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REPORT OF THE ARCTIC FISHERIES WORKING GROUP

Copenhagen, 26 September - 3 October 1984

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REPORT OF THE ARCTIC FISHERIES WORKING GROUP

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REPORT OF THE ARCTIC FISHERIES WORKING GROUP

26 September - 3 October 1984

1. PARTICIPANTS

A Hylan	Norway
T Jakobsen	Norway
O Nakken (Chairman)	Norway
K Sunnanå	Norway
A Vazquez	Spain

2. TERMS OF REFERENCE

At the 71st Statutory Meeting, the Council decided (C.Res.1983/2:8:13):

"that the Arctic Fisheries Working Group should meet at ICES headquarters from 26 September to 3 October 1984 to:

- (i) assess catch options for 1985 inside safe biological limits for cod and haddock in Sub-areas I and II,
- (ii) analyse the effect of changes in the data sets of weight at age and age at first maturity on the time series of stock and spawning stock biomass.

3. NORTH-EAST ARCTIC COD

3.1 Status of the Fisheries

3.1.1 Landings prior to 1984 (Tables 1-3 and Figure 5A)

The revised figure for total landings in 1982, 363 730 tonnes, is 1 139 tonnes less than the figure used by the Working Group in 1983 (Anon., 1984a), but 63 730 tonnes in excess of the TAC. Provisional figures for 1983 indicate a further decline in the landings (Table 1), the total catch of cod in 1983 amounting to 290 000 tonnes which is 18 000 tonnes less than anticipated by the 1983 Working Group and close to the TAC of 300 000 tonnes. From 1982 to 1983 the catches declined in all areas both for trawl and other gears. The most significant reductions were observed in the Norwegian catches by conventional gears in Sub-area I and Division IIA and in the total USSR fishery (Tables 2-3).

3.1.2 Expected landings in 1984 (Tables 1 and 2)

The total landings for 1984 were estimated to 279 000 tonnes based on catch statistics for the first half of the year from Norway, USSR, Faroe Islands, Federal Republic of Germany, and on information on catch quotas for other countries. As seen in Table 1, the landings in 1984 were expected to be distributed somewhat differently compared to 1982 and 1983. In Divisions IIA and IIB the declining trend is expected to continue, while landings from Sub-area I increase owing to higher vulnerability and larger catches of cod off East-Finmark during spring and summer 1984.

3.1.3 Catch per unit effort (Tables 4 - 6)

The total trawl catches of cod and haddock combined and the total trawl effort (Norwegian units, Table 4) continued to decline in 1983 in all areas, but catch per unit of effort in the total trawl fisheries was maintained in Sub-area I, and only slightly reduced in Division IIA. For cod, the catch per unit of effort figures (Table 5) tended to increase in all areas from 1982 to 1983 except for the USSR fleet in Sub-area I. Catch per unit of effort data from the Lofoten fishery (spawning stock) are given in Table 6. In the past three years the figures for gillnets and longline/handline show opposite trends. This was explained in the 1983 Working Group Report (Anon., 1984a).

3.2 Catch in Numbers at Age (Table 15)

Age compositions for 1982 were revised using the same data base as the 1983 Working Group and taking into account revised landings. For 1983 the data available for calculating catch in numbers were:

- (a) Landings by areas from each country for the whole year.
- (b) Age compositions from the Norwegian catches in all three regions, age compositions from USSR catches in Sub-area I and Division IIA for the first half of the year (data submitted to the 1983 Working Group), age compositions from Spanish catches in Division IIB, and age compositions from the catches of the Federal Republic of Germany in Division IIA.

Catch in numbers at age for other countries were arrived at by using the USSR age composition in Sub-area I and the age composition from Norwegian trawl catches outside the 12 nautical mile limit in Division IIA. In Division IIB the age composition from Spanish trawlers was used for the Spanish and the USSR catches. Catch in numbers for Norway, Spain and USSR were summed, and the resulting age composition was used for the landings by other countries.

Catch in numbers for 1984 were calculated from the expected landings and age compositions for the first half of the year from Norway, USSR and the Federal Republic of Germany. Catch in numbers for other countries was arrived at by using the age compositions from Norwegian trawlers in Sub-area I and Division IIA. In Division IIB the USSR age composition was applied to all the expected landings.

3.3 Weight at Age (Tables 7 - 8)

Table 7 shows figures of mean length at age in the Norwegian winter surveys (Dalen et al., 1984). The values for 7 and 8 year old fish are not representative for the stock, since large portions of these age groups were on spawning migration and thus south of the area covered by the surveys. For 3-6 year olds the values show an increasing trend for all year classes following the 1975 year class. Data on weight at age in all the Norwegian surveys in 1982, 1983 and 1984 show a similar trend, and the figures deviate significantly from those used in previous assessments and which have been kept unaltered for many years. The Working Group, therefore, decided to use the Norwegian winter survey data on weight at age for 3-6 year olds in 1983 and 1984 as input weights in the stock these years. The "old" values were used for all age groups and all years prior to 1983 and for the 7 years and older fish in 1983 and 1984.

Data for the weight at age in the catches were available from Norwegian catches in 1983 and 1st half of 1984, and from Spanish catches in 1983. Weights in the USSR catches were calculated from the length at age data from 1st half of 1983 and 1984 by applying the formula $W = 0.9 \times L^3$, which is the mean from the Norwegian and Spanish data for 1983. It was decided to use the weighted mean values of these data for the age groups 3-6 in 1983 and leave the older age groups unchanged.

The Norwegian survey data and the USSR length at age data from the catches show an average increase of 15% in weight at age for the age groups 3-7 from 1983 to 1984. The mean weights at age in the catches of 1984 were then calculated as the weights of 1983 raised by 1.15 for age groups 3-7, leaving the older ages unchanged. The weight at age data used in the VPA are shown in Table 8.

The recent increase in the differences in weight at age for the younger fish in the catches and in the stock may be explained by the shift in the fishing pattern. The heavy fisheries on younger age groups no longer persist owing to poor year classes and increased mesh sizes in trawls in the recent years.

3.4 Age at Maturity (Table 9)

Prior to 1981 the Working Group had taken the mature part of the stock to be all fish of age 8 and older. In 1982 the Working Group consi-

dered, however, that it would be more realistic to use a maturity ogive.

An analysis of the published maturity ogives indicated that during the last 40 years (1942-81) there had been a slight trend of decreasing age at first maturity (Anon., 1983). Therefore, in 1982 the Working Group introduced a series of ogives which reflected the observed trend.

For the period 1980-82 there was a large difference between data supplied by Ponomarenko (1982) and by Hylen and Nakken (1982). It is not clear whether the differences in these two data sets were due to methodology or to a real change in maturity in 1982, but the Working Group was aware of the sampling problems which Ponomarenko had faced in obtaining accurate maturity ogives from trawl catches only. These problems were to a certain extent solved by the Hylen and Nakken method.

The Working Group decided in 1983 to apply two approaches in calculating spawning stock biomass. As Alternative 1, the spawning stock biomass was calculated with maturity ogives given by Hylen and Nakken, using the 1982 data for the period 1946-82 and the ogive derived in 1983 for that year and for the prediction period (Table 9). As Alternative 2 the 1982 approach was continued, applying the average of the Ponomarenko and Hylen and Nakken data sets for 1982 and using an average, giving double weight to the Ponomarenko data for 1981, 1983 and for the prediction period.

The Working Group recommended in its 1982 and 1983 reports that age at maturity data for earlier years should be made available for each single year in order to make a detailed analysis of the maturity ogives in the past. No additional data were made available to this meeting for the years prior to 1982 and no new analysis of the maturity ogives in earlier years could be carried out. A maturity ogive for 1984, obtained from survey data (Dalen *et al.*, 1984, Godø *et al.*, 1984a and Godø *et al.*, 1984b) by applying corrections for fishing between survey time and 1 January was given by Hylen and Nakken (1984).

The Working Group decided therefore to calculate spawning stock biomass for the period 1982-84 using the respective ogives given by Hylen and Nakken for these years (Table 9). None of these ogives could be applied to the previous years with any confidence, and it was decided to use a knife-edge maturity ogive (fish 8 years and older as mature) for the entire period prior to 1982, as used also by the Working Group in its reports before the 1982 report. For the prediction period, the 1984 maturity ogive was applied.

3.5 Survey Results

Survey results which had become available since the 1983 Working Group meeting were:

The Joint Norwegian-USSR O-Group Survey in August-September 1984 (Anon., 1984b).

The Barents Sea Acoustic and Bottom Trawl Survey in February 1984 (Dalen *et al.*, 1984).

The Svalbard Bottom Trawl Survey in September 1983 (Godø et al., 1984a).

The Spawning Ground Acoustic Surveys (Godø et al., 1984b).

Evaluation of the Norwegian Survey Results (Hysten and Nakken, 1984).

In addition, members of the Working Group had information on the preliminary results of the USSR bottom trawl survey during the winter 1983-1984.

3.5.1 0-Group surveys (Table 10)

The abundance indices for the year classes 1982, 1983 and 1984 are all larger than any of those from the period 1976-1981 and the two last years' figures are only exceeded by that of the 1970 year class.

3.5.2 The bottom trawl surveys (Tables 11 - 13)

In the Norwegian surveys the indices for all year classes show an increasing trend during the first 3 - 5 years of the life of the fish, probably caused by a lower availability to the trawls by the smaller specimens (Dalen et al., 1984).

The indices from the 1984 bottom trawl survey in the Barents Sea (Table 11) for the year classes prior to 1981 were in agreement with previous results, indicating that the 1980 year class in this area was slightly less abundant than the preceding ones. The index for the 1981 year class which in the two previous years was quite low, showed an unexpected high increase from 1983 to 1984, probably due to difficulties in the separation of 2 and 3 year old fish in the 1984 survey. In the Svalbard area (Table 12) both the 1980 and the 1981 year classes seemed to be less abundant than the previous ones, particularly the 1979 year class.

Both the 1982 and the 1983 year classes were far more abundant in the 1984 (and 1983) bottom trawl surveys than the preceding year classes, thus confirming the results of the 0-group surveys.

3.5.3 Acoustic surveys (Table 14)

Details of the acoustic surveys in 1984 are given in the respective survey reports and in Hysten and Nakken 1984 where the surveys are also evaluated.

The acoustic estimates of abundance for 3-7 year old fish in the eastern part of the Barents Sea were considerably increased from 1983 to 1984. In this area, the 1984 estimates for these age groups were suspected to be overestimates due to a combined effect of high echo abundance from the 1982 and 1983 year classes and the lower catchability of these small fish (Dalen et al., 1984). The acoustic surveys of the spawning grounds in 1984 indicated spawning stock size about 20% below that found in 1983 (Godø et al., 1984b).

The acoustic abundance estimates of 1 and 2 year old fish in the 1984 Barents Sea survey supported the observations from the 0-group and bottom trawl surveys: The 1982 year class was considerably more abundant than the preceding year classes, while the acoustic estimate of the 1983 year class as 1 year olds was the highest ever observed since the surveys started in 1976.

3.5.4 Evaluation of the surveys

Hysten and Nakken (1984) evaluated the Norwegian survey results for 1984 (and 1983). They discussed the sources of errors affecting the results and found: "The most serious of these errors was the upward bias of the acoustic estimates of age group 3 and older fish in the eastern Barents Sea. In this area large quantities of 1 and 2 year old fish made up the bulk of the echo abundance, but since the trawl catches oversample the larger fish and the length distributions from the catches are used directly in the conversion of echo abundances for fish densities, the older age groups (3+) were overestimated. We have, therefore, neglected the acoustic estimates for the eastern Barents Sea and estimated the number of fish in each age group in this area this way:

$$N_{1984} = \frac{N_{1983}}{IND_{1983}} \cdot IND_{1984}$$

where N_{1983} is the acoustic estimate in 1983
 IND_{1983} is the bottom trawl index in 1983
 IND_{1984} is the bottom trawl index in 1984.

This estimator simply expresses the assumption that the ratio between acoustic estimates and bottom trawl indices for each age group were equal in 1983 and 1984".

Hysten and Nakken used the corrected acoustic estimates together with estimates from the other cruises and the landings in 1984 to assess the total stock and the spawning stock per 1 January 1984. Their results are presented in Table 14, where also the results from the two preceding years appear. In general, the results of the 1984 surveys confirmed the impression from the bottom trawl survey and the 0-group survey:

The estimate of 4 year olds and older fish fitted reasonably well with the previous years' observations while the estimate of 3 year olds (1981 year class) seemed high, and the two youngest year classes (1982 and 1983) were far more abundant than any of the preceding ones.

Particularly the 1983 year class seemed strong and was estimated to 2 400 million individuals at age 1.

3.6 Recruitment (Tables 17 and 18, Figures 4 and 5C)

A summary of the information available from the surveys on the year classes 1981-1984 is given in the text table below.

	1981	1982	1983	1984
0-group index	0.10	0.59	1.69	1.55
1 year, bottom trawl index	0.1	45	355	
2 year, bottom trawl index	6	127		
1 year, acoustic, $N \cdot 10^{-6}$	1	-	2 400	
2 year, acoustic, $N \cdot 10^{-6}$	15	506		

The 0-group indices indicate that the 1983 and 1984 year classes were about 3 times as abundant as the 1982 year class. The bottom trawl indices indicated a 1983 year class which was 8 times stronger than the 1982 year class, while the acoustic survey indicated a ratio of 4:1 between the 1983 and the 1982 year classes when a reasonable natural mortality coefficient was accounted for.

The 1982 year class was estimated to about 400 million specimens at age 3 both from the relationship in Figure 4 and from the acoustic estimate of 2 year old fish when applying an annual natural mortality coefficient of 0.2. The 1983 year class was estimated to 1 000 and 3 200 million individuals at age 3, using the 0-group index and the bottom trawl index respectively, and 1 500 million individuals when projecting the 1 year acoustic estimate. The Working Group therefore agreed on an estimate of 3 year old fish of 1 500 million individuals in the 1983 year class. The abundance of the 1984 year class was also set to 1 500 million individuals giving more weight to the ratio between the 1983 and 1984 0-group indices (1:1) than to the values obtained from the relationship in Figure 4.

3.7 Fishing Mortalities - VPA Runs

A preliminary VPA was run using input F values for 1984 based on the 1983 exploitation pattern from last year's Working Group Report scaled to $F_{5-10} = 0.55$ to match the expected catch in 1984. A comparison with the stock estimates from the acoustic survey showed a good agreement for some age groups and it was evident that relatively minor changes in the input F values would improve this agreement. An evaluation of the total stock based on the acoustic survey has been made only since 1982 and the addition of 1984 as the 3rd year in this series means that the reliability of the survey data is better established and that more information is available for tuning the VPA to the survey results. A new series of input Fs based chiefly on the survey results were used in a VPA and the text table below shows the VPA stock number estimates 1982-1984 compared with those from the acoustic survey.

Age	1982		1983		1984		F
	Stock Number (millions)		Stock Number (millions)		Stock Number (millions)		
	Survey	VPA	Survey	VPA	Survey	VPA	
3	87	137	29	67	121	63	.06
4	105	135	81	104	58	52	.25
5	103	99	99	92	59	68	.45
6	95	81	58	64	54	57	.60
7	154	91	43	41	30	37	.70
8	23	15	50	37	19	19	.60
9	12	5	13	5	12	14	.50
10	1	2	5	1	4	2	.50

The agreement is generally good for the age groups 5-7. The high survey estimate of 7-year-old cod in 1982 is explained by the special behaviour of that year class during the 1982 survey (Hyllen and Nakken, 1983). Excluding this year class, a linear regression of the survey and the VPA results for age groups 5-7 in 1982-1984 gives a correlation coefficient of 0.97. This demonstrates that a high correlation between VPA and survey results can be obtained with input F values that appear to be at a reasonable level. For age group 4, the acoustic survey tends to give underestimates, usually of about 20 per cent, and the 3-year-old cod is also usually underestimated, although 1984 for special reasons deviates from this pattern (Dalen *et al.*, 1984). From age 8 or 9 the survey tends to produce overestimates compared to the VPA. The reason for this is not clear. Figure 1 shows the fishing mortalities generated by other gears than trawl for the 8-12 year olds.

Plots of fishing mortality generated by Norwegian trawlers versus effort by the same fleet are presented for age groups 5-6 combined in Sub-area I (Figure 2) and age groups 5-8 combined in Division IIA (Figure 3). The effort in 1984 is estimated on the basis of data from only part of the whole year's trawl fishery, and especially in Sub-area I this fraction is very low. The Working Group therefore felt that no great reliance could be put on the 1984 values. In the plots, the points representing the most recent years are mostly above the regressed line and this indicates an increase in catchability. Plots showing catchability ($Q = F/\text{Effort}$) versus year are therefore included on Figure 2 and Figure 3. Both catchability plots show an increasing trend, but the increase appears to be more rapid in the period 1980-1983 than in the 1970's. This is not unreasonable, considering that Norwegian trawlers have been severely restricted by quotas in the 1980's, and therefore may have tended to choose the grounds and seasons which give the highest catch rates. Unfortunately, the trend in catchability in the most recent years indicated by the plots is highly dependent on the input F values in the VPA. There is no independent information that can be used to give a reliable estimate of this trend and the plots are therefore at this stage of no practical use in estimating input Fs for the VPA.

In view of the lack of reliable data from other sources, the Working Group agreed that the assessment should be based primarily on the acoustic survey results. The input F values given in the text table are therefore used in the final VPA. For the age groups 5-8 the Fs were chosen to produce stock numbers close to those estimated in the survey. For age 4, the usual underestimate in the survey was taken into account and the Working Group also felt that it was reasonable to expect that the increased weight at age 4 observed in 1984 would give an increase in the fishing mortality compared to the most recent years. F at age 3 was chosen to make the 1981 year class approximately the same size as the 1980 year class, as other information indicates (Tables 10 - 13). For age 9, the survey results indicate that the fishing mortality should be lower than for age 8 ($F_8 = 0.6$) and a value of 0.5 was chosen for the age groups 9-13, and 0.45 for the age groups 14-15+.

The fishing mortalities in the VPA are shown in Table 16 and the VPA stock numbers in Table 17 and Figure 5A. The fishing patterns show a shift towards younger fish from 1983 to 1984 but the exploitation

remains at the same level. This is a reduction of about 20% compared to the period 1979-1982. The historic trend in fishing mortality is shown in Figure 1 and in Figure 5B.

3.8 Short-term Projection of Stock Biomass and Catch

In Table 18 the input for the catch and stock biomass predictions are given. The natural mortality, maturity ogive, and weight at age in catch and stock are those used for 1984 in the assessment.

The Working Group expected the rich 1982-1984 year classes to be more heavily exploited at age 3 and 4 than the preceding ones. The F values for these age groups were therefore increased by approximately 0.1 giving the fishing pattern in Table 18.

The input number of 3 year old recruits were taken to be 400, 1 500, and 1 500 million individuals for the 1982, 1983, and 1984 year classes respectively (see 3.6).

Projections of catches in 1985 and stock size at 1 January 1986 are given in Figure 6. The yield per recruit curve is shown in the upper part of the figure. $F_{\max} = 0.33$ compared to a current level of $F_{5-10} = 0.56$. Management options for 1985 are given in the text table below.

MANAGEMENT OPTIONS

Species: NORTH EAST ARCTIC COD
Area : ICES Sub-areas I and II

1984				Management option for 1985	1985				1986	
Stock biom. (3+)	Spawn. stock biom.	$F_{(5-10)}$	Catch (3+)*		Stock biom. (3+)	Spawn. stock biom.	$F_{(5-10)}$	Catch (3+)	Stock biom. (3+)	Spawn. stock biom.
735	374	0.558	279	F_{\max}	730	303	0.33	170	1 569	297
				$F_{1985} = F_{1984}$			0.56	269	1 465	235
				TAC 1985 = 350			0.79	350	1 380	180
				TAC 1985 = 300			0.64	300	1 432	216
				TAC 1985 = 250			0.51	250	1 485	247

Weight in thousand tonnes

*Expected catch estimated by the Working Group

3.9 Medium-term Projection of Stock Biomass and Catch

Also for the medium-term projection, the 1984 values for the weight-at-age in the catches and in the stock were used. It should be noted that slower growth of the strong year classes 1983-1984 would give lower estimates of catches and stock biomass for 1986, and especially for 1987, than those presented. An increase in the exploitation on the younger age groups is also likely to produce lower catch weights for these age groups.

The following text table shows the development of the spawning stock for 5 alternatives of fishing strategy in the period 1985-1987. The total biomass and catches for 1988 and 1989 are not given in the table because of the uncertainty of the growth of the 1983 and 1984 year classes and the unknown recruitment of 3 year old fish in these years.

NORTH EAST ARCTIC COD.

Projections of stock, spawning stock biomass and catch.

Management strategy Year	$\bar{F}_{max} = 0.33$				$\bar{F}_{84} = 0.56$			
	STB	SSBI	SSBII	Catch	STB	SSBI	SSBII	Catch
1985	730	303		170	730	303		268
1986	1 569	297		314	1 465	235		462
1987	2 843	341	327	625	2 575	231	218	893
1988		605	334			409	187	
1989		1 067	364			680	171	

Management strategy Year	TAC = 250				TAC = 300				TAC = 350			
	STB	SSBI	SSBII	\bar{F}	STB	SSBI	SSBII	\bar{F}	STB	SSBI	SSBII	\bar{F}
1985	730	303		0.51	730	303		0.64	730	303		0.79
1986	1 485	247		0.27	1 432	216		0.35	1 380	186		0.44
1987	2 819	309	295	0.12	2 709	260	247	0.16	2 599	215	202	0.20
1988		681	378			604	307			533	249	
1989		1 478	534			1 346	444			1 220	362	

STB : Stock biomass

SSBI : Spawning stock biomass using maturity ogive for 1984

SSBII: Spawning stock biomass as for SSBI except fish of the 1983-1985 year classes.

All alternatives give two sets of figures for the spawning stock biomass in 1987-1989. One set - SSBI - shows the values arrived at when applying the maturity ogive used for 1984 to the whole period. The alternative - SSBI - shows the spawning stock biomass when all fish of the 1983 and 1984 year classes at ages 6 years or less were removed from the spawning stock. The reason for presenting these two alternatives was that the Working Group considered it unlikely that the two last years' strong year classes with distribution areas extending far to the east and north in the Barents Sea, would become mature at a rate similar to that observed during the past 3 years.

All alternatives of fishing strategy result in a spawning stock level in 1986 below that of 1985, the 1986 level being 186 and 297 000 tonnes for catches in 1985 of 350 000 tonnes and 170 000 tonnes, respectively. In 1987 and 1988, the spawning stock biomass increases for 4 of the alternatives, but continue to decrease if the fishing mortalities in 1985 and 1986 are kept similar to those in 1984 and if the 1983 and 1984 year classes do not contribute to the spawning stocks. Bearing in mind the differences observed in maturity ogives for cod during the past 30 years (Anon., 1983), the Working Group was of the opinion that Alternative 5 should not be chosen since this may result in a spawning stock in the late 1980's, which is about half the present level. The spawning stock levels of 350 000 - 400 000 tonnes in 1983/1984 have produced rich year classes and the Working Group, therefore, consider Alternative 4 (F_{max}) as the better as far as future recruitment is concerned.

3.10 Stock and Recruitment Relationship

In its last report (Anon., 1984a), the Working Group made plots of parent stock and number of 3 year olds for the period 1946-1976 for two alternatives of spawning stock. The differences in the spawning stocks arrived at by the two alternatives are large (see discussion in 3.4). The main use of a stock/recruitment relationship would be to determine a minimum level above which the spawning stock should be maintained in order to safeguard recruitment. The Working Group found it extremely difficult from the amount of information available up to now to decide on such a minimum level, because of the uncertainties encountered regarding parent stock size in the past. Diurnal measurements of the spawning stock exist only for the last three years, 1982-1984. In these years, the spawning stock biomass was estimated to 400 000, 330 000, and 370 000 tonnes respectively, and year classes of fair and strong abundance have been produced. Until information is available which permits the calculation of more precise figures for the spawning stock in the past, the Working Group recommends that effort should be made to keep the spawning stock as close to the level of 1982-1984 as possible, or higher.

4. NORTH-EAST ARCTIC HADDOCK

4.1 Status of the Fisheries (Tables 19 - 20, Figure 9A)

4.1.1 Landings prior to 1984

The revised figure for total landings in 1982, 46 955 tonnes, is about 300 tonnes less than the figure used by the Working Group in 1983

(Anon., 1984a). Provisional figures for 1983 showed a further decline in the catches of haddock both in Sub-area I and in Division IIa. The total catch in 1983 of about 22 000 tonnes is well below the figure of 27 000 tonnes estimated by the 1983 Working Group.

4.1.2 Expected landings in 1984 (Table 19)

Based on information about landings in the first half of the year from Norway, USSR, Faroe Islands and the Federal Republic of Germany, the Working Group estimated the landings in 1984 to be approximately the same as in 1983. However, since a significant part of the haddock catches are now taken in the Norwegian coastal fishery in autumn, the landings for the whole year are difficult to estimate.

4.1.3 Catch per unit of effort (Table 21)

Cpue in the Norwegian fisheries showed a sharp decline from 1982 to 1983, both in Sub-area I and Division IIa, the 1983 figures being only half the 1982 figures.

4.2 Catch in Numbers at Age (Table 24)

Age compositions for 1982 were revised using the same data base as the 1983 Working Group and taking into account the revised landing figures. For 1983, the data available for calculating catch in numbers at age were:

- (a) Landings by areas from each country for the whole year;
- (b) Age compositions from the Norwegian catches, age compositions from the USSR catches in Sub-area I and Division IIa for the first half of the year (data submitted to the Working Group in 1983), age compositions from the Federal Republic of Germany catches in Division IIa.

Catch in numbers at age for the landings of other countries were arrived at by using the age compositions from Norwegian catches in Sub-area I, age compositions from Norwegian trawl catches outside the 12 nautical mile limit in Division IIa, and age compositions from Norwegian trawl catches off East Finnmark in Division IIb. For 1984, the catch in numbers at age were calculated from the expected landings and the age compositions for the first half of the year from the Norwegian catches in the respective areas, following the scheme used for the 1983 data.

4.3 Weight at Age

In the 1983 Working Group report, the same set of weights was used for both catch and stock. There was no evidence indicating significant changes in the stock weights, which therefore have been kept unchanged.

In the most recent years, an increasing part of the catches have been taken by Norway which in 1984 is expected to account for about 90% of the landings. This has led to changes in the catch weights and the Working Group felt that it would be most appropriate to use the weight-at-age data from the Norwegian landings in 1983 as catch weights in 1983, 1984 and for the predictions. The catch and stock weights are shown in Table 27.

4.4 Age at Maturity (Table 27)

Only two maturity ogives (Sonina 1981, and Sætersdal 1954) were available for haddock at the Working Group meeting in 1983. No additional data were made available to this meeting, so therefore the Working Group decided to apply the standard maturity ogive established last year (Sætersdal 1954) for the whole period and for the prediction period.

4.5 Survey Results

The survey information that was used originated from the same surveys as for cod (see Section 3.5).

4.5.1 0-group surveys

Table 22 shows the 0-group indices for haddock. In the last three years, the indices have increased considerably compared with the period 1977-1981, the index for 1984 being the highest observed since the 0-group survey started.

4.5.2 Bottom trawl surveys (Table 23)

The abundance indices from the Norwegian bottom trawl surveys in the Barents Sea in February are shown in Table 23. The indices for the year classes prior to 1982 are all low and their confidence limits rather high (Dalen et al., 1984). As for cod, it is thought that the index of 15.2 for the 1981 year class as 3-year-olds is an overestimate. The indices for the 1982 and 1983 year classes are much higher than those for the preceding year classes, thus confirming the results from the 0-group surveys, and also indicating a similar ratio for year class strength between these two year classes (1:2) as do the 0-group indices.

4.5.3 Acoustic surveys

Acoustic estimates of haddock are given by Dalen et al. (1984). The estimates for the year classes prior to 1982 are all low, showing 10-15 million 4-year-old fish in the 1978-1980 year classes. The estimate for the 1981 year class as 3-year-olds (in 1984) was probably biased upwards for the same reasons as for cod.

In the 1984 acoustic survey, the 1982 and 1983 year classes were estimated to 1 000 million and 2 100 million individuals, respectively.

4.5.4 Evaluation of the surveys

The estimates and indices arrived at for the year classes prior to 1982 were very low and variable both for the bottom trawl and for the acoustic surveys. The maximum information that can be extracted from the figures is that these year classes, 1978-1981, at an age of 3 years probably constituted 10 - 25 million specimens, taking into account that the acoustic estimates for this age group tend to be an underestimate - at least for cod.

The estimates for the 1982 and 1983 year classes are in good agreement with the results from the 0-group and bottom trawl surveys. However, Nakken and Ulltang (1982) showed that the acoustic surveys of the 1975 year class tended to overestimate haddock and underestimate cod at ages 2, 3 and 4. The acoustic estimates of the youngest age groups should therefore be used with care.

4.6 Recruitment (Tables 26 and 27, Figure 9C)

Information available on the abundance of the recruiting year classes 1982, 1983 and 1984 is:

	<u>Year class</u>		
	<u>1982</u>	<u>1983</u>	<u>1984</u>
O-group index	0.38	0.62	0.78
1-year, bottom trawl	315	663	
2-year, bottom trawl	356		
1-year, acoustic	-	2 148	
2-year, acoustic	1 002		

The figures for the O-group and the bottom trawl surveys are abundance indices and those for the acoustic surveys are given in millions of individuals. Looking at Table 22, it appears that only one single year class, the 1969 year class, has recruited more than 1 000 million individuals at age 3, while several year classes have amounted to about 300 million individuals at this age. The figures above indicate the following ratios between the abundance of the three year classes:

<u>1982</u>	<u>1983</u>	<u>1984</u>
1	1.5	2.0

A natural mortality coefficient of 0.2 was applied in order to compare the two acoustic estimates. On the basis of these considerations, the Working Group decided to use figures for the 3 year olds in these three year classes as follows:

<u>1982</u>	<u>1983</u>	<u>1984</u>
200	300	400

where the figures are in millions of individuals.

4.7 Fishing Mortalities - VPA Runs

A preliminary VPA was made using input F values for 1984 based on the 1983 exploitation pattern from last year's Working Group Report scaled to $F_{4-7} = 0.20$ to match the expected catches in 1984. With the current low stock size, O-group indices and survey results are of limited values in estimating the size of the most recent year classes in the VPA. In an adjusted VPA, the exploitation pattern was changed slightly to correspond better to that of the years 1980-1982 except that the F at ages 3 and 4 were set relatively higher to give a better agreement between surveys and VPA for the year classes 1980 and 1981 (Tables 22 and 23). Apart from this, it could only be concluded that the trial VPA was not inconsistent with the other information.

The adjusted VPA shows a sharp decline in fishing mortalities after 1982 to a level in 1984 of about half the level in 1980-1982. Normally a major part of the haddock is taken as by-catch in the fisheries for cod. Therefore, comparison between fishing mortality, catch per unit of effort and biomass for these two species is thought to

allow conclusions to be drawn for haddock based on the cod assessment. In Figure 7, \bar{F}_{6-7} generated on cod by Norwegian trawlers in Division IIA is plotted against \bar{F}_{5-7} generated by the same fleet on haddock. In Figure 8, the ratio of the biomasses (3+) of cod and haddock is plotted against the ratio of total international trawl catches of cod and haddock.

In both plots, the scatter of points is too large to allow accurate estimation of the current fishing mortality level on haddock. However, in both cases the 1984 point is close to the regressed line and since there is no other information on the level of exploitation in 1984, the trial VPA was accepted as the final.

The fishing mortalities and stock numbers from the haddock VPA are given in Tables 25 and 26. The historic trend in fishing mortality is given in Figure 9B.

4.8

Short-Term Projection of Stock Biomass and Catch

In Table 27 are given the different input data used in the 1985 and medium-term projections. As mentioned earlier, the weight-at-age in catches were revised for 1984. This weight-at-age series is also used for 1985. Also, the 1984 fishing pattern is assumed for 1985. These data do not give an F_{max} value on the yield per recruit curve as can be seen in Figure 10, Alternative 1. $F_{0.1}$ is almost equal to F_{1984} . Therefore, only one option is given for the short-term projection presented in the table below.

MANAGEMENT OPTIONS

Species: HADDOCK

Area : ICES Sub-areas I and II

1984				Management option for 1985	1985				1986	
Stock biom. (3+)	Spawn. stock biom.	$\bar{F}_{(4-7)}$	Catch (3+)		Stock biom. (3+)	Spawn. stock biom.	$\bar{F}_{(4-7)}$	Catch (3+)	Stock biom. (3+)	Spawn. stock biom.
110	62	.25	21	$F_{1984}=F_{1985}$	229	58	.25	47	434	66

$1) F_{0.1} = 0.23$

4.9

Medium-Term Projection of Stock Biomass and Catch

For the medium-term projection, several alternatives are given. Alternative 1 is the same as in the short-term projection. The Working Group expects that the strong 1982, 1983, and 1984 year classes will be more heavily exploited than the previous ones. The fishing mortalities are therefore increased with 0.1 for ages 3 and 4 are presented as Alternative 2. There is no F_{max} on the yield per recruit curve for this alternative either.

On the basis of stronger year classes and heavier fishing, the Working Group also considers a third alternative with the weight in the catch reduced to the same level as the weight in the stock. This represents

a change of weights for 3, 4, and 5 year olds. Together with the expected fishing pattern, this gives an F_{max} , as seen in Figure 10, Alternative 3. This F_{max} is almost the same as the expected F_{4-7} in 1985, and this alternative is presented in the projection table. Also $F_{0.1}$ for the same situation is given as alternative 4.

North-East Arctic HADDOCK. Projections of stock and spawning stock biomass and catch.

Alternative	1			2			3			4		
Management strategy	$F_{84} = 0.24$ ($F_{0.1} = 0.23$)			$\bar{F}_{4-7} = 0.31$			$\bar{F}_{4-7} = 0.31$ ($F_{max} = 0.34$)			$F_{0.1} = 0.19$		
Year	SB	SSB	Catch	SB	SSB	Catch	SB	SSB	Catch	SB	SSB	Catch
1985	229	58	47	229	58	75	229	58	42	229	58	27
1986	434	66	101	415	64	166	415	64	89	434	70	62
1987	737	109	181	664	94	260	665	94	148	728	114	106
1988		203			162			162			212	
1989		340			256			256			361	

1. Fishing pattern and fishing mortality as applied for 1984. Expected weight-at-age data.
2. Expected fishing pattern and weight-at-age data. Fishing mortalities in 1984 adjusted for the change in the 1984 fishing pattern.
3. Expected fishing pattern. Fishing mortalities as in 2. Weight-at-age data the same as used in 1983 by the Working Group (Anon., 1984).
4. Expected fishing pattern and weight-at-age data as in VPA.

The stock and catch predictions for 1988 and 1989 are not given. because the estimates are considered to be very uncertain.

The spawning stock biomass of haddock is currently at a low level, and a significant increase will not occur until 1987, when about 25 per cent of the 1982 year class is expected to reach maturity. Also, the current low level of fishing mortalities means that a relatively large change in exploitation is needed to make a significant difference to the spawning stock biomass in 1986, even in relative terms.

The spawning stock biomass in 1987 will also be relatively insensitive to the 1985 TAC. For the long-term development in the spawning stock biomass, changes in the exploitation pattern may be much more crucial than the 1985 TAC.

5. DEFICIENCIES IN DATA BASE

The deficiencies in the data base were:

- (a) Lack of age compositions from other countries than Norway, USSR, Spain and Federal Republic of Germany.
- (b) Lack of age compositions for the second half of 1983 from USSR fisheries.
- (c) Lack of weight-at-age data for years prior to 1982. Such data should always be given together with the age compositions.
- (d) The results from the USSR bottom trawl surveys 1983-1984 should have been made available.
- (e) Insufficient knowledge of the rate of maturation in years prior to 1982. The use of the published information produces a time series of the spawning stock which does not seem reasonable. Reliable information on maturation rates in the past is essential both for a stock and recruitment relationship and for the prediction of the spawning stock.

REFERENCES

- Anon., 1983. Report of the Arctic Fisheries Working Group, Copenhagen, 21-28 September 1982. ICES C.M.1983/Assess:2, 1-62 (mimeo.)
- Anon., 1984a. Report of the Arctic Fisheries Working Group, Copenhagen, 15-22 September 1983. ICES C.M.1984/Assess:3, 1-62 (mimeo.)
- Anon., 1984b. Preliminary report of the International O-Group Fish Survey in the Barents Sea and Adjacent Waters in August-September 1984. ICES C.M.1984/H:36 (mimeo.)
- Dalen, J., Hylen, A., Jakobsen, I., Nakken, O., and Randa, K. 1984. Preliminary report of the Norwegian investigations on young cod and haddock in the Barents Sea during the winter 1984. ICES C.M. 1984/G:44, 1-26 (mimeo.)
- Codø, O.R., Randa, K., and Smedstad, O.M. 1984a. Preliminary report of the Norwegian Groundfish Survey at Bear Island and West-Spitsbergen in the autumn 1983. ICES C.M.1984/G:46, 1-18 (mimeo.)
- Codø, O.R., Nakken, O., and Raknes, A. 1984b. Acoustic estimates of spawning cod off Lofoten and Møre in 1984. ICES C.M.1984/G:47, 1-10 (mimeo.)
- Hylen, A. and Nakken, O. 1982. Stock size of North-east Arctic cod estimated from acoustic survey data 1982. ICES C.M.1982/G:61, 1-24 (mimeo.)
- Hylen, A. and Nakken, O. 1983. Stock size of North-east Arctic cod estimated from survey data 1982/1983. ICES C.M.1983/G:57, 1-14 (mimeo.)
- Hylen, A. and Nakken O., 1984. Stock size of North-east Arctic cod, estimates from survey data 1983/1984. ICES C.M.1984/G:45, 1-12 (mimeo)
- Nakken, O. and Ulltang, Ø. 1983. A comparison of the reliability of acoustic estimates of fish stock abundances and estimates obtained by other assessment methods in the North-east Atlantic. ICES Symp. Fish. Acoust., Bergen, Norway, June 1982. No. 38:1-19 (mimeo.)
- Ponomarenko, I.Ya. 1982. Portion of mature cod specimens and sex ratio in different age and length groups within the 60's and 70's. ICES C.M.1982/G:18, 1-20 (mimeo.)
- Saetersdal, G. 1954. Some investigations on the Arcto-Norwegian haddock. ICES C.M.1954 (47) (mimeo.)
- Sonina, M.A. 1981. The ratio of mature and immature haddock Melanogrammus aeglefinus (L.) in the Barents Sea and Norwegian Seas. ICES C.M. 1981/G:23, 1-25 (mimeo.)

Table 1. COD. Total nominal catch (tonnes) by fishing areas
(landings of Norwegian coastal cod not included).

Year	Sub-area I	Division IIa	Division IIb	Total Catch
1960	357 327	155 116	91 599	622 042
1961	409 694	153 019	220 508	783 221
1962	548 621	139 848	220 797	909 266
1963	547 469	117 100	111 768	776 337
1964	206 883	104 698	126 114	437 695
1965	241 489	100 011	103 430	444 930
1966	292 253	134 805	56 653	483 711
1967	322 798	128 747	121 060	572 605
1968	642 452	162 472	269 160	1 074 084
1969	679 373	255 599	262 254	1 197 226
1970	603 855	243 835	85 556	933 246
1971	312 505	319 623	56 920	689 048
1972	197 015	335 257	32 982	565 254
1973	492 716	211 762	88 207	792 685
1974	723 489	124 214	254 730	1 102 433
1975	561 701	120 276	147 400	829 377
1976	526 685	237 245	103 533	867 463
1977	538 231	257 073	109 997	905 301
1978	418 265	263 157	17 293	698 715
1979	195 166	235 449	9 923	440 538
1980	168 671	199 313	12 450	380 434
1981	137 033	245 167	16 837	399 037
1982	96 576	236 125	31 029	363 730
1983*	64 803	200 279	24 910	289 992

* Provisional figures

Expected Catches

1984	73 000	184 000	22 000	279 000
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Table 2 Total nominal catches (thousand tonnes) by trawl and other gear for each area

ICES areas	Sub-Area I				Division IIa				Division IIb	
	Cod		Haddock		Cod		Haddock		Cod	Haddock
Year	Trawl	Others	Trawl	Others	Trawl	Others	Trawl	Others	Trawl	Trawl
1967	238.0	84.8	73.8	34.3	38.7	90.0	20.5	7.5	121.1	0.4
1968	588.1	54.4	98.1	42.9	44.2	118.3	31.4	8.6	269.2	0.7
1969	633.5	45.9	41.3	47.7	119.7	135.9	33.1	7.1	262.3	1.3
1970	524.5	79.4	36.7	22.8	90.5	153.3	20.2	6.4	85.6	0.5
1971	253.1	59.4	27.3	29.0	74.5	245.1	15.0	6.6	56.9	0.4
1972	158.1	38.9	193.4	27.8	49.9	285.4	34.4	7.6	33.0	2.2
1973	459.0	33.7	241.2	42.5	39.4	172.4	13.9	9.4	88.2	13.0
1974	677.0	46.5	133.1	25.9	41.0	83.2	39.9	7.1	254.7	15.1
1975	526.3	35.4	103.5	18.2	33.7	86.6	34.6	9.7	147.4	9.7
1976	466.5	60.2	77.7	16.4	112.3	124.9	28.1	9.5	103.5	5.6
1977	471.5	66.7	57.6	14.6	100.9	156.2	19.9	8.6	110.0	9.5
1978	360.4	57.9	53.9	10.1	117.0	146.2	15.7	14.8	17.3	1.0
1979	161.5	33.7	47.8	16.0	114.9	120.5	20.3	18.9	8.1	0.6
1980	133.3	35.4	30.5	23.7	83.7	115.6	14.8	18.9	12.5	0.1
1981	91.5	45.1	19.0	17.9	77.2	167.9	21.8	18.7	17.2	0.5
1982	44.8	51.8	9.0	8.9	65.1	171.0	18.5	10.5	21.0	-
1983*	36.6	28.2	3.7	3.8	56.6	143.7	7.6	6.3	24.9	0.2
1984*	36.8	36.4	3.8	4.4	33.3	150.9	5.2	7.4	21.5	0.3

* Provisional

Table 3. North-East Arctic COD. Nominal catch (tonnes, whole weight) by countries (landings of Norwegian coastal cod not included). (Sub-area I and Divisions IIA and IIB combined).
Data provided by Working Group members.

Year	Faroe Islands	France	German Dem. Rep.	Germany, Fed. Rep.	Norway	Poland	United Kingdom	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	5 543	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	11 511	20 941	8 946	24 369	344 502	6 986	89 061	343 057 ¹⁾	18 090	867 463
1977	9 167	15 414	3 463	12 763	388 982	1 084	86 781	369 876 ¹⁾	17 771	905 301
1978	9 092	9 394	3 029	5 434	363 088	566	35 449	267 138 ¹⁾	5 525	698 715
1979	6 320	3 046	547	2 513	294 821	15	17 991	105 846	9 439	440 538
1980	9 981	1 705	233	1 921	232 242	3	10 366	115 194	8 789	380 434
1981	12 825	3 106	298	2 228	277 818	-	5 262	83 000	14 500	399 037
1982	11 998	761	302	1 717	287 525	-	6 601	40 311	14 515	363 730
1983*	11 106	126	473	1 243	234 000	-	5 840	22 975	14 229	289 992

* Provisional fig

¹⁾ Murman cod included

Table 4 North-East Arctic COD and HADDOCK catches ('000 tonnes) and total trawl effort in Norwegian units

AREAS	SUB-AREA I			DIVISION IIa			DIVISION IIb	Total
Year	CPUE x 10 ⁻³	Ct x 10 ⁻³	Trawl effort x 10 ⁻³	CPUE x 10 ⁻³	Ct x 10 ⁻³	Trawl effort x 10 ⁻³	Ct x 10 ⁻³	Trawl effort x 10 ⁻³
1972	0.96	351.5	366.1	1.17	84.3	72.0	35.2	473.5
1973	1.40	700.2	500.1	1.09	53.3	48.9	101.2	622.7
1974	2.02	810.1	401.0	1.70	80.9	47.5	269.8	584.4
1975	2.08	629.8	302.7	1.80	68.3	37.9	130.8	404.5
1976	1.96	544.2	277.6	1.93	140.4	72.7	109.1	406.2
1977	1.65	529.1	320.6	1.30	120.8	92.9	119.5	489.6
1978	1.50	414.3	276.2	1.26	132.7	105.3	18.3	394.2
1979	1.21	209.3	172.9	1.24	135.2	109.0	8.7	289.1
1980	1.92	163.8	85.3	1.49	98.5	66.1	12.6	158.6
1981	2.06	110.5	53.6	1.39	98.4	70.7	17.7	134.9
1982	1.82	53.8	29.5	1.39	83.6	60.1	31.0	109.9
1983*	1.85	40.3	21.7	1.22	63.0	51.6	25.1	91.2
1984*		40.6			38.5		22.1	

* Projected figures

Table 5. North-East Arctic COD.
Catch per unit effort (tonnes, round fresh)

Year	Sub-area 1			Division IIb			Division IIa		
	Norway ¹⁾	U.K. ²⁾	USSR ³⁾	Norway ¹⁾	U.K. ²⁾	USSR ³⁾	Norway ¹⁾	U.K. ²⁾	Norway ⁴⁾
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		0.056	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	0.90	0.047	0.34	0.59	0.051	0.18	1.08	0.055	11.5
1973	1.05	0.057	0.56	0.43	0.054	0.57	0.71	0.043	6.8
1974	1.75	0.079	0.90	1.94	0.106	0.77	1.19	0.028	3.4
1975	1.82	0.077	0.85	1.67	0.100	0.43	1.36	0.033	3.4
1976	1.69	0.060	0.66	1.20	0.081	0.30	1.69	0.035	3.8
1977	1.54	0.052	0.50	0.91	0.056	0.25	1.16	0.044	5.0
1978	1.37	0.062	0.37	0.56	0.044	0.08	1.12	0.037	7.1
1979	0.85	0.046	0.36	0.62	-	0.06	1.06	0.042	6.4
1980	1.47	-	0.36	0.41	-	0.16	1.27	USSR	5.0
1981	1.42	-	0.41	(0.96)	-	0.07	1.02	0.35	6.2
1982	1.30	-	0.35	-	-	0.26	1.01	0.34	6.4
1983	1.58	-	0.31	(1.31)		0.36	1.05	0.38	7.6
1984 [*]			-			-		(0.30)	7.0

* Projected figures for January-March

- 1) Norwegian data - tonnes per 1 000 tonne-hours fishing
- 2) United Kingdom data - tonnes per 100 tonne-hours fishing
- 3) USSR data - tonnes per hour fishing
- 4) Norwegian data - tonnes per gill-net boat week in Lofoten

Table 6. North East Arctic COD.

Catch per unit effort. Data from the Lofoten fishery are given in gutted weight with head off.

Year	Norwegian vessels		
	Catch (kg per man per day worked in the Lofoten fishery (Division IIa))		
	Gill-net	Long-line	Hand-line
1960	77.8	148.3	56.7
1961	101.5	141.1	75.5
1962	94.9	134.4	57.8
1963	80.8	116.3	56.2
1964	104.5	62.1	51.5
1965	81.8	78.3	68.4
1966	121.8	131.9	72.6
1967	107.9	245.4	120.7
1968	158.0	184.6	61.5
1969	170.6	200.4	142.8
1970	180.3	304.3	127.6
1971	334.3	510.7	192.7
1972	318.7	400.1	110.2
1973	189.7	366.5	112.1
1974	96.3	146.4	63.9
1975	122.0	188.3	96.1
1976	131.4	258.4	134.8
1977	173.2	279.6	143.5
1978	237.6	381.7	134.6
1979	201.3	306.0	125.1
1980	169.9	207.8	100.9
1981	217.0	327.9	109.6
1982	199.1	753.4	252.0
1983	308.0	348.8	134.0
1984	301.0	208.4	95.6

Table 7. Length at age from the Norwegian surveys in 1978-1984 in cm.
The 1975 year class is indicated. The values for 7 and 8
years old fish are uncertain.

Age	1978	1979	1980	1981	1982	1983	1984
3	32.13	33.10	34.15	35.50	37.55	34.85	35.79
4	45.86	42.02	42.50	44.65	46.32	46.77	49.23
5	54.19	53.27	52.45	52.96	54.71	56.02	57.89
6	64.63	64.37	63.46	61.28	63.09	64.45	67.39
7	67.56	74.73	73.58	69.59	70.84	73.30	79.60
8	76.87	82.97	83.61	77.90	82.87	80.38	82.20

Table 8. Input data to the VPA-run on COD.
Weight in catches and weight in stock versus age

Age	Weight in stock and catches 1982 and earlier	Weight in stock		Weight in catches	
		1983	1984	1983	1984
3	0.65	0.36	0.53	0.90	1.04
4	1.00	1.01	1.20	1.46	1.68
5	1.55	1.63	1.90	2.19	2.52
6	2.35	2.53	2.91	2.78	3.20
7	3.45	3.45	3.97	3.45	3.97
8	4.70	4.70	4.70	4.70	4.70
9	6.17	6.17	6.17	6.17	6.17
10	7.70	7.70	7.70	7.70	7.70
11	9.25	9.25	9.25	9.25	9.25
12	10.85	10.85	10.85	10.85	10.85
13	12.50	12.50	12.50	12.50	12.50
14	13.90	13.90	13.90	13.90	13.90
15+	15.00	15.00	15.00	15.00	15.00

Table 9. North-East Arctic COD.

Maturity ogives used in the assessment, Alternative 1, for the estimate of the spawning stock biomass

Period	1946-1982 ¹	1983 ²	1984 ³
Age	Percentage mature		
3		1	
4	5	8	1
5	10	10	18
6	34	30	32
7	65	73	69
8	82	88	100
9	92	97	100
10	100	100	100
11	100	100	100
12	100	100	100
13	100	100	100
14	100	100	100
15+	100	100	100

¹Hylen and Nakken, 1982

²Hylen and Nakken, 1983

³Hylen and Nakken, 1984

Table 10. North-East Arctic COD.

Year class strength. Number per hour trawling for USSR Young Fish Surveys is for 3 year old fish

Year class	USSR Survey No. per hour trawling			USSR assessment	O-group survey index (Logarithmic) All areas	Virtual Population No. of 3 year olds x 10 ⁻⁶ *) M = 0.2
	Sub-area I	Division IIb	Mean			
1957	12	16	13	- Average		791
1958	16	24	19	+ Average		919
1959	18	14	16	+ Average		731
1960	9	19	13	Poor		474
1961	2	2	2	Poor		339
1962	7	4	6	Poor		778
1963	21	120	76	Rich		1 584
1964	49	45	46	Rich		1 293
1965	<1	<1	<1	Very poor	+	170
1966	2	<1	1	Very poor	0.02	112
1967	1	<1	1	Very poor	0.04	197
1968	7	1	5	Poor	0.02	405
1969	11	6	9	Poor	0.25	1 016
1970	74	86	76	Rich	2.51	1 819
1971	37	24	32	Average	0.77	524
1972	53	17	40	Average	0.52	622
1973	74	5	46	Rich	1.48	615
1974	6	1	4	Poor	0.29	350
1975	93	4	62	Rich	0.90	654
1976	4	<1	3	Poor	0.13	214
1977	2	1	1	Poor	0.49	165
1978	1	3	2	Poor	0.22	169
1979	<1	8	3	Poor	0.40	(137)
1980	(<1)	(<1)	(<1)	Poor	0.13	(69)
1981	(<1)	(<1)	(<1)	Poor	0.10	(66)
1982					0.59	
1983					1.69	
1984					1.55	

() = estimated

*) = USSR Murman cod included for 1974-78.

Table 11. North-East COD. Results from the Norwegian bottom trawl survey in the Barents Sea. Index of number of fish in each year class.

Year	YEAR CLASS												TOTAL
	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	
1981				0.7	11.0	8.6	16.9	34.1	37.9	4.8	1.0	0.3	115.3
1982			0.1	0.9	16.1	20.4	21.4	16.0	15.8	1.4	0.2		92.3
1983		44.6	5.9	10.8	28.0	31.9	14.3	4.7	3.0	0.6			143.8
1984	355.3	126.6	60.2	19.2	15.6	9.4	3.0	0.4	0.2				589.9

Table 12. COD. Results from the Norwegian bottom trawl survey in the Svalbard area. Index of number of fish in each year class.

Year	YEAR CLASS												TOTAL
	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	
1981			0.1	22.2	9.0	5.5	1.6	6.1	3.8	0.7	0.4	0.4	49.8
1982		1.5	4.0	22.3	9.6	2.8	1.9	2.9	0.4	0.1	0.1		45.6
1983	14.6	5.1	6.2	9.5	3.0	2.5	1.3	1.6	0.4	0.2			44.4

Table 13. COD. Results from the USSR bottom trawl survey in the Barents Sea and the Norwegian Sea. Mean catch in numbers caught per hour of trawling.

Year	A G E						
	3	4	5	6	7	8	TOTAL
1979	5.9	33.8	9.8	4.3	2.9	2.1	59
1980	5.0	3.8	10.6	2.9	1.0	1.2	25
1981	5.3	3.9	2.2	4.6	0.8	0.5	17
1982	3.1	2.9	1.7	0.4	1.1	0.5	10

Data provided by Working Group members 1982.

Table 14. COD. Stock numbers in millions at 1 January 1982 and 1983 from Hylen and Nakken (1982) (1983).

Year	A G E												
	1	2	3	4	5	6	7	8	9	10	11	12	13
1982	1	4	81	105	103	95	154	23	12	6	3	2	1
1983		27	29	81	99	58	43	50	13	5	2	+	+
1984	2 382	506	121	58	59	54	30	19	12	4			

Table 15. North-East Arctic COD.
Virtual Population Analysis. Catch in numbers. Unit: thousands.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
3	42416	13196	5298	15725	55937	34467	5709	2307	7164	7754	35536	294262
4	170566	106984	45912	25999	55644	160048	174585	24545	10792	13739	45431	131493
5	167241	205549	97950	78299	34676	69235	267961	238511	25813	11851	26832	61000
6	89460	95498	58575	68511	42539	22061	107051	181239	137629	9527	12089	20569
7	28297	35518	19642	25444	37169	26295	26701	79363	96420	59290	7918	7248
8	21996	16221	9162	8438	13500	25139	16599	26989	31920	52003	34885	8528
9	7956	11894	6196	3569	5077	11323	11597	13463	8733	12093	22315	19130
10	2728	3484	5553	1467	1495	2329	5657	5092	3249	2434	4572	4499
11	2603	1021	783	1161	380	687	657	1913	1232	762	1215	677
12	1647	1025	172	131	403	316	122	414	260	418	353	195
13	392	498	387	67	77	225	124	121	106	149	315	81
14	260	129	264	91	9	40	70	23	39	42	121	59
15+	103	157	131	179	70	14	46	46	35	25	40	55
TOTAL	535665	491574	248025	229081	251976	352179	612679	574026	323792	170067	191622	547596
	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	
3	91855	45282	85337	39594	78822	8600	3911	3407	8948	3108	3481	
4	437377	59793	114341	168609	45400	77484	17066	9466	20933	19594	10807	
5	203772	226646	79993	136335	88495	43677	81936	20803	19345	20473	22340	
6	47006	118567	118236	52925	56823	31943	40061	63433	28064	17656	23575	
7	12630	29522	47872	61821	25407	16815	17664	21788	42496	17004	16861	
8	4570	9353	13962	23336	31821	8274	7442	9933	8595	16329	7663	
9	2523	2617	4051	5659	9408	10974	3508	4267	2878	2545	4918	
10	5607	1555	936	1521	1227	1785	5196	1311	708	646	697	
11	2127	1926	558	610	913	427	678	882	271	229	205	
12	322	575	442	271	446	103	79	109	260	74	104	
13	151	231	139	122	748	59	24	37	27	58	44	
14	83	15	26	92	48	36	26	5	5	20	15	
15+	62	37	53	54	51	45	8	1	5	5	3	
TOTAL	807865	496126	465946	490951	539609	200224	175609	135440	132355	99741	90513	

Table 16. North-East Arctic COD.
Virtual Population Analysis. Fishing mortality coefficient.
Unit: Year-1. Natural mortality coefficient = 0.20.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
3	0.066	0.031	0.017	0.023	0.040	0.030	0.024	0.023	0.041	0.021	0.039	0.196
4	0.305	0.236	0.144	0.111	0.104	0.152	0.207	0.221	0.142	0.103	0.167	0.199
5	0.648	0.738	0.352	0.389	0.212	0.181	0.408	0.481	0.382	0.228	0.298	0.353
6	0.823	0.999	0.481	0.445	0.379	0.202	0.467	0.537	0.571	0.236	0.384	0.392
7	0.607	0.962	0.569	0.397	0.465	0.427	0.401	0.768	0.619	0.518	0.314	0.419
8	0.654	0.873	0.716	0.515	0.566	0.668	0.520	0.927	0.857	0.828	0.667	0.638
9	0.800	0.935	1.047	0.690	0.680	0.835	0.764	1.132	0.959	0.930	1.117	1.001
10	0.963	1.293	0.833	0.770	0.709	0.788	0.725	0.949	0.970	0.771	1.222	0.713
11	0.808	1.333	1.059	0.734	0.460	0.862	0.535	1.128	0.636	0.639	1.216	0.576
12	0.810	0.910	0.864	0.491	0.616	0.889	0.355	0.782	0.432	0.461	0.704	0.635
13	0.673	0.621	1.145	1.052	0.606	0.864	1.151	0.721	0.466	0.474	0.768	0.340
14	0.500	0.490	0.610	0.960	0.370	0.750	0.740	0.680	0.540	0.340	0.910	0.310
15+	0.500	0.490	0.810	0.960	0.370	0.750	0.740	0.680	0.540	0.340	0.910	0.310
(5-10)U	0.749	0.967	0.660	0.534	0.502	0.517	0.548	0.799	0.723	0.585	0.667	0.586
	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	
3	0.214	0.084	0.166	0.133	0.142	0.045	0.026	0.023	0.075	0.051	0.060	
4	0.496	0.210	0.312	0.560	0.221	0.203	0.119	0.082	0.167	0.232	0.250	
5	0.537	0.521	0.479	0.754	0.667	0.344	0.342	0.208	0.241	0.282	0.450	
6	0.507	0.701	0.572	0.683	0.648	0.543	0.611	0.485	0.476	0.360	0.600	
7	0.445	0.703	0.695	0.678	0.852	0.662	0.666	0.816	0.710	0.599	0.700	
8	0.483	0.703	0.886	0.906	0.934	0.766	0.708	1.039	0.898	0.786	0.600	
9	0.403	0.604	0.774	1.209	1.280	1.047	0.904	1.254	1.038	0.775	0.500	
10	0.957	0.460	0.451	0.766	0.981	0.929	1.071	1.104	0.716	0.699	0.500	
11	0.913	1.115	0.303	0.603	1.792	1.222	1.226	1.042	0.718	0.536	0.500	
12	0.601	0.681	0.859	0.236	1.312	1.189	0.767	0.651	1.081	0.453	0.500	
13	1.739	1.255	0.342	0.618	2.049	0.586	1.053	1.142	0.327	0.761	0.500	
14	0.700	0.860	0.430	0.400	0.530	0.560	0.340	0.340	0.440	0.430	0.450	
15+	0.700	0.860	0.430	0.400	0.530	0.560	0.340	0.340	0.440	0.430	0.450	
(5-10)U	0.555	0.610	0.643	0.833	0.927	0.715	0.717	0.617	0.660	0.584	0.558	

North-East Arctic COD.

Table 17. Stock size in numbers. Unit: thousands. - Biomass totals. Unit: tonnes.

All values are given for 1 January.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
3	731060	473648	338965	778297	1583541	1293334	170103	112218	197121	405034	1015816	1818561
4	711544	560267	375876	272737	623016	1245998	1027772	135920	89793	154922	324612	799599
5	383017	429262	362442	266366	199856	459904	875920	684297	89191	63790	114450	224645
6	173646	164112	168008	208774	147805	132414	314183	476723	346502	49853	41580	69585
7	67909	67439	49469	85058	109496	62820	88550	161273	228039	160351	32244	23192
8	50000	30293	19535	22940	46806	56328	44227	48539	61243	100490	78182	19283
9	15729	21779	10357	7815	11224	21765	23057	21523	15728	21704	35933	32841
10	4792	5785	6840	2977	3211	4654	7730	9024	5681	4933	7011	9624
11	5112	1498	1300	2434	1129	1294	1734	3065	2659	1762	1668	1691
12	3230	1865	523	369	957	583	447	831	812	1239	762	453
13	873	1176	615	112	145	423	196	257	311	432	640	309
14	779	364	518	160	32	83	146	51	102	160	220	243
15+	286	444	257	315	245	29	90	102	92	95	73	226
TOTAL NO	2147976	1752474	1334525	1648355	2727506	3299637	2554768	1653822	1037479	964767	1653390	3000452
SPS NO	80801	62701	39745	37123	63792	85160	76234	83391	86833	130816	124688	64670
TOT. BIOM	2900074	2513295	1906201	2189400	3028463	3856483	3980021	3419435	2427779	1870436	2052081	2972262
SPS BIOM	477312	378725	242659	213831	341265	460042	440169	473221	470396	683002	680838	398552
	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
3	524448	621846	614977	550433	654332	214382	163551	168548	136004	68993	65085*****	
4	1223955	346698	468275	426622	251222	464688	167758	131847	134919	103998	53081	50801
5	536206	610213	230022	280633	198388	164821	310695	121945	99408	91612	67515	34229
6	129306	256610	296617	116635	108119	83357	95712	180734	81112	63983	50598	35246
7	38511	63760	104217	137047	48218	37898	39649	42536	91129	41239	36531	25431
8	12486	20204	25841	42574	50979	16844	10003	16679	15406	36669	18554	14652
9	8344	6306	8190	8727	14085	18341	6410	6457	4833	5140	13677	8537
10	9886	4567	2623	3093	2132	3207	5270	2126	1509	1401	1938	6792
11	3863	3108	2346	1472	1175	655	1057	1478	577	604	570	963
12	778	1270	834	1419	659	160	158	249	427	231	289	283
13	197	349	526	289	918	145	40	59	106	119	122	144
14	130	28	31	300	128	97	60	11	15	63	45	61
15+	134	70	166	180	136	115	20	4	15	16	9	28
TOTAL NO	7488355	1935029	1754910	1369428	1336490	1004709	806170	672672	506341	414065	313415	
SPS NO	35868	35903	40802	58058	76211	39563	29005	27063	123228	107137	91213	
TOT. BIOM	3070231	2737103	2515813	2153009	1808096	1415847	1286906	1153813	1008375	808872	734566	
SPS BIOM	237440	217371	234671	317320	404426	229701	163580	151921	401491	379893	373731	

Table 18. North-East Arctic COD.
Input data for the catch and stock projections.
Input variables by age group.

Age	1985 stock size	fishing pattern	natural mortality	maturity ogive	weight in the catch	weight in the stock
3	400 000	0.15	0.20	0.00	1.040	0.530
4	50 801	0.35	0.20	0.01	1.680	1.200
5	34 229	0.45	0.20	0.18	2.520	1.900
6	35 246	0.60	0.20	0.32	3.200	2.910
7	25 431	0.70	0.20	0.69	3.970	3.970
8	14 852	0.60	0.20	1.00	4.700	4.700
9	8 337	0.50	0.20	1.00	6.170	6.170
10	6 792	0.50	0.20	1.00	7.700	7.700
11	963	0.50	0.20	1.00	9.250	9.250
12	283	0.50	0.20	1.00	10.850	10.850
13	144	0.50	0.20	1.00	12.500	12.500
14	61	0.45	0.20	1.00	13.900	13.900
15+	28	0.45	0.20	1.00	15.000	15.000
	1 000 individuals				kg	kg

Recruitment: 1985 400 millions
(age 3 years) 1986 1 500 millions
1987 1 500 millions

Table 19. North-East Arctic HADDOCK.
Total nominal catch (tonnes) by fishing areas.
(Data provided by Working Group members.)

Year	Sub-area I	Division IIb	Division IIa	Total
1960	125 675	1 854	27 925	155 434
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	94 064	5 649	37 566	137 279
1977	72 159	9 547	28 452	110 158
1978	63 965	979	30 478	95 422
1979	63 841	615	39 167	103 623
1980	54 205	68	33 616	87 889
1981	36 834	455	39 864	77 153
1982	17 948	2	29 005	46 955
1983*	7 550	185	13 872	21 607

*Provisional figures.

EXPECTED CATCHES

1984	8 000	+	13 000	21 000
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Table 20. North-East Arctic HADDOCK. Nominal catches (tonnes) by countries. (Sub-area I and Divisions IIa and IIb combined). (Data provided by Working Group members.)

Year	Faroe Islands	France	German Dem.Rep.	Germany, Fed.Rep.	Norway	Poland	United Kingdom	U.S.S.R.	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	91 910	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	-	101 726
1969	2	-	309	1 490	67 549	-	37 234	24 211	25	130 820
1970	541	-	656	2 119	37 716	-	20 423	26 802	-	87 257
1971	81	-	16	896	45 715	43	16 373	15 778	3	78 905
1972	137	-	829	1 433	46 700	1 433	17 166	196 224	2 231	266 153
1973	1 212	3 214	22	9 534	86 767	34	32 408	186 534	2 501	322 626
1974	925	3 601	454	23 409	66 164	3 045	37 663	78 548 ¹⁾	7 348	221 157
1975	299	5 191	437	15 930	55 966	1 080	28 677	65 015 ¹⁾	3 163	175 758
1976	537	4 459	348	16 660	49 492	986	16 940	42 485 ¹⁾	5 358	137 265
1977	213	1 510	144	4 798	40 118	-	10 878	52 210 ¹⁾	287	110 158
1978	466	1 411	369	1 521	39 955	1	5 766	45 895 ¹⁾	38	95 422
1979	343	1 198	10	1 948	66 849	2	6 454	26 365	454	103 623
1980	497	226	15	1 365	61 886	-	2 948	20 706	246	87 889
1981	381	414	22	2 398	58 856	-	1 682	13 400	-	77 153
1982	496	53	-	1 258	41 421	-	827	2 900	-	46 955
1983*	428	-	1	729	19 371	-	259	680	139	21 607

*Provisional figures. ¹⁾ Murman haddock included.

Table 21. North-East Arctic HADDOCK.
Catch per unit effort

Year	Sub-area I		Division IIB		Division IIA	
	Norway ¹⁾	United ²⁾ Kingdom	Norway ¹⁾	United ²⁾ Kingdom	Norway ¹⁾	United ²⁾ Kingdom
1960		33		2.8		34
1961		29		3.3		36
1962		23		2.5		42
1963		13		0.9		33
1964		18		1.6		18
1965		18		2.0		18
1966		17		2.8		34
1967		18		2.4		25
1968		19		1.0		50
1969		13		2.0		42
1970		7		1.0		31
1971		8		3.0		25
1972	0.06	14	0.02	23.0	0.09	18
1973	0.35	22	0.18	20.0	0.39	20
1974	0.27	20	0.09	15.0	0.51	74
1975	0.26	15	0.06	4.0	0.44	60
1976	0.27	10	+	3.0	0.24	38
1977	0.11	4	+	0.2	0.14	16
1978	0.13	5	+	4.0	0.14	15
1979	0.36	-	0.07	-	0.18	-
1980	0.45	-	+	-	0.22	-
1981	0.64	-	-	-	0.37	-
1982	0.51	-	-	-	0.38	-
1983	0.27	-	(0.04)		0.17	
1984*						

*Projected figures

1) Norwegian data - tonnes per 1 000 tonne-hours fishing

2) United Kingdom data - tonnes per 100 tonne-hours fishing

Table 22. North-East Arctic HADDOCK.

Year class strength. The number per hour trawling for USSR Young Fish Surveys is for 2 year old fish.

Year class	USSR Survey No.per hour trawling Sub-area I	O-group survey index (Logarithmic) All areas	Virtual Population No. of 3 year olds x 10 ⁻⁶ *)
1957	9		242
1958	4		109
1959	14		241
1960	40		274
1961	50		320
1962	3		100
1963	9		243
1964	12		291
1965	<1	0.01	20
1966	<1	0.01	17
1967	13	0.08	164
1968	<1	+	97
1969	69	0.29	1 025
1970	33	0.64	270
1971	3	0.26	54
1972	9	0.16	49
1973	8	0.26	56
1974	35	0.51	115
1975	96	0.60	171
1976	13	0.38	143
1977	1	0.33	18
1978	<1	0.12	6
1979	<1	0.20	(18)
1980	<1	0.15	(21)
1981	(<1)	0.03	(23)
1982		0.38	
1983		0.62	
1984		0.78	

() = Estimated

*) = USSR Murman haddock included for 1974-77.

Table 23. North-East Arctic HADDOCK.

Results from the Norwegian bottom trawl survey in the Barents Sea.

Index of number of fish in each year class.

Year	YEAR CLASS											Total
	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	
1981				0.3	4.8	2.3	9.5	2.0	6.1	0.5	0.2	25.7
1982			0.5	0.9	1.8	2.1	2.2	5.5	2.7	0.2		15.9
1983		314.5	5.7	4.1	3.8	1.9	2.3	3.9	1.8			338.9
1984	663.2	355.8	15.2	1.6	0.7	0.2	0.3	0.4				1 037.4

Table 24. North-East Arctic HADDOCK.

Virtual Population Analysis. Catch in numbers - Unit: thousands.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
3	39604	28567	22305	5911	20157	15918	657	1520	23004	1979	230229	70204
4	30947	72995	49162	46161	22469	41373	67632	1963	2408	24359	22246	258773
5	49028	19035	30592	40032	62724	13505	41267	44526	1870	1258	42849	24018
6	35922	13627	5000	12578	28640	25736	7740	18956	21995	918	3196	6872
7	3209	9290	3519	1672	5711	8878	15599	3611	7948	9279	1606	418
8	1344	1243	2709	970	578	1617	5292	4925	1974	3056	6736	422
9	1778	561	832	893	435	218	655	1624	1978	826	2630	1680
10	243	409	104	122	188	176	162	315	726	1043	896	525
11	247	79	206	204	186	155	101	43	166	369	988	146
12	432	84	234	173	25	70	115	43	26	130	538	340
13	20	169	121	14	8	27	18	14	52	27	53	68
14+	8	41	67	205	7	7	19	2	19	4	42	13
TOTAL	160832	146100	115651	108885	147328	107686	139285	77542	62166	43248	312009	363479
	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	
3	9684	10037	13989	55967	47311	17540	627	486	663	704	1982	
4	41701	14089	13449	22043	18812	35290	22878	2561	900	1930	2681	
5	86111	33871	6808	7366	4076	10645	21794	22124	3372	884	1903	
6	5827	49712	20789	2586	1389	1429	2971	10685	12203	1374	311	
7	4138	2135	40044	7781	1626	812	250	1034	2625	3262	553	
8	382	1236	1247	11043	2596	546	504	162	344	906	1500	
9	617	92	1349	311	6215	1460	230	162	75	52	299	
10	2043	131	193	388	162	2310	842	72	60	37	65	
11	955	500	279	96	258	161	1299	330	91	29	14	
12	276	147	652	101	3	87	111	564	320	21	24	
13	458	53	331	84	74	2	35	27	204	21	19	
14+	143	92	46	98	65	53	15	42	54	91	146	
TOTAL	154315	112095	99176	107800	82567	70361	51556	38249	21131	9331	9497	

Table 25. North-East Arctic HADDOCK.

Virtual Population Analysis. Fishing mortality coefficient - Unit: Year-1
 Natural mortality coefficient = 0.20

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
3	0.200	0.122	0.060	0.067	0.126	0.062	0.057	0.102	0.168	0.023	0.283	0.536
4	0.595	0.680	0.317	0.235	0.388	0.300	0.402	0.149	0.233	0.268	0.378	0.593
5	1.048	0.935	0.690	0.462	0.575	0.427	0.554	0.506	0.207	0.184	1.059	0.918
6	1.043	0.992	0.859	0.690	0.722	0.494	0.467	0.536	0.506	0.148	0.962	0.466
7	0.620	0.956	0.770	0.655	0.800	0.510	0.639	0.415	0.452	0.416	0.416	0.302
8	0.663	0.523	0.848	0.497	0.497	0.554	0.660	0.425	0.420	0.314	0.609	0.182
9	0.978	0.652	0.820	0.772	0.456	0.353	0.457	0.433	0.502	0.311	0.488	0.297
10	0.400	0.633	0.255	0.261	0.359	0.315	0.562	0.417	0.551	0.258	0.656	0.167
11	0.400	0.218	0.780	0.990	0.798	0.568	0.301	0.247	0.405	0.303	0.414	0.206
12	0.719	0.230	1.953	1.883	0.295	0.937	1.160	0.202	0.232	0.645	0.979	0.244
13	0.600	0.600	0.600	0.600	0.600	0.600	0.600	0.400	0.400	0.400	0.600	0.300
14+	0.600	0.600	0.600	0.600	0.600	0.600	0.600	0.400	0.400	0.400	0.600	0.300
(4- 7)0	0.827	0.891	0.659	0.511	0.621	0.433	0.516	0.402	0.350	0.254	0.704	0.570
	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	
3	0.220	0.254	0.321	0.758	0.561	0.145	0.038	0.101	0.057	0.038	0.100	
4	0.342	0.569	0.634	1.265	0.629	0.502	0.285	0.215	0.273	0.169	0.200	
5	0.412	0.516	0.601	0.890	0.863	0.922	0.674	0.490	0.483	0.471	0.250	
6	0.594	0.432	0.704	0.483	0.405	0.884	0.730	0.853	0.555	0.371	0.300	
7	0.573	0.453	0.752	0.630	0.646	0.441	0.565	0.612	0.522	0.261	0.250	
8	0.499	0.333	0.524	0.477	0.445	0.467	0.544	0.429	0.422	0.342	0.200	
9	0.437	0.212	0.742	0.237	0.545	0.488	0.566	0.335	0.361	0.103	0.180	
10	0.712	0.154	0.913	0.491	0.187	0.400	0.580	0.186	0.275	0.304	0.180	
11	0.502	0.374	0.564	2.207	0.719	0.328	0.412	0.473	0.578	0.151	0.180	
12	0.741	0.134	1.244	0.409	0.382	0.570	0.343	0.316	1.231	0.139	0.180	
13	0.600	0.300	0.500	0.500	0.600	0.475	0.475	0.130	0.180	0.220	0.180	
14+	0.600	0.300	0.500	0.500	0.600	0.475	0.475	0.130	0.180	0.220	0.180	
(4- 7)0	0.480	0.492	0.673	0.817	0.636	0.667	0.513	0.543	0.458	0.323	0.250	

North-East Arctic HADDOCK.

Table 26. Stock size in numbers. Unit: thousands. Biomass totals. Unit: tonnes.

Alle values are given for 1 January.

	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973
3	240750	274171	320368	100064	242598	291101	19785	17210	164100	96811	1025120	269938
4	75409	161452	198718	242173	76591	175043	223969	15604	12720	113631	77475	632296
5	81904	34056	66980	113519	156738	42541	106124	122682	11006	8247	71126	43461
6	56815	23518	10949	27515	61148	72202	22716	49948	60558	7328	5619	20187
7	7541	16389	7143	3796	11294	24319	36055	11653	23921	29877	5172	1759
8	3028	3337	5156	2709	1615	4155	11958	15576	6301	12458	16137	2794
9	3094	1278	1619	1808	1349	804	1754	5062	8335	3388	7454	7188
10	808	953	545	584	684	714	463	1013	2688	5046	2032	3746
11	821	443	414	353	368	391	427	216	547	1548	3193	863
12	1025	450	292	155	107	136	181	258	138	299	936	1728
13	48	409	293	34	19	65	44	47	173	90	128	288
14+	19	99	162	496	17	17	46	7	63	13	102	55
TOTAL NO	471302	516555	612639	498208	552529	611468	423720	239275	290550	278737	1214495	984301
SPS NO	68174	49695	45808	63378	86354	84404	94209	87591	74432	60348	57422	70463
TOT. BIOM	576983	540327	615723	629430	713770	713563	644190	477595	422987	385997	1027416	1031521
SPS BIOM	165055	122300	102474	130804	190294	202135	227128	220967	210696	180267	167858	151389

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985
3	54014	49242	55398	114728	171435	143180	18495	5587	17669	20641	22941*****	
4	157942	35507	31287	33196	43999	97876	101419	14576	4136	13669	16264	16995
5	286193	91855	16462	13593	7668	19204	48519	62466	9629	2577	9453	10902
6	14209	155261	44868	7589	4569	2648	6251	20254	31319	4862	1317	6027
7	10367	6421	82530	18172	3732	2494	896	2466	7064	14719	2747	799
8	1064	4785	3343	31841	7927	1602	1314	509	1094	3433	9100	1752
9	1907	529	2807	1620	16172	4158	822	625	271	587	1997	6100
10	4375	1008	350	1095	1047	7676	2091	467	366	155	434	1565
11	2594	1758	707	115	549	711	4212	958	517	228	93	297
12	575	1286	990	330	10	219	420	2283	469	178	160	64
13	1109	224	921	234	179	6	101	244	1362	117	127	110
14+	346	390	128	273	157	153	43	379	227	507	975	754
TOTAL NO	534697	348267	240292	222585	257439	279929	184583	110813	73943	61672	65609	
SPS NO	102325	120726	110937	59563	35547	27403	29309	33455	29542	21941	18807	
TOT. BIOM	832815	666606	482762	327390	290168	304273	264247	217145	151047	107609	109726	
SPS BIOM	223636	296562	313330	183831	116499	83608	78541	89563	84537	66340	62620	

Table 27. North-East Arctic HADDOCK.
Input data for stock size and catch projections.
List of variables by age

Age	1985 stock size	1984 fishing pattern	expected fishing pattern	natural mortality	maturity ogive	weight in the catch	weight in the stock
3	200 000	0.10	0.20	0.20	0.00	1.520	0.660
4	16 995	0.20	0.40	0.20	0.05	1.860	1.030
5	10 902	0.30	0.30	0.20	0.23	2.100	1.790
6	6 027	0.25	0.30	0.20	0.53	2.380	2.380
7	799	0.20	0.25	0.20	0.88	2.860	2.860
8	1 752	0.18	0.20	0.20	0.98	3.330	3.330
9	6 100	0.18	0.18	0.20	1.00	3.700	3.700
10	1 365	0.18	0.18	0.20	1.00	4.410	4.410
11	297	0.18	0.18	0.20	1.00	5.400	5.400
12	64	0.18	0.18	0.20	1.00	6.700	6.700
13	110	0.18	0.18	0.20	1.00	7.400	7.400
14+	754	0.18	0.18	0.20	1.00	8.000	8.000
	1 000 individuals					kg	kg

Recruitment: 1985 200 millions
(age 3) 1986 300 millions
1987 400 millions

Figure 1. North-East Arctic COB.

Fishing mortalities on 8-12 years old generated by gears other than trawl (Danish seine, gill net, long and hand line).

Fishing mortality
(8-12 years)

1.0

0.5

70

72

74

76

78

80

82

YEAR

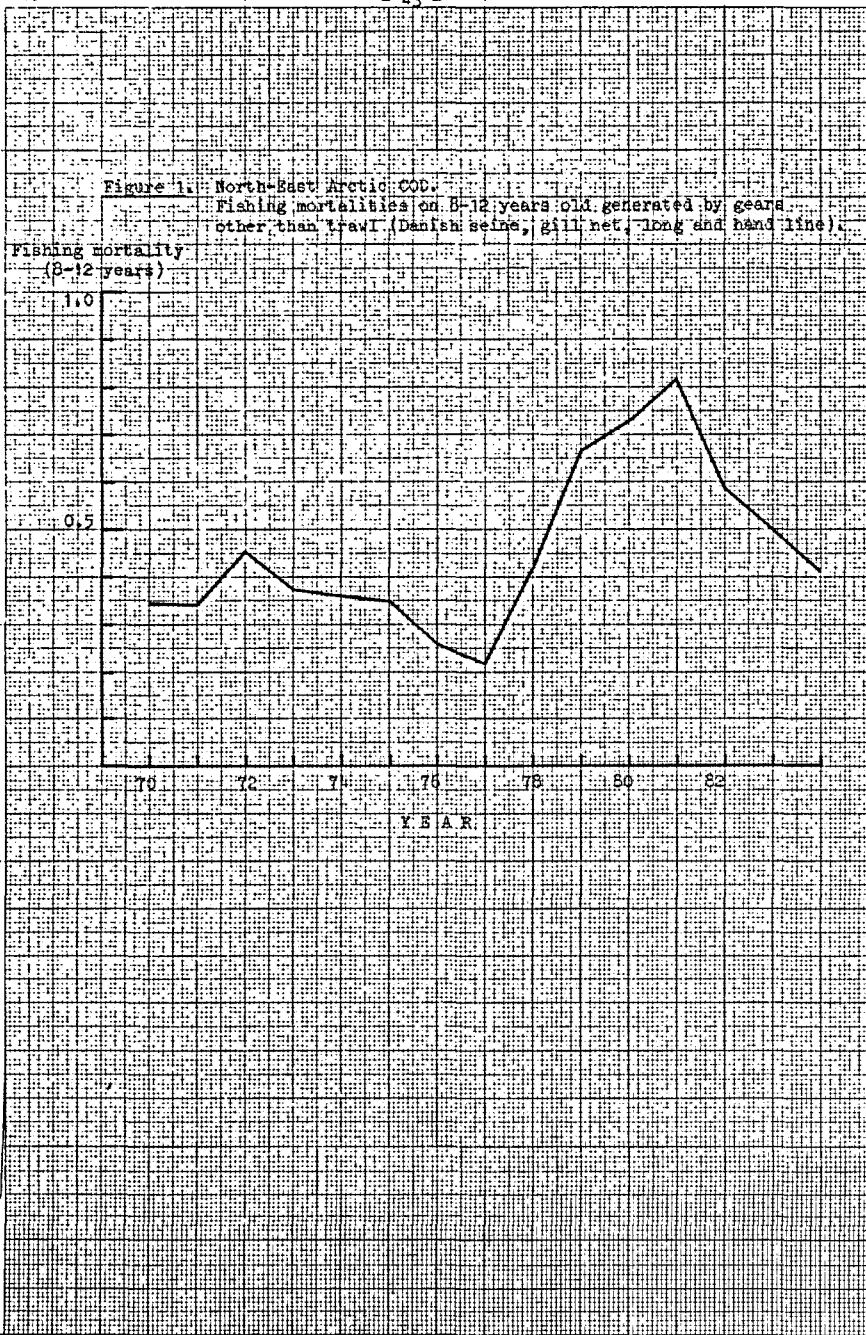


Figure 2. North-East Arctic COD. Fishing mortality generated by Norwegian trawlers in Sub-area I on 5-6 year old cod versus effort by the same fleet (in Norwegian units) in this area. Catchability (Q) versus year calculated from the same data sets.

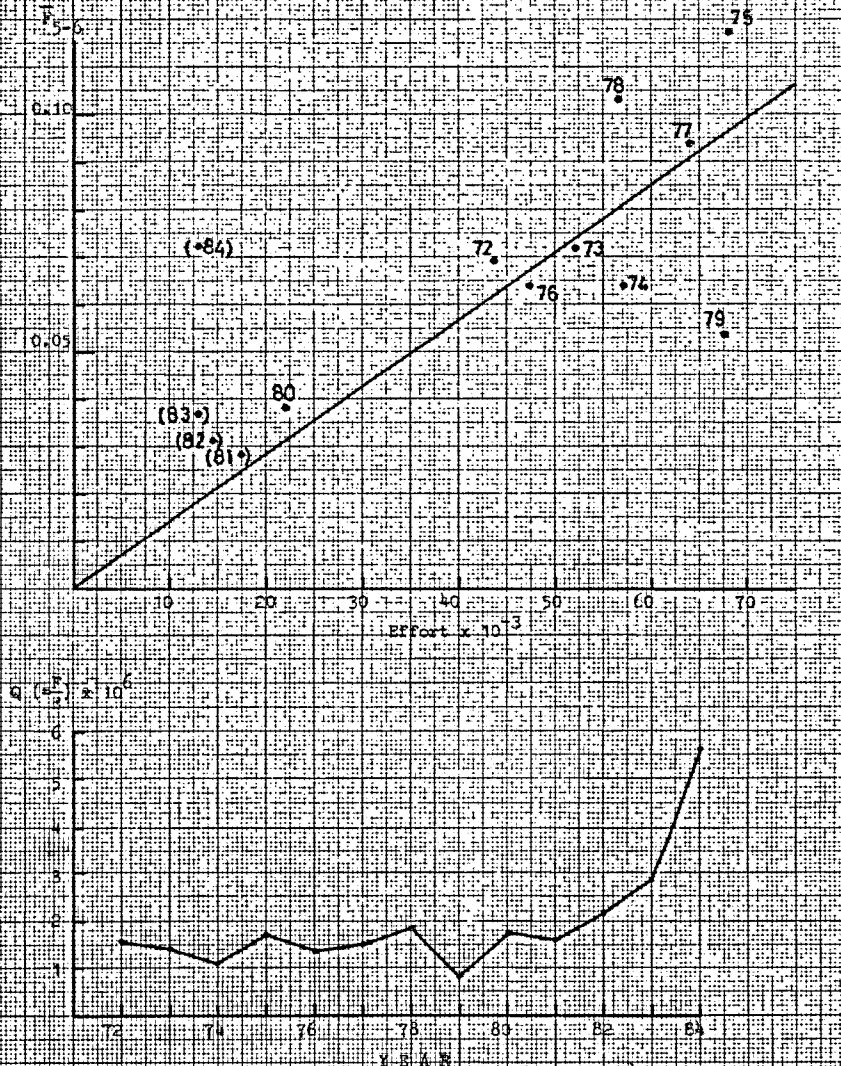


Figure 1. North-East Arctic COD.
Fishing mortality generated by Norwegian trawlers in Division 11a on 5-8 year old cod versus effort by the same fleet (in Norwegian units) in this area. Catchability (Q) versus year calculated from the same data sets.

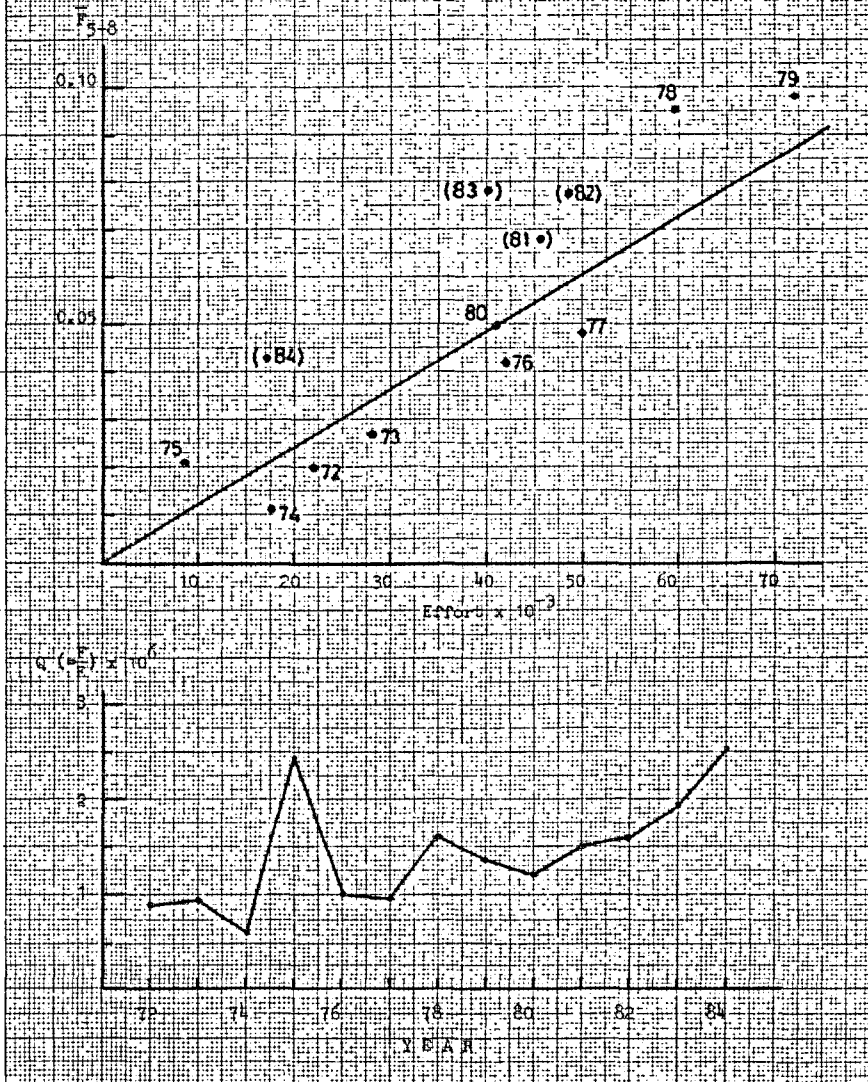


Figure 3. North-East Arctic COD. The logarithm of the numbers of 3 year old fish from the YPA versus the logarithmic O-group survey index.

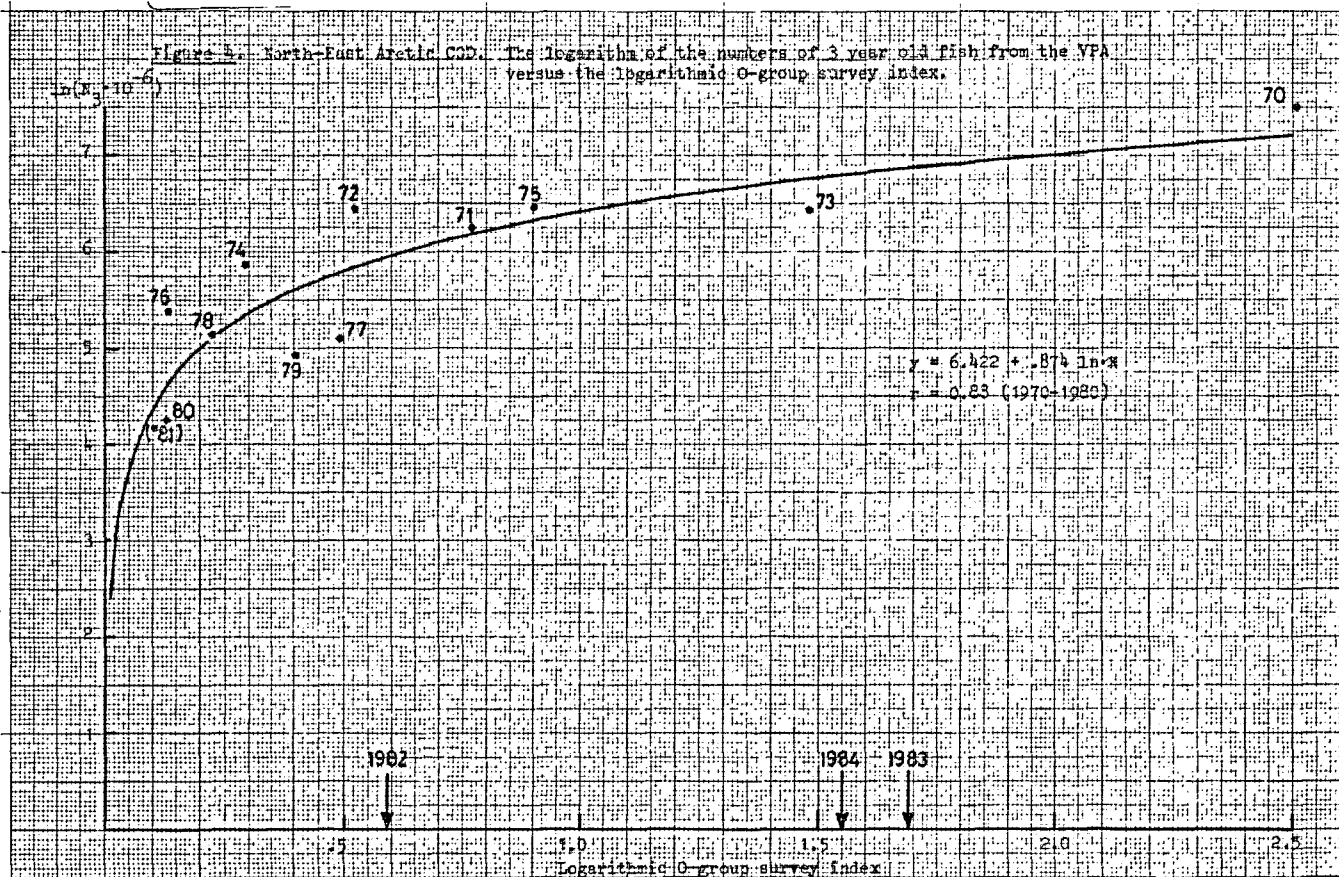


Figure 3. North-east Arctic cod.

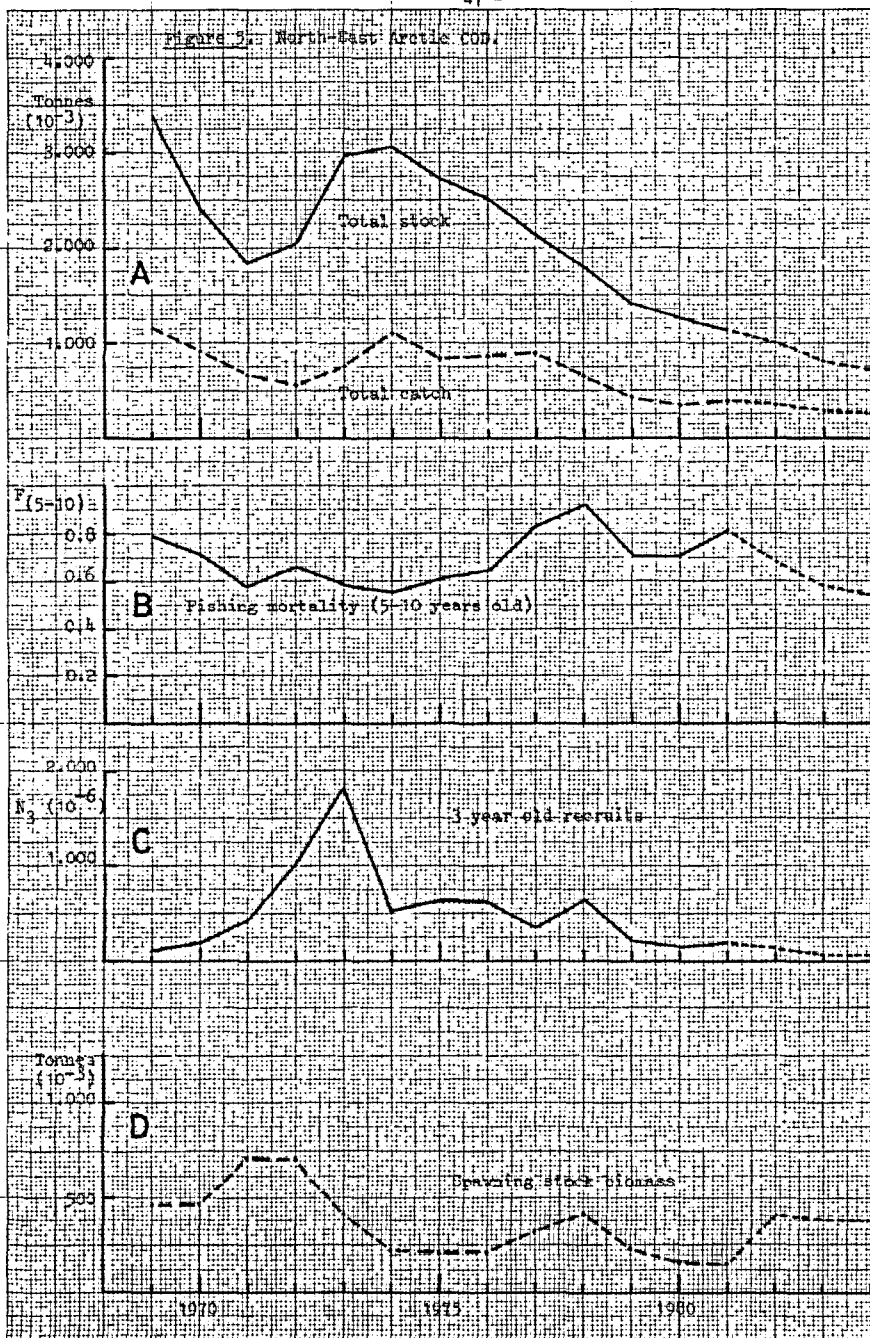


Figure 6. North-East Arctic COD. Y/R, Yield 1985, recruited biomass (3+) and spawning stock biomass at beginning of 1986 for different levels of fishing mortalities in 1985.

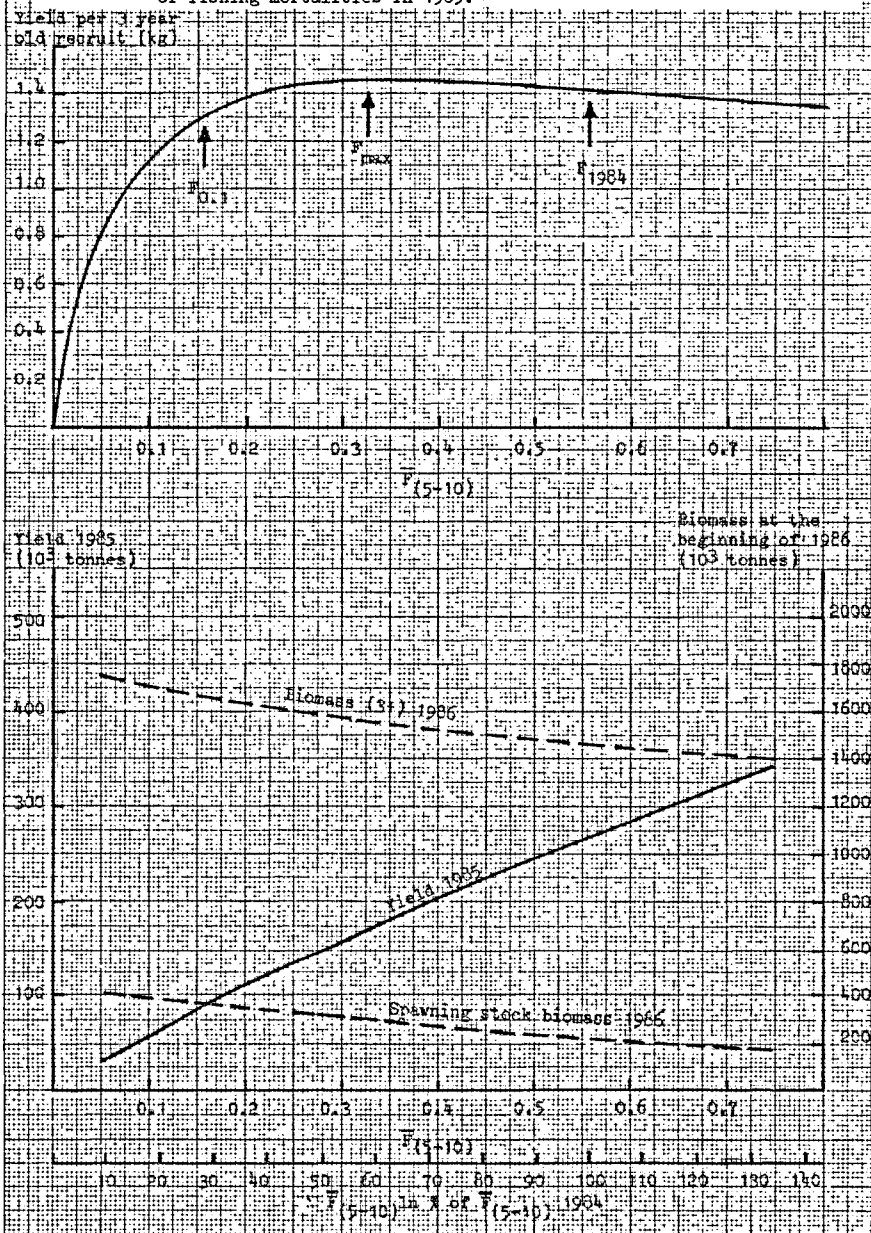


Figure 7. North-East Arctic COD and HALDOCK.
The fishing mortalities generated on cod (6-7 years old) in Division II and haddock (5-7 years old) in Sub-area II. Both sets of data refer to Norwegian trawlers for the years 1967-1984.

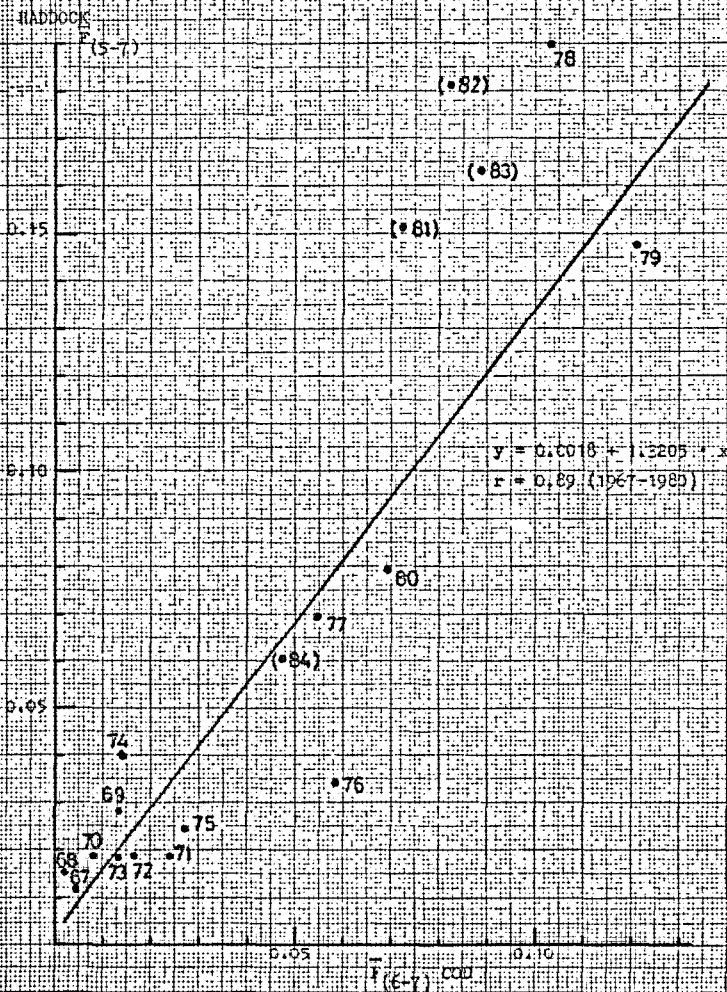
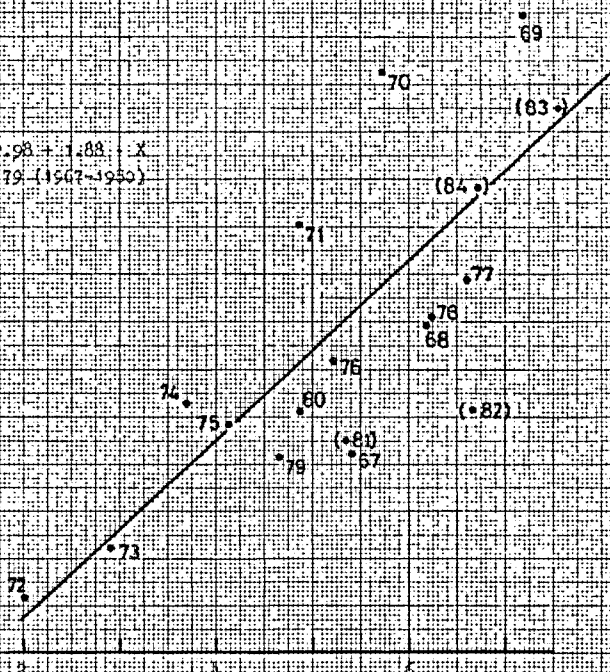


Figure 8. North-East Arctic COD and Haddock. Total international trawl catch ratio versus biomass ratio (1:1) for the years 1967-1984.

Trawl catch ratio
(COD/HADDOCK)

$$Y = -2.98 + 1.83 \cdot X$$

$$R = 0.79 \text{ (1967-1980)}$$



Biomass ratio
(COD/HADDOCK)

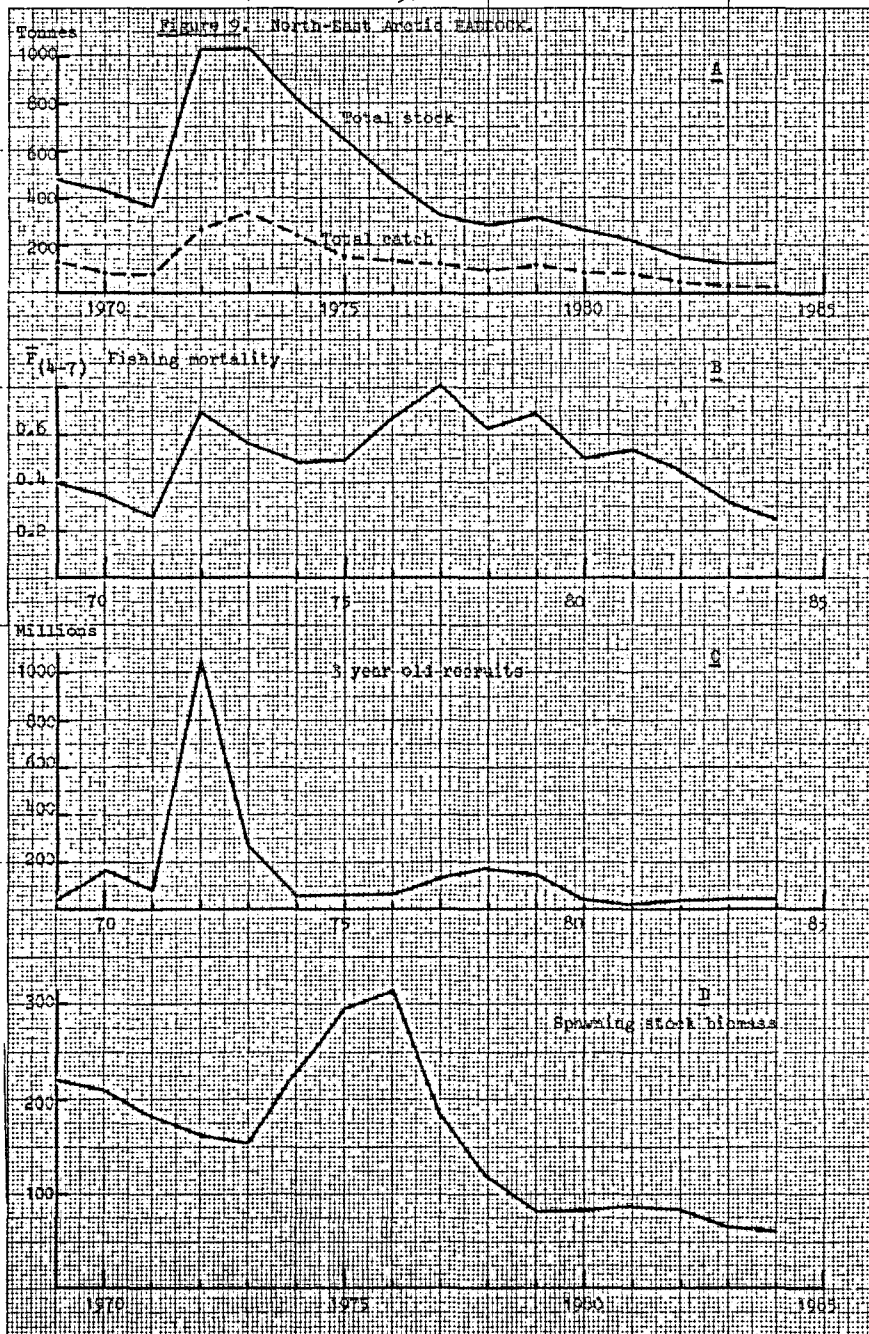
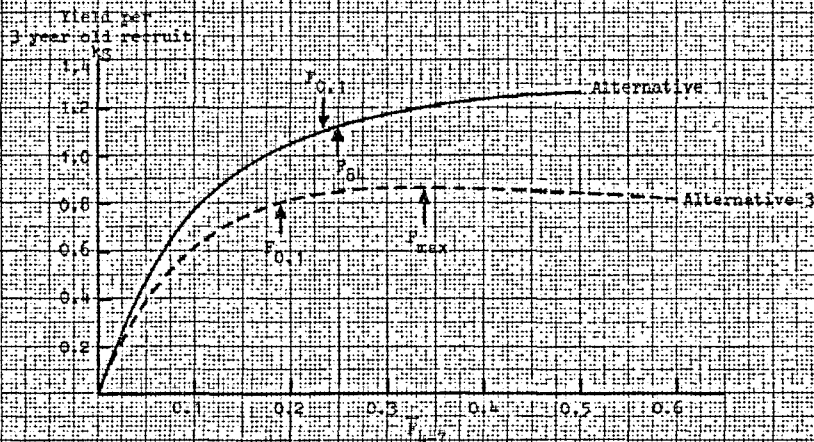


Figure 19. North-East Arctic HALIBUT. Y/R, yield 1985, total recruited biomass (age 3+) and spawning stock biomass at the beginning of 1986 for different levels of fishing mortalities in 1985.



Yield 1985
('000 tonnes)

