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REPORT OF THE NORTH-EAST ARCTIC FISHERIES WORKING GROUP

18-22 March 1974, Charlottenlund Slot, Denmark.



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Report of the North-East Arctic Fisheries Working Group

1. Participation

Mr D.J. Garrod	United Kingdom
Mr A. Hylan (Chairman)	Norway
Mr B.W. Jones	United Kingdom
Mr S.D. Melnikov	USSR
Dr V.P. Ponomarenko	USSR

Mr D. de G. Griffith, ICES Statistician, also took part in the Meeting.

2. Terms of Reference

At the 1973 Statutory Meeting of ICES the following Resolution (C.Res.1973/2:20) was adopted:

"It was decided that:

the North-East Arctic Fisheries Working Group meets at Charlottenlund from 18 to 22 March 1974 to:

- a) continue assessments of the Arcto-Norwegian cod and haddock stocks;
- b) assess the effects on individual countries' catches of the proposed increase in mesh size to 145 mm manila;
- c) examine the proposal for such an increase in relation to other proposed regulatory measures, e.g. quotas;
- d) examine the effect of the proposal concerning mesh size on the size of the spawning stock and whether it would obtain the optimal level of recruitment."

3. The Status of the Fisheries

3.1. Cod (Tables 1 - 4).

At the 1973 Meeting of the Working Group provisional catch and effort statistics were not available for all countries and therefore the data for 1972 given in this Report differ from the estimates which were given in the last Report.

In 1973 there was a big improvement in catches from Sub-area I and Division IIb resulting from the recruitment of the 1969 and the very rich 1970 year classes. Catches in Division IIIa declined as expected as a result of the reduced size of the mature part of the stock. The abundant 1963 and 1964 year classes which gave improved catches on the Norway coast in 1971 and 1972 are now past making their maximum contribution to the catches. The spawning fishery is now expected to continue to decline until the 1969 and 1970 year classes reach maturity.

The estimates of total fishing effort on cod in English and USSR units (Table 3) give conflicting indications of the trend in the amount of fishing. Part of this discrepancy is likely to be due to an underestimate of catch-per-unit-effort of English trawlers because of rejection at sea of young fish. The general impression, however, is that there was an increase in the amount of fishing in Sub-area I and Division IIb while there was very little change in Division IIa.

3.2. Haddock (Tables 5 - 7).

The estimates for haddock landings in 1972 given in the 1973 Report were much more seriously in error than were those for cod. 1972 catches in all areas showed big increases compared with 1971 following the recruitment of the abundant 1969 year class. Catches increased again in 1973 in Sub-area I and Division IIb, but the decline in Division IIa resulted from the reduced size of the mature part of the stock as year classes after those of 1963 and 1964 are of lower abundance.

Fishing effort on haddock probably reduced slightly in 1973 after an increase in 1972.

4. Fishing Mortality (Tables 8 and 9).

Provisional age composition data were available for catches in 1973 taken by England, Norway, Federal Republic of Germany and the USSR. These data provided the basis of estimates of the age composition of the total 1973 catches of cod and haddock which were used to update the Virtual Population Analysis (VPA). Revised data for the 1972 catches were also available.

For cod, estimates of fishing mortality in 1973, used to initiate the VPA, were similar to the values used at the last Meeting of the Group. These estimates were derived from information on probable trends in fishing effort with additional guidance from an analysis of the data by a new method (unpublished) being developed by Mr J. Pope of the Fisheries Laboratory, Lowestoft, England. For haddock, values slightly lower than last year were used since it is believed that the fishing effort on haddock in 1973 was slightly lower than in 1972. Results of the VPA are given in Tables 8 and 9.

5. Recruitment (Tables 10 and 11).

For cod, the year classes 1965 - 1968 have all been very weak (Table 10). The fisheries in Sub-area I and Division IIb are now beginning to benefit from the recruitment of more abundant year classes. The 1969 year class now seems to be not so abundant as had appeared from the rather poor provisional data available at the 1973 Meeting. The most recent estimate indicates that it is slightly above average size. The 1970 year class which recruited to the fishery in 1973 is fulfilling earlier expectations and it is well above average abundance, although it is still too early to have an accurate estimate of its size. Of the subsequent year classes of cod, the indications from 0-group and young fish surveys, are that those of 1971 and 1972 are of about average size and that of 1973 is very abundant.

For haddock (Table 11), the very abundant 1969 year class has been joined in the fishery by the 1970 year class which is also well above average abundance. The 0-group survey results suggest that the 1971 - 1972 year classes are of average size and that of 1973 below average.

6. Effective Mesh Size in Use

Bottom trawling experiments with double cod ends were made in April and June 1973 by Norway off the East Finmark coast. The mesh sizes in both cod ends were 130 mm. The catches were sorted by fishermen into those fish acceptable for landing and those to be discarded, according to current commercial practice. In this manner discarding rates, by number, of between 23 - 28% were found. All fish less than 35 cm and most of the fish in the length group 35 - 39 cm were discarded. No fish greater than 49 cm were discarded.

Some of the countries fishing in the North-East Arctic are known to discard small fish at sea. Presuming this to be reflected in the length composition of landings which show a higher mean length, the discard factors deduced from the experiments were applied to the landings of countries B and C in Figure 1.

The adjusted length frequency of these landings then appear to be very similar to the unadjusted landings of country A. The correction implies discarding of 44% and 37% by numbers by countries B and C in 1973.

The similarity between length compositions of commercial catches, adjusted for discarding, and the length composition of experimental hauls using double cod ends of 130 mm might be taken to indicate that the enforcement of Commission regulations is inadequate.

No doubt this may occur from time to time, but a similar effect might be achieved by the concentration of the fishery in areas where the new year class is most abundant, so that the selection of cod by trawl cod ends of the Commission size is influenced by the abundance and behaviour of the fish. Whatever its cause, it is apparent that in 1973 at least the effective mesh size of cod ends was lower than 130 mm, and 115 mm has been adopted as a working value for estimating the immediate loss that may be caused by changing to a new mesh size.

7. Assessments

The effects of changes in mesh regulations were calculated in two ways. The Gulland method using length composition data was used to estimate immediate losses. Another method based on age composition of the stock and fishing mortality data was used to estimate the long-term change and also the catches to be expected in each year 1975 - 1977 if a mesh size of 130 mm or 145 mm were to be introduced in 1975.

7.1. Estimates of Immediate Losses (Gulland Method).

If the Gulland method is to be successfully applied the length composition of the population should be relatively stable. At present in the North-East Arctic the size compositions of the stock fluctuates from year to year with variations in year class strength. The result of a mesh change in this situation will depend critically on the relative abundance of the recruiting year classes. The calculations were based on the average length compositions of the catches in 1968 and 1969 for cod and 1969 and 1970 for haddock when the relative strengths of the recruiting year classes were similar to those expected in 1975 and 1976. For cod, some allowance has been made for rejection. It has been assumed that there was no rejection by USSR vessels, but the rejection rate for trawlers of all other countries was estimated on the basis of the relative abundance of the smallest age groups in their landings compared with USSR catches. No allowance was made for rejection of

haddock. The immediate loss was calculated for increases to 130 mm and 145 mm from 115 mm which is the present estimated effective mesh size.

For cod, an increase to 130 mm would be expected to result in a 6% immediate loss for USSR catches with very little change for other countries. An increase to 145 mm would result in immediate losses of 16% and 7% for USSR and U.K., and 6% for Norwegian trawlers. For haddock, the magnitude of the immediate losses would be greater, being 20%, 3% for USSR and U.K. and 3% for Norwegian trawlers, for a change to 130 mm. The corresponding immediate losses for a change to 145 mm would be 36%, 12% and 11%.

7.1.2. Estimates Based on the Age Composition Method.

The Tables below summarise the immediate and long-term effects of possible adjustments to the mesh regulations, depending upon the effective mesh size at present in use (see Section 6).

Immediate Effects (%)

Species	Method	1973 Effective Mesh (mm)	New Mesh (mm)	USSR	Norway		U.K.	Germany (F.R.)	Others	Total
					Trawl	Total				
COD	VPA	115	130	-11		- 2	- 7		- 7	- 8
	Gulland			- 6	- 1		- 2	- 1	- 1	
	VPA	115	145	-17		- 8	-14		-13	-13
	Gulland			-16	- 6		- 7	- 1	- 2	
		130	145	- 7		- 6	- 7		- 6	- 6
HADDOCK	VPA	115	130	-16		+ 5	- 4		-27	- 9
	Gulland			-20	- 3		- 3	- 1	- 2	
	VPA	115	145	-33		- 7	-20		-45	-25
	Gulland			-36	-11		-12	- 7	- 8	
		130	145	-20		-11	- 7		-25	-17

If a new mesh regulation were introduced in 1975, the trawl fisheries which would show the greatest immediate losses would be those of the Barents Sea and the Bear Island - Spitsbergen area, and there would be a greater loss for haddock than for cod.

Long-Term Effects (%)

Species		1973 Effective Mesh (mm)	New Mesh (mm)	USSR	Norway All Gears	U.K.	Others	Total
COD	(M=0.3)	115	130	-3	+ 8	+ 1	+ 2	+ 2
	(M=0.3)	115	145	-5	+13	+ 1	0	+ 3
	(M=0.2)	115	145	-1	+15	+ 4	0	+ 7
	(M=0.3)	130	145	-2	+ 5	0	0	+ 1
HADDOCK		115	130	-7	+27	+28	+11	+ 9
		115	145	-10	+53	+56	+33	+18
		130	145	-4	+21	+22	+20	+ 9

The long-term change in the cod fishery would be small, even allowing for some uncertainty in the level of natural mortality that should apply. However, with a total long-term gain of perhaps 5% there would be some redistribution of catch in favour of fisheries based on older cod. There would be a somewhat greater long-term gain in the total catch of haddock (perhaps up to 20%) but with a greater redistribution of catch between areas and countries.

7.2. Estimates of Future Catches and the Effect of Changes in Mesh Regulations Based on Age Composition.

7.2.1. Trends in Catches.

Prospective catches of cod and haddock have been estimated for two levels of fishing and three mesh sizes as summarised in Table 12. Prospective catches at the present mesh size are abstracted below for two levels of fishing: (i) if the 1973 level is maintained and (ii) if it is reduced by 25% to approach the level of fishing mortality giving the Maximum Sustainable Yield per recruit.

		Catch ('000 tons)					
		Level of Fishing (F) as in 1973			F = 3/4 of the Level in 1973		
		I + IIb	IIa	Total	I + IIb	IIa	Total
COD	1974	577	109	686			
	1975	736	77	813	585	62	647
	1976	804	105	909	684	97	781
	1977	828	171	999	726	178	905
HADDOCK	1974	207	17	224			
	1975	182	37	220	144	30	174
	1976	162	22	184	141	20	161

If cod catches in 1974 do not exceed the tripartite Agreement level of 550 000 tons then prospective catches for 1975 - 1977 will be slightly higher. Haddock catches have also been estimated assuming the 1973 level of fishing is maintained but these may be influenced by interaction between the two fisheries. For example, if cod and haddock are always caught together, then the haddock catch may be limited by the possibilities for catching cod.

The estimated catches given above can be compared with separate estimates of 1 110, 1 165 and 1 240 thousand tons for the years 1974, 1975 and 1976 respectively prepared by USSR scientists using a technique based upon the historic performance of the fishery relative to changes in year class strength (see Appendix). However, the Group noted that in 1968 the catch of this magnitude came from a stock which contained two outstanding year classes (1963 and 1964) as 4 and 5 year-old fish, and additional stock of older age groups whereas now, in 1974, the stock contains only one good year class (1970) as 4 year olds and the stock of older age groups is particularly weak. The Group therefore considered the USSR estimates for 1974 and 1975 to be optimistic.

7.3. The Effect of Regulations Upon the Size of the Spawning Stock.

The Group has previously expressed concern at the declining size of the spawning stock of cod, and earlier reports have stressed the need to ensure that an adequate quantity of cod from the 1970 year class survive to augment the spawning stock from 1978 onwards. The effects of regulation of the fishing mortality and/or mesh size on the size of the spawning stock are summarised below by comparison of the expected size of the spawning stock at the beginning of 1978 (before the spawning season) for different mesh adjustments.

Effective Mesh Size In Force (mm)	New Mesh (mm)	Level of Fishing 1975 - 1977 as in 1973		Level of Fishing 1975 - 1977 = 0.75 x 1973 Level	
		Index of Cod Spawning Stock in 1978	No. of Cod Aged 8+ in 1978 (Millions)	Index of Cod Spawning Stock in 1978	No. of Cod Aged 8+ in 1978 (Millions)
115	Present Effective	734	99	1 020	142
115	130	759	101	1 052	145
115	145	806	106	1 063	150

Clearly a reduction in fishing mortality will achieve more rapid recovery of the spawning stock than mesh regulation; the most rapid recovery would be achieved by a combination of measures. It is not certain what the best level of spawning stock should be, but the Group noted that in 1970 - 1972 the number of mature cod of 8 years and older averaged 136 million. This might perhaps be a first objective, knowing that the recovery can be expected to continue in the years following 1978 and may later come to approach more closely the level of 212 million, averaged in the years 1959 -

The cod catches in thousands of tons for the period 1974 - 1977, associated with the two levels of fishing, are:

	Level of Fishing (F) as in 1973	F = 3/4 of the Level in 1973
1974	686	686
1975	813	647
1976	909	781
1977	999	905

Together, these serve to show that a recovery in the spawning stock at least to the 1970 - 1972 level could be achieved by careful regulation of the catches in the coming years. In effect, management can take advantage of the improving stock to reduce fishing mortality without reducing actual catches. It is, however, essential that a regulation be maintained to prevent unrestricted increase in fishing on the whole stock within the period 1975 - 1977, and to prevent too high a proportion of the allowable catch being taken from the mature stock.

Table 1. COD.
Total Nominal Catch by Fishing Areas (Metric Tons).

Year	Sub-Area I	Division IIb	Division IIa	Total
1960	380 962	94 599	155 116	630 677
1961	409 694	222 451	149 122	781 267
1962	548 621	222 611	138 396	909 628
1963	547 469	113 707	116 924	778 100
1964	202 566	126 029	108 803	437 398
1965	241 489	103 407	99 855	444 751
1966	292 244	56 568	134 664	483 476
1967	322 781	121 050	128 729	572 560
1968	642 449	268 908	162 472	1 073 829
1969	670 158	266 117	254 985	1 191 260
1970	551 015	85 423	240 150	876 588
1971	311 788	56 907	336 269	704 964
1972	197 234	33 220	338 553	569 007
1973 ^{x)}	501 903	87 499	211 211	800 613

^{x)}Provisional figures.

Table 2. COD.
Nominal Catch (In Metric Tons) by Countries
(Sub-Area I and Divisions IIa and IIb Combined).

Year	England	Germany (F.R.)	Norway	USSR	Others	Total
1960	141 175	9 472	231 997	213 400	34 633	630 677
1961	157 909	8 129	268 377	325 780	21 072	781 267
1962	174 914	6 503	225 615	476 760	25 836	909 628
1963	129 779	4 223	205 056	417 964	21 078	778 100
1964	94 549	3 202	149 878	180 550	9 219	437 398
1965	89 874	3 670	197 085	152 780	1 342	444 751
1966	103 012	4 284	203 792	169 300	3 088	483 476
1967	87 008	3 632	218 910	262 340	670	572 560
1968	140 054	1 073	255 611	676 758	333	1 073 829
1969	231 066	5 434	305 241	612 215	37 287	1 191 260
1970	179 562	9 451	377 606	276 632	33 337	876 588
1971	78 160	9 726	407 044	144 802	65 232	704 964
1972	56 669	3 405	394 181	96 653	18 099	569 007
1973 ^{x)}	76 493	14 240	280 021	387 196	42 643	800 613

^{x)}Provisional figures.

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 Inter-national Effort		National Effort		Total Inter-national Effort		National Effort		Total Inter-national 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 ^{x)}	97	61	887	96	18	12	160	15	27	7	486	14

1) Hours fishing \times average tonnage $\times 10^{-6}$ = millions on ton-hours.

2) Hours fishing (catch/catch per hour fishing) $\times 10^{-4}$.

3) Number of men fishing at Lofoten $\times 10^{-3}$.

x) Provisional figures.

Table 4. COD.
Catch Per Unit Effort (Metric Tons, Round Fresh).

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	0.50	0.051	0.16	0.055	11.5
1973 ^{x)}	0.057	0.60	0.054	0.85	0.043	6.8

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.

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 ^{x)}	257 147	12 112	29 533	298 792

x) Provisional figures.

Table 6. HADDOCK.
Nominal Catch (In Metric Tons) by Countries
(Sub-Area I and Divisions IIa and IIb Combined).

Year	England	Germany (F.R.)	Norway	USSR	Others	Total
1960	45 469	5 597	47 263	57 025	100	155 454
1961	39 625	6 304	60 862	85 345	1 098	193 234
1962	37 486	2 895	54 567	91 940	1 000	187 888
1963	19 809	2 554	59 955	63 526	900	146 744
1964	14 653	1 482	38 695	43 870	200	98 900
1965	14 314	1 568	60 447	41 750	-	118 079
1966	27 723	2 098	82 090	48 710	-	160 621
1967	24 158	1 705	51 954	57 346	1 323	136 486
1968	40 102	1 867	64 076	75 654	27	181 726
1969	37 234	1 490	67 549	24 211	27	130 509
1970	20 344	2 119	36 716	26 802	620	86 601
1971	15 605	896	45 715	15 778	308	78 302
1972	16 846	1 433	46 700	196 225	4 113	265 317
1973 ^{x)}	31 574	8 654	64 960	186 585	7 019	298 792

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	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 ^{x)}	22	20	21.0	13.6

^{x)} Provisional figures.

Table 8. Fishing Mortality 1969 - 1973.
Estimated by Virtual Population Analysis.

Age Year	COD (M = 0.3)					HADDOCK (M = 0.2)				
	1969	1970	1971	1972	1973 ^{x)}	1969	1970	1971	1972	1973 ^{x)}
3	0.02	0.03	0.02	0.04	0.20	0.11	0.18	0.02	0.20	0.30
4	0.16	0.13	0.10	0.15	0.20	0.21	0.26	0.30	0.28	0.35
5	0.37	0.28	0.24	0.31	0.35	0.54	0.32	0.21	1.31	0.55
6	0.46	0.42	0.19	0.46	0.45	0.63	0.57	0.26	1.28	0.60
7	0.69	0.53	0.38	0.25	0.60	0.48	0.60	0.50	1.00	0.60
8	0.83	0.75	0.74	0.44	0.65	0.51	0.52	0.49	0.84	0.60
9	1.04	0.85	0.89	0.96	0.65	0.47	0.40	0.44	1.07	0.60
10	0.87	0.89	0.71	1.24	0.65	0.48	0.39	0.38	1.25	0.60
11	0.91	0.60	0.64	1.14	0.65	0.16	0.50	0.35	0.76	0.60
12	0.79	0.32	0.52	0.79	0.65	0.45	0.14	0.96	1.37	0.60
13	0.75	0.53	0.41	1.06	0.65	0.24	1.74	0.21	1.58	0.60
14 ^{x)}	0.65	0.65	0.65	0.65	0.65	0.60	0.60	0.60	0.60	0.60

x) Assumed values.

Table 9. Stock Size 1969 - 1973 (Millions of Fish) from
Virtual Population Analysis.

Age Year	COD (M = 0.3)					HADDOCK (M = 0.2)				
	1969	1970	1971	1972	1973	1969	1970	1971	1972	1973
3	137	243	507	1 178	2 000	16	152	126	1 393	385
4	188	100	174	368	842	11	11	104	101	934
5	888	118	65	117	234	117	7	7	63	63
6	564	455	66	38	63	44	56	4	5	14
7	182	265	222	40	18	10	19	26	3	1
8	54	68	115	113	23	13	5	9	13	1
9	24	18	24	41	54	5	7	3	4	5
10	10	6	6	7	12	1	2	4	1	1
11	4	3	2	2	2			1	2	
12	1	1	1	1	1				1	1
13				1						

Table 10. Arcto-Norwegian Cod.
Year Class Strength. The Number per Hour Fishing for USSR Young Fish Survey is for 3-Year-Old Fish.

Year Class	USSR Survey. No. per Hour Trawling			USSR Assessment	O-Group Survey	Virtual Population No. of 3 Year Olds 10 ⁻⁶
	Sub-Area I	Division IIb	Mean			
1956	10	21	14	- Average		932
1957	12	16	13	- Average		1 060
1958	16	24	19	+ Average		1 253
1959	18	14	16	+ Average		1 044
1960	9	19	13	Poor		697
1961	2	2	2	Poor		527
1962	7	4	6	Poor		1 156
1963	21	120	76	Rich		2 263
1964	49	45	46	Rich		1 930
1965	<1	<1	<1	Very Poor	Very Poor	258
1966	2	<1	1	Very Poor	Very Poor	137
1967	1	<1	1	Very Poor	Poor	243
1968	7	1	5	Poor	Very Poor	507
1969	11	6	9	Poor	Rich	1 178
1970	74	86	79	Rich	Very Rich	(2 000)
1971	(12)	(25)	(18)	Average	Average	(950)
1972	(15)	(18)	(16)	Average	Average	(950)
1973	(18)	(18)	(18)	Average	Very Rich	(2 000)

(): Estimated

Table 11. Arcto-Norwegian Haddock.
Year Class Strength. The Number per Hour Trawling for USSR Young Fish Survey is for the 3-Year-Old Fish.

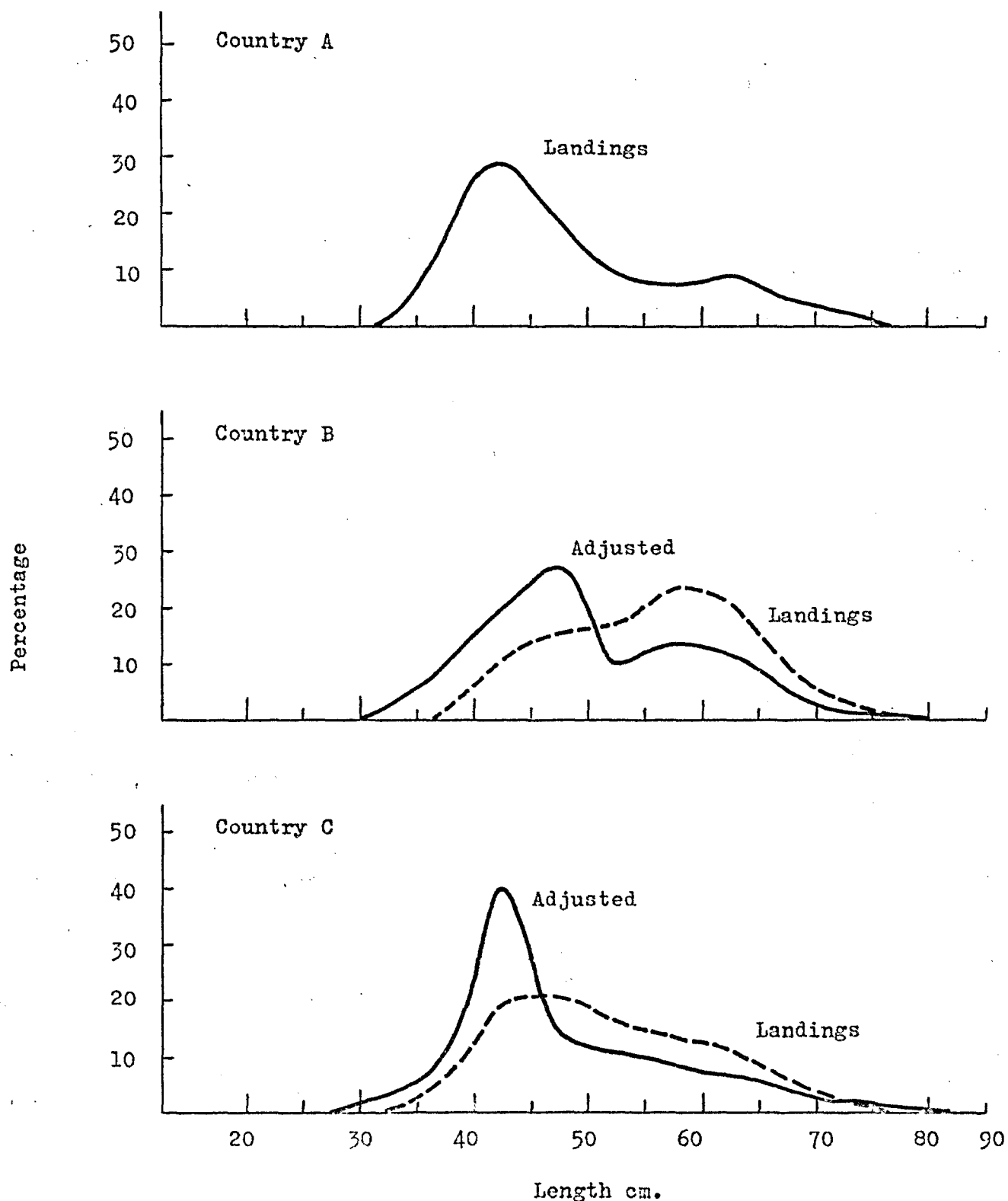
Year Class	USSR Survey. No. per Hour Trawling. Sub-Area I		O-Group Survey	Virtual Population No. of 3 Year Olds 10 ⁻⁶
1956		27		325
1957		14		241
1958		5		110
1959		33		240
1960		72		273
1961		34		314
1962		4		97
1963		12		232
1964		15		282
1965		<1	Very Poor	14
1966		<1	Very Poor	16
1967		8	Average	152
1968		3	Very Poor	126
1969		120	Very Rich	1 393
1970		31	Rich	(385)
1971		(3)	Average	(131)
1972		(2)	Average	(186)
1973		(2)	Poor	(186)

(): Estimated

Table 12. Estimated Catches of Cod and Haddock for Two Levels of Fishing.

	Effective Mesh Size (mm)	Level of Fishing (F) as in 1973				F = 3/4 of the Level in 1973		
		Year	I+IIb	IIa	Σ	I+IIb	IIa	Σ
COD	Present	1974	577	109	686			
		1975	736	77	813	585	62	647
		1976	804	105	909	684	97	781
		1977	828	171	999	726	178	905
	130	1975	674	77	751	530	62	592
		1976	756	105	861	640	98	738
		1977	796	172	968	695	179	874
	145	1975	628	76	704	494	62	556
		1976	729	101	834	610	96	707
		1977	762	177	938	618	181	799
HADDOCK	Present	1974	207	17	224			
		1975	182	37	220	144	30	174
		1976	162	22	184	141	20	161
	130	1975	160	41	201	129	32	161
		1976	131	41	172	117	38	155
	145	1975	130	36	166	102	28	130
		1976	126	42	168	117	42	159

Figure 1. Percentage Length Compositions of Cod Landed in 1973 by Three Countries. Adjusted Length Compositions Allowing for Estimated Rejection Rates are also shown for Countries B & C.



Prediction Equations of Total Annual Catch of the North-East Arctic Cod and Haddock Stocks

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At recent levels of intensity, the fishery is based on 3 - 7 year-old fish in the fattening areas and on 7 - 10 year olds on the spawning grounds.

In 1974 - 1976, fish of the ages mentioned above will belong to those year classes given below.

Year of Fishery	Age, Year Class							
	3	4	5	6	7	8	9	10
1974	1971	1970	1969	1968	1967	1966	1965	1964
1975	1972	1971	1970	1969	1968	1967	1966	1965
1976	1973	1972	1971	1970	1969	1968	1967	1966

The estimates of abundance of these year classes of cod are shown in Appendix Table I, and for haddock in Appendix Table II.

The fish at the age of 4, 5 and 6 years dominated in cod catches in the fattening areas. The cod of the extremely abundant 1970 year class and two fairly abundant year classes will be at the mentioned ages in 1974/5/6 (the 1968 and 1969 year classes in 1974, the 1971 and 1969 ones in 1975 and the 1971 and 1972 year classes in 1976).

Thus, the state of the cod stocks in the fattening areas in 1974, 1975 and 1976 will be at the level of maximum years. The mature cod stocks in these years will be minimum for the recent 10 - 15 years observed.

Haddock constitute on the average about 20% of the long-term mean catch of cod. The fish of the abundant 1969 and 1970 year classes at the age of 4 and 5 years will form the basis of haddock catches in 1974, at ages 5 and 6 in 1975, and at 6 and 7 years old in 1976.

The 3, 4 and 5 year olds are the most important for the haddock fishery. The commercial haddock stocks, excluding 1974, will be below the long-term mean level.

Taking into account the age composition of the catches, PINRO composed methods for commercial forecasts of fish resources for trawl fishery of demersal fishes in the Barents Sea. The fishery forecasts compiled by these methods are of satisfactory reliability.

The prediction equations used for forecasting the total catches of cod and haddock by all countries in 1974, 1975 and 1976 are as follows:

$$y = 4.58x + 388 \quad r = 0.70 \quad (1)$$

x = index of cod stock abundance for the whole area, 1974 - 1989,
(1975 = 105, 1976 = 113);
y = cod yield (thousands of tons) in the fattening areas by all countries.

$$y = 5.98x + 214 \quad r = 0.82 \quad (2)$$

x = index of cod stock abundance in Sub-area I,
(1974 = 92, 1975 = 97, 1976 = 101);
y = cod yield (thousands of tons) in Sub-area I by all countries.

$$y = 1.34x + 14 \quad r = 0.95 \quad (3)$$

x = cod yield (thousands of tons) in Sub-area I by all countries,
(1974 = 764, 1975 = 794, 1976 = 818);
y = cod yield (thousands of tons) in the fattening areas by all countries.

$$y = 0.997x + 189 \quad r = 0.95 \quad (4)$$

x = cod yield (thousands of tons) in the fattening areas by all countries,
(1974 = 920, 1975 = 975, 1976 = 1 050);
y = cod yield (thousands of tons) over the whole fishing area by all countries.

$$y = 0.0029x + 189 \quad r = 0.86 \quad (5)$$

x = cod yield (thousands of tons) in the fattening areas by all countries,
(1974 = 920, 1975 = 975, 1976 = 1 050);
y = cod yield (thousands of tons) in Division IIa by all countries.

$$y = 3.38x + 24 \quad r = 0.64 \quad (6)$$

x = index of haddock stock abundance,
(1974 = 31, 1975 = 7, 1976 = 2);
y = haddock yield (thousands of tons) by USSR trawlers.

$$y = 0.889x + 91 \quad r = 0.89 \quad (7)$$

x = haddock yield (thousands of tons) by USSR trawlers,
(1974 = 130, 1975 = 50, 1976 = 30);
y = haddock yield (thousands of tons) over the whole fishing area by vessels of all countries.

Almost all the equations give a satisfactory coincidence of calculated catches and actual ones. The poorest agreement is observed in the calculation of the cod catches in Division IIa. This may be explained by the fact that different cod are fished over this area ("capelin" cod, pre-spawning and spawning), and also various fishing gears are used there (trawls, long-lines, nets, purse-seines). If the cod catches in Division IIa are divided by fishing gears and fishery types, then the reliability of forecasting catches in this area would be considerably improved taking into account their age composition.

Calculated total catches of cod and haddock from predicted equations are given in Appendix Table III. On the basis of the data from this Table, Appendix Table IV was compiled.

Appendix Table IV shows the calculated catch of cod and haddock by all countries at the existing level of fishing intensity and also with a reduction of 20% in the fattening areas and on the spawning grounds, i.e. over the whole area inhabited by the cod stocks.

Appendix Table I. Young Cod Catch at the Third Year of Life (From Data of Autumn - Winter Investigations Undertaken by PINRO).
Specimens per Hour Trawling.

Year Class	Southern Barents Sea Sub-area 1	NW Areas Division IIb	Whole Area
1946	5.8	-	5.8
1947	21.0	3.7	17.5
1948	18.1	19.7	19.2
1949	29.4	5.9	23.6
1950	76.1	40.2	74.5
1951	6.5	2.2	6.4
1952	2.8	1.0	2.8
1953	10.6	1.7	8.8
1954	5.6	4.9	5.6
1955	8.7	12.3	9.2
1956	10.3	21.0	13.6
1957	11.8	16.3	13.1
1958	15.7	24.3	18.9
1959	17.6	14.4	16.2
1960	9.3	18.7	13.2
1961	2.3	1.8	2.0
1962	7.0	3.6	5.5
1963	21.3	120.3	75.6
1964	49.0	45.3	46.3
1965	0.5	0.2	0.4
1966	1.5	0.0	1.0
1967	1.4	0.3	1.0
1968	6.8	1.0	4.6
1969	10.5	6.0	8.9
1970	74.3	85.5	78.8
1971 ^{x)}	12.1	25.3	18.0
1972 ^{x)}	15.0	18.3	16.0
1973 ^{xx)}	18.0	18.0	18.0

x) Calculated according to survival coefficient.

xx) Preliminary data.

Appendix Table II. Young Haddock Catches at the 2nd and 3rd Years of Life (From the Autumn - Winter Determination Carried Out by PINRO), (Specimens per Hour Trawling).

Year Class	The Southern Barents Sea, Sub-area I	
	2nd Year of Life	3rd Year of Life
1946	-	1
1947	< 1	1
1948	32	26
1949	1	11
1950	247	262
1951	19	12
1952	5	10
1953	40	25
1954	7	3
1955	3	2
1956	18	27
1957	9	14
1958	4	5
1959	14	33
1960	40	72
1961	50	34
1962	3	4
1963	9	12
1964	12	15
1965	< 1	< 1
1966	< 1	< 1
1967	13	8
1968	< 1	3
1969	69	120
1970	38	31
1971	3	(3)
1972	(2)	(2)
1973	(2)	(2)

Bracketed figures are preliminary estimates.

Appendix Table III. Calculated Catches of Cod and Haddock
(in Thousands of Tons).

No. of Prediction Equation	Year	COD			Haddock Total
		Total	Sub-Area I Division IIb	Division IIa	
(1)	1974		800		
	1975		870		
	1976		900		
(3)	1974		1 040		
	1975		1 080		
	1976		1 110		
Average of (1) & (3)	1974		920		
	1975		975		
	1976		1 050		
(4)	1974	1 100			
	1975	1 160			
	1976	1 240			
(5)	1974			190	
	1975			190	
	1976			190	
(7)	1974				210
	1975				140
	1976				120

Appendix Table IV. Predicted Total Catches of Cod and Haddock at the Existing Level of Fishing Intensity and at the Recommended Level of Fishing (in Thousands of Tons).

	1974			1975			1976		
	Total	Fattening Areas	IIa	Total	Fattening Areas	IIa	Total	Fattening Areas	IIa
<u>At the Existing Level of Fishing Intensity</u>									
COD	1 110	920	190	1 165	975	190	1 240	1 050	190
HADDOCK	210			140			120		
Total	1 320			1 305			1 360		
<u>At the Recommended Level of Fishing</u>									
COD	890	740	150	925	775	150	990	840	150
HADDOCK	210			140			120		
Total	1 100			1 065			1 110		