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International Council for the
Exploration of the Sea

C.M.1977/F:6
Demersal Fish (Northern) Committee

REPORT OF THE NORTH-EAST ARCTIC FISHERIES WORKING GROUP

Charlottenlund, 14-18 March 1977

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Note See also Doc. C.M.1977/F:6 - APPENDIX.

Report of the North-East Arctic Fisheries Working Group

1. Participants

S Ehrich	Federal Republic of Germany
A Hylen (Chairman)	Norway
J Janusz	Poland
B W Jones	U.K. (England)
V P Ponomarenko	U.S.S.R.
C J Rørvik	Norway
N Schultz	German Democratic Republic
A Schumacher	Federal Republic of Germany
I G Tsenker	U.S.S.R.
B Vaske	German Democratic Republic.

V M Nikolaev (ICES Statistician) also participated in the meeting.

2. Terms of Reference

At the 1976 Statutory Meeting of ICES it was decided (C.Res.1976/2:30) that:

> "the North-East Arctic Fisheries Working Group should meet at Charlottenlund from 14-18 March 1977 to:
>
> (a) assess TACs for 1978 for cod and haddock;
>
> (b) examine any new data from midwater trawl fisheries and study the effect on the exploitation of these species;
>
> (c) assess, if possible, the effective mesh size in use, and report on the effects of increases in mesh size".

In addition, following a NEAFC request from the November Mid-term Meeting, this Working Group was requested by the Chairman of the Liaison Committee of ICES to provide description of life histories, fisheries and distributions of the stocks in relation to zones under national fisheries jurisdiction for North-East Arctic cod and haddock, plaice, halibut, common dab, long rough dab, lumpsucker, Polar cod, and catfishes in Sub-area I and Divisions IIa and IIb.

In an understanding between the Chairmen of the Saithe (Coalfish) Working Group, the North Sea Roundfish Working Group and the Faroe Working Group, blue ling, ling, and tusk for the whole ICES area were included in the additional terms of reference for the Faroe Working Group.

3. Status of the Fisheries

3.1 Cod (Tables 1-4)

The preliminary figure for the total catch in 1975 was about 836 000 tons which was close to the final figure of more than 829 000 tons. Also the preliminary data on the landings from Sub-area I and Divisions IIa and IIb were in quite good agreement with the final figures.

The 1976 fishery was limited by the same international quota scheme as in 1975. The total landings were limited to 810 000 tons of North-East Arctic cod. In addition, Norway and U.S.S.R. each could add 40 000 tons to their quota. This covers their catch of Norwegian coastal cod and Murman cod respectively. As was the case last year, the coastal cod is

treated as an independent unit for management purposes. The U.S.S.R. landings of Murman cod were included in the assessment for North-East Arctic cod.

Total landings are given in Table 1 for Sub-area I and Divisions IIa and IIb. Totals for each country are given in Table 2. The preliminary figure for the total landings shows an increase from 1975 to 1976 of about 30 000 tons, making up a total of approximately 859 000 tons. This figure should be compared with the total allowable catch of 850 000 tons. In Sub-area I and Division IIb the landings in 1976 decreased by 4% and 30% respectively. The decrease in Division IIb is caused mainly by low abundance of the most recent year classes in this area (Table 16). In Division IIa the increase in the landings was estimated to be 80%. This was caused by a high contribution to the catches of the 1970 (38% by number) and 1969 (18% by number) year classes which have been estimated to be very strong and of average size respectively. No specific year class dominated the catches in Sub-area I. In Division IIb the 1970 year class contributed substantially to the catches (40% by number).

3.2 Haddock (Tables 5-7)

The catches of North-East Arctic haddock were not limited by a quota regulation in 1976. However, vessels from the countries which had exhausted their quotas for cod were not allowed to continue a directed trawl fishery for haddock. The effect of this regulation was small, since normally most of the catches are taken as by-catch when fishing for cod.

As for cod, the preliminary figures for the 1975 landings were close to the final ones. Total landings in 1976 were about 143 000 tons, compared with 176 000 tons in 1975.

A decrease in landings was observed for Sub-area I and Division IIa. The reduction is estimated as 18% and 25% respectively. The most abundant year class in the catches was the 1969 year class which contributed 27% by number, followed by the 1973 year class with 22%. In Sub-area I the younger year classes of 1973-75 made a contribution of 43% by number to the catches.

4. Virtual Population Analysis (VPA) (Tables 8-15)

4.1 Age composition

Assessments were made for cod and haddock with catch/age composition data for 1950-74 as used in earlier assessments, together with updated age compositions for 1975 and preliminary data for 1976 (Tables 8 and 13). The data included U.S.S.R. landings of Murman cod and haddock.

4.2 Natural mortality

For cod the assessments were made using values for the coefficient of natural mortality of $M = 0.2$ and 0.3, and for haddock a value of $M = 0.2$ has been used.

4.3 Fishing mortality

The Group experienced some difficulties in deciding the appropriate values of fishing mortality for 1976 which are required to initiate the virtual population analysis.

4.3.1 Cod

In recent years the cod stock declined to a low level following a series of years of poor recruitment. Subsequently the stock size began to increase again with the recruitment of the more abundant year classes of 1970 and later years. As a result the fishery has become more unstable and the more traditional pattern of the fishery has changed. There was evidence that with the recruitment of the very abundant 1970 year class

the fishery concentrated on that year class. As a result there have been changes in the exploitation pattern in recent years as well as changes in the overall level of fishing mortality, and these factors made it difficult to determine appropriate F-at-age array for the most recent year.

Information which the Group used to determine 1976 F values included effort data and estimates of year classes' strength available from the international 0-group surveys, from U.S.S.R. young fish surveys, and from English commercial catch per unit effort data for age groups 3 to 5.

In past years the Group had each year modified the exploitation pattern on cod to allow for some concentration on the 1970 year class. However, the Group considered that the 1970 year class has now become less attractive to the fishery in Sub-area I and Division IIb, because its abundance is decreasing and more recent relatively abundant year classes have recruited to the immature stock. In addition, the 1970 year class is becoming less available in Sub-area I and Division IIb. Accordingly the Group came to the opinion that the exploitation pattern on cod in 1976 was more likely to have reverted to a more normal pattern and therefore the Group adopted the exploitation pattern based on the average for 1970-74. In deciding the overall level of fishing mortality, the Group was guided mainly by the year class strength indices from the pre-recruit surveys and the English c.p.u.e. data, and F values were adopted which gave VPA year class strength estimates intermediate between those indicated from the U.S.S.R. pre-recruit surveys and the English c.p.u.e. data. The resultant F values used for 1976 are given in Tables 9 and 11, together with VPA-calculated values for the earlier years. The relative values of F for 1975 and 1976 in the Tables are not entirely consistent with the indications from Table 3 that fishing effort probably increased from 1975 to 1976.

4.3.2 Haddock

For haddock the procedure was similar to that for cod with the exploitation pattern being based on the average for 1970-74, and the level of fishing mortality was decided on the basis of year class strength estimates (Table 14). In recent years there appears to have been a change in the exploitation pattern for haddock. In the past the maximum rates of mortality were experienced by age groups of five and older, but more recently age groups four to six have been subjected to the highest exploitation rates with lower rates in both the younger and older age groups.

4.4 Stock size

Estimates of stock size from VPA are given in Tables 10 and 12 for cod and in Table 15 for haddock.

5. State of the Stocks

5.1 Fishing mortality

Because of the changing exploitation pattern for cod, it is difficult to make comparisons of changes in fishing mortality in the last few years, but there appears to have been no major overall change in the level of fishing mortality in 1976. For haddock the level of fishing mortality appears to have been relatively stable during the last three years.

5.2 Recruitment

Estimates of abundance of pre-recruit year classes are available from international 0-group surveys and U.S.S.R. young fish surveys (Tables 16 and 17). Revised estimates of absolute year classes' strength from VPA are also given in Tables 18 and 19.

5.2.1 Cod

The 1970 year class is established to be an outstanding one. The 1971 year class has been estimated to be about average and the most recent assessments indicate that the 1972 year class is above average. The most recent assessments indicate that the 1973 year class is above average, and it might even be as large as the 1964 year class which has been recorded as a rich one. The 1974 year class was estimated to be poor in the pre-recruit surveys and this assessment is still valid. In the 0-group survey, the 1975 year class was rich, and the first estimate based on data from the U.S.S.R. young fish survey supported this. The 1976 year class has been estimated to be weak both in the 0-group survey and the U.S.S.R. young fish survey. Values for absolute abundance of year class strength for use in catch predictions are given in Table 18.

5.2.2 Haddock

The 1971 year class is established to be poor and recruit survey data indicate that the 1972 and 1973 year classes are below average. Both the 0-group survey and the most recent U.S.S.R. young fish survey indicate that the 1974 year class is rich. The 1975 year class was recorded in the 0-group survey as the most abundant one since these surveys started, and this has been confirmed by the most recent U.S.S.R. young fish surveys. In the 0-group survey the 1976 year class was abundant, but this has not been confirmed by the data from the U.S.S.R. young fish survey. Estimates of year class strength for use in catch prediction calculations are shown in Table 19.

5.3 Spawning stock biomass

Estimates of spawning stock biomass were prepared using the stock numbers in each year as estimated by VPA and weight-at-age data given in Table 20. The mature stock has been taken as fish of 8 years and older for cod and of 6 years and older for haddock. For cod two estimates were calculated corresponding to values of natural mortality of M = 0.2 and 0.3. Estimates of spawning stock biomass for cod are given in Table 18 and for haddock in Table 19, and the trend with time is illustrated in Figures 1 and 2. No correction has been made for catches of cod taken in the spawning fishery before spawning takes place, and the spawning stock estimates relate to the biomass of the adult stock at the beginning of each year.

For cod the spawning stock size reached a very low level in 1975 and 1976. From 1977 onwards there will be improved recruitment to the adult stock as the more abundant 1969 and subsequent year classes reach maturity. If catches in 1977 do not exceed the level of 850 000 tons recommended by the Liaison Committee, the adult stock size of cod is expected to recover to about 1 million tons by the beginning of 1978.

For haddock the variation in spawning stock biomass has been less marked than for cod. The present relatively high level of the spawning stock is a consequence of the very abundant 1969 year class reaching maturity in 1975. As later year classes are much less abundant it is expected that the spawning stock will decline below the 1976 peak during the next three years, but it will still remain above the long-term average.

6. Yield Per Recruit

As a consequence of the changes in the exploitation pattern for both cod and haddock, yield per recruit curves have been recalculated using the exploitation patterns and weight-at-age data given in Table 20. For cod the yield per recruit curves were calculated for values of M = 0.2 and 0.3, and to make comparison easier the transformation to yield has been made by multiplying yield per recruit by average recruitment (M = 0.2, R_3 = 818; M = 0.3, R_3 = 1 239. Averages for year classes 1947-73). In Figures 2 and 3 curves of yield (cod) or yield per recruit (haddock)

have been plotted against the values of F on the age groups subject to maximum exploitation. Also included in the Figures are curves showing the dependence of equilibrium spawning stock biomass (or spawning stock biomass per recruit) on fishing mortality.

From the yield curves for cod F_{max} = 0.3 (M = 0.2) and 0.6 (M = 0.3). The estimated fishing mortality in the fully exploited age groups in 1976 was F = 0.7 (M = 0.2) and F = 0.6 (M = 0.3). For haddock from the yield per recruit curve F_{max} = 0.3 compared with the estimated value for 1976 of F = 0.6.

7. Estimation of Total Allowable Catches (TACs)

Data used in calculating predicted catches are given in Table 20. Estimates of stock sizes in 1977 were derived from the estimates of stock size and fishing mortality rates in 1976. For 1977 it was assumed that catches of both cod and haddock would be at the recommended levels of 850 000 tons and 110 000 tons respectively. To take these catches from the 1977 stocks would require the fishing mortalities on the age groups subject to maximum exploitation of F = 0.5 (M = 0.3) of F = 0.55 (M = 0.2) for cod and F = 0.49 for haddock, assuming that the exploitation pattern remained unchanged. The estimated stocks at the beginning of 1978 were then calculated from the 1977 stock sizes and fishing mortality rates.

7.1 Cod

In making its recommendation for a cod TAC for 1978, the Group had to consider the need to maintain the size of the spawning stock as well as the most appropriate level of fishing mortality to maximise yield. The spawning stock biomass of cod is expected to increase to about 1 million tons by 1978. The Group recommends that every attempt should be made to maintain the spawning stock at, or above, this level. If the spawning stock size is not to fall below 1 million tons in 1979, the fishing mortality on cod should not exceed F = 0.45 in 1978 (M = 0.2 and M = 0.3). For F = 0.45 in 1978 the catch would be expected to be 850 000 tons (M = 0.2 and M = 0.3). This assessment is summarised in the text table below:

		M = 0.2	M = 0.3
1976	Spawning stock biomass (thousands of tons)	250	291
1977	Catch (thousands of tons)	850	850
	Fishing mortality on fully-exploited age groups	0.55	0.50
	Spawning stock biomass (thousands of tons)	551	630
1978	Catch (thousands of tons)	850	850
	Fishing mortality on fully-exploited age groups	0.45	0.45
	Spawning stock biomass (thousands of tons)	1 047	1 122
1979	Spawning stock biomass (thousands of tons)	1 100	1 100

If the cod TAC were to be maintained at 850 000 tons during 1977 and 1978, this would involve a progressive reduction in fishing effort corresponding to a reduction in fishing mortality from F_{1976} = 0.6 to F_{1977} = 0.5, and F_{1978} = 0.45 for M = 0.3. (Equivalent values for

M = 0.2 are $F_{1976} = 0.7$, $F_{1977} = 0.55$ and $F_{1978} = 0.45$). A value of F = 0.45 in 1978 would be below F_{max} (= 0.6) for M = 0.3, but above F_{max} (= 0.3) for M = 0.2. A catch of 850 000 tons in 1978 would allow the spawning stock to be maintained at 1 million tons into 1979. The Working Group therefore recommends that the TAC for 1978 for the North-East Arctic cod should be set at 850 000 tons (including U.S.S.R. landings of Murman cod).

7.2 Haddock

For haddock, the Group followed the approach adopted in previous years of estimating haddock TACs on the basis of the expected by-catch in the fishery regulated for the conservation of the cod stock. The consequences for haddock if the cod TAC were maintained at 850 000 tons would be expected to be as follows:

		M = 0.2
1976	Spawning stock biomass (thousands of tons)	334
1977	Catch (thousands of tons)	110
	Fishing mortality on age groups subject to maximum exploitation	0.49
	Spawning stock biomass (thousands of tons)	263
1978	Catch (thousands of tons)	150
	Fishing mortality on age groups subject to maximum exploitation	0.45
	Spawning stock biomass (thousands of tons)	217
1979	Spawning stock biomass (thousands of tons)	209

The Group considers that it would be difficult to regulate the haddock fishery independently of the cod fishery. However, a TAC for haddock, based on the expected by-catch in the cod fishery, would have the advantage of preventing effort being diverted to fishing for haddock if cod quotas are taken before the end of the year. The Working Group therefore recommends that a TAC for the North-East Arctic haddock for 1978 should be set at 150 000 tons. It is expected that to take this catch would require a fishing mortality of F = 0.45 in 1978. This may be compared with the value of $F_{max} = 0.3$ for the same exploitation pattern.

7.3 Summary of recommended TACs for 1978

North-East Arctic cod (including Murman cod)	850 000 tons
North-East Arctic haddock	150 000 tons

The above TACs are the Group's recommendations based on the assessments described above. They are very much dependent on the estimates of fishing mortality in 1976. In Section 4 the Group described the difficulties associated with determining these values of fishing mortality. While this potential source of error remains, there is the possibility that the recommended TACs will be either too high or too low. A TAC which was too high could cause long-term damage to the stock, while a TAC which was too low would result in a loss of catch although some of any such loss could be recovered to some extent in later years. In view of these considerations, the Group recommends that it would be prudent to proceed with some caution in adopting TACs.

8. Midwater Trawl

The effect of midwater trawls on the stocks compared to the effects of bottom trawls will depend on their relative selectivities and also on behaviour and vertical distribution of fish. No new data on selectivity of midwater trawls and no new data on length composition of catches taken

by pelagic gear were available at this meeting. It was reported to the Working Group that the fisheries of the German Democratic Republic, Poland and the U.S.S.R. were conducted with bottom trawls only. In the United Kingdom fishery, only small quantities of cod were taken by midwater trawls, whereas the Norwegian fishing vessels may use midwater trawls only outside the 12-mile zone, but the catches taken by this gear could not be quantified at present. Vessels of the Federal Republic of Germany have used midwater trawls since 1974, mainly in Sub-area I and Division IIb. In 1975 the catch by midwater trawls was about 9 800 tons of cod and 4 400 tons of haddock, representing 33% and 28% respectively of the total catch of these two species taken in the North-East Arctic by vessels of the Federal Republic of Germany. In the absence of length composition data and total catch data from the midwater trawl fishery, the Group is still not in a position to assess the effects of midwater trawling on the stocks of cod and haddock in the North-East Arctic.

9. Mesh Assessments

The Chairman of the Working Group discussed with Mr K P Andersen of the Danish Institute for Fisheries and Marine Research the possibility of using the method he has developed based on the length compositions of catches to assess the effective mesh sizes in use in the trawl fisheries for North-East Arctic cod and haddock. Mr Andersen was willing to assist the Group in making the assessment but he advised that the time that would be required would be more than was available during this meeting. Because of the working and computer time required to make an assessment of effective mesh size and the effects of changes in mesh size, the Working Group recommends that the necessary length composition data should be submitted to the Chairman before 1 June 1977, and that provision be made for a small number of Working Group members to meet together and make the assessment with the assistance of Mr K P Andersen. This should be done sufficiently early for the results to be circulated to all Working Group members well in advance of any future full meeting of the Group.

Table 1. Cod.
Total nominal catch by fishing areas
(metric tons).

Year	Sub-area I	Division IIb	Division IIa	Total catch
1960	375 327	91 599	155 116	622 042
1961	409 694	220 508	153 019	783 221
1962	548 621	220 797	139 848	909 266
1963	547 469	111 768	117 100	776 337
1964	206 883	126 114	104 698	437 695
1965	241 489	103 430	100 011	444 930
1966	292 253	56 653	134 805	483 711
1967	322 798	121 060	128 747	572 605
1968	642 452	269 160	162 472	1 074 084
1969	679 373	262 254	255 599	1 197 226
1970	603 855	85 556	243 835	933 246
1971	312 505	56 920	319 623	689 048
1972	197 015	32 982	335 257	565 254
1973	492 716	88 207	211 762	792 685
1974	723 489	254 730	124 214	1 102 433
1975	561 701	147 400	120 276	829 377
1976*	539 124	103 650	216 379	859 153

*Provisional figures

Table 2. Cod.
Nominal catch (metric tons, whole weight) by countries.
(Sub-area I and Divisions IIa and IIb combined)

Year	Faroe Islands	France	German Dem.Rep.	Germany Fed.Rep.	Norway	Poland	U.K.	U.S.S.R.	Others	Total All countries
1960	3 306	22 321		9 472	231 997	20	141 175	213 400	351	622 042
1961	3 934	13 755	3 921	8 129	268 377	-	158 113	325 780	1 212	783 221
1962	3 109	20 482	1 532	6 503	225 615	-	175 020	476 760	245	909 266
1963	-	18 318	129	4 223	205 056	108	129 779	417 964	-	775 577
1964	-	8 634	297	3 202	149 878	-	94 549	180 550	585	437 695
1965	-	526	91	3 670	197 085	-	89 962	152 780	816	444 930
1966	-	2 967	228	4 284	203 792	-	103 012	169 300	121	483 704
1967	-	664	45	3 632	218 910	-	87 008	262 340	6	572 605
1968	-	-	255	1 073	255 611	-	140 387	676 758	-	1 074 084
1969	29 374	-	5 907	5 343	305 241	7 856	231 066	612 215	133	1 197 226
1970	26 265	44 245	12 413	9 451	377 606	5 153	181 481	276 632	-	933 246
1971	5 877	34 772	4 998	9 726	407 044	1 512	80 102	144 802	215	689 048
1972	1 393	8 915	1 300	3 405	394 181	892	58 382	96 653	166	565 287
1973	1 916	17 028	4 684	16 751	285 184	843	78 808	387 196	276	792 686
1974	5 717	46 028	4 860	78 507	287 276	9 898	90 894	540 801 [1]	38 453	1 102 434
1975	11 309	28 734	9 981	30 037	277 099	7 435	101 834	343 580 [1]	19 368	829 377
1976*	11 206	28 000	8 946	24 780	333 828	6 986	88 027	342 104 [1]	15 276	859 153

*Provisional figures

1) Murman cod included

Table 3. Cod.
Estimates of total international fishing effort
in Sub-area I and Divisions IIa and IIb.

Year	SUB-AREA I				DIVISION IIb				DIVISION IIa			
	National Effort		Total International Effort		National Effort		Total International Effort		National Effort		Total International Effort	
	U.K.[1]	USSR[2]	U.K. units	USSR units	U.K.	USSR	U.K. units	USSR units	U.K.	Norway[3]	U.K. units	Norwegian units
1960	95	43	512	91	42	11	97	34	39	10	252	26
1961	94	53	518	109	51	22	173	39	30	9	255	20
1962	93	61	590	94	51	16	168	29	34	10	210	21
1963	78	62	635	91	45	9	120	22	29	7	176	19
1964	42	30	351	55	49	17	136	32	36	6	157	17
1965	42	25	367	62	37	11	95	4	33	5	150	16
1966	63	33	387	69	23	16	71	29	46	5	199	15
1967	51	30	395	61	10	12	110	13	50	5	261	22
1968	86	45	584	67	9	24	151	26	52	6	288	15
1969	115	45	593	72	24	19	197	26	73	5	272	18
1970	122	35	573	77	24	15	122	27	55	5	346	16
1971	82	23	576	74	4	27	79	34	48	5	523	14
1972	71	41	418	111	7	11	65	17	35	6	602	14
1973	96	61	860	94	18	12	161	16	27	7	485	14
1974	92	48	906	86	9	18	243	42	29	5	435	16
1975	109	31	731	67	5	19	109	34	28	4.077	366	13
1976*	97	44	911	82	21	18	128	36	35	4.274	622	18

1) Hours fishing x average tonnage x 10^{-6} = millions on ton-hours

2) Hours fishing (catch/catch per hour fishing) x 10^{-4}

3) Number of men fishing at Lofoten x 10^{-3}

* Provisional figures

Table 4. Cod.
Catch per unit effort (metric tons, round fresh) in Sub-area I and Divisions IIa and IIb.

Year	SUB-AREA I		DIVISION IIb		DIVISION IIa	
	U.K.[1]	USSR[2]	U.K.	USSR	U.K.	Norway[3]
1960	0.075	0.42	0.105	0.31	0.067	3.0
1961	0.079	0.38	0.129	0.44	0.058	3.7
1962	0.092	0.59	0.133	0.74	0.066	4.0
1963	0.085	0.60	0.098	0.55	0.066	3.1
1964	0.058	0.37	0.092	0.39	0.070	4.8
1965	0.066	0.39	0.109	0.49	0.066	2.9
1966	0.074	0.42	0.078	0.19	0.067	4.0
1967	0.081	0.53	0.106	0.87	0.052	3.5
1968	0.110	1.09	0.173	1.21	0.056	5.1
1969	0.113	1.00	0.135	1.17	0.094	5.9
1970	0.100	0.80	0.100	0.80	0.066	6.4
1971	0.056	0.43	0.071	0.16	0.062	10.6
1972	0.047	0.34	0.051	0.18	0.055	11.5
1973	0.057	0.56	0.054	0.57	0.043	6.8
1974	0.079	0.90	0.106	0.77	0.028	3.4
1975	0.077	0.85	0.100	0.43	0.033	3.4
1976*	0.059	0.66	0.082	0.30	0.033	3.8

1) U.K. data - tons per 100 ton-hours fishing
2) USSR data - tons per hour fishing
3) Norwegian data - tons per gill net boat week at Lofoten
* Provisional figures

Table 5. Haddock.
Total nominal catch by fishing areas (metric tons).

Year	Sub-area I	Division IIb	Division IIa	Total
1960	125 675	1 854	27 925	155 454
1961	165 165	2 427	25 642	193 234
1962	160 972	1 727	25 189	187 888
1963	124 774	939	21 031	146 744
1964	79 056	1 109	18 735	98 900
1965	98 505	939	18 640	118 079
1966	124 115	1 614	34 892	160 621
1967	108 066	440	27 980	136 486
1968	140 970	725	40 031	181 726
1969	88 960	1 341	40 208	130 509
1970	59 493	497	26 611	86 601
1971	56 300	435	21 567	78 302
1972	221 183	2 155	41 979	265 317
1973	283 728	12 989	23 348	320 065
1974	159 037	15 068	47 033	221 138
1975	121 686	9 726	44 330	175 742
1976*	99 567	10 973	33 044	143 584

*Provisional figures

Table 6. Haddock.
Nominal catch (in metric tons) by countries.
(Sub-area I and Divisions IIa and IIb combined).

Year	Faroe Islands	France	German Dem.Rep.	Germany Fed.Rep.	Norway	Poland	U.K.	USSR	Others	Total
1960	172	-	-	5 597	47 263	-	45 469	57 025	125	155 651
1961	295	220	-	6 304	60 862	-	39 650	85 345	558	193 234
1962	83	409	-	2 895	54 567	-	37 486	91 940	58	187 438
1963	17	363	-	2 554	59 955	-	19 809	63 526	-	146 224
1964	-	208	-	1 482	38 695	-	14 653	43 870	250	99 158
1965	-	226	-	1 568	60 447	-	14 345	41 750	242	118 578
1966	-	1 072	11	2 098	82 090	-	27 723	48 710	74	161 778
1967	-	1 208	3	1 705	51 954	-	24 158	57 346	23	136 397
1968	-	-	-	1 867	64 076	-	40 129	75 654	-	181 726
1969	2	-	309	1 490	67 549	-	37 234	24 211	25	130 820
1970	541	-	656	2 119	36 716	-	20 423	26 802	-	87 257
1971	81	-	16	896	45 715	49	16 373	15 778	3	78 911
1972	137	-	829	1 433	46 700	1 433	17 166	196 224	2 223	266 145
1973	1 212	3 214	22	9 583	86 767	325	32 408	186 534	-	320 065
1974	925	3 601	454	23 409	66 164	3 045	36 293	78 548[1]	8 699	221 138
1975	299	5 191	437	15 930	55 966	1 080	28 661	65 015[1]	3 163	175 742
1976*	304	625	348	16 328	47 462	986	16 667	56 554[1]	4 310	143 584

* Provisional figures

1) Murman haddock included

Table 7. Haddock.
Catch per unit effort and estimated total international effort.

Year	Catch per Effort (U.K.) Kilos/100 ton-hours			Estimated Total International Effort in U.K. Units $\frac{\text{Total Catch in Tons} \times 10^{-6}}{\text{Tons/100 Ton-Hours Sub-area I}}$
	Sub-area I	Divisions IIa	Divisions IIb	
1960	33	34	2.8	4.7
1961	29	36	3.3	6.7
1962	23	42	2.5	8.2
1963	13	33	0.9	11.2
1964	18	18	1.6	5.5
1965	18	18	2.0	6.6
1966	17	34	2.8	9.4
1967	18	25	2.4	7.6
1968	19	50	1.0	9.6
1969	13	42	2.0	10.0
1970	7	31	1.0	12.4
1971	8	25	3.0	9.8
1972	14	18	23.0	19.0
1973	22	20	20.0	14.5
1974	20	74	15.0	11.1
1975	15	60	4.0	11.7
1976[*]	10	38	3.0	14.4

[*] Provisional figures.

Table 8. Age composition of the total catches of COD (in 000's) 1967-1976
Input for the VPA.

Age	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976 *
3	34 467	3 709	2 307	7 164	7 754	35 536	294 262	91 855	45 282	84 896
4	160 048	174 585	24 545	10 792	13 739	45 431	131 493	437 377	59 798	113 930
5	69 235	267 961	238 511	25 813	11 831	26 832	61 000	203 772	226 646	82 316
6	22 061	107 051	181 239	137 829	9 527	12 089	20 569	47 006	118 567	120 674
7	26 295	26 701	79 363	96 420	59 290	7 918	7 248	12 630	29 522	52 182
8	25 139	16 399	26 989	31 920	52 003	34 885	8 328	4 370	9 353	14 976
9	11 323	11 597	13 463	8 933	12 093	22 315	19 130	2 523	2 617	4 341
10	2 329	3 657	5 092	3 249	2 434	4 572	4 499	5 607	1 555	929
11	687	657	1 913	1 232	762	1 215	677	2 127	1 928	477
12	316	122	414	260	418	353	195	322	575	420
13	225	124	121	106	149	315	81	151	231	114
14	40	70	23	39	42	121	59	83	15	18
15+	14	46	46	35	25	40	55	62	37	43

* Provisional figures.

Table 9. Fishing mortalities for COD, 1967-76, estimated by VPA for M = 0.30

Age	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976*
3	0.02	0.02	0.02	0.03	0.01	0.03	0.13	0.11	0.04	0.06
4	0.12	0.17	0.18	0.11	0.07	0.12	0.13	0.32	0.11	0.15
5	0.15	0.34	0.40	0.32	0.19	0.23	0.27	0.36	0.31	0.24
6	0.17	0.40	0.46	0.48	0.21	0.33	0.31	0.39	0.41	0.30
7	0.36	0.35	0.68	0.55	0.45	0.30	0.38	0.35	0.51	0.36
8	0.58	0.46	0.82	0.75	0.75	0.59	0.66	0.47	0.54	0.60
9	0.73	0.68	1.02	0.83	0.85	1.04	0.89	0.49	0.66	0.60
10	0.71	0.64	0.86	0.86	0.65	1.12	0.69	0.83	0.74	0.60
11	0.77	0.50	0.97	0.59	0.58	0.95	0.54	1.00	0.93	0.60
12	0.69	0.33	0.80	0.37	0.46	0.66	0.43	0.62	0.98	0.60
13	0.75	0.74	0.74	0.55	0.42	0.88	0.35	0.80	1.65	0.60
14	0.41	0.63	0.32	0.64	0.50	0.83	0.45	0.84	0.18	0.60
15+*	0.65	0.65	0.65	0.65	0.65	0.80	0.70	0.70	0.70	0.60

*Assumed values. See text section 4.

Table 10. Stock size of COD, 1967-76 (in 000's) estimated by VPA for M = 0.30

Age	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
3	1 823 890	241 359	165 660	306 467	621 774	1 663 380	2 807 510	1 008 010	1 325 550	1 684 870
4	1 619 630	1 321 630	175 624	120 747	220 897	453 975	1 201 810	1 828 340	668 207	943 202
5	579 041	1 063 020	830 002	109 150	80 222	151 886	297 475	777 947	982 401	443 883
6	166 769	369 815	559 677	412 379	58 900	49 332	89 641	168 417	403 130	534 917
7	98 851	104 706	183 085	260 981	188 713	35 507	26 265	48 904	84 843	198 007
8	64 792	50 886	54 868	68 711	111 774	89 521	19 564	13 301	25 493	37 854
9	24 828	26 752	23 795	17 964	24 032	39 030	36 837	7 468	6 150	10 973
10	5 223	8 857	10 039	6 366	5 802	7 646	10 256	11 238	3 395	2 348
11	1 451	1 907	3 474	3 162	1 988	2 245	1 849	3 805	3 615	1 206
12	724	497	856	972	1 301	829	645	797	1 039	1 062
13	486	270	264	286	499	609	316	312	319	288
14	137	171	95	94	122	243	187	165	104	45
15+	20	67	67	51	37	55	79	89	53	64

Table 11. Fishing mortalities for COD 1967-76 estimated by VPA for M = 0.20.

Age	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976*
3	0.03	0.03	0.02	0.04	0.02	0.03	0.17	0.15	0.05	0.07
4	0.15	0.21	0.23	0.15	0.10	0.16	0.17	0.40	0.14	0.18
5	0.18	0.41	0.48	0.41	0.24	0.29	0.33	0.44	0.37	0.28
6	0.20	0.47	0.54	0.57	0.26	0.41	0.38	0.46	0.49	0.35
7	0.43	0.40	0.77	0.62	0.52	0.35	0.46	0.42	0.60	0.42
8	0.67	0.52	0.92	0.84	0.84	0.67	0.77	0.55	0.64	0.70
9	0.84	0.78	1.14	0.94	0.94	1.16	0.99	0.57	0.77	0.70
10	0.82	0.73	0.98	0.99	0.74	1.26	0.77	0.94	0.85	0.70
11	0.90	0.58	1.13	0.69	0.67	1.10	0.62	1.11	1.06	0.70
12	0.80	0.39	0.92	0.44	0.53	0.78	0.50	0.68	1.12	0.70
13	0.86	0.87	0.84	0.64	0.48	1.01	0.40	0.95	1.82	0.70
14	0.48	0.73	0.38	0.74	0.57	0.94	0.52	0.95	0.22	0.70
15+*	0.75	0.75	0.75	0.75	0.75	0.90	0.80	0.80	0.80	0.70

*Assumed values. See text section 4

Table 12. Stock size of COD (in 000's) 1967-76 estimated by VPA for M = 0.20

Age	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
3	1 293 790	163 441	108 869	201 212	423 230	1156 320	2 096 780	733 721	979 162	1 383 890
4	1 244 160	1 028 150	130 465	87 052	158 272	339 510	914 633	1 451 620	517 949	760 802
5	459 614	874 426	684 610	84 729	61 547	117 192	237 036	630 396	796 007	370 165
6	132 721	313 946	475 498	346 763	46 209	39 745	71 827	139 268	333 379	448 246
7	82 682	88 801	161 080	227 040	160 567	29 263	21 693	40 342	71 884	166 713
8	56 033	44 109	48 744	61 091	99 676	78 359	16 848	11 263	21 699	32 447
9	21 751	23 418	21 427	15 892	21 577	35 274	32 986	6 366	5 309	9 405
10	4 529	7 719	8 829	5 605	5 056	6 908	9 096	10 004	2 954	2 013
11	1 255	1 633	3 056	2 702	1 701	1 975	1 609	3 434	3 202	1 033
12	627	416	749	805	1 112	712	539	712	925	910
13	425	232	231	245	426	536	268	267	295	247
14	115	147	79	81	106	215	159	147	84	39
15+	18	58	58	44	32	49	69	77	46	55

Table 13. Age composition of the total catches of HADDOCK (in 000's) 1967-1976. Input for the VPA.

Age	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976 *
3	15 918	657	1 520	23 004	1 979	230 229	70 204	9 684	10 037	27 002
4	41 373	67 632	1 963	2 408	24 359	22 246	258 773	41 701	14 089	16 435
5	13 505	41 267	44 526	1 870	1 258	42 849	24 018	88 111	33 871	6 899
6	25 736	7 748	18 956	21 995	918	3 196	6 872	5 827	49 712	17 366
7	8 878	15 599	3 611	7 948	9 279	1 606	418	4 138	2 135	32 986
8	1 617	5 292	4 925	1 974	3 056	6 736	422	382	1 236	1 184
9	218	655	1 624	1 978	826	2 630	1 680	617	92	1 344
10	176	182	315	726	1 043	896	525	2 043	131	190
11	155	101	43	166	369	988	146	935	500	219
12	76	115	43	26	130	538	340	276	147	635
13	27	18	14	52	27	53	68	458	53	382
14	7	19	2	19	4	42	13	143	92	42

* Provisional figures.

Table 14. Fishing mortalities for HADDOCK 1967-76 estimated by VPA for M = 0.20

Age	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976*
3	0.06	0.04	0.10	0.16	0.02	0.27	0.33	0.22	0.15	0.22
4	0.30	0.39	0.15	0.22	0.26	0.37	0.54	0.34	0.56	0.40
5	0.43	0.54	0.48	0.21	0.17	0.97	0.88	0.35	0.51	0.60
6	0.50	0.47	0.52	0.47	0.15	0.81	0.39	0.55	0.34	0.54
7	0.49	0.65	0.41	0.43	0.37	0.41	0.23	0.43	0.40	0.40
8	0.56	0.62	0.44	0.42	0.29	0.50	0.18	0.33	0.22	0.40
9	0.29	0.46	0.39	0.31	0.31	0.43	0.22	0.43	0.12	0.40
10	0.45	0.42	0.42	0.30	0.27	0.65	0.14	0.46	0.15	0.40
11	0.46	0.51	0.16	0.41	0.25	0.45	0.20	0.40	0.19	0.40
12	1.24	0.75	0.43	0.14	0.66	0.68	0.27	0.73	0.10	0.40
13	0.42	1.22	0.18	1.49	0.21	0.62	0.16	0.72	0.29	0.40
14*	0.60	0.60	0.40	0.40	0.40	0.60	0.30	0.60	0.30	0.40

*Assumed values. See text section 4.

Table 15. Stock size of HADDOCK (in 000's) 1967 - 1976 estimated by VPA for M = 0.20.

Age	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
3	298 061	19 885	18 373	169 762	98 461	1 086 180	271 122	54 377	77 782	150 310
4	177 201	229 667	15 688	13 671	118 265	78 826	682 228	158 909	35 804	54 639
5	42 563	107 890	127 335	11 075	9 026	74 916	44 565	326 865	92 646	16 704
6	71 648	22 734	51 388	64 351	7 384	6 256	23 238	15 102	188 482	45 512
7	25 034	35 604	11 668	25 095	32 971	5 218	2 274	12 858	7 148	109 664
8	4 146	12 541	15 209	6 313	13 417	18 664	2 832	1 485	6 816	3 936
9	948	1 947	5 536	8 036	3 398	8 237	9 246	1 938	873	4 468
10	530	580	1 007	3 075	4 801	2 040	4 385	6 058	1 033	632
11	461	276	312	542	1 865	2 993	869	3 117	3 128	728
12	116	238	135	217	295	1 195	1 565	580	1 713	2 111
13	86	28	93	72	154	125	498	975	229	1 270
14	17	46	7	63	13	102	55	346	390	140

Table 16. ARCTO-NORWEGIAN COD.
Year class strength. The number per hour fishing for U.S.S.R. Young Fish Surveys is for 2 year old fish.

Year class	USSR Survey No. per Hour Trawling			USSR Assessment	0-Group Surveys	Virtual Population No. of 3-year-olds x 10^{-6} *	
	Sub-area I	Division IIb	Mean			M = 0.2	M = 0.3
1957	12	16	13	-Average		791	1 060
1958	16	24	19	+Average		919	1 252
1959	18	14	16	+Average		730	1 046
1960	9	19	13	Poor		473	699
1961	2	2	2	Poor		340	530
1962	7	4	6	Poor		778	1 160
1963	21	120	76	Rich		1 581	2 251
1964	49	45	46	Rich		1 294	1 824
1965	<1	<1	<1	Very poor	6	163	241
1966	2	<1	1	Very poor	<1	109	166
1967	1	<1	1	Very poor	34	201	306
1968	7	1	5	Poor	25	423	622
1969	11	6	9	Poor	93	1 156	1 663
1970	74	86	76	Rich	606	2 097	2 808
1971	37	24	32	+Average	157	(734)	(1 008)
1972	53	17	40	+Average	140	(979)	(1 326)
1973	70	5	46	+Average	684	(1 384)	(1 685)
1974	(11)	(1)	(7)	Poor	51	(525)	(700)
1975	(234)	(1)	(130)	Rich	343	(1 000)	(1 200)
1976	(2)	(1)	(2)	Poor	43		

( ) = estimated.

* USSR Murman cod included for 1974, 1975 and 1976.

Table 17. ARCTO-NORWEGIAN HADDOCK.
Year class strength. The number per hour trawling for U.S.S.R. Young Fish Surveys is for 2 year old fish.

Year class	USSR Survey No. per Hour Trawling Sub-area I	0-Group Surveys	Virtual Population No. of 3-year-olds x 10^{-6} *
1957	9		242
1958	4		110
1959	14		241
1960	40		276
1961	50		319
1962	3		100
1963	9		245
1964	12		298
1965	<1	7	20
1966	<1	<1	18
1967	13	42	170
1968	<1	8	98
1969	69	82	1 086
1970	38	115	271
1971	3	73	(54)
1972	9	46	(78)
1973	9	54	(150)
1974	(35)	147	(275)
1975	(168)	170	(900)
1976	(<1)	112	

( ) = estimated.

* USSR Murman haddock included for 1974, 1975 and 1976.

Table 18. Estimates of the spawning stock and the year class strength for COD. Estimates from VPA.

M = 0.2			
Year	Spawning stock biomass tons x 10^{-3}	Year class	Year class strength at 3 years old Millions
		1947	705
		1948	1 097
		1949	1 192
1950	1 458	1950	1 593
1951	1 385	1951	645
1952	1 155	1952	273
1953	903	1953	441
1954	827	1954	805
1955	869	1955	498
1956	993	1956	685
1957	929	1957	791
1958	1 019	1958	919
1959	837	1959	730
1960	600	1960	473
1961	514	1961	340
1962	474	1962	778
1963	377	1963	1 581
1964	243	1964	1 294
1965	213	1965	163
1966	338	1966	109
1967	458	1967	201
1968	437	1968	423
1969	470	1969	1 156
1970	467	1970	2 097
1971	676	1971	(734)
1972	675	1972	(979)
1973	380	1973	(1 384)
1974	215	1974	(525)
1975	203	1975	(1 000)
1976	(250)		
1977	(551)		
1978	(1 047)		
1979	(1 115)		

M = 0.3			
Year	Spawning stock biomass tons x 10^{-3}	Year class	Year class strength at 3 years old Millions
		1947	1 070
		1948	1 666
		1949	1 773
1950	1 731	1950	2 333
1951	1 645	1951	958
1952	1 359	1952	411
1953	1 079	1953	649
1954	979	1954	1 133
1955	1 012	1955	697
1956	1 161	1956	932
1957	1 098	1957	1 060
1958	1 212	1958	1 251
1959	1 014	1959	1 046
1960	698	1960	699
1961	587	1961	530
1962	542	1962	1 160
1963	427	1963	2 251
1964	280	1964	1 824
1965	250	1965	241
1966	395	1966	166
1967	527	1967	306
1968	502	1968	622
1969	528	1969	1 663
1970	528	1970	2 808
1971	759	1971	(1 008)
1972	762	1972	(1 326)
1973	430	1973	(1 685)
1974	246	1974	(700)
1975	235	1975	(1 200)
1976	291		
1977	(630)		
1978	(1 122)		
1979	(1 077)		

( ) = provisional figures

Table 19. Estimates of the spawning stock and the year class strength for HADDOCK. Estimated from VPA for M = 0.20.

Year	Spawning stock biomass tons x 10^{-3}	Year class	Year class strength at 3 years old Millions
		1947	67
		1948	552
		1949	63
1950	270	1950	1 029
1951	151	1951	127
1952	95	1952	52
1953	66	1953	169
1954	179	1954	53
1955	156	1955	69
1956	474	1956	325
1957	324	1957	241
1958	202	1958	110
1959	160	1959	240
1960	129	1960	276
1961	105	1961	319
1962	147	1962	100
1963	106	1963	245
1964	67	1964	298
1965	76	1965	20
1966	140	1966	18
1967	193	1967	170
1968	166	1968	98
1969	178	1969	1 086
1970	225	1970	271
1971	172	1971	(54)
1972	137	1972	(78)
1973	122	1973	(150)
1974	122	1974	(275)
1975	328	1975	(900)
1976	334		
1977	(263)		
1978	(217)		
1979	(209)		

( ) = provisional figures.

Table 20. Parameters used in the catch prediction.

Age	COD			HADDOCK		
	Stock size beginning of 1978 (millions of fish)*	Proportion of F (adult) 1976 - 1978	Mean weight per age (kgs)	Stock size beginning of 1977 (millions of fish)	Proportion of F (adult) 1976-1978	Mean weight per age (kgs)
3	1 200.0 1 000.0	0.10	0.65	(900.0)	0.37	0.41
4	493.3 406.8	0.26	1.00	188.3	0.67	0.62
5	768.5 750.0	0.40	1.55	58.4	1.00	0.97
6	364.8 341.9	0.50	2.35	15.1	0.90	1.59
7	149.2 142.4	0.60	3.45	4.0	0.67	2.33
8	161.1 152.2	1.00	4.70	12.8	0.67	2.72
9	46.0 42.4	1.00	6.17	35.6	0.67	3.56
10	6.9 6.2	1.00	7.70	1.3	0.67	4.41
11	2.0 1.8	1.00	9.25	1.5	0.67	5.40
12	0.4 0.4	1.00	10.85	0.20	0.67	6.70
13	0.22 0.2	1.00	12.50	0.24	0.67	7.40
14	0.19 0.17	1.00	13.90	0.68	0.67	8.00

* Upper figure: for M = 0.3
Lower figure: for M = 0.2

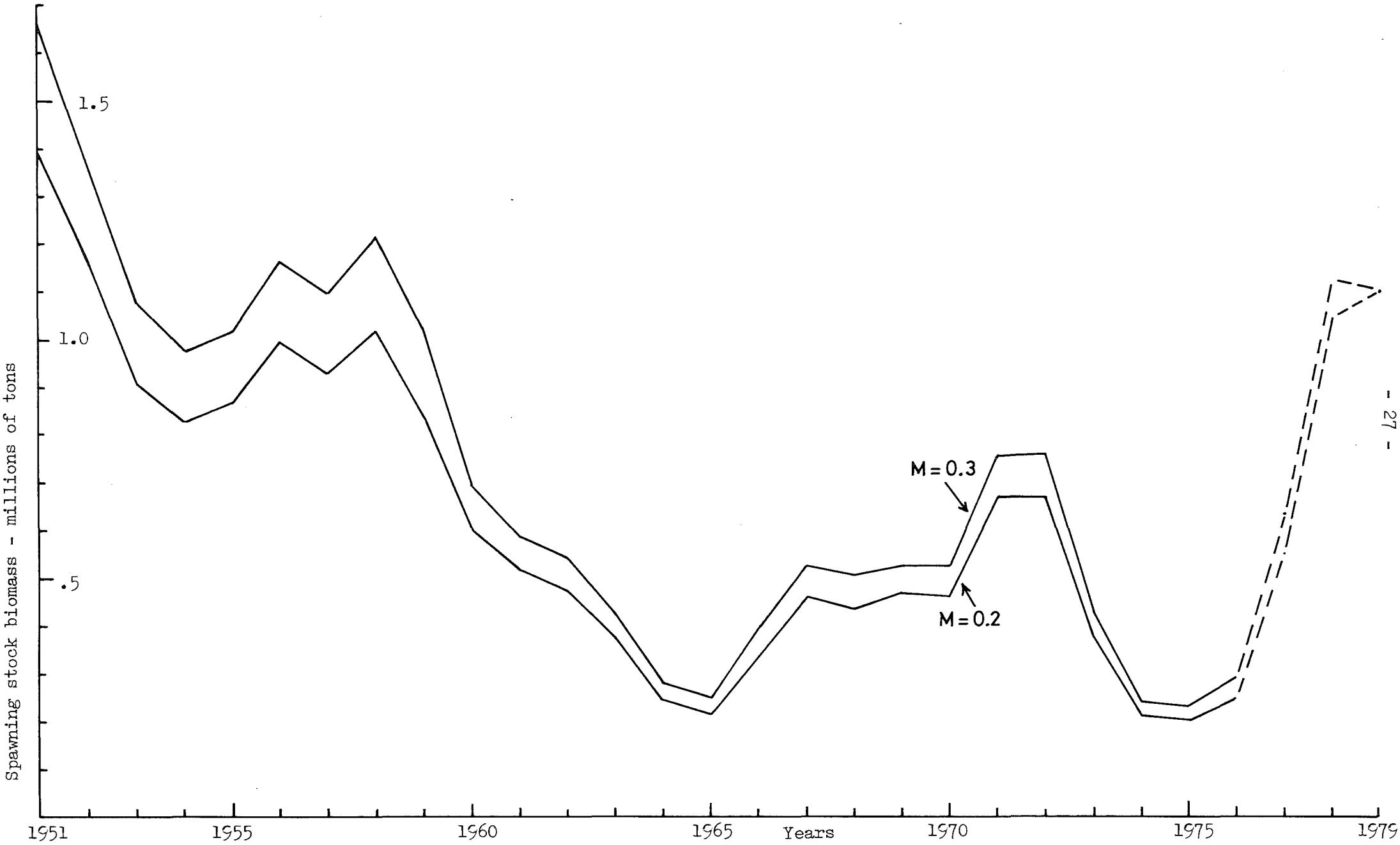

Figure 1. North-East Arctic Cod.
The spawning stock biomass 1951-1979 estimated from VPA for M = 0.20 and M = 0.30.

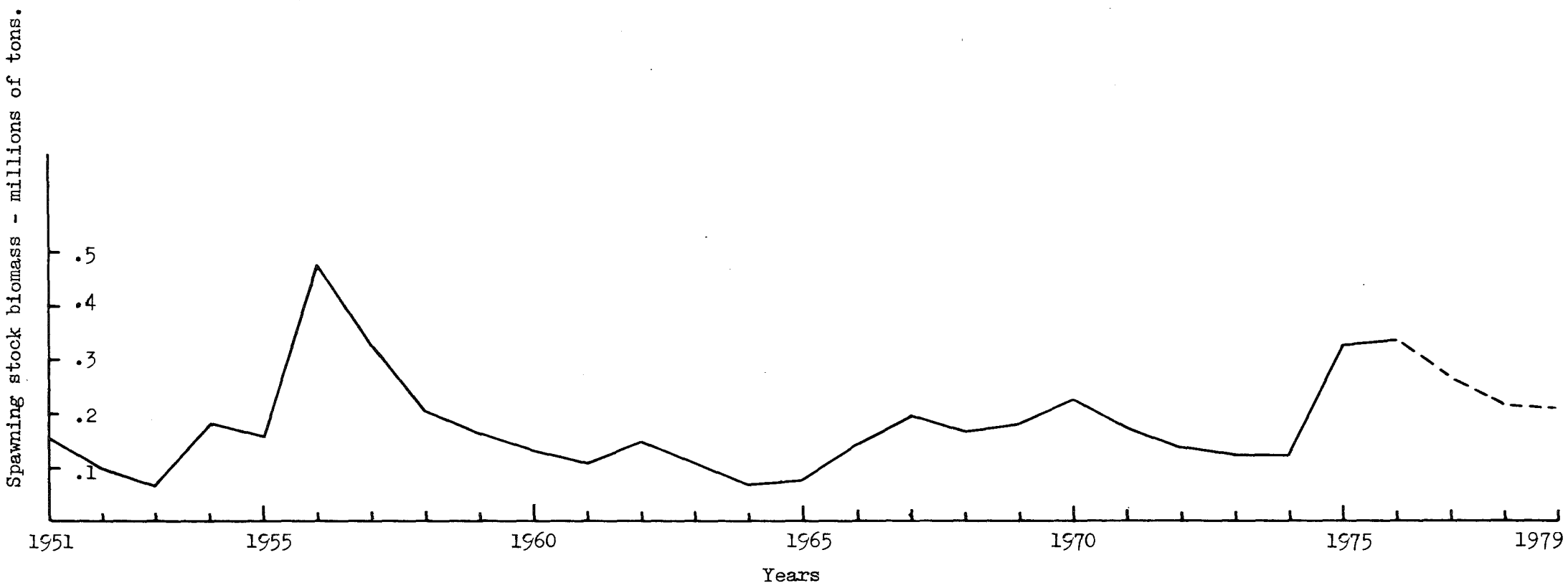

Figure 2. Haddock.
The spawning stock biomass 1951-1979 estimated from VPA for M = 0.20.

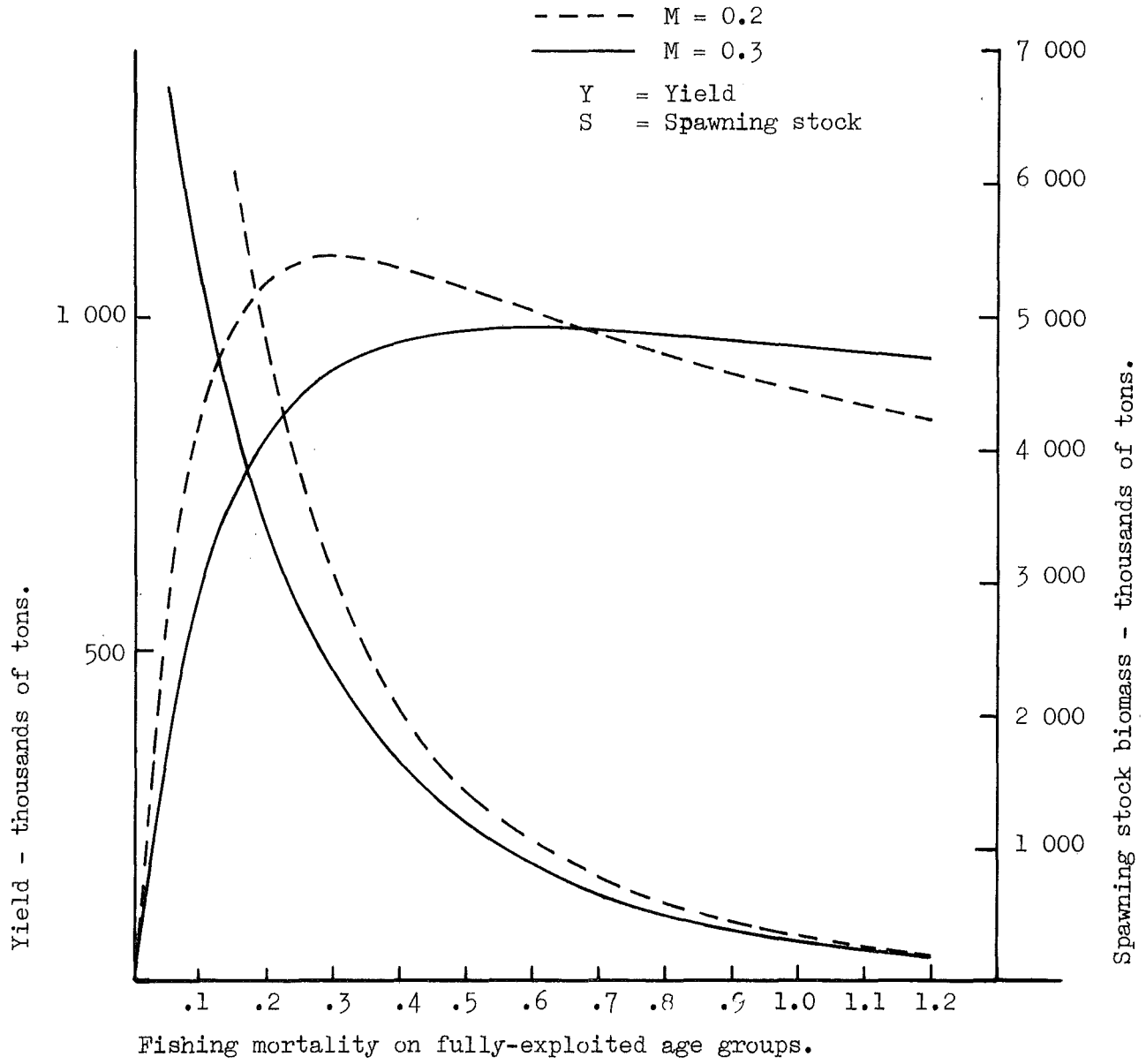

Figure 3. North-East Arctic Cod.
Curves of yield and spawning stock biomass for the present exploitation pattern assuming average recruitment.

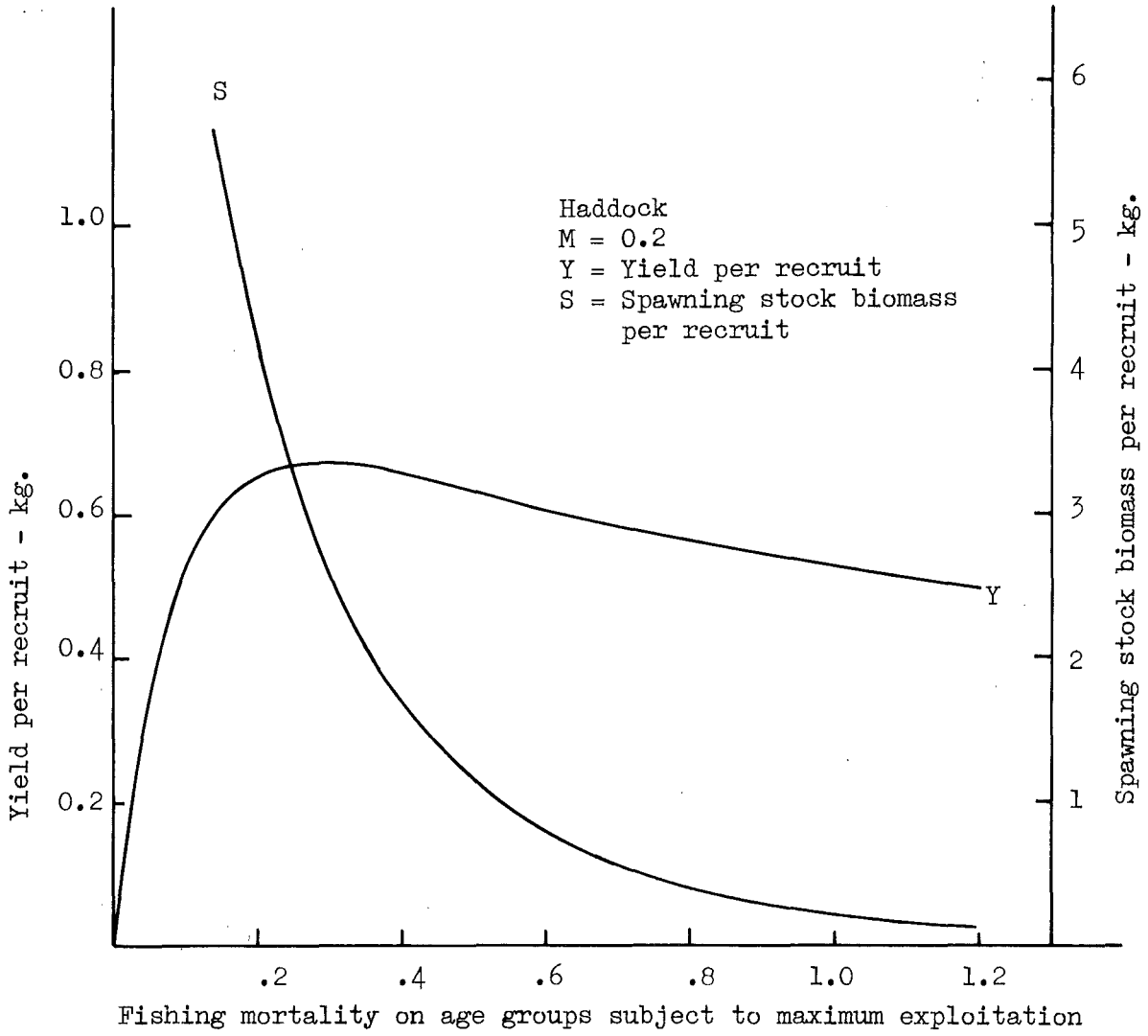

Figure 4. Haddock.
Curves of yield per recruit and spawning stock biomass per recruit for present exploitation pattern.