

ON THE STOCK STATUS OF ATLANTIC BIGEYE TUNA EVALUATED BY PRODUCTION MODEL ANALYSIS

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SUMMARY

Using primarily the longline catch and effort data, the stock status of the Atlantic bigeye tuna resources was evaluated by production model for the hypothesized stock units for the North, South and entire Atlantic. The effect of prevailing deep longline operation was taken into account for the input effort data of the model.

RESUME

L'état des stocks de thon obèse de l'Atlantique a été évalué par le modèle de production pour des unités hypothétiques du stock: Atlantique nord, sud et entier, à partir des données palangrières de prise et effort. Les conséquences d'une prédominance des opérations de palangre profonde ont été prises en considération lors de l'entrée des données d'effort du modèle.

RESUMEN

Se hace una evaluación de la situación de los stocks de los recursos de patudo en el Atlántico, mediante un modelo de producción para unidades de stock hipotéticas; Norte, Sur y total del Atlántico. Se tuvieron en cuenta las consecuencias de la efectividad de las operaciones de palangre profundo, respecto a la entrada de datos de esfuerzo del modelo.

1. Introduction

Atlantic bigeye tuna are one of the most oceanic fish species being distributed trans-Atlantic in the tropical and temperate waters. The stock structure of the species is understood to be composed of a single Atlantic-wide stock together with a possibility of two separated substock in the northern and southern hemispheres, respectively. Historical fluctuation of annual catch indicates upward trend, reaching to high catch level close to 60,000 MT in recent two years (Fig.1). A principal bigeye fishery in the Atlantic has been longline fishery covering overall habitat, and its catch shares about two thirds of the total catch. Baitboat fisheries for bigeye has been operating taking measurable amount in the local waters around Canary and Madera Islands and off Dakar. Tropical baitboat and purse seine fleets catch bigeye as by-product.

In 1982, the SCRS evaluated the status of the bigeye resources such that the stock has been recently utilized heavily but not beyond the extent of expected maximum sustainable yield level (ICCAT 1983). Based on fishery data updated to 1981 and estimation of effective fishing effort of longline fishery, this report presents the results of an appraisal of the Atlantic bigeye stock by using production model.

2. Material and method

- 1) Catch data, including separation for north and south, was referred to Statistical Bulletin (ICCAT 1982), for which minor revision was made by the ICCAT secretariate (pers. comm.)
- 2) Effective effort was calculated from the catch and effort data of Japanese longline fishery, which provide basic and reasonable effort estimates. The technique of estimation was employed after Honma (1973) and brief explanation of the technique was also given in Kume (1983). The resultant estimated

effort statistics are shown in Table 1.

3) Taking into account of recently prevailing deep longline operation, new treatment of effort data for the years 1980 and 1981 was introduced in this study. The deep longlineing (DL) sets the gear deeper to improve bigeye catch and consequently the catchability increases more than that of regular longlining (RL) (Suzuki and Kume 1982). The original logbook records were sorted out to differentiate DL (more than 11 branch lines per basket) and RL (less than 10 branch lines per basket) in the main bigeye fishing grounds (Fig. 2) for 1980 and 1981. Table 2 shows the status of DL development by area, and overall percentages of DL operation were 20 % and 30 % for 1980 and 1981, respectively. Assuming the catchability increased a factor of 1.3 in 1980 and 1.4 in 1981, new effort data were tentatively estimated as 297 million hooks for 1980 and 354 million hooks for 1981. This estimates will be incorporated in later relevant section.

- 4) Input catch data to the model was cited from ICCAT Task I statistics. Since no other better estimates of cpue which represents relative abundance of the stock are available, the cpue of Japanese longline fishery expressed in terms of weight, being converted from cpue in number, was employed to estimate overall fishing effort on bigeye. Table 3 shows the input data up to 1981.
- 5) Input parameters into the model were identical to the studies previously conducted, namely number of dominant year classes in the catch (parameter k) was selected as 4 as previously employed. The model, generalized production model by Fox (1975), was fitted to input data and parameters for shape parameters of $m=0, 1.001$ and 2.

3. Trends in cpue of longline fishery

Since the share of the Japanese longline bigeye catch has been large and covering almost entire bigeye distribution, its cpue would represent an index

of abundance of the stock. Fig. 3 indicates the change in cpue of bigeye tuna caught by the Japanese longline fishery. Since 1961 when longline fishery expanded in entire bigeye distribution, the cpue has been decreasing gradually, and recent cpue levelled at about two thirds of the initial exploitation, regardless of supposed stock unit. This represents the decline of adult or spawning stock, because the longline catch has been composed of medium- and large-sized individuals. It is, however, noted that such decline in relative abundance is far less than experienced in other tuna species, and the current level of the adult stock remains still relatively high.

4. Production model analysis

The results of computation of the population parameters in the production model are summarized in Table 4 and Figs. 4-6. Fitting new effort estimates, which incorporated deep longlining operation, was also conducted for whole Atlantic case.

Atlantic-wide stock

The model estimated MSY's of 114,200 MT, 59,700 MT and 53,700 MT for $m=0$, 1.001 and 2 cases, respectively. The re-computation of the model with new effort data for 1980 and 1981 resulted in minor decrease in MSY estimates, though fit indices improved. In 1980 and 1981, total bigeye catches recorded 58,800 MT and 56,300 MT, respectively, and revised effort in 1981 exceeded by about 10 % over a computed MSY level in the case of $m=2$. It appears that Atlantic bigeye fisheries in recent years operated near or at the estimated MSY level. It is also expected that further increase in effort would lower the cpue and would not give increase in catch.

North Atlantic stock

Although the degree of fit index was lowest among computations for three stocks assumed, the model predicted the MSY's of 74,100 MT, 37,800 MT and

32,900 MT depending on shape parameter used. Both the catch and effort recently observed did not attain to the MSY level, but effort level was close to the MSY level for the case of $m=2$. It may be that the stock would respond to the fishery, in equilibrium sense, by marginal increase in catch with increasing effort, unless the effort increase is to the great extent.

South Atlantic stock

The catches of 28,600 MT and 27,700 MT recorded in 1980 and 1981 were beyond the MSY estimates of the model for the cases of $m=1.001$ and 2, though corresponding efforts were below the MSY level. The fishery seems to be operating near the MSY level, and the effort at current or higher level would lower the catches which located higher than estimated equilibrium curves.

In summary, it appears that the recent status of the bigeye tuna in the Atlantic has been utilized close to or at the MSY level, regardless of the stock structure hypothesis. This conclusion is nearly the same as that derived by the previous analysis (Kume 1983). To improve the present analysis, more detailed analysis on effort standardization is important, especially on the effect of prevailing deep longline operation. It is also suggested that age-structured model approach, such as cohort analysis, should be carried out to better understand the stock behavior.

References

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Table 1. Catch, effective effort and CPUE(hook rate) on Atlantic bigeye tuna by the longline fleet, 1957-81.

WHOLE ATLANTIC

YEAR	JAPANESE LONGLINE FLEET				WHOLE LL FLEET	
	CATCH IN NUMBER (1000)	YIELD IN WEIGHT (1000 MT)	EFFECTIVE HOOKS (MILLION)	HOOK RATE	YIELD IN WEIGHT (1000 MT)	EFFECTIVE HOOKS (MILLION)
1957	8.7	0.5	2.7	0.320	0.5	2.7
1958	14.8	0.5	5.9	0.251	0.5	5.9
1959	44.8	1.5	11.4	0.394	1.5	11.4
1960	70.6	2.9	15.5	0.454	3.0	16.0
1961	243.7	11.0	29.8	0.818	11.2	30.3
1962	367.9	15.7	54.0	0.682	16.0	55.0
1963	285.3	14.5	47.4	0.602	15.0	49.0
1964	343.7	17.3	61.1	0.563	17.8	62.9
1965	648.3	28.5	117.9	0.550	29.4	121.6
1966	232.1	17.6	48.1	0.482	19.6	53.6
1967	180.9	8.5	31.5	0.575	13.2	48.9
1968	204.6	10.3	31.2	0.655	18.8	56.9
1969	263.6	10.3	38.1	0.691	23.0	85.1
1970	187.3	9.0	33.5	0.559	28.1	104.6
1971	394.9	20.3	85.7	0.461	39.1	165.1
1972	346.0	18.1	79.5	0.435	32.5	142.7
1973	391.3	20.0	77.1	0.507	37.9	146.1
1974	457.3	20.9	69.0	0.663	39.1	129.1
1975	449.1	17.4	113.5	0.396	40.8	266.1
1976	171.0	7.3	50.6	0.338	27.4	189.9
1977	189.6	9.2	36.5	0.520	29.1	115.5
1978	209.2	9.3	48.9	0.428	28.2	148.3
1979	270.4	12.0	64.4	0.420	27.2	146.0
1980	451.3	20.5	96.9	0.466	41.3	195.2
1981	469.0	21.0	118.6	0.396	40.1	226.5

NORTH ATLANTIC

YEAR	JAPANESE LONGLINE FLEET				WHOLE LL FLEET	
	CATCH IN NUMBER (1000)	YIELD IN WEIGHT (1000 MT)	EFFECTIVE HOOKS (MILLION)	HOOK RATE	YIELD IN WEIGHT (1000 MT)	EFFECTIVE HOOKS (MILLION)
1957	7.3	0.4	2.0	0.396	0.4	2.0
1958	13.0	0.4	5.1	0.256	0.4	5.1
1959	39.9	1.3	9.6	0.417	1.3	9.6
1960	50.1	2.1	10.3	0.488	2.1	10.3
1961	67.6	3.1	9.1	0.742	3.1	9.1
1962	199.1	8.5	29.1	0.684	8.5	29.1
1963	166.0	8.4	26.2	0.635	8.4	26.2
1964	219.2	10.9	37.4	0.586	10.9	37.4
1965	339.1	14.7	56.5	0.601	14.7	56.5
1966	121.6	8.8	25.0	0.486	9.1	25.9
1967	75.3	3.4	14.9	0.506	4.1	18.0
1968	86.1	4.0	13.3	0.645	6.2	20.6
1969	65.2	2.4	12.9	0.504	6.4	34.4
1970	103.9	4.7	17.2	0.603	13.0	47.6
1971	258.5	13.1	60.0	0.431	18.6	85.2
1972	227.8	11.8	56.9	0.401	14.8	71.4
1973	219.4	11.1	37.0	0.593	19.1	63.7
1974	388.9	17.6	54.0	0.720	25.6	78.5
1975	320.0	12.4	83.0	0.385	24.6	164.7
1976	137.2	5.9	44.7	0.307	14.0	106.1
1977	107.5	5.3	21.7	0.495	16.1	65.9
1978	126.8	5.8	28.8	0.440	13.2	65.5
1979	127.4	5.1	30.9	0.412	10.8	65.4
1980	268.2	11.1	51.5	0.520	17.9	83.0
1981	275.5	11.4	72.8	0.378	19.3	123.2

SOUTH ATLANTIC

YEAR	JAPANESE LONGLINE FLEET				WHOLE LL FLEET	
	CATCH IN NUMBER (1000)	YIELD IN WEIGHT (1000 MT)	EFFECTIVE HOOKS (MILLION)	HOOK RATE	YIELD IN WEIGHT (1000 MT)	EFFECTIVE HOOKS (MILLION)
1957	1.4	0.1	0.6	0.218	0.1	0.6
1958	1.8	0.1	0.8	0.219	0.1	0.8
1959	4.9	0.2	1.8	0.266	0.2	1.8
1960	20.5	0.8	6.2	0.333	0.9	7.0
1961	176.0	8.0	21.1	0.833	8.1	21.4
1962	168.8	7.2	26.9	0.627	7.5	28.0
1963	119.3	6.1	23.0	0.519	6.6	24.9
1964	124.6	6.4	25.0	0.498	6.9	27.0
1965	309.2	13.9	61.6	0.502	14.7	65.1
1966	110.5	8.8	23.0	0.480	10.6	27.7
1967	105.6	5.2	17.3	0.610	9.2	30.6
1968	118.5	6.2	18.0	0.658	12.6	36.6
1969	198.4	7.9	24.5	0.810	16.6	51.5
1970	83.4	4.3	16.3	0.512	15.1	57.2
1971	136.5	7.1	26.4	0.517	20.5	76.2
1972	118.2	6.3	24.1	0.490	17.7	67.7
1973	171.9	8.8	38.7	0.445	18.8	82.7
1974	68.4	3.2	14.9	0.458	13.5	62.9
1975	129.0	5.0	32.4	0.398	16.2	105.0
1976	33.8	1.4	6.3	0.539	13.4	60.3
1977	82.2	3.8	14.7	0.561	13.0	50.3
1978	82.5	3.5	20.5	0.402	15.0	87.9
1979	143.0	6.8	34.3	0.417	16.4	82.7
1980	183.1	9.4	44.1	0.415	23.4	109.8
1981	193.5	9.6	45.5	0.425	20.8	98.6

Table 3. Input fishery data on production model for Atlantic bigeye tuna, 1961-81.

WHOLE ATLANTIC

YEAR	MEAN WEIGHT (KG)	HOOK RATE (KG/100 HOOKS)	TOTAL CATCH (1000 MT)	TOTAL EFFORT (MILLION)
1961	45	36.8	17.0	46.2
1962	43	29.3	23.1	78.8
1963	51	30.7	26.0	84.7
1964	50	28.2	23.5	83.3
1965	50	27.5	39.2	142.5
1966	48	23.1	25.0	108.2
1967	50	29.8	24.7	85.8
1968	48	31.4	23.0	73.2
1969	44	30.4	33.6	110.5
1970	49	27.4	39.2	143.1
1971	47	21.7	52.1	240.1
1972	44	19.1	42.8	224.1
1973	40	20.3	53.9	265.5
1974	47	31.2	59.8	191.7
1975	50	19.8	56.5	285.4
1976	47	15.9	38.8	244.0
1977	49	25.5	46.4	182.0
1978	45	19.3	45.3	234.7
1979	44	18.5	40.7	220.0
1980	45	21.0	58.8	280.0
1981	45	17.7	56.3	318.1

NORTH ATLANTIC

YEAR	MEAN WEIGHT (KG)	HOOK RATE (KG/100 HOOKS)	TOTAL CATCH (1000 MT)	TOTAL EFFORT (MILLION)
1961	46	34.1	8.9	26.1
1962	43	29.4	15.6	53.1
1963	51	32.4	19.3	59.6
1964	50	29.3	16.6	56.7
1965	53	31.9	24.4	76.5
1966	43	20.9	14.4	68.9
1967	43	21.8	15.1	69.3
1968	48	31.0	9.2	29.7
1969	50	25.2	15.0	59.5
1970	47	28.3	22.6	79.9
1971	45	19.4	29.0	149.5
1972	41	16.4	22.1	134.8
1973	36	21.3	30.0	140.8
1974	48	34.6	40.3	116.5
1975	52	20.0	38.8	194.0
1976	46	14.1	22.6	160.3
1977	49	24.3	28.1	115.6
1978	46	20.2	26.8	132.7
1979	40	16.5	20.3	123.0
1980	41	21.3	30.3	142.3
1981	41	15.6	28.5	182.7

SOUTH ATLANTIC

YEAR	MEAN WEIGHT (KG)	HOOK RATE (KG/100 HOOKS)	TOTAL CATCH (1000 MT)	TOTAL EFFORT (MILLION)
1961	46	38.3	8.1	21.1
1962	43	27.0	7.5	27.8
1963	51	26.5	6.7	25.3
1964	51	25.4	6.9	27.2
1965	48	24.1	14.8	61.4
1966	53	25.4	10.6	41.7
1967	54	32.9	9.6	29.2
1968	48	31.6	13.7	43.4
1969	41	33.2	18.6	56.0
1970	51	26.1	16.6	63.6
1971	48	24.8	23.0	92.7
1972	47	23.0	20.7	90.0
1973	44	19.6	24.0	122.4
1974	44	20.2	19.6	97.0
1975	47	18.7	17.7	94.7
1976	48	25.9	16.3	62.9
1977	47	26.4	18.3	69.3
1978	44	17.7	18.6	105.1
1979	48	20.0	20.4	102.0
1980	51	21.2	28.6	134.9
1981	50	21.1	27.7	131.3

Table 2. Number of operation, catch and catch-per-effort (catch in number per set:C/E) of bigeye tuna in the Atlantic for regular longlining (RL) and deep longlining (DL) of Japanese longline fishery in the main bigeye fishing ground for the years 1980 and 1981.

Area		1980		1981	
		longline RL	method DL (%)=	longline RL	method DL (%)=
A	No. of op.	4,920	273 (5.2)	5,895	2,066 (26.0)
	Catch	93,951	7,234	64,997	39,493
	C/E	19.1	26.5	11.0	19.1
B	No. of op.	440	8 (1.7)	570	27 (4.5)
	Catch	18,456	36	13,653	430
	C/E	41.9	4.5	24.0	15.9
C	No. of op.	1,081	457 (29.7)	867	1,020 (54.1)
	Catch	38,384	17,795	20,056	39,780
	C/E	35.5	38.9	23.1	39.0
D	No. of op.	556	585 (51.3)	954	558 (36.9)
	Catch	18,786	28,534	22,859	19,206
	C/E	33.8	48.8	24.0	34.4
E	No. of op.	1,527	603 (28.3)	1,820	491 (21.2)
	Catch	36,275	18,615	51,222	16,956
	C/E	23.8	30.1	28.1	34.5

Table 4. Estimated population parameters by production model analysis for Atlantic bigeye tuna stock, 1961-1981. Figures in the parentheses show the estimates based on new effort data.

	m	Degree of fit index	f-optimum (million hooks)	Y-max (1,000 MT)	1979-1981 Catch (1,000 MT)
Whole	0	.485 (.506)		114.2 (108.4)	
Atlantic	1.001	.488 (.514)	459 (434)	59.7 (57.5)	40.7-56.3
	2	.492 (.524)	320 (306)	53.7 (52.2)	
North	0	.291		74.1	
Atlantic	1.001	.294	305	37.8	20.3-30.3
	2	.298	202	32.9	
South	0	.586		49.2	
Atlantic	1.001	.586	203	26.2	20.4-28.6
	2	.576	143	23.7	

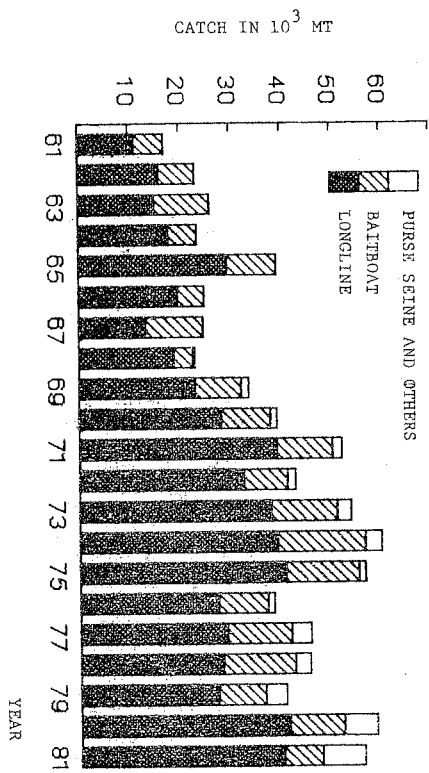


Fig. 1. Annual catch of bigeye tuna by gear in the Atlantic, 1961-81.

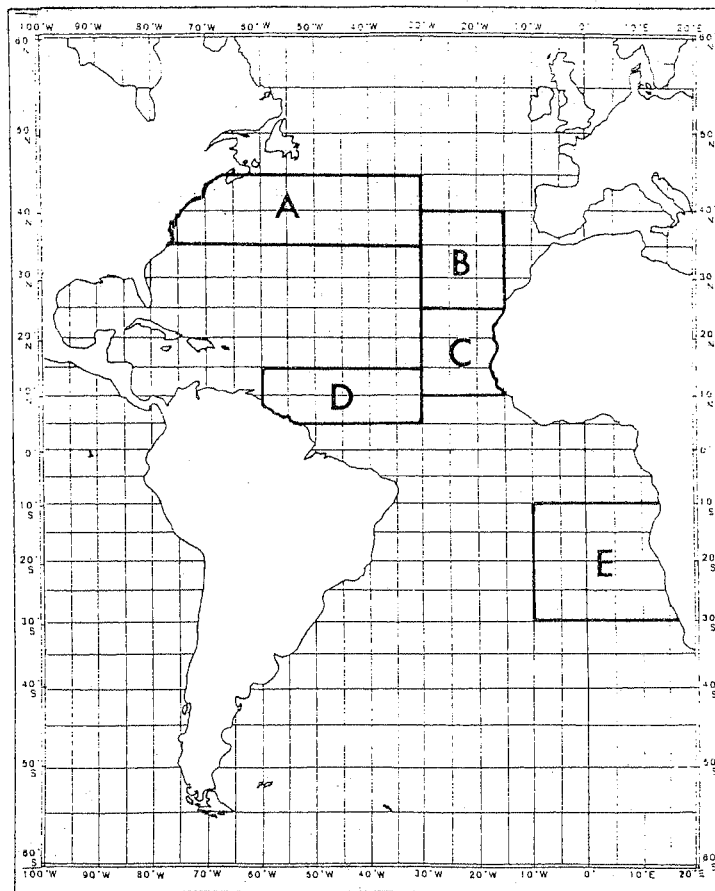


Fig. 2. Division of bigeye fishing grounds, in which deep longline operation was differentiated in 1980 and 1981.

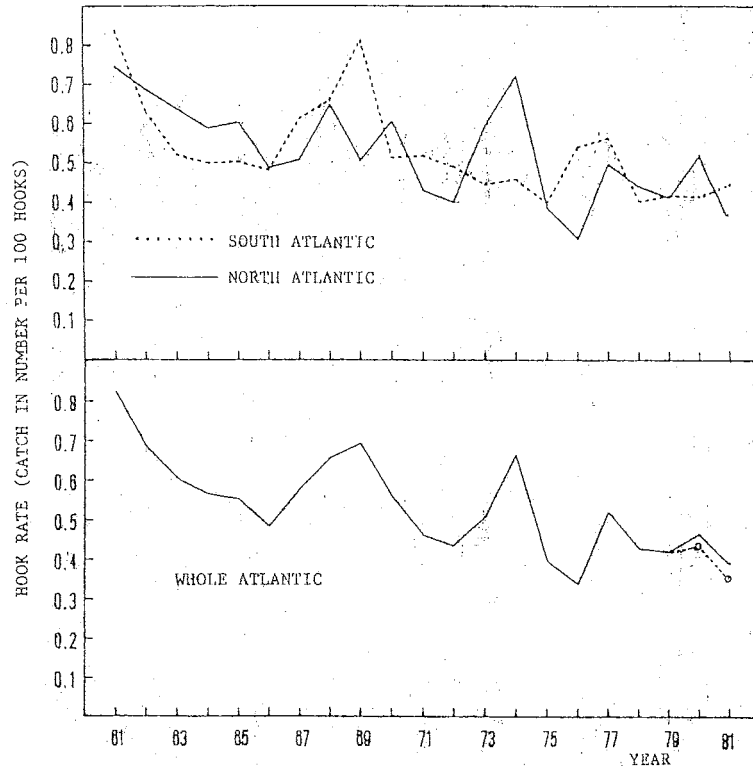


Fig. 3. Annual change in hook rates in the whole Atlantic (lower pannel) and in the north and south Atlantic (upper pannel), 1961-81. Circles in the lower pannel show revised cpue in 1980 and 1981.

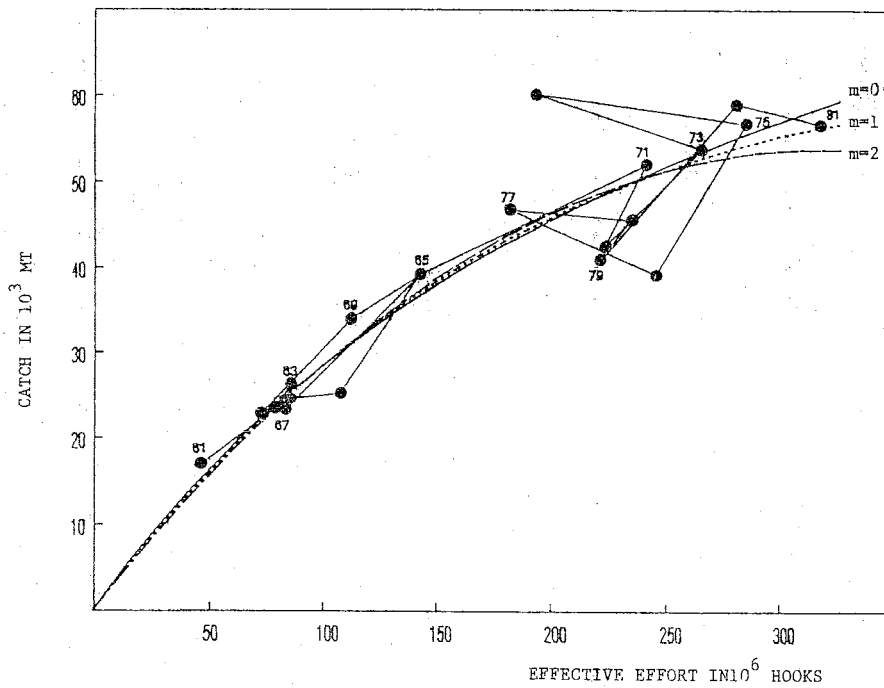


Fig. 4. Yield curves obtained from the production model analysis for bigeye tuna in the whole Atlantic, 1961-81.

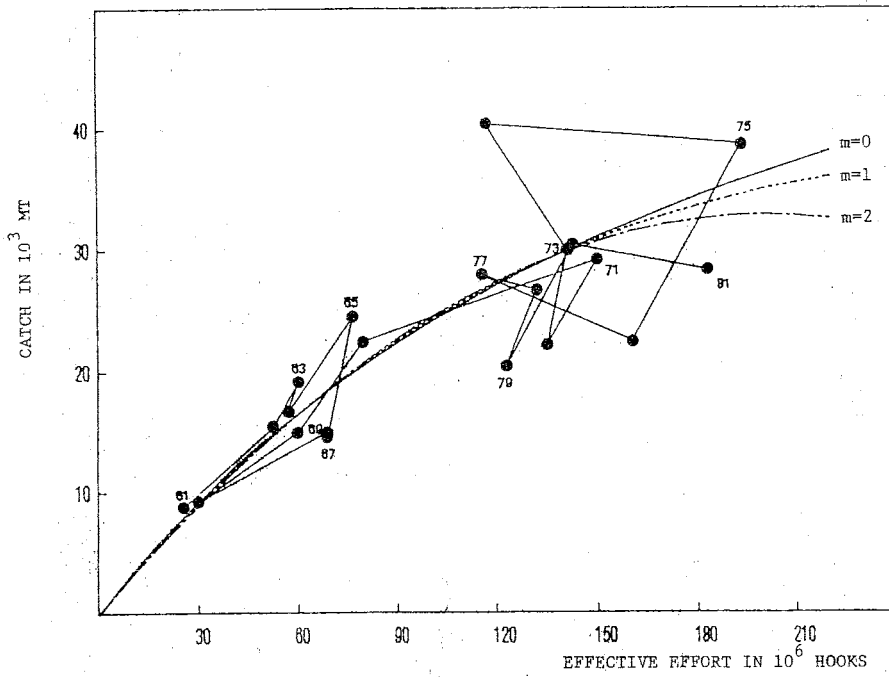


Fig. . Yield curves obtained from the production model analysis for bigeye tuna in the north Atlantic, 1961-81.

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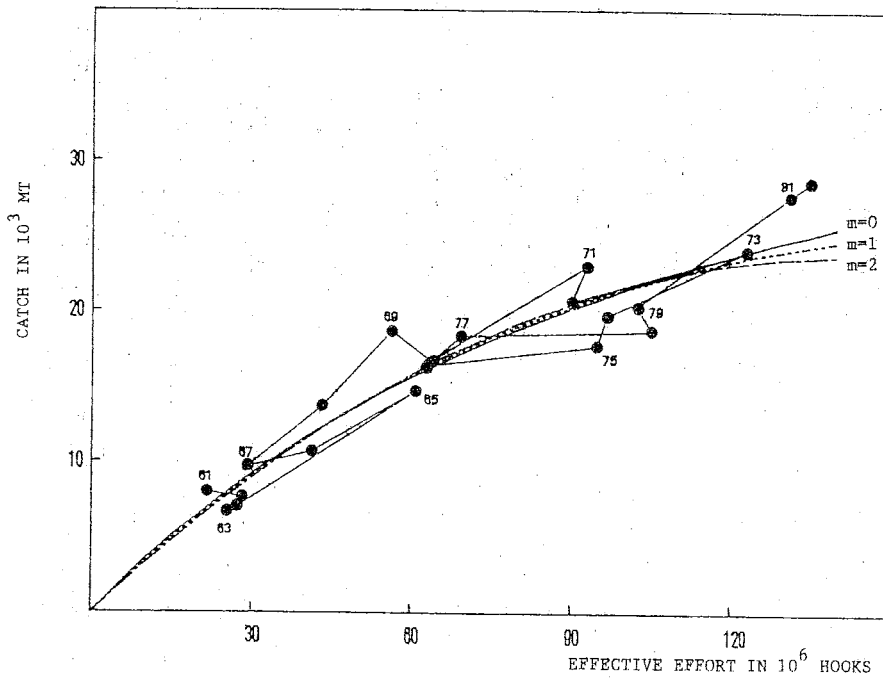


Fig. 6. Yield curves obtained from the production model analysis for bigeye tuna in the south Atlantic, 1961-81.