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REPORT OF THE ARCTIC FISHERIES WORKING GROUP

Copenhagen, 16 - 23 September 1981

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REPORT OF THE ARCTIC FISHERIES WORKING GROUP

16-23 September 1981

1. PARTICIPANTS

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2. TERMS OF REFERENCE

At the 68th Statutory Meeting, the Council decided (C.Res.1980/2:6/16):

"that the Arctic Fisheries Working Group should meet at ICES headquarters from 16-23 September 1981 to assess TACs for cod and haddock in Sub-areas I and II".

In addition, the Working Group considered a suggestion from the Dialogue Meeting (October 1980), which reads as follows:

"From the Norwegian side it was asked if ACFM would be in a position to recommend a specific TAC for the Svalbard Fishery Protection Zone, which is outside the economic zones of any country, and it was agreed that the ICES Arctic Fisheries Working Group and ACFM should be asked to look into the feasibility of this during the coming year".

3. SELECTION OF A SUITABLE MEASURE OF FISHING MORTALITY WHICH COULD BE EXPRESSED AS A SINGLE FIGURE

The question of selecting a suitable measure of fishing mortality has been considered as requested. A paper by Chevalier and Mesnil (C.M.1981/G:86) was considered in which the reference to the fishing mortality at age is described as the norm of the fishing mortality vector, denoted by

$$\|F\|_n = \left(\sum_i |F_i| \cdot |F_i| \right)_n^{1/2} = \left(\sum_i F_i^2 \right)_n^{1/2}$$

for a year n with i indicating the year classes.

There were also two weighting functions available, providing weighting factors P_i for each year class which are involved in the equation as

$$\|F\|_n = \left(\sum_i P_i \cdot F_i^2 \right)_n^{1/2}$$

They are inversely proportional to recruitment, growth and natural mortality. The calculated unweighted

\bar{F}_u

showed clearly the trends of the fishing mortality from year to year as tested by the time series 1964 to 1980 from an Arctic cod VPA, but the values of the

\bar{F}_u

were unfamiliar in comparison with the values of the components of the vector (see Figure 1). The trends could be shown just as well by the mean of the fishing mortalities themselves.

In selecting an average fishing mortality which is related to fishing effort, the Working Group decided to include only the age groups in the average which are contributing substantially to the catches. These are the age groups 5 to 10 and 4 to 7 for cod and haddock, respectively. The Working Group further investigated the possibility of using the average weighted by stock numbers in order to minimize the bias introduced by year class fluctuations. This procedure, however, resulted in considerable difficulties since the numbers per age group serving as weighting factor are different in the three elements of the assessments. Average weighted fishing mortalities are, therefore, not directly comparable between

- 1) the historic record derived from VPA
- 2) the reference F_s on the yield per recruit curve, and
- 3) the F values used in the catch predictions, particularly if the catch projection is carried further to cover medium and long-term aspects.

The Working Group, therefore, used the unweighted average fishing mortality considering the possible bias due to year class fluctuations as a more tolerable disadvantage compared to the loss of comparability. However, the Working Group feels that any kind of measuring a fishing mortality vector in terms of a single figure is hiding the very useful detailed information of the relations between the elements of the vector and from the scientific point of view there is no substitute for it.

4. EFFORT IN THE TRAWL FISHERIES

During the 1979 meeting of the Arctic Fisheries Working Group a first attempt was made to examine the effects of treating the cod and haddock as a mixed fishery (C.M.1979/G:20). Using the English trawler catch per unit of effort data for cod and haddock combined, estimates were made of the total international effort using the catch data from all years.

Correlations were also established between United Kingdom cpue trawler data and various estimates derived from Norwegian trawl fisheries. Since 1979, United Kingdom vessels have taken less and less part in the fishery, and the index of abundance as cpue is no longer valid. In order to calculate effort for the most recent years, Norwegian cpue data have been expressed in United Kingdom units.

The data presented in C.M.1979/G:20 refer to the total catch by all gears. A major part of the catch in Division IIA is derived from non-trawling gears.

The trawl cpue data are not applicable to the total catches. The catches of non-trawl gears have been extracted for each area and the cpue has been applied to the trawl catch data in assessing effort changes. The total catches of cod and haddock for each fishery area for trawl and non-trawling gears are given in Table 1.

Table 2 gives the English cpue data for cod and haddock combined, and the derivation of the total trawler effort in each fishery area. In Division IIb no catch per effort data are available since 1978, and only small catches are ascribed to this area. Even in the years of high catches the proportion of the total English effort expended in that area was relatively small. In calculating the total effort, that derived from Sub-area I and Division IIa has simply been raised by the additional catch in Division IIb.

Some preliminary estimates have been made for 1981 based on Norwegian trawler data and the projected catches. It would seem likely that the total trawler effort exerted in 1981 will be somewhat lower than in 1980, continuing the declining tendency of recent years.

5. NORTH-EAST ARCTIC COD

1 Status of the Fisheries (Tables 3 to 6)

Revised figures for cod landings in 1979 amounted to 440 538 tonnes, about 3 500 tonnes less than the preliminary figures used in the previous Working Group report (C.M.1980/G:12). This is 259 462 tonnes less than the 1979 TAC of 700 000 tonnes, Murman cod included.

Provisional figures for the 1980 fishery indicate a decline of about 13% to a level of 381 709 tonnes, which is 8 291 tonnes less than the TAC of 390 000 tonnes, Murman cod included. The catches in Sub-area I and Division IIa decreased by 22 791 tonnes and 43 638 tonnes, respectively compared to 1979. However, in Division IIb the catch increased by 7 600 tonnes to the level 17 523 tonnes, which is about the 1978 level but well below the average for the period 1960-80 of 119 400 tonnes.

Total landings for 1981 were estimated to be 400 000 tonnes compared to the TAC of 300 000 tonnes, Murman cod included. For assessment purposes this catch was split into regions and by countries in order to establish the appropriate age compositions.

The more westward distribution of cold water masses observed in 1978, 1979 and 1980 continued in 1981. A corresponding westward distribution of cod has been observed in all four years, and the fishing activity of the different fleets has been adapted to this new distribution pattern.

Catch per unit of effort figures for the trawler fleets have continued to decline in the period 1976-79 for all three regions. However, this trend was reversed in 1980. For conventional gears fishing in Division IIa the catch per unit effort figures continued to decline from 1978 to 1980. This development was reversed in the current year. The increase in the catch per unit of effort figures for the conventional gears might be interpreted as a combined effect of increased available stock abundance, especially of six year olds, higher availability and catchability in the Lofoten area.

5.2 Virtual Population Analysis (VPA)

5.2.1 Age compositions (Table 10)

The age compositions used for 1979 were adjusted for the revised catch figures. Preliminary age compositions were estimated for 1980 landings by applying age distributions submitted by the Federal Republic of Germany, Norway and USSR. Age compositions were derived for the projected 1981 landings by applying age distributions for the

first half of 1981 submitted by Norway and the Federal Republic of Germany. Catches in numbers of 3 and 4 year olds were adjusted as described in Section 5.2.3.

These catch at age data were used as input data for the VPA. Natural mortality was set at 0.2, as customary.

5.2.2 Survey data

Stock abundances are given from Norwegian acoustic surveys in 1977-81 (Table 7). Year class abundance estimates of cod for the period 1977-80 differ to a small extent from the figures given in the previous report (C.M.1980/G:12). These differences are caused by completing age/length keys used in converting length compositions to age compositions.

Difficulties in the acoustic equipment during the 1980 survey introduced a bias into the survey estimates, the magnitude of which cannot be quantified. During the 1981 survey, quantitative measurements of reduction in the receiving intensity of the echo signals under bad weather conditions were available. Therefore, necessary corrections in the integrator values for every 5 nautical miles sailed were made on the basis of the quality of the paper recordings. Such corrections affect directly the estimated stock abundance. However, such corrections could not be made for the surveys in earlier years.

The Norwegian acoustic survey in January-February does not cover the full distributional area of the cod stock. Division IIB is not covered by the survey. At present, only a small part of the year classes of cod is present in the area, so the addition to the survey figures would be small. The older fish are distributed more to the west and south of the area surveyed. Therefore, the stock abundance estimates of these year classes of cod are regarded as underestimates.

A Norwegian groundfish survey was made in January/February 1981, at the same time as the acoustic survey. This was conducted by 2 commercial vessels and one research vessel working with a codend mesh size of 35 mm. Nearly 300 hauls were achieved. Age compositions for cod in this Norwegian groundfish survey in 1981 (Table 8) were stratified by area.

Data from the USSR groundfish survey in April/May 1981 were not available.

5.2.3 Fishing mortalities

This year the Working Group separated the fishing mortalities between the conventional gears (gillnet, longline, handline and Danish seine) and the trawl fisheries. This was done on the basis of the catch at age by the conventional gears relative to the total fishery (Table 9).

The data from the acoustic and the groundfish surveys have been used to assess the fishing mortalities in 1981 on age groups 4 to 7.

For the younger fish, the groundfish survey age data, derived from a small-meshed trawl, were considered to better represent the abundance of the age groups 3 and 4 in the stock than their frequency in the commercial catches from an area where the younger fish are under-represented. The expected 1981 catch of age group 4 was adjusted by the groundfish age distribution and the mortality was calculated dependent on the stock size estimate in the acoustic survey.

Age group 3 catch was treated in a similar manner using the groundfish survey data, and a fishing mortality was derived on the assumption of the recruitment level projected in the previous report, i.e. 100 million.

For age groups 5 to 7, the F values were calculated which would generate the expected 1981 catches from the stock sizes indicated in the acoustic survey.

The partitioned fishing mortalities as generated by trawl on the 5 year olds, and the 6-7 year olds (unweighted average) were plotted against the total international trawl effort in United Kingdom units (Table 2, Figures 2 and 3).

It is concluded that the acoustic estimates on the 5-7 year olds seem reasonable, with the possible exception of 7 year olds. Since the 7 year olds have partly migrated to the spawning area outside the surveyed area, the abundance from the acoustic survey is probably an underestimate. The implied fishing mortality on this age group in 1981 by the conventional gears is considerably higher than in the preceding years (Figure 4), where it appears to be against the trend. However, in the absence of clear evidence, and realising that this age group (1974 year class) is of minor importance in the catch prediction, the Working Group decided to adopt 0.50 as the input fishing mortality on the 7 year olds.

The unweighted average fishing mortalities on the 8 to 12 year olds, as generated by the conventional gears, were calculated to be 0.44 in 1975-79 in a preliminary run. Raising this by the factor 1.32 (total catch in number of 8+ divided by conventional catch of 8+ in 1981) gave a value of 0.58. This was rounded off to 0.60 which was then taken as the input (unweighted average) on the 8 to 12 year olds. Using the average fishing pattern for 1970-75 as calculated in Doc. C.M.1980/G:12, the individual fishing mortalities on the age groups 8 years and older were calculated. The input fishing mortalities on the oldest age groups were the same as in previous years.

The resulting average fishing mortalities on the 8-12 year olds (1967-81) generated by the conventional gears are shown in Figure 4.

The resulting total fishing mortalities, stock size by number and weight are given in Tables 11 to 13.

The historic yield and spawning stock biomass from 1960 to 1981 are shown in Figure 5.

5.3

Catch Prediction

The parameter used for calculating catches in 1982 and stock sizes in 1983 are given in Table 14. No change has been made on the average weight per age group from the previous assessment. The exploitation pattern has been adjusted according to the F at age array developed for 1981, because the exploitation pattern emerging from the estimated terminal fishing mortality for 1981 reflects the reduction in total trawl effort in recent years, and since no increase in trawl effort is expected to take place in 1982 and in the next few years.

The size of the 1980 year class at age 3 has been estimated on the basis of the USSR young fish survey, and the estimate of the strength of the 1981 year class was derived from the ICES 0-group survey (Table 15). Both these indices are very low, indicating that the 1980 and 1981 year classes are very poor and of the same order as the 1978 and 1979 year classes, i.e., 100 million cod.

The results of the catch prediction are given in Figure 6. In the text table below, management options for 1982 related to the reference points on the yield per recruit curve (see Figure 7) and to certain levels of spawning stock biomass and catch are given:

Management Options

Species: COD

Area: ICES SA I and II

1981				Management option for 1982	1982				1983	
Stock biom. (3+)	Spawning stock biomass (8+)	\bar{F} (5-10)	Catch (3+)		Stock biom. (3+)	Spawning stock biomass (8+)	\bar{F} (5-10)	Catch (3+)	Stock biom. (3+)	Spawning stock biomass (8+)
1562	225	.48	400	$F_{0.1}$	1434	221	.14	142	1540	710
				F_{max}			.25	240	1420	630
				$F_{1982} = F_{1981}$.48	420	1200	490
				TAC 1982 = 300			.32	300	1350	580
				TAC 1982 = 400			.45	400	1220	510

Weights in thousand of tonnes

5.4 Effects of 1982 TACs on Spawning Stock Biomass

In the 1979 report of the Arctic Fisheries Working Group (C.M.1979/G:20) it was pointed out that, based on a Ricker stock/recruitment relation, the optimum level of spawning stock biomass ranges from 500 000 tonnes to 1 000 000 tonnes. The lower level of this range is considered by the Working Group as a minimum requirement to reduce the probability of recruitment failure due to low spawning stock levels.

The relatively strong 1975 year class will be fully recruited to the spawning stock in 1983.

Its contribution to the spawning stock biomass in 1983 is expected to be within a range of approximately 500 000 tonnes to 300 000 tonnes, depending on the level of exploitation in 1982.

However, the 1975 year class is followed by a series of at least 6 relatively poor or even very weak year classes. As a consequence, the spawning stock biomass can only be maintained into 1984 at the required minimum level, if the exploitation in 1982 and 1983 does not exceed the $F = 0.4$ level. This management strategy is associated with catch levels around 350 000 tonnes for the years 1982 and 1983 (see text table on p.7). Fishing at F_{max} from 1982 onwards is expected to keep the spawning stock biomass safely within its optimal range up to the beginning of 1986.

In view of the expected low recruitment levels, a careful management of particularly the 1975 year class is highly advisable.

Calculated spawning stock biomass in 1982-86 and calculated catch 1982-84 at constant levels of exploitation (in thousand tonnes).

(Catch figures for 1985 and 1986 are depending on recruiting year classes beyond 1981 and are, therefore, not given in the text table.)

Management strategy	$F_{0.1} = 0.14$		$F_{max} = 0.25$		$F = 0.4$		$F = 0.5$		$F = 0.6$	
	SSB	Catch	SSB	Catch	SSB	Catch	SSB	Catch	SSB	Catch
1982	221	142	221	240	221	362	221	434	221	500
1983	710	176	630	269	534	354	479	388	430	409
1984	1 043	196	832	269	608	307	494	309	403	300
1985	1 074		764		479		353		261	
1986	1 014		645		349		235		160	

6. NORTH-EAST ARCTIC HADDOCK

6.1 Status of the Fisheries (Tables 16 to 18)

Final figures for the catch of haddock of 103 623 tonnes in 1979 differ only slightly from the figure given in the previous Working Group report (C.M.1980/G:12). The preliminary figure for 1980 of 87 246 tonnes shows a decrease from 1979 of about 16 000 tonnes (16%).

The TAC for 1980 was exceeded by about 12 000 tonnes.

Estimated total landings of haddock for 1981 is 78 000 tonnes, compared to the TAC of 110 000 tonnes. As for cod, the total catch was split by regions and by countries.

In 1980 the catch per unit of effort followed an upward trend and was higher in Sub-area I and Division IIIa than in 1979. The abundance of haddock in Division IIb has been very low during the last 5-6 years, and the cpue figures do not reflect any changes in the abundance. The increase in cpue was mainly due to the 5-6 year old fish of the good 1975 and 1976 year classes, respectively.

6.2 Virtual Population Analysis (VPA)

6.2.1 Age compositions

Catches in numbers per age group were revised for 1978 and 1979 following changes in the catch data. The data for 1980 given in the previous report, which had been based only on the first 6 months' sampling, were updated for the total annual sampling.

For 1981 projections of the total annual catch by age were made from the data available from Norway and the Federal Republic of Germany (Table 20).

6.2.2 Fishing mortality and input F

From the catch at age data, the ratios of numbers in the non-trawl catches to the totals are shown in Table 19. It can be seen that the proportion varies considerably between periods being particularly high in recent years. These ratios have been applied to the F values derived from VPA to partition values ascribable to the trawl and other fisheries separately.

The main part of the annual catches derive from age groups 4-7. The relation between the mean fishing mortality on these age groups due to trawls are plotted on the total trawl fishing effort in Figure 8(a). Ignoring the aberrant 1972 value, when the fleets were concentrated on the abundant 1969 year class of haddock, there is a clear relationship between fishing mortality and effort for the 1967-78 data. The data based on Norwegian cpue (1979-81) are not inconsistent with the relationship and indicate the recent order of the reduction in fishing mortality. Based on these data, a mean fishing mortality for 1981 of about $F = 0.1$ would be indicated for the trawl fishery. For 1978-80, the mean proportion of the catch taken by conventional gears was 62%. Applying this to the fishing mortality for trawl would give a total average mortality on age groups 4-7 of about 0.26.

In previous assessments, the exploitation pattern for input F was based on the 1970-75 period mean. At this time, the mean proportion of the trawl catch of the reference age groups 4-7 was 78%. This proportion was reduced to a mean of 41% by 1978-81. A new exploitation pattern thus had to be estimated.

In Figures 8(b) and 8(c), the plots of trawl fishing mortalities on total trawl effort are shown for ages 6 and 5. Again 1972 is seen to be aberrant in both cases. In the case of the 6 year olds, there is a grouping in the distribution of points in that the 1977-80 data lie outside the general distribution. In these years the trawl catch proportion is reduced to 56% compared with 78% in the reference period 1970-75. Additionally, it can be seen from VPA that these low levels of mortality in trawl catches can also be associated with low stock sizes (mean 6.4×10^6). The mean stock size for the other years since 1967 was 50.0×10^6 .

In assessing an estimate of the trawl F for 1981, a line has been drawn through the mean values of F and effort for 1977-80 and the origin. This would suggest an F value of about 0.1 for trawls, and taking the mean F for conventional gears for 1977-79 at 0.21 gives an input F value of 0.31 for 6 year olds in 1981.

For the 5 year olds, a line has also been drawn through the means of the 1977-80 trawl F and effort values. From this it might be concluded that the F due to trawlers in 1981 would be of the order of 0.20. From Table 19 it can be seen that the conventional gear has taken about 50% of the total catch in recent years. The input F value on 5 year olds is thus set at 0.40.

Input F values for age groups 3 and 4 were selected to give the expected levels of recruitment derived from the USSR groundfish survey and the 0-group surveys. The F values on older age groups were selected to make-up the balance of the predicted catch in 1981 to 80 000 tonnes.

Two tests of the validity of these procedures were devised. Figure 9 shows the relationship between the biomass of haddock recruited to the trawl fisheries from the final VPA and an estimate of trawl cpue.

To estimate what is called the recruited biomass, the average fishing pattern (P) by trawlers in 1973-77 were calculated:

Age	3	4	5	6	7	8	9	10+
P	.61	1.0	.97	.87	.89	.65	.53	.50

For each year, the recruited biomass was calculated as:

$$\sum_{i=3}^{14+} N_i \cdot W_i \cdot P_i$$

N_i being the stock size by number, and W_i the mean weight of age group i .

The recruited biomass is an estimate of that part of the total stock that is available to the trawlers.

The cpue was taken as the total trawl catches of haddock (Table 1) and the total trawl effort for Sub-area I and Divisions IIA + IIB (Table 2). It is seen that the values derived for 1979, 1980 and 1981 from the final VPA fit the data plot based on earlier years.

Finally, in Figure 10 is shown the plot of cod/haddock trawl catch ratio to biomass ratio from the two final VPA runs for cod and haddock. Again, the 1979-81 data are not inconsistent with the relationship derived for the years which are free from effects of VPA input.

The results of the VPAs are given in Tables 21 to 23. The historic yield and spawning stock biomass are shown in Figure 11.

6.3 Catch Prediction

The parameter used for calculating catches for 1982 and resulting stock sizes in 1983 are given in Table 24. No changes have been made in the average weight per age group used in the previous assessment, since these parameters have been revised at the May 1980 meeting of the Working Group.

The exploitation pattern emerging from the estimated F at age array for 1981 and used in the catch projection reflects the recent and and expected future developments in the fishery, i.e., reduced trawl effort and increased efficiency in the fishery with conventional gears.

Recruitment of the 1980 and 1981 year classes has been estimated from the USSR young fish survey and the ICES international 0-group survey, respectively (Table 25). The indices derived from these surveys indicate that both these year classes are very poor and consequently a figure of 50 million haddock was used in the catch prediction.

The results of the catch prediction are given in Figure 12. In the table below, four management options are listed which are related to reference points on the yield per recruit curve (see Figure 13) as well as to a given catch level in 1982. These options have to be evaluated in the light of the comments made in the following section.

Management Options

Species: HADDOCK

Area: ICES SA I and II

1981				Management option for 1982	1982				1983	
Stock biom. (3+)	Spawning stock biomass (6+)	\bar{F} (4-7)	Catch (3+)		Stock biom. (3+)	Spawning stock biomass (6+)	\bar{F} (4-7)	Catch (3+)	Stock biom. (3+)	Spawning stock biomass (6+)
370	156	.26	80	TAC 1982 = 1981 catch	346	217	.33	80	312	186
				F _{0.1}			.205	52	344	214
				F _{max}			.49	110	280	156
				Maintaining 1981 level of exploit.			.26	64	330	200

6.4 Effects of 1982 TACs on Spawning Stock Biomass

Following the increase in 1981 from the very low 1980 level, the spawning stock in 1982 is expected to increase further to a level of about 220 000 tonnes due to the contribution by the good 1976 year class in 1982 of about 100 000 tonnes. No further increase in spawning stock biomass can be expected up to 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 cautional approach in the long-term policy is advisable.

6.5 By-Catch of Haddock in the Cod Fishery

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

The ratio of cod and haddock in the catches (see Figure 10) indicates that, at present biomass levels, the amount of haddock taken as by-catch in the fishery for cod is about 1/5 of the cod catch.

7. SPECIFIC TACs FOR THE SVALBARD FISHERY PROTECTION ZONE

The cod and haddock in the Svalbard fishery protection zone (the major part of Division IIb) are part of the North-East Arctic cod and haddock stocks. These components are variable and are included in the TAC calculations for these stocks. No data are available which would allow separate estimates of TACs for this zone to be made.

8. LONG-TERM PROJECTION

ACFM has been asked to provide, if possible, long-term projections of yield and stock so that fishery objectives and management strategy might be considered. It is not possible to predict the success of spawning for future years. Thus, the rate of recruitment of small fish to the fishable stock cannot be predicted. The short-term projections (2-3 years) are based on the pre-recruit survey estimates.

For the long term, then, a probabilistic model must be used. This will provide longer term expectations and variability over a period of future years, but cannot provide specific estimates for any of the individual future years.

8.1 The Model

Although variations in stock size and yields are affected by variations in growth rate and fishing patterns, the major changes in stock size are caused by changes in the annual size of the recruiting year class. Expectations and variations in future recruitment, therefore, provide a basis for long-term fishery outlook and management. This is obtained by considering recruitment as a random variable.

Observations of the annual catch and stock composition (VPA) are available for the last three decades. For both cod and haddock, the first age to be significantly exploited is the 3 year old group. A frequency density function of the annual 3 year old recruitment (numbers of fish) was constructed. The year class size was scaled so that the intervals are expressed relative to the lowest. That is,

the second smallest interval mid-point is twice the size of the first, the third three times the first, and so on. The average year class size is 5 times greater than the lowest by the method of scaling. The frequency density function and cumulative frequency distribution are given in Figure 14 for cod and haddock.

This portrays the relative frequency of occurrence. To relate this to absolute size, the average total weight of the year class as four year olds for haddock and five year olds for cod was calculated for each interval. This corresponds approximately to the average annual additions to fishable stock from the relative year class size intervals.

Future implications may be inferred on the assumption that the historic pattern will continue. This may not happen - things do change - but the events which cause year class variations are not known, and this assumption is the least that one must make to look to the future.

The annual catches have been treated in the same manner, and plotted for comparison in Figure 15 for cod and Figure 16 for haddock. The catch is not in any sense a random variable, but this treatment provides a means of considering the effect of any desired future distribution of annual catches compared to recruitment. If the areas under the two curves are the same, the stock size over the period will not change.

8.2 Results

The frequency density function is rather highly skewed to the right. That is, year classes vary between years up to a factor of 13 (even up to a factor of 24 for haddock), but 60% to 70% of them are lower than the mean size. Approximately 50% of the year classes are less than the 4 x interval. The median size year class for haddock is 80 000 tonnes, the mean size is 150 000 tonnes. For cod, the median is 600 000 tonnes and the mean is about 700 000 tonnes. For haddock, 80% of the year classes would be expected to be less than 185 000 tonnes, and for cod, less than 870 000 tonnes.

The cumulative percentages of the recruitment distributions may be interpreted as the probability or risk of achieving a constant annual yield of the indicated level without changing stock size.

For a constant fishing mortality, the two curves should match.

The frequency distribution of annual catches must be balanced against the recruitment distribution, if the population is to remain the same over the period considered. For example, for cod, about 85% of the annual catches in 1950-79 exceeded the recruitment. The 15% which were less than annual recruitment did not balance the excesses, and the stock decreased by 2 million tonnes. For haddock, 70% of the annual catches exceeded recruitment; the 30% which were less again did not balance the excesses, and the stock declined by half.

To maintain the present stock size over future years, the distribution of annual catches must be shifted significantly to the left so that the recruitment and catch distributions are balanced. To rebuild, a further shift to the left is required; the frequency of catches less than the median recruitment governs the rate of rebuilding.

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	136.7	35.7	30.7	23.7	77.4	114.4	14.1	18.6	17.5	0.1
1981*	127.2	32.4	20.8	21.2	71.3	156.7	17.0	18.4	12.5	0.2

*provisional

Table 2 Cod and Haddock catches (thousand tonnes) and total trawl effort in English units

Areas	Sub-Area I			Division IIa			Division IIb	Total Trawl Effort
	cpue x 10 ⁻⁴	C _t x 10 ⁻³	Trawl effort x 10 ⁻⁷	cpue x 10 ⁻⁴	C _t x 10 ⁻³	Trawl effort x 10 ⁻⁷	C _t x 10 ⁻³	
1967	.101	311.8	3.09	.078	59.2	0.76	121.5	5.11
1968	.129	686.2	5.32	.106	75.6	0.71	269.9	8.17
1969	.126	674.8	5.35	.136	152.8	1.12	263.5	8.53
1970	.104	561.2	5.40	.097	110.7	1.14	86.1	7.38
1971	.064	280.4	4.38	.087	89.5	1.03	57.3	6.25
1972	.061	351.5	5.76	.073	84.3	1.15	35.2	7.47
1973	.079	700.2	8.86	.063	53.3	0.85	101.2	11.01
1974	.099	810.1	8.18	.102	80.9	0.79	269.8	11.69
1975	.092	629.8	6.85	.093	68.3	0.73	130.8	9.00
1976	.070	544.2	7.77	.073	140.4	1.92	109.1	11.23
1977	.056	529.1	9.45	.060	120.8	2.01	119.5	13.57
1978	.067	414.3	6.18	.052	132.7	2.55	18.3	9.02
1979	.055	209.3	3.81	.035	135.2	3.86	8.7	7.86
1980	.057	167.4	2.94	.035	91.5	2.61	17.6	5.93
1981*	.071	148.0	2.08	.042	88.3	3.08	12.7	4.40

*provisional

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*	172 375	17 523	191 811	381 709

*) Provisional figures

Expected Catches

1981	160 000	12 000	228 000	400 000
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Table 4 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	-	1 074 084
1969	29 374	-	5 907	5 343	305 241	7 856	231 066	612 215	133	1 197 226
1970	26 265	44 245	12 413	9 451	377 606	5 153	181 481	276 632	-	933 246
1971	5 877	34 772	4 998	9 726	407 044	1 512	80 102	144 802	215	689 048
1972	1 393	8 915	1 300	3 405	394 181	892	58 382	96 653	166	565 287
1973	1 916	17 028	4 684	16 751	285 184	843	78 808	387 196	276	792 686
1974	5 717	46 028	4 860	78 507	287 276	9 898	90 894	540 801 ¹⁾	38 453	1 102 434
1975	11 309	28 734	9 981	30 037	277 099	7 435	101 834	343 580 ¹⁾	19 368	829 377
1976	11 511	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	1 740	233	1 924	229 628	3	10 366	115 194	12 640	381 709

*) Provisional figures.

1) Murman cod included.

Table 5 COD. Catch per unit effort
(tonnes, round fresh)

Year	Sub-area I			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		0.058	0.37		0.092	0.39		0.070	4.8
1965		0.066	0.39		0.109	0.49		0.066	2.9
1966		0.074	0.42		0.078	0.19		0.067	4.0
1967		0.081	0.53		0.106	0.87		0.052	3.5
1968		0.110	1.09		0.173	1.21		0.056	5.1
1969		0.113	1.00		0.135	1.17		0.094	5.9
1970		0.100	0.80		0.100	0.80		0.066	6.4
1971		0.056	0.43		0.071	0.16		0.062	10.6
1972	0.90	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 ⁵⁾	1.27	-	5.0
1981*	1.42						1.16		6.2

*) Projected figures

- 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. 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

Table 7. North-East Arctic COD.
Estimates of year class abundance. (No. x 10⁻⁶) from the Norwegian Acoustic Survey.

Year	Year class												Total No.
	1980	1979	1978	1977	1976	1975	1974	1973	1972	1971	1970	Older	
1977					45	882	104	315	139	52	47	12	1 596
1978				28	235	797	153	172	25	14	17	1	1 442
1979			16	14	109	502	77	45	14	4	2	+	783
1980		1	10	20	80	182	21	9	2	+	+		325
1981	3	73	58	124	243	270	41	8	3	4			827

Table 8. North-East Arctic COD.
Relative stratified age compositions in the Norwegian groundfish survey in 1981.

	Cod
1	0.8
2	8.7
3	7.2
4	15.5
5	29.6
6	31.7
7	4.4
8	1.2
9	0.4
10+	0.4

Table 9. North-East Arctic COD.

The ratio of catch generated by conventional gears versus the total catch.

Age	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980 ¹⁾	1981 ¹⁾
3	.128	.161	.068	.024	.048	.051	.010	.005	.012	.075	.106	.046	.351	.241	.081
4	.117	.043	.049	.063	.155	.090	.055	.018	.034	.082	.041	.103	.146	.248	.244
5	.100	.042	.047	.110	.215	.108	.056	.043	.043	.112	.047	.121	.144	.176	.214
6	.167	.037	.062	.124	.263	.276	.082	.148	.056	.137	.107	.111	.230	.212	.322
7	.262	.101	.069	.226	.328	.570	.231	.285	.203	.244	.356	.174	.289	.429	.647
8	.345	.497	.181	.288	.483	.682	.873	.367	.385	.410	.386	.528	.464	.602	.806
9	.387	.601	.604	.430	.427	.671	.789	.672	.562	.567	.427	.544	.738	.707	.820
10	.383	.456	.562	.615	.384	.497	.682	.678	.713	.602	.436	.275	.708	.763	.853
11	.524	.397	.358	.575	.689	.481	.582	.758	.675	.346	.361	.275	.602	.678	.341
12	.535	.689	.179	.405	.597	.474	.317	.925	.824	.733	.827	.137	.738	.941	.870

1) Preliminary

Table 10. North-East Arctic COD.
 Catch in numbers (thousands) - VPA.

	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	103	1	1	1	1	1	1	38	1
2	675	2522	869	151	1	275	591	2210	4701
3	5298	15725	55937	54467	3709	2307	7164	7754	35536
4	45912	25999	55644	160048	174585	24545	10792	13739	45431
5	97950	78299	34676	69235	267961	238511	25813	11831	26832
6	58575	68511	42539	22061	107051	181239	137829	9527	12089
7	19642	25444	37169	26295	26701	79363	96420	59290	7918
8	9162	8438	18500	25139	16399	26989	31920	52003	34885
9	6196	3569	5077	11323	11597	13463	8933	12093	22315
10	3553	1467	1495	2329	3657	5092	3249	2434	4572
11	783	1161	380	687	657	1913	1232	762	1215
12	172	131	403	316	122	414	260	418	353
13	387	67	77	225	124	121	106	149	315
14	264	91	9	40	70	23	39	42	121
15+	151	179	70	14	46	46	55	25	40
TOTAL	248803	231604	252846	352331	612681	574302	324384	172315	196324
	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	1	115	1	706	1	3	0	28	0
2	8277	21347	1184	1908	11288	802	224	453	600
3	294262	91855	45282	85337	39594	78822	8600	3462	7000
4	131493	437377	59798	114341	168609	45400	77484	16539	15000
5	61000	205772	226046	79993	136335	88495	43677	81373	30200
6	20569	47006	118567	118236	52925	56823	31943	40218	72700
7	7248	12630	29522	47872	61821	25407	16815	17353	14800
8	8328	4370	9353	13962	23338	31821	8274	7619	8500
9	19130	2523	2617	4051	5659	9408	10974	3523	3800
10	4499	5607	1555	936	1521	1227	1785	3099	1500
11	677	2127	1928	558	610	913	427	510	1900
12	195	322	575	442	271	446	103	68	100
13	81	151	231	139	122	748	59	19	10
14	59	83	15	26	92	48	38	22	10
15+	55	62	37	53	54	51	45	7	10
TOTAL	555874	829347	497311	468560	502240	340414	200448	174293	156130

Table 11. North-East Arctic COD.
Fishing mortality - VPA

	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
2	0.001	0.001	0.001	0.001	0.000	0.001	0.001	0.002	0.002
3	0.017	0.023	0.040	0.030	0.024	0.023	0.041	0.021	0.039
4	0.144	0.111	0.104	0.152	0.207	0.221	0.142	0.103	0.167
5	0.352	0.389	0.212	0.181	0.408	0.481	0.382	0.228	0.297
6	0.481	0.445	0.379	0.202	0.467	0.537	0.571	0.236	0.384
7	0.509	0.397	0.465	0.427	0.401	0.768	0.619	0.518	0.314
8	0.716	0.515	0.566	0.668	0.520	0.927	0.837	0.828	0.667
9	1.047	0.690	0.680	0.835	0.764	1.132	0.959	0.930	1.117
10	0.833	0.770	0.709	0.788	0.725	0.949	0.970	0.771	1.222
11	1.059	0.734	0.460	0.862	0.535	1.128	0.636	0.639	1.216
12	0.864	0.491	0.616	0.889	0.355	0.782	0.432	0.461	0.704
13	1.145	1.052	0.606	0.864	1.151	0.721	0.466	0.474	0.768
14	0.810	0.960	0.370	0.750	0.740	0.680	0.540	0.340	0.910
15+	0.810	0.960	0.370	0.750	0.740	0.680	0.540	0.340	0.910
F(5-10),U	0.666	0.534	0.502	0.517	0.548	0.799	0.723	0.585	0.667
F(5-10),W	0.433	0.421	0.358	0.270	0.433	0.561	0.596	0.540	0.520
	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000
2	0.014	0.030	0.002	0.005	0.012	0.002	0.001	0.004	0.010
3	0.194	0.211	0.083	0.162	0.134	0.112	0.025	0.024	0.080
4	0.200	0.490	0.207	0.307	0.548	0.224	0.154	0.061	0.140
5	0.354	0.538	0.510	0.469	0.734	0.631	0.348	0.240	0.150
6	0.391	0.508	0.703	0.552	0.659	0.802	0.491	0.628	0.350
7	0.420	0.444	0.706	0.698	0.634	0.790	0.590	0.546	0.500
8	0.638	0.485	0.700	0.892	0.916	0.810	0.653	0.589	0.570
9	1.001	0.403	0.608	0.768	1.236	1.321	0.747	0.652	0.670
10	0.713	0.957	0.460	0.456	0.754	1.046	1.021	0.486	0.650
11	0.576	0.913	1.115	0.303	0.614	1.683	1.511	0.967	0.630
12	0.635	0.601	0.681	0.859	0.236	1.378	0.944	1.174	0.500
13	0.340	1.739	1.255	0.342	0.618	2.049	0.663	0.441	0.520
14	0.310	0.700	0.860	0.430	0.400	0.530	0.560	0.560	0.440
15+	0.310	0.700	0.860	0.430	0.400	0.530	0.560	0.560	0.440
F(5-10),U	0.586	0.5	0.610	0.639	0.822	0.900	0.642	0.523	0.482
F(5-10),W	0.444	0.531	0.578	0.561	0.716	0.740	0.465	0.345	0.293

Table 12. North-East Arctic COD.
Stock size in numbers - VPA.

	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	2365878	1930600	253969	167266	294661	604533	1517259	2741836	801807
2	951359	1936924	1580641	207931	136945	241247	494948	1242226	2244791
3	338965	778297	1583541	1293334	170103	112120	197268	404696	1015052
4	375876	272737	623010	1245998	1027772	135920	89713	155043	324335
5	562442	266366	199856	459904	875926	684297	89191	63725	114548
6	168008	208774	147805	132414	314183	476723	346502	49853	41527
7	49489	85058	109496	82826	88550	161273	228039	160351	32244
8	19535	22940	46806	56328	44227	48539	61248	100490	78182
9	10357	7815	11224	21765	23657	21523	15728	21704	35933
10	6840	2977	3211	4654	7730	9024	5681	4933	7011
11	1300	2434	1129	1294	1734	3065	2859	1762	1868
12	323	569	957	583	447	831	812	1239	762
13	615	112	185	423	196	257	511	432	640
14	518	160	32	83	146	51	102	160	220
15+	257	515	248	29	96	102	92	95	73
TOTAL	4651762	5515879	4562115	3674834	2986375	2499504	3049754	4948545	4698991
SPAWN. ST.	59745	37123	65792	85160	78234	83391	86833	150816	124688
	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	967001	937526	521199	1233938	579501	236294	150272	81279	0
2	656463	792253	767478	426721	1009625	474455	193458	123032	66520
3	1833653	529991	629368	627288	347646	816417	387726	158188	100321
4	798974	1236283	351235	474434	436698	248941	597355	309678	126387
5	224617	535754	620266	233735	285670	206598	162955	419259	238618
6	69066	129120	256191	304811	119665	112209	90034	94189	270046
7	25148	38578	63607	103877	143719	50681	41209	45092	41159
8	19283	12450	20259	25717	42297	62402	18839	18697	21383
9	32841	8344	6277	8235	8626	13861	22725	8030	8492
10	9624	9886	4567	2799	3129	2052	3028	8813	3426
11	1691	5863	3108	2346	1452	1205	590	894	4439
12	453	778	1270	834	1419	644	183	107	278
13	509	197	349	526	289	918	133	58	27
14	243	180	28	81	306	128	97	56	31
15+	226	134	70	166	180	136	115	18	31
TOTAL	4638833	4235337	3245273	3445508	2980222	2226938	1668720	1267389	881157
SPAWN. ST.	64670	35832	35929	40704	57698	81344	45710	36673	38106

Table 13. North-East Arctic COD.
Biomass - VPA.

1 January	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	220527	505893	1029302	840667	110567	72878	128224	263052	659784
4	375876	272737	625016	1245998	1027772	135920	89713	155043	324335
5	561785	412868	309776	712851	1357686	1060661	138245	98774	177550
6	394818	490620	347343	311173	738350	1120299	814280	117153	97588
7	170756	293451	377761	285751	305499	556393	786735	553212	111240
8	91816	107820	219989	264744	207866	228134	287864	472304	367454
9	63901	48218	69252	134291	145965	132795	97041	133915	221707
10	52670	22922	24722	35838	59524	69481	43744	37984	53982
11	12028	22517	10441	11968	16037	28349	26444	16302	17277
12	3510	4008	10381	6351	4855	9019	8815	13447	8266
13	7684	1396	2313	5287	2455	3210	3891	5400	7999
14	7197	2226	444	1148	2028	707	1421	2222	3060
15+	3854	4726	3723	434	1438	1526	1376	1427	1092
TOTAL	1966201	2189400	3028463	3856483	3980021	3419372	2427794	1870235	2051335
SPAWN. ST.	242659	215831	341265	460042	440169	473221	470596	683002	680838
	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	1191801	344494	409089	407737	225970	530671	252022	102822	65209
4	798974	1236283	351235	474454	436698	248941	597555	309678	126387
5	348157	830418	961413	362290	442789	320228	252581	649851	369858
6	163715	303431	602049	716306	281212	263691	211579	221344	634607
7	79801	133092	219445	358375	495829	174849	142172	155566	141998
8	90632	58515	95219	120870	198795	293288	88542	87877	100501
9	202627	51482	38730	50810	53223	85522	140211	49543	52396
10	74107	76124	35169	21551	24092	15798	23319	67862	26378
11	15638	35733	28746	21697	13435	11143	5458	8265	41057
12	4916	8446	13778	9049	15395	6983	1988	1156	3017
13	3856	2458	4366	6576	3614	11474	1661	730	337
14	3377	2500	393	1133	4251	1774	1347	780	428
15+	3397	2015	1047	2492	2693	2034	1721	268	462
TOTAL	2981121	3084571	2760680	553321	2197996	1966395	119956	1655742	1562636
SPAWN. ST.	398552	237272	217449	234179	315499	428016	264246	216481	224577

Table 14 North-East Arctic COD

Parameters used in catch predictions (M = 0.2)

Age	Relative Fishing Mortality ($F_{5-10} = 1.0$)	Mean Weights (kg)	Stock Size at Beginning of 1982 (in thousands)
3	0.162	0.65	100 000*
4	0.287	1.00	75 820
5	0.312	1.55	89 959
6	0.723	2.35	168 151
7	1.035	3.45	155 803
8	1.185	4.70	20 439
9	1.397	6.17	9 901
10	1.347	7.70	3 558
11	1.310	9.25	1 464
12	1.035	10.85	1 935
13	1.085	12.50	138
14	0.911	13.90	13
15+	0.911	15.00	32

*) Recruitment estimate of 1979, 1980 and 1981 year class.
(see Section 5.3)

Table 15 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 ¹⁾ survey index	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		730
1960	9	19	13	Poor		473
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	6	170
1966	2	<1	1	Very Poor	<1	112
1967	1	<1	1	Very Poor	34	197
1968	7	1	5	Poor	25	405
1969	11	6	9	Poor	93	1 015
1970	74	86	76	Rich	606	1 834
1971	37	24	32	Average	157	530
1972	53	17	40	Average	140	629
1973	74	5	46	Rich	684	627
1974	6	1	4	Poor	51	348
1975	93	4	62	Rich	343	(816)
1976	4	<1	3	Poor	43	(388)
1977	2	>1	1	Poor	173	(158)
1978	1	3	2	Poor	106	(100)
1979	(>1)	(1)	(>1)	Poor	94	
1980	(>1)	(>1)	(>1)	Poor	49	
1981					65	

() = estimated

*) USSR Murman cod included for 1974-1978

¹⁾ C.M. 1981/G:78

Table 16 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	155 454
1961	165 165	2 427	25 642	193 234
1962	160 972	1 727	25 189	187 888
1963	124 774	939	21 031	146 744
1964	79 056	1 109	18 735	98 900
1965	98 505	939	18 640	118 079
1966	124 115	1 614	34 892	160 621
1967	108 066	440	27 980	136 486
1968	140 970	725	40 031	181 726
1969	88 960	1 341	40 208	130 509
1970	59 493	497	26 611	86 601
1971	56 300	435	21 567	78 302
1972	221 183	2 155	41 979	265 317
1973	283 728	12 989	23 348	320 065
1974	159 037	15 068	47 033	221 138
1975	121 686	9 726	44 330	175 742
1976	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 *	64 431	67	32 748	87 246

*Provisional figures

Expected catches

1981	42 000	37 800	200	80 000
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Table 17 HADDOCK. Nominal catch (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	U.K.	USSR	Others	Total
1960	172	-	-	5 597	47 263	-	45 469	57 025	125	155 651
1961	295	220	-	6 304	60 862	-	39 650	85 345	558	193 234
1962	83	409	-	2 895	54 567	-	37 486	91 940	58	187 438
1963	17	363	-	2 554	59 955	-	19 809	63 526	-	146 224
1964	-	208	-	1 482	38 695	-	14 653	43 870	250	99 158
1965	-	226	-	1 568	60 447	-	14 345	41 750	242	118 578
1966	-	1 072	11	2 098	82 090	-	27 723	48 710	74	161 778
1967	-	1 208	3	1 705	51 954	-	24 158	57 346	23	136 397
1968	-	-	-	1 867	64 076	-	40 129	75 654	-	181 726
1969	2	-	309	1 490	67 549	-	37 234	24 211	25	130 820
1970	541	-	656	2 119	36 716	-	20 423	26 802	-	87 257
1971	81	-	16	896	45 715	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 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	220	15	1 365	61 410	-	2 948	20 706	85	87 246

* Provisional figures

1) Murman haddock included

Table 18 HADDOCK
Catch per unit effort

Year	Sub-area I		Division IIb		Division IIa	
	Norway ¹⁾	U.K. ²⁾	Norway ¹⁾	U.K. ²⁾	Norway ¹⁾	U.K. ²⁾
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*	0.92	-	-	-	0.54	-

*) Provisional figure

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

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

Table 19

HADDOCK

Ratio "Conventional" Catch/Total Catch in Number

Age Group	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981
3	.38	.29	.33	.15	.40	.07	.04	.06	.04	.14	.06	.12	.66	.80	.20
4	.33	.19	.60	.25	.50	.07	.12	.12	.08	.28	.12	.47	.47	.75	.42
5	.31	.24	.44	.33	.31	.14	.06	.16	.11	.19	.18	.56	.52	.51	.51
6	.26	.38	.37	.35	.44	.06	.14	.16	.18	.11	.23	.43	.71	.75	.47
7	.17	.28	.39	.34	.45	.25	.25	.10	.19	.11	.21	.75	.63	1.00	.58
8	.25	.25	.37	.30	.39	.13	.25	.25	.08	.33	.22	.42	.80	.60	.50
9	-	.43	.31	.35	.38	.12	.24	.17	-	.15	.33	.02	.53	.67	.50
10	.50	.50	.33	.50	.40	.11	1.00	.05	-	.50	-	.50	.57	.90	1.00
11	-	1.00	-	-	.25	.10		.11	-	-	-	-	1.00	.55	.30
4-7	.27	.27	.45	.32	.43	.13	.14	.14	.14	.17	.19	.54	.58	.75	.48

Table 20.

North-East Arctic HADDOCK.
Catch in numbers (thousands) - VPA.

	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	149	1	1	1	1	1	480	15	133
2	831	3483	2559	53	33	1058	276	3535	9369
3	22305	5911	26157	15918	657	1520	23004	1979	230229
4	49162	46161	22469	41373	67632	1963	2408	24359	22246
5	30592	40032	62724	13505	41267	44526	1870	1258	42849
6	5800	12578	28840	25736	7748	18956	21995	918	3196
7	3519	1672	5711	8878	15599	3611	7948	9279	1606
8	2709	970	578	1617	5292	4925	1974	3056	6736
9	852	893	435	218	655	1624	1978	826	2630
10	104	122	188	176	182	315	726	1043	896
11	206	204	186	155	101	43	166	369	988
12	234	123	25	76	115	43	26	130	538
13	121	14	8	27	18	14	52	27	53
14+	67	205	7	7	19	2	19	4	42
TOTAL	116631	112369	149888	107740	139319	78601	62922	46798	321511
	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	1	281	1321	3475	184	46	0	0	0
2	5915	3713	4355	7496	18456	2033	48	0	900
3	70204	9684	10037	13989	55967	47311	17540	483	500
4	258773	41701	14089	13449	22043	18812	35290	21403	3800
5	24018	88111	33871	6808	7368	4076	10645	21901	23400
6	6872	5827	49712	20789	2586	1389	1429	2800	16500
7	418	4138	2135	40044	7781	1626	812	237	600
8	422	382	1236	1247	11043	2596	546	458	200
9	1680	617	92	1349	311	6215	1466	262	200
10	525	2043	131	193	388	162	2310	969	100
11	146	935	500	279	96	258	181	1163	500
12	360	276	147	652	101	3	87	96	300
13	68	458	53	331	84	74	2	39	50
14+	13	143	92	46	98	65	53	53	10
TOTAL	369395	158309	117771	110147	126506	84666	70409	49864	41060

Table 21. North-East Arctic HADDOCK.
Fishing mortality - VPA.

	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002
2	0.007	0.013	0.008	0.002	0.002	0.006	0.003	0.003	0.030
3	0.020	0.067	0.126	0.062	0.037	0.102	0.167	0.023	0.284
4	0.317	0.235	0.388	0.300	0.402	0.149	0.233	0.268	0.376
5	0.690	0.462	0.575	0.427	0.554	0.506	0.207	0.184	1.058
6	0.859	0.690	0.722	0.494	0.467	0.536	0.506	0.148	0.962
7	0.770	0.655	0.800	0.510	0.639	0.415	0.452	0.476	0.416
8	0.848	0.497	0.497	0.554	0.660	0.425	0.420	0.314	0.609
9	0.820	0.772	0.436	0.353	0.457	0.433	0.362	0.311	0.488
10	0.235	0.261	0.359	0.315	0.562	0.417	0.351	0.258	0.656
11	0.780	0.990	0.798	0.568	0.301	0.247	0.405	0.303	0.414
12	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	0.400	0.400	0.400	0.600
14+	0.600	0.600	0.600	0.600	0.600	0.400	0.400	0.400	0.600
(0.4-7)0	0.659	0.511	0.621	0.433	0.515	0.402	0.350	0.254	0.703
(0.4-7)1	0.437	0.340	0.566	0.378	0.467	0.480	0.432	0.286	0.702
	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	0.000	0.003	0.008	0.011	0.001	0.001	0.000	0.000	0.000
2	0.003	0.063	0.066	0.057	0.075	0.071	0.071	0.020	0.010
3	0.320	0.216	0.242	0.309	0.146	0.078	0.105	0.017	0.011
4	0.596	0.519	0.555	0.591	1.165	0.608	0.345	0.221	0.109
5	0.908	0.475	0.466	0.576	0.772	0.697	0.859	0.375	0.400
6	0.465	0.582	0.438	0.586	0.450	0.315	0.566	0.579	0.310
7	0.302	0.570	0.437	0.772	0.455	0.572	0.307	0.169	0.231
8	0.182	0.499	0.331	0.495	0.501	0.268	0.382	0.284	0.210
9	0.297	0.437	0.212	0.732	0.218	0.592	0.239	0.319	0.193
10	0.167	0.712	0.154	0.913	0.479	0.169	0.458	0.245	0.193
11	0.206	0.502	0.374	0.564	2.207	0.687	0.288	0.441	0.193
12	0.244	0.741	0.134	1.244	0.409	0.382	0.525	0.243	0.193
13	0.300	0.600	0.300	0.500	0.500	0.600	0.475	0.475	0.193
14+	0.300	0.600	0.300	0.500	0.500	0.600	0.475	0.475	0.193
(0.4-7)0	0.588	0.472	0.474	0.632	0.710	0.548	0.519	0.336	0.262
(0.4-7)1	0.617	0.390	0.462	0.669	0.813	0.592	0.414	0.291	0.302

Tabl. 2. North-East Arctic HADDOCK.
Stock size in numbers = VPA.

1 January	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	366771	437721	29585	25720	240370	145437	1529682	432685	89855
2	123135	300152	358375	24221	21057	201710	119073	1251964	354239
3	320368	100064	242598	291101	19783	17210	164190	97239	1021828
4	198718	242173	76591	175043	223969	15604	12720	113705	77826
5	66980	118519	156738	42541	106124	122682	11006	8247	71186
6	10949	27515	61148	72202	22716	49948	60558	7328	5619
7	7143	3798	11294	24319	36055	11653	23921	29877	5172
8	5156	2709	1615	4155	11958	15576	6301	12458	16137
9	1019	1808	1349	804	1954	5062	8335	3388	7454
10	545	584	684	714	463	1013	2688	5046	2032
11	414	353	368	391	427	216	547	1548	3193
12	292	155	107	136	181	258	138	299	936
13	293	34	19	65	44	47	173	90	128
14+	162	496	17	17	46	7	63	13	102
TOTAL	1102544	1236081	940489	661429	691147	586422	1939394	1963888	1655708
SPAWN. ST.	26572	37452	76602	102803	73844	83779	102723	60048	40774
	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	81444	92282	184698	347713	247758	74753	75216	121872	0
2	73447	66680	75300	150024	281544	202681	61161	61581	99781
3	281567	54798	51242	57721	116065	213858	164105	50031	50419
4	629603	167444	36148	32923	34686	45084	132551	118546	40526
5	43747	284001	99620	16985	14924	8858	20088	76827	77795
6	20235	14441	153471	51199	7814	5647	3612	6965	43239
7	1759	10407	6610	81069	23320	4079	3375	1679	3197
8	2794	1064	4818	3497	30656	12117	1885	2034	1161
9	7188	1907	529	2834	1746	15206	7586	1053	1253
10	3746	4375	1008	350	1116	1149	6890	4891	627
11	863	2594	1758	707	115	566	795	3570	3133
12	1728	575	1286	990	330	10	233	488	1880
13	288	1109	224	921	234	179	6	113	313
14+	55	346	390	128	273	157	153	153	63
TOTAL	1148465	702023	617102	747061	760580	584344	477655	449803	323385
SPAWN. ST.	38656	36818	170094	141695	65603	39111	24535	20946	54866

1 January

Table 22. NORTH-EAST ARCTIC HADDOCK.
Biomass - VPA

	1964	1965	1966	1967	1968	1969	1970	1971	1972
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	211443	66042	160115	192127	13057	11359	108306	64178	674407
4	204680	249438	78889	180294	230688	16072	13101	117116	80160
5	119894	212150	280562	76148	189962	219601	19701	14763	127424
6	26058	65487	145532	171840	54065	118875	144127	17440	13374
7	20428	10861	32301	69552	103117	33329	68414	85449	14793
8	17169	9021	5378	13836	39820	51868	20984	41487	53737
9	5991	6689	4990	2976	7231	18728	30839	12537	27579
10	2403	2576	3015	3149	2041	4467	11852	22254	8961
11	2237	1904	1990	2111	2303	1167	2952	8361	17244
12	1956	1041	719	910	1215	1732	926	2001	6271
13	2168	251	143	484	323	344	1279	664	950
14+	1298	3971	136	136	368	53	505	106	814
TOTAL	615723	629430	713770	713563	644190	477595	423047	386356	1025712
SPAWN. ST.	79706	101800	194204	264994	210483	230563	281878	190300	143721
	1973	1974	1975	1976	1977	1978	1979	1980	1981
1	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0
3	185834	36167	33820	38096	76603	141146	108309	33020	35276
4	648492	172467	37233	33911	35726	46437	136527	122103	41741
5	78308	508362	178320	30403	26714	15856	35958	137520	139252
6	48160	34369	365261	121854	18598	13440	8597	16577	102909
7	5030	29764	18903	231856	66695	11666	9653	4801	9144
8	9303	3544	16043	11644	102084	40348	6276	6772	3866
9	26596	7057	1957	10486	6459	56261	28066	3896	4637
10	16520	19293	4446	1545	4922	5068	30383	21571	2763
11	4660	14008	9493	3820	621	3057	4293	19277	16918
12	11578	3853	8017	6636	2208	69	1562	3271	12595
13	2131	8206	1661	6812	1729	1326	43	836	2318
14+	441	2770	3118	1023	2180	1259	1228	1228	501
TOTAL	1037052	839860	678871	498085	344539	335934	370895	370870	364921
SPAWN. ST.	124419	122864	429499	395676	205496	132495	90101	78228	155652

Table 24 North-east Arctic HADDOCK
Parameters used in catch prediction
M = 0.2

Age	Relative Fishing Mortality ($F_{4-7} = 1.0$)	Mean Weights (kg)	Stock Size at the Beginning of 1982 (Thousands)
3	0.004	0.66	50 000*
4	0.42	1.03	40 828
5	1.52	1.79	29 753
6	1.18	2.38	42 695
7	0.88	2.86	25 965
8	0.78	3.33	2 078
9	0.74	3.70	770
10	0.74	4.41	846
11	0.74	5.40	423
12	0.74	6.70	2 115
13	0.74	7.40	1 269
14+	0.74	8.00	254

*Recruitment estimate of 1979, 1980 and 1981 year classes see Section 6.2.2.

Table 25 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	Virtual Population No. of 3 year olds x 10 ^{-6*}
1957	9		
1958	4		
1959	14		
1960	40		
1961	50		320
1962	3		100
1963	9		243
1964	12		291
1965	<1	7	20
1966	<1	<1	17
1967	13	42	164
1968	<1	8	97
1969	69	82	1 022
1970	33	115	282
1971	3	73	55
1972	9	46	(51)
1973	8	54	(58)
1974	35	147	(116)
1975	96	170	(214)
1976	13	112	(164)
1977	>1	116	(50)
1978	>1	61	(50)
1979	3	69	
1980	(>1)	54	
1981		30	

() = Estimated

*) = USSR Murman haddock included for 1974-1978

Fishing mortality index

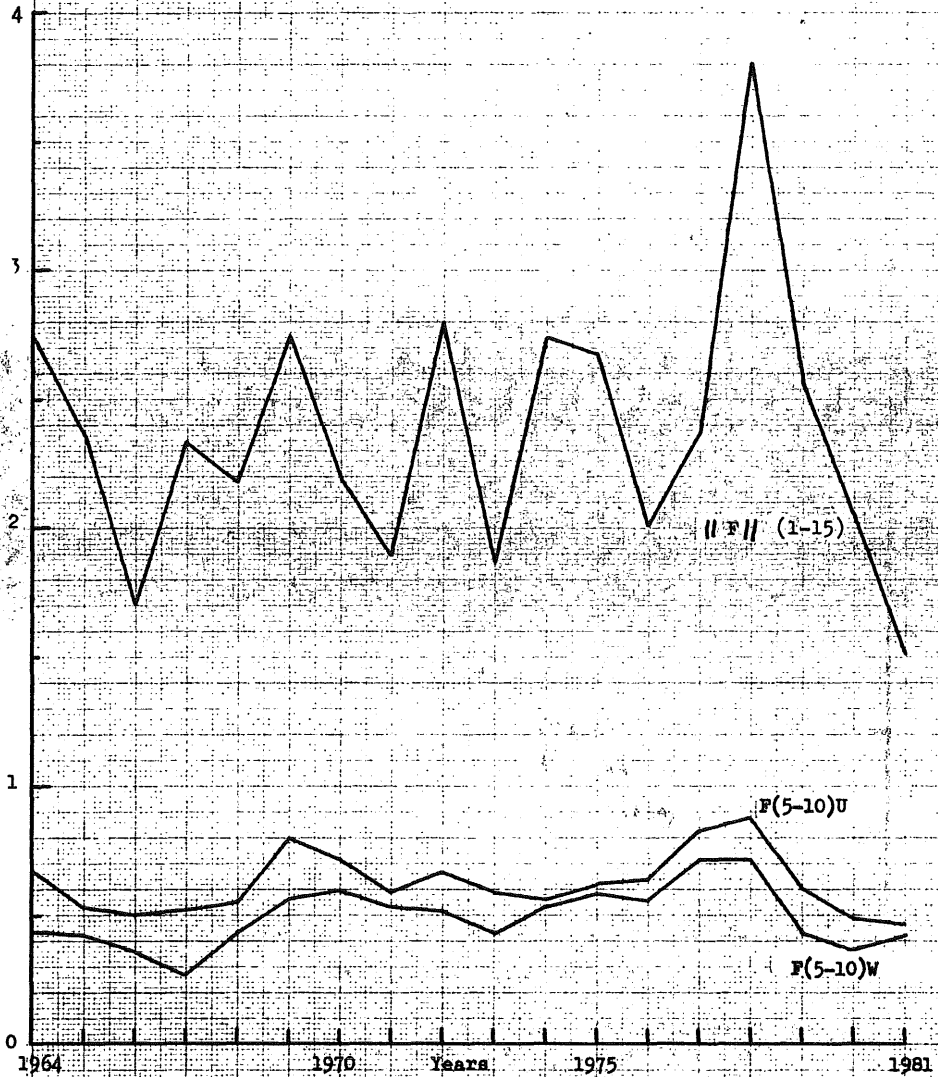


Figure 1.

North-east Arctic Cod

Comparison of the three methods to express the F-at-age array in a simple figure (see Section 3).

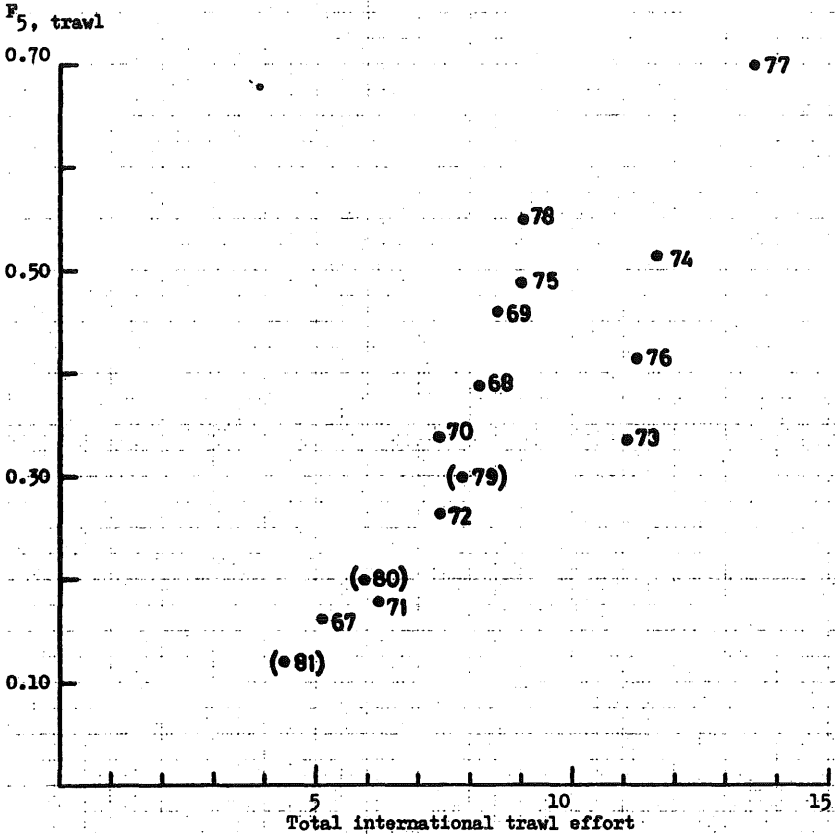


Figure 2. North-East Arctic COD.
Fishing mortality generated by the trawlers on the five year olds
versus the total international trawl effort (in UK units $\times 10^{-7}$).

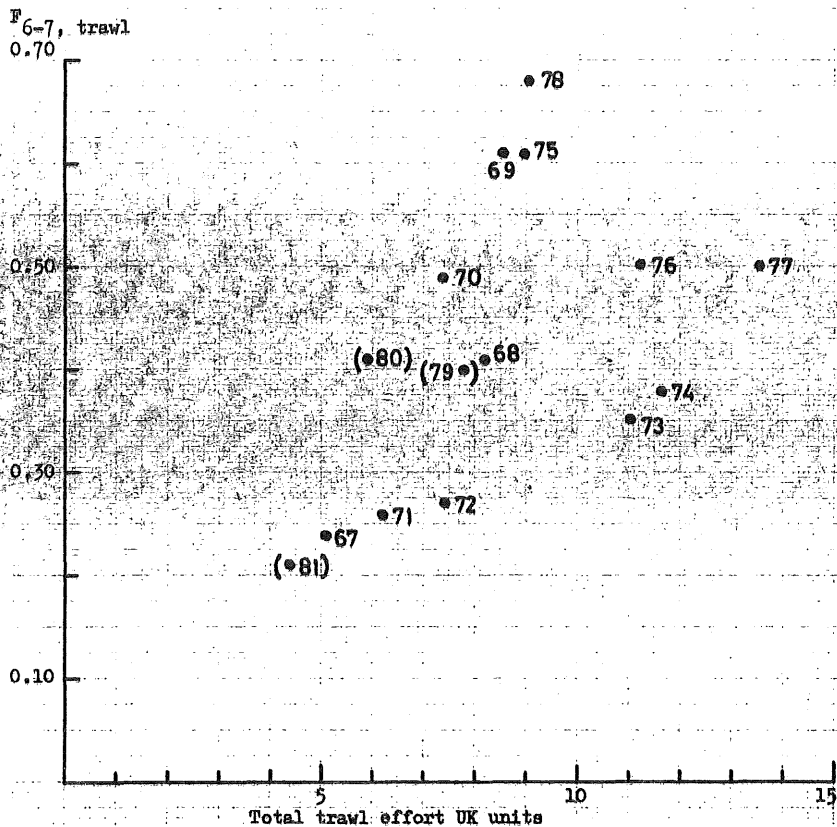


Figure 3. North-East Arctic COD. Fishing mortality on the five and six year olds (unweighted average) generated by trawlers versus the total trawl effort in Sub-area I and Divisions IIa and IIb.

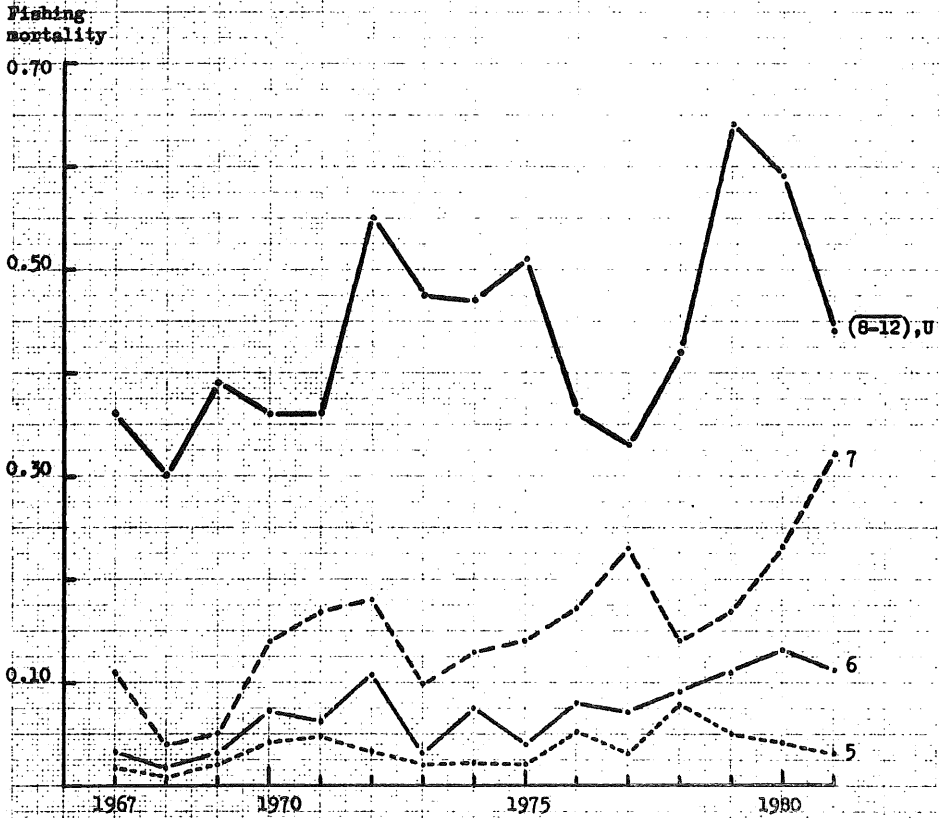


Figure 4. North-East Arctic COD. Fishing mortalities generated by conventional gears on the five to twelve year olds (U = Unweighted).

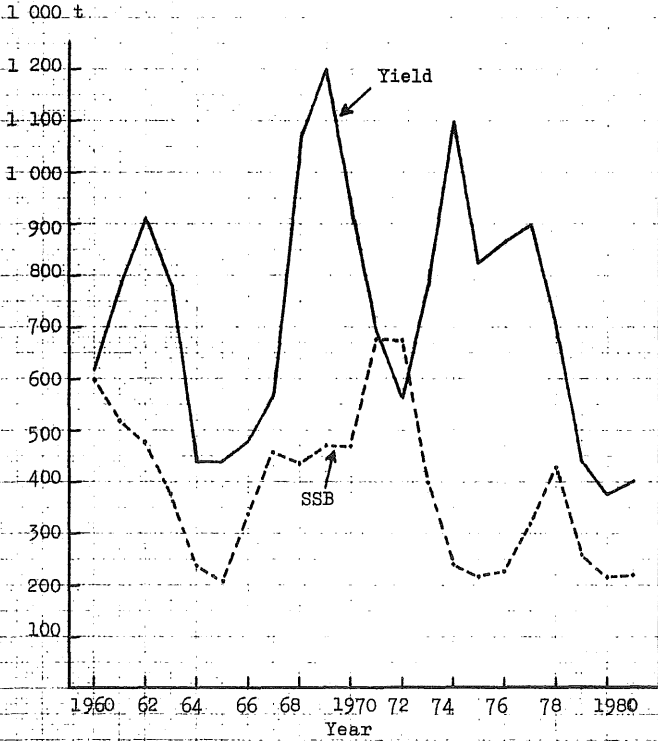


Figure 5. North-East Arctic COD.
Historic yield and spawning stock biomass 1960-81.

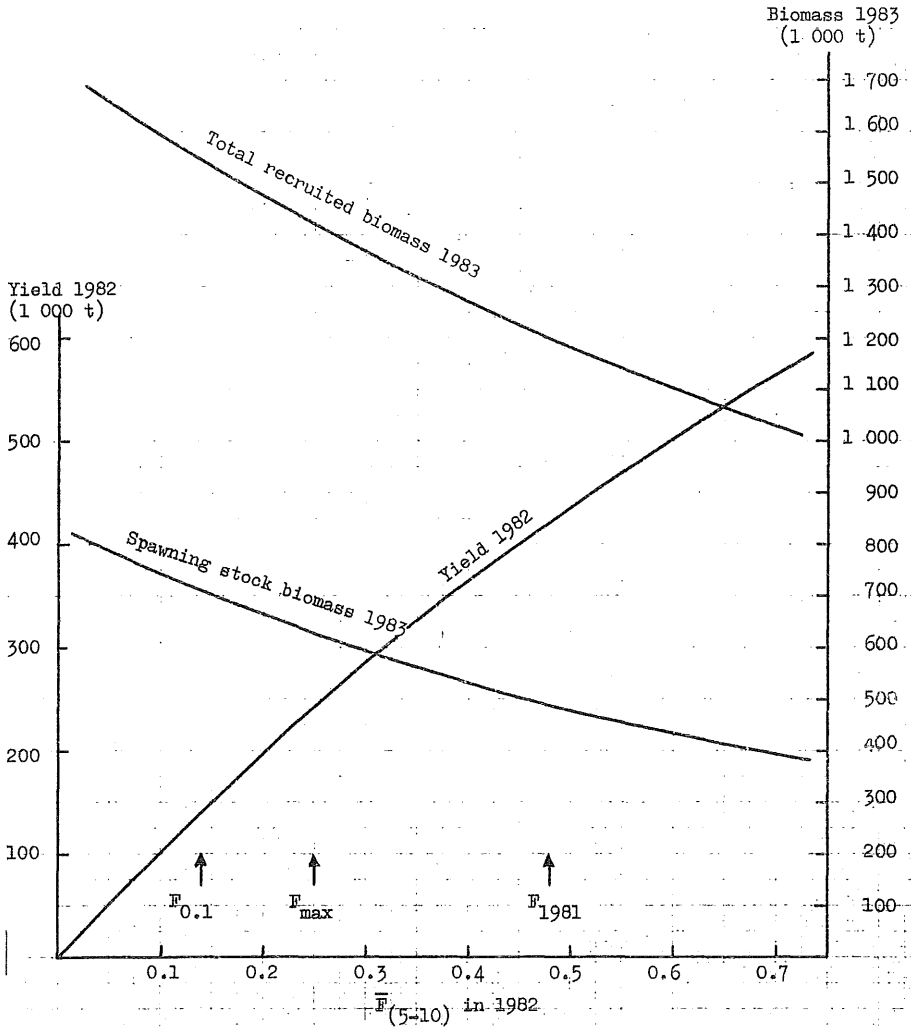


Figure 6. North-East Arctic COD. Yield 1982, total recruited biomass (age 3+) and spawning stock biomass (age 8+) at beginning of 1983 for different levels of fishing mortality in 1982.

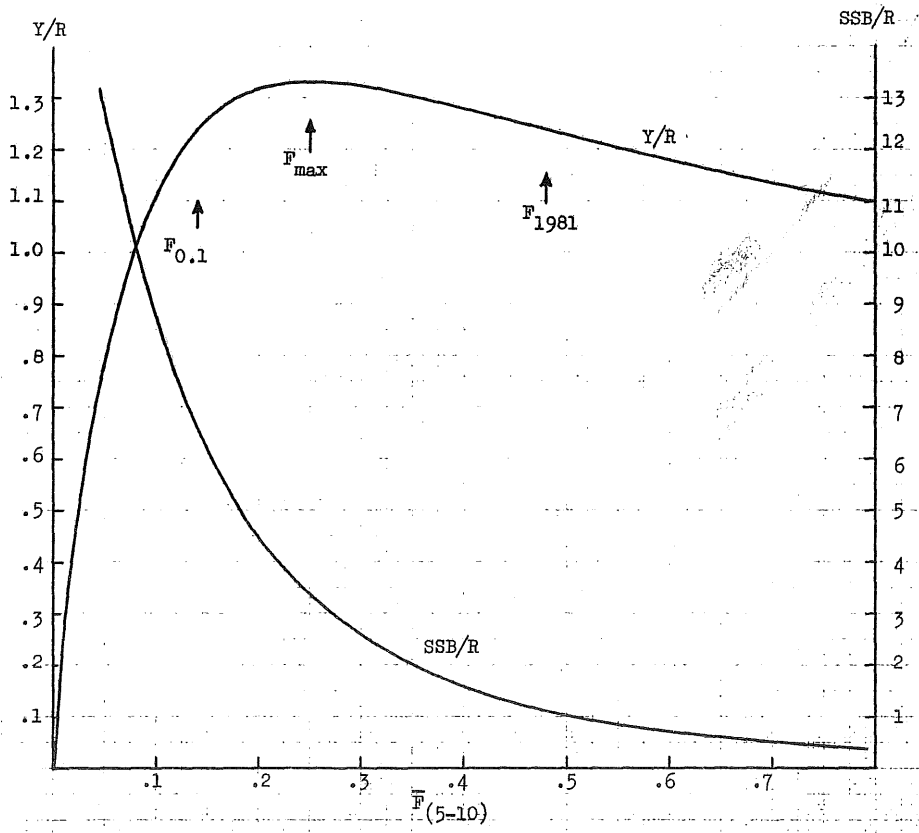


Figure 7. North-East Arctic COD.
Yield per recruit and spawning stock biomass per recruit.

(a) Based on Norwegian opue

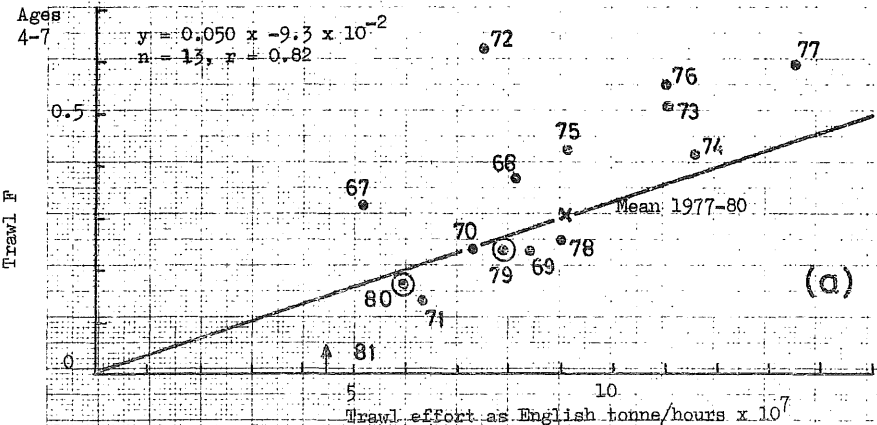
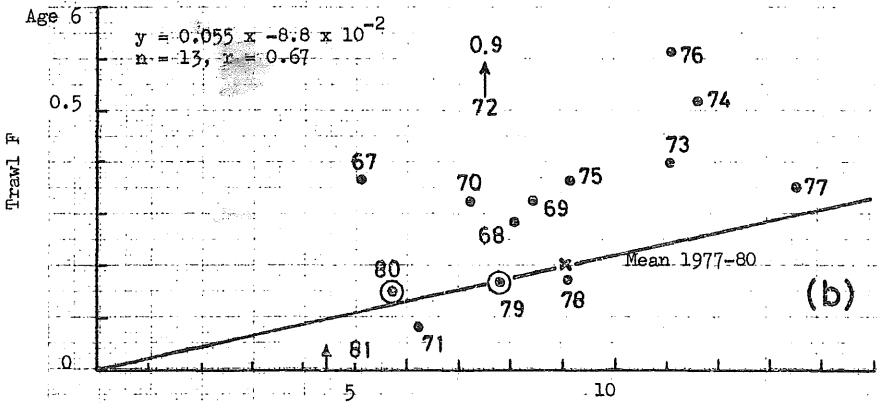
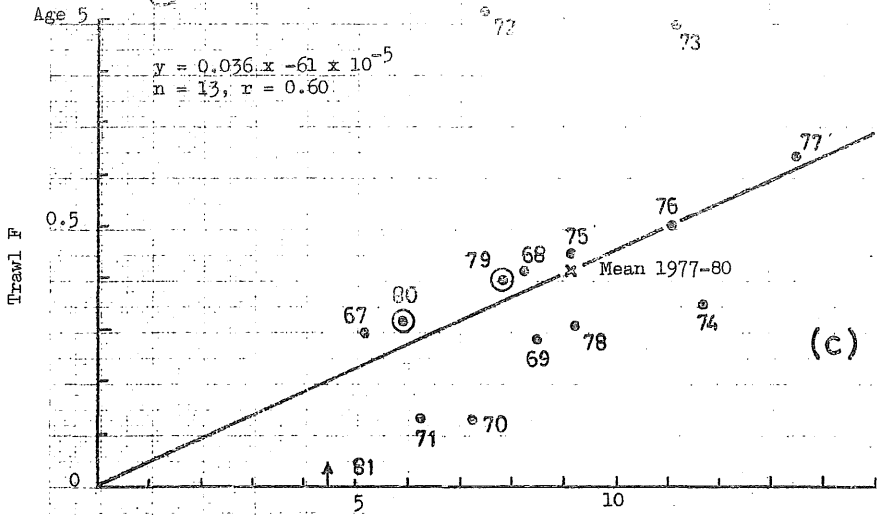


Figure 8. North-East Arctic HADDOCK.

Regression of fishing mortality for ages 5, 6 and 4+7 against total trawl effort in English units.

Recruited biomass
(1 000 t)

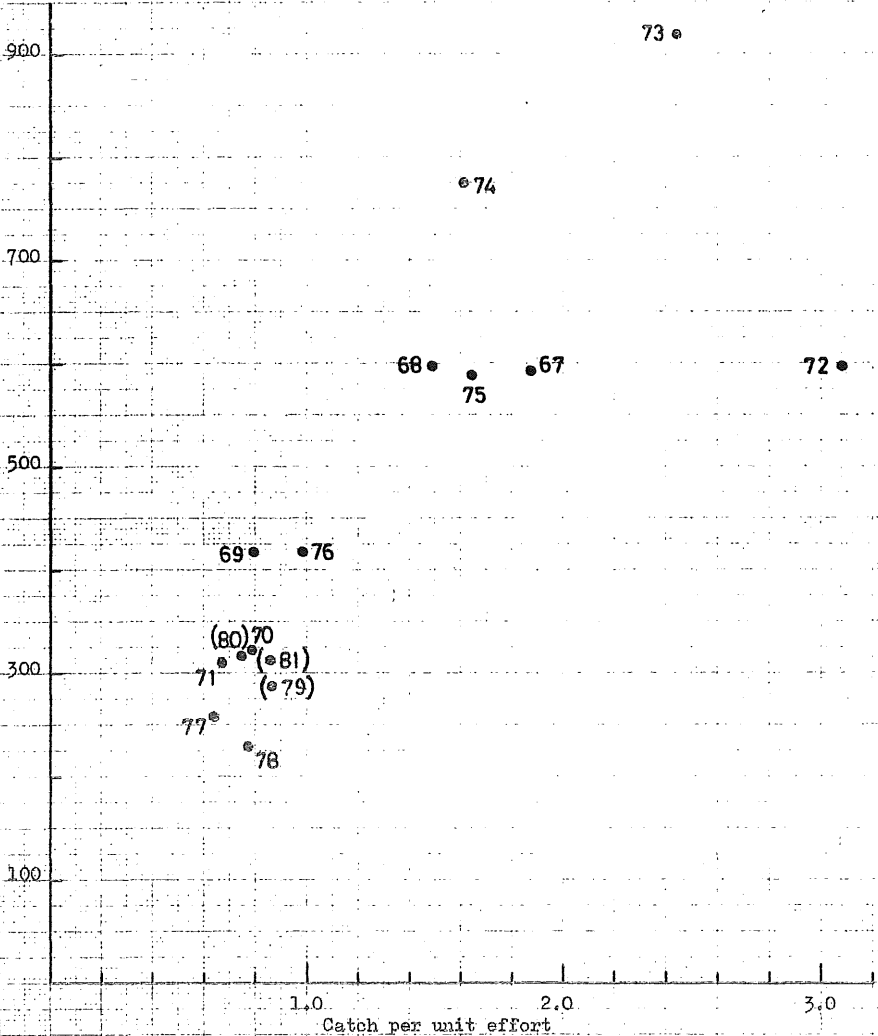


Figure 9. North-East Arctic HADDOCK.
The total trawl catch divided by the total trawl effort (in UK units) versus the biomass of the stock recruited to the trawl fisheries (opue are on relative scale).

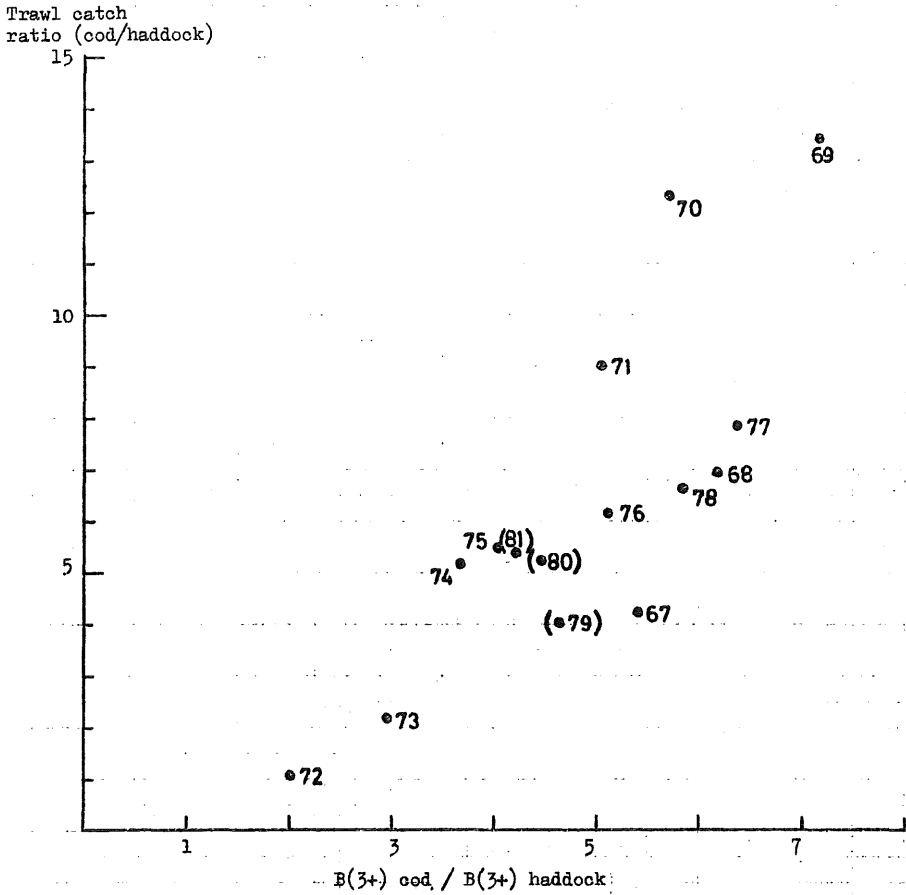


Figure 10. North-East Arctic COD and HADDOCK.
Total international trawl catch ratios versus biomass ratios
(3+) for the years 1967-81.

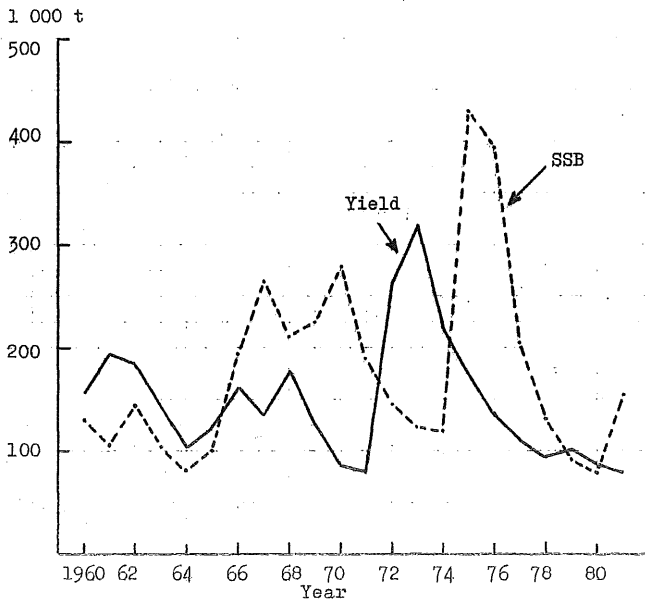


Figure 11. North-East Arctic HADDOCK.
Historic yield and spawning stock biomass
1960-81.

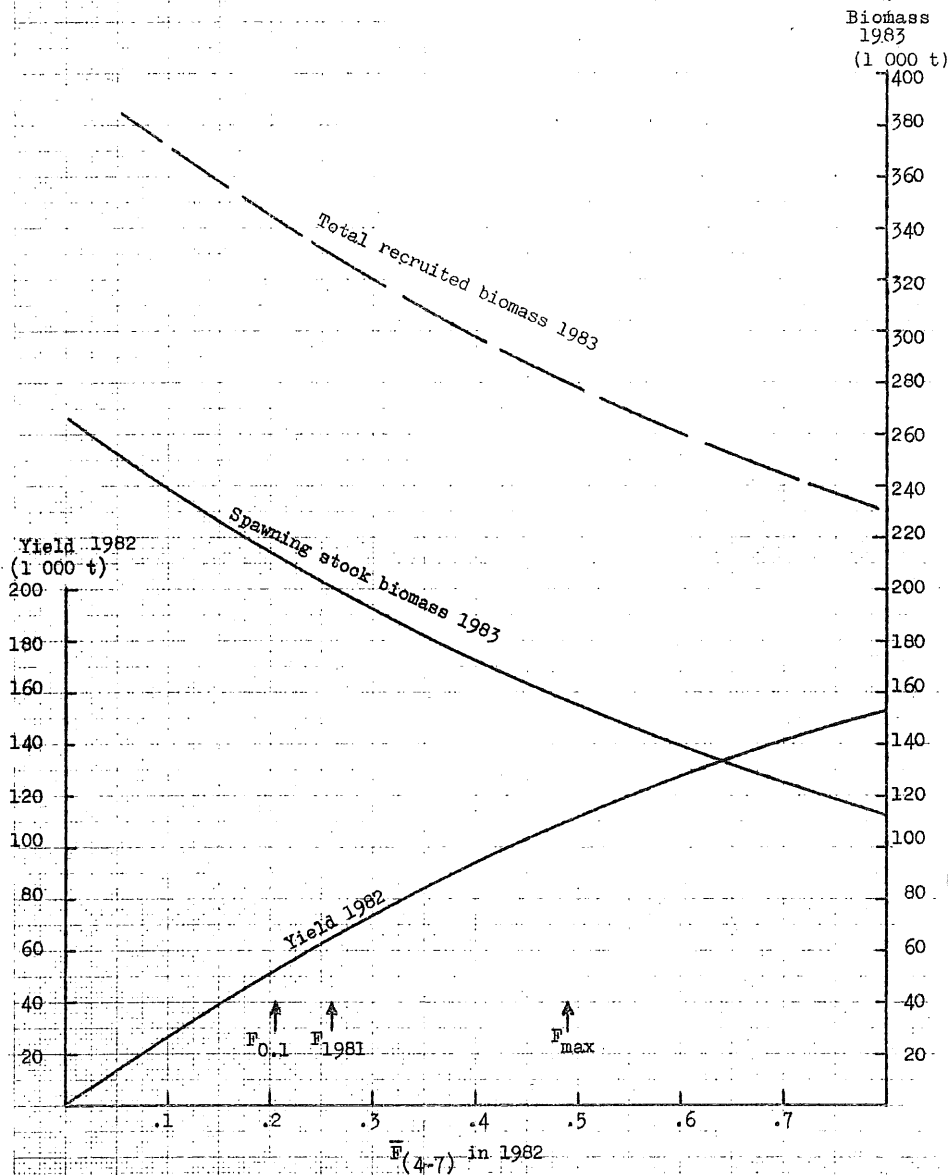


Figure 12. North-East Arctic HADDOCK.
Yield 1982, total recruited biomass (age 3+) and spawning stock biomass (age 8+) at beginning of 1983 for different levels of fishing mortality in 1982.

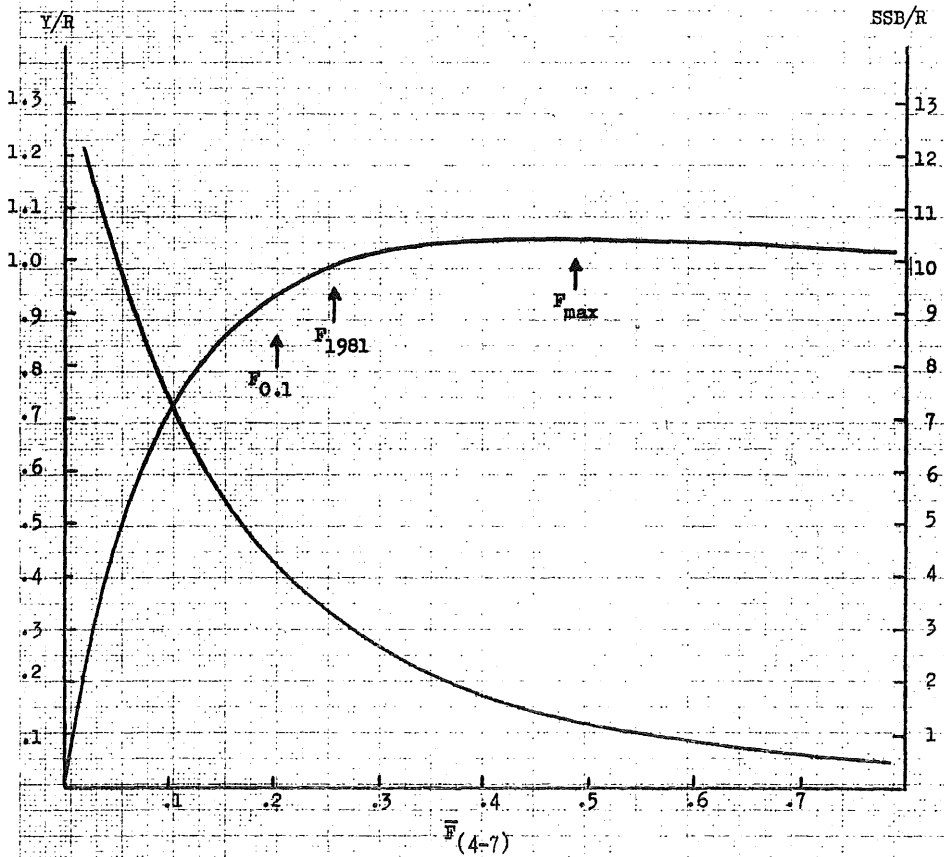


Figure 15. North-East Arctic HADDOCK.
Yield per recruit and spawning stock biomass per recruit.

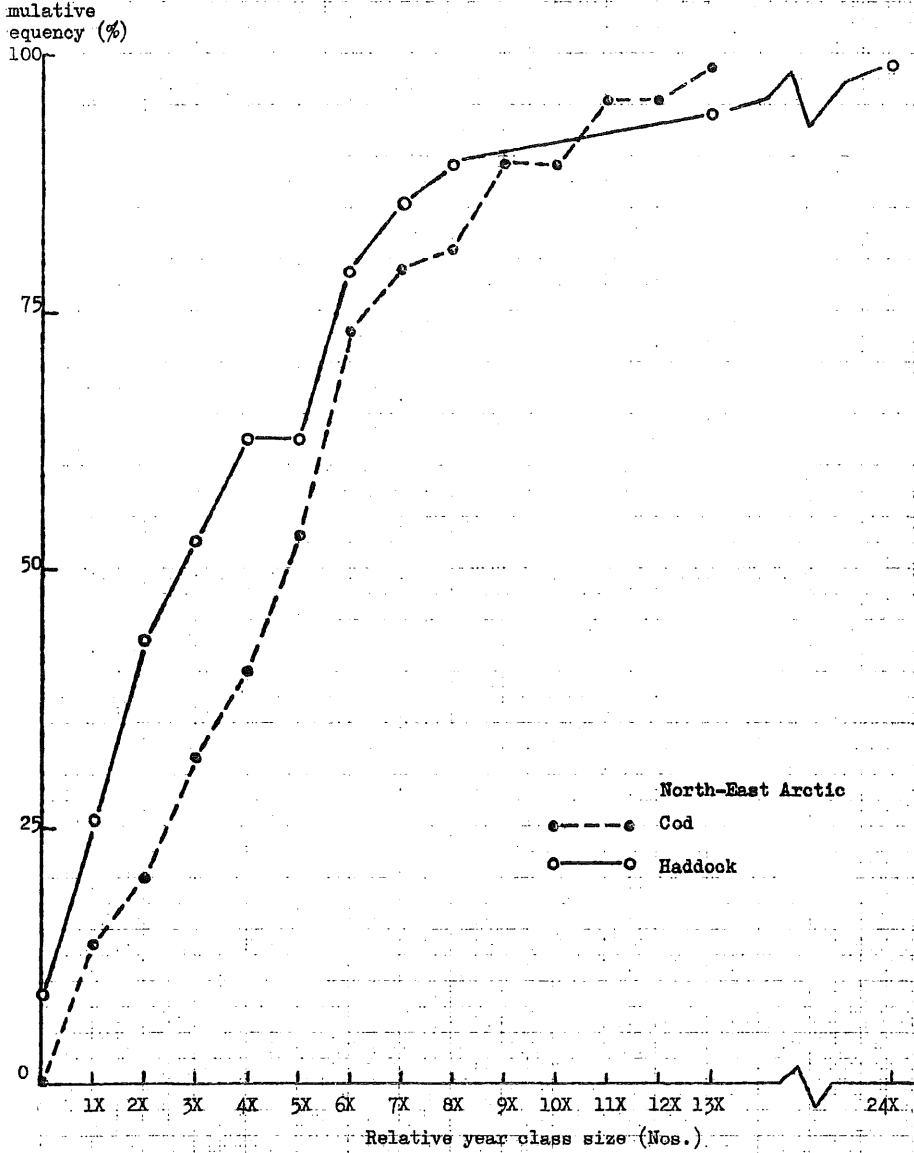


Figure 14 (see also next page). Recruitment distributions 1950-79.

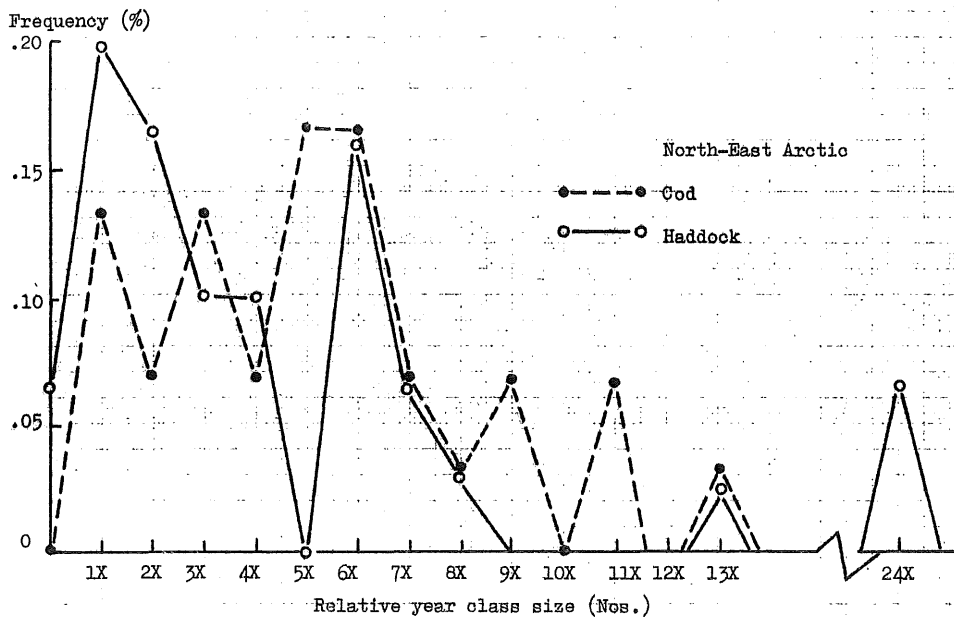


Figure 14 (see also former page). Recruitment distributions 1950-79.

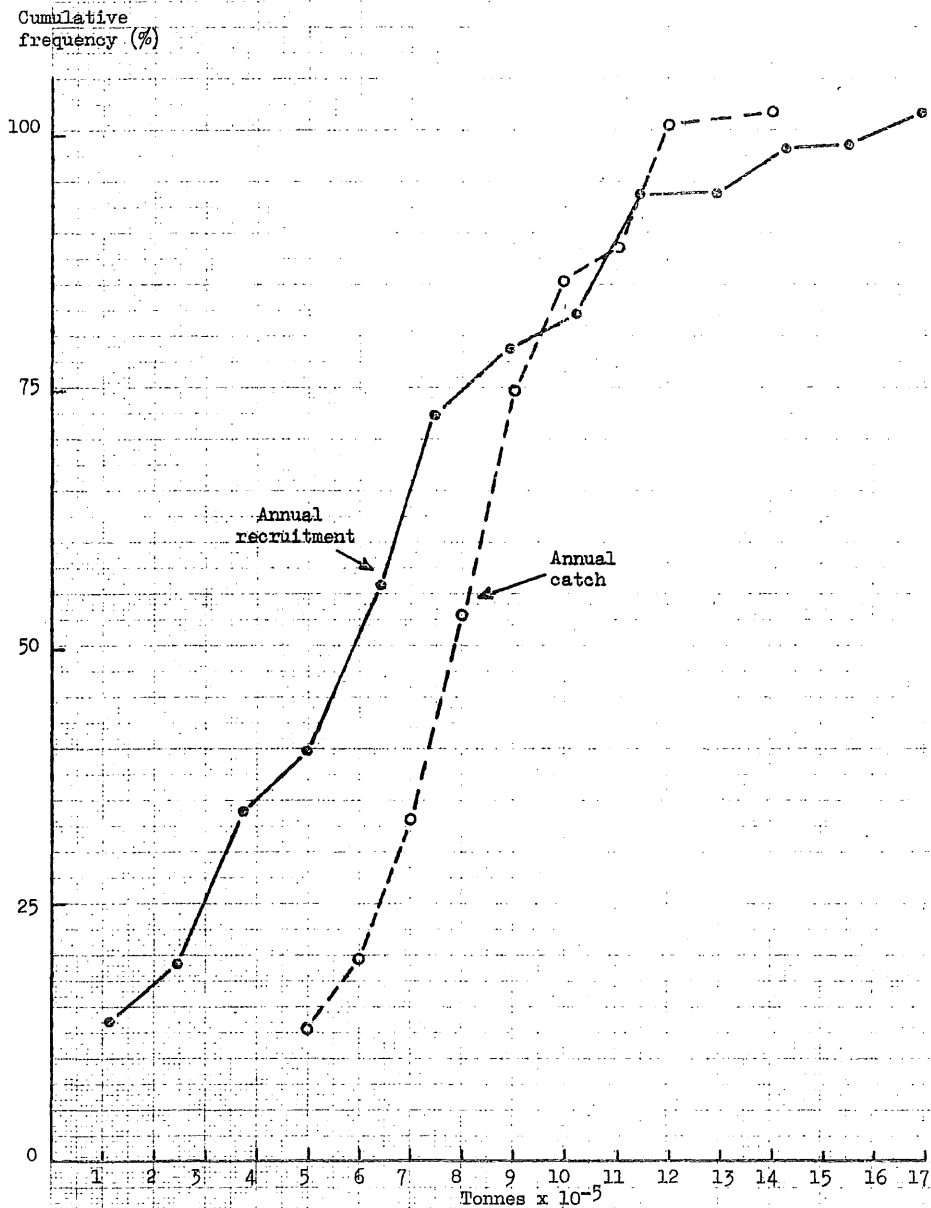


Figure 15. North-East Arctic COD.
Recruitment and catch distributions 1950-79.

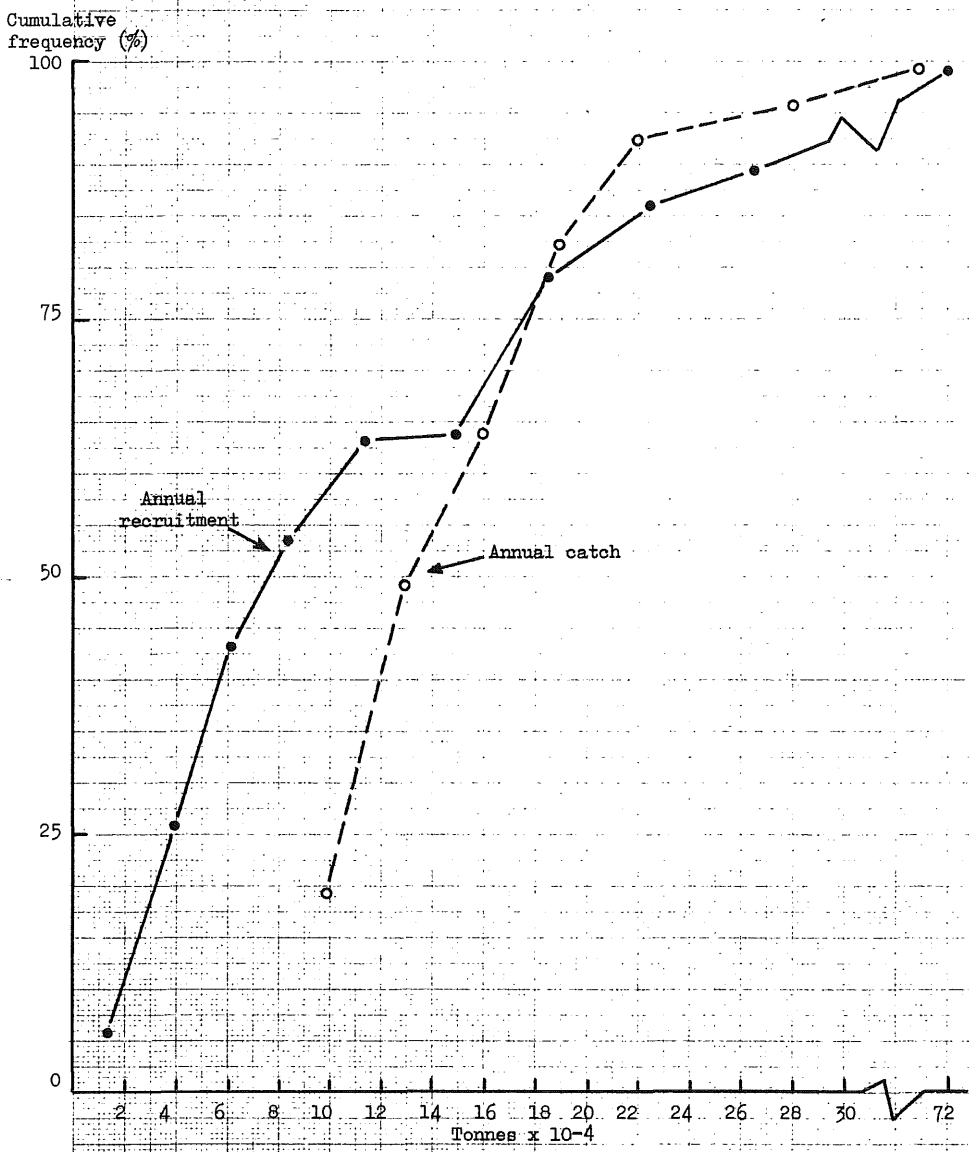


Figure 16. North-East Arctic HADDOCK.
Catch distributions 1950-79.

