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Alternative assessment of mackerel stock in ICNAF Area

by

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Introduction

The assessment was prepared in accordance with the opinion of STACRES from 1976 April meeting on desirability of presentation of a new assessment expressing the view of GDR, Polish and USSR scientists. The new data available from the fishery have not been included as they would not change the basic assumptions used in the assessment. The data will be presented in the form of working papers and perhaps useful in further discussion.

Recruitment

To justify assumptions on recruitment level in 1976 and 1977 the observed in preceding years stock size - recruitment relationship was analysed. The method used at the last

meeting in April was applied with slight modification. Size of each year-class at age 1 was plotted along with spawning stock size /which had born this year-class one year earlier/ for two different starting F_{3+} /1.1 and 0.65/ in 1975 separately /Fig. 1/.

The assumed size of the spawning stock in 1967 was calculated /using F = 0.06/ and shown on the figure. The predicted sizes of spawning stocks and recruited year-classes in 1976 and 1977 are presented too. Thus the size of the parent stock and the size of its off spring can be compared directely for the period from 1967 to 1977. Up to 1970 there are only minor differences between the two options on starting F's and both imply clearly the inverse relationship between the sizes of spawning stock and the recruiting year-classes.

It should be noted that the extremly abundant 1967 year-class was the off spring of spawning stock of relatively low size /about 1500 x 10^6 by numbers/ which is of comparable size with the parent stock in 1974 and 1975 for both hypotheses on starting F. The other characteristic feature is the second extreme at which the very abundant spawning stock has resulted in a poor 1970 year-class. The sizes of this year-class for both F's are at median level of recruitment i.e about 30 per cent below the average. In 1970-1972 the stock size gradually decreased but it was not coupled with continuing decline of recruitment albeit the relatively low abundance of recruited year-classes agrees well with the observed earlier inverse stock size - recruitment relationship. In 1973 and 1974 when the further decline of the spawning

stock took place the size of incoming year-classes began to increase. The magnitude of this increase can be questioned due to strong dependence on starting value of F in 1975. When F = 1.1 is assumed the sizes of 1973 and 1974 year-classes are below and over the median value respectively. If in turn F = 0.65 is assumed the sizes of these yaer-classes are at and beyond the mean value /5 years average of 1969-1973/ /fig.1/.

Taking into account the observed relationship it must be stated that without any further research there is no rationale to admit the decreasing trend in recruitment in the current situation and thus the very small size of 1975 and 1976 year-classes, at least at the present level of the spawning stock. The two year-classes are the progeny of parent stock of size of around the 1967 stock level and this implies the possibility of appearance of a more abundant year-class. Therefore the assumptions adopted in April assessment /1976/ on the extremly low size of these two year-classes /about 30% below median value/ are to be considered as arbitrary decisions not sufficiently proven. Moreover even rejecting the hypothesis on very large fluctuations of the recruitment to this stock in earlier times like it was suggested by E. Anderson /Res. Doc. 76/IV/12 / the observed changes in size of recruited year-classes since 1967 do indicate that the variability in their sizes can reach 700% or more. Because the last very abundant year-class occured 9 years ago there is at present a high probability of incoming to the stock a new rich year-class.

For lack of better information on stock size - recruitment relationship at the current level of spawning stock as well as on factors governing the appearance of rich and poor year-classes it seemed to be a reasonble procedure to adopt for the needs of actual assessment the 5-years average which was calculated ommitting the very abundant 1967 year-class and including /the poorest on record/ 1972 year-class.

To detect the effect of recruitment lower than average on predicted catches and to be on conservative but still realistic side the median value was used too. The median values for both assumptions of F's are close to the mean abundance of 1970-1974 year-classes i.e. from the period of low recruitment.

The two levels of recruitment /mean and median/ used for each option of F_{3+} in 1975 were as follows:

Option	F	Mean	Median
1	0.60	2070	1470
2	0.65	2040	1430
3	0.75	1985	1405

Partial recruitment

For age - groups 1 and 3 the agreed /April 1976 assessment/ partial recruitment of 25% and 100% respectively was adopted. However, an analysis of fishing mortalities of 2 years

old fish in relation to F's of fully recruited ages from 1968 to 1973 did not indicate the complete recruitment of this age--group to the fishery. In most cases the rate was below 50-60%. Even in last two years /1973 and 1974/ which were strongly influenced by assumption on complete recruitment of age-group 3 the partial recruitment of 2 years old fish was 84% and 95% respectively. In such circumstances the choice of 100% rate for this age-group was out any observed range and therefore was selected on arbitvary basis. Taking this into acoount the agreed earlier procedure i.e. regression of partial recruitment of age 2 on 3 + stock size was used to estimate the partial recruitment in 1975. The obtained values were as follows:

Range of time	Starting F_{3+} in VPA	N_{3+}	Regression eqation	Partial recruitment /age 2/
1968 - 1973	1.10	697	y = 79.68 - 0.0091x	73.34
	.90	788	y = 79,58 - 0.0089x	72.55
	.75	889	y =79.67 - 0.0088x	71.87
	.50	1200	y = 79.41 - 0.00828x	69.47
1968-1972	1.10	697	y = 65.77 - 0.00663x	61.15
	.90	788	y = 65.90 - 0.00657x	60.72
	.75	889	y = 65.78 - 0.00649x	60.01
	.50	1200	y = 65.97 - 0.00643x	58.36

To be on conservative side the partial recruitment of 75% was used for age 2. This value is by 31.5% higher /or by 18% in absolute terms/ than the value agreed during 1975 assessment in Woods Hole.

Estimate of fishing mortality in 1975

Two ways of F estimation in 1975 were followed. The first was based on US spring survey abundance indices /Res. Doc. 76/IV/12 and W.P. 76/IV/61/ and the other on distant water fleet c.p.u.e. /W.P. 76/IV/69/.

In the first instance the regression of F_{3+} /using F = 1.1 as starting point in 1975/ on indices of fishing effort /for SA 5-6/ from US spring surveys for 1968-73 was calculated. Although the method used is essentialy the same as adopted by Pelagic Working Group in April there is a few important differences between them:

a/ In the way followed by the Working Group the effort for 1968-1972 was plotted against $\overbrace{F}^{\text{from}}$ VPA commencing in 1974 /from 1975 assessment in Woods Hole/ which means that two years strongly influenced by starting F were ommitted. In the actual procedure the effort for 1968-1973 was taken against F from VPA commencing in 1975 - therefore the same 2 years time interval was maintained.

b/ The procedure applied here has the advantage of using one point more /the data for 1973/. From statistical piont view it means that the regression line is more accurate.

c/ Another reason for application the period from 1968 to 1973 was to limit the necessary extrapolation out of the observed range of data to the minimum. In the

method adopted by Working Group /because F was estimated in 1974/ the extrapolation was two years ahead and in way applied here - one year only.

d/ The starting F used in actual regression /1.1/ was taken from the newest 1976 assessment while set of F's used in procedure adopted by Working Group was derived from 1975 assessment using much lower starting value of F /0.6/.

The resulting straight line regression equation from described procedure is as follows:

$$y = 0.0945 + 0.00000023x$$

Because the index of fishing effort in 1974 was 2 520 718 /W.P. 76/IV/61/ the F_3 in 1974 = 0.6742.

Using the same VPA technique /forward/ as in the last assessment F_{3+} in 1975 was estimated for 0.638. To be on conservative side for the purpose of current assessment the value 0.65 was used.

However the latest recalculated results /by E. Anderson - personal communication/ of US spring surveys including previously excluded part of Georges Bank area confirm the doubts expressed by GDR, Polish and USSR scientists at April meeting /Assessment Subcommittee Report/. The new data show that the abundance in years when fishery has begun was in fact lower than in option presented in April. Applying regression to these

data for direct estimation of F_{3+} in 1974 the resulting value of F is much lower than from above and equals 0.629. From the same regression F_{3+} in 1975 equals 0.753. In spite of the fact that this value implies 40% decrease in c.p.u.e. of DWF from 1974 to 1975 im comparison to 25% observed /a maximum from GDR fishery/ which seems to be much in excess of the true situation, F_{3+} = 0,75 was taken for the actual assessment computations as an extreme value.

The next estimate of F_{3+} in 1975 was based on DWF c.p.u.e. /W.P. 76/IV/69/ applying the observed decline of c.p.u.e. in GDR mackerel fishery by 25% between 1974 and 1975 /Summ. Doc. 76/IV/18/ against F's in 1968-73 from VPA commencing in 1975 /F_{3+} = 1.1/.

The resulting regression equation is:

$$y = 0.026458 + 0.00626x$$

therefore F_{3+} in 1975 = 0.599

For further computations F = 0.60 was used.

Results of the assessment and discussion

The resulting stock sizes for the three options on starting F /0.60, 0.65, 0.75/ in 1975 are of the order of 800-950 th. tons /Tables 1-3/ in comparison to about 600 th. tons obtained in April by Pelagic Working Group. The very low exploitation rate

observed up to 1972 /Fig. 2/ implies that the main cause of declining stock size was rather due to appearance of a few relatively poor year-classes /1970-1972/ than the intensity of the fishery. As the stock at the begining of 1976 was smaller than in 1975 /for all the options/ the assumption on catch in 1976 /310 th.tons/ on TAC level seems to be an overestimation. Taking this into account for catch predictions an additional option was included assuming 1976 catch of about 250 th. tons. That alternative is perhaps the most probable one /options 1B, 2B, 3B/.

The predicted catches in 1977 at F_{opt} level /0.35/ for F_{3+} in 1975 = 0.60 /options 1A, 1B, 1C/ are in the range from 154.7 to 174.7 th. tons, for F_{3+} = 0.65 /options 2A, 2B, 2C/ are from 138.7 to 157.8 th. tons, and for F_{3+} = 0.75 catches from 98.4 to 128.0 th. tons are predictes /Table 4, Fig.3/. The respective stock sizes varies at the begining of 1977 from 557.1 to 872.3 th. tons /Table 4, Fig. 4/.

The results of the assessment indicate practically for the all options on F and recruitment that the biomass of the stock will be at the lowest level in 1977 and after that point due to exploitation at F_{opt} the stock will begin to recover. The rate of the increase is related to actual stock size. The lower stock biomass in 1977 the faster recovery of the stock can be expected assuming a constant level of recruitment /Fig. 4/.

It must be emphasised that as the result of future exploitation at F_{opt} each appearance of a better year-class than an average one will increase the stock biomass to a much higher level than that predicted here.

From the earlier considerations it seems that the most probable options ~~is~~ are 1B or 2B computed on the basis of F_{3+} in 1975 = 0.60 and ~~=~~ 0.65 and assuming about 250 th. tons to be caught in 1976. The resulting catch in 1977 is 174.7 and 157.8 th. tons i.e. nearly 50% less than TAC in 1976. Even if the ~~con~~tant median recruitment level was the true value in 1975 and 1976 /option 1C and 2C/, /Table 4, Fig. 3/, the allowable catch in 1977 could still be ~~about 140 th. tons~~ between 154.7 and 138.7. Similar level of allowable catch in 1977 is confirmed too by the result of the option on highest starting F_{3+} /0.75/ /option 3B/ implying catch of 128 th. tons.

Summerizing the obtained results it seems that the TAC of the order of between 150 and 175 th. tons in 1977 would be a compromise level - minimizing the risk of the overexploatation of the stock on one ~~side~~ hand and maximizing the fishery on the other.

Table 1. **Fishing mortalities and stock sizes from VPA analysis for F_{3+} in 1975 = 0.60**

	Year-class	1968	1969	1970	1971	1972	1973	1974	1975
F	1959	.007	/.08/						
	60	.12	.30	.62	.54	1.51	/.49/		
	61	.03	.08	1.22	1.84	.38	.29	.60	
	62	.08	.08	.47	.46	1.30	.77	.60	
	63	.10	.07	.22	.30	.87	1.11	.60	
	64	.08	.06	.19	.29	.33	.60	.36	.60
	65	.10	.07	.17	.33	.52	.48	.60	.60
	66	.05	.07	.21	.49	.53	.43	.60	.60
	67	.02	.04	.13	.31	.47	.51	.66	.60
	68	.001	.05	.02	.08	.27	.42	.60	.60
	69		.001	.06	.17	.28	.51	.53	.60
	1970			.002	.08	.09	.51	.50	.60
	71				.001	.03	.41	.71	.60
	72					.009	.11	.58	.60
	73						.001	.06	.45
	74							.001	0.15
	75								
	76								
Wtd. F		.09 /3+/	.08 /3+/	.24 /4+/	.35 /4+/	.37 /3+/	.49 /3+/	.61 /3+/	.60 /3+/
Stock size /10^6/	1959	18.2	13.4						
	60	88.4	58.1	31.9	12.7	5.5	.9		
	61	63.0	45.3	31.0	6.8	.8	.4	.2	
	62	142.1	97.2	66.5	30.8	14.4	2.9	1.0	
	63	174.5	116.9	80.8	48.1	26.4	8.2	2.0	
	64	219.2	149.9	104.6	64.1	35.5	18.9	7.7	4.0
	65	679.6	455.3	314.6	196.6	104.8	46.1	21.1	8.6
	66	2359.2	1663.2	1149.3	689.6	313.1	136.5	65.8	26.8
	67	7336.8	5326.5	3792.5	2468.9	1346.6	620.7	276.2	105.8
	68	4209.3	3119.1	2199.0	1596.5	1092.0	618.1	301.0	122.5
	69		4116.5	3050.3	2129.1	1330.7	745.2	331.6	144.6
	1970			1991.7	1471.9	1006.8	681.6	303.3	136.2
	71				2291.9	1698.3	1221.1	600.8	218.7
	72					1373.0	1007.8	669.2	277.7
	73						2871.5	2127.8	1485.2
	74							3713.4	2747.9
	75								
	76								
Age 1+ Total /10^6/		11081.0	11044.9	10820.5	8715.1	6968.9	5108.4	4707.7	5278.0
Wt /10^3 tons/		2043.3	2636.7	2093.4	1939.6	1700.8	1337.9	1022.7	944.6
Spawning stock Total /10^6/		2564.6	5262.6	6670.7	6178.6	4767.2	3490.0	2245.3	1787.5
Wt /10^3tons/		901.4	1672.3	1673.4	1664.3	1480.3	1256.4	780.0	561.4

Table 2. **Fishing mortalites and stock sizes from VPA analysis at F_{3+} in 1975 = 0.65**

	Year-class	1968	1969	1970	1971	1972	1973	1974	1975
	1959	.007	/.08/						
	60	.12	.30	.61	.53	1.53	/.50/		
	61	.03	.08	1.22	1.84	0.38	.30	.65	
	62	.08	.08	.47	.45	1.28	.80	.65	
	63	.10	.07	.22	.31	.88	1.14	.65	
	64	.08	.06	.19	.30	.34	.61	.37	.65
	65	.10	.07	.17	.34	.53	.49	.63	.65
	66	.05	.07	.21	.50	.54	.44	.63	.65
F	67	.02	.04	.14	.31	.47	.52	.69	.65
	68	.001	.05	.02	.09	.28	.43	.62	.65
	69		.001	.06	.17	.29	.53	.55	.65
	1970			.002	.08	.09	.52	.52	.65
	71				.001	.03	.42	.74	.65
	72					.009	.12	.61	.65
	73						.001	.06	.49
	74							.002	.16
	75								
	76								
Wtd. F		.09 /3+/	.08 /3+/	.24 /4+/	.35 /4+/	.38 /3+/	.50 /3+/	.64 /3+/	.65 /3+/
	1959	18.2	13.4						
	60	88.1	57.9	31.8	12.8	5.6	0.9		
	61	63.0	45.3	31.0	6.8	0.8	0.4	0.2	
	62	142.5	97.5	66.7	30.9	14.6	3.0	1.0	
	63	173.9	116.5	80.5	47.9	26.0	8.0	1.9	
	64	217.4	148.7	103.8	63.6	34.9	18.4	7.4	3.8
	65	680.1	455.7	314.9	196.8	103.7	45.2	20.5	8.1
Stock	66	2366.8	1668.6	1153.0	691.8	310.6	134.2	64.0	25.3
size	67	7286.5	5290.0	3766.5	2425.6	1317.1	609.8	268.3	99.8
/10^6/	68	4177.1	3095.2	2182.1	1584.2	1072.5	600.6	289.5	115.5
	69		4093.5	3029.2	2114.4	1321.5	732.1	319.2	136.3
	1970			1938.0	1432.2	979.6	663.2	291.8	128.4
	71				2251.3	1668.2	1199.4	584.1	206.2
	72					1347,0	988.7	649.6	261.8
	73						2685.2	1989.7	1388.8
	74							3515.2	2597.7
	75								
	76								
Age 1+									
Total /10^6/		11051.0	11000.1	10759.5	8607.0	6860.2	5003.9	4487.2	4971.7
Wt /10^3 tons/		2037.9	2626.9	2083.9	1919.4	1674.8	1310.0	983.2	889.4
Spawning stock									
Total /10^6/		2581.9	5259.9	6639.2	6117.6	4702.2	3415.5	2172.7	1679.6
Wt. /10^3 tons/		901.2	1669.4	1666.9	1648.4	1458.9	1127.6	754.3	528.5

Table 3. **Fishing mortalities and stock sizes from VPA analysis at F_{3+} in 1975 = 0.75**

	Year-class	1968	1969	1970	1971	1972	1973	1974	1975
F	1959	.008	.106						
	60	.116	.308	.632	.553	1.630	.594		
	61	.024	.083	1.216	1.806	.321	.302	.640	
	62	.078	.078	.469	.454	1.309	.798	.640	
	63	.099	.069	.223	.307	.274	1.138	.640	
	64	.086	.064	.190	.303	.344	.642	.401	.750
	65	.104	.070	.177	.342	.544	.513	.671	.750
	66	.050	.072	.214	.501	.557	.458	.679	.750
	67	.015	.043	.136	.316	.482	.543	.741	.750
	68		.055	.019	.087	.287	.448	.667	.750
	69			.058	.176	.298	.550	.596	.750
	70				.087	.097	.547	.566	.750
	71					.030	.433	.798	.750
	72						.124	.658	.750
	73							.068	.563
	74								.188
	75								
	76								
	77								
Wtd. F		.094 /3+/	.077 /3+/	.170 /3+/	.275 /3+/	.388 /3+/	.524 /3+/	.691 /3+/	.750 /3+/
Stock size /10^6/	1959	14	10						
	60	87	58	31	12	5			
	61	63	45	31	7	1			
	62	141	97	66	31	14	3	1	
	63	175	118	81	48	26	8	2	
	64	214	146	101	62	34	18	7	3
	65	672	449	310	193	101	44	19	7
	66	2343	1651	1138	680	305	130	61	23
	67	7160	5224	3707	2397	1294	592	255	90
	68		3012	2112	1535	1042	579	274	104
	69			2950	2063	1282	705	301	123
	70				1407	955	643	275	116
	71					1616	1161	558	186
	72						941	616	236
	73							1804	1248
	74								2235
	75								
	76								
	77								
Age 1+									
Total /10^6/		10870	10809	10528	8435	6677	4825	4174	4372
Wt. /10^3/		2008.5	2588.2	2045.1	1883.0	1635.4	1265.5	925.4	791.8
Spawning stock									
Total /10^6/		2538.5	5185.0	6522	5996.5	4583.5	3303.5	2062.	1513.0
Wt /10^3/		889.6	1648.0	1640.0	1617.8	1425.8	1090.3	715.7	476.7

Table 4. **The predicted catches and stock sizes at different levels of mortality and recruitment**

/in th. tons/

Option	Mean recruitment at age 1 /No.x10^6/		1975	1976	1977	1978	1979	1980	1987
1 A	2070	F	.60	.70	.35	.35	.35	.35	.35
		Catch	283.4	309.2	157.1	161.8	191.0	200.2	213.3
		Stock /1+/	944.6	898.2	801.5	882.6	937.8	974.1	1025.0
		Spawning stock	561.4	548.1	492.8	563.7	618.5	654.8	705.7
1 B	2070	F	.60	.53	.35	.35	.35	.35	.35
		Catch	283.4	251.5	174.7	189.0	198.5	205.0	213.3
		Stock /1+/	944.6	898.2	872.3	930.3	967.4	973.6	1025.0
		Spawning stock	561.4	548.1	557.7	611.0	648.1	654.1	705.7
1 C	1470	F	.60	.55	.35	.35	.35	.35	.35
		Catch	283.4	252.1	154.7	154.0	154.0	152.4	151.4
		Stock /1+/	944.6	841.5	738.4	737.2	733.3	731.2	730.6
		Spawning stock	561.4	548.4	515.9	510.5	506.6	504.5	503.9
2 A	2040	F	.65	.78	.35	.35	.35	.35	.35
		Catch	283.4	310.4	141.8	165.4	182.8	190.5	210.3
		Stock /1+/	889.4	835.6	737.9	835.3	903.2	947.8	1010.0
		Spawning stock	528.5	498.4	435.8	520.6	588.7	633.1	695.3
2 B	2040	F	.65	.60	.35	.35	.35	.35	.35
		Catch	283.4	254.5	157.8	177.2	189.9	198.4	210.3
		Stock /1+/	889.4	835.6	802.8	881.3	930.4	963.7	1010.0
		Spawning stock	528.5	498.4	495.1	566.6	615.7	649.0	695.3
2 C	1430	F	.65	.61	.35	.35	.35	.35	.35
		Catch	283.4	250.6	138.7	142.1	144.2	145.6	147.4
		Stock /1+/	889.4	777.7	672.1	687.3	695.4	700.8	707.9
		Spawning stock	528.5	498.4	456.4	466.7	474.8	480.2	487.3
3 A	1985	F	.75	1.00	.35	.35	.35	.35	.35
		Catch	283.4	311.8	111.4	143.1	167.0	182.5	198.8
		Stock /1+/	791.8	722.5	613.0	743.7	836.2	897.0	982.7
		Spawning stock	476.7	413.9	324.0	437.5	530.0	590.8	676.5
3 B	1985	F	.75	.75	.35	.35	.35	.35	.35
		Catch	283.4	254.9	128.0	155.2	174.2	186.7	198.8
		Stock /1+/	791.8	722.5	680.8	790.4	864.6	913.8	982.7
		Spawning stock	476.7	413.9	385.8	484.2	558.4	607.6	676.5
3 C	1405	F	.75	.77	.35	.35	.35	.35	.35
		Catch	283.4	251.7	98.4	122.2	131.6	136.7	144.8
		Stock /1+/	791.8	667.4	557.1	607.6	642.0	664.4	695.5
		Spawning stock	476.7	413.9	348.3	390.9	425.3	447.7	478.8

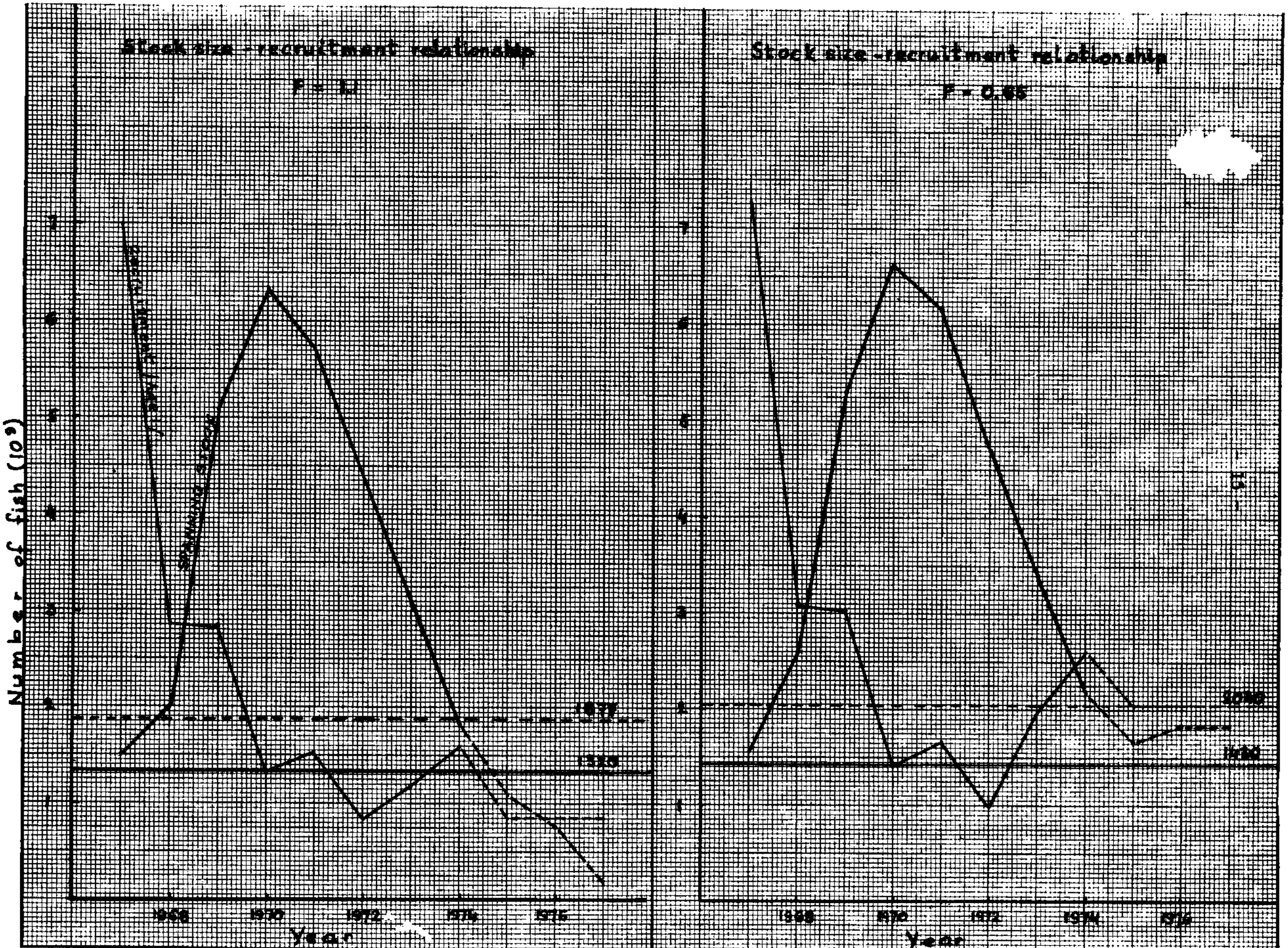
Stock size - recruitment relationship
F = 1.1
Recruitment (age 1)
Spawning stock
1977
1320
Stock size - recruitment relationship
F = 0.65
2050
1480
Number of fish (10⁹)
1968
1970
1972
1974
1976
Year

Fig. 1.

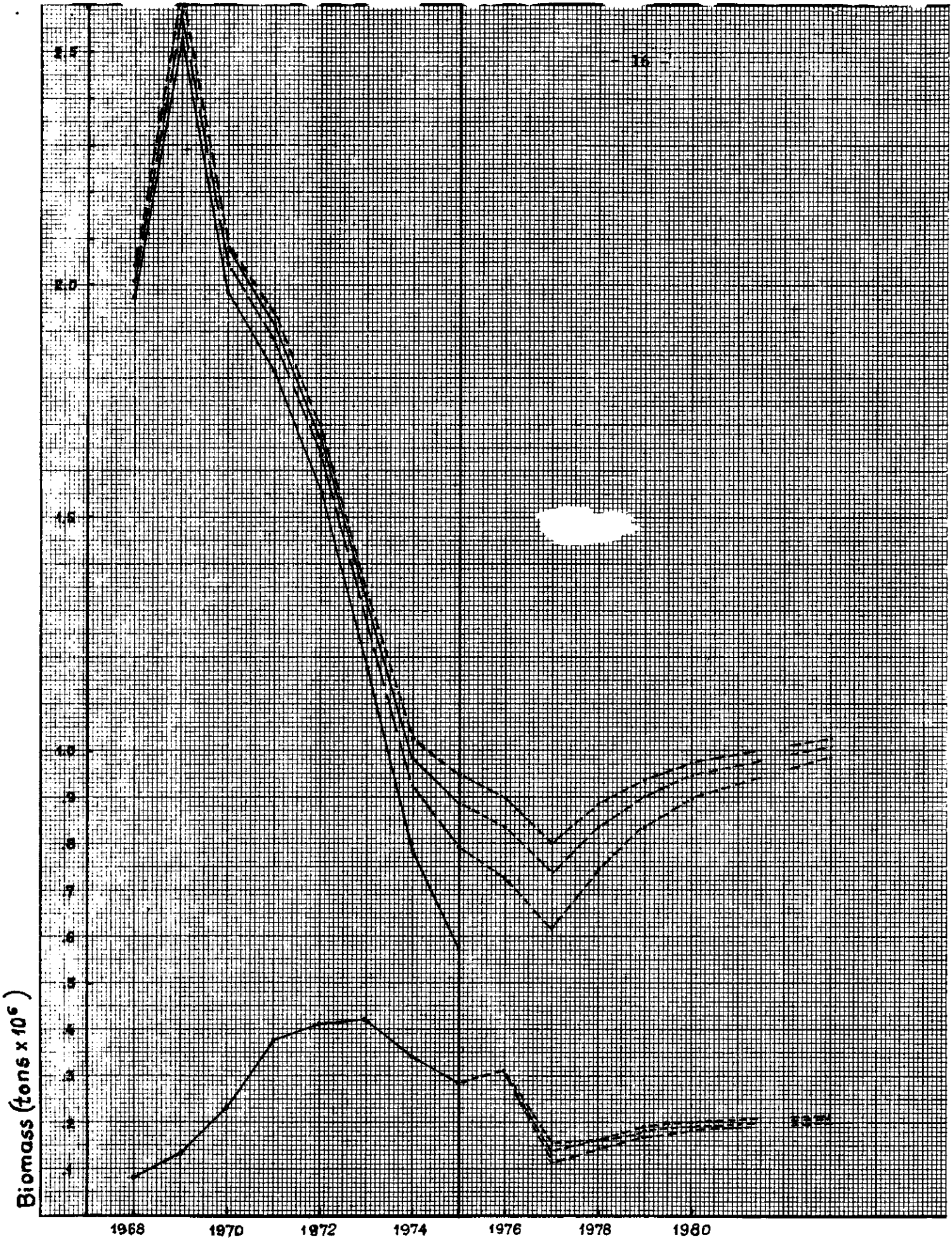
Biomass (tons x 10⁶)
2.5
2.0
1.5
1.0
.9
.8
.7
.6
.5
.4
.3
.2
.1
1968
1970
1972
1974
1976
1978
1980
Year

FIG. 2.

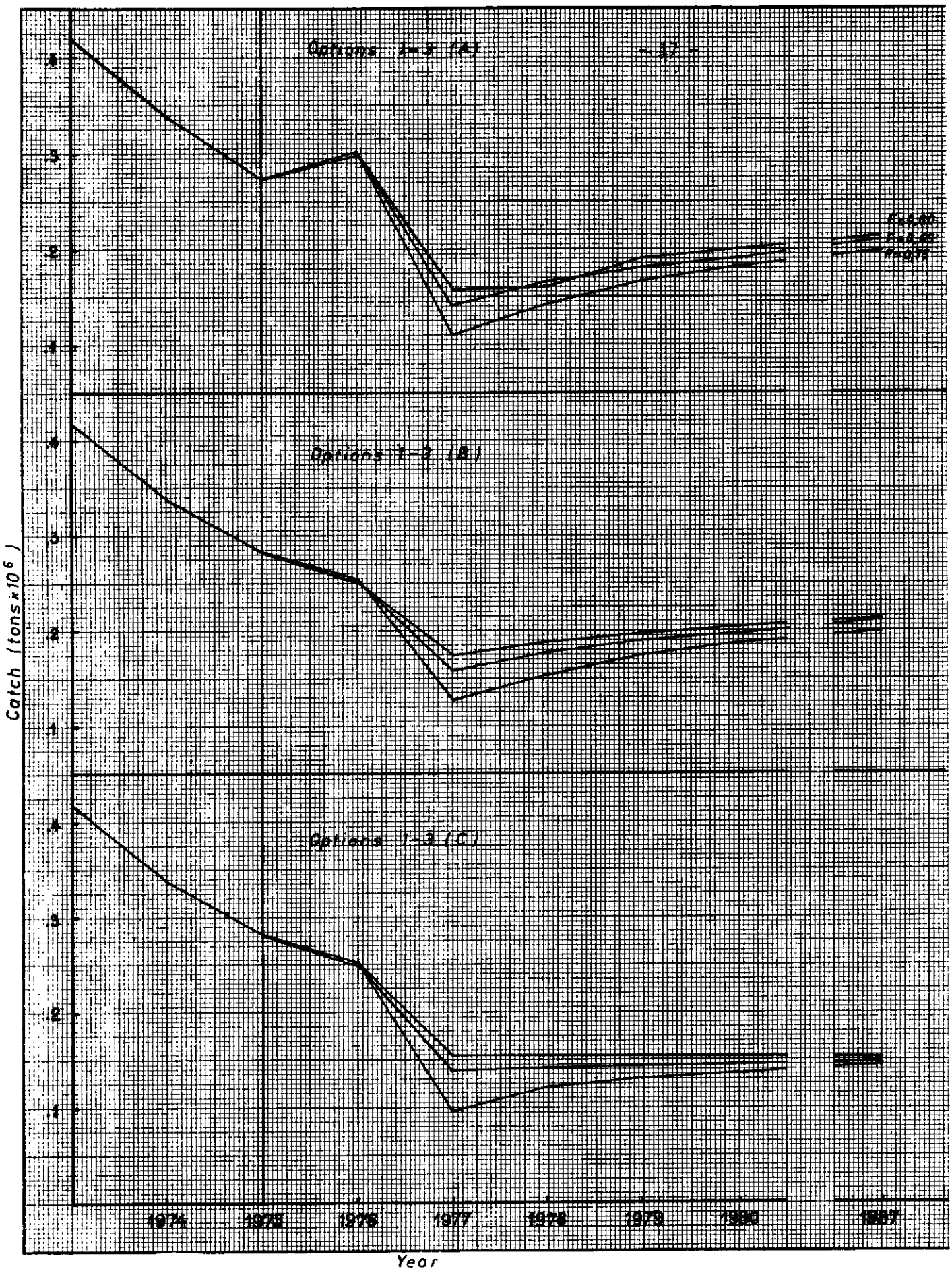
Options 1-3 (A)
Options 1-3 (B)
Options 1-3 (C)
Catch (tons*10^6)
Year
1974
1975
1976
1977
1978
1979
1980
1987

FIG. 3.

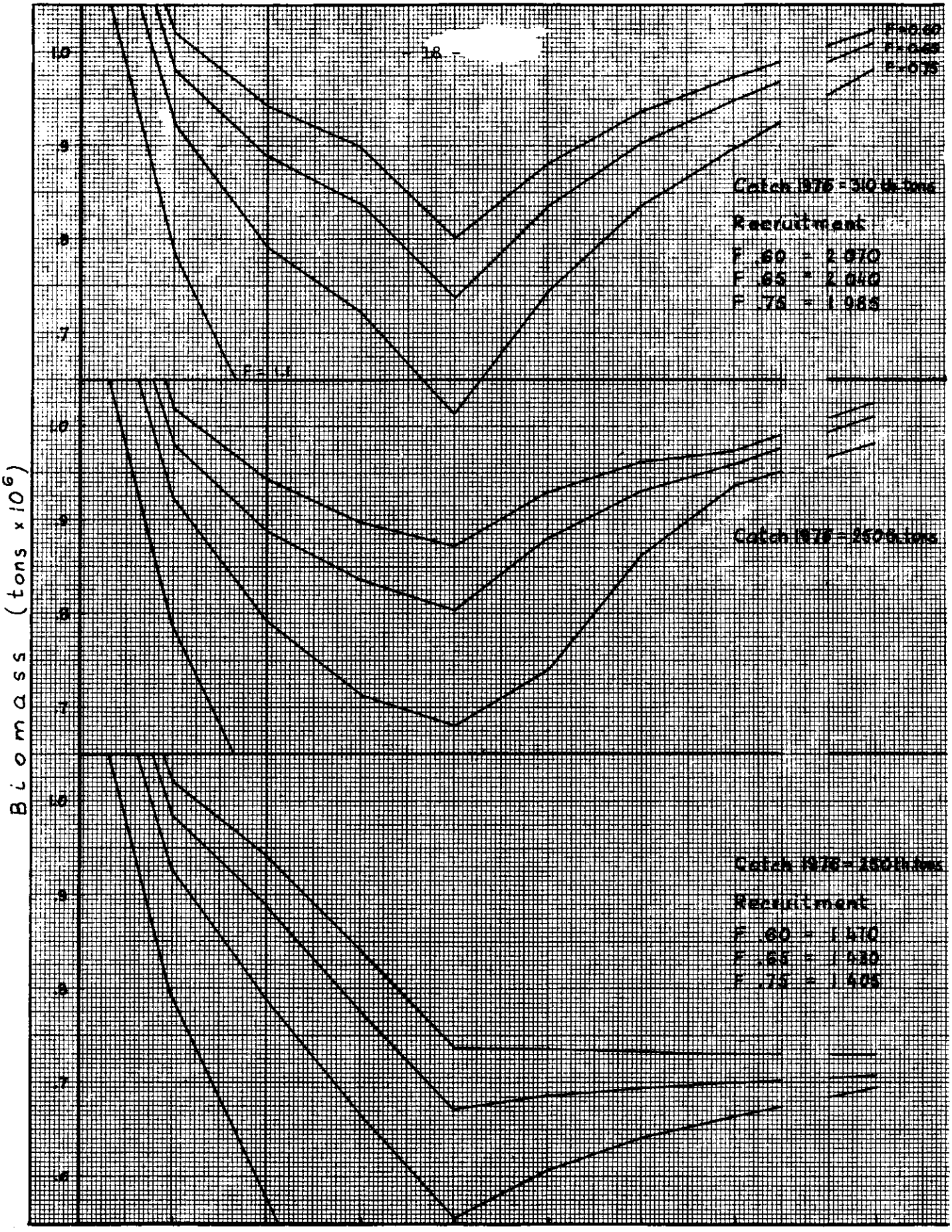
F=0.60
F=0.65
F=0.75
Catch 1976 = 310 th. tons
Recruitment
F .60 = 2 970
F .65 = 2 640
F .75 = 1 985
Catch 1976 = 2500 th. tons
Catch 1976 = 2501 th. tons
Recruitment
F .60 = 1 470
F .65 = 1 430
F .75 = 1 405
Biomass (tons x 10^6)
YEAR
1974
1975
1976
1977
1978
1979
1980
1987

FIG. 4.