

This Report not to be cited without prior reference  
to the Council.\*)

International Council for  
the Exploration of the Sea

C.M. 1984/Assess:3

**REPORT OF THE ARCTIC FISHERIES WORKING GROUP**  
**15 - 22 September 1983**

This document is a report of a Working Group of the International Council for the Exploration of the Sea and does not necessarily represent the views of the Council. Therefore, it should not be quoted without consultation with the General Secretary.

\*) General Secretary  
ICES  
Palægade 2-4  
DK-1261 Copenhagen K  
DENMARK



## CONTENTS

REPORT OF THE ARCTIC FISHERIES WORKING GROUP .....	1
1. PARTICIPANTS .....	1
2. TERMS OF REFERENCE .....	2
2.1. Timing of the meeting .....	2
3. EFFORT IN THE TRAWL FISHERIES .....	3
4. NORTH-EAST ARCTIC COD .....	4
4.1. Status of the Fisheries (Tables 3 to 6) .....	4
4.2. Age compositions .....	5
4.3. Age at maturity (Tables 7 and 8) .....	5
4.4. Survey data .....	6
4.4.1. Bottom trawl surveys .....	7
4.4.2. Acoustic surveys (Table 12) .....	7
4.4.3. Young fish surveys (Tables 13 and 26) ....	7
4.4.4. Evaluation of the acoustic surveys .....	7
4.5. Fishing mortalities .....	8
4.6. Projection of Catch and Stock Size .....	10
4.6.1. Management Options .....	11
4.6.2. Medium-term projection .....	11
4.7. Effects of 1984 TAC's on Spawning Stock Biomass .	12
4.8. Stock and Recruitment Relationship .....	13
5. NORTH-EAST ARCTIC HADDOCK .....	15
5.1. Status of the Fisheries (Tables 19 to 21 ) .....	15
5.2. Virtual Population Analysis (VPA) .....	15
5.2.1. Age compositions (Table 22 ) .....	15
5.2.2. Age at maturity (Table 25) .....	16
5.2.3. Fishing mortality in 1983 .....	16
5.3. Catch Projection .....	16
5.3.1. Management Options .....	17
5.4. Effects of the 1984 TACs on Spaw. Stock Biomass .	17
5.5. By-catch of Haddock in the Cod Fishery .....	18
6. DISTRB. OF COD IN AND AROUND THE "MENTELLA BOX" .....	18
7. DENSITY DEPENDENCE .....	18
8. DEFICIENCIES IN THE DATA BASE .....	19
References .....	20
Tables 1 - 27 .....	21
Figures 1 - 23 .....	47



REPORT OF THE ARCTIC FISHERIES WORKING GROUP  
15-22 September 1983

1. PARTICIPANTS

A Hylen	Norway
B W Jones	United Kingdom
K Randa	Norway
C J Rørvik	Norway
A Schumacher (Chairman)	Federal Republic of Germany

## 2. TERMS OF REFERENCE

At the 70th Statutory Meeting, the Council decided (C.Res.1982/2:5:14):

"that the Arctic Fisheries Working Group should meet at ICES

headquarters from 21-28 September to:

- (i) assess catch options for 1984, inside safe biological limits, for cod and haddock in Sub-areas I and II,
- (ii) advise on the distribution of cod in and around the "mentella box",
- (iii) review which data are available in the Working Group files for evaluating density dependence in the parameters of the models used in fish stock assessments,
- (iv) specify deficiencies in data required for the assessments".

### 2.1. Timing of the meeting

The original dates proposed for the meeting were changed to 15-22 September at the request of the two main fishing nations in the area on the grounds that a symposium on North-East Arctic cod and haddock was scheduled by the USSR to start on the 26 September in Leningrad. For that reason and probably due to some communication problems, scientists from the USSR could not participate in the meeting of the Working Group. Dr Babayan from the USSR, present at ICES Headquarters in the Blue Whiting Assessment Group, made available the data of the USSR fishery for 1982 and for the first half of 1983. These data have been incorporated in the assessments.

### 3. EFFORT IN THE TRAWL FISHERIES

In recent years the proportion of the catches taken by trawlers has been declining. Catches by trawls and other gears are given in Table 1. In previous years estimates of total trawler effort in English trawler units have been calculated. With the decline in the amount of fishing by English trawlers their catch per unit effort data are no longer considered representative. At its 1982 meeting an alternative approach was developed by the Working Group to calculate total trawl effort in Norwegian fresh-fish-trawler units and the results are given in Table 2.

#### 4. NORTH-EAST ARCTIC COD

##### 4.1. Status of the Fisheries (Tables 3 to 6)

The revised figure for cod landings in 1981 is 399 037 tonnes, which is 507 tonnes more than the figure used in the previous Working Group Report (ANON 1983a). This is 99 037 tonnes in excess of the TAC of 300 000 tonnes.

Provisional figures for 1982 indicate a decrease from the 1981 level by 34 168 tonnes to 364 869 tonnes, which are close to the 366 000 tonnes anticipated by the Working Group at its 1982 meeting but well in excess of the TAC of 300 000 tonnes. Catches in Sub-area I continued to decline and reached a level of 97 012 tonnes. The catches in Division IIa declined by 8 339 tonnes and increased in Division IIb by 14 192 tonnes from 1981 to 1982.

Expected total landings for 1983 were estimated to be 308 000 tonnes compared to a TAC of 300 000 tonnes. For assessment purposes this catch was split by regions and by countries and gears in order to establish appropriate age compositions.

Since 1974 an increasing part of the total catch has been taken in Division IIa, reaching a level of 65% in 1982 compared to 11% in 1974. This is the result of the combined effect of a more westward distribution of fish since 1978 due to hydrographical changes, poor year classes among the younger age groups and as a consequence reduced fishing effort in Sub-area I.

Catch and effort data from Norwegian trawlers in 1983 were only available for the first four months in 1983. Based on these data, and catch and effort data on a monthly basis from the period 1976 - 1982, catch per unit effort for the whole year of 1983 was estimated using an analysis of variance technique that corrects for area and monthly effects on availability. This statistical analysis reduced the "raw" catch per unit effort values for the period January - April (1983) by about 20% both for Sub-area I and Division IIa to the projected ones given in Table 5.

Catch per unit effort for the trawler fleets continued to decline in the period 1980 - 1983 in Sub-area I. In Division IIa the preliminary figure of catch per unit effort indicate an increase in availability from 1982 to 1983. In Division IIb catch per unit effort has been fluctuating in the period 1980 - 1982. However, the recent figures for Division IIb have been calculated on the basis of limited data.

For long-line and hand-line fishing in Division IIa, catch per unit effort more than doubled in the period 1980 - 1982. However, it decreased by about 50% from 1982 to 1983.

For gill net catch per unit effort fluctuated in the same period. However, the reduced catch per unit effort from 1981 to 1982 is considerable compared with other type of gears. This was mainly caused by the high rate of maturation of the relatively strong 1975 and 1976 year classes in 1982. The fish were too small to be caught by gill nets with the normal mesh size, but they were highly vulnerable to the long-line and hand-line fisheries. These year classes were



in 1983 readily available to gill nets which resulted in an increased catch per unit effort compared to 1982.

#### 4.2. Age compositions

Age compositions for 1981 were revised and preliminary data were available for 1982. In addition, estimated age compositions for the expected landings in 1983 were prepared.

For 1981 age composition data were available for the Federal Republic of Germany, Norway and the USSR. For other countries in Sub-area I and Division IIa age compositions were based on those of Norwegian trawlers fishing outside the 12 nm zone. For Division IIb age compositions for other countries were derived by pro-rating the USSR age compositions.

For 1982 age composition data were available for the Federal Republic of Germany, Norway, Spain and the USSR. Age compositions for other countries were derived in Sub-area I from the USSR age composition, in Division IIa from age compositions of Norwegian trawlers fishing outside the 12 nm zone. For Division IIb age compositions for Norway, Spain and USSR were summed and then raised to total landings for all countries.

For 1983 age compositions for the expected landings for the whole year were based on data available for the first six months. For Sub-area I data for Norway and USSR were summed and raised to the total landings for all countries. For Division IIa data were available for the Federal Republic of Germany, Norway and the USSR. Age compositions for other countries were based on data for Norwegian trawlers fishing off the northern coast of Norway. For Division IIb data were available only for Norway, and age compositions for other countries were based on those of a Norwegian trawler fishing NW of Bear Island.

#### 4.3. Age at maturity (Tables 7 and 8)

In its previous assessments the Working Group has taken the mature part of the stock to be all fish of age eight and older. The Group considered, however, that it would be more realistic to use a maturity ogive as recommended by ACFM.

An analysis of the published maturity ogives indicated that during the last 40 years (from 1942 to 1981) there has been a slight trend of decreasing age at first maturity. Therefore, the Working Group introduced in its 1982 assessments a series of ogives which reflected the observed trend (Table 7).

For the period 1980 to 1982 there was a large difference between the data supplied by PONOMARENKO (1982) and by HYLEN and NAKKEN (1982) probably because these were derived by applying different methods.

The maturation ogive given by PONOMARENKO is based on trawl sampling in Sub-areas I and II in the period November 1980 to February 1981 when the fish migrate to wintering and spawning areas. The calculations of the maturity ogive are based on summarised data.

HYLEN and NAKKEN based their calculations of maturation curves on total stock estimates obtained by acoustic surveys

in January-March in Sub-area I and in Division IIa (DALEN et al. 1982, GODO et al. 1982) and a bottom trawl survey in September-October in Division IIb in the preceding year (RANDA and SMEDSTAD 1982). Corrections for fishing between survey time and 1 January have been made.

Total spawning stock biomass was calculated from the total stock in each survey area by applying the rate of mature fish in each age group as obtained in the biological samples from the respective areas. Corrections for mature fish in the commercial catches were made by applying the proportion of mature fish per age group in samples of landings from the respective areas.

In addition, a different and new approach in estimating the maturity ogive has been undertaken by HYLEN and RØRVIK (1983) using a modified mesh assessment model. Their resulting ogives for the period 1967 to 1977 are similar to those derived by other methods for the same period. These results are preliminary and further studies are needed before any firm conclusions can be drawn. However, this method may provide an alternative and check on other methods.

It is not clear whether the difference in the PONOMARENKO and HYLEN and NAKKEN data sets was due to methodology or to a real change in maturity in 1982. Therefore, in 1982 the Working Group decided for 1982 to use an average of the two sets of data, and for 1981 and for the prediction period to use an average giving double weighting to the PONOMARENKO data. As ALTERNATIVE 2 this approach in calculating the spawning stock biomass was continued, although the Working Group was aware of the sampling problems involved in obtaining accurate maturity ogives only from trawl catches. These problems are to a certain extent resolved by the HYLEN and NAKKEN method. Therefore, the Working Group decided as ALTERNATIVE 1 to calculate spawning stock biomass with the ogives given by HYLEN and NAKKEN using the 1982 data for the period 1946 to 1982 and the ogive derived in 1983 (HYLEN and NAKKEN 1983, DALEN et al. 1983, GODO et al. 1983) for that year and in the projections (Table 8).

The Working Group recommended in its 1982 report that age-at-maturity data for earlier years should be made available for each single year in order to make a more detailed analysis of the maturity ogives in the past. However, no data were available at this meeting.

The Working Group, therefore, repeats its recommendation from last years report:

It is recommended that age-at-maturity data for the earlier years should be made available in more detail, and that any weight-at-age data for past years should be provided. On the basis of the data available at the 1984 Working Group meeting a revision of the maturity ogive towards a more detailed analysis will be undertaken.

#### 4.4. Survey data

#### 4.4.1. Bottom trawl surveys (Tables 9 to 11 and 27)

Data were taken from reports of the Norwegian groundfish survey in the Barents Sea (DALEN et. al. 1983) and in the Svalbard area (RANDA and SMEDSTAD 1983). The absolute level of the indices given this year are different from the ones given in last year's Working Group Report due to a different computing procedure used this year as described in the papers.

The results from the Norwegian bottom trawl surveys in the Barents Sea are difficult to interpret. They do not show the declining trend in the stock from 1981 to 1983 as shown by the acoustic surveys and by the USSR bottom trawl surveys in 1979-1982 (ANON 1983a). It is thought that the total cod population in the survey area is not properly covered by the bottom trawl because the stock components available to that gear at survey time vary from year to year. Therefore, the results from the Norwegian bottom trawl surveys are difficult to utilize for assessments in isolation. However, the results of the bottom trawl surveys are an essential component of the stock biomass estimates in combination with the acoustic survey results.

Since no scientists from the USSR were present at the meeting, no information was available from the USSR bottom trawl survey in 1983.

#### 4.4.2. Acoustic surveys (Table 12)

Results from the Norwegian acoustic surveys in the Barents Sea are given in DALEN et. al. (1983) and for the Lofoten and Møre areas in GODO et. al. (1983). The Norwegian surveys are summarized in HYLEN and NAKKEN (1983) to give a total stock estimate of cod in the same way as described in last year's Working Group Report.

#### 4.4.3. Young fish surveys (Tables 13 and 26)

Data from the International 0-group fish survey were taken from ANON (1983) giving an 0-group index for cod and haddock. How this index is calculated is described in RANDA (1983). No data were available from the USSR young fish survey.

#### 4.4.4. Evaluation of the acoustic surveys

HYLEN and NAKKEN (1983) give a total stock estimate of 407 million fish of which the acoustic surveys accounts for 340 million or 83.7%. The HYLEN and NAKKEN assessment is therefore very dependent on the acoustic surveys and the acoustic method.

It is generally accepted that the acoustic method tends to underestimate the abundance of fish located near the bottom. This is mostly due to the echosounder having a deadzone of 1-2 m off the bottom, depending on the depth and bottom configurations. This source of error becomes increasingly important as the stock size decreases.

As in 1982 the Norwegian acoustic surveys did not cover the Helgeland area and the stock in that area was estimated

under the assumption that the ratio between the catch and the stock was the same as in the Møre area.

The Vesteraalen area is difficult to survey with the acoustic method. The edge of the continental shelf where the cod is mostly recorded is very steep and fish staying close to the bottom are therefore difficult to detect with acoustic instruments.

Biological sampling is also difficult in both the Vesteraalen and the Lofoten areas due to the bottom conditions and the presence of passive gears (gill nets, long-lines etc.). This limits the material available for constructing both length distributions and age length keys. However, the stock estimates in the Helgeland and Vesteraalen areas make up only 3% of the total acoustic estimate in HYLEN and NAKKEN (1983), and even a severe error in the stock estimate in these areas would not influence the total estimate very much.

The Lofoten estimate of 50 million fish was based on 6 different surveys using 3 different vessels which all gave similar results. Due to the limited biological sampling in this area by research vessels, length distributions from purse seine catches from the eastside of the Lofoten islands were applied together with an age-length key from long-line fishing of the same area. This may perhaps have led to an overestimate of the older age groups because the fish west of the islands at this time of the year are generally smaller than the fish in the area where the samples have been taken.

The HYLEN and NAKKEN (1983) estimate of the Barents Sea component is 275 million fish. This estimate consists of two parts, firstly 210 million fish actually recorded in the acoustic survey and secondly an estimate of 65 million fish in the deadzone of the echosounder. The details of this estimate are described in the paper. Each year class was then raised in equal proportions to give a total of 275 million.

As stated by HYLEN and NAKKEN (1983) the 65 million is probably not a very precise estimate. It is also likely that both the numbers and the age distribution may vary geographically and perhaps also between years in this "deadzone stock". It is, however, the first attempt to correct for the likely underestimation in the previous Norwegian acoustic surveys.

#### 4.5. Fishing mortalities (Tables 14 to 16 Figures 1 to 7, and 9)

Last year Norwegian survey data (HYLEN and NAKKEN, 1982) were available which gave an independent estimate of stock size, and these data were of value in providing a means of estimating F values for the most recent data year. However, there were indications that both the youngest age-groups and the year class 1975 were not well estimated by the survey.

A second and intensified Norwegian survey was made in 1983 (HYLEN and NAKKEN, 1983) and this provides estimates of stock size for each age at 1 January 1983 (Section 4.4).

A preliminary VPA was made using input F values for 1983 based on the 1982 exploitation pattern used at last year's Working Group scaled to  $F_{(5-10)} = 0.4$  to arrive at the expected catch for 1983. The calculated values of numbers in

the stock at each age in 1982 and 1983 were then compared with the estimates from Norwegian surveys and in general the agreement was good. Some of the problems associated with the 1982 survey had been resolved in 1983 and the Working Group had more confidence in the survey stock estimates for 1983. A further VPA was made using input F values for 1983 calibrated by the survey estimates of stock numbers for that year. The results for 1982 and 1983 were as follows:

Age	1982			1983		
	Stock number (millions)		F	Stock number (millions)		F
	Survey	VPA		Survey	VPA	
3	81	109	.10	29	30	.02
4	105	144	.17	81	80	.08
5	103	92	.26	99	99	.28
6	95	83	.40	58	58	.52
7	154	103	.57	43	43	.72
8	23	25	.40	50	50	.55
9	12	9	.42	13	13	.43
10	6	5	.28	5	5	.25
11				2	2	.18

In general there is good agreement between the back-calculated VPA-stock numbers for 1982 and the 1982 survey estimates. There is, however, a big difference between the estimates for the 7-year olds (1975 year class) but it is thought that for this year class there may have been a certain amount of double counting in the survey resulting in an overestimate. The differences in the estimates for age groups 3 and 4 are likely to be due to poor sampling of the youngest age groups by the 1982 survey.

Effort data from Norwegian trawlers in Sub-area I and Division IIA were used to check the 1983 F-values given in the text table above against the partitioned F-values generated by the same fleet in the same area.

For age group 5 the estimated fishing mortality was close to the line which was drawn to the mean of the 1972-79 data points and the origin for both Sub-area I and Division IIA (Figures 2 and 4).

For age groups 6 and 7 the 1983 estimates from survey results are consistently well above the respective lines and outside the scatter of data points on the graphs. It was therefore decided to reduce the F-values on these age groups about half way towards the line thereby giving the two sources of information equal weight (Figures 3 and 5 for age group 6 and Figure 6 for age group 7).

The calculated F-values from the surveys for the older (10+) age groups are unusually low and of the same order as the fishing mortality generated (mainly in Division IIA) by gears other than trawls alone (Figure 1). In view of the likely overestimate of older fish in the surveys (see Section 4.4) fishing mortalities on age groups 10 and older were raised to the level which was estimated from the survey for the 9 year old fish, i.e. 0.43. This adjustment has only marginal effects on the assessment since these age groups make up less than 2% of the catch in numbers.

F-values for 1983 determined as described above have been used to initiate the VPA. Maturity ogives derived as described in Section 4.3 have been used in the spawning stock biomass calculations (two alternatives), but no sum-of-products (SOP) corrections have been applied. Input data and calculated fishing mortalities, stock numbers and stock biomass are given in Tables 14-16. The historic trends in catch, fishing mortality, recruitment, total recruited biomass and spawning stock biomass are illustrated in Figure 9, A-D.

#### 4.6. Projection of Catch and Stock Size (Table 17, Figure 10)

The parameters used for calculating catches in 1984 and stock sizes in 1985 are given in Table 17. According to the sum-of-products check which resulted in a deviation of only 6%, no revision of the weight at age data was required for 1983 and the projection.

The exploitation pattern from the 1983 assessment has been adjusted to account for the fact that fishing is expected to concentrate on the mature component of the stock. This was done by shifting the maxima upwards by one year from age groups 7 and 8 to age groups 8 and 9.

In the 1982 assessment the size of the 1980 and 1981 year classes at age 3 has been estimated on the basis of the USSR youngfish survey. Both these indices are very low (Table 13), although not precise they indicate that these year classes are very poor. On this basis they were assumed to be 100 million, the conservative level for poor year classes used by the Working Group in previous assessments. In the present assessment the Working Group used the estimate from the acoustic surveys of about 30 million for the 1980 year class (Table 12). Since all available information (0-group survey, acoustic survey, USSR young fish survey) indicate that the 1980 and 1981 year classes are of about the same strength, the 1981 year class was set at the same level. It is not expected that a possible underestimate of their strength would seriously affect the results of the projection, since the relative fishing mortality on the respective age groups is very low.

The estimate of the strength of the 1982 year class of 400 million cod at age 3, which are expected to recruit to the fishery in 1985, was derived from the International 0-group fish survey (Table 13, Figure 8). Observations reported from the 1982 USSR egg- and larval survey (ANON 1983a) as well as indications of improved environmental conditions confirm that the 1982 year class might be stronger than the preceding ones. The increase in spawning stock biomass in 1982 due to the contribution of the 1975 year class might also have contributed to the production of a good year class in 1982.

For the 1983 year class the index from the 0-group survey is about 3 times higher than that for the 1982 year class. From Figure 8 its size is estimated to be about 900 million 3 years old cod. The estimate of this year class does not affect the projection for 1984 and only marginally the medium-term projection of the spawning stock biomass for 1987 and 1988.

The Working Group is concerned about the survival of young

cod from the 0-group stage to their recruitment to the fishery due to by-catches of young cod in the growing shrimp fishery.

The results of the projections are given in Figure 10. In the text tables below, management options for 1984 related to the reference points on the yield per recruit curve (Figure 10) and to certain levels of catch in 1984 are given.

#### 4.6.1. Management Options

Note: In the columns "Spawning stock biomass", two figures are given. The upper one refers to ALTERNATIVE 1, the lower one to ALTERNATIVE 2. (Section 4.3)

Species: NORTH EAST ARCTIC COD

Area: ICES SUB-AREAS I AND II

1983				Manage-	1984				1985	
Stock biom. (3+)	Spawn- ing stock biom.	F (5-10)	Catch (3+)	option for 1984	stock biom. (3+)	spawn- ing stock biom.	F (5-10)	Catch (3+)	stock biom. (3+)	spawn- ing stock biom.
963	533 310	.438	308	F 0.1	703	480 307	.15	94	1 000	557 378
				F max			.27	157	920	494 230
				F 1984 =			.44	240	830	410 270
				F 1963						
				TAC 1964 =300			.60	300	760	353 235
				TAC 1984 =200			.355	200	870	450 300
				TAC 1984 =150			.256	150	930	501 338

Weights in thousand tonnes

\* expected catch estimated by the working group

#### 4.6.2. Medium-term projection

Calculated spawning stock biomass (SSB) in 1984-88(87) at the beginning of the year and calculated catch 1984-86 for different management strategies. Catch figures for 1987 and 1988 are dependent on recruiting year classes beyond 1983 and are therefore not given in the text tables below.

Spawning stock estimate: ALTERNATIVE 1

Management strategy	$\bar{F} = 0.15$ 0.1		$\bar{F} = 0.27$ max		$\bar{F} = \bar{F}_{1983}$ = 0.44		TAC 200		IAC 250		TAC 300	
Year	SSB	Catch	SSB	Catch	SSB	Catch	SSB	F	SSB	F	SSB	F
1984	480	94	480	157	480	236	480	0.36	480	0.47	480	0.60
1985	557	97	494	145	415	187	451	0.44	401	0.67	352	1.07
1986	615	104	492	145	360	169	387	0.50	282	0.95	180	2.05
1987	660		494		337		357		201		106	
1988	760		558		364							

Spawning stock estimate: ALTERNATIVE 2

Management strategy	$\bar{F} = 0.15$ 0.1		$\bar{F} = 0.27$ max		$\bar{F} = \bar{F}_{1983}$ = 0.44		TAC 200		TAC 250		TAC 300	
	Year	SSB	Catch	SSB	Catch	SSB	Catch	SSB	F	SSB	F	SSB
1984	307	94	307	157	307	236	307	0.36	307	0.47	307	0.60
1985	378	97	334	145	278	187	303	0.44	269	0.67	235	1.07
1986	432	104	340	145	241	169	262	0.50	184	0.95	111	2.05
1987	476		342		217		219		113		43	
1988	549		378		236							

#### 4.7. Effects of 1984 TAC's on Spawning Stock Biomass

The early maturation of the relatively good 1975 year class observed in 1981 and in 1982 has increased the spawning stock biomass at the beginning of 1981 and 1982 from the



very low 1980 level. This increase is levelling off in 1983 and 1984.

It has to be noted that the 1975 year class is followed by a series of 6 poor year classes. As a consequence the level of spawning stock biomass estimated for 1984 can only be maintained if the level of exploitation does not exceed  $F_{(max)}$ . This strategy is associated with catches in the order of 150 000 tonnes. If management aims at increasing the level of spawning stock biomass during the 1984-87 period, then fishing at  $F_{0.1}$  is required which would result in catch levels around 100 000 tonnes.

Management strategies based on stable catch levels above 200 000 tonnes in the period 1984-87 are all associated with levels of fishing mortality in excess of  $F_{(max)}$  and increasing with time. Spawning stock biomass is estimated to decline rapidly under this type of management if the stable TAC is higher than 200 000 tonnes.

No substantial increase in spawning stock biomass can be expected before 1988 when the year classes 1982 and 1983, which are expected to be strong, start to enter the spawning stock.

#### 4.8. Stock and Recruitment Relationship (Table 18, Figures 11 - 13)

Until the 1981 meeting the Working Group had used a "knife-edge" type of maturity pattern for the calculation of spawning stock biomass. This assumed fish of age 7 and younger to be immature and fish of age 8 and older to be mature. In order to improve the estimates of spawning stock biomass, a series of maturity ogives were used at the 1982 meeting (ANON 1982). As explained in Section 4.3 of the present report, estimates of spawning stock biomass for the period 1946 to 1977 have been calculated on the basis of more recent data derived from Norwegian samples at spawning time in the spawning area adjusted for the total stock. This approach gives more weight to adequate sampling but has to ignore possible trends in time at present.

In addition an examination of the sum-of-products (SOP) check showed large discrepancies for the earlier years of the historic series. A single set of weight-at-age data has been used for the whole period 1946-1982. It was considered likely that the main source of the SOP error was due to changes in the weight at age in the stock. Consequently the computed spawning stock biomass (Table 18) were corrected for the SOP discrepancies. The combined effects of the changes in the maturity-at-age data and the SOP corrections of weight-at-age data can be seen in Figure 11 where the different estimates of spawning stock biomass can be compared.

The corrected spawning stock biomass data have been used together with the current estimates of the numbers of recruits at 3 years old to calculate a new stock/recruitment relationship (Table 18 and Figure 12). The line on the graph was fitted by the method of RICKER (1975).

As with previous stock/recruitment plots for the North-east Arctic cod, the revised data show a considerable scatter of points about the fitted line. The curve indicates that maximum recruitment should be produced from a spawning stock biomass of about 2 million tonnes (ALTERNATIVE 1) as

compared to 600 000 tonnes (ALTERNATIVE 2) estimated from the 1982 assessment (Figure 13). This large difference illustrates the difficulties to accurately estimate the optimum level of spawning biomass at which the probability of recruitment failure is minimized. However, it should be noted that the maximum level of spawning stock biomass on both these stock/recruitment curves was only reached during the immediate post-war years after a period when the stock had been virtually unfished for several years.

In view of the conflicting results of the stock/recruitment analysis it is difficult to draw firm conclusions from these assessments at present until a more refined evaluation of the historic data series can be undertaken (Section 4.3).

## 5. NORTH-EAST ARCTIC HADDOCK

### 5.1. Status of the Fisheries (Tables 19 to 21 )

Final figures for the catch of haddock of 77 153 tonnes in 1981 differ only slightly from the figure given in the previous Working Group report (ANON 1983a). The preliminary figure for 1982 of 47 252 tonnes shows a considerable decrease from 1981 of about 30 000 tonnes (39 %).

In the previous Working Group report total landings of haddock for 1982 were estimated as 49 000 tonnes, this is only about 1 750 tonnes above the reported figure of 47 252 for that year. For the first time in the period for which data were available, which was in 1981, the catch of haddock was higher in Division IIa than in Sub-area I. As expected the same situation occurred in 1982 when the catch in Division IIa exceeded that in Sub-area I by about 38 %. This might be due to the more westerly distribution of the fish as well as to the fact that a great proportion of the haddock stock consists of spawning fish which are exploited mainly in Division IIa. Expected total catch of haddock in 1983 is estimated at 27 000 tonnes, and for the reasons given above the catch in Division IIa is again expected to be higher than in Sub-area I. The projected catch per unit effort data for Norwegian trawlers in 1983 (Table 21) were estimated by analysis of variance as described for cod in Section 4.1.

An upward trend in catch per unit effort of Norwegian trawlers in Sub-area I was observed from 1977 to 1981. However, catch per unit effort declined by about 20% from 1981 to 1982, followed by a reduction from 1982 to 1983 by about 50%. The reason is that a great proportion of the stock has reached the age of maturity in 1981-1982, particularly the good year classes 1975 and 1976. These fish migrate to the spawning areas in Division IIa and the increase in catch per unit effort up to 1982 in that area might be explained by this migration. However, in 1983 catch per unit effort in Division IIa declined considerably. Although the 1983 figure is preliminary, this indicates that the year classes now recruiting to the spawning stock are poor.

### 5.2. Virtual Population Analysis (VPA)

#### 5.2.1. Age compositions (Table 22 )

Catches in numbers per age-group were revised for 1981 according to the total reported catch by France of 414 tonnes.

The data for 1982 given in the previous report, which were based only on samples taken during the first 6 months, have been updated according to the samples taken during the whole year by Norway.

For 1983 the projections of the total annual catch in numbers by age were made based on data available for the first half of the year from the Federal Republic of Germany, Norway and the USSR.

#### 5.2.2. Age at maturity (Table 25)

In the earlier assessments the Working Group has taken the mature part of the stock to be all fish of age 6 and older. In order to obtain a more realistic estimate of the mature part of the stock it was decided at the 1982 meeting of the Working Group to apply a maturity ogive for the estimate of the spawning stock biomass.

Only two series of data (SONINA 1981 and SAETERSDAL 1954) were available for haddock but since these are similar the data published by Saetersdal are used (Table 25). The Working Group noted that such a limited material is not sufficient, particularly in view of possible trends in time, but even the application of a standard maturity ogive is considered an improvement compared to the previous approach. It is recommended that existing material should be made available in more detail and further sampling be undertaken.

#### 5.2.3. Fishing mortality in 1983

The exploitation pattern for 1983 was taken to be close to the one selected for 1982 in last year's assessment (ANON 1983a), which was based on the average exploitation pattern for the years 1978-1981.

The major part of the haddock catch is taken as by-catch in the fishery for cod, and the haddock stock is exposed virtually to the same effort as cod. Therefore, comparison between fishing mortality, catch per unit effort and biomass of these two species is thought to allow conclusions to be drawn for haddock based on the cod assessment.

Having the VPA on cod finalized (Tables 15 and 16), an average  $F$  of 0.24 on the 4-7 year's olds was decided on. This level of exploitation in 1983 gave a reasonable value of the average fishing mortality on the 5-7 years old haddock in 1983 versus the average fishing mortality on the 6-7 years old cod, both averages referring to the Norwegian trawlers in Division IIa (Figure 14).

The resulting biomass of haddock compared also reasonably well with the total biomass on cod when related to the ratio of these two species in the 1983 trawl catches (Figure 15).

This level of exploitation in 1983 results in a decrease in total stock biomass during 1982 as also reflected in the last year's catch per unit effort data from the Norwegian trawlers (Table 21).

The results of the VPA on haddock are given in Tables 23 and 24. Historic trends in the total stock and catches, fishing mortality, recruitment and spawning stock biomass are shown in Figures 16A-D.

#### 5.3. Catch Projection

For the 1980 year class the VPA estimate of 14 million 3 year olds was used as input recruitment for the projections.

From the 0-group survey index (Table 25) the 1981 year class seems to be even less abundant. However, judged from the Norwegian bottom trawl survey in 1983 (Table 26) the 1981 year class as 2 year olds is of similar abundance as the 1979 year class as 2 years old. The Norwegian bottom trawl survey gives a ratio between the 1981 and 1979 year classes both as 2 years old of 1.19. Raising the VPA estimate of the 1979 year class as 3 years old (18 million) by this factor gives 21 million, while a rounded figure of 20 million was actually used for the 1981 year class.

The 0-group survey index for the 1982 year class is similar to the index for the 1976 year class (Table 25), and the Norwegian bottom trawl survey (Table 26) indicates that the 1982 year class is much more numerous as 1 year old than the 1980 and 1981 year classes. Therefore the VPA estimate for the 1976 year class of 165 million was accepted as an estimate for the 1982 year class. In Table 27 the parameters used for the projections are given.

### 5.3.1. Management Options

Species: HADDOCK

Area: ICES SUB-AREAS I AND II

1983					1984					1985	
Stock (3+)	spawn- ing stock biom.	F (4-7)	Catch (3+)	Management option for 1983	Stock (3+)	spawn- ing stock biom.	F (4-7)	Catch (3+)	Stock (3+)	spawn- ing stock biom.	
156	112	.24	27	F 0.1	143	100	.17	16	235	91	
				F max			.36	35	216	76	
				F 1984 =			.24	25	227	85	
				F 1985							

Weights in thousands of tonnes

+ expected catch

### 5.4. Effects of the 1984 TACs on Spawning Stock Biomass

From the very low 1979-1980 level, the spawning stock in 1982 has slightly increased to a level of about 117 000 tonnes due to the contribution by the good 1975 and 1976 year classes in 1982 (Figure 16). However, this development discontinued in 1983 and no further increase in spawning stock biomass can be expected up to about 1987, since all the year classes recruiting to the spawning stock during this period are poor. If management aims at maintaining a reasonable spawning stock size over a longer period, a cautious approach in the long-term policy is advisable.

### 5.5. By-catch of Haddock in the Cod Fishery

In setting the TAC for haddock it has to be remembered that a considerable part of the haddock catch is taken as a by-catch in the fisheries for other species (mostly cod) in Sub-areas I and II.

The ratio of cod and haddock in the trawl catches (Figure 15) indicates that, at present biomass levels, the amount of haddock taken as by-catch in the trawl fishery for cod in 1984 is expected to be about 1/7 of the cod catches.

### 6. DISTRIBUTION OF COD IN AND AROUND THE "MENTELLA BOX"

Material available to the group were distribution maps of cod greater than 41 cm and less than 42 cm from the Norwegian bottom trawl surveys (DALEN et. al., 1983) in the Barents Sea in the months January to March 1981 - 1983 (Figures 18 to 23) and the USSR paper by SHESTOVA and LUKMANOV (1983).

On the basis of this limited material the group feels that no firm advice on the distribution of cod in and around the "mentella box" can be given at the present meeting.

### 7. DENSITY DEPENDENCE

DATA AVAILABLE IN WORKING GROUP FILES FOR EVALUATING DENSITY DEPENDENCE IN THE PARAMETERS OF THE MODELS USED IN FISH STOCK ASSESSMENT North-East Arctic cod and haddock stock density in terms of numbers or biomass as well as recruitment can be determined from data held in Working Group computer files by VPA. Weight at age data currently on file are constant for each year. Annual maturity ogives are not established with sufficient accuracy to allow analysis of density dependent phenomena.

## 8. DEFICIENCIES IN THE DATA BASE

The text table below gives the percentage of the catch in Sub-area I and Divisions IIa and IIb and of the total catch reported without accompanying age compositions. This faces the Working Group with the problem of splitting these catches using age compositions from other fleets and areas.

	Cod				Haddock			
	Subarea I	Division IIa	Division IIb	Division Total	Subarea I	Division IIa	Division IIb	Division Total
1980	7.5	6.1	50.5	8.2	2.7	7.4	-	4.5
1981	6.9	4.7	38.3	9.9	7.2	5.1	100	5.8
1982	10.5	4.3	1.1	5.7	15.9	5.9	-	9.9

From this table it is seen that this was a considerable problem for cod in 1980 and 1981 particularly in Division IIb, mainly caused by Spain. However, Spain has made great effort to overcome this problem and monthly age compositions were submitted for the 1982 catches. Even with this improvement there are still 20 801 tonnes of cod catches for 1982 without age compositions reported. For the first half of 1983, no age compositions were submitted by countries (Faroes, France, Spain and United Kingdom) with an expected catch for this year of about 36 000 tonnes.

With the exception of Spain these countries did not report age compositions for their 1982 catches either. Attention is drawn to the fact, that the meeting of the Working Group was scheduled to be held in autumn in order to be able to use data from the fishery of the first half of the current year. It is recommended that countries having substantial catches in the area in the first half of the year report those to the ICES Secretariat in time for the meeting of the Working Group together with the corresponding biological data.

The Working Group still feels that the biological data, such as the maturation ogive and weight at age data, should be updated each year for both cod and haddock and requests data on these subjects to be presented annually.

The Working Group expressed last year the need to revise the mean weight at age for both cod and haddock. This year an extensive study of data from English landings of cod in the period 1957 - 1979 was submitted as a working document. Based on these data alone it was not possible to revise the weight at age data used in this year's assessment. This subject needs to be further studied and existing data for both cod and haddock should therefore be made available for the present situation and for the historical record.

## REFERENCES

- ANON 1983a. Report of the Arctic Fisheries Working Group, Copenhagen, 21-28 September 1982. ICES C.M. 1983/Assess:2, 1-62 (mimeo.).
- ANON 1983b. Preliminary report of the International O-group fish survey in the Barents Sea and adjacent waters in August-September 1983. ICES C.M. 1983/G:35, 1-28 (mimeo.).
- DALEN, J., HYLEN, A., NAKKEN, O., RANDA, K. and SMEDSTAD, O.M. 1982 Norwegian investigation on young cod and haddock in the Barents Sea during winter 1982. ICES C.M. 1982/G:41, 1-22 (mimeo.).
- DALEN, J., HYLEN, A., NAKKEN, O., RANDA, K. and SMEDSTAD, O.M. 1983. Preliminary report of Norwegian investigation on young cod and haddock in the Barents Sea during the winter 1982. ICES C.M. 1983 /G:15, 1-23 (mimeo.).
- GODO, O.R., NAKKEN, O., RAKNES, A. and SUNNANAA, K. 1982. Acoustic estimate of spawning cod off Lofoten and Møre in 1982. ICES C.M. 1982 /G:62, 1-16 (mimeo.).
- GODO, O.R., NAKKEN, O., RAKNES, A. and SUNNANAA, K. 1983. Acoustic estimates of spawning cod off Lofoten and Møre in 1982. ICES C.M. 1983/G:37, 1-24 (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 1982/83. ICES C.M. 1983/ G:57, 1-14 (mimeo.).
- HYLEN, A. and RØRVIK, C.J. 1983. Estimating the maturity ogive for North-East Arctic cod by a modified mesh assessment model. ICES C.M. 1983/G:33, 1-36 (mimeo.).
- PONOMARENKO, I.YA. 1982. Portion of mature cod specimens and sex ratio in different age and length groups within the 60'ies and 70ies. ICES C.M. 1983/G:18, 1-20 (mimeo.).
- RANDA, K. 1983. Abundance and distribution of O-group Arcto-Norwegian cod and haddock 1965 - 1982. Leningrad, September 1983. PINRO/HI symposium:1-26 (mimeo.).
- RANDA, K. and SMEDSTAD, O.M. 1982. The Norwegian groundfish survey at Bear Island and West-Spitsbergen in autumn 1981. ICES C.M. 1982/G:42, 1-17 (mimeo.).
- RANDA, K. and SMEDSTAD, O.M. 1983. Preliminary report of the Norwegian groundfish survey at Bear Island and West-Spitsbergen in autumn 1982. ICES 1983/G:34, 1-19 (mimeo.).
- RICKER, W E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Bd. Can., 191: 382 p.
- SAETERSSDAL, G. 1954. Some investigation on the Arcto-Norwegian haddock. ICES 1954 (47) (mimeo.).
- SHESTOVA, L.M. and LUKMANOV, E.G. 1983. Biological substantiation of redfish fishery in the Barents Sea. ICES 1983/:34, 1-21 (mimeo.).
- SONINA, M. A. 1981. The ratio of mature and immature haddock *Melanogrammus aeglefinus* (L.) in the Barents and Norwegian seas. ICES C.M. 1981/G:23, 1-25. (mimeo.).



Table 1 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	45.1	51.8	8.9	8.9	65.9	171.0	18.8	10.5	31.0	-
1983*	44.4	40.1	5.8	7.2	60.8	142.3	7.1	6.8	20.8	-

\*) provisional

Table 2. North-East Arctic COD and HADDOCK catches ('000 tonnes) and total trawl effort in Norwegian Norwegian units.

AREAS	SUB-AREA I			DIVISION IIa			DIVISION IIb	Total Trawl effort x 10 <sup>-3</sup>
Year	CPUE x 10 <sup>-3</sup>	Ct x 10 <sup>-3</sup>	Trawl effort x 10 <sup>-3</sup>	CPUE x 10 <sup>-3</sup>	Ct x 10 <sup>-3</sup>	Trawl effort x 10 <sup>-3</sup>	Ct x 10 <sup>-3</sup>	
1972	0.96	351.5	366.15	1.17	84.3	72.05	35.2	473.59
1973	1.40	700.2	500.14	1.09	53.3	48.90	101.2	622.78
1974	2.02	810.1	401.04	1.70	80.9	47.59	269.8	584.48
1975	2.08	629.8	302.79	1.80	68.3	37.94	130.8	404.57
1976	1.96	544.2	277.65	1.93	140.4	72.75	109.1	406.24
1977	1.65	529.1	320.67	1.30	120.8	92.92	119.5	489.64
1978	1.50	414.3	276.20	1.26	132.7	105.32	18.3	394.28
1979	1.21	209.3	172.98	1.24	135.2	109.03	8.7	289.13
1980	1.92	163.8	85.31	1.49	98.5	66.11	12.6	158.69
1981	2.06	110.5	53.64	1.39	98.4	70.79	17.7	134.97
1982	1.82	54.0	29.67	1.39	84.7	60.94	31.0	110.86
1983*	1.51	50.2	33.25	1.35	67.9	50.30	20.8	98.26

\*) projected figures

Table 3 COD. Total nominal catch (tonnes) by fishing areas  
(landings of Norwegian coastal COD not included).

Year	Sub-area I	Division IIb	Division IIa	Total catch
1960	375 327	91 599	155 116	622 042
1961	409 694	220 508	153 019	783 221
1962	548 621	220 797	139 848	909 266
1963	547 469	111 768	117 100	776 337
1964	206 883	126 114	104 698	437 695
1965	241 489	103 430	100 011	444 930
1966	292 253	56 653	134 805	483 711
1967	322 798	121 060	128 747	572 605
1968	642 452	269 160	162 472	1 074 084
1969	679 373	262 254	255 599	1 197 226
1970	603 855	85 556	243 835	933 246
1971	312 505	56 920	319 623	689 048
1972	197 015	32 982	335 257	565 254
1973	492 716	88 207	211 762	792 685
1974	723 489	254 730	124 214	1 102 433
1975	561 701	147 400	120 276	829 377
1976	526 685	103 533	237 245	867 463
1977	538 231	109 997	257 073	905 301
1978	418 265	17 293	263 157	698 715
1979	195 166	9 923	235 449	440 538
1980	168 671	12 450	199 313	380 434
1981	137 033	16 837	245 167	399 037
1982*	97 012	31 029	236 828	364 869

\*) provisional figures

Expected Catches

1983	84 000	21 000	203 000	308 000
------	--------	--------	---------	---------

Table 4.

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	USSR	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	-	1 074 024
1969	29 374	-	5 907	5 343	305 241	7 856	231 066	612 215	133	1 197 226
1970	26 265	44 245	12 413	9 451	377 606	5 153	181 481	276 632	-	933 246
1971	5 877	34 772	4 998	9 726	407 044	1 512	80 102	144 802	215	689 048
1972	1 393	8 915	1 300	3 405	394 181	892	58 382	96 653	166	565 287
1973	1 916	17 028	4 684	16 751	285 184	843	78 808	387 196	276	792 606
1974	5 717	46 028	4 860	78 507	287 276	9 898	90 894	540 801 <sup>1)</sup>	38 453	1 102 434
1975	11 309	28 734	9 981	30 037	277 099	7 435	101 834	343 580 <sup>1)</sup>	19 368	829 377
1976	11 511	20 941	8 946	24 369	344 502	6 986	89 061	343 057 <sup>1)</sup>	18 090	867 463
1977	9 167	15 414	3 463	12 763	388 982	1 084	86 781	369 876 <sup>1)</sup>	17 771	905 301
1978	9 092	9 394	3 029	5 434	363 088	566	35 449	267 138 <sup>1)</sup>	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	1 900	302	1 717	287 525	-	6 601	40 311	14 515	364 869

\*) provisional figures

1) Murman cod included

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

Year	Sub-area I			Division IIb			Division IIa		
	Norway <sup>1)</sup>	U.K. <sup>2)</sup>	USSR <sup>3)</sup>	Norway <sup>1)</sup>	U.K. <sup>2)</sup>	USSR <sup>3)</sup>	Norway <sup>1)</sup>	U.K. <sup>2)</sup>	Norway <sup>4)</sup>
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 <sup>5)</sup>	1.27	<u>USSR</u>	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	1.24*	-	-	-	-	-	1.20*	-	7.6

\*) 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
- 5) Data from redfish fishery in Division IIb, cod is by-catch

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

Table 7. North-East Arctic COD.  
Maturity ogives used to estimate the spawning stock biomass;  
alternative 2.  
(Anon., 1983a)

PERIOD:	1942-52	1958-66	1966-78	1965-69	1975-76	1977-78	1977-80	1978-9	1980-81	1982
Age	Percentage mature									
3							1	1		5
4			1		1	1	1	1	2	10
5			2		5	3	4	6	6	34
6			5							
7	3	7	13	7	11	12	13	19	17	65
8	10	26	31	20	21	32	38	36	36	82
9	24	42	57	42	42	56	62	70	61	92
10	42	55	74	63	80	69	67	75	79	100
11	61	68	85	84	90	81	71	81	90	100
12	79	79	85	98	92	82	80	82	92	100
13	92	87	91	100	98	86	60	86	98	100
14	99	92	100	100	96	100		100	96	100
15+	100	100	100	100	100	100	100	100	100	100

Table 8. North-East Arctic COD.  
Maturity ogives used in the  
assessment, alternative 1,  
for the estimate of the  
spawning stock biomass

PERIOD	1946-1982 <sup>1</sup>	1983 <sup>2</sup>
Age	Percentage mature.	
3		1
4	5	8
5	10	10
6	34	30
7	65	73
8	82	88
9	92	97
10	100	100
11	100	100
12	100	100
13	100	100
14	100	100
15+	100	100

<sup>1</sup>Hylen and Nakken, 1982.

<sup>2</sup>Hylen and Nakken, 1983.



Table 10. North-East Arctic COD.  
Results from the Norwegian bottom trawl survey in the Barents Sea.  
Index of number of fish in each year class.

Year	YEAR CLASS										
	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	TOTAL
1981		0.7	11.0	8.6	10.9	24.1	27.9	4.8	1.0	0.2	115.5
1982	0.1	0.9	10.1	20.6	21.4	16.0	15.0	1.4	0.2		92.5
1983	44.6	5.9	10.2	25.0	31.9	14.5	4.7	2.0	0.0		142.2

Table 11. COD. Results from the Norwegian bottom trawl survey in the Svalbard area. 19682 of number of fish in each yearclass.

Year	YEAR CLASS										
	1981	1980	1979	1978	1977	1976	1975	1974	1973	1972	TOTAL
1981		0.1	22.2	9.0	5.5	1.2	0.1	2.5	0.7	0.4	49.2
1982	1.5	4.0	22.2	9.5	2.6	1.9	2.3	0.4	0.1		45.0

Table 11. 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	AGE					
	3	4	5	6	7	TOTAL
1979	5.9	35.0	9.3	4.5	2.9	2.1
1980	5.0	2.8	10.5	2.9	1.0	1.2
1981	5.3	5.7	2.2	4.0	0.0	1.7
1982	2.1	2.9	1.7	0.4	1.1	0.5

data provided by working group members 1982.

Table 12. COD. Stock numbers in millions at 1 January 1982 and 1983 from Hylen and Nakken (1982) (1983).

Year	AGE										
	1	2	3	4	5	6	7	8	9	10	11
1982	1	4	81	135	133	92	154	23	12	6	3
1983	27	29	31	99	58	43	50	13	5	2	+

Table 13. 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	0-group survey index (Logarithmic) All areas	Virtual Population No. of 3 year olds x 10 <sup>-6</sup> *)
	Sub-area I	Division IIb	Mean			M = 0.2
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	1 821
1971	37	24	32	Average	0.77	525
1972	53	17	40	Average	0.52	623
1973	74	5	46	Rich	1.48	622
1974	6	1	4	Poor	0.29	377
1975	93	4	62	Rich	0.90	692
1976	4	<1	3	Poor	0.13	241
1977	2	1	1	Poor	0.49	180
1978	1	3	2	Poor	0.22	(180)
1979	<1	8	3	Poor	0.40	(107)
1980	( <sup>&lt;</sup> 1)	( <sup>&lt;</sup> 1)	( <sup>&lt;</sup> 1)	Poor	0.13	( 30)
1981	( <sup>&lt;</sup> 1)	( <sup>&lt;</sup> 1)	( <sup>&lt;</sup> 1)	Poor	0.10	
1982					0.59	
1983					1.69	

( ) = estimated

\*) USSR Murman cod included for 1974-1978

Table 14. VIRTUAL POPULATION ANALYSIS

NORTH-EAST ARCTIC COD

CATCH IN NUMBERS UNIT: THOUSANDS

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
3	45478	42416	13196	5298	15725	55937	34467	3709	2307	7164	7754	35336
4	132655	170566	106984	45512	25999	55644	160048	174535	24345	10792	13739	45431
5	123458	167241	205549	97950	78299	34676	69235	267961	238511	25813	11831	26832
6	51167	89460	95498	56575	66511	42539	22061	107051	181239	137829	9527	12089
7	36740	28297	355118	19642	25444	37169	26295	26701	79363	96420	59290	7918
8	1376	21996	16221	9162	8438	18500	25139	16399	26399	31920	52103	34885
9	5791	7956	11894	6196	3569	5077	11323	11597	13663	8933	12093	22315
10	6778	2728	3364	3553	1467	1455	2329	3657	5092	5249	2434	4372
11	5660	2603	1021	783	1161	380	687	657	1913	1232	762	1215
12	1662	1647	1025	172	131	403	516	122	414	260	416	353
13	910	392	496	387	67	77	225	124	121	106	149	315
14	230	280	129	264	91	9	40	70	23	39	42	121
15+	108	103	157	131	179	70	14	46	46	35	25	40
TOTAL	429963	535685	491574	248025	229081	251976	352179	612679	574026	325792	170067	191622

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	294262	91855	45282	85337	39594	78822	8600	3911	3407	8954	545
4	131493	437377	59798	114341	108609	45400	77484	17036	9466	20951	5589
5	61000	203772	226646	79993	136335	88495	43677	81986	20803	19398	22053
6	20569	47006	118567	118230	32925	56823	31943	40061	63433	28167	21035
7	7248	12630	29522	47872	61321	45407	16815	17664	42666	21788	20316
8	6328	4370	9353	13962	23358	31821	3274	7442	9933	8418	19361
9	19130	2523	2617	4051	5659	9408	10974	3508	4267	2883	4130
10	4499	5607	1535	735	1521	1227	1785	3196	1311	709	1006
11	677	2127	1928	558	610	913	427	678	882	271	296
12	195	322	575	442	271	446	103	79	109	261	89
13	81	151	231	139	122	748	59	24	37	27	122
14	59	35	15	26	92	46	36	26	3	5	19
15+	55	62	37	55	54	51	45	8	1	5	13
TOTAL	547596	807865	496126	465946	490751	359669	200224	175669	135440	132755	95174

Table 15. VIRTUAL POPULATION ANALYSIS

## NORTH-EAST ARCTIC COD

## FISHING MORTALITY COEFFICIENT

## NATURAL MORTALITY COEFFICIENT = 0.20

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
3	0.056	0.066	0.031	0.017	0.023	0.040	0.030	0.024	0.023	0.041	0.021	0.039
4	0.271	0.305	0.236	0.144	0.111	0.104	0.152	0.207	0.221	0.142	0.103	0.167
5	0.493	0.648	0.738	0.352	0.389	0.212	0.181	0.408	0.481	0.382	0.228	0.298
6	0.516	0.823	0.999	0.481	0.445	0.375	0.202	0.467	0.571	0.571	0.238	0.384
7	0.527	0.607	0.962	0.509	0.597	0.465	0.427	0.401	0.768	0.619	0.218	0.314
8	0.686	0.654	0.873	0.710	0.515	0.560	0.668	0.520	0.927	0.637	0.328	0.667
9	0.732	0.800	0.935	1.047	0.690	0.680	0.655	0.764	1.132	0.959	0.930	1.117
10	0.780	0.963	1.293	0.833	0.770	0.709	0.708	0.775	0.949	0.970	0.771	1.222
11	0.929	0.808	1.533	1.059	0.734	0.460	0.362	0.525	1.128	0.636	0.639	1.216
12	0.998	0.810	0.910	0.864	0.431	0.610	0.389	0.355	0.682	0.432	0.461	0.704
13	0.715	0.673	0.621	1.145	1.052	0.606	0.364	1.131	0.721	0.466	0.474	0.768
14	0.500	0.500	0.490	0.810	0.960	0.370	0.759	0.740	0.680	0.540	0.340	0.910
15+	0.500	0.500	0.490	0.810	0.960	0.370	0.759	0.740	0.680	0.540	0.340	0.910

( 5-1000

0.667

1953

1982

1951

1980

1979

1978

1977

1976

1975

1974

1973

( 5-1000

1953

1982

1951

1980

1979

1978

1977

1976

1975

1974

1973

( 5-1000

1953

1982

1951

1980

1979

1978

1977

1976

1975

1974

1973

( 5-1000

1953

1982

1951

1980

1979

1978

1977

1976

1975

1974

1973

( 5-1000

1953

1982

1951

1980

1979

1978

1977

1976

1975

1974

1973

( 5-1000

1953

1982

1951

1980

1979

1978

1977

1976

1975

1974

1973

( 5-1000

1953

1982

1951

1980

1979

1978

1977

1976

1975

1974

1973

( 5-1000

1953

1982

1951

1980

1979

1978

1977

1976

1975

1974

1973

( 5-1000

1953

1982

1951

1980

1979

1978

1977

1976

1975

1974

1973

( 5-1000

1953

1982

1951

1980

1979

1978

1977

1976

1975

1974

1973

( 5-1000

1953

1982

1951

1980

1979

1978

1977

1976

1975

1974

1973

( 5-1000

1953

1982

1951

1980

1979

1978

1977

1976

1975

1974

1973

( 5-1000

1953

1982

1951

1980

1979

1978

1977

1976

1975

1974

1973

( 5-1000

1953

1982

1951

1980

1979

1978

1977

1976

1975

1974

1973

( 5-1000

1953

1982

1951

1980

1979

1978

1977

1976

1975

1974

1973

( 5-1000

1953

1982

1951

1980

1979

1978

1977

1976

1975

1974

1973

( 5-1000

1953

1982

1951

1980

1979

1978

1977

1976

1975

1974

1973

( 5-1000

1953

1982

1951

1980

1979

1978

1977

1976

1975

1974

1973

( 5-1000

1953

1982

1951

1980

1979

1978

1977

1976

1975

1974

1973

( 5-1000

1953

1982

1951

1980

1979

1978

1977

1976

1975

1974

1973

( 5-1000

1953

1982

1951

1980

1979

1978

1977

1976

1975

1974

1973

( 5-1000

1953

1982

1951

1980

1979

1978

1977

1976

1975

1974

1973

( 5-1000

1953

1982

1951

1980

1979

1978

1977

1976

1975

1974

1973

( 5-1000

1953

1982

1951

1980

1979

1978

1977

1976

1975

1974

1973

( 5-1000

1953

1982

1951

1980

1979

1978

1977

1976

1975

1974

1973

Table 16. VIRTUAL POPULATION ANALYSIS

NORTH-EAST ARCTIC COD

STOCK SIZE IN NUMBERS UNIT: THOUSANDS

BIOHAZS TOTALS UNIT: TONNES

ALL VALUES ARE GIVEN FOR 1 JANUARY

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
3	919213	731060	473648	338965	778297	1583541	1293234	170103	112218	197121	405034	1015782
4	613527	211544	560267	375876	272737	623016	1245998	1027772	135920	89793	194922	324612
5	347203	383017	429262	362442	266366	199856	459904	875976	684297	89191	63790	114450
6	138919	173646	164112	168003	208774	147805	132414	314183	476723	346502	49853	41380
7	103444	67909	62439	49489	85058	109496	82326	83550	161273	228039	160351	22244
3	38168	50000	30293	19535	22940	46606	50326	44222	48539	61248	100490	78182
9	12166	15779	21279	19357	7815	11224	21765	23657	21523	15728	21704	35933
10	15627	4792	5785	6840	2977	3211	4654	7730	9024	5681	4933	7011
11	9937	5112	1498	1300	2434	1129	1244	1734	3065	2859	1762	1868
12	2372	3230	1805	323	369	957	383	447	831	612	1239	762
13	1942	873	1176	615	112	185	423	196	257	511	432	640
14	779	364	364	516	160	32	83	146	51	102	160	220
15+	300	236	444	257	315	248	29	96	102	92	95	73
TOTAL NO	2202107	2147976	1752431	1334525	1648355	2727566	3299637	2554768	1653627	1034479	964467	1653556
SPS NO	251336	247602	222671	179724	198913	227021	280428	271742	415071	353995	246295	170312
TOT. BIOM	2955283	2900074	2513295	1966201	2169400	3028463	3956433	3980021	3419435	2427779	1370436	2052059
SPS BIOM	911950	613222	703287	541209	603044	721896	820767	1027839	1216953	1217565	1004527	736458

SPS NO	41553	34786	28060	19063	19545	28276	31330	32183	39520	54773	52592	43566
SPS BIOM	284067	222143	181252	119742	107899	147768	175059	185914	222216	257826	270861	256070

continued..

Table 16. (ctd)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
3	1820750	524765	623542	622452	277001	691559	241407	179927	179554	107697	30357	*****
4	799572	1225740	540957	469662	452740	272968	493150	139824	143767	144175	80099	24562
5	224845	536244	611658	230234	231774	203573	182014	335824	140056	109177	99170	60538
6	69535	129306	256591	297791	116308	109050	87410	110255	201107	95932	71927	61565
7	23192	38511	63760	104203	138000	48358	38053	42951	54383	107752	53244	39474
8	19232	12486	20204	25841	42562	57752	16957	16017	19305	25029	50037	25403
9	32841	8744	6306	8190	8727	14075	15963	6962	6956	7001	12946	25636
10	9024	9886	4567	2823	5093	2132	3199	5771	2200	1909	3153	6895
11	1691	3863	3108	2346	1472	1175	655	1031	1661	637	926	1679
12	453	778	1270	334	1419	659	160	158	284	753	279	494
13	309	197	349	526	289	918	145	40	59	102	582	149
14	243	180	28	81	306	128	97	66	11	15	60	204
15+	226	134	70	166	180	156	115	20	4	15	41	53
TOTAL NO	3002614	2490434	1938411	1765154	1404369	1402283	1089531	888847	749900	600195	402623	
SPS NO	150700	216851	238960	250989	228916	167949	133580	135157	151598	151179	138508	
TOT. B10M	2973653	3072187	2740661	2525102	2182405	1368813	1507906	1409870	1309369	1171901	965423	
SPS B10M	548464	556839	657318	739546	745058	592940	419896	404296	463594	509099	535322	

2

SPS NO	30927	23906	25404	29834	57260	50646	37157	31416	76750	93251	73946	
SPS B10M	196833	152849	137524	146538	247418	239690	167641	138765	257610	336701	509791	

Table 17. North-East Arctic COD.  
Input data for the catch projections.

LIST OF INPUT VARIABLES BY AGE GROUP:

AGE	1984 Stock Size S ('000)	F-Pattern	N	MATURITY OGIVE ALT. 1	MATURITY OGIVE ALT. 2	WEIGHT IN THE STOCK AND THE CATCH
3	30000.00	0.0500	0.200	0.0100	0.0000	0.6500
4	24362.00	0.1800	0.200	0.0800	0.0200	1.0000
5	60536.00	0.6400	0.200	0.4000	0.0500	1.5500
6	61365.00	0.9100	0.200	0.3000	0.1500	2.3500
7	39674.00	0.9100	0.200	0.7500	0.3500	3.4500
8	25603.00	1.2600	0.200	0.8800	0.5100	4.7000
9	25635.00	1.2600	0.200	0.9700	0.7100	6.1700
10	6595.00	1.0000	0.200	1.0000	0.8600	7.7000
11	1679.00	1.0000	0.200	1.0000	0.9500	9.2500
12	694.00	1.0000	0.200	1.0000	0.9400	10.8500
13	149.00	0.8000	0.200	1.0000	0.9900	12.5000
14	204.00	0.8000	0.200	1.0000	1.0000	13.9000
15+	53.00	0.8000	0.200	1.0000	1.0000	15.0000

Recruitment (age 3) 1985 400 million  
1986 900 million

Table 18. North-East Arctic COD. Spawning stock biomass from maturity ogives and recruitment at age 3; originating from the spawning stock for 1946 to 1977 (80).

Year	$\times 10^3$ t		$\times 10^3$ nos.		Year	$\times 10^3$ t		$\times 10^3$ nos.	
	Sp.stock Alt. 1	Sp.stock Alt. 2	Sp.stock Alt. 1	Recruitment		Sp.stock Alt. 1	Sp.stock Alt. 2	Sp.stock Alt. 1	Recruitment
1946	2 810	1 244		468	1965	541	97		170
1947	2 269	1 073		710	1966	680	139		112
1948	1 907	843		1 090	1967	727	154		197
1949	1 718	621		1 192	1968	983	178		405
1950	1 686	549		1 593	1969	1 116	194		1 016
1951	1 640	463		644	1970	1 185	251		1 821
1952	1 244	327		273	1971	1 123	303		525
1953	1 153	322		440	1972	794	276		624
1954	1 221	293		805	1973	626	225		622
1955	1 493	307		497	1974	572	157		377
1956	1 583	312		685	1975	592	124		692
1957	1 296	289		791	1976	757	149		241
1958	1 151	307		919	1977	740	245		180
1959	951	346		731	1978	595	240		(180)
1960	851	295		474	1979	450	180		(108)
1961	827	258		339	1980	393	135		(30)
1962	746	204		778	1981	512	283		
1963	554	142		1 564	1982	548	366		
1964	443	98		1 293	1983	565	328		



**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*	17 869	2	29 381	47 252

\* Provisional figures.

EXPECTED CATCHES

1983	13 000	-	14 000	27 000
------	--------	---	--------	--------

Table 20. North-East Arctic Haddock. Nominal catches (tonnes) by countries. (Sub-area I and Divs. IIa and IIb combined).  
(Data provided by Working Group members.)

38

Year	Faroe Islands	France	German Dem. Rep.	Germany Fed. Rep.	Norway	Poland	U.K.	USSR	Others	Total
1960	172	-	-	5 597	47 263	-	45 469	57 025	125	155 651
1961	295	220	-	6 304	60 862	-	39 650	85 345	558	193 234
1962	83	409	-	2 895	54 567	-	37 486	91 910	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	36 716	-	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	434	32 408	186 534	2 501	322 626
1974	925	3 601	454	23 409	66 164	3 045	37 663	78 548 <sup>1)</sup>	7 348	221 157
1975	299	5 191	437	15 930	55 966	1 080	28 677	65 015 <sup>1)</sup>	3 163	175 758
1976	537	4 459	348	16 660	49 492	986	16 940	42 485 <sup>1)</sup>	5 358	137 265
1977	213	1 510	144	4 798	40 118	-	10 878	52 210 <sup>1)</sup>	287	110 158
1978	466	1 411	369	1 521	39 955	1	5 766	45 895 <sup>1)</sup>	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	350	-	1 258	41 421	-	827	2 900	-	47 252

\* 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 <sup>1)</sup>	U.K. <sup>2)</sup>	Norway <sup>1)</sup>	U.K. <sup>2)</sup>	Norway <sup>1)</sup>	U.K. <sup>2)</sup>
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		16		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				0.15	

\*) Projected figures

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

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

Table 22. VIRTUAL POPULATION ANALYSIS

## NORTH-EAST ARCTIC HADDOCK

CATCH IN POUNDS UNIT: THOUSANDS

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
3	15430	39604	28567	22305	5911	26157	15918	657	1520	23004	1979	230229
4	50539	30947	12995	49162	46161	22469	41373	6632	1963	2608	24559	22246
5	63334	49028	19035	50592	40052	62724	13505	41267	44526	1870	1238	42849
6	8706	33922	13627	5800	12378	23840	25736	7748	18956	21995	918	3196
7	5276	3209	9290	5219	1627	5711	6876	15599	5011	7948	9279	1000
8	4407	1244	1243	2709	970	578	1617	5292	4925	1974	3056	6736
9	687	1773	561	832	893	435	213	055	1624	1978	826	2050
10	527	245	409	104	122	188	176	182	315	726	103	896
11	1277	247	79	206	204	166	155	101	43	106	369	988
12	67	482	84	234	123	25	76	115	43	26	130	538
13	60	20	169	121	14	6	27	18	14	52	27	53
14+	20	8	41	67	205	7	7	19	2	19	4	42
TOTAL	155082	160832	146100	115651	108885	147328	107636	139283	67542	62166	43248	312009

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
3	70204	9684	10037	13989	59967	47311	17540	627	486	881	502
4	25873	41701	16089	13449	22043	18812	35290	22878	2561	899	2125
5	24019	8811	33871	6808	7369	4076	10645	21794	22124	3373	775
6	6812	3827	49712	25789	2386	1389	1429	2971	10685	12302	1768
7	478	4138	2135	40044	7781	1626	812	250	1034	2646	4335
8	422	382	1236	1247	11043	2556	546	504	162	346	1624
9	1640	617	92	1349	311	6215	1466	230	162	75	55
10	525	2043	131	195	368	162	2310	842	72	82	42
11	146	935	500	279	96	758	181	1299	530	94	39
12	340	276	147	652	101	3	87	111	564	322	20
13	68	458	53	331	84	74	2	35	27	207	33
14+	13	143	92	46	98	65	53	15	42	34	114
TOTAL	363479	154315	112095	99176	107866	82587	70361	51556	38249	21261	11410

Table 23. VIRTUAL POPULATION ANALYSIS

## NORTH-EAST ARCTIC HADDOCK

## FISHING MORTALITY COEFFICIENT

NATURAL MORTALITY COEFFICIENT = 0.20

	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
41												
3	0.169	0.200	0.122	0.080	0.067	0.126	0.062	0.037	0.102	0.168	0.023	0.283
4	0.484	0.595	0.680	0.317	0.235	0.388	0.300	0.402	0.149	0.232	0.268	0.378
5	0.691	1.048	0.935	0.690	0.462	0.575	0.427	0.554	0.506	0.207	0.184	1.059
6	0.706	1.043	0.992	0.859	0.690	0.722	0.494	0.467	0.536	0.506	0.148	0.962
7	0.720	0.620	0.956	0.770	0.655	0.800	0.510	0.639	0.415	0.452	0.416	0.416
8	0.820	0.663	0.523	0.843	0.497	0.497	0.554	0.660	0.425	0.420	0.314	0.609
9	0.626	0.973	0.652	0.620	0.772	0.436	0.353	0.457	0.433	0.302	0.311	0.488
10	0.455	0.400	0.633	0.235	0.261	0.359	0.315	0.562	0.417	0.351	0.258	0.656
11	0.751	0.400	0.218	0.780	0.990	0.798	0.568	0.301	0.247	0.405	0.303	0.414
12	0.304	0.719	0.230	1.953	1.883	0.295	0.937	1.160	0.202	0.232	0.645	0.979
13	0.600	0.600	0.600	0.600	0.600	0.600	0.600	0.600	0.400	0.400	0.400	0.600
14+	0.600	0.600	0.600	0.600	0.600	0.600	0.600	0.600	0.400	0.400	0.400	0.600
( 4- 7)0	0.650	0.827	0.691	0.659	0.511	0.621	0.433	0.516	0.402	0.350	0.254	0.704
	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	
3	0.335	0.221	0.254	0.319	0.768	0.325	0.124	0.031	0.076	0.055	0.040	
4	0.593	0.341	0.576	0.635	1.245	0.646	0.430	0.237	0.169	0.197	0.180	
5	0.912	0.411	0.514	0.615	0.893	0.826	0.977	0.518	0.378	0.350	0.260	
6	0.466	0.594	0.432	0.697	0.502	0.408	0.600	0.836	0.522	0.374	0.500	
7	0.372	0.573	0.453	0.752	0.619	0.691	0.445	0.306	0.811	0.234	0.220	
8	0.182	0.499	0.333	0.524	0.476	0.431	0.527	0.553	0.333	0.716	0.220	
9	0.297	0.437	0.212	0.742	0.237	0.543	0.465	0.442	0.343	0.254	0.220	
10	0.167	0.712	0.154	0.913	0.491	0.187	0.398	0.536	0.240	0.292	0.220	
11	0.206	0.502	0.374	0.564	2.207	0.719	0.326	0.409	0.416	0.563	0.220	
12	0.244	0.741	0.134	1.244	0.409	0.582	0.570	0.343	0.312	0.940	0.220	
13	0.300	0.600	0.300	0.500	0.500	0.600	0.475	0.475	0.130	0.180	0.220	
14+	0.300	0.600	0.300	0.500	0.500	0.600	0.475	0.475	0.130	0.180	0.220	
( 4- 7)0	0.570	0.480	0.494	0.675	0.815	0.643	0.663	0.474	0.470	0.289	0.240	

Table 24. VIRTUAL POPULATION ANALYSIS  
NORTH-EAST ARCTIC HADDOCK

STOCK SIZE IN HUNDREDS		UNIT: THOUSANDS											
BIOMASS TOTALS		UNIT: TONNES											
ALL VALUES ARE GIVEN FOR 1 JANUARY													
		1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972
5	109031	240750	274171	320366	100064	742598	291101	19783	17210	164106	96811	1025261	
4	162273	75409	161452	198718	242173	76591	175043	223969	15604	12720	113621	77475	
3	135505	81904	34056	80980	118519	156736	42541	106124	122652	11006	6247	71120	
6	18754	56815	23518	10949	27515	61148	72202	22716	49948	60558	7328	5619	
7	7599	7581	16389	7145	3798	11754	24319	36055	11653	23921	29877	3172	
8	8577	3078	3357	5156	2709	1615	4155	11958	15576	6501	12458	16137	
9	1846	3594	1273	1619	584	684	306	1954	5062	8335	3568	7454	
10	1579	808	952	545	595	368	714	463	1013	2688	5046	2032	
11	2055	871	445	414	535	368	591	427	216	247	1548	3193	
12	132	1025	450	292	155	107	130	181	258	138	299	936	
13	145	48	409	293	34	19	65	44	47	173	90	128	
14+	48	19	99	162	496	17	17	46	7	63	13	102	
TOTAL NO	451196	471302	516555	612639	498208	552579	611408	425720	239275	290250	278737	1214036	
SPS NO	71408	68174	49695	45803	63378	86524	84404	94209	87591	74432	60348	57422	
TOT. BIOD	612468	576985	540327	615722	629430	713770	713582	644190	477595	422987	385977	1027509	
SFS BIOD	160651	165053	122500	102474	130604	190294	202135	227123	220967	210596	180267	167858	

continued...

Tabel 24. (ctd)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
3	270479	53613	49197	56336	113706	187051	164991	22835	7291	18303	14116	*****
4	632412	158383	55179	51250	53473	43171	110636	119271	16150	5531	14190	11104
5	43461	286291	92215	16195	13562	7890	16532	58928	77066	12537	3719	9704
6	20187	14209	15542	45161	7171	4545	2627	5709	28726	45255	7255	2548
7	1759	10367	6421	82597	18409	3554	2475	1040	2027	13950	24354	4388
8	2794	1064	4785	3343	31375	8115	1453	1298	527	738	9040	16002
9	7183	1907	529	2807	1620	16217	4316	795	612	368	295	5940
10	3746	4375	1008	550	1095	1047	7715	2219	571	555	234	194
11	883	2594	1758	707	115	549	711	4242	1063	239	217	154
12	1728	575	1286	990	330	10	219	420	2507	574	111	143
13	282	1109	224	921	234	179	6	101	244	1382	184	73
14+	55	340	390	128	273	157	153	43	379	227	635	536
TOTAL NO	984967	534835	348335	240687	221843	272485	314036	216812	138842	97439	74330	
SPS NO	70469	102370	120356	111088	59717	35621	20017	32460	41251	42219	37366	
TOT. RIOT	1031909	833180	667076	483358	327291	300262	331240	303495	267623	205580	158041	
SPS BIOM	151395	228699	296795	314255	184334	116867	84438	83667	105931	117609	112661	

Table 25. 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 (Logrithmic) All areas	Virtual population No. of 3 year olds x 10 <sup>-6*</sup>
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	114
1975	96	0.60	187
1976	13	0.38	165
1977	1	0.33	23
1978	<1	0.12	( 7)
1979	<1	0.20	(18)
1980	<1	0.15	(14)
1981	(<1)	0.03	
1982		0.38	
1983		0.62	

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



Table 26. 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
	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973	
1981			0.5	4.8	2.3	9.5	2.0	0.1	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	514.5	5.7	4.1	3.0	1.9	2.3	3.9	1.0			337.6

Table 27. North-East Arctic HADDOCK.  
Input data for catch projections.

LIST OF INPUT VARIABLES BY AGE GROUP:

AGE	1984 Stock Size (1 000)	F-PATTERN	M	MATURITY OGIVE	WEIGHT IN THE CATCH	WEIGHT IN THE STOCK
3	20000.00	0.1700	0.200	0.0000	0.0000	0.0000
4	11104.00	0.7500	0.200	0.0500	1.0300	1.0300
5	9704.00	0.9000	0.200	0.2300	1.7900	1.7900
6	2342.00	1.7800	0.200	0.5300	2.3800	2.3800
7	4353.00	1.2500	0.200	0.6600	2.6000	2.6000
8	16002.00	1.0000	0.200	0.9800	3.3300	3.3300
9	5940.00	0.9000	0.200	1.0000	3.7000	3.7000
10	194.00	0.9000	0.200	1.0000	4.4100	4.4100
11	154.00	0.9000	0.200	1.0000	5.4000	5.4000
12	143.00	0.9000	0.200	1.0000	6.7000	6.7000
13	73.00	0.9000	0.200	1.0000	7.4000	7.4000
14+	558.00	0.9000	0.200	1.0000	8.0000	8.0000

Recruitment (age 3) 1985 165 million

Figure 1 North-East Arctic Cod. Fishing mortalities on 8-12 years old generated by years other than trawl (Danish seine, gill net, long and hand line).

Fishing mortality  
(8-12 years)

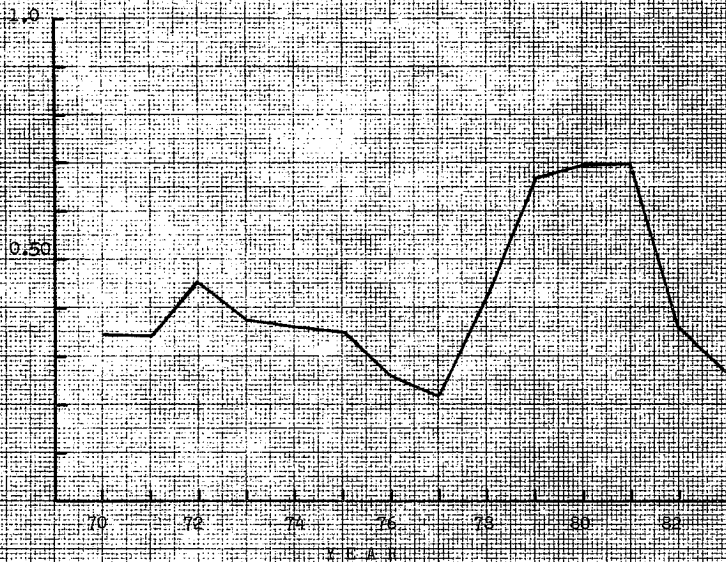


Figure 2 North-East Arctic COD. Fishing mortality generated by Norwegian trawlers in Sub-area I on the 5 years old versus effort by the same fleet (in Norwegian units) in this area.

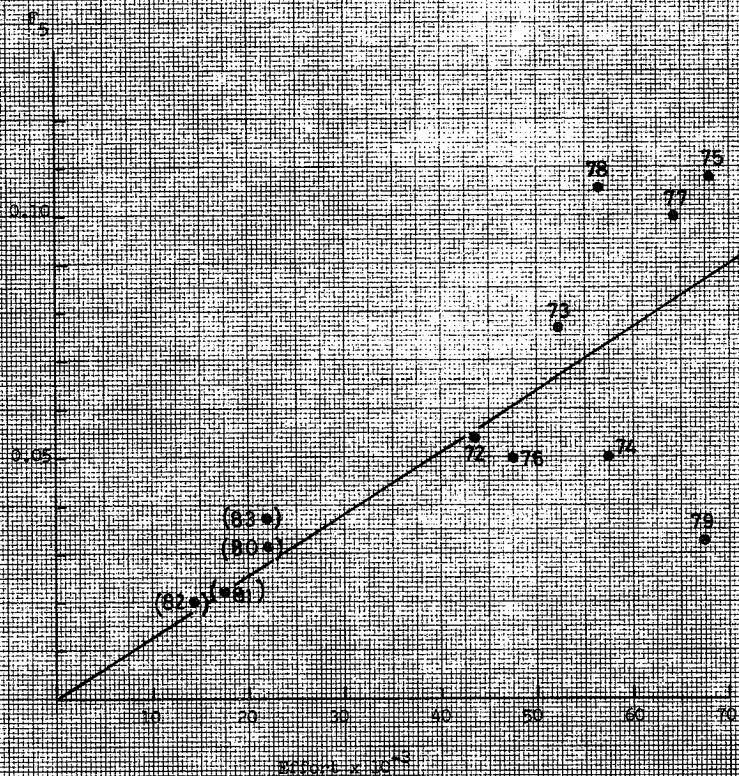


Figure 3 North-East Arctic COD. Fishing mortality generated by Norwegian trawlers in Sub-area 1 on the 6 years old versus effort by the same fleet (in Norwegian units) in this area. The upper value for 1983 is the one implied by using the estimate from the acoustic survey in 1982.

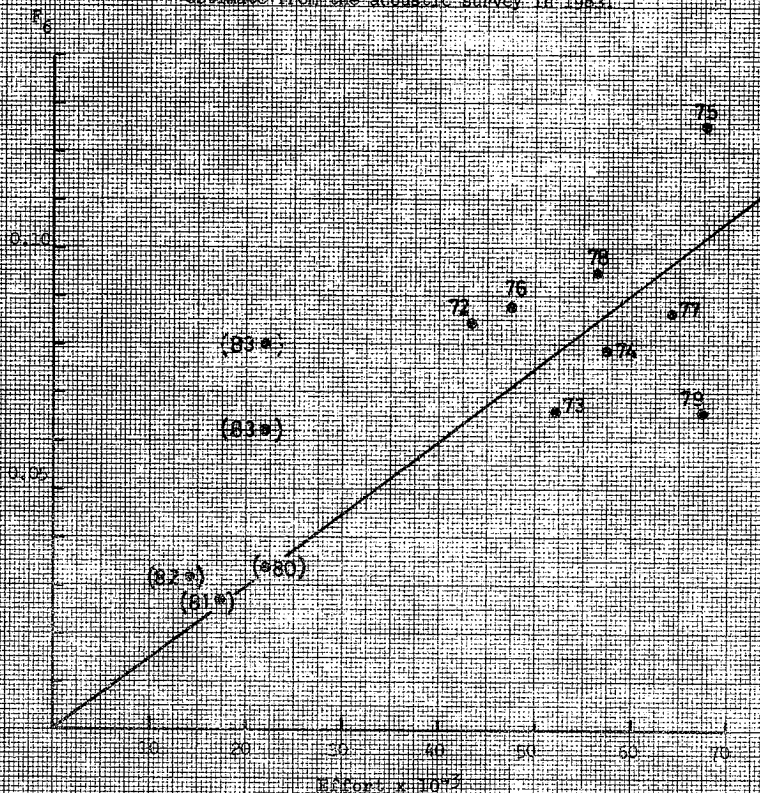
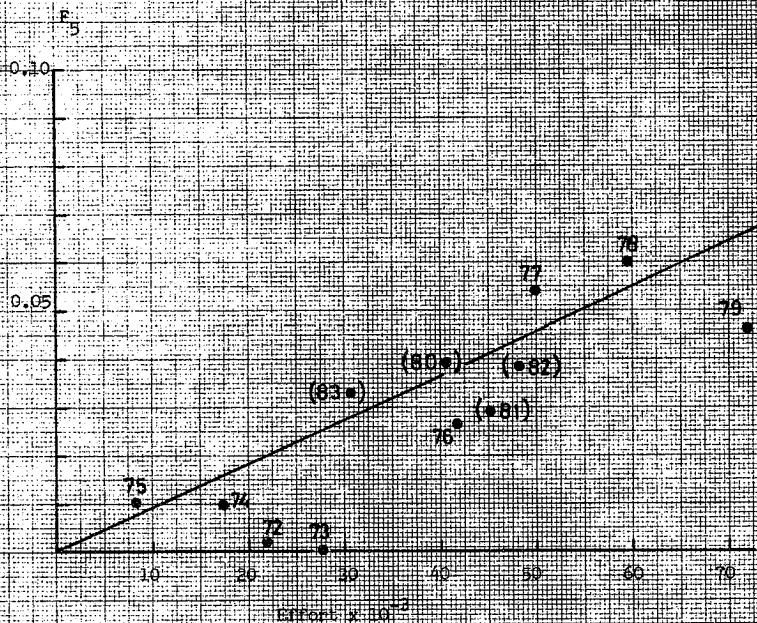


Figure 4 North-East Arctic Cod. Fishing mortality generated by Norwegian trawlers in Division III on 5 years old versus effort by the same fleet in Norwegian units in this area.





**Figure 5** North-East Arctic COD. Fishing mortality generated by Norwegian trawlers in Division IIIa on 6 years old versus effort by the same fleet (in Norwegian units) in this area. The upper value for 1983 is the one implied by using the estimate from the acoustic survey in 1983.

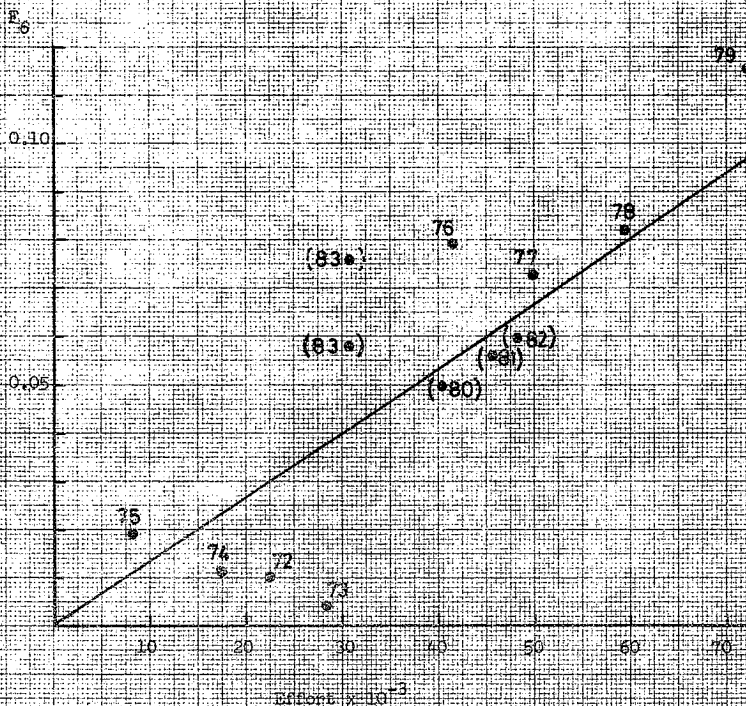


Figure 6 North-East Arctic COW. Fishing mortality generated by Norwegian trawlers in Division IIA on 7 years old versus effort by the same fleet (in Norwegian units) in this area. The upper value for 1973 is the one implied by using the estimate from the acoustic survey in 1973.

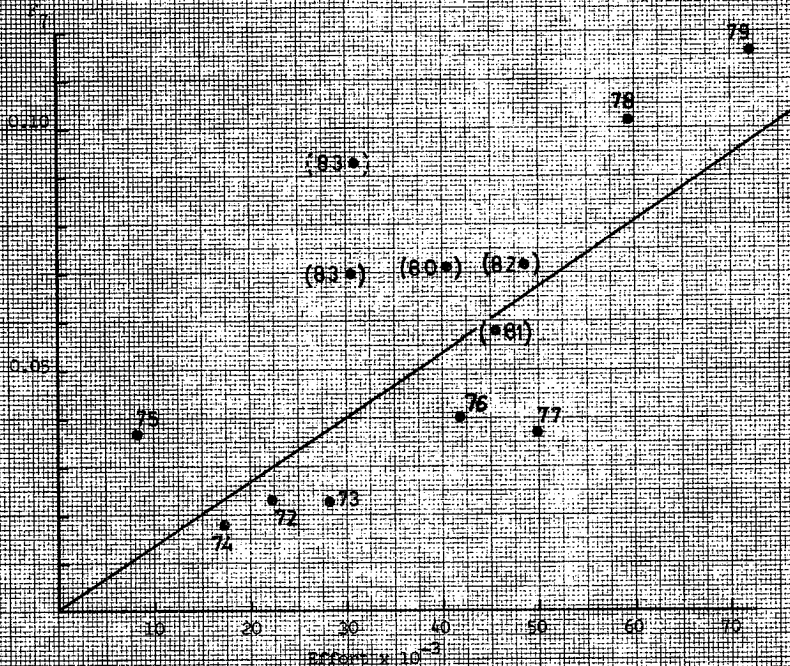




Figure 7 North-East Arctic COD. Fishing mortality generated by Norwegian trawlers in Division 11a on 8 years old versus effort by the same fleet (in Norwegian units) in this area.

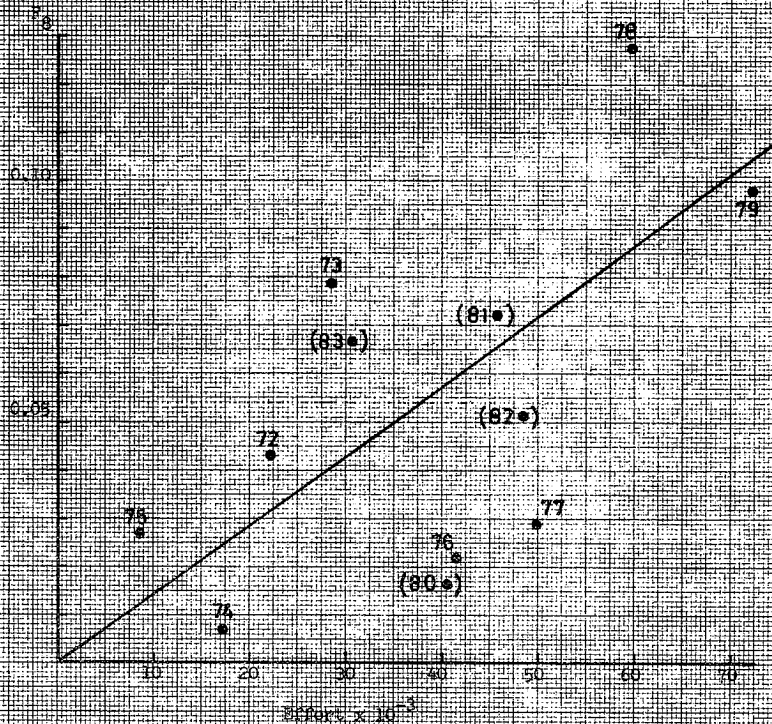


Figure 8. NORTH-EAST ARCTIC OOD. The logarithm of the numbers of 3 years old from the TPA versus the logarithmic O-group survey index.

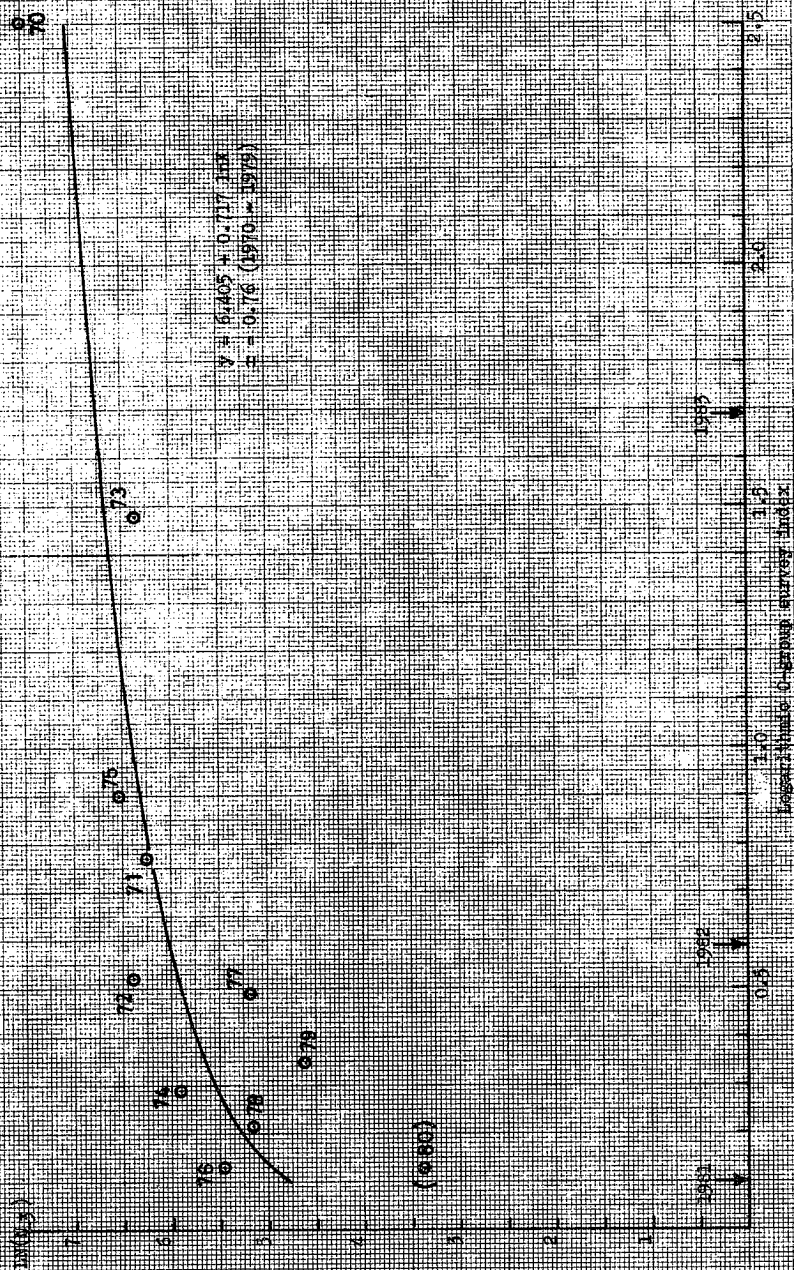


Figure 9. NORTH EAST ARCTIC COD

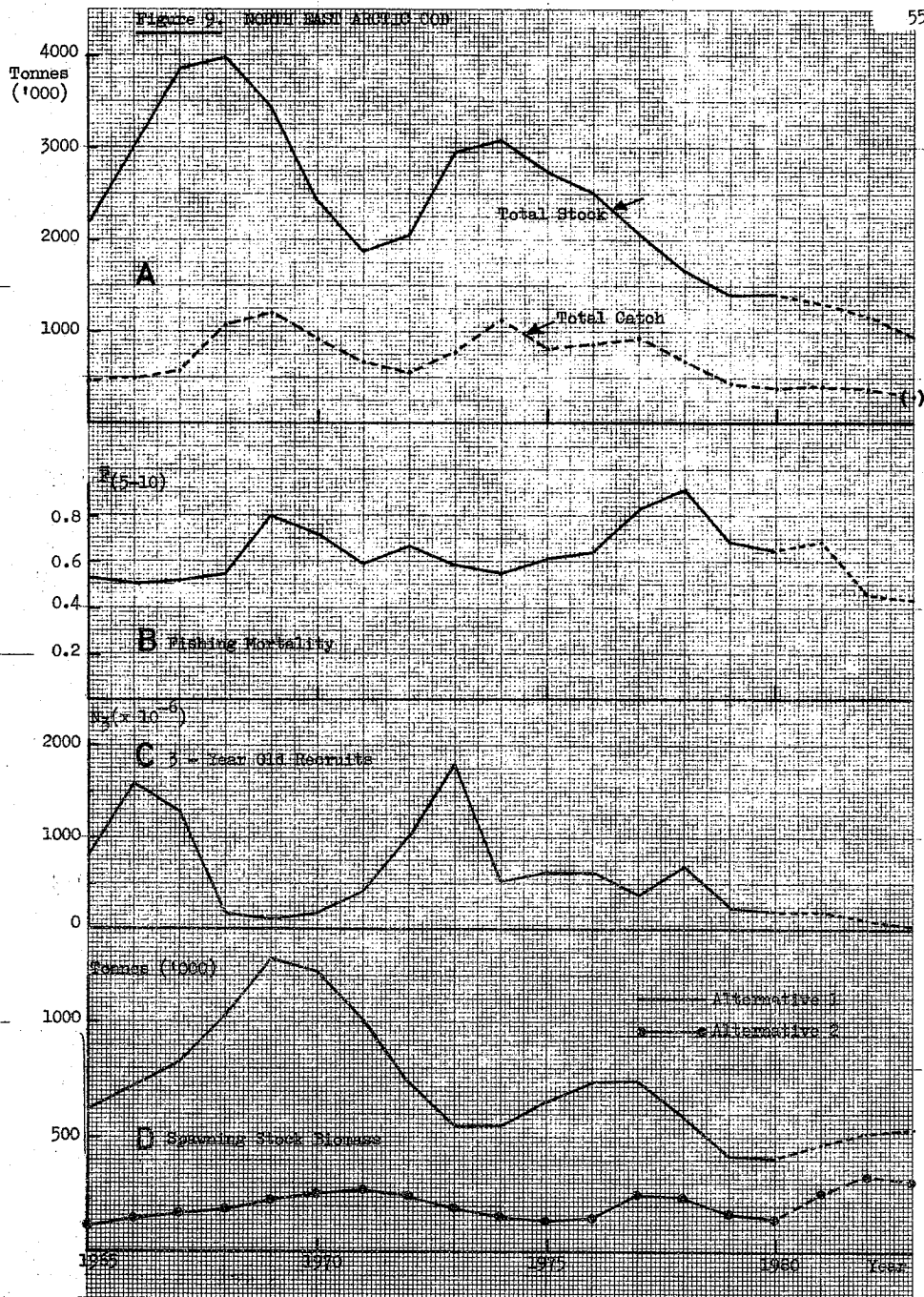
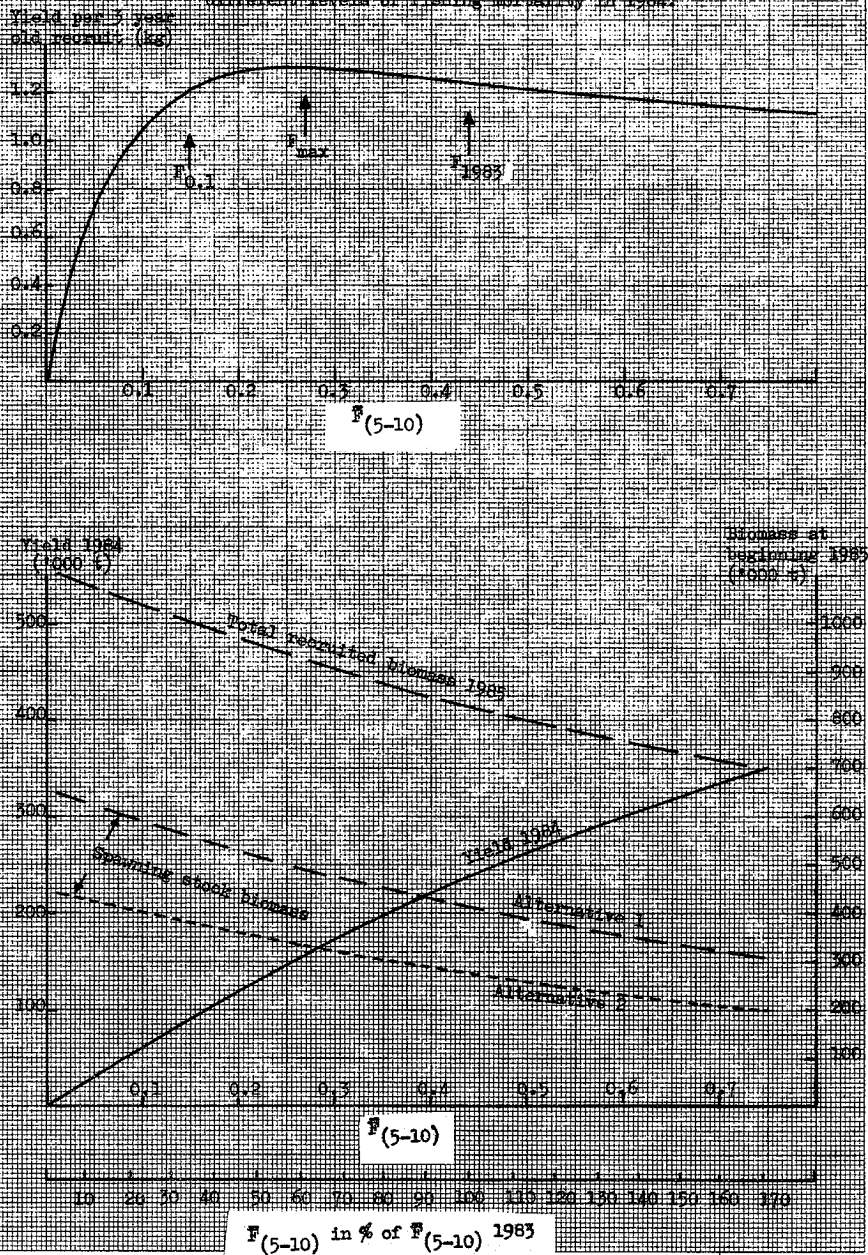


Figure 10. NORTH-EAST ARCTIC COD. Y/N. Yield 1984, total recruited biomass (age 3+) and spawning stock biomass at beginning of 1985 for different levels of fishing mortality in 1984.



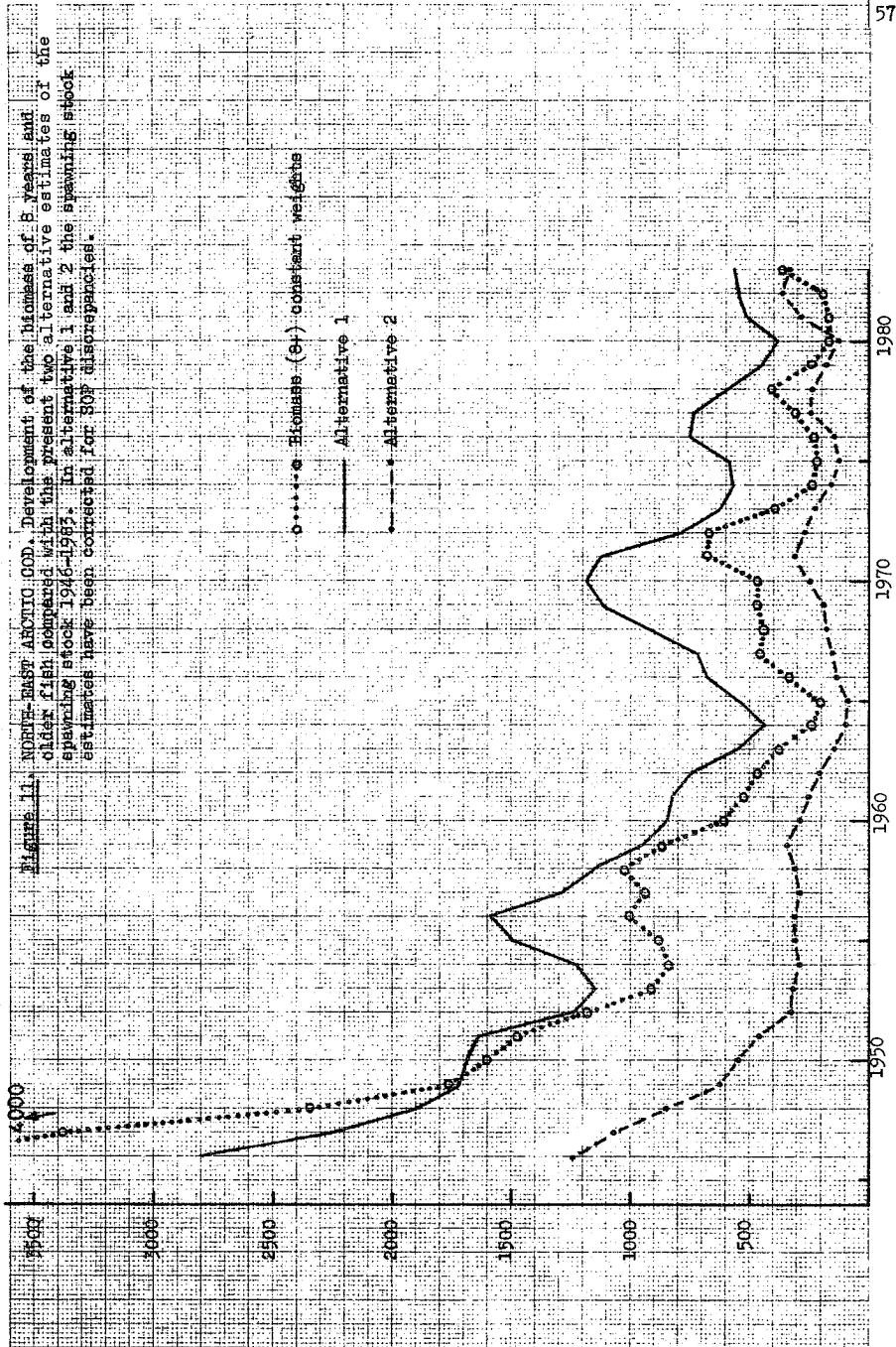


Figure 12. NORTH-EAST ARCTIC COD. Spawning stock versus recruitment at age 3, year classes 1946-77 (SSB from Norwegian maturity ogive, corrected for SGP discrepancies).

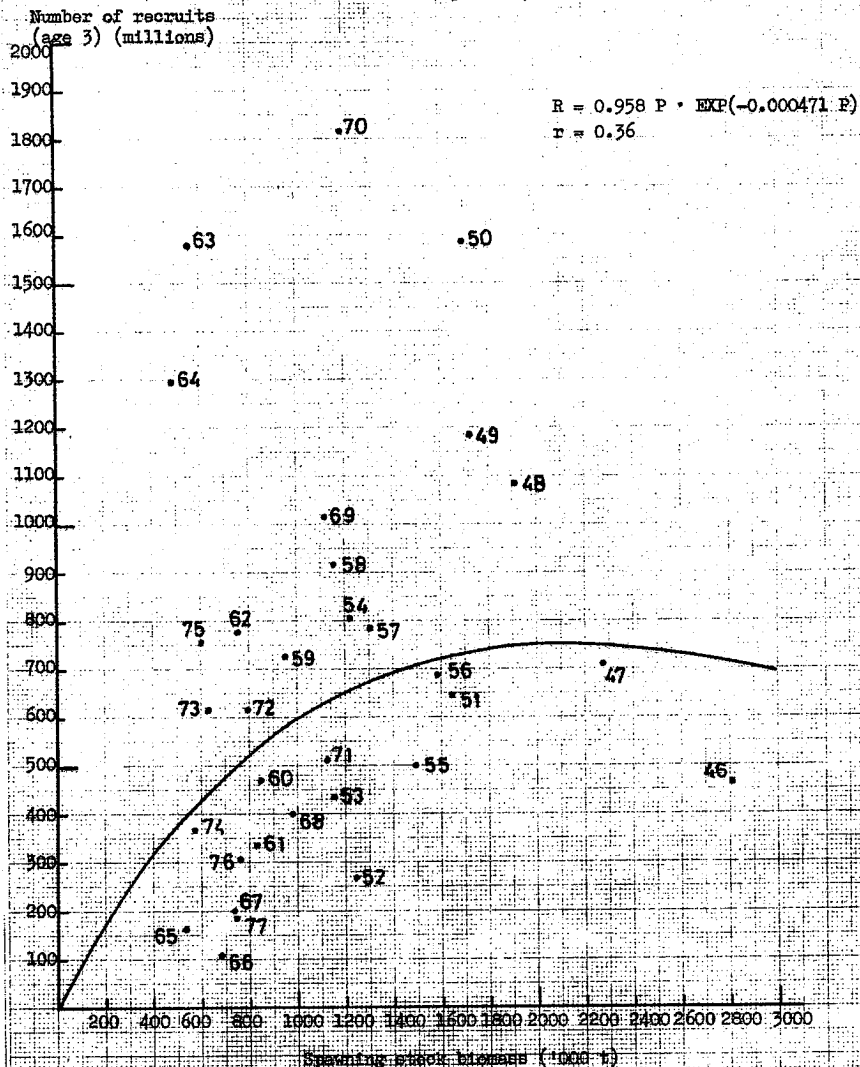




Figure 13. NE-Arctic COD. Spawning stock  
versus recruitment at age 3, year  
classes 1946-76.

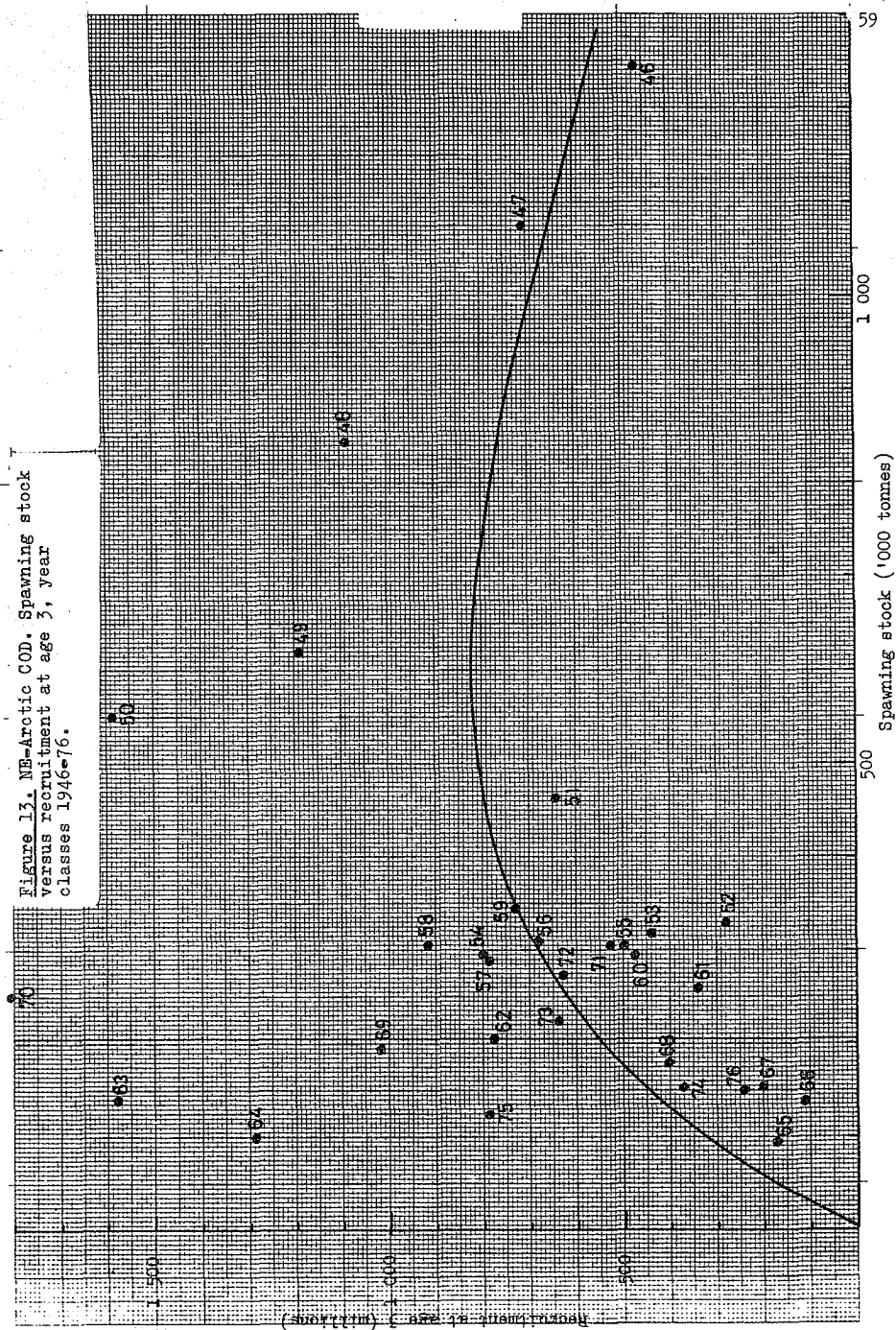


Figure 14. NORTH-EAST ARCTIC COD and HADDOCK. The fishing mortalities generated on COD (6-7 years old) in Division IIa and HADDOCK (5-7 years old) in Sub-area II. Both sets of data refer to Norwegian trawlers for the years 1967-83.

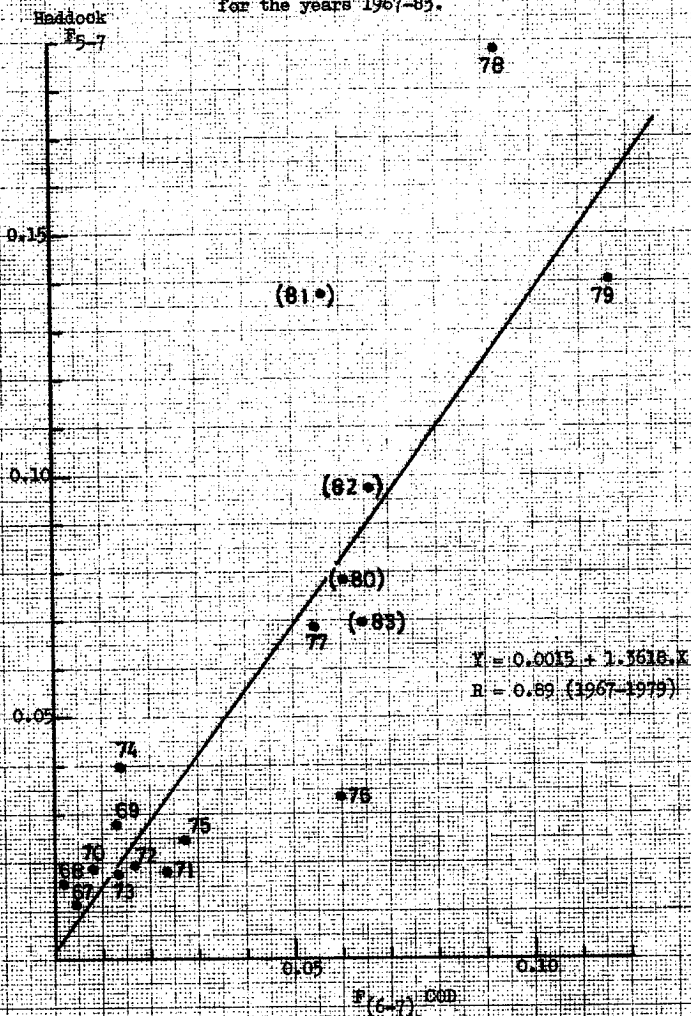
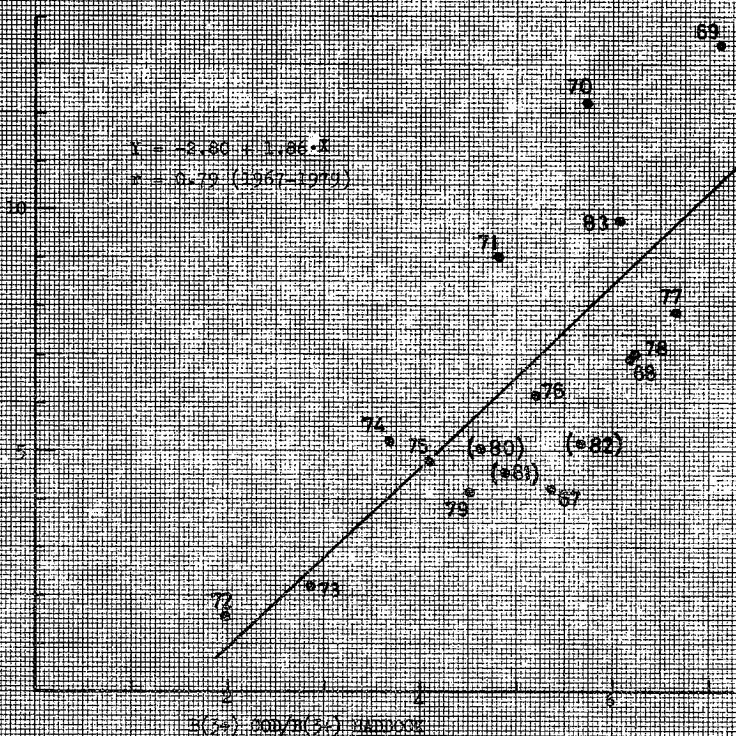




Figure 15. NORTH-EAST ARCTIC COD and HADDOCK. Total international trawl catch ratio versus biomass ratio (34) for the years 1967-1983.

Trawl catch ratio in tonnes  
(COD/HADDOCK)



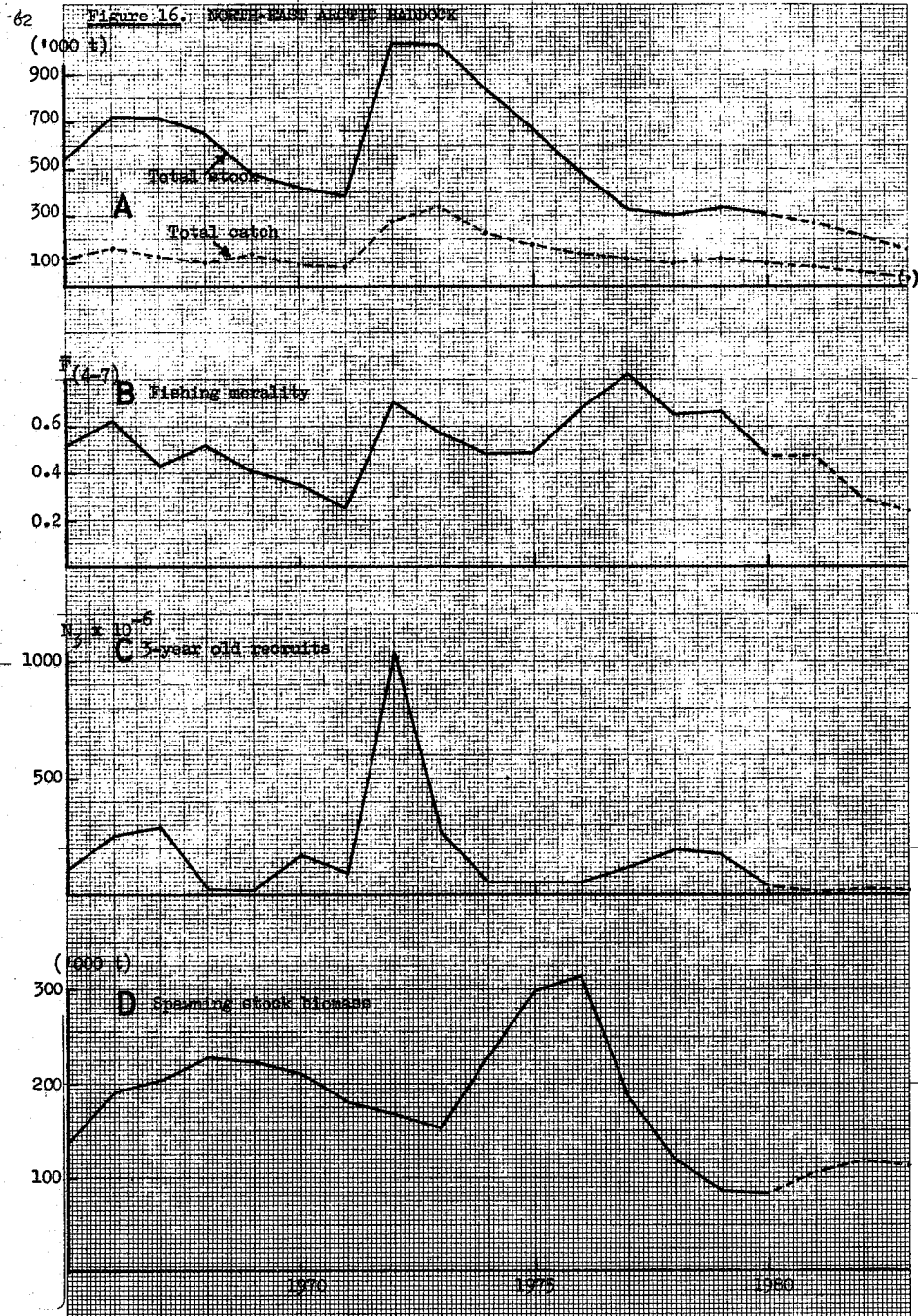
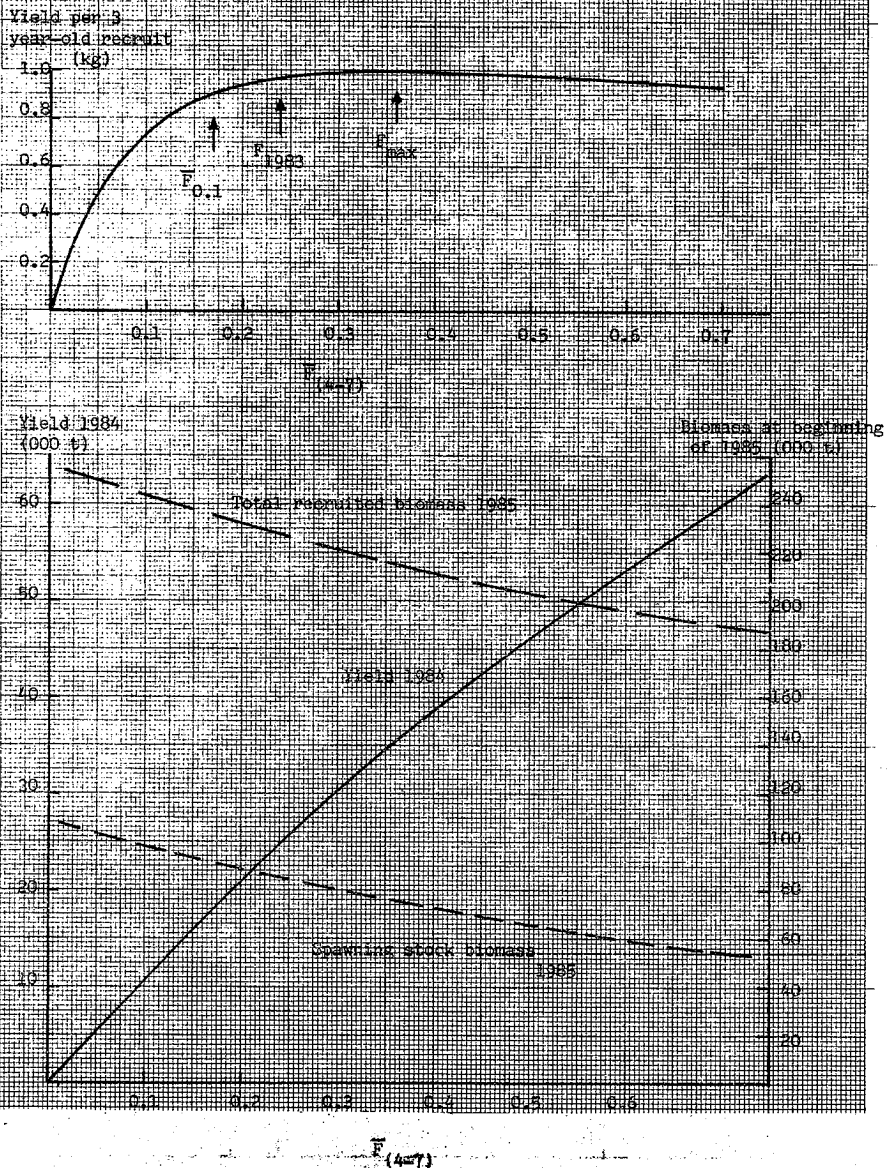


Figure 17. Northeast Arctic Haddock, Y/R, yield 1984, total recruited biomass (age 5+) and spawning stock biomass at beginning of 1985 for different levels of fishing mortality in 1984.



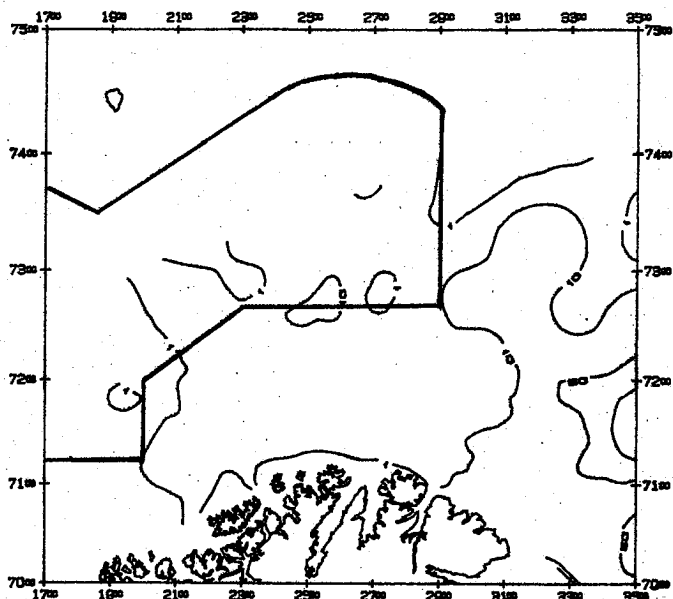


Figure 18. distribution of cod less than 42 cm from the Norwegian bottom trawl survey 1981. (Numbers per hour of trawling)

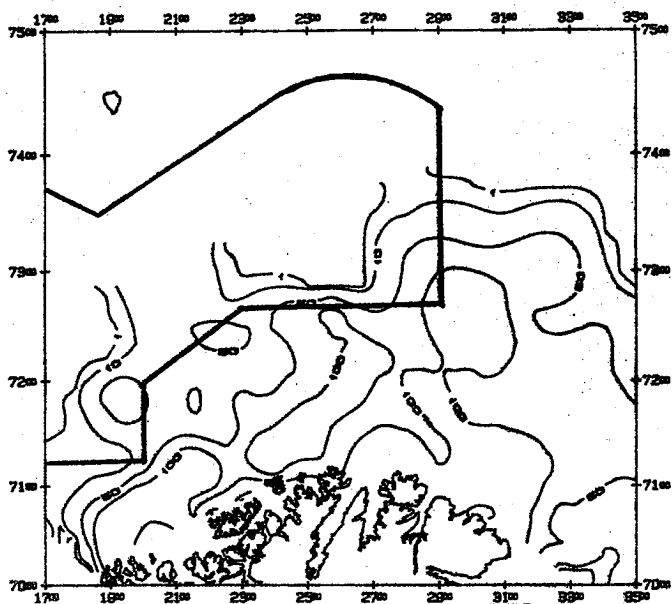


Figure 19. distribution of cod greater than 41 cm from the Norwegian bottom trawl survey 1981. (Numbers per hour of trawling)

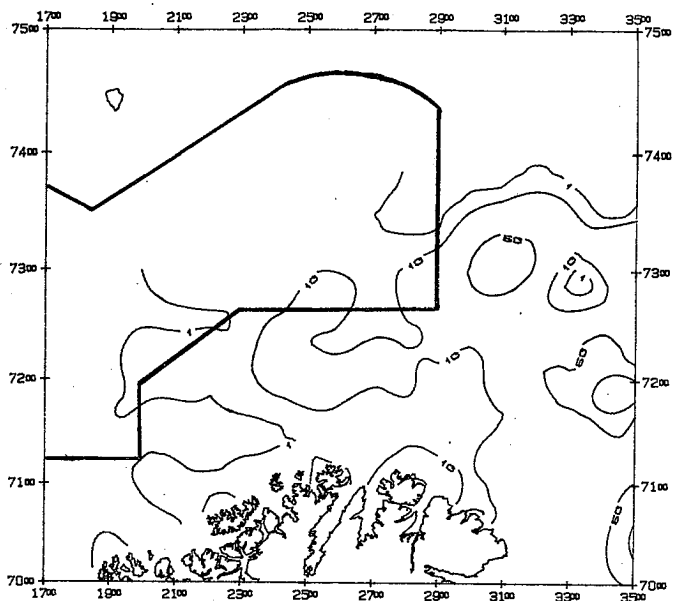


Figure 20. Distribution of cod less than 42 cm from the Norwegian bottom trawl survey 1982. (Numbers per hour of trawling)

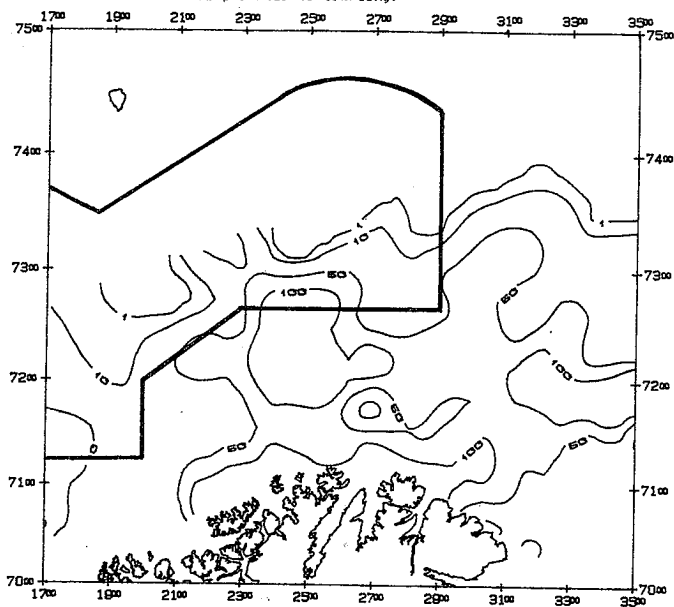


Figure 21. Distribution of cod greater than 41 cm from the Norwegian bottom trawl survey 1982. (Numbers per hour of trawling)

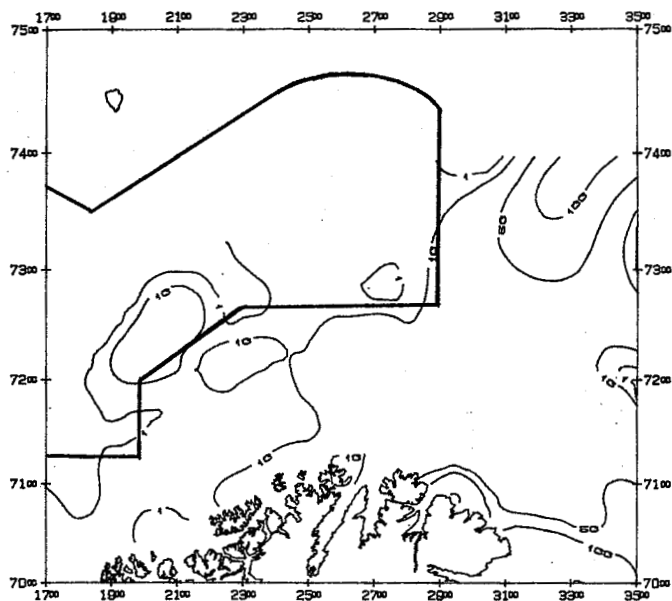


Figure 22. Distribution of cod less than 42 cm from the Norwegian bottom trawl survey 1963. (Numbers per hour of trawling)

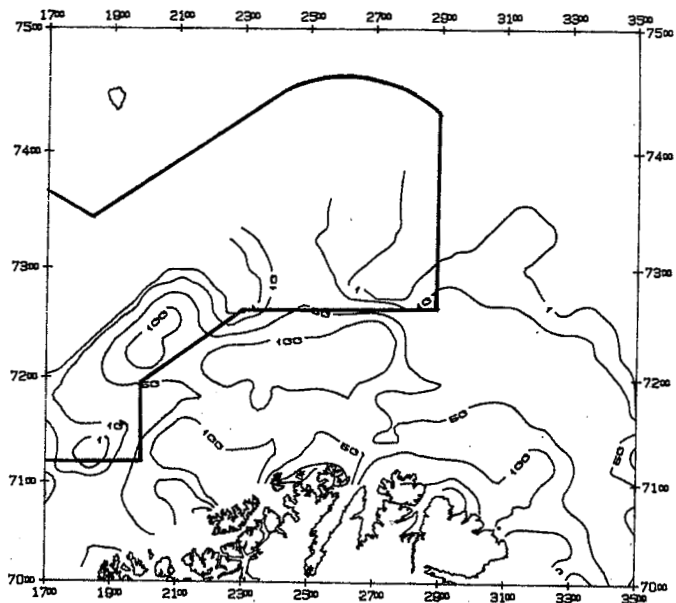


Figure 23. Distribution of cod greater than 41 cm from the Norwegian bottom trawl survey 1963. (Numbers per hour of trawling)



