

A NOTE ON THE PRESENT STATUS OF THE ATLANTIC BIGEYE TUNA

by

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SUMMARY

Recent bigeye catch by surface gears has become almost half of the total catch, and the surface catch is predominated by the small-sized fish. Such increased catch of small bigeye is alerting the decrease in the total yield on sustainable basis.

To assess current status of the Atlantic bigeye stock, a production model analysis was conducted. In addition, the impact of taking small bigeye on the catches of fisheries taking larger fish was tentatively evaluated under possible values of fishing mortality.

RESUME

Les prises de thon obèse par les engins de surface ont récemment atteint presque la moitié de la prise totale, et le poisson de petite taille prédomine dans les prises de surface. Une telle augmentation de la prise de petit thon obèse doit mettre en garde contre la baisse de la production totale, dans un but d'aménagement.

L'analyse du modèle de production a été effectuée pour évaluer l'état actuel du stock de thon obèse atlantique. On a, de plus, tenté d'effectuer une évaluation, selon les valeurs raisonnables de la mortalité par pêche, de l'impact de la capture de petit thon obèse sur les prises des pêcheries qui prennent de plus grands poissons.

RESUMEN

Recientemente, la captura de patudo con artes de superficie ha constituido la mitad de la captura total, y dicha captura se compone principalmente de peces de pequeña talla. Este aumento en la pesca de patudo pequeño, atrae la atención sobre la disminución del rendimiento total sostenible.

Con el fin de evaluar la situación del stock atlántico de patudo, se efectuó un análisis del modelo de producción. Por otra parte, y de forma provisional, se evaluó con posibles valores de mortalidad por pesca, el impacto de la pesca de patudo pequeño por parte de las pesquerías que capturan peces más grandes.

Annual catch of bigeye tuna in the Atlantic peaked to be about 52,000 tons in 1974 and 1975, and thereafter downed to less than 40,000 tons in 1976 and 1977, according to catch statistics of ICCAT (1978). The main gear taking Atlantic bigeye has been longline fishing, but recently the share of the catch by surface fisheries has been on the increase. The recent catch of surface gears has been attaining almost to half of the catch, in which small-sized bigeye are included predominantly. The latest stock assessment suggested that the recent level of exploitation of the resource has been high and the further increase in yield will not be expected by investing more fishing effort. It was also pointed out that the increased catch of small-sized bigeye is alerting the decrease in the total yield by Y/R study. At the same time, the necessity of minimum size regulation at 3.2 kg common to yellowfin has been under discussion, partly because of the practise of false reporting of yellowfin tuna as bigeye.

To assess a current status of the bigeye stock, a production model analysis was conducted in this report based on up-dated catch and effort statistics. In addition, the impact of taking 1.0-1.5 age bigeye on catches of fisheries taking larger fish was tentatively evaluated under possible values of fishing intensity.

1. Production model analysis

The fishery data up-dated until 1976 were fitted to the computer program PRODFIT of a generalized production model developed by Fox (1975). Two cases of stock structure in the Atlantic were considered: whole Atlantic, and north and south Atlantic. Concerning the fishing effort, one of the input data of the model, there is some difference in the procedure of this report from the previous analysis (Kume 1978 a).

Catch data

The catch of longline fishery was summarized from the statistics by ICCAT (1978), and the separation of the catch into north and south Atlantic was made in the document by Kume (1978 ms a), in which its details are described. As to the surface catch, the figures were taken from Marcille and Armada (1978 ms), in which the past surface catch data, especially those of French-Ivory Coast-Senegal and Spanish fleet, are given as revised for bigeye tuna.

Cpue

The annual cpue of bigeye for the longline fishery was estimated as catch in number per 100 hooks based on the catch and effort statistics of Japanese and Taiwanese longline fisheries by Kume (1978 ms a). This cpue was converted to that in terms of weight using the average weight of annual longline catch, that is the cpue in terms of number was multiplied by respective annual mean weight in kg of the catch. Since the official catch data in earlier years were of landing basis, they do not correspond accurately to the available catch data in number that were on catch-at-sea basis, and in certain years the calculated mean weight turned out to be unrealistic. Therefore, the annual age composition of the longline bigeye catch from 1965 to 1976 (Kume 1978 b and 1978 ms b) were utilized to obtain the annual mean weight. Those of years prior to 1974 were calculated by simply using the available data in weight and in number.

Fishing effort

The fishing effort was given by dividing the catch by the cpue. In the above section, estimated was the cpue in kg per 100 hooks for the longline fishery. The effort of surface fisheries was substituted by the longline effort, namely the total fishing effort was calculated by dividing the combined catch of longline and surface fisheries by the cpue. All relevant statistics, 1961-1976, thus estimated are shown in Tables 1-3.

Input parameters

Three m 's in the model were chosen as 0, 1.001, and 2, and the number of dominant year class in the catch (k) was selected for two figures, 4 and 5.

Results

Estimated equilibrium curves for $k=5$ are shown in Figs. 1-3, being incorporated with observed catch and effort. In Table 4, tabulated are calculated maximum sustainable yield (Y_{max}), optimum fishing effort (f_{opt}), degree of fit index and 1976 and 1977 catches. Both numbers of dominant year class ($k=4$ and 5) gave almost similar results.

For the Atlantic-wide stock analysis, estimated Y_{max} increased compared to the past analysis probably partly because of the increased surface catch revised by Marcille and Armada (1978 ms). Although best fit to the model was obtained for $m=0$, its Y_{max} appears to be unlikely, since this Y_{max} is realized at an infinite effort and the shape of the curve beyond the experienced level of effort is not predictable. Observed 1976 catch of 38,800 tons is below the equilibrium catch (48,200-50,100 tons) of corresponding effort (2854×10^3 hooks). It appears that recent utilization of bigeye resource on Atlantic-wide basis has been on high level of exploitation, but the fishing effort has not exceeded the MSY level.

In the north Atlantic, the fluctuation of the expected relation between catch and effort has become large in recent years, and the fishery data did not fit well to the model. This may be attributed to some deficiency in estimating overall standardized effort as an input to the model or the change in year class strength. Though the fitness to the model was low, the observed catch in 1976 seems to be far below the expected catch by the observed effort.

The degree of fit index for the case of south Atlantic data was the highest. The analysis indicates that the recent level of exploitation since 1971 has been remaining at around the estimated MSY for both catch and effort. The observed 1976 catch, 18,800 tons, was a little higher than the equilibrium yield.

2. Evaluation of the effect of taking small-sized fish

Multi-gear Y/R analysis revealed that the expansion of surface fisheries taking small-sized bigeye lowers the total Y/R under most likely fishing mortalities of present structure of the bigeye fishery (Marcille 1978 ms and Kume 1978 a). Estimated in this section is the impact of taking 1.0-1.5 age fish on the change in catch of fisheries taking subsequent ages.

There are supposed to be three types bigeye fisheries, each of which is catching different size of fish. The diagrammatic presentation is as follows:

Age	1.0	2.0	3.0	4.0	5.0
Length (cm)	44.4	61.1	76.2	89.9	102.1
Weight (kg)	1.9	5.0	9.7	16.0	23.5
Fishery-A	-----				
Fishery-B	-----				
Fishery-C			----- -----> 9.5' age		

$$L_t (\text{length in cm}) = 214.8 (1 - e^{-2.066t - 0.0249})$$

$$\text{Log } W (\text{weight in kg}) = -4.6938 + 3.0187 \log L (\text{length in cm})$$

Three fisheries are considered to be representative of present bigeye fisheries; Fishery-A...Tuna-based pole-and-line fleet, Fishery-B...Purse seine and Spanish-Portuguese pole-and-line fleets and Fishery-C...Longline fleet.

When 1,000 tons of 1.0-1.5 age of bigeye is caught by Fisheries-A and -B, the catch is equivalent to 0.333 million in number of fish by the average weight of 3 kg per fish. Murphy and Sakagawa (1977) assumed a natural mortality coefficient (M) of bigeye to be in the range of 0.35-0.73, and 0.45 and 0.43 for the M were estimated by Kume (1977). Taking M=0.50, this 0.333 millions of fish would become 0.294 million at the beginning of 1.5 age if they are not captured. Later on, these fish are caught by Fisheries-B and -C.

The fishing mortality coefficient (F) of the longline fishery for recent years would be between 0.35 and 0.50, assuming that the catchability coefficient is 0.22×10^{-8} estimated by Kume (1977). The F of Fishery-B is uncertain, but the values have been increasing and probably less than 0.5. In this study, F of Fishery-C is set at 0.4 and for the F of Fishery-B, 0.1, 0.3 and 0.5 are arbitrarily selected. The later catches of the 0.294 million fish by Fisheries-B and -C were computed on the basis of the above assumed parameters (Table 5). It is suggested that the impact of 1,000 tons catch of 1.0-1.5 age fish would result in loss of about 2.7 times as much for the later catches of Fisheries-B and -C, and the share of the possible catch by fishery would be subject to change in the F of Fishery-B by which smaller fish are taken. If M=0.45 is assumed, the expected loss would become about 3.0 times as much. It should be noted that the above speculation would give general magnitude of the effect but that the most likelihood of the computation is in substance dependent on the accuracy of the input F of the fisheries, so that a study on evaluating real fishing mortality rates by fisheries is important and should be further continued.

It is obvious that the increased catch of very small-sized fish would not be desirable to maintain an efficient utilization of bigeye resources. This effect would emerge finally in the cpue of the longline fishery, on which closer attention must be needed.

References

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Table 1. Catch, cpue (hook rate: catch in kg per 100 hooks), average weight and effective effort in number of hooks for the bigeye fishery in the whole Atlantic, 1961-76.

WHOLE ATLANTIC					
YEAR	HOOK RATE (NUMBER)	MEAN WEIGHT (KG)	HOOK RATE (WEIGHT)	TOTAL CATCH 10 ³ TONS	EFFORT IN 10 ⁵ HOOKS
1961	0.818	45	36.81	11.2	304.3
1962	0.682	43	29.32	16.0	545.5
1963	0.602	51	30.70	17.4	566.8
1964	0.563	50	28.15	26.4	937.8
1965	0.550	50	27.50	34.6	1258.2
1966	0.482	48	23.14	24.2	1045.8
1967	0.569	50	28.45	21.3	748.7
1968	0.541	48	25.97	22.6	870.2
1969	0.601	44	26.44	30.0	1134.6
1970	0.504	49	24.70	34.6	1400.8
1971	0.416	47	19.55	50.4	2578.0
1972	0.372	44	16.37	41.5	2535.1
1973	0.406	40	16.24	49.2	3029.6
1974	0.534	47	25.10	53.4	2127.5
1975	0.369	50	18.45	53.1	2878.0
1976	0.290	47	13.63	38.9	2854.0

Table 2. Catch, cpue (hook rate: catch in kg per 100 hooks), average weight and effective effort in number of hooks for the bigeye fishery in the north Atlantic, 1961-76.

NORTH ATLANTIC						
YEAR	HOOK RATE (NUMBER)	MEAN WEIGHT (KG)	HOOK RATE (WEIGHT)	CATCH 10 ³ TONS LONGLINE	CATCH 10 ³ TONS SURFACE	EFFORT IN 10 ⁵ HOOKS
1961	0.742	46	34.13	3.1	-	90.8
1962	0.684	43	29.41	8.5	-	289.0
1963	0.635	51	32.39	8.4	2.7	259.3
1964	0.586	50	29.30	10.9	8.8	672.4
1965	0.601	53	31.85	14.7	5.5	634.2
1966	0.486	43	20.90	8.9	5.2	674.6
1967	0.507	43	21.80	3.8	9.0	587.2
1968	0.536	48	25.73	5.6	4.1	377.0
1969	0.528	50	26.40	5.8	8.0	522.7
1970	0.545	47	25.62	11.0	8.1	745.5
1971	0.390	45	17.55	18.6	10.1	1635.3
1972	0.377	41	15.46	14.3	8.0	1442.4
1973	0.469	36	16.88	19.1	10.5	1753.6
1974	0.623	48	29.90	25.5	12.6	1274.2
1975	0.363	52	18.88	23.1	14.1	1970.3
1976	0.253	46	11.73	12.5	7.5	1705.0

Table 3. Catch, cpue (hook rate: catch in kg per 100 hooks), average weight and effective effort in number of hooks for the bigeye fishery in the south Atlantic, 1961-76.

SOUTH ATLANTIC							
YEAR	HOOK RATE (NUMBER)	MEAN WEIGHT (KG)	HOOK RATE (WEIGHT)	CATCH 10 ³ TONS LONGLINE	CATCH 10 ³ TONS SURFACE	TOTAL CATCH 10 ³ TONS	EFFORT IN 10 ⁵ HOOKE
1961	0.833	46	38.32	8.2	0.0	8.2	214.0
1962	0.627	43	26.96	7.4	0.1	7.5	278.2
1963	0.519	51	26.47	6.3	0.0	6.3	238.0
1964	0.498	51	25.40	6.7	0.0	6.7	263.8
1965	0.502	48	24.10	14.3	0.1	14.4	597.5
1966	0.480	53	25.44	9.7	0.0	9.7	381.3
1967	0.598	54	32.29	7.4	0.9	8.3	257.0
1968	0.541	48	25.97	10.6	1.4	12.0	462.1
1969	0.644	41	26.40	14.0	1.1	15.1	572.0
1970	0.447	51	22.80	10.4	1.0	11.4	500.0
1971	0.442	48	21.22	18.2	3.4	21.6	1017.9
1972	0.369	47	17.34	16.5	2.2	18.7	1078.4
1973	0.370	44	16.28	16.2	3.5	19.7	1210.1
1974	0.380	44	16.72	10.7	4.5	15.2	909.1
1975	0.379	47	17.81	12.8	5.0	17.8	999.4
1976	0.372	48	17.86	8.4	10.4	18.8	1052.6

Table 4. Parameters estimated by production model analyses for the Atlantic bigeye fishery, 1961-76. The figures in the parentheses indicate estimated equilibrium yields for 1976.

		m	degree of fit index	(10 ⁵ fopt hooks)	Ymax (10 ³ tons)	catch (10 ³ tons)	
						1976	1977
k=4	Whole Atlantic	0	0.588	∞	100.0	38.8	46.6
		1.001	0.582	4,365	52.7	(50.1)	
	North Atlantic	0	0.300	∞	78.4	20.0	
		1.001	0.295	3,317	37.9	(32.3)	
	South Atlantic	0	0.854	∞	31.9	18.8	
		1.001	0.860	1,464	18.5	(17.7)	
k=5	Whole Atlantic	0	0.537	∞	98.3	38.8	46.6
		1.001	0.528	4,391	52.2	(49.5)	
	North Atlantic	0	0.247	∞	81.6	20.0	
		1.001	0.241	3,476	38.6	(32.1)	
	South Atlantic	0	0.872	∞	29.0	18.8	
		1.001	0.859	1,382	17.9	(17.5)	

Table 5. The calculation of later catches of Fisheries-B and -C if 1,000 tons of catch of 1.0-1.5 age fish is not taken. (M=0.5)

Fishery	F	Age range	Average weight (kg)	Number of fish Number of fish caught	Number of fish Number of fish caught	Catch in weight (ton)
B	0.1	1.5-2.5	10	294,000	22,108	227
		2.5-3.5	24	101,351	12,133	291
		3.5-4.5	41	86,551	23,355	958
C	0.4	4.5-5.5	61	36,002	9,496	579
		5.5-6.5	81	14,637	3,820	313
		6.5-7.5	101	5,951	1,568	158
		7.5-8.5	119	2,420	638	76
		8.5-9.5	135	904	260	35
B	0.3	1.5-2.5	10	294,000	60,711	607
		2.5-3.5	24	132,102	27,279	655
		3.5-4.5	41	59,358	15,656	642
C	0.4	4.5-5.5	61	24,133	6,365	388
		5.5-6.5	81	9,812	2,588	210
		6.5-7.5	101	3,989	1,052	106
		7.5-8.5	119	1,622	428	51
		8.5-9.5	135	659	174	23
B	0.5	1.5-2.5	10	294,000	92,922	929
		2.5-3.5	24	108,157	34,184	820
		3.5-4.5	41	39,789	10,494	430
-C	0.4	4.5-5.5	61	16,177	4,267	260
		5.5-6.5	81	6,577	1,735	141
		6.5-7.5	101	2,674	705	71
		7.5-8.5	119	1,087	287	34
		8.5-9.5	135	442	116	16

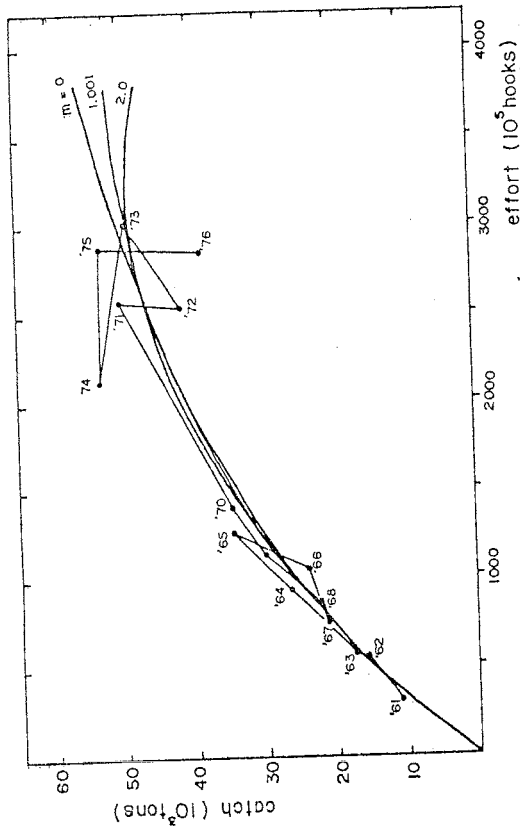


Fig. 1. Yield curves obtained from the production model analysis for bigeye tuna in the whole Atlantic Ocean, 1961-76.

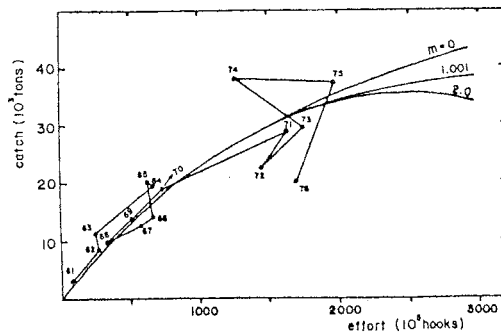


Fig. 2. Yield curves obtained from the production model analysis for bigeye in the north Atlantic, 1961-76.

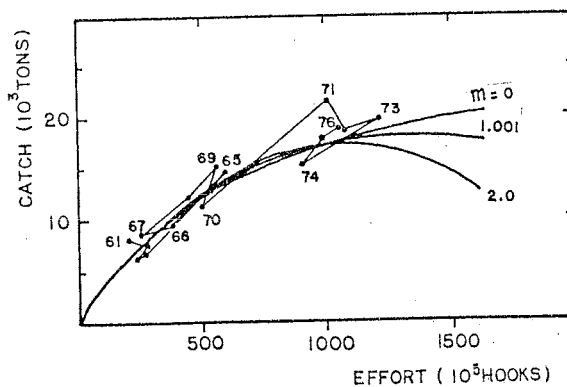


Fig. 3. Yield curves obtained from the production model analysis for bigeye in the south Atlantic, 1961-76.