

MANAGEMENT OF THE POPULATION OF BIGEYE TUNA (THUNNUS OBESUS) OF THE ATLANTIC

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SUMMARY

Based on recent compilation of statistical data, a cohort analysis was applied to the bigeye tuna stock of the Atlantic.

Results of projections of the catches and biomasses for different intensities of fishing mortalities and exploitation patterns are given.

RESUME

Une récente compilation de données statistiques a permis d'appliquer une analyse de cohortes au stock de thon obèse de l'Atlantique.

Les résultats de projections de la capture et de la biomasse pour diverses intensités de mortalité par pêche et divers régimes d'exploitation sont indiqués.

RESUMEN

Se aplicó un análisis de cohortes al stock de patudo en el Atlántico, basado en una recopilación reciente de datos estadísticos.

Se facilitan los resultados de las proyecciones de las capturas y biomosas de diferentes intensidades de mortalidad por pesca y condiciones de explotación.

1. INTRODUCTION

The catch data were compiled from ICCAT statistical bulletins and Scientific Papers, for the period of 1965-1978.

Cohorte analyses and projections were carried out by a WANG 2200 computer, using basic language (programs are available in I.N.I.P.).

For all the analyses, one stock was assumed in the total Atlantic area, instead of assuming a North and South stock (KUME and MORITA, 1976).

2. THE FISHERIES

The exploitation of the Bigeye tuna stock of the Atlantic is carried out mainly by different fleets.

2.1. Portuguese and Canarian Baitboat Fisheries

These fleets operate in Madeira, Açores and Canarian Islands.

About 17% of the total Atlantic caught of Bigeye tuna is caught by these fleets.

The catches are predominating of 2 years old fishes (Tab.1).

2.2. FIS Baitboat Fisheries

The FIS fleet is composed of vessels from France, Ivory Coast and Senegal, based in Dakar.

About 6% of the total Atlantic caught of Bigeye is caught by these fleets.

The catches are predominating of 1 year old fishes (Tab.2).

2.3. TEMA Baitboats Fisheries

The TEMA fleet include baitboat vessels from Japan, Korea, Panama and Ghana, based in Tema.

About 3% of the total Atlantic caught of Bigeye is caught by this fleet.

This fleet explores exclusively the fishes swimming in the surface, in the central Atlantic area, and catches are predominating of juvenis (Tab. 3).

2.4. Purse Seine

The Purse seiners are composed essentially of FISM (France, Ivory Coast, Senegal and Morocco) and American purse seiners.

About 3% of the total Atlantic caught of Bigeye is caught by these fleets.

Purse seiners explore the surface strata of North and Centre Atlantic area, predominating the catches of juvenis (Tab.4).

2.5. Longline

Include the fleet from Japan, Panama, Taiwan, Cuba and U.S.S.R., exploiting deep strata.

About 67% of the total Atlantic caught of Bigeye is caught by these fleets.

The catches are predominating of older fishes (Tab.5).

3. COHORTE ANALYSES

3.1. Catches

The average weights at age, were estimated by the following

formulas (POTIER et FONTENEAU,1981):

$$L = 338.53(1 - e^{-0.104097(t+0.5425)}) \quad \text{CHAMPAGNAT,PIANET}$$

$$W = 2.15 \times 10^{-5} \times L^{2.984} \quad \text{SANTOS GUERRA}$$

L - Fork length (cm) of the fish

W - average weight (Kg.)

t - age

The catches in number by ages,were raised,when necessary,by the ratio of the total weight caught (ICCAT,statistical bulletins) and the calculated total weights.

For some gears,the available catches at length were previously converted into ages. When necessary interpolated values were used.

For the years 1965 to 1975 was adopted average percentage compositions of 1975-1978 of Portugal and Canarian baitboats,to estimate the catches in number at age,for those vessels catches,on those years; for the FIS baitboat and for the year 1978,was adopted average percentage compositions of 1965-1977; for TEMA bait boat and for the years 1965-1976,was adopted average percentage compositions of 1976-1978; for FIS purse seiners and for 1978,was adopted average percentage compositions of 1967-1977 and,for American purse seiners,for 1965-1976,was adopted average percentage compositions of 1976-1978.

Total catches,in number,at age,for all gears,for the period of 1965-1978 are available in Table 6.

3.2. Natural Mortality.

It was adopted the value of $M = 0.45$,according to KUME(cit. in GOMES, 1980).

3.3. Terminal Fishing Mortalities

3.3.1. For the last age (10^+),all years (1965-1978) were assumed values

of $F = 0.02;0.08;0.15$ and 0.20

3.3.2. For the last year (1978),the values of F were taken as the averages F's at ages,calculated by an initial cohorte analyses,with the terminal F as given by FONTENEAU(1981).

3.4. Results of Cohorte Analyses

Fishing mortality

The arithmetic average of values of F,from V.P.A.,for 3 periods: 1965-1968;1969-1973 and 1974-1978 (Tab.7),were considered to analyse exploitation patterns (Figs.2,3,4).

The F's are convergent from the ages of 4 to 0 year old.

The higher values of mortalities appear in the age 5^+ ,as expected, due to the longline fisheries patterns.

The mortalities of 0-2 years old fish were very small before 1969 as surface fishing only started to develop after that year (Fig.1).

Recruitment

For all assumptions of terminal F it appears that recruitment was higher in 1975,being now at levels below 1969-1973. However,the assumption of $F = 0.02$,showed a very high value of recruitment in 1967 (Fig.5).

Spawning Biomass

The age of sexual maturity was taken as 3 years old(according to KUME and MORITA,1966).

It was estimated the spawning biomass for each alternative of terminal F (Tab.8).

The spawning biomass is at levels around 120 000 T,after 1969

(Fig.6). The higher and lower values correspond to recruitment values 3 years before.

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4. PROJECTIONS

4.1. Starting Values

The initial population used in the projections (Tab.9), was the 1978 population, estimated by cohort analyse for terminal $F = 0.15$.

The averages weights at age, of the total catch were taken as the weighted mean of the averages weights at age of different gears, being the weight the total catches of those gears (Tab.9).

The average weight at age of the population, at the beginning of the year, was estimated using CHAMPAGNAT, PLANET and SANTOS GUERRA formulas (Tab.9).

A value of $M = 0.45$ was adopted as expressed before.

Five different exploitation regimes were tried:

- 1 - No change in 1978 fishing regime.
- 2 - Closure of BB TEMA fisheries, once this gear catches mainly juvenis (0-1 year old), increasing by 20% the longline and BB FIS fisheries and, keeping the level of fishery of purse seiners of Portugal + Canarian baitboat fisheries.
- 3 - To maintain the level of fishing of BB TEMA, to increase by 50% the level of purse seiners fishing and to intensify by 20% the BB FIS, BB Portugal + Canarian and longline level.
- 4 - To decrease BB TEMA and purse seiners fishing by about 50%, to maintain the level of BB FIS and longline and to intensify by 20% BB Port. + Can. fishing.
- 5 - To increase only the fishing of BB Port. + Can. by 20%, maintaining the fishing levels of the other fisheries.

4.2. Results

Table 10 present the results of the projections for the 5 different exploitation regimes.

The catch projection for 1980, 1st alternative (54 000 T), agrees with the amount caught in this year (56 000 T).

Under the regime 3, the longterm yield (61 000 t), will be around 27% higher and the Biomass about 20% more, than at present.

Under the regime 4, the longterm yield (56 000 T), will be around 17% higher and the spawning Biomass around 20% higher, than at present.

4.2.1. Yield curves

Yield curves for the 5 different exploitation pattern are given in Figures 7, 8, 9, 10 and 11.

For the 1st alternative of exploitation pattern, the MSY is of 48 000 T at $F_{Max.} = 0.3$. For $F = 0.2$, the longterm yield is almost the MSY, but the Biomass is 31% higher than at $F_{Max.}$.

For the 2nd alternative, the MSY is of 54 000 T and the Biomass of 216 000 T, at $F_{Max.} = 0.3$. At $F = 0.2$, the longterm yield is of 51 000 T but the Biomass is 26% higher than at $F_{Max.}$.

For the 3rd alternative: MSY of 62 000 T, at $F_{Max.} = 0.4$. Also in this case, at $F = 0.3$, the longterm yield is of 61 000 T (only 1 000 T less), but the Biomass is 17% higher than at $F_{Max.}$.

For the 4th alternative: MSY of 56 000 T, at $F_{Max.} = 0.3$ and 0.4. At $F_{Max.} = 0.3$ the Biomass is 19% higher.

For the 5th alternative: MSY of 48 000 T, at $F_{Max.} = 0.2$ and 0.3. At $F_{Max.} = 0.2$ the Biomass is 30% higher.

5. CONCLUSIONS

It seems that the alternative 3 of the different projections gives a maximum yield (61 000 T) and higher Biomass (21% more).

The alternative 4 of the projections gives a maximum yield of 56 000 T and a Biomass around 20% higher.

The effort should be maintained but the effort of Guinea Golf surface fisheries should not increase, because they catch too young fishes.

The minimum size catch of Bigeye, 3.2 Kg., should be strictly respected, what nowadays seems not to happen.

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Age:	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
0+					0	0	0	0	0	0	0	0	0	0
1					1 767	14 024	15 865	11 311	16 506	22 876	29 886	15 547	8 543	7 825
2					12 192	96 785	109 486	78 053	113 909	157 868	269 455	73 835	58 756	25 420
3					3 398	26 977	30 518	21 756	31 750	44 003	27 513	41 454	19 647	18 332
4					3 264	25 913	29 314	20 791	30 498	42 269	27 040	15 975	36 562	42 712
5					3 197	25 382	28 713	20 489	29 873	41 401	32 735	27 201	16 080	27 968
6					2 406	19 102	21 609	15 405	22 462	31 157	21 823	12 955	20 499	24 913
7					730	5 796	6 557	4 875	6 822	9 455	7 587	1 728	5 409	10 813
8					66	471	533	380	655	769	943	0	712	503
Tot.	0	0	0	0	27 013	214 450	242 595	172 840	252 395	349 797	416 997	188 699	170 270	158 084

TABLE 1 - Total catches, in number, at age for Portuguese + Canarian Baitboat fisheries.

IDADE	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
0+	1 146	1 375	1 688	3 182	4 081	1 720	2 133	1 836	3 024	1 572	18 084	0	1 114	11 091
1	8 957	10 748	25 387	37 929	25 192	40 812	25 086	68 204	62 712	15 898	132 298	94 927	123 573	166 597
2	7 767	9 320	14 147	25 033	33 665	6 659	28 906	24 448	29 090	13 840	27 671	32 104	76 796	84 650
3	5 226	6 271	5 686	13 119	13 889	11 751	679	3 045	3 523	9 380	2 937	2 299	11 143	26 476
4	1 190	1 428	1 328	2 996	3 196	2 681	1 181	397	1 163	1 851	277	780	2 716	6 360
5	240	288	241	578	546	647	149	60	508	601	72	191	1 038	1 456
6	59	71	63	145	159	126	0	16	100	37	0	0	174	270
7	15	18	15	35	60	0	0	0	16	6	0	0	54	53
TOTAL	24 600	29 519	48 555	83 017	80 788	64 596	58 224	98 006	100 136	43 105	181 339	130 301	216 608	296 874

Table 2. Total catches, in number, at age for FIS baitboat fisheries.

AGE	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
0+	54 444	1 111	164 444	280 000	611 111	4 261 111	4 782 222	3 750 000	5 704 444	7 593 333	6 319 000	676 535	585 949	503 569
1	12 364	162	38 000	64 364	140 727	981 091	1 101 273	863 455	1 313 455	1 748 546	1 452 909	102 920	238 419	147 100
2	387	0	1 097	1 871	4 065	28 255	31 742	24 903	37 871	50 357	41 871	994	9 264	5 245
3	32	0	125	192	415	3 093	3 355	2 620	3 994	5 335	4 441	0	1 498	226
4	19	0	57	76	190	1 295	1 448	1 143	1 733	2 305	1 924	0	707	65
5	0	0	14	14	42	266	294	220	350	462	392	0	164	0
TOTAL	67 246	1 293	203 740	346 317	756 350	5 225 024	5 922 334	4 642 345	7 061 847	9 400 398	7 811 537	960 475	832 927	658 231

TABLE 3 - Total catches, in number, at age for TEMA baitboat fisheries.

AGE	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
0*			4 692	10 284	53 718	291 203	343 440	240 132	616 404	748 429	356 110	197 814	523 463	1 487 533
1			8 643	15 955	25 596	117 837	133 005	121 081	131 363	286 436	143 838	292 580	765 645	142 848
2			1 750	5 395	6 723	40 658	66 853	36 847	126 223	102 048	59 762	82 933	62 533	44 153
3			280	598	649	3 031	1 974	2 153	8 353	16 911	7 364	3 733	16 804	8 231
4			135	250	466	2 207	2 493	1 365	6 250	6 805	3 856	645	9 455	9,350
5			50	67	102	328	106	62	2 213	1 377	551	44	2 644	771
6			6	7	12	34	0	4	457	188	34	33	200	66
7			0	0	1	3	0	0	54	0	4	0	0	6
TOTAL	0	0	15 566	32 557	87 267	455 311	547 871	401 644	891 317	1 162 196	571 519	583 752	1 380 999	1 673 320

TABLE 4 - Total catches, in number, at age for purse seiners (FIS + American) fisheries.

AGE	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
0*	0	0	0	0	0	0	0	0	0	0	0	0	0	43
1	17 180	7 217	2 048	5 347	9 858	10 570	22 585	19 565	19 908	12 274	12 107	5 827	13 233	4 358
2	64 057	22 845	21 335	34 805	93 979	37 593	92 837	97 439	143 834	69 066	72 868	32 140	126 761	60 433
3	124 337	54 478	43 758	80 955	103 889	101 331	144 983	154 380	203 338	233 068	183 160	119 250	203 229	254 335
4	178 024	65 705	49 709	106 629	105 112	104 714	192 532	97 849	117 566	187 450	211 723	173 508	205 265	204 857
5	135 743	49 249	40 692	63 603	76 896	81 291	141 552	95 315	94 560	115 616	124 100	135 146	38 166	85 244
6	91 427	24 557	23 523	38 286	45 880	47 431	73 366	60 326	58 266	78 118	77 086	53 632	24 010	25 559
7	38 282	12 383	11 710	17 342	23 197	22 417	30 354	27 345	21 999	36 848	49 532	29 632	1 380	648
8	7 034	2 773	2 355	3 726	5 155	6 149	7 921	6 019	4 275	13 413	27 002	10 916	15	0
9	1 571	224	219	670	599	876	1 204	845	664	2 969	5 903	8 942	50	50
10*	182	32	43	63	66	109	272	235	46	652	1 239	2 205	50	50
TOTAL	655 652	239 445	195 443	351 431	464 631	412 481	707 606	559 316	664 454	749 474	764 720	571 308	888 185	803 870

TABLE 5 - Total catches, in number, at age for longline fisheries.

AGE	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978
0	55 910	2 485	175 824	253 466	688 910	4 554 034	5 127 795	3 991 958	6 323 872	8 343 334	6 664 184	1 074 315	1 110 528	584 251
1	35 441	18 147	74 076	123 555	203 140	1 164 334	1 297 814	1 083 618	1 543 942	2 086 032	1 771 038	511 651	1 147 429	458 627
2	72 211	32 165	38 279	67 105	150 624	210 163	329 914	261 680	450 927	333 208	471 637	227 877	333 187	233 648
3	123 555	80 750	49 653	94 684	122 240	146 093	181 509	183 654	250 958	308 637	225 415	186 748	256 321	257 680
4	177 233	87 133	51 223	109 551	112 228	136 810	226 968	121 545	157 210	240 673	244 620	180 808	256 785	283 494
5	135 933	49 537	40 937	64 282	80 783	107 914	170 814	116 130	127 504	159 457	157 680	162 582	110 292	112 455
6	81 455	24 625	23 592	38 438	48 457	66 693	94 975	75 751	81 305	109 500	95 943	66 620	44 633	50 635
7	35 277	12 351	11 725	17 377	23 888	28 218	36 911	32 020	28 691	46 309	57 123	31 550	6 852	11 322
8	7 034	2 773	2 355	3 725	5 214	6 620	8 454	6 399	4 830	14 162	27 950	10 815	727	505
9	1 571	234	219	670	588	876	1 204	845	664	2 855	5 803	8 642	50	50
10	152	52	43	88	66	109	272	235	46	652	1 238	2 205	50	50
TOTAL	747 708	270 257	483 304	813 522	1 415 245	5 421 652	7 476 630	5 674 153	8 970 148	11 705 020	9 746 112	2 454 538	3 289 043	3 338 158

TABLE 6 - Total catches, in number, at age for all gears.

AGE	1965-68	1969-73	1974-78
0 ⁺	0.02	0.36	0.23
1	0.01	0.23	0.17
2	0.02	0.12	0.10
3	0.07	0.11	0.14
4	0.17	0.15	0.32
5	0.32	0.18	0.53
6	0.45	0.26	0.75
7	0.55	0.30	0.98
8	0.38	0.24	0.43
9	0.18	0.08	0.25
10 ⁺	0.02	0.02	0.02

AGE	1965-68	1969-73	1974-78
0 ⁺	0.02	0.38	0.31
1	0.02	0.24	0.22
2	0.03	0.12	0.12
3	0.10	0.13	0.17
4	0.25	0.18	0.37
5	0.44	0.29	0.62
6	0.68	0.46	0.95
7	1.07	0.67	1.27
8	1.12	0.70	0.95
9	0.73	0.41	0.68
10 ⁺	0.15	0.15	0.15

AGE	1965-68	1969-73	1974-78
0 ⁺	0.02	0.38	0.28
1	0.02	0.24	0.21
2	0.03	0.12	0.12
3	0.10	0.13	0.16
4	0.24	0.17	0.36
5	0.42	0.26	0.59
6	0.63	0.40	0.87
7	0.94	0.55	1.12
8	0.67	0.53	0.76
9	0.50	0.26	0.51
10 ⁺	0.08	0.08	0.08

AGE	1965-68	1969-73	1974-78
0 ⁺	0.02	0.38	0.33
1	0.02	0.24	0.23
2	0.03	0.12	0.13
3	0.10	0.13	0.17
4	0.26	0.18	0.38
5	0.45	0.30	0.62
6	0.69	0.48	0.96
7	1.12	0.72	1.32
8	1.24	0.77	1.05
9	0.85	0.50	0.76
10 ⁺	0.20	0.20	0.20

TABLE 7 - Average of values of F, for 3 periods(1965-1968;1969-1973 and 1974-1978), for 4 alternatives of terminal F:

- A) $F_t = 0.02$
- B) $F_t = 0.08$
- C) $F_t = 0.15$
- D) $F_t = 0.20$

	1955	1956	1957	1958	1959	1970	1971	1972	1973	1974	1975	1976	1977	1978
$F_t = 0.02$	111 595	91 262	142 677	186 034	285 104	321 685	327 501	298 617	277 537	250 100	201 263	163 473	174 063	231 323
$F_t = 0.08$	67 396	66 373	67 002	120 307	161 188	189 316	200 847	187 574	183 909	174 983	145 403	124 175	143 474	185 053
$F_t = 0.15$	63 574	64 758	61 277	110 147	142 056	169 238	181 635	171 031	169 593	162 915	135 012	116 366	135 054	170 821
$F_t = 0.20$	82 446	63 710	79 614	107 156	138 521	163 420	176 087	166 244	165 425	159 622	133 336	114 410	132 210	163 094

TABLE 8 - Total values of spawning Biomass(Ton.), for 4 alternatives of terminal F(0.02;0.08;0.15 and 0.20).

AGE	[N _i]	W̄	W ₁	[F _i]				M
				2° h	3° h	4° h	5° h	
0*	11 445 526	0.4	0.1	0.15	0.07	0.12	0.24	0.45
1	4 430 963	4.4	2.6	0.11	0.07	0.08	0.14	0.45
2	3 864 061	15.5	9.8	0.08	0.08	0.07	0.07	0.45
3	2 817 149	31.4	22.7	0.15	0.14	0.12	0.13	0.45
4	1 519 881	52.6	41.3	0.27	0.28	0.24	0.24	0.45
5	430 689	78.3	64.9	0.48	0.49	0.43	0.44	0.45
6	133 542	107.6	92.6	0.68	0.74	0.67	0.67	0.45
7	23 441	121.8	123.5	0.90	1.05	1.02	1.02	0.45
8	4 503	168.7	156.6	0.15	0.18	0.18	0.18	0.45
9	443	206.6	191.1	0.18	0.18	0.15	0.15	0.45
10*	443	243.8	226.2	0.18	0.18	0.15	0.15	0.45

TABLE 9 - Starting values for projections.

	1	2	3	4	5
Same Regime		0 BB TEMA +20Z BB FIS +20Z LL = PS = BB P+C	0 BB TEMA +20Z BB FIS +20Z LL -50Z PS +20Z BB P+C	-50Z BB TEMA = BB FIS = LL -50Z PS +20Z BB P+C	= BB TEMA = BB FIS = LL = PS +20Z BB P+C
B	1979	221	221	221	221
	1980	231	228	230	230
	1981	226	223	230	223
	1892	215	217	228	212
	LT	205	221	246	203
B _s	1979	171	171	171	171
	1980	191	186	186	190
	1981	178	171	171	176
	1982	167	164	170	165
	LT	158	168	188	155
Y	1979	45	49	49	44
	1980	54	57	57	55
	1981	57	59	60	58
	1982	54	56	58	55
	LT	48	54	61	49

TABLE 10 - Results of Projections in 1 000T.

Biomass(B)

Spawning Biomass(B_s)

Yield(Y)

LT - longterm.

* - estimated

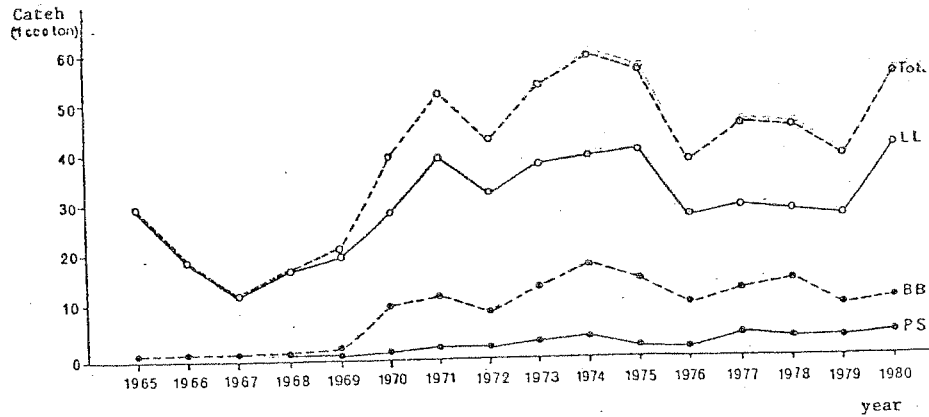


FIGURE 1 - Evolution of Bigeye catches, By year (1965-1978), by gear (LL, BB, PS) and total catches.

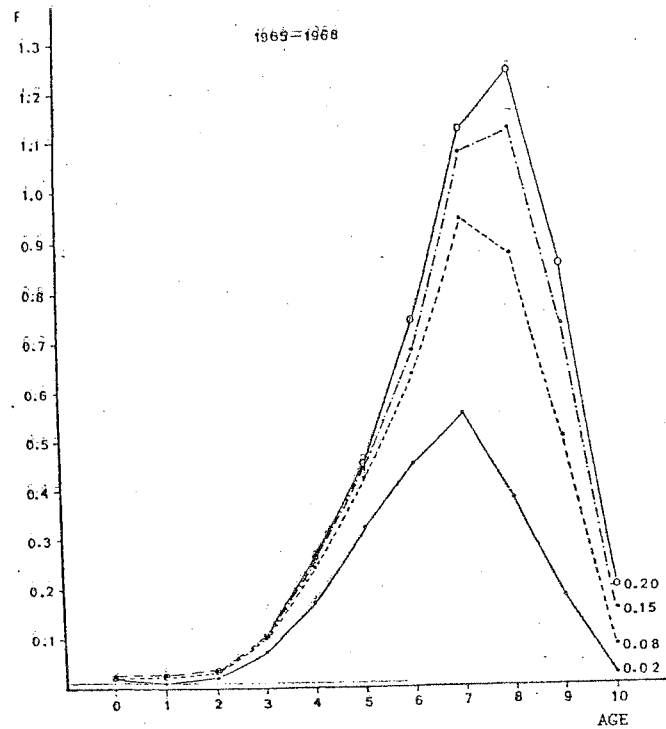


FIGURE 2 - Fishing mortality at age, for 4 alternatives of terminal $F(0.02; 0.08; 0.15 \text{ and } 0.20)$, for the period of 1965-1968.

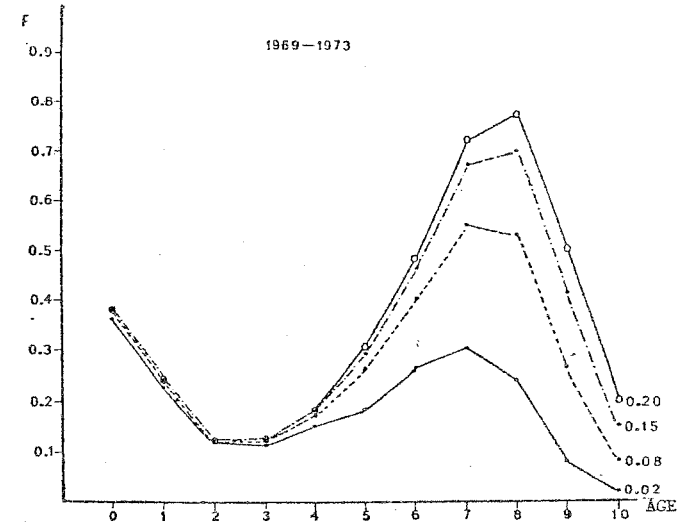
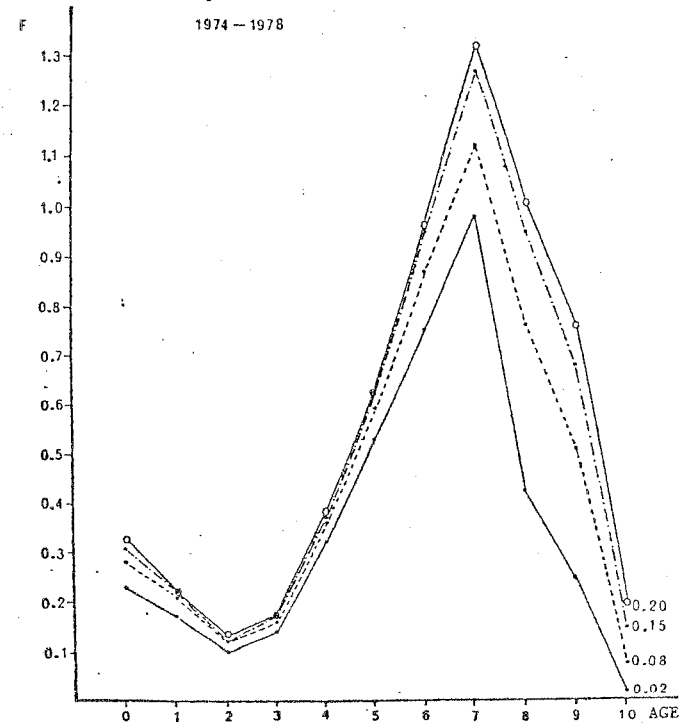


FIGURE 3 - Fishing mortality, at age, for 4 alternatives of terminal $F(0.02; 0.08; 0.15 \text{ and } 0.20)$, for the period of 1969-1973.



373 FIGURE 4 - Fishing mortality, at age, for 4 alternatives of terminal $F(0.02; 0.08; 0.15 \text{ and } 0.20)$, for the period of 1974-1978.

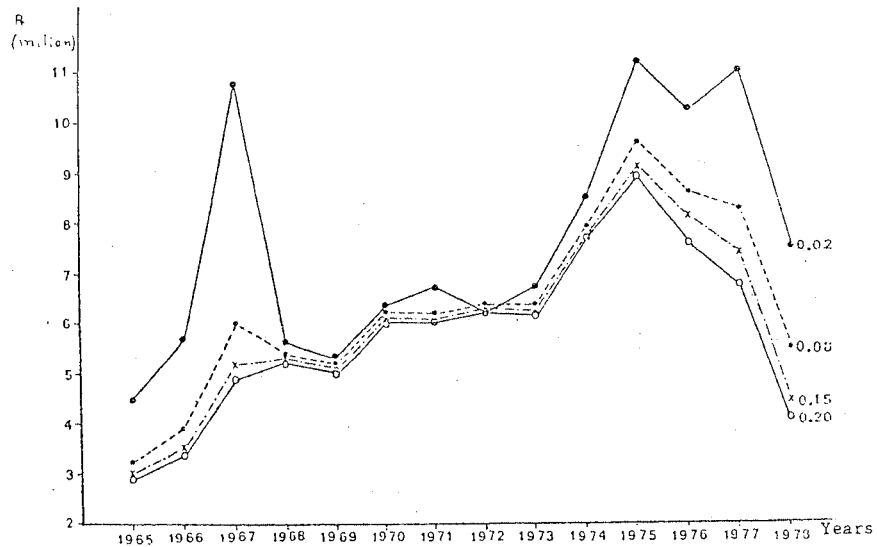


FIGURE 5 - Bigeye recruitment, expressed in number of fishes of 1+ year old, for 4 alternatives of terminal F (0.02; 0.08; 0.15 and 0.20).

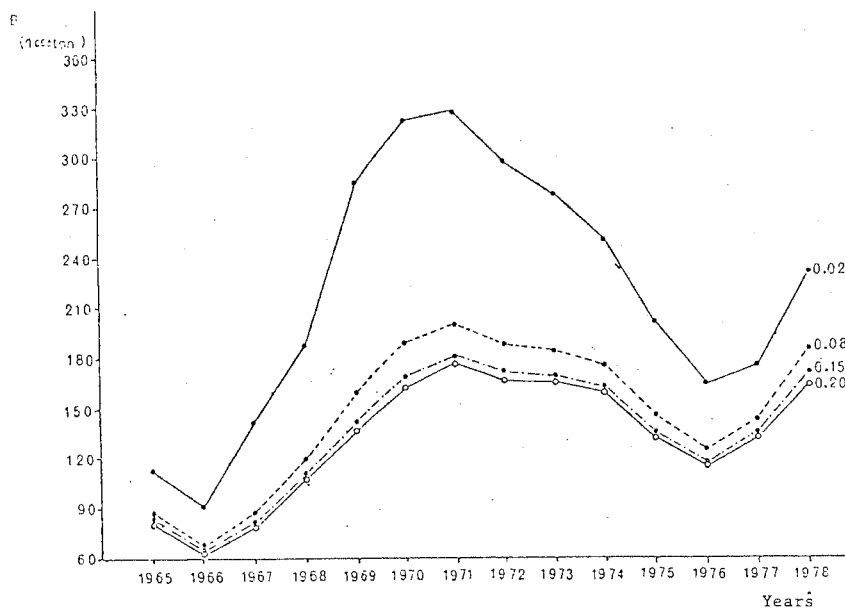


FIGURE 6 - Total values of spawning Biomass for 4 alternatives of terminal F (0.02; 0.08; 0.15 and 0.20).

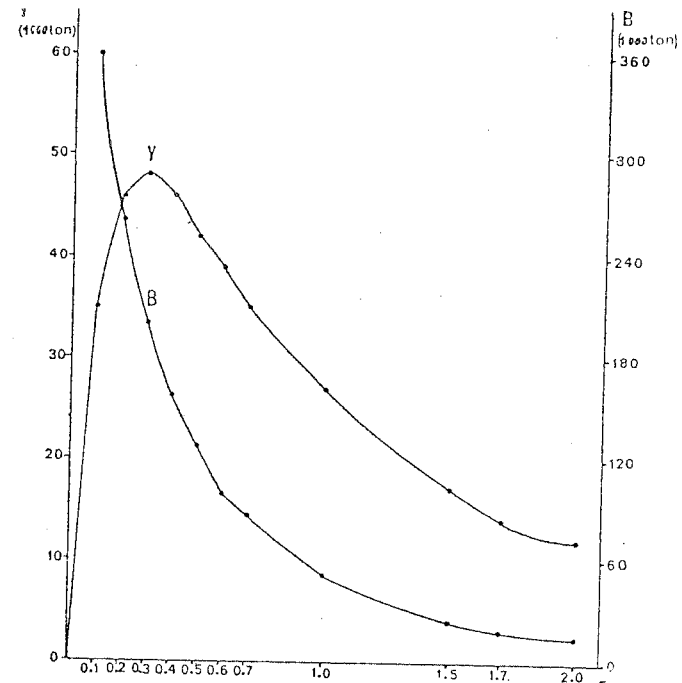


FIGURE 7 - Total values of catches (Y) and Biomass (B) for the 1st alternative of exploiting pattern.

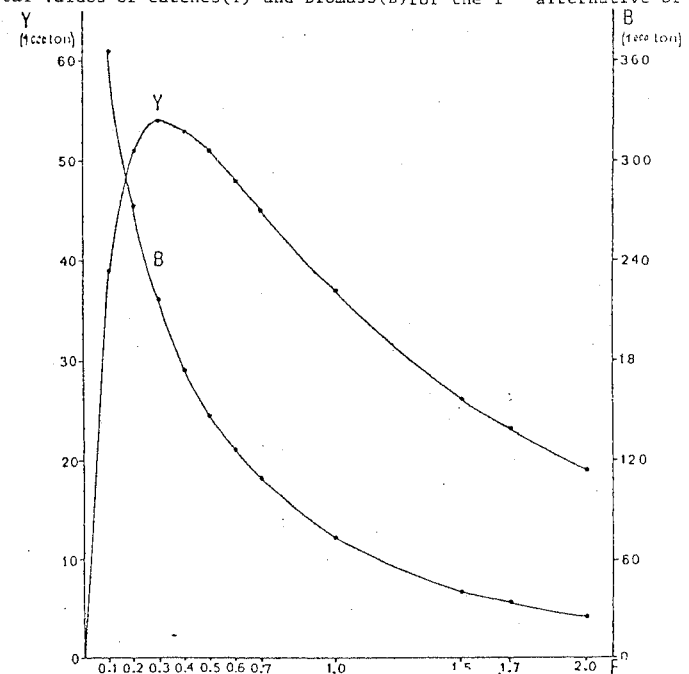


FIGURE 8 - Total values of catches (Y) and Biomass (B) for the 2nd alternative of exploiting pattern.

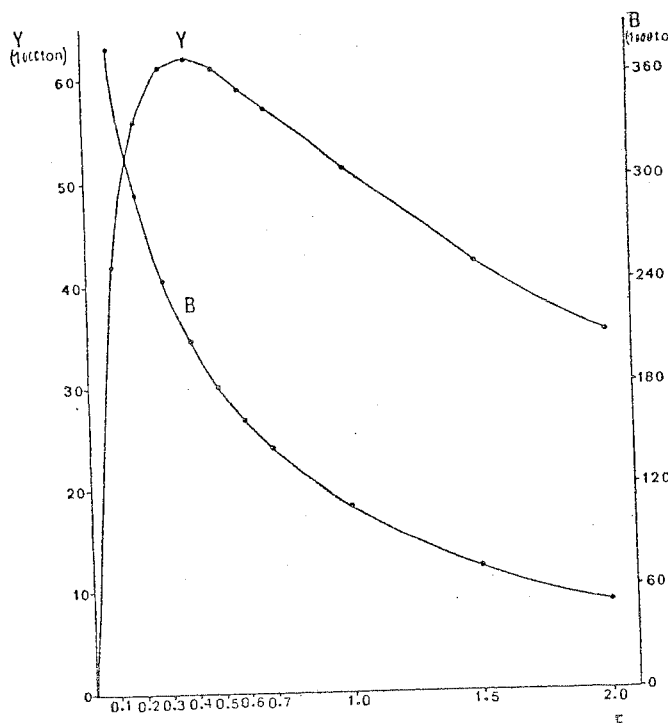


FIGURE 9 - Total values of catches(Y) and Biomass(B) for the 3rd alternative of exploiting pattern

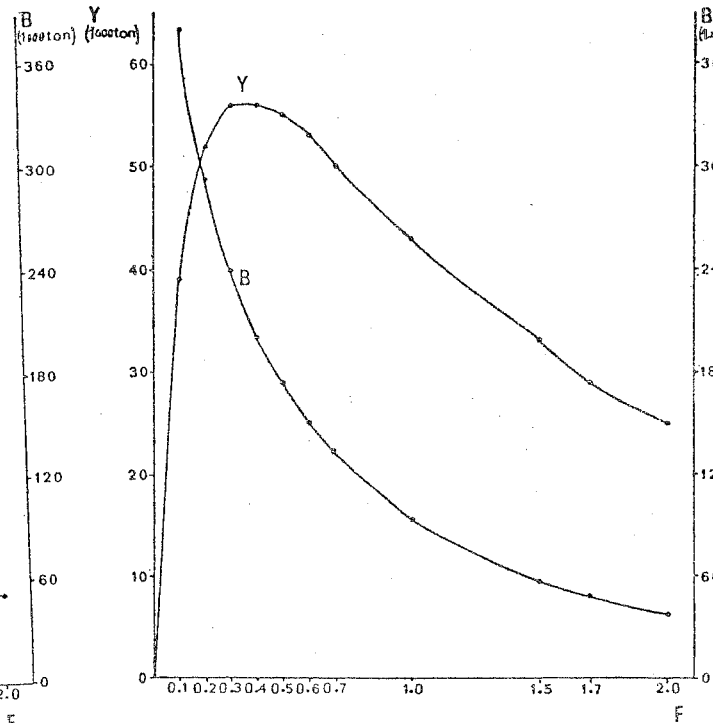


FIGURE 10 - Total values of catches(Y) and Biomass(B) for the 4th alternative of exploiting pattern.

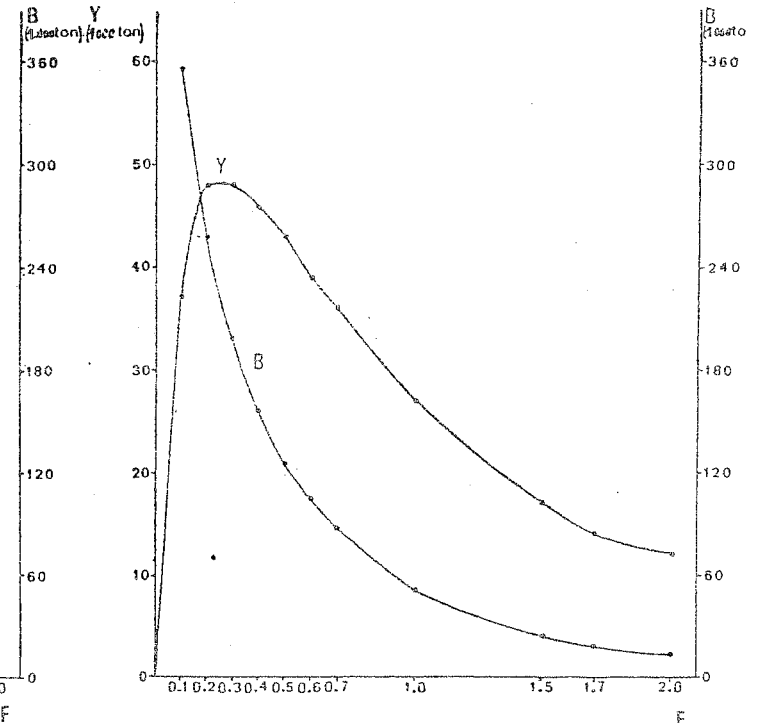


FIGURE 11 - Total values of catches(Y) and Biomass(B) for the 5th alternative of exploiting pattern.