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Demersal Fish (Northern) Committee



Report of the Meeting of the North-East Arctic Fisheries

Working Group

Copenhagen, 14th - 16th January 1970

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1. Participants:-

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2. Introduction

At its meeting in January 1969 the Group reviewed previous assessments of the north-east Arctic fisheries and in order to assist NEAFC in their consideration of the regulation of fishing mortality in this area, at a further meeting in February 1969 it prepared estimates of the catch that might be taken in the period 1969-71. After consideration of the Report by NEAFC and ICES the Group was asked by ICES (C.Res.1969/2:4) to meet again to update these earlier estimates of future catches in the light of the most recent developments in the fishery.

During the year the Group had reviewed the post 1946 data for the cod and haddock fisheries, which are necessary to prepare the required estimates of catches in 1970-71. These depend upon estimates of the absolute stock size in 1969, future changes in fishing mortality, and the number of juvenile fish recruiting to the fisheries.

3. Cod

a) The Status of the Fishery in 1968

Total nominal catches of cod, fishing effort and catch per unit effort are given in Tables 1-4. These are abstracted in Table 5 for comparison with the estimates of the catch expected in 1968 prepared at the last meeting on the assumption that fishing mortality would increase by 10 per cent from its 1967 level.

The total landings increased more than had been expected. However, estimates of fishing effort show that this also increased considerably. The national data cannot be accurately evaluated in terms of the total effective effort on the entire stock because of its geographical distribution in three different areas but our best estimate is that fishing effort in 1968 increased by approximately 40 per cent from its 1967 level. Comparison of the change in catch per unit effort (stock abundance) shows better agreement though the improvement was slightly greater than anticipated. The overall increase is due mainly to the recruitment of the strong 1963 and 1964 year-classes, but the 1962 year-class is also more numerous than expected.

It should be noted that the estimates for catches in 1968-70 given in the last report depended to a large extent on the assumption that fishing mortality would increase by 10 per cent in 1968. This parameter of the calculation cannot be predicted in advance because the amount of fishing deployed in a given area is to some extent a function of fishing prospects in other areas throughout the North Atlantic. In the event the increase in fishing effort, and hence mortality and catch in 1968, was much larger than anticipated though the estimates of stock abundance were accurate. Had the fishing effort increased by only 10 per cent total catches would have been about 850 000 tons.

b) Estimates of Fishing Mortality

Using the reviewed age-composition data, estimates of fishing mortality were revised using the virtual population technique. This requires an assumption concerning the level of mortality in the most recent year. The value $F = 1.12$ for fully recruited age-groups was selected from inspection of catch per unit effort data 1967/68. With appropriate adjustment for partially recruited age-groups based on the variation of fishing mortality with age in the period 1953-62, these give the estimates of fishing mortality for 1960-68 summarised in Table 6a. Table 6b gives a comparison between estimates of fishing mortality in 1967 derived by two different assumptions regarding fishing mortality in 1968 ($F_{\max} = 1.12$ and $F_{\max} = 1.00$). The agreement between these two shows that estimates of fishing mortality in 1967 are not very sensitive to poor assumptions concerning fishing mortality in the final year.

The Group was, therefore, satisfied with estimates of mortality up to 1967, but those for 1968 cannot have the same level of accuracy. This is especially important because estimates of future catches depend critically on fishing mortality in 1968, and particularly upon the mortality of partially recruited 4-6 year-olds, because this mortality also determines estimates of stock size. It has to be emphasized that this mortality cannot be measured explicitly by known techniques; it can only be deduced from the fishing mortality on fully recruited age-groups and the pattern of variation of fishing mortality with age in earlier years. It is possible that this will have changed with the degree of concentration of the fishery on different age-groups. As its best estimate of fishing mortality for 1968, the Group has presumed an increase of 40 per cent from the level in 1967, as indicated by the fishery statistics, and it will be noted that these values when applied to the absolute stock do give the appropriate total catch in 1968.

This analysis thus gave estimates of absolute stock size at the beginning of 1969, and the fishing mortality up to that time, which is now close to its previous peak in 1962-63.

c) Recruitment to the Fishery

The virtual population analysis gives estimates of the size of the year-classes up to 1964 which have recruited to the main fishery. No new data were available to revise previous estimates of year-classes 1965-68, which will recruit to the fishery in the period for which the projections are required, although very preliminary estimates of the 1965 year-class (3 year olds in 1968) confirm that it is extremely poor. The estimates of recruitment used are listed in Table 7, although the estimate for 1964 may be revised in later years, when the fishing mortality on it in 1968 can be measured more accurately.

d) Estimates of Catch Quotas

Taking the parameters described in the preceding paragraphs the Group estimated catches in 1969 and in 1970-71 on a number of assumptions regarding future changes in fishing mortality.

Taking 1967 as the initial year (this being a baseline referred to in NEAFC discussions), the stock changes in 1967 and 1968 have been reconstructed from the estimated stock size and fishing mortality. In order to prepare estimates of stock size and catches for 1970 and 1971, it was also necessary to estimate changes that have taken place in 1969. Provisional estimates of catch for that year suggest landings will again be close to one million tons. Using the Group's estimates of stock at the beginning of 1969 this level of catch could only have been attained, if fishing mortality had been further increased to at least 60 per cent above its 1967 level. On the other hand, provisional fishing effort data (Table 3) suggest that changes in fishing by different nations may counterbalance each other to leave fishing mortality in 1969 close to its 1968 level, though we would expect this to give a catch less than the provisional figure indicates. The estimates of catch in 1970-71 were, therefore, carried out for both possibilities, assuming further that in either of these years fishing mortality may be regulated to its 1967 level ($F_{\max} = 0.80$) and to the level previously determined to give the maximum yield per recruit ($Y_{\max} = 0.53$). This gives the matrix of possibilities of both fishing mortality and catches, which is given in Table 8.

The Group did not consider any larger reductions in fishing mortality, as were included in the previous report, nor did it carry out any further analyses, but it is still of the view that reductions in fishing mortality to a lower level would increase the probability of rich year-classes in the future for the reasons discussed in the Appendix to the 1969 report (C.M.1969/F:2).

4. Haddock

a) The Status of the Fishery in 1968

The statistics for the years 1960-68 are given in Tables 9-11, and Table 12 compares the actual nominal catches, fishing effort and catch per unit effort in 1968 with those predicted in the last report. As for cod the catch in 1968 was greater than anticipated. Estimates of total international fishing effort based on U.K. units suggest an increase comparable to that expected, but the catch per unit effort increased slightly rather than decreased. The major part of these discrepancies is thought to have arisen from deficiencies in the data available at the 1969 meeting. For example, the analysis of year-class strength based upon data reviewed during the year show that recruitment has been better than hitherto supposed.

b) Estimates of Fishing Mortality and Recruitment

Estimates were derived by the methods used to analyse the cod fishery. An estimate of fishing mortality in fully recruited age-groups was derived from catch per unit effort data and used for entry into a virtual population analysis, assuming the variation of fishing mortality with age to have remained close to that of former years. Results of this analysis are summarized in Table 13. The fishing mortality is estimated to be rather lower than the value used for the previous prediction, but it does show an increase of some 30 per cent over the 1967 values, which is consistent with observed fishing effort data.

Estimates of recruitment for year-classes before 1964 have also been modified according to the revised data. For the year-classes 1965-68 which will recruit in the near future, USSR data suggest that the 1967 year-class may be stronger than previously supposed, but otherwise estimates of recruitment for these years have not been changed. The estimated recruitment of 3 year old haddock in each year-class is summarized in Table 14.

c) Estimates of Catch Quotas 1970-71

The estimation has followed the method used for the cod fishery, reconstructing the stock and catches since 1967 with projections for 1969, 1970 and 1971 according to an assumption concerning changes in fishing mortality in those years.

However, in view of the low level of catches predicted for 1970 and 1971, and bearing in mind the limitations of the data for this fishery (see below), the Group considered that it would not be meaningful to prepare the predictions in as much detail as for cod. We examined the catches to be expected if the fishing mortality remained at its 1968 level and was subsequently reduced to the 1967 level, or that required to give the maximum yield per recruit in either 1970 or 1971. The results are summarized in Table 15. It will be noted that the catch for 1968 is less than that observed. The Group considered that this discrepancy could be within the margin of error of the estimates of total international landings of haddock in terms of weight, and in terms of the numbers of haddock per unit weight which, in 1968 were not entirely consistent with the records from earlier years. Haddock landings by USSR are estimated as a proportion of the total landings of cod, haddock and coalfish, using a factor derived from the catches by scouting vessels. The total landings of these species by USSR in 1968 amounted to some 750 000 tons. The discrepancy of 30 000 tons between the observed and predicted catch of haddock is less than 5 per cent of the USSR catch of gadoid species and a part of it could be accounted for by small errors in the estimated proportion of haddock. The Group considered this aspect of the recording of statistics should be closely examined to seek improvement because small errors will have a significant effect on total haddock landings, especially if these are small in relation to the cod.

5. The Mixture of Arcto-Norwegian Cod and Coastal Cod in Norwegian Waters

The assessments carried out by the Working Group have dealt only with the Arcto-Norwegian cod. However, there is a second cod population living in Norwegian coastal waters which is distinguished by characteristics of their otolith structure. The coastal cod live in Norwegian waters throughout their lives whereas the Arcto-Norwegian cod visit the area at different times during the course of their annual migratory movements. Mature cod are caught as far south as the southern part of Division IIa, but outside the spawning season few Arcto-Norwegian cod, if any, are found south of Vestfjord, north of Vestfjord, and especially in the northern part of Division IIa and along the Finmark coast both types of cod are found throughout the year, with the proportion of coastal cod decreasing from the fjords towards the open sea areas. Samples of cod from outside the Norwegian fishing limits, in the Barents Sea and at Bear Island, have contained less than two per cent coastal cod (by numbers), and it is considered that their proportion in catches by other countries, especially in the northern part of Division IIa, has been insignificant in recent years. This interpretation is supported by tagging experiments in which the returns of coastal cod by trawlers fishing offshore have been very small compared to the returns of Arcto-Norwegian cod tagged in the same locality. This difference in geographical distribution between the stocks is the justification for the estimation and exclusion from the total landings of cod in the north-east Arctic area, of all cod caught south of Vestfjord outside the spawning time, and the so-called fjord cod landed in the area Vestfjord-Troms outside the spawning time. Even so a proportion of coastal cod will be included in the total landings of Arcto-Norwegian cod. A detailed note on the allocation of Norwegian catches is given in Appendix I.

As an example, the total quantity of coastal cod excluded from Norwegian landings in Division IIa in 1968 was 50 954 tons. A similar but less complex allocation is necessary for haddock and resulted in the exclusion of 3 206 tons in 1968.

The coastal cod and the population of "other haddock" have long been recognised as being distinct from the main Arcto-Norwegian stocks fished offshore, and the levels of catches from them have been allocated by area and season for simplicity but this cannot be a precise division. The proportion of cod and haddock excluded contains some fish from the true Arcto-Norwegian stocks and, equally, some coastal fish are included in statistics of the main stock. This precludes a separate assessment of the coastal stocks, and this situation could only be changed by a substantial increase in sampling effort to detect the true proportions of the two groups in the landings.

The Group also noted that although coastal cod populations do occur along the USSR coast of Sub-Area I, their catches are included in the statistics for the Arcto-Norwegian stock.

6. The Accuracy of Estimates of Future Catches

There are three principal sources of error in the catch estimate, the assumption concerning fishing mortality in the final year of data (here 1968), which determines estimates of absolute stock size in the following year, the estimates of recruitment in future years, and the lack of the most up-to-date information about the fishery (1969). There are of course additional sources of error in random variation of the fishery, which cannot be predicted, e.g. changes in catchability and natural mortality.

a) Errors in Estimates of Fishing Mortality

It is necessary to stress again the comment in para. 3.b), that the correct value of fishing mortality in the final year 1968 is essential for the accurate estimation of absolute stock size, but it cannot be measured explicitly; it can only be judged from recorded changes in fishing effort between the two final years 1967/68. Moreover, the age-groups contributing most to the fishery are only partially recruited and, therefore, the maximum fishing mortality judged from the effort change has to be adjusted by the pattern of recruitment in former years. This may have changed.

Errors from this source may over- or underestimate stock size according to the direction of the error. The Group also noted that the same error would also prevent accurate monitoring of the efficiency of regulation in the preceding year, but only in that year.

b) Errors in Estimates of Recruitment in Future Years

Once year-classes are adequately represented in commercial catches (4-5 years old) the size of year-classes and stock can be estimated from the virtual population analysis. Estimates of future recruitment at present depend upon young-fish surveys. Statistical comparison of estimates of year-class strength from earlier surveys, which have also been evaluated from the commercial fishery show that the precision of these estimates is poor, especially when the abundance of young fish recorded in the surveys is low.

The young-fish surveys at present carried out in this area cannot do more than indicate the relative magnitude of successive year-classes. The error created may not be large for the estimate of catch for the first year for which a prediction is given, but in subsequent years the year-classes recruited in those years will contribute a substantial part of the catch and at their worst the errors may be compounded.

This source of error together with the error in estimating fishing mortality makes it impossible for the Group to define confidence limits of the estimated catches.

c) Delay in the Compilation of Data

The time period involved in preparation of the data for the most recent year (here 1969) at present prevents these from being considered by the Group in its estimation of catches for the year immediately following (1970). This means that the estimated catch for the first year predicted (1970) will be based upon good measures of fishing mortality and stock three years previously (1967), a careful judgement of these parameters two years previously (1968), and a rough appraisal for the year immediately previous (1969) for which data are not available. This again, though undesirable, may not be too serious in a regulated fishery, but it could introduce additional errors at the inception of regulation. In the view of the Group this can only be overcome by greatly increased effort in data preparation at the national level, or by re-scheduling of the meetings that wish to consider the catch estimates.

Although it is not possible to define the accuracy of the catch quotas at this time, as scientists the Group felt an obligation to record the practical problems they have encountered in preparing the present estimates. If all sources of error were to be added together it is true that the cumulative error could be large, especially for the estimation of catches three years in advance but this does not mean that the estimates prepared here are misleading. The Group considers its estimate of catches for 1970 to be very realistic. Moreover it is anticipated that catch quotas may need to be reviewed annually so that the longer-term errors will not influence the quotas set for a given year. Precision can also be expected to improve with time as more knowledge and experience is accumulated.

Table 1. Cod. Total nominal catch by divisions
(metric tons). Revised figures.

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 ^{x)}				1 102 000

Table 2. Cod. Nominal catch by countries (Sub-area I
and Divisions IIa and IIb combined).
Revised figures.

Year	England	Germany	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 ^{x)}	230 000	2 000	300 000	570 000		1 102 000

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 International Effort		National Effort		Total International Effort		National Effort		Total International Effort	
	UK ¹⁾	USSR ²⁾	UK units	USSR units	UK	USSR	UK units	USSR units	UK	Norway ³⁾	UK units	Norwegian units
1960	95	43	512	91	42	11	97	34	39	10	232	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	13
1968	86	45	584	67	9	24	151	26	52	6	288	15
1969 ^{x)}	91	37			12	17			72			

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

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

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

x) Provisional figures.

Table 4. Cod. Catch per unit effort (metric tons, round fresh).

Year	Sub-area I		Division IIb		Division IIa	
	UK ¹⁾	USSR ²⁾	UK	USSR	UK	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	0.95	0.173	1.03	0.056	5.2

- 1) UK 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. Comparison of actual and predicted changes from 1967 to 1968 in nominal catch, fishing effort, and catch-per-unit-effort.

Year	Total Nominal Catch		Fishing Effort (% Change)								Predicted total International Effort	Catch per Unit of Effort (% Change)					
			Actual national effort				Estimated total international effort					Actual				Predicted	
	Actual	Predicted	Sub-area I		Div. IIb		Sub-area I		Division IIb			Sub-area I		Div. IIb			
			UK	USSR	UK	USSR	UK units	USSR units	UK units	USSR units		UK	USSR	UK	USSR		
1967	573	(571)	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
1968	1 074	802	1.69	1.50	.90	2.00	1.48	1.10	1.37	2.00	1.10	1.36	1.79	1.63	1.18	1.27	1.27

Table 6a. Virtual population estimates of fishing mortality on cod 1960-1968.

M = 0.3

Year \ Age	1960	1961	1962	1963	1964	1965	1966	1967	1968
3	.04	.04	.05	.02	.02	.02	.04	.04	.06
4	.17	.22	.25	.18	.12	.11	.10	.16	.25
5	.28	.42	.56	.60	.29	.35	.23	.20	.52
6	.38	.44	.73	.86	.40	.38	.36	.25	.71
7	.34	.46	.53	.86	.50	.34	.40	.45	.69
8	.38	.59	.58	.78	.65	.46	.50	.60	.74
9	.32	.66	.69	.84	.89	.65	.65	.76	.85
10	.61	.67	.88	1.06	.72	.63	.72	.82	1.12
11	.74	.79	.68	1.22	.69	.63	.37	1.06	1.12
12	.58	.86	.66	.74	.75	.27	.54	.68	1.12

Table 6b. Comparison of estimates of fishing mortality in 1967 using two different assumptions for fishing mortality in 1968.

Fishing mortality on fully recruited age-groups

Years Age	1967	1968 (F.max = 1.12)	1967	1968 (F.max = 1.00)
3	.04	.06	.04	.05
4	.15	.25	.24	.30
5	.20	.52	.27	.90
6	.25	.71	.33	1.00
7	.45	.69	.56	1.00
8	.60	.74	.70	1.00
9	.76	.85	.89	1.00
10	.82	1.12	.93	1.00
11	1.06	1.12	1.45	1.00

Table 7. Absolute number of 3-year old cod recruiting to the fishery.

Year-class	Recruits $\times 10^{-6}$
1946	769
1947	1035
1948	1795
1949	1772
1950	2339
1951	960
1952	405
1953	626
1954	1118
1955	693
1956	914
1957	1028
1958	1233
1959	1034
1960	647
1961	403
1962	905
1963	1799
1964	1121
1965	(100)
1966	(100)
1967	(100)
1968	(100)

Table 8. Estimates of the nominal catch of cod ('000 tons) at selected levels of fishing mortality.

Fishing Mortality	
F = 0.80	1967 level
F = 1.10	1968 level and assumption 1 (F = 1967 + 40%) for 1969 level
F = 1.26	assumption 2 (F = 1967 + 60%) for 1969 level
F = 0.53	level of fishing mortality giving maximum yield per recruit (see 1968 Report)

Y_W = catch weight ('000 tons)

	1967	1968	1969	1970	1971
Assumption 1, F in 1969 = 1967 + 40%					
F	0.80	1.10	1.10	1.10	1.10
Y_W	571	1029	816	526	313
F	0.80	1.10	1.10	1.10	0.80
Y_W	571	1029	816	526	245
F	0.80	1.10	1.10	1.10	0.53
Y_W	571	1029	816	526	174
F	0.80	1.10	1.10	0.80	0.80
Y_W	571	1029	816	411	293
F	0.80	1.10	1.10	0.80	0.53
Y_W	571	1029	816	411	208
F	0.80	1.10	1.10	0.53	0.53
Y_W	571	1029	816	291	244
Assumption 2, F in 1969 = 1967 + 60% and is reduced again in 1970 ^{x)}					
F	0.80	1.10	1.26	1.10	1.10
Y_W	571	1029	914	483	290
F	0.80	1.10	1.26	1.10	0.80
Y_W	571	1029	914	483	227
F	0.80	1.10	1.26	1.10	0.53
Y_W	571	1029	914	483	161
F	0.80	1.10	1.26	0.80	0.80
Y_W	571	1029	914	377	271
F	0.80	1.10	1.26	0.80	0.53
Y_W	571	1029	914	377	192
F	0.80	1.10	1.26	0.53	0.53
Y_W	571	1029	914	267	225

x) The Group considered it would be unrealistic to expect fishing mortality to remain at this high level F = 1.26 in 1970 in view of the reduction in catch per unit effort implied by the reduced catches.

Table 9. HADDOCK. Total nominal catch by divisions (metric tons). Revised figures.

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 ^{x)}				132 000

Table 10. HADDOCK. Nominal catch by countries (Sub-area I and Divisions IIa and IIb combined). Revised figures.

Year	England	Germany	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 ^{x)}	37 000	1 000	64 000	30 000	-	132 000

x) Provisional figures.

Table 11. HADDOCK. Catch per unit effort and estimated total international effort.

Year	Catch per effort (UK) Kilos/100 ton-hours			Estimated total international effort in UK units <u>Total catch in tons x 10⁻⁶</u> <u>tons/100 ton-hours Sub-area I</u>
	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

Table 12. Comparison of actual and predicted changes from 1967 to 1968 in nominal catch, fishing effort and catch per unit effort of haddock.

Year	Total nominal catch ('000 tons)		Total international fishing effort (% change)		Catch per unit effort (% change)	
	Actual	Predicted	Actual	Predicted	Actual	Predicted
1967	136	(137)	1.00	1.00	1.00	1.00
1968	182	86	1.26	1.20	1.06	.53

Table 13. Virtual population estimates of fishing mortality on haddock 1960-1968.

M = 0.2

Year Age	1960	1961	1962	1963	1964	1965	1966	1967	1968
2	.03	.02	.02	.01	.01	.02	.01	.02	.04
3	.20	.17	.20	.12	.08	.08	.13	.06	.16
4	.38	.49	.60	.69	.32	.25	.47	.32	.40
5	.50	.69	1.07	.94	.71	.48	.62	.58	.60
6	.60	.70	1.04	1.04	.87	.73	.76	.56	.80
7	.50	.71	.61	.94	.85	.69	.91	.57	.80
8	.54	.80	.61	.49	.81	.64	.57	.71	.80
9	.71	.57	.96	.64	.72	.71	.58	.37	.80
10	.38	.31	.27	.58	.21	.18	.33	.64	.80
11	1.18	.45	.20	.21	.64		.64	.64	.80
12	.37		.31	.14					

Table 14. Numbers of 3 year old haddock in each year-class.

Year-class	Recruits 10^{-6}	Year-class	Recruits 10^{-6}
1946	119	1958	109
1947	69	1959	239
1948	553	1960	272
1949	63	1961	310
1950	1 040	1962	86
1951	125	1963	234
1952	51	1964	294
1953	170	1965	(40)
1954	54	1966	(40)
1955	68	1967	(150)
1956	326	1968	(40)
1957	241		

Table 15. Estimates of the nominal catch of haddock ('000 tons) at selected levels of fishing mortality.

Fishing Mortality

F = 0.60	1967
F = 0.80	1968
F = 0.30	level of fishing mortality giving maximum yield per recruit (see 1969 Report)

	1967	1968	1969	1970	1971
F	0.60	0.80	0.80	0.80	0.80
Y _W	130	151	130	100	74
F	0.60	0.80	0.80	0.80	0.60
Y _W	130	151	130	100	59
F	0.60	0.80	0.80	0.80	0.30
Y _W	130	151	130	100	33
F	0.60	0.80	0.80	0.60	0.60
Y _W	130	151	130	81	68
F	0.60	0.80	0.80	0.60	0.30
Y _W	130	151	130	81	38
F	0.60	0.80	0.80	0.30	0.30
Y _W	130	151	130	45	48

Appendix I. The allocation of catches to Arcto-Norwegian cod, coastal cod, and Arctic haddock in the Norwegian fishery statistics.

1. Landings of Arcto-Norwegian Cod in Division IIa.

These represent the total catch of cod in this Division from about the 25th January to 20th April (i.e. the observed spawning season) irrespective of locality. Landings of cod from the coastal areas of Sub-area I between the end of January and 20th March are also included, since they are drawn from the same biological community as the fish landed in Division IIa.

Landings of cod from areas south of Lofoten outside these times are taken to be coastal cod and are excluded from the landings.

Landings in Division IIa, Lofoten-Troms during the remainder of the year, less a small amount of 'fjord' cod, are recorded as caught in Sub-area I.

2. Landings of Arcto-Norwegian Cod in Sub-area I.

The landings are the recorded total taking into account the adjustments noted above.

3. Landings of Arcto-Norwegian Cod in Division IIb.

These landings represent the total landing unmodified.

4. Landings of Haddock.

The landings of haddock in the area Lofoten-Troms from gears other than trawl, and the catch of trawlers fishing north of Vestfjord are recorded as taken in Division IIa. All haddock caught south of Lofoten are excluded. All haddock landed in Sub-area I are included in the statistics reported to the Working Group.

5. The quantity of cod and haddock excluded by this allocation by time and area have been estimated for 1968:-

<u>COD</u>	From the area south of Lofoten in spawning time, which does contain some coastal cod, 9 773 tons were <u>included</u> .	
	Cod taken south of Lofoten at other times of the year are <u>excluded</u>	29 400 tons
	Coastal cod and 'fjord' cod taken in the Lofoten-Troms area outside the spawning season and <u>excluded</u>	21 554 tons
	Total quantity of cod excluded from Norwegian landings	50 954 tons
<u>HADDOCK</u>	All landings south of Lofoten <u>excluded</u>	3 206 tons