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A preliminary assessment of the state of mackerel stock of ICNAF Subarea 5 and Statistical Area 6, 1968-1972

by

A. Paciorkowski, M. Liwoch, R. Grzebielec,
and
W. Borowski, S. Uciński
Sea Fisheries Institute, Gdynia, Poland

INTRODUCTION

The total landings of mackerel from the southern part of the ICNAF area and from the pannel 6 considerably increased in last few years. This increase was most spectacular between 1968 and 1971 when the catches rose nearly sixfold from about 60,000 tons in 1968 to 350,000 in 1971.

In the above mentioned area the mackerel catches fluctuated also in the past over a large range of values. Gulland pointed out that historic catches of up to 100,000 tons were noted, while in the fifties and early sixties they were much lower. These fluctuations were probably connected with changes in abundance of different year classes and with some economic factors.

The mackerel catches in the last years were much higher than ever noted. This creates the possibility to analyse the influence of increasing catches in the stock abundance and stress to the need to work up a stock assessment. This is not an easy

task just at this moment, because although we have some of the informations needed available, the period of intensive explocations is not very long.

The assessment presented in this paper is based on the analysis of total catches, the CPUE values obtained by the Polish vessels and on the age composition of the USSR, GDR and Polish catches. The relevant data on the USSR and GDR catches were kindly provided to us by the experts of the above mentioned two countries. Some of the results of the last cruise of our research vessel "Wieczno" are also included in this paper.

STOCK IDENTITY

The problem of the occurence of more or one unit stock of mackerel in the ICNAF area is not yet solved.

K.T. Mackay /ICNAF Res.Doc. 73/70/ accepts Sette's view on the subdivision of the mackerel from the northwest Atlantic into a southern and northern population. The later inhabiting the Gulf of St.Laurence and the coast of Nova Scotia and the former the pannels 5 and 6. Some mixing of these stocks may occure only on the overwintering grounds which extend from the Sable Island to Cape Hatteras.

If we then accept that so called northern population overwinters mostly in the northern part of the overwintering area, and taking into account that the biggest winter catches are made in pannel 6 and in the southermost part of pannel 5, then even if one accepts the two stocks hypotesis, one can assume that the mixing of these two stocks is not very substancial.

As the vast majority of the catches is taken throughout the year in the pannels 5 and 6, we can assume that almost all of these catches are composed from one population.

CATCHES AND CATCH PER UNIT EFFORT

In 1972 total mackerel catches in ICNAF subarea 5 and 6 accounted for 363.135 m.tons. This value in comparison with catches of 1968 means a sixfold increase. Table 1 presents the catches of mackerel in both subareas over the period of last five years 1968-1972.

T a b l e 1

Year	SA : 5	SA : 6	SA : 5 + 6
1968	50,776	8,869	59,645
1969	65,267	43,031	108,298
1970	102,561	97,218	199,779
1971	116,440	232,304	348,744
1972	174,599	188,536	363,135 x/
Total	509,643	569,958	

x/ The figure does not incorporate USA, FRG, Japan, Canada, Spain and Cuba catches.

Up to 1970 the larger part of mackerel catches was taken in subarea 5, but catches in subarea 6 have increased more rapidly. In 1971 - 1972 the subarea 6 had prevailing significance but in the last year some decrease in catches was observed. The catches in subarea 5 systematically agumented.
This increase is shown in Figure 1.

The fluctuations of mackerel catch per unit effort are presented by the results achieved by B-18 and B-20 type trawlers. The contributions of mackerel catches against total catches of these vessels in subarea 5 and 6 are given in Table 2.

T a b l e 2

Year	B 18 Total catches	B 18 Mackerel catches	B 18 %	B 20 Total catches	B 20 Mackerel catches	B 20 %
1968	19,776	6,150	31	28,154	2,925	10
1969	16,238	4,486	28	26,157	9,507	36
1970	46,073	29,050	63	23,719	9,181	39
1971	49,199	35,156	71	18,768	8,676	46
1972	36,353	28,495	78	13,511	10,632	79

The continous increase of the share of mackerel in the total catches especially for B-18 freezing-trawlers from the above table is fairly visible. This increase have been caused by the shifting of our fleet from herring to mackerel. Due to the larger abundance of mackerel, when comparing with the herring stock, this shifting was connected with a general increase in the catch rates.

Estimation of four alternatives of catch per unit effort is given in Table 3A.

Table 2 A

POLAND — M A C K E R E L — Season: XI - V — Subarea ICNAF: 5 + 6

Year	E_1 /days/	C_1 /tons/	C_1PUE_1 S_1	C_1PUE_1 S_2	E_2 /days/	C_2 /tons/	C_2PUE_2 S_1	C_2PUE_2 S_2
			B - 18					
1968	-	-	-	-	69	1 771	25,6	25,2
1969	-	-	-	-	18	496	27,5	24,2
1970	471	16 422	34,9	36,7	529	17 315	32,7	34,8
1971	982	31 289	31,9	38,1	982	31 289	31,9	38,1
1972	760	24 414	32,1	32,2	760	24 414	32,1	32,2
1973 x/	108	4 229	39,1	34,3	-	-	-	-
			B - 20					
1968	-	-	-	-	69	790	11,4	11,4
1969	-	-	-	-	444	5 459	12,3	12,1
1970	411	2 812	6,8	8,5	645	6 292	9,7	11,6
1971	393	3 476	8,8	10,8	665	7 089	10,7	11,0
1972	1 057	10 324	9,8	9,2	1 057	10 324	9,8	9,2
1973 x/	275	3 442	12,5	10,5	-	-	-	-

x/ - Preliminary data Jan.- March

B 6

S y m b o l s :

E_1 - the first estimator of effort

$$E_1 = \sum_{i=1}^{7} E_1^i$$

$$E_1^i := \text{if } CM_M^i \geqslant 0{,}6\ CM_T^i \text{ then } EM_T^i \text{ else } 0$$

where

CM_M^i - monthly /i/ mackerel catches /in m.tons/

CM_T^i - monthly /i/ total catches /in m.tons/

EM_T^i - monthly /i/ total effort /in fishing days/

i = 1 November

.
.
.

i = 7 May

C_1 - mackerel catches corresponding to first estimator of effort

$$C_1 = \sum_{i=1}^{7} C_1^i \qquad \text{where}$$

$$C_1^i := \text{if } E_1^i > 0 \text{ then } CM_M^i \text{ else } 0$$

E_2 - the second estimator of effort

$$E_2 = \sum_{i=1}^{7} E_2^i$$

$$E_2^i := \text{if } CM_M^i < 0.2\ CM_T^i \text{ then } 0$$

$$\text{else if } 0.2 \leqslant CM_M^i / CM_T^i < 0.6 \text{ then } EM_T^i \left(CM_M^i / CM_T^i \right)$$

$$\text{else } EM_T^i$$

C_2 - mackerel catches corresponding to the second estimator of effort.

$$C_2 = \sum_{i=1}^{7} C_2^i$$

$$C_2^i := \underline{\text{if}}\ E_2^i > 0\ \underline{\text{then}}\ CM_M^i \quad \underline{\text{else}}\ 0$$

S_1 - the first way of catch per effort calculation

$$S_1 : C_1PUE_1 = \frac{C_1}{E_1}$$

$$C_2PUE_2 = \frac{C_2}{E_2}$$

S_2 - the second way of catch per effort calculation

S_2 : C_1PUE_1, C_2PUE_2 arythmetic mean of monthly catch per effort in fishing grounds 5Y, 5Ze, 5Zw, 6A, 6B, 6C for the period November - May.

Mortality Estimates

Total instantaneous mortality rate used as basic data for cohort analysis was estimated from Polish B-18 freezing-trawlers catch per unit effort by number of fish in age groups (taking) under consideration the combined percentage age-composition of mackerel catches of USSR, Poland and GDR in the years 1968-1972 /Table 3/. The natural logarithms of (relative) abundance of each age group (Table 3A) were plotted against age /Fig. 2/ and the regression equation calculated for the descending part of the curve

/2 - 9 years old fish/. The slope of the straight line being an estimate of mean total instantaneous mortality rate over the period under consideration is equal to 0.59. The estimate of Z is in full agreement with estimates of Z obtained by ICNAF mackerel expert of AtlantNIRO /Kaliningrad/ - V.I.Isaakov /ICNAF Res.Doc. 73/23/, using two different methods. The mean total mortality estimates in cited paper were 0.59 and 0.60 for period 1968-1971.

During the special meeting in Rome there was presented a paper by David W.K. Au /Sp.Mtg.Res.Doc. 73/10/ in which the natural mackerel mortality in the ICNAF area was assumed to be M = 0.9. In comparison with values of Z = 0.6 obtained in this paper this value of M seems to be a substantial overestimate. On the other hand K.H.Postuma in his paper on the abundance of mackerel in North Sea /Jour.Cons.Int.Expl.Mer Vol.34 No.3,1972/ determined the natural mortality rate of this stock for M= 0.25. Comparing, however, age composition of North Sea mackerel stock given by K.H.Postuma and that for the stock of ICNAF area considerable differences are observed. The mean ratio of fish 7 years old and older of North Sea mackerel stock in seven successive years /1962 - 1968/ is higher than 50%, while the ICNAF stock of mackerel is composed of much younger, mainly 2 - 5 years old fishes /more than 70%/. According to unpublished calculations of M for mackerel stock of ICNAF area and of Scomber japonicus carried out in Soviet Union /personal communication/ - the coefficients are equal to M= 0.4,

and M = 0.6 respectively. Some tentative calculations made in our Institute lead us to conclusion that the instantaneous natural mortality of the ICNAF stock is close to 0.35.

Stock Biomass, Stock in Numbers and Recruitment.

The assessment of the biomass of mackerel stock exploited in ICNAF subarea 5 and 6 and its mortality rates /Z and F/ over period 1968 - 1972 was carried out by means of Cohort Analysis.

The number of fish in each year class at 1-st January of the last year of exploitation was calculated with Murphy's method:

$$N_n = \frac{C_n}{E_n\ /1 - S_n/}$$

The year class by numbers at the beginning of earlier years of fishing activity were found as follows:

$$N_{n-1} = \frac{N_n}{S_{n-1}}$$

The instantaneous mortality coefficients and survival rates were calculated of the following equation:

$$\frac{C_n}{N_{n+1}} = E_n \frac{1 - S_n}{S_n}$$

In practice, as the only available tables /Schumacher's/ were prepared for reversed expression / $\frac{S_n}{E_n\ /1-S_n/}$ the value of equivalent ratio was calculated /$\frac{N_n + 1}{C_n}$ /.

The total catches of mackerel by numbers per year class in ICNAF subarea 5 and 6 in years 1968 - 1972 used for Cohort Analysis are given in Table 4.

As noted before the most likely natural instantaneous mortality coefficients seem to be 0.35 to 0.40. The calculations of year class by numbers were carried out for M = 0.25 and 0.30 to compare the range of biomass changes at different levels of natural mortality rates. The total instantaneous mortality coefficient used as entrance data for Cohort Analysis was 0.6.

The year class numbers and stock biomass obtained from Cohort Analysis are given in Tables 6 - 9 and the resulting fishing mortalities - in Tables 10 - 14.

It should be noted that for comparison two stock biomass were calculated of each alternative - one which incorporates one year old fish and another for adult stock /II - IX age groups/. Moreover, the biomass is diminished by omitting in Cohort Analysis the fish of ten years old and older.

The final results of Cohort Analysis are presented in Table 15 and Table 16. Annual fishing mortality rates were calculated as the mean values of II - IX age groups and therefore they are a bit higher than the weighted mean.

Fig. 4 presents the stock biomass of the two years old and older fish in the years 1968 to 1972 under various assumption for M. The increase in biomass between 1968 and 1969 was due to the appearance of the very abundant 1967 year class.

The two following year classes were of medium strength /see Fig. 5/ and the 1970 and 1971 rather poor. This caused a gradual decrease of the biomass. According to our opinion under the most likely assumption of M = 0.35 the biomass increased from 1,370,000 tons in 1968 to 2,915,000 tons in 1969 and then decreased again to 1,851,000 tons in 1972.

The 1972 year class seems to be very abundant. This is shown in Fig. 5. Also in the research cruise of our research vessel "Wieczno" carried out in Spring 1973, this year class was extremely abundant forming 53.7 % by numbers of the catches. Thus we can expect an increase of the stock biomass in the next years.

Yield per Recruit.

The yield per recruit was calculated assuming

$t_c = 2$

$W_\infty = 806.7$ grams

$L_\infty = 46.15$ cm

$K = 0.228$

$t_0 = -2.2476$

for different values of M and F. The parameters of the von Bertalanffy growth equation were obtained from the Polish length per age data. These parameters are very similar to those given by V.I.Isaakov /ICNAF Res.Doc. 73/23/. In the most

likely range of values for M the curves have a rather flat top, and are therefore similar to the shape of those obtained for herring.

If we put on the graphs in Fig. 6, the F values obtained in the Cohort Analysis, we see that they lay still on the steeply ascending part of the curve which point to the fact that a further increase in F can give substantially larger catches than the actual on a sustained basis.

Literature Cited

V.I. Isaakov, 1973 - Growth and Total Mortality of Mackerel from the New England Area, ICNAF Res.Doc. 73/23.

K.T. Mac Kay, 1973 - Aspects of the Biology of Atlantic Mackerel in ICNAF Subarea 4 ICNAF Res. Doc. 73/70

K.H. Postuma, 1972 - On the Abundance of Mackerel /Scomber scombrus L./ in Northern and North-Eastern North Sea in the Period 1959 - 1969. Journal du Con. Int.Expl.Mer Vol. 34, No. 3, 1972.

TABLE 3. **Combined Percentage Age - Compositions of Mackerel Catches of GDR, Poland and USRR Data**

Year	1972	1971	1970	1969	1968	1967	1966	1965
1972	0,91	3,44	6,18	23,15	18,11	33,88	9,07	2,72
1971		0,08	7,57	20,97	7,86	40,02	17,18	3,43
1970			0,36	16,43	3,61	43,72	21,77	4,97
1969				0,63	30,95	39,69	19,14	4,63
1968					0,90	27,59	39,31	21,57

Year	1964	1963	1962	1961	1960	1959	1958
1972	0,71	1,09	0,74				
1971	1,03	0,81	0,69	0,36			
1970	1,74	1,56	2,45	2,26	1,13		
1969	1,43	1,28	1,11	0,57	0,36	0,21	
1968	4,29	3,94	1,86	0,32	0,16	0,04	0,02

Table 3A. **Mackerel Catch per Unit Effort in Numbers by Age-Groups Taken by B-18 freezing-trawlers in 5 and 6 ICNAF Subarea**

Year	0	I	II	III	IV	V	VI	VII	VIII	IX	X+	
1972	910	3440	6180	23150	18110	33880	9070	2720	710	1090	740	100 000
1971	97	9147	25339	9497	48357	20759	4145	1244	979	834	435	120 833
1970	471	21490	4722	57186	28475	6501	2276	2040	3205	2956	1478	130 800
1969	690	33909	43485	20970	5073	1567	1402	1216	625	395	230	109 562
1968	893	27376	39005	21403	4257	3909	1846	317	159	40	20	99 888
N	2160	95362	118731	132206	104272	66616	18739	7537	5678	5315	2903	Relative abundance of age-groups /559 819 N/
ln N	7,6779	11,4658	11,6843	11,7920	11,5540	11,1064	9,8384	8,9280	8,6430	8,5774	7,9735	Natural logarithm of relative abundance

C1

Table 4. Total catches of mackerel by numbers per year-class in ICNAF Subareas 5 and 6, 1968-1972.

Year	1972	1971	1970	1969	1968	1967	1966	1965	1964
1972	10 475	39 696	71 339	267 145	209 018	391 030	104 653	31 326	8 172
1971		1 085	100 896	279 661	104 735	533 579	229 062	45 794	13 793
1970			2 975	137 274	30 174	365 290	181 919	41 522	14 563
1969				2 855	140 547	180 238	86 933	21 035	6 482
1968					2 080	63 699	90 746	49 804	9 914

Year	1963	1962	1961	1960	1959	1958	Total catch in numbers /x 10^{-3}/	Total catch /m.tons/	Mean weight /in grams/
1972	12 605	8 549					1 154 008	370 000	321
1971	10 770	9 182	4 739				1 333 296	351 078	263
1970	13 042	20 463	18 910	9 451			835 583	208 985	250
1969	5 810	5 030	2 603	1 649	962		454 144	114 088	251
1968	9 099	4 298	742	377	90	50	230 899	59 662	258

Stock number per age-class and total biomass of mackerel stock from Cohort analysis in ICNAF areas 5 and 6 as first January 1968-1972. /Z = 0.60, and M = 0.40/

Year	1972	1971	1970	1969	1968	1967	1966	1965
1972	10 475 000	992 400	475 593	1 780 967	1 393 453	2 606 867	697 687	208 840
1971		1 481 194	832 912	2 993 222	2 208 325	4 517 967	1 323 884	365 764
1970			1 246 874	4 647 860	3 325 791	7 160 011	2 206 472	596 646
1969				6 937 104	5 164 272	10 898 038	3 389 359	916 507
1968					7 707 869	16 338 888	5 158 842	1 423 147

Year	1964	1963	1962	1961	1960	1959	Stock numbers x 10^{-3}	Stock biomass
1972	21 562	24 476					7 209 445 /8 201 845/ x/	2 314 232 /2 632 792/
1971	48 454	49 247	17 829				11 464 692 /12 297 604/	3 015 214 /3 234 270/
1970	90 063	88 893	50 940	36 718			13 555 534 /18 203 394/	3 388 883 /4 550 848/
1969	142 731	139 331	82 294	58 190	3 202		15 629 652 /20 793 924/	3 923 043 /5 219 275/
1968	226 198	218 387	127 786	87 635	5 223	175	9 247 393 /25 586 281/	2 385 827 /6 601 260/

x/ —

Table 6. Stock numbers per year-class and total biomass of mackerel stock from Cohort Analysis in ICNAF Subareas 5 and 6 at first January 1968-1972. /Z = 0.60, and M = 0.35/

Year	1972	1971	1970	1969	1968	1967	1966	1965
1972	10 475 000	968 195	379 463	1 420 984	1 111 798	2 079 947	556 665	166 628
1971		1 375 277	657 648	2 340 995	1 707 831	3 567 662	1 056 290	291 818
1970			936 820	3 494 022	2 471 535	5 480 280	1 706 446	462 469
1969				4 963 099	4 091 843	8 012 105	2 520 560	683 115
1968					5 812 277	11 445 864	3 685 029	1 028 788

Year	1964	1963	1962	1961	1960	1959	Stock numbers /x 10^{-3}/	Stock biomass /m.tons/
1972	25 550	26 043					5 767 078 /6 735 273/x/	1 851 232 /2 162 023/
1971	49 371	49 417	18 971				9 082 355 /9 740 003/	2 388 659 /2 561 621/
1970	87 228	85 645	50 589	39 070			10 383 262 /13 877 284/	2 595 815 /3 469 321/
1969	131 367	128 983	77 710	58 313	3 407		11 615 560 /15 707 403/	2 915 505 /3 942 558/
1968	197 842	194 251	115 985	83 543	5 290	186	5 310 914 /16 756 778/	1 370 216 /4 323 249/

x/ Figures in brackets include fish from I age group and older

Table 7. Stock numbers per year-class and total biomass of mackerel stock from Cohort Analysis in ICNAF Subareas 5 and 6 at first January 1968-1972. /Z = 0.60, and M = 0.30/

Year	1972	1971	1970	1969	1968	1967	1966	1965
1972	10 475 000	945 143	315 659	1 182 057	924 858	1 730 221	463 066	138 611
1971		1 275 497	541 439	1 909 624	1 366 112	2 937 557	887 100	240 227
1970			734 653	2 735 851	1 881 697	4 384 413	1 405 864	373 023
1969				3 692 107	2 695 841	6 097 932	1 994 133	529 111
1968					3 638 112	8 307 809	2 800 749	775 554

Year	1964	1963	1962	1961	1960	1959	Stock numbers /x 10^{-3}/	Stock biomass /m.tons/
1972	25 779	28 518					4 808 769 x/ /5753 912 /x/	1 543 615 /1 847 006/
1971	50 886	50 925	20 774				7 463 205 /8 004 644/	1 962 823 /2 105 221/
1970	85 523	83 896	51 548	42 783			8 308 747 /11 044 598/	2 077 187 /2 761 149/
1969	122 526	120 195	75 363	60 685	3 731		9 003 676 /11 699 517/	2 259 923 /2 936 579/
1968	177 317	172 199	106 898	82 790	5 455	204	4 119 166 /12 426 975/	1 062 745 /3 206 159/

x/ figures in brackets include fish from I age group and older

Table 8. Stock numbers per year-class and total biomass of mackerel stock from Cohort Analysis in ICNAF Subareas 5 and 6 at first January 1968-1972. /Z = 0.60, and M = 0.25/

Year	1972	1971	1970	1969	1968	1967	1966	1965
1972	10 475 000	923 163	271 251	1 015 760	794 745	1 486 806	397 920	119 110
1971		1 186 585	460 528	1 625 216	1 138 603	2 498 834	769 671	204 305
1970			594 997	2 238 589	1 492 271	3 616 258	1 195 141	307 688
1969				2 877 364	2 075 481	4 834 569	1 630 479	419 765
1968					2 667 713	6 270 517	2 200 376	595 411

Year	1964	1963	1962	1961	1960	1959	Stock numbers /x 10^{-3} /	Stock biomass /m.tons/
1972	29 609	31 992					4 147 193 /5 070 356/ x/	1 331 249 /1 627 584/
1971	53 446	53 320	23 305				6 366 700 /6 827 228/	1 674 442 /1 795 561/
1970	84 700	83 574	52 966	47 995			6 880 503 /9 119 092/	1 720 126 /2 279 773/
1969	116 667	114 016	73 666	64 771	4 185		7 258 118 /9 333 599/	1 821 788 /2 342 733/
1968	160 698	157 047	99 414	84 009	5 821	228	3 303 004 /9 573 521/	852 175 /2 469 968/

x/ Figures in brackets include fish from I age group and older

Table 9. Stock numbers per year-class and total biomass of mackerel stock from Cohort Analysis in ICNAF; Subareas 5 and 6 at first January 1968-1972. /Z = 0.70, and M = 0.35/

Year	1972	1971	1970	1969	1968	1967	1966	1965
1972	10 475 000	963 195	283 091	1 060 099	829 436	1 551 706	415 290	123 913
1971		1 375 277	521 346	1 837 260	1 300 056	2 826 423	852 751	230 322
1970			743 717	2 756 958	1 881 412	4 430 130	1 421 252	375 729
1969				3 930 338	2 833 452	6 476 798	2 121 272	560 789
1968					4 024 790	9 265 305	3 133 341	353 560

Year	1964	1963	1962	1961	1960	1959	Stock numbers /x 10^{-3}/	Stock biomass
1972	21 116	24 571					4 309 222 /5 277 417/ x/	1 383 260 /1 694 051/
1971	46 105	47 526	17 899				7 158 342 /7 679 688/	1 832 644 /2 019 758/
1970	82 330	83 233	49 173	36 862			8 360 121 /11 127 079/	2 090 030 /2 731 770/
1969	123 991	125 351	75 535	55 515	3 214		9 542 465 /12 375 917/	2 395 159 /3 106 355/
1968	188 723	186 782	112 739	79 534	4 991	175	4 561 345 /13 827 650/	1 176 956 /3 567 534/

x/ Figures in brackets include fish from I age group and older

Table 10. Annual fishing mortality rates per year-class of mackerel stock in ICNAF Subareas 5 and 6 from Cohort Analysis, 1968-1972. /Z = 0.60, and M = 0.40/

Year	1972	1971	1970	1969	1968	1967	1966	1965
1972	0,001	0,05	0,20	0,20	0,20	0,20	0,20	0,20
1971		0,001	0,16	0,12	0,06	0,15	0,24	0,16
1970			0,004	0,04	0,01	0,06	0,11	0,09
1969				0,001	0,04	0,02	0,03	0,03
1968					0,001	0,005	0,02	0,04

Year	1964	1963	1962	1961	1960	1959	$\bar{F}$	Z	E
1972	0,60	0,93					0,20	0,60	0,33
1971	0,41	0,30	0,93				0,19	0,59	0,32
1970	0,22	0,19	0,65	0,93			0,11	0,51	0,22
1969	0,06	0,05	0,08	0,06	0,93		0,045	0,44	0,10
1968	0,06	0,05	0,04	0,01	0,09	0,93	0,037	0,44	0,08

Table 11. Annual fishing mortality rates per year-class of mackerel stock in ICNAF Subareas 5 and 6 from Cohort Analysis, 1968-1972. /Z = 0.60, and M = 0.35/

Year	1972	1971	1970	1969	1968	1967	1966	1965	1964
1972	0,001	0,001	0,25	0,25	0,25	0,25	0,25	0,25	0,52
1971		0,05	0,20	0,15	0,08	0,19	0,29	0,21	0,39
1970			0,004	0,05	0,02	0,08	0,13	0,11	0,22
1969				0,001	0,05	0,03	0,04	0,04	0,06
1968					0,001	0,007	0,03	0,06	0,06

Year	1963	1962	1961	1960	1959	$\bar{F}$	Z	E	
1972	0,82					0,25	0,60	0,42	
1971	0,29	0,82				0,22	0,57	0,39	
1970	0,20	0,63	0,82			0,13	0,48	0,27	
1969	0,06	0,08	0,05	0,82		0,05	0,40	0,12	
1968	0,06	0,05	0,01	0,09	0,82	0,045	0,39	0,11	

Table 12. Annual fishing mortality rates per year-class of mackerel stock in ICNAF Subareas 5 and 6 from Cohort Analysis, 1968-1972. /Z = 0.60, and M = 0.30/

Year	1972	1971	1970	1969	1968	1967	1966	1965	1964
1972	0,001	0,05	0,30	0,30	0,30	0,30	0,30	0,30	0,45
1971		0,001	0,24	0,18	0,09	0,23	0,35	0,25	0,38
1970			0,005	0,06	0,02	0,10	0,16	0,14	0,22
1969				0,001	0,06	0,03	0,05	0,05	0,06
1968					0,001	0,009	0,04	0,08	0,07

Year	1963	1962	1961	1960	1959	$\bar{F}$	Z	E
1972	0,70					0,30	0,60	0,50
1971	0,28	0,70				0,25	0,55	0,45
1970	0,20	0,61	0,70			0,14	0,44	0,32
1969	0,06	0,08	0,05	0,70		0,055	0,35	0,16
1968	0,06	0,05	0,01	0,08	0,70	0,05	0,35	0,14

Table 13. Annual fishing mortality rates per year-class of mackerel stock in ICNAF Subareas 5 and 6 from Cohort Analysis, 1968-1972. /Z = 0.60, and M = 0.25/

Year	1972	1971	1970	1969	1968	1967	1966	1965	1964
1972	0,001	0,05	0,35	0,35	0,35	0,35	0,35	0,35	0,37
1971		0,001	0,28	0,22	0,11	0,27	0,41	0,29	0,34
1970			0,006	0,07	0,20	0,12	0,19	0,16	0,21
1969				0,001	0,08	0,04	0,06	0,06	0,07
1968					0,001	0,01	0,05	0,10	0,07

Year	1963	1962	1961	1960	1959	$\bar{F}$	Z	E
1972	0,58					0,35	0,60	0,58
1971	0,26	0,58				0,27	0,52	0,52
1970	0,20	0,57	0,58			0,18	0,43	0,42
1969	0,06	0,08	0,05	0,58		0,06	0,31	0,19
1968	0,07	0,05	0,01	0,08	0,58	0,06	0,31	0,19

Table 14. Annual fishing mortality rates per year-class of mackerel stock in ICNAF Subareas 5 and 6 from Cohort Analysis, 1968-1972. /Z = 0.70, and M = 0.35/

Year	1972	1971	1970	1969	1968	1967	1966	1965	1964
1972	0,001	0,005	0,35	0,35	0,35	0,35	0,35	0,35	0,60
1971		0,001	0,26	0,20	0,10	0,25	0,37	0,27	0,43
1970			0,005	0,06	0,02	0,10	0,16	0,14	0,23
1969				0,001	0,06	0,03	0,05	0,05	0,06
1968					0,001	0,008	0,04	0,07	0,07

Year	1963	1962	1961	1960	1959	$\bar{F}$	Z	E
1972	0,90					0,35	0,70	0,50
1971	0,31	0,90				0,27	0,62	0,435
1970	0,21	0,66	0,90			0,14	0,49	0,29
1969	0,06	0,08	0,06	0,90		0,055	0,40	0,14
1968	0,06							

Table 15 Total biomass of mackerel stock in ICNAF subarea 5 and 6 from Cohort Analysis at different levels of mortality rates at first January 1968 - 1972 /m. tons/

Year	Mortality rates				
	Z = 0,60				Z = 0,70
	M = 0,25	M = 0,30	M = 0,35	M = 0,40	M = 0,35
1972	1 331 249	1 543 615	1 851 232	2 314 232	1 383 260
1971	1 674 442	1 962 823	2 388 659	3 015 214	1 882 644
1970	1 720 126	2 077 187	2 595 815	3 388 883	2 090 030
1969	1 821 788	2 259 923	2 915 505	3 923 043	2 395 159
1968	852 175	1 062 745	1 370 216	2 385 827	1 176 956

T a b l e 16 Annual total and fishing mortality rates of mackerel stock in ICNAF subarea 5 and 6 from Cohort Analysis 1968 - 1972

Year	Mortality rates									
	M = 0,25		M = 0,30		M = 0,35		M = 0,40		M = 0,35	
	F	Z	F	Z	F	Z	F	Z	F	Z
1972	0,35	0,60	0,30	0,60	0,25	0,60	0,20	0,60	0,35	0,70
1971	0,27	0,52	0,25	0,55	0,22	0,57	0,19	0,59	0,27	0,62
1970	0,18	0,43	0,14	0,44	0,13	0,48	0,11	0,51	0,14	0,49
1969	0,06	0,31	0,05	0,35	0,05	0,40	0,04	0,44	0,05	0,40
1968	0,06	0,31	0,05	0,35	0,04	0,39	0,04	0,44	0,05	0,40

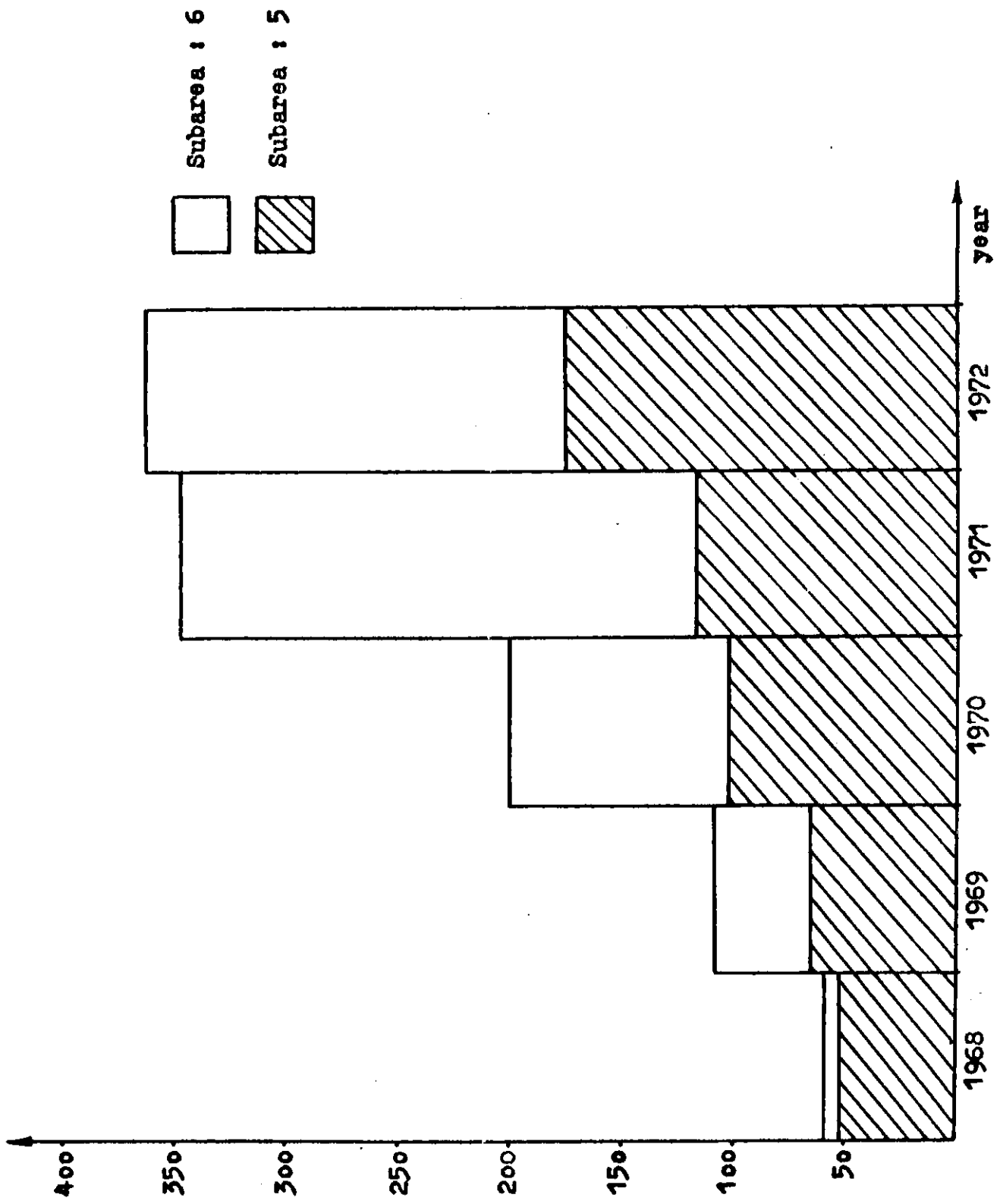

Fig. 1. Total mackerel catches in subareas 5 and 6

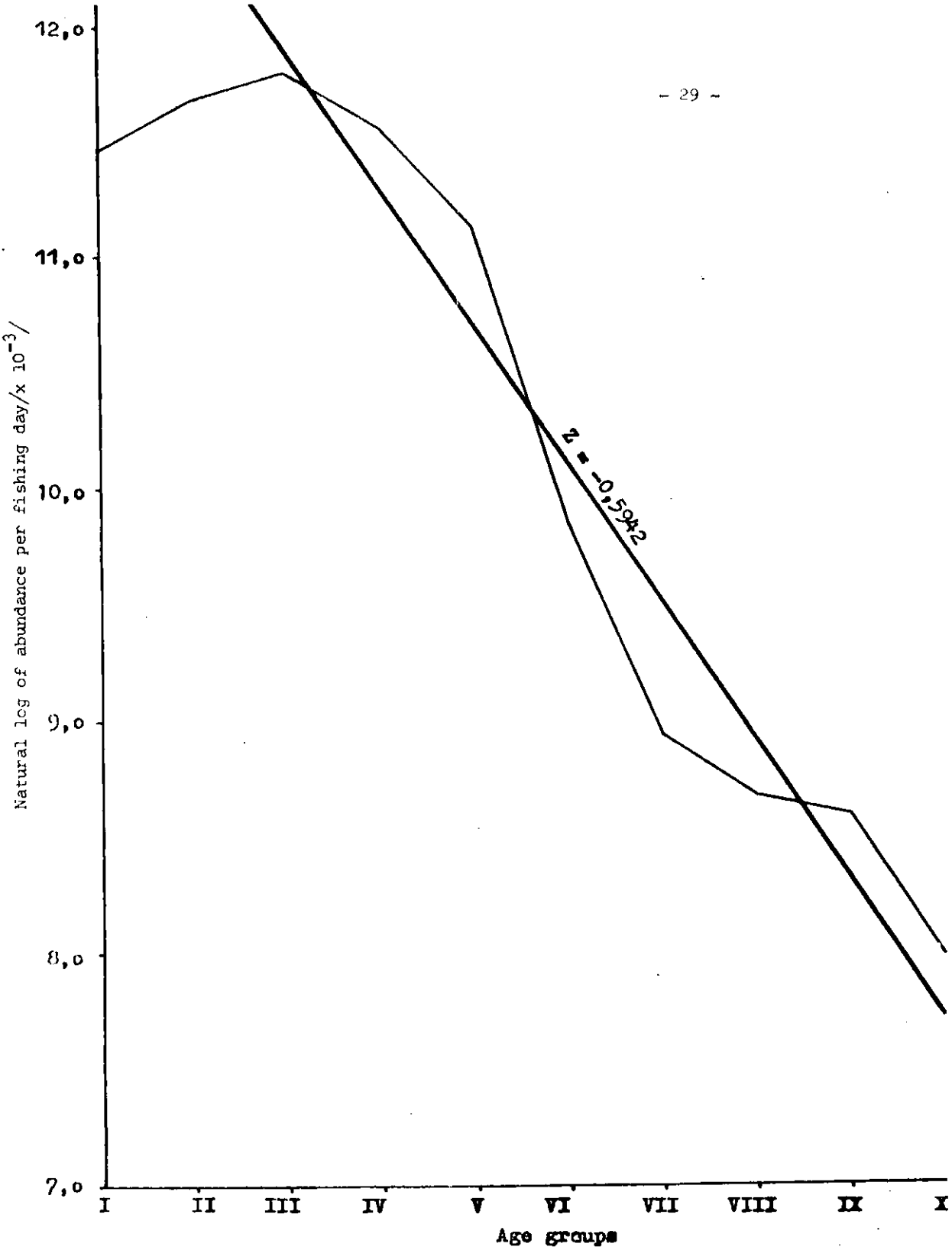

Fig. 2. Determination of mean total instantaneous mortality /Z/ of mackerel stock in ICNAF area for period 1968-1972

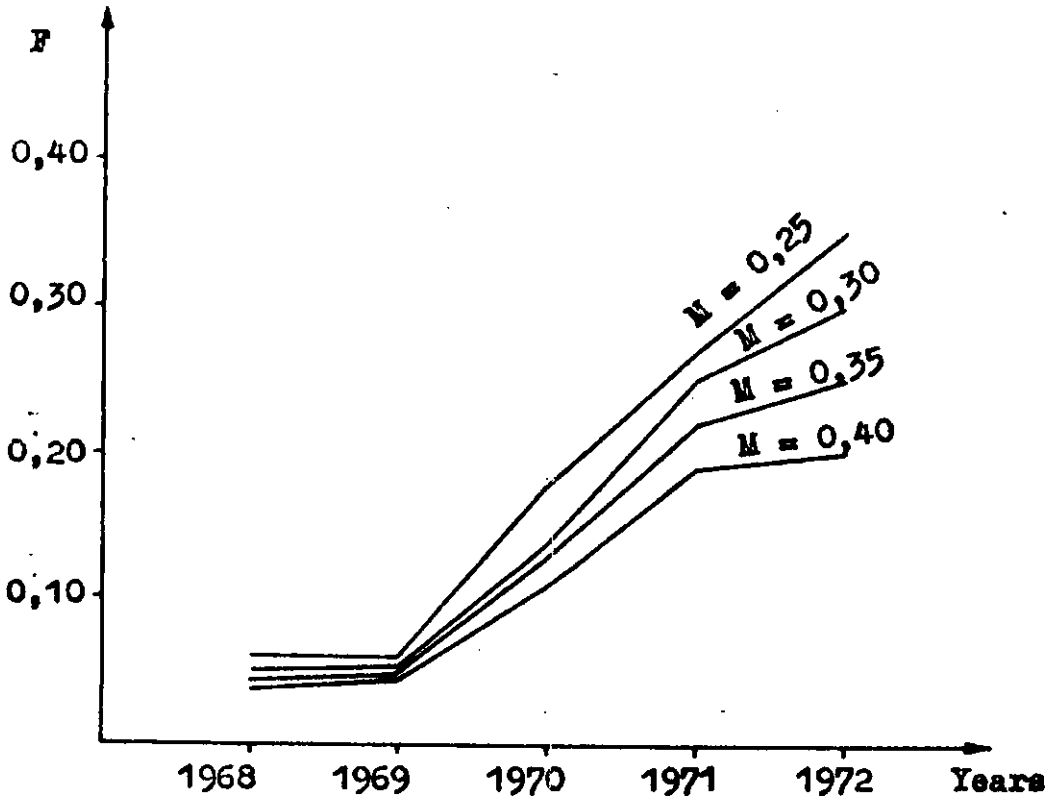

Fig. 3. Fishing mortalities of mackerel stock in ICNAF area estimated from cohort analysis at different levels of M.

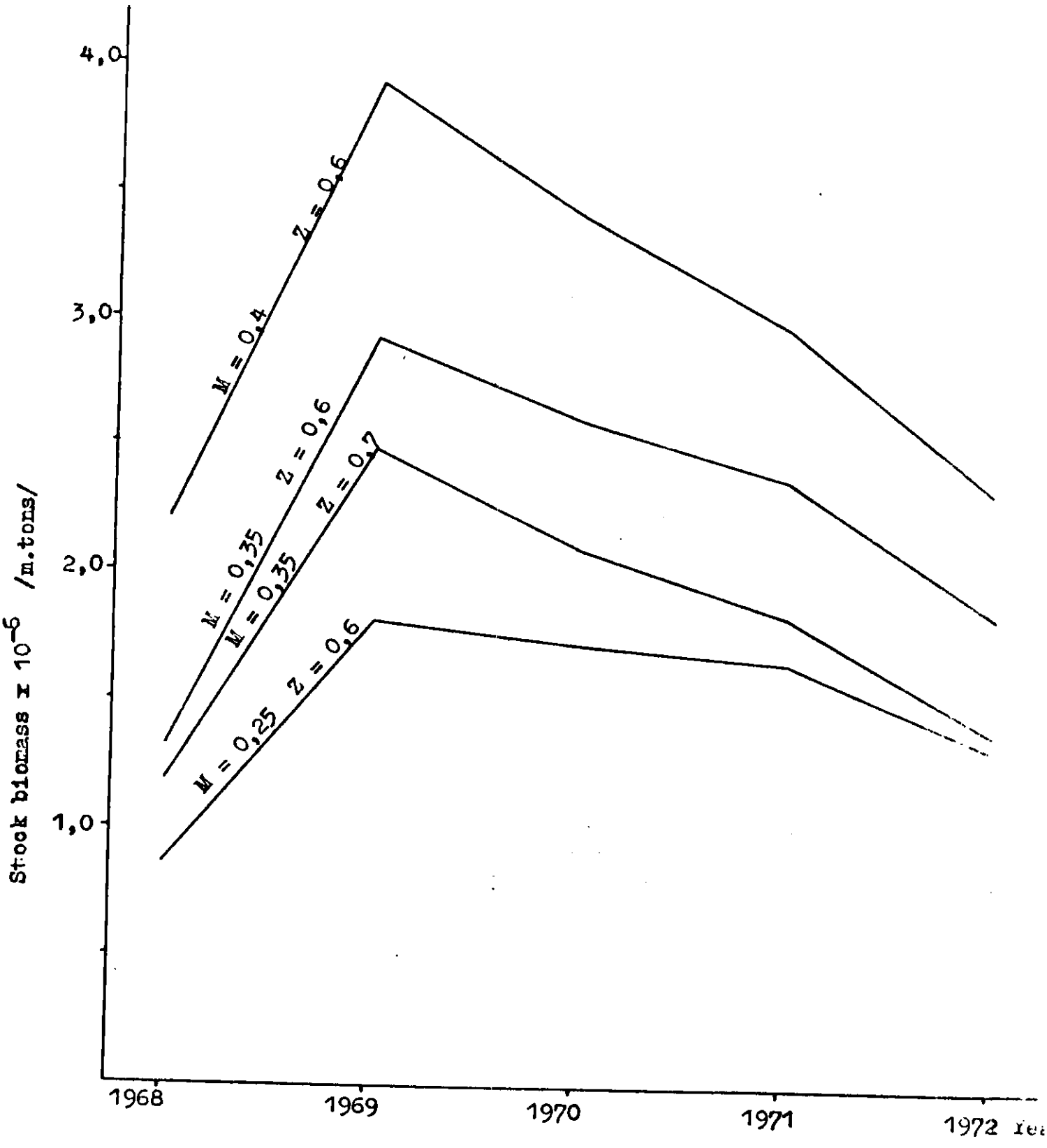

Fig. 4. Biomass of mackerel stock in ICNAF area of two years old and older estimated from cohort analysis at different levels of natural mortality

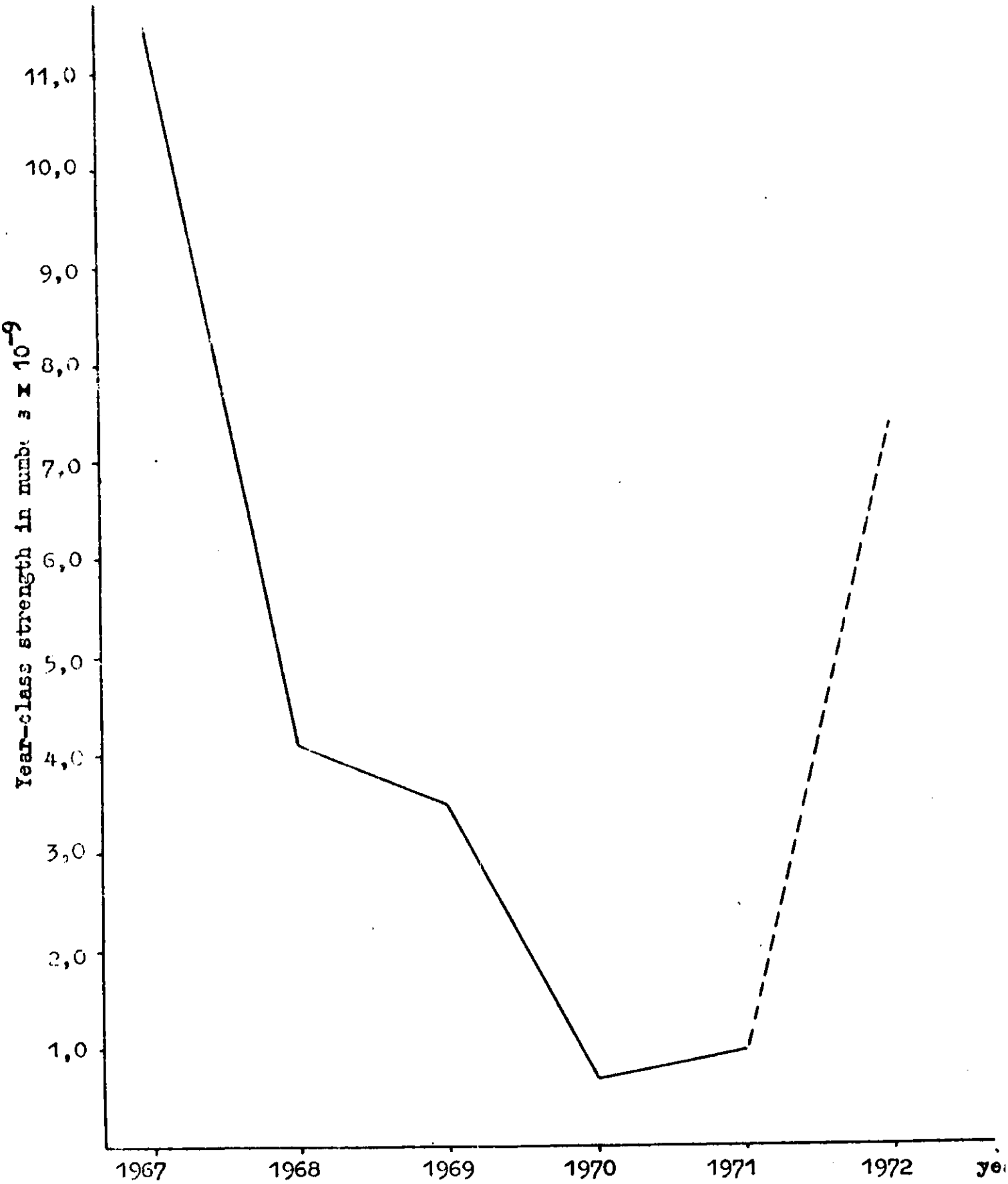

Fig. 5. Year-class strength /in numbers of one year old fish/ of mack rel stock in ICNAF area /Z = 0,60 M = 0,35/

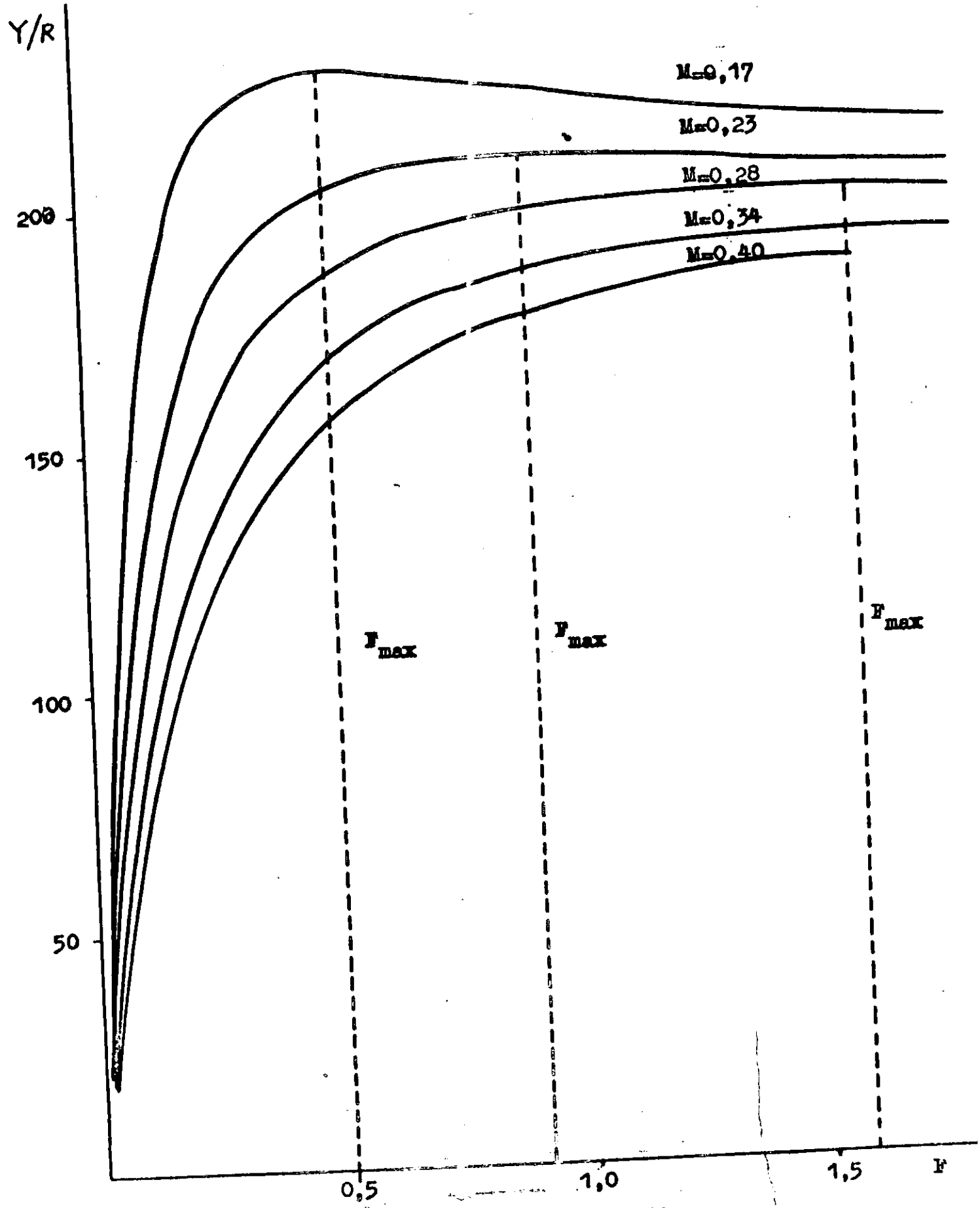

Fig. 6. Yield per recruit