6	29.2
1968	0.658	48	31.6	13.7	43.4
1969	0.810	41	33.2	18.6	56.0
1970	0.512	51	26.1	16.6	63.6
1971	0.517	48	24.8	23.0	92.7
1972	0.489	47	23.0	20.7	90.0
1973	0.445	44	19.6	24.0	122.4
1974	0.459	44	20.2	19.6	97.0
1975	0.398	47	18.7	17.7	94.7
1976	0.540	48	25.9	16.3	62.9
1977	0.562	47	26.4	18.3	69.3
1978	0.402	44	17.7	18.6	105.1
1979	0.417	48	20.0	20.4	102.0
1980	0.396	51	20.2	28.6	141.6
1981	0.408	50	20.4	27.9	136.8
1982	0.431	51	22.0	36.6	166.4

Table 2. Estimated population parameters by production model analysis for Atlantic bigeye tuna stock, 1961-1982.

	m	Degree of fit index	f-optimum (million hooks)	Y-max (1,000 MT)	1980-82 Catch (1,000 MT)
Whole Atlantic	variable	.484	-	124.0	57.6-65.6
	0	.484	-	123.8	
	1.001	.480	513	64.5	
	2	.474	358	58.1	
North Atlantic	variable	----- non-calculable -----			28.9-30.3
	0	.310	-	73.6	
	1.001	.314	308	38.1	
	2	.319	201	32.9	
South Atlantic	variable	.556	-	57.7	27.9-36.6
	0	.556	-	57.7	
	1.001	.536	260	31.3	
	2	.510	177	27.8	

Table 3. The range of expected yield (1,000 MT) at effort level of 300 million hooks and its percentage in the PRODSIM runs with given error levels.

error level	Catch		Effort		Catch and effort	
	range	%	range	%	range	%
± 5 %	53.0-58.5	2.5	54.5-57.0	1.1	52.5-59.0	2.9
± 10 %	49.0-59.5	4.8	53.0-58.5	2.5	49.5-62.0	5.6
± 15 %	47.5-63.5	7.2	52.0-60.0	3.6	47.0-64.5	7.8

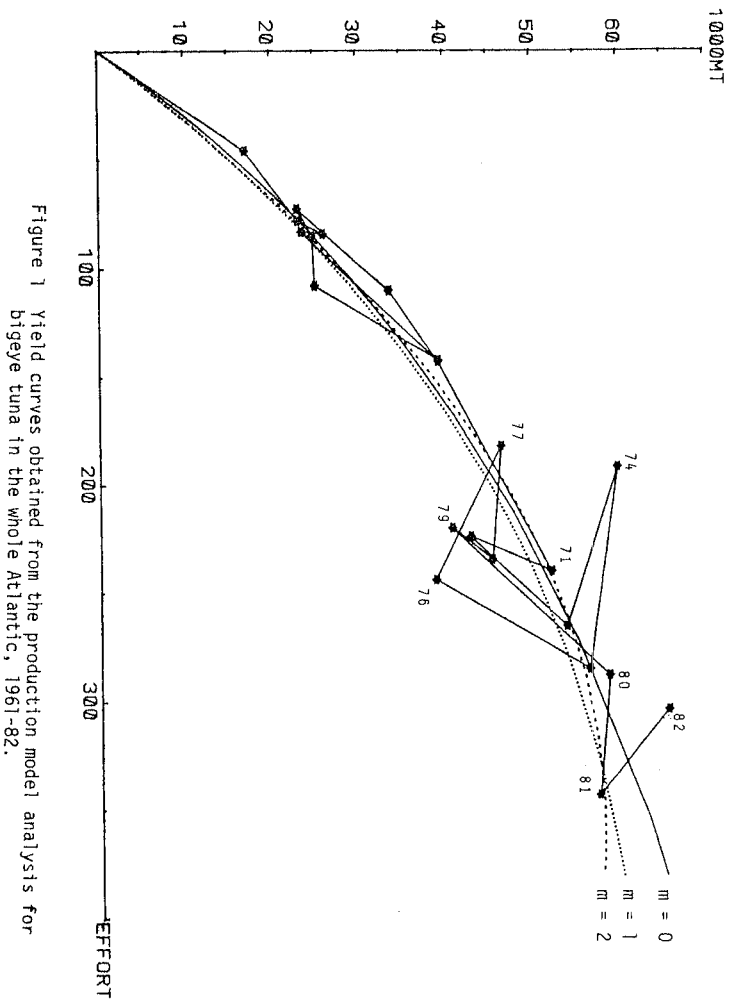

Figure 1 Yield curves obtained from the production model analysis for bigeye tuna in the whole Atlantic, 1961-82.

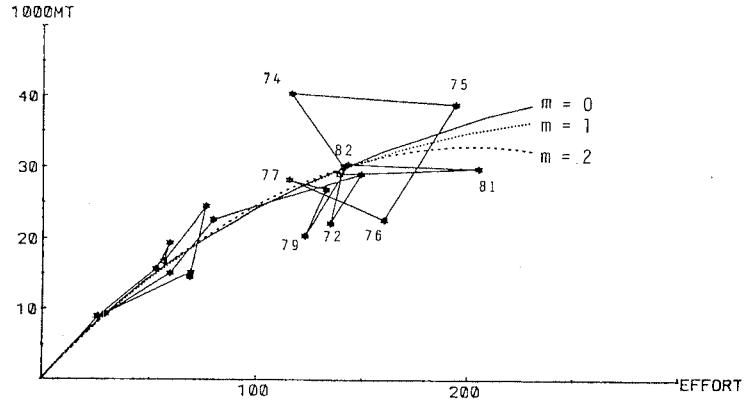

Figure 2 Yield curves obtained from the production model analysis for bigeye tuna in the north Atlantic, 1961-82.

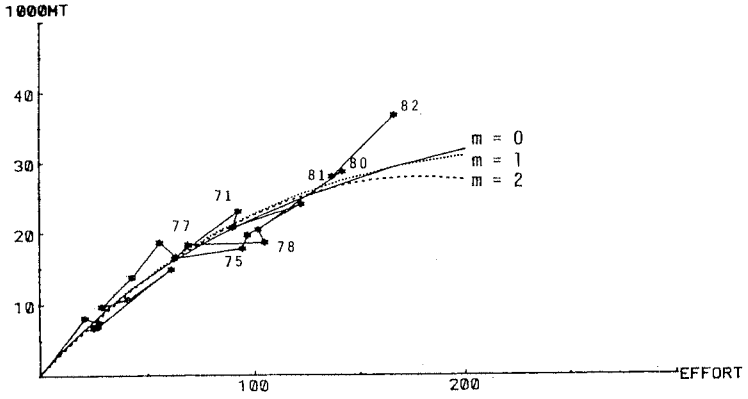

Figure 3 Yield curves obtained from the production model analysis for bigeye tuna in the south Atlantic, 1961-82.

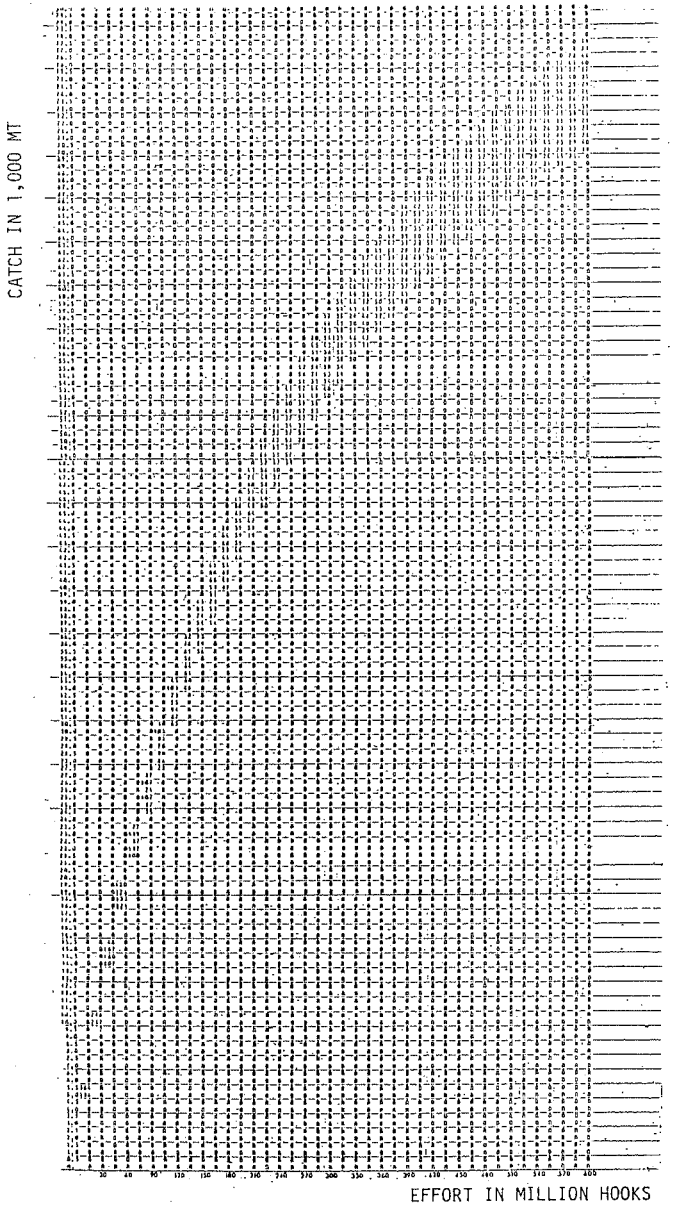

Figure 4 An example of the PRODSIM runs for the case of error level of ± 5 % given to the catch data.