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International Council for the
Exploration of the Sea

C.M.1979/G:20
Demersal Fish Committee

REPORT OF THE ARCTIC FISHERIES WORKING GROUP

Charlottenlund, 28 May - 1 June 1979

This Report has not yet been approved by the International Council for the Exploration of the Sea; it has therefore at present the status of an internal document and does not represent advice given on behalf of the Council. The proviso that it shall not be cited without the consent of the Council should be strictly observed.

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REPORT OF THE ARCTIC FISHERIES WORKING GROUP

1. PARTICIPANTS

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ICES Statistician, V. Nikolaev, also participated in the meeting.

2. TERMS OF REFERENCE

At the 66th Statutory Meeting the Council decided (C.Res.1978/2: 43) that:-

"the Arctic Fisheries Working Group should meet in the spring 1979 to:-

(a) assess TACs for 1980 for cod and haddock,

(b) examine any new data from midwater trawl fisheries and study the effect on the exploitation of these species,

(c) assess, if possible, the effective mesh size in use, and report on the effects of increases in mesh size".

The Working Group was also asked by the ACFM to answer some questions put before the ICES by the Norwegian Ministry of Fisheries concerning the management advice given for North-East Arctic cod in the ACFM report for 1978. These questions were asked in a letter dated December 1978 (see Annex 1).

3. NORTH-EAST ARCTIC COD

3.1 Status of the Fisheries (Tables 1-6)

Final figures for cod landings in 1977 amounted to 905 301 tonnes, about 15 000 tonnes higher than the preliminary figure used in the previous Working Group report (C.M.1978/G:64). This is 55 301 tonnes (about 6%) higher than the total TAC of 850 000 tonnes, Murman cod included.

Preliminary figures for the 1978 fishery indicate a substantial reduction in catches of more than 220 000 tonnes (-24%) from the 1977 level to about 684 000 tonnes. This reduction in catch was reported from all areas and was very pronounced in Division IIb where the catch dropped by 83% to the lowest level recorded since 1960.

The 1978 catch is about 20% below the TAC for 1978 of 850 000 tonnes and about 206 000 tonnes (-23%) less than the catch level of 890 000 tonnes assumed in the previous assessment for 1978 as basis for the calculation of TACs. The high catch from Sub-area I and Division IIb in 1977 was achieved by an increase in total international effort since the declining trend in catch per unit effort continued during 1977 in that area. In Division IIa total international effort decreased in both United Kingdom and Norwegian units, reflecting an increase in catch per unit effort in 1977.

In 1978 the changes in total international effort as measured in the different national units are reflecting changes in catch per unit effort of the respective fleets as well as a considerable change in the area distribution of the fishery (Table 3).

Particularly in Division IIb effort of both United Kingdom and USSR vessels was reduced by more than 80% and the total international effort in United Kingdom and USSR units was reduced by 78% and 37% respectively. This development can be explained by low stock density in that area since all fleets reported reduced catch per unit effort figures continuing the downward trend observed in Division IIb since 1974 for all high seas fisheries. Exceptionally the catch per unit effort increased in the Lofoten gill-net, long-line fisheries and in the Norwegian coastal trawl fisheries (Tables 4, 5, and 6) in 1977, 1978, and 1979 over the earlier years.

3.2 Abundance Indices - cpue

Table 5 gives the catches per unit effort by Norwegian long-liners, gill-netters and hand-liners in the Lofoten fishery for 1960-78 and by English trawlers fishing in Sub-area I and Division IIa. These latter data refer to the catches of adult fish, i.e. age groups ≥ 8.

Assuming the catch of one operation (ΔC) is proportional to the stock density

$$\Delta C = q \Delta f \quad N/A$$

where q is constant, f is fishing effort exerted by unit operation, N is the stock abundance, and A is the area inhabited by the stock (Gulland, 1969). The catch for a single operation can be written in terms of catch per unit effort

$$\frac{\Delta C}{\Delta f} = \frac{q}{A} N$$

Assuming A is constant from year to year over the area of the fishery and the stocks, averaging over one season gives:

$$C/f = q'N$$

If N is defined as the spawning stock biomass of fish older than 7 years calculated from the VPA then

$$q' = \text{cpue/spawning stock.}$$

Catchability coefficients, q', have been calculated from the data in Table 5 and the stock biomasses from Table 11.

Figures 1, and 2 show the trend of q' with time in the Lofoten data, while Figures 3a-b show the trend for the United Kingdom trawl data in Division IIa and Sub-area I. The new data for 1978 have resulted in some revision of the changes in q' described in the previous report (C.M.1978/G:64).

In Figures 1 and 2 there is a steady increase in q' with time. This follows from the known increase in efficiency of these gears with time. In the case of gill-nets, more and larger nets, and new net materials have come into use in recent years, effects which would not be reflected in a unit of effort in terms of men-per-day-worked used in Table 5. But it is seen that there is little indication of any change in q' since 1971. Again for long-liners changes in length of the line or number of hooks or further refinements to the fishing gear are unaccounted in the estimates of Table 5. The latest VPA estimates of spawning biomass lead to the same conclusions as for gill-netters in relation to recent changes in q'. the hand-line remains fairly constant from 1964-74. This gear has during recent years been mechanised, which can account for the increased q' in 1975 and 1976.

Figures 3a-b show the catchability coefficients calculated from English catches per unit effort. For Sub-area I the data refer to the age groups 4-7 which form the bulk of the catches in that area. It is seen that there is a steady decrease in q' with time. Part of this may be due to the likelihood that the area fished is not a constant part of the stock distribution. In more recent years, a variety of regulations have been introduced which must have affected vessels' freedom to operate as in earlier years. Nevertheless, the level of q' from 1972 to the present appears fairly stable.

In Division IIa the data refer to the spawning stock (age group ≥ 8). Again a decline is observed which, in part, could be accounted for as a result of the extension of closed areas and declining spawning stock biomass and the disruption of normal fishing patterns as a result of management decisions on the fleet deployment in fishing under TAC allocations. The increases in q' in 1962-64 and 1970 in Sub-area I and the appearance of peak q' values in 1964-66 and 1973 could be associated with fishing concentrating on good year classes in Sub-area I in the earlier years followed by similar increases when these fish enter the spawning fishery some three years later.

Table 6 gives abundance indices from Norwegian freezer trawlers and English conventional trawlers (i.e. not freezers) for the period 1972-78. A number of regressions of those data are shown in Figure 4. Figure 4A shows a positive correlation between English and Norwegian vessels in Sub-area I. A positive correlation exists between Norwegian vessels operating in Sub-area I and Division IIa (Figure 4C). In contract, there is a negative correlation between English and Norwegian vessels fishing in Division IIa (Figure 4B). These latter vessels may operate in some place from which non-Norwegian vessels are excluded but not within 12 miles of the coast. A similar relation is seen in the English data (Figure 4D). The English data in Division IIa clearly underestimate stock abundances in the period after 1973.

The relationship between the abundance index of age groups 4-7 in the English trawl catches in Sub-area I and the stock biomass is shown in Figure 5. There is a close correlation between the two sets of data and this fact was used in selecting the input fishing mortalities for the 1978 catch data in the VPA calculation.

3.3 Fishing Mortality versus Effort

Mean fishing mortalities for 4-7 years olds derived from a preliminary VPA run were plotted on the estimate of total international effort derived in Table 3. A line was fitted through the origin and the mean values for 1967-74. In selecting input F values for these age groups, account has been taken of the total effort in 1977 and 1978. The mean F values from the final VPA run have been used in Figure 6.

No correlation exists between fishing mortalities of 8-12 year olds and the estimate of the international effort. As has been shown earlier, these data are derived from English trawler catch per unit effort and in recent years their catch rates may be biased in Division IIa. As much of the fishing mortality in Division IIa is generated by passive gears, the increase in efficiency of these resulting in increased fishing mortality may not be reflected in the international effort estimate. It has been estimated that 53% of the fishing mortality on the 8-12 years is generated by these gears for the period 1967-77.

3.4 Virtual Population Analysis (VPA)

The age compositions used for the 1977 landings were adjusted for catch figures and preliminary age compositions were derived for 1978 (Table 7).

The assessment of stock size has been made using a natural mortality of 0.2.

Fishing mortalities for 4-7 year olds were chosen following the reasoning discussed in Section 3.3. The mean mortality of 4-7 year olds was set at 0.51. The distribution of F with age was set using the exploitation pattern based on the period 1970-76 (Table 8).

In addition to the relation between fishing mortality on 4-7 year olds and fishing effort (Figure 6), the relationships between the final VPA estimates of stock of 3, 4, and 5 year olds and the catches per unit effort in the English trawl fishery in Sub-area I were also considered. These are given in Figures 7 - 9. All are highly correlated and the position of the estimated cpue for 1978 is shown on the X-axes.

The F value on 3 year olds using the exploitation pattern in Table 8 gave a low level of F. In view of the reported heavy fishing on this abundant year class and the fact that the relative F values on 3 year olds have been high during recent years (Figure 10), this low value was thought to be unlikely. The F value was set at the highest levels observed on an abundant year class, being the mean of those generated in 1973 and 1974.

In view of the fact that 53% of the fishing mortality on 8-12 year olds is generated by the passive gears, and that they may still be increasing in efficiency, the Working Group considered that the fishing mortality on these age groups would not be likely to differ greatly from the 1970-75 average. A level of F - 0.70 gives a catchability coefficient (q') for 1979 consistent with the recent values for each of the gears (Figures 1 - 3).

The calculated estimates of fishing mortalities for earlier years resulting from VPA are given in Table 9, and stock size estimates in Table 10.

3.5 The Spawning Stock Recruitment Relationship for Cod

The estimation of the mature stock size depends on the mean maturation age applied to the age composition of the stock. A maturation give estimated by Garrod (1967) on the basis of spawning class compositions in the period 1941-53 (Rollefsen, 1954) indicated a mean maturation age of 10 1/4 years.

A mean maturation age of 9 years was used by Hylen and Dragesund (1973), while Garrod and Jones (1973) considered half of the 7 year olds and all older fish to be mature. A knife-edged maturation of 8 years has been used by the North-East Arctic Fisheries Working Group in recent years, and this seems to be in conformity with more recent unpublished Norwegian data from the spawning area (Hylen and Rørvik, 1975). On this basis the mature stock was estimated at the beginning of the year assuming that all fishes

10 years and older were mature in the period 1946-53,

9 years and older were mature in the period 1954-69 and

8 years and older were mature in the period 1970-78.

A first estimate of the mature stock size (S'_j) for each year (j) at 1st of January was obtained by using the result from the VPA, the mean weights (Table 12) and the above changes in the age of maturity.

However, the growth rate in this cod stock has obviously increased. An estimate of the mean growth rate, relative to the growth rate giving the mean weights is obtained by the ratio:

$$W_{korij} = \frac{C_{j,\ ToT}}{\sum_{i=3}^{15} C_{i,j} \times W_i} \quad \text{where}$$

$C_{j},\ T_{O}T$ = actual total catch in weight in year j

$C_{i,\ j}$ = total catch in number of age group in year j.

W_i = mean weight at age i.

The result is given in Table 11.

The corrected estimate of the mature stock at the beginning of each year is then,

$$S_j = S'_j \times W_{korij} \quad \text{(see table 11)}$$

It should be noted that because of the higher age of maturity applied to the stock before 1970 and the varying growth rate the corrected estimate of the mature stocks is considerably different from the uncorrected estimates given in Anon (1978) and Table 11, especially for the earlier years.

The corresponding values of the corrected spawning stock and the recruitment are plotted in Figure 11.

The Ricker-curve is:-

$$R_{3,j} = S_j \, e - S_j$$

or

$$l_n \, (R_{3,j}/S_j) = l_n - S_j$$

Assuming that S_j is considerably more accurate than $l_n \, (R_{3,j}/S_j)$ ordinary linear regression of $l_n \, (R_j/S)$ versus S_j, is used instead of functional regression. This gives,

$$\alpha \, GM = 3.08 \quad \beta = 1.36 \times 10^{-3}$$

The index GM indicates that this is the geometric mean. Using formula (11.6) in Ricker (1975) the conversion factor from the GM to arithmetic mean (AM) is:

$$_{\alpha}AM = 1.194 \times {}_{\alpha}GM = 3.67$$

Then,

$$R_{3,j} = 3.67 \times S_j \times e^{(-1.36 \times 10^{-3} \times S_j)}$$

This relation is drawn in Figure 11. $R_{3,j}$ is in millions, and S_j is in thousands of tonnes.

3.6 Catch Prediction

3.6.1 Relative fishing mortalities in 1979 and 1980 (Table 12)

The Working Group did not expect the present 1978 exploitation pattern to change in 1979 and 1980, the year for which catch predictions are to be made, as long as the present effective mesh size will be maintained. Consequently, the relative fishing mortality estimated for 1978 (see Section 3.4) was used in the catch predictions.

Assuming a change in trawl mesh size in 1980 from the present effective mesh size to 135 mm and 150 mm respectively, and comparable changes for Danish seine, different F at age arrays were estimated for catch predictions in 1980. In evaluating the effects of an increase in mesh size (see Section 5.2) fishing mortalities for all age groups were estimated for the present mesh size as well as for the larger mesh sizes. The ratio of the F generated by the larger mesh sizes to the F under the present exploitation pattern (for the different age groups) was then applied to the 1978 F at age array in order to describe in terms of relative F the exploitation pattern developing from the fishery with larger meshes.

3.6.2 Recruitment

Using the new VPA estimates on the number of recruits at age 3, the correlation of the VPA results (Table 13) and the USSR young fish survey indices was revised (Figure 12). The strength of the 1976 and 1977 year classes was estimated as poor at age 1 and 2 in earlier surveys. The most recent survey confirmed the previous results and a survey index of "1" was applied to the revised regression giving an estimate of 310 million cod at age 3 for both the 1976 and 1977 year classes to be used in the catch prediction.

3.6.3 Yield per recruit curves (Figures 13 - 14)

Yield per recruit curves and curves for spawning stock biomass per recruit were calculated for cod using the present exploitation pattern as well as the ones developed for a fishery using 135 mm and 150 mm mesh sizes, respectively.

The long-term effects on yield per recruit and spawning stock biomass per recruit of changes in the pattern of exploitation from the present one can be seen on the graphs. For the present exploitation pattern $F_{max} = 0.25$ for the 135 mm mesh size and the 150 mm mesh size $F_{max} = 0.29$ and 0.32, respectively. The corresponding values for $F_{0.1}$ are 0.15, 0.17, and 0.18.

3.6.4 Mean weight per age group

The weight of the catches calculated from the catch in numbers and the average weight per age figures used in previous assessments were compared with reported catches (See Section 3.5). The differences in the most recent years are as small as 1% (Table 11) and therefore no corrections of the average weights per age group were necessary.

3.6.5 Catch in 1979

The catch prediction was carried out assuming that the 1979 TAC of 700 000 tonnes will be fully taken. This catch is associated with a fishing mortality of F = 0.95. In the light of the fact that the reported catch in 1978 reached only 80% of the TAC, and in view of the declining trend in cpue in almost all trawl fisheries, the Working Group did not expect that the TAC in 1979 would be fully taken. Therefore, an alternative catch prediction was done based on the assumption that the catch in 1979 would be 500 000 tonnes generating a fishing mortality of F = 0.60.

3.7 Management Options

Following the guidelines from the Advisory Committee on Fishery Management (ACFM), the Working Group in addition to calculating TAC for 1980 estimated the spawning stock biomass (8 year old and older cod) and total biomass (3 year old and older cod) for 1981, for options related to the reference points on the Y/R curve as suggested by ACFM. In addition, other options have been considered which are related to certain levels of spawning stock biomass.

Alternative calculations have been made for the assumption that the trawl mesh size would increase in 1980 to 135 mm or 150 mm, respectively. The options and the results of the calculations are given in Tables 14 - 15. For the three alternatives of exploitation pattern the ratios between the options remain almost in the same order of magnitude, although the absolute figures are at different levels, except for the spawning stock biomass which is not affected by a change in exploitation pattern for the age groups 3 to 6 in 1980.

3.7.1 Effects of 1980 TACs on spawning stock biomass

Assuming that the catch in 1979 will be 700 000 tonnes, the 1980 catches calculated for the different options vary between 501 000 tonnes and 67 000 tonnes, the first one being associated with a high level of fishing mortality, F = 0.95, in 1979 leaving the spawning stock biomass as low as 166 000 tonnes at the beginning of 1981, whereas the lowest calculated catch would bring the spawning stock biomass back to the 1979 level, which is 27% below the 527 000 tonnes estimated for 1978. If the fishery will be allowed to take catches of 400 - 500 000 tonnes in 1980, the spawning stock biomass will reach low levels by 1981 (Table 14), comparable to that prevailing in 1964-65 and 1974-76 (uncorrected spawning stock, Table 11.)

In 1982 the poor 1974 year class will enter the spawning stock, In the following years the originally rich but heavily fished 1975 year class, and the poor 1976-78 year classes (Table 13) will enter the spawning stock. As also stressed by the Working Group in its previous report (C.M.1978/G:64) this will bring the spawning stock to a dangerously low level in the mid 1980s unless the fishing mortalities are reduced well below the present level in the coming years.

The curve in Figure 11 describing a Ricker stock recruitment relation shows an optimum level of spawning stock biomass for the range 500 000 tonnes to 1 000 000 tonnes. Even a zero TAC for 1980 could not increase the spawning stock to the level of 500 000 tonnes, which is considered by the Working Group as a minimum requirement to reduce the probability of recruitment failure due to low spawning stock levels.

Under the assumption af a catch of 500 000 tonnes in 1979, the minimum level of spawning stock biomass of 500 000 tonnes can be reached in 1981 by fishing at $F_{0.1}$ which would result in a TAC of 133 000 tonnes in 1980.

The basic requirement for re-building the spawning stock is that it should not be allowed to fall below the 1980 level, and therefore no option should seriously be considered which would lead to a further decline in stock size. This approach implies that the 1980 catch should not exceed 337 000 tonnes or 412 000 tonnes respectively depending on the assumption concerning the 1979 catches. If, however, the catches in 1979 deviate greatly from the assumptions made in this assessment, the TAC for 1980 will have to be re-established on that basis.

A possible change in exploitation pattern in 1980 would still prevent a further decline in spawning stock size by 1981; however, the total catch figures associated with this approach are lower (see Tables 14 and 15), caused by an immediate loss on the younger fish expected when the mesh size is increased.

3.7.2 Effects of 1980 TACs on total biomass (age 3 and older) in 1981

On the assumption of a total catch in 1979 of 700 000 tonnes (Table 14) the total biomass cannot be maintained at the 1979 level at the beginning of 1981 by any option considered. For the present exploitation pattern the option which keeps the spawning stock at the 1980 level will also prevent a further decline in total biomass which is already 25% below the 1979 level. An increase in mesh size in 1980 to 135 mm or 150 mm would increase the total biomass above the 1980 level under all options, except that which keeps F as high as in 1979. This demonstrates the beneficial effect on the total stock of an increase in mesh sizes.

If the catch in 1979 will be about 500 000 tonnes (Table 15), then the total biomass will only be reduced by 10% at the beginning of 1980. Maintaining the total biomass at the 1980 level at the present exploitation pattern would require that not more than 350 000 tonnes will be taken in 1980. Larger meshes (135 mm or 150 mm) introduced in 1980 would keep the total stock and the spawning stock biomass about the 1980 level with corresponding catches of 350 000 tonnes and 325 000 tonnes, respectively.

It should be noted that the management option aiming at keeping the spawning stock biomass at the 1980 level is considered by the Working Group as a minimum requirement on conservations grounds.

4. NORTH-EAST ARCTIC HADDOCK

4.1 Status of the Fisheries (Tables 16-19)

The final figure for the catch of haddock of 110 158 tonnes in 1977 differs only slightly from that given in the previous report. The catch in 1977 is 27 121 tonnes (-20%) less than the catch of 1976. The preliminary figure for 1978 of 94 026 tonnes shows a further reduction of haddock catches by about 16 000 tonnes (-15%) from the 1977 level (Tables 16 - 17). Although the reduction in catch was reported for all areas, as in the cod fishery, the reduction in Division IIb was substantial and amounted to about 8 600 tonnes, representing a drop of 90% compared with the previous year.

The assumed catch of haddock for 1978 of 125 000 tonnes as the basis for the catch prediction in the previous assessment was overestimated by about 31 000 tonnes (25%).

Catch per unit effort figures for 1978 did not fall below the very low 1977 level (Table 18). This indicates that the downward trend observed in all areas since 1974 due to declining abundance of the abundant 1969 year class has been reversed as a result of the 1975 year class entering the fishery. This year class was expected to be of similar strength as the rich 1969 year class as also indicated by the USSR young fish survey results (Table 19). However, the catch per unit effort did not increase substantially in Sub-area I and Division IIb compared to the 1972 situation when the 1969 year class recruited to the fishery.

4.2 Virtual Population Analysis (VPA)

The preliminary age compositions used for the 1977 landings in Doc. C.M.1978/G:64 were adjusted for the final catch figures in Table 16. The new catch figures are given in Table 20.

The assessments were made for a natural mortality coefficient of M = 0.20.

The exploitation pattern used for 1977 in Doc. C.M.1978/G:64 was based on the average for the years 1970-74. This was maintained unchanged for the VPA input fishing mortality pattern for 1978 (Table 21).

The level of fishing mortality on the 3 - 6 year old haddock in 1978 was estimated from the regression of total international effort in United Kingdom units and the mean fishing mortality in 1965-75 on these age groups using the results from a preliminary VPA run (Figure 15). Applying this regression to the total international effort in 1978 gave a mean fishing mortality on age groups 3 - 6 F = 0.65 (Figure 15). This value corresponds to a fishing mortality on the 7 year and older $\bar{F}_{7+}$ - 0.60 with the assumed exploitation pattern. The relation between the mean fishing mortalities on 3 - 6 year olds as given in the final run, versus total effort, differs little from the one given in Figure 15.

Estimates of fishing mortalities for earlier years resulting from VPA are given in Table 21 and stock size estimates in Table 22. Estimates of spawning stock biomass and subsequent year class strength are given in Table 23.

4.3 Catch Prediction

4.3.1 Relative fishing mortalities in 1979 and 1980

For the year 1979 the relative Fs for age groups 4 and 5 have been changed compared with the 1978 F at age array, expecting the fishery in 1979 to concentrate on the 1975 year class, with the effect of decreased relative F on the 1974 year class. Although the 1975 year class is at present one of the most abundant year classes in the stock (Table 24), it did not come up to the expected strength based on the USSR young fish survey as in the previous report (C.M.1978/G:64). The relative Fs on the 4 and 5 years old in 1980 are therefore changed back to those used for 1978. For all other age groups the relative Fs in 1979 and 1980 are assumed to be the same as those applied for 1978.

Assuming a change in 1980 from the present effective mesh size to an effective mesh size of 115 mm and 150 mm respectively, corresponding F at age arrays have been estimated (Table 24). This was made by the same method as described in Section 3.6.1. Applying these exploitation patterns expected catches in 1980 and stock sizes in 1981 were estimated.

4.3.2 Recruitment

The number of recruits at age 3 as estimated by VPA are given in Table 19 together with the USSR young fish survey indices. The correlation between them is revised in Figure 16. The USSR survey indices for the 1976 and 1977 year classes applied to the revised regression give an estimate at age 3 of about 170 and 100 million fish for the 1976 and 1977 year classes, respectively. These numbers are used in the catch prediction.

No relationship was observed between spawning stock biomass and the recruitment (Figure 17).

4.3.3 Yield per recruit curves

Yield per recruit curves and curves for spawning stock biomass per recruit (Figure 18 - 19) were calculated for haddock using the present exploitation pattern, and for those generated by a mesh size of 135 mm and 150 mm. The long-term effects on yield per recruit and spawning stock biomass per recruit by changing the pattern of exploitation can be read off the diagrams:

F_{max} = 0.18 for the present exploitation pattern and

F_{max} = 0.25 for a mesh size of 135 mm and F_{max} = 0.30 for a mesh size of 150 mm. Corresponding Fs for $F_{0.1}$ are 0.11, 0.13, and 0.14.

4.3.4 Mean weight per age group

The weight of the catches calculated from the catch in numbers and the average weight per age group used in previous reports were compared with reported catches (see Section 3.5). The reported catches in the period 1970-78 were up to 40% higher than the calculated catches (Table 23). Some new average weight at age data indicate that the average weight used in the assessments are too low for young haddock. This is also suggested by the high positive correlation found between the proportion of 3 to 5 year old haddock by numbers in the catches and the respective weight correction factors (Figure 20).

The proportion of 3 - 5 year old haddock is according to the assessment expected to be about 95% of the total number caught in 1979. Applying this figure in the regression gives a weight correction factor of 1.36. This weight correction factor is used to convert calculated catches in 1979 and 1980 to expected catches.

No correction is made for the estimates of spawning stock size biomass in Table 23 as has been done for cod (Section 3.5).

4.3.5 Catch in 1979

The TAC for 1979 is 206 000 tonnes. The fishing mortality needed to take this TAC is on the average F = 1.57 on the 7 to 12 year old and F = 1.84 on the 3 to 6 year old haddock. The highest fishing mortality in the past is F = 0.95 on the 3 - 6 year old (1977). The average fishing mortality on the 7 - 12 year old in 1977 was F = 0.88, close to F = 0.99 (1950) the highest recorded. The total international effort recorded on haddock in 1977 is also the highest since 1960 (Table 18). Taking the TAC in 1979 would require nearly a doubling of the fishing mortalities and the total effort compared with 1977.

If the quota in 1979 is taken, the stock (3 years and older) at the beginning of 1980 is estimated to be 137 000 tonnes, of which 14 000 tonnes would comprise the spawning stock (6 years and older). The lowest spawning stock recorded since 1950 is 66 000 tonnes in 1953 (Table 23).

The Working Group considered it unlikely that the TAC for 1979 would be taken. Assuming the same effort is exerted in 1979 as that in 1977, the fishing mortality on the 3 to 6 year old haddock in 1979 would be F = 0.90 as e estimated from the regression line in Figure 15. In order to achieve this fishing mortality with the exploitation pattern assumed for 1979 (Table 24), the fishing mortality on the 8 - 12 year olds should be F = 0.76. These fishing mortalities would generate an expected catch in 1979 of 140 000 tonnes.

4.4 Management Options

Catch predictions for haddock have been calculated following the same approach as for cod (see Section 3.6) including a consideration of possible increases in mesh size in 1980. The catch predictions are given in Table 25.

At the present pattern of exploitation the calculated spawning stock biomasses for 1981 vary between 28 000 and 65 000 tonnes depending on the different options. These results show for all options considered that the spawning stock will remain below the level of 1978 (86 000 tonnes) and far below the long-term average over the years 1950 - 75 of 165 000 tonnes. This level cannot be reached even under zero TAC in 1980. Since the spawning stock biomass will be very low in 1979 and in 1980 (34 000 tonnes) far below the lowest on record (66 000 tonnes), the Working Group felt that it would not be sufficient in this situation just to maintain the 1980 level in 1981 but rather to increase the spawning stock at least to the lowest level on record. This objective could be achieved by fishing at $F_{0.1}$ resulting in a catch of 20 000 tonnes for 1980. Under this option total biomass (age 3 and older) is also expected to exceed the 1979 level of 288 000 tonnes which is still below the 1962-75 average of 390 000 tonnes.

If mesh sizes will be increased in 1980 the objective outlined above still remains valid. The difference, however, appears in the catch associated with $F_{0.1}$ which is 14 000 tonnes and 11 000 tonnes for 135 mm and 150 mm mesh size, respectively. The lower catch figure is due to the immediate loss of young fish in the catches. This will, however, lead to a further increase in total stock biomass.

In the previous assessment (C.M.1978/G:64) the stock and the spawning stock biomass in 1978 and subsequent years have been greatly overestimated. The reasons are as follows:

1. The Working Group did not consider the extremely high provisional estimate of total international effort as a reliable value because of the mixed fishery problem. Furthermore no F/effort relation was established to estimate fishing mortality from effort data.

2. The fact that the TAC in 1977 was not fully taken, was not interpreted as an indication of reduced stock size but rather as reduced F compared to the previous year.

3. The strength of the 1975 year class was overestimated on the basis of the USSR young fish survey. High catch figures (in numbers) of 2 year old fish were taken as confirmation of the young fish survey results. Therefore, the fishing mortality on the 1975 year class was not raised to a higher level.

5. MESH ASSESSMENTS

5.1 Method

At the 1977 meeting the Working Group discussed the possibility of using a method developed recently by K. P. Andersen at the Danish Institute for Fisheries and Marine Research. Based on the length- or age-compositions of the catches, this method can assess the effective mesh sizes in use in the fisheries for cod and haddock. Necessary length composition data were exchanged during 1977. A preliminary mesh assessment for North-East Arctic cod was presented at the 1978 March meeting to the members of the Working Group, together with the data base, an outline of the theory and a listing of the computer programme used.

The data base has now been updated and mesh assessments have been made for both the North-East Arctic cod and haddock. An additional programme computing the effects of changes in the mesh size, based on another method by K. P. Andersen was distributed at this meeting of the Working Group.

The Andersen method for mesh assessments was used by Høydal (C.M.1977/F:51). A paper by Hylen, Høydal, Rørvik and Sparre, describing the method in detail is in preparation.

The essence of the method is that the simulated relative length (or age) distributions of the catches in each of the fisheries are compared with the observed relative length (or age) distributions. The mesh sizes of the fisheries are systematically changed until the sum of the squared distances between the observed and the estimated relative length distributions are minimised. The outcome is the estimate of the effective mesh sizes.

The total F exerted was partioned between the different fisheries until the estimated catches (in numbers) had the same relative distribution with respect to the fisheries as the observed relative distributions of the catches.

The model assumes a stable recruitment; therefore the age and length compositions used are the averages for the period 1967-77, 1967 was chosen as the starting year, since the legal mesh size has remained unchanged since then.

In the assessments a selection factor of 3.96 was used for cod and 3.63 for haddock. This is the factor by which the mesh size has to be multiplied to obtain the 50% selection length. A constant of 1.09 for the ratio of the 75% selection length to the 50% selection length was used for all cod fisheries, except for the long- and hand-line fishery. For this fishery, a ratio of 1.18 was used, since this ration was found to give a considerably better fit between the estimated and observed length distributions. For the haddock fisheries a ratio of 1.10 was used for all fisheries.

The Danish seine, gill-net and long- and hand-line fishery were treated as if they were trawl fisheries. In the gill-net fishery for cod, and upper fixed selection curve was applied in the model with a 50% selection at age 13.5 (118.6 cm) and a 75% selection at age 12.5 (112.9 cm). Different vulnerability and discards were also taken into account.

The type of equation used for the selectivity curves and the curves for vulnerability and the retention in the discard process is:-

$$f(L) = EXP\ (\alpha\ (L-L_{50\%}))/(1\&EXP(\ L-L_{50\%}))$$

where

$$\alpha = 1/2\ \ln\ (3)/(L_{75\%} - L_{50\%})$$

f(L) describes a sigmoid curve as a function of length. The von Bertalanffy parameters used give the relation between length and age.

The choice of the parameters used for the best estimate of the effective mesh sizes in use was made on the basis of several simulations, where the following factors were involved:-

1. Improvement of the fit between the observed and the estimated relative length distributions.
2. Caution where it was evident that the effective mesh size would be considerably below the legal mesh size of 120 mm.
3. The vulnerability curves should not be unrealistic (judged from knowledge of the biology of the stock).

5.2 Effective Mesh Sizes

The choice of the parameters used in the assessments of the effective mesh sizes in use in the cod fishery is given in Table 26.

This set of fixed input parameters was used in the assessment both on the basis of the length- and age-distributions. The two best estimates of the effective mesh sizes used in the cod fisheries are given in Table 27. These are the averages for the years 1967-77.

The estimates of the effective mesh sizes are primarily dependent on the parameters for the increasing vulnerability and the discard practice. In general terms, the older the fish are before they become vulnerable and the larger the fish are which will be discarded at sea, the lower the estimate of the effective mesh size.

In order to give an estimate of the upper limit of what effective mesh size could be, the effective mesh sizes were assessed with 100% vulnerability from age 0 and onwards, and with no discarding at all. The other parameters were the same as for the best estimates (Table 26). The parameters used for haddock are given in Table 28. The estimates of the maximum possible effective mesh size are given in Table 27 for both species. These 4 estimates of the upper limits for the effective mesh sizes are comparable, especially within the two species.

The programme computing the effects on the changes of the mesh sizes also calculates the fishing mortalities generated by the different fisheries for a given set of mesh sizes. Figure 21 shows the total fishing mortalities generated by those effective mesh sizes estimated from the length distributions of cod in 1967-77 (Table 27). Figure 21 also shows the observed total fishing mortalities for 1967-77 as estimated from the VPA on cod done by this Working Group in October 1978 (C.M.1978/G:64). These two curves are based on fairly independent data. The good correspondence between these curves, and the closeness of the two sets of estimates of the effective mesh sizes in the cod fisheries (Table 27) indicate that the length- and age-compositions and the fixed input parameters (Table 26) are fairly consistent.

The effective mesh sizes used in the haddock fisheries have not yet been estimated. However, the effective mesh size in use in the haddock fisheries are probably not very much different from the ones used in the cod fisheries, since the haddock is mainly taken as by-catch in the cod fisheries.

Of the two estimates of the effective mesh-sizes in the cod fisheries the one based on the length distribution is considered to be the most reliable. This is because the length distributions contain more points. The intervals are in 5 cm groups, from 10 to 130 cm. Furthermore, each interval for the smaller and critical length groups represents about 6 months' time intervals. Thus, the length distributions are more refined with respect to than the age distributions. It also appears that the estimates of the effective mesh sizes, when estimated from the age distributions, are dependent on the t_0 in the von Bertalanffy equation, while the effective mesh sizes estimated from the length distributions are insensitive to t_0 (the age at length 0).

5.3 Effects of Mesh Changes

The effects of a change from the effective mesh size used in the period 1967-77 to new mesh sizes were estimated as an extension of the results from the mesh assessments (see Section 5.2). Three alternatives of what the new effective mesh sizes could be were considered:-

1. The legal mesh size of 120 mm becomes the effective mesh size for the trawlers.

2. The effective mesh size for the trawlers becomes 135 mm, and for Danish seine 125 mm.

3. The effective mesh size for the trawlers becomes 150 mm, and for Danish seine 135 mm.

The estimates of the effects of an increase in mesh size for the total and the individual cod fisheries are given in Tables 29-31. These tables give both the short- and the long-term effects applying to the average situation for the period 1967-77. The immediate loss in the total fishery if the mesh size is increased is 15% for 120 mm, 28% for 135 mm , and 41% for 150 mm mesh size in the trawl fisheries. The expected long-term change, however, is an increase of the total yield of 11%, 20% and 27%, respectively.

The long-term increase in the spawning stock is 22%, 50% and 90%, respectively. Figure 14 indicates that the spawning stock would benefit even more from mesh size changes, when compared with the present (1978) exploitation pattern and $\bar{F}_{8-12} = 0.70$.

The discards in the total fishery are estimated by the mesh assessment method to be 0.5% by weight and 2% by number of the total catch (1967-77). A reduction of 16%, 55% and 69% of the discards (by weight) is expected, if the mesh size in the trawl fisheries is increased to effective mesh sizes of 120 mm, 135 mm or 150 mm, respectively (Table 32).

Tables 33 - 35 indicate for haddock the expected increases of the long-term yields of 4%, 7% and 8% for an increase of the effective mesh size to 120 mm, 135 mm or 150 mm, respectively. The long-term increase in the spawning stock is expected to be 33%, 68% and 113% respectively for the same mesh size increases compared with the effective mesh sizes in 1967-77. The discards on the total fishery are estimated by the mesh assessment method to be 0.8% by weight and 3% by number (1967-77). The long-term reduction in the total discards (by weight) is estimated to be 2%, 44%, and 62% for the different alternative mesh sizes (Table 36).

It is assumed in these calculations that the distribution of the fleets remain the same after the mesh change. It is, however, likely that as the mesh size is increased, particularly those fisheries that experience the highest immediate loss will concentrate more in areas where the larger fish are abundant. This will reduce the immediate loss and further improve the fishing pattern. It is also likely that the catch rate of the larger fish will increase somewhat even without shift of fishing grounds. It has been observed that increased mesh size appears to increase the efficiency of the gear on those age groups that are not subject to trawl selectivity.

Despite of the long-term gains to be expected from the average situation described above the major concern of the Working Group is the increased relative exploitation levels on younger ages in recent years (Figure 10). Increase in mesh size would prevent the fishery in the North-East Arctic being changed into a single year class fishery depending entirely on most recent recruitment. This type of development has already been observed in several gadoid fisheries in the North Atlantic and adjacent waters. An increase in mesh size would also increase the contribution to the spawning stock biomass of the recruiting year classes.

6. MIDWATER TRAWL

The effect of this gear was studied by this Working Group last year (C.M.1978/G:5). Very limited midwater trawl fisheries took place in 1978, and no new data for these fisheries were available to the Working Group. Therefore, the effect on the exploitation by this gear on the cod and haddock stocks has not been further studied.

7. COD AND HADDOCK AS A MIXED FISHERY

While in some areas and at certain times of the year directed haddock fisheries occur, a great part of the haddock catches are taken while fishing for cod. The average total biomasses of cod and haddock taken by 5 year periods up to 1974 and annually thereafter are shown in the text table overleaf:-

Biomasses of Cod and Haddock (VPA)

Years	Cod (million tonnes)	Haddock (million tonnes)	% of haddock of total biomass
1950-54	4.4	0.5	10
1955-59	3.6	0.5	12
1960-64	2.6	0.4	13
1965-69	3.3	0.4	10
1970-74	2.5	0.5	17
1975	2.9	0.4	12
1976	2.7	0.3	10
1977	2.4	0.2	8
1978	1.9	0.2	10

Over this period it appears that the haddock have amounted to about 12% of the total biomass of the two species. Because of the opportunistic behaviour of trawler skippers it is thought that rather than measure catch per unit effort for the cod and haddock separately, more realistic catch per effort (or effort estimate) might be derived by combining the catches of both species. The data are given in Table 37 for Sub-area I, and Divisions IIa and IIb separately. In each case they have been used to derive estimates of total international effort. For both Sub-area I and Division IIa a trend in increasing effort occurs; however, in Division IIb the effort tends to fluctuate without trend. The total international effort derived by summing the area data are shown in Figure 22 together with the changes in total biomass from VPA. It is seen that even at the steady levels of effort in the period 1956-67, the total biomass show a decreasing tendency. The rapid increase in effort after 1967 has prevented any recovery of the biomass of the two stocks despite several good year classes (Tables 13 and 19).

In Figure 23 the international effort estimates are shown for the major areas. The peaks in effort in Division IIb can be associated with changes in the abundance of year class strength of cod and haddock. For example, the peak observed in 1977 could be associated with the recruitment of both the rich 1973 cod year class and the 1974 and 1975 haddock year classes. The peak in 1974 corresponds to the recruitment of the 1970 cod year class and the 1969 and 1970 haddock year classes. The trough in 1970-73 occurs when the poorest cod year classes on record and some of the lowest haddock recruited. These changes are also mirrored in the changes in Sub-area I.

The peak in 1969 in Division IIb corresponds with the recruitment of the rich 1963 and 1964 cod yaar classes, while again the preceding trough corresponds with the recruitment of the relatively poor 1960 and 1961 year classes of cod, though the haddock year classes were strong at that time. The high efforts of 1956-62 while partly being attracted by the recruiting 1957-59 cod year classes was probably sustained on the accumulated stock from earlier years of relatively low fishing effort. Examination of Figure 22 shows the steep decline in total biomass over this period, from its maximum of about 5.5 million tonnes in 1953-55, while the total effort was doubling from its early 1950s level.

The recent peaks in Division IIa are seen to coincide with the recent high spawning stock biomass.

Using the English catch data by area a weighted mean of the catch per effort data has been circulated and this is given in Table 38. The data have been plotted in Figure 24 on the VPA biomass of cod and haddock older than 4 years, which should be the major part of the catches. A close correlation (r = .78) is seen between the estimates, implying that catch per effort is a reliable estimate of stock size. No corrections have been made either for change in growth rate or catchability changes.

In Figure 25 the weighted catch per unit effort (Table 38) has been plotted on the estimate of total international effort derived in Table 37. The data have been fitted using the exponential fit of Fox (1970). The regression was fitted as

$$\ln\ y = a + bx$$

where y is catch per unit effort,
and x total international effort

The regression parameters are

$$a = -1.4042$$
$$b = -0.085$$

Following the Gulland-Fox method (Ricker 1975) the maximum sustainable yield could be of the order of 1×10^6 tonnes of both species under the average fishing pattern of the period. The data have not been corrected for the large changes in q' recorded of this period and this estimate must be treated with caution.

It is clear from this analysis, that the principles of treating the North-East Arctic cod and haddock as a mixed fishery deserve further studies.

8. SHORTCOMINGS AND GAPS IN DATA REQUIRED FOR STOCK ASSESSMENT PURPOSES

One reason for postponing the Working Group meeting to late May was in order to improve the quality of the provisional data from the most recent year's fisheries. This was achieved at least by the main fishing nations in the area. However, provisional data for 1978 were still lacking for some countries.

Only limited information was available for the fisheries in the first part of 1979. The Working Group is still of the opinion that information from the year of the assessments would contribute to improved reliability of the assessments. The Working Group, therefore, recommends that relevant data for the fisheries in the first part of the current year should be made available.

During the meeting of the Arctic Fisheries Working Group it has been shown that the stock size assessments and the catch predictions have to rely very much on the cpue figure for the different fisheries. It is therefore essential to obtain improved measures of fishing effort. On the other hand, cpue data could well be affected by change in fishing pattern after 1975, when new regulatory measures were introduced in the area. Before new series of cpue data are established, the relationships which involve cpue will have to be used with some caution.

This difficulty might be overcome by searching for independent measures of stock size and year class strength. Such measures can be obtained by multi-ship surveys. Well-equipped research vessels are needed for such surveys and their equipment should be standardised as much as possible.

9. FUTURE WORK

All age- or length-groups of cod and haddock are not evenly distributed over the whole area of distribution. Age- and length-compositions of the catches must therefore be collected on a smaller basis than the ICES Sub-area I and Division IIa and IIb and over a shorter period than one year. This information would have to be made available if useful discussion on closed areas or seasons aiming at increasing the age at first capture has to be possible. The Working Group had a preliminary discussion concerning the area break-down of the North-East Arctic for biological sampling. It was decided to exchange information on the sampling area units used by the different countries, and this matter will be discussed by correspondence.

Standardised formats have already been adopted by the Council for reporting stock record data on demersal species on a quarterly basis. This should be borne in mind when discussing the area break-down.

REFERENCES

Fox, W.W. 1970. An exponential yield model for optimizing exploited fish populations. Trans.Am.Fish.Soc. 99: 80 - 88.

Garrod, D.J. 1967. Population Dynamics of the Arcto-Norwegian Cod. J.Fish.Res.Bd.Canada, 24(1): 145 - 190.

Garrod, D.J. and Jones, B.W. 1973. Stock and recruitment relationship in the North-East Arctic cod stock and the implications for management of the stock. In Report of the North-East Arctic Fisheries Working Group. ICES,Doc.C.M.1973/F:3, pp 1 - 35, (mimeo).

Gulland, J.A. 1969. Manual of methods for fish stock assessment. Part 1. Fish Population Analysis. Rome. FAO, 154 pp.

Hylen, A. and Dragesund, O. 1973. Recruitment of young Arcto-Norwegian cod and haddock in relation to parent stock size. Rapp.p.-vRéun.Cons. int.Explor.Mer, 164: 57 - 68.

Hylen, A. and Rørvik, C.J. 1975. Assessments of the Arcto-Norwegian cod stock. ICES, Doc.C.M.1975/F:34, pp 1 - 23 (mimeo).

Ricker, W.E. 1975. Computation and Interpretation of Biological Statistics of Fish Populations. Bull.Fish.Res.Bd. Canada, Bulletin 191, 382 pp.

Rollefsen, G. 1953. Observations of the cod and cod fisheries of Lofoten. Rapp.p.-v.Réun.int.Explor.Mer, 136: 40 - 47.

Table 1 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*	422 037	19 198	242 944	684 179

* Provisional figures

Table 2 COD. Nominal catch (tonnes, whole weight) by countries (landings of Norwegian coastal cod not included). (Sub-are 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*	9 057	8 773	3 029	5 434	350 070	453	35 448	267 138[1)]	4 777	684 179

*Provisional figures

1) Murman cod included

Table 3 COD. Estimates of total international effort in Sub-area I and Divisions IIa and IIb.

Year	SUB-AREA I				DIVISION IIb				DIVISION IIa			
	National effort		Total international effort		National effort		Total international effort		National effort		Total international effort	
	U.K.[1]	USSR[2]	U.K. units	USSR units	U.K.	USSR	U.K. units	USSR units	U.K.	Norway[3]	U.K. units	Norwegian units
1960	95	43	500	89	42	11	87	30	39	9 489	232	52
1961	94	53	519	108	51	22	171	50	30	8 410	264	41
1962	93	61	596	93	51	16	166	30	34	7 812	212	35
1963	78	62	644	91	45	9	114	20	29	7 153	177	38
1964	42	30	357	56	49	17	137	32	36	6 103	150	22
1965	42	25	366	62	37	11	95	21	33	6 883	152	34
1966	63	33	395	70	23	16	73	30	46	6 796	201	34
1967	51	30	399	61	10	12	114	14	50	7 153	248	37
1968	86	45	584	59	9	24	156	22	52	7 930	290	32
1969	115	45	601	68	24	19	194	22	73	6 747	272	43
1970	122	35	604	75	24	15	86	11	55	6 893	369	38
1971	82	23	558	73	4	27	80	36	48	6 913	516	30
1972	71	41	419	58	7	11	65	18	35	8 674	610	29
1973	96	61	864	88	18	12	163	15	27	9 156	492	31
1974	92	48	916	80	9	18	240	33	29	6 590	444	37
1975	109	31	729	66	5	19	147	34	28	4 906	364	35
1976	96	44	878	80	21	18	128	35	34	5 862	678	62
1977	84	56	1035	106	46	31	196	41	39	6 583	584	52
1978*	35	68	681	113	9	5	44	26	26	6 145	657	34

* Provisional figures

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

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

3) gill-net boat week at Lofoten x 10[illegible]

Table 4 COD. Catch per unit effort
(tonnes, round fish)

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*	1.38	0.062	0.37	0.52	0.044	0.08	1.12	0.037	7.1
1979*									6.2

* Provisional figure

1) Norwegian data - tonnes per 1000 tonne-hours fishing

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

3) USSR data - tonnes per hour fishing

4) Norwegian data - tonnes per gill-net boat week in Lofoten

Table 5 COD. Catch per unit effort. Data from the Lofoten Fishery are given in gutted weight with head off. The United Kingdom data are given in round fish weight.

Year	Norwegian vessels			English trawlers	
	Catch (kg per man per day worked in the Lofoten Fishery (Division IIa)			t/100 tonne-hour of age groups ≥ 8	t/100 tonne-hour of 4 - 7 year olds
	Gill-net	Long-Line	Hand-Line	Division IIa	Sub-area I
1960	77.8	148.3	56.7	.0214	.064
1961	101.5	141.1	75.5	.0129	.067
1962	94.9	134.4	57.8	.0304	.084
1963	80.8	116.3	56.2	.0291	.082
1964	104.5	62.1	51.5	.0230	.055
1965	81.8	78.3	68.4	.0039	.053
1966	121.8	131.9	72.6	.0223	.056
1967	107.9	245.4	120.7	.0166	.076
1968	158.0	184.6	61.5	.0095	.105
1969	170.6	200.4	142.8	.0068	.110
1970	180.3	304.3	127.6	.0079	.089
1971	334.3	510.7	192.7	.0179	.036
1972	318.7	400.1	110.2	.0151	.021
1973	189.7	366.5	112.1	.0209	.038
1974	96.3	146.4	63.9	.0027	.076
1975	122.0	188.3	96.1	.0020	.069
1976	131.4	258.4	134.8	.0015	.047
1977	173.2	279.6	143.5	.0043	.046
1978	237.6	381.7	134.6	.0074	.037
1979*	201.3	306.0	125.1		

* Provisional figures

Table 6 COD. Catch per unit effort for Norwegian freezers and for English conventional trawlers.

Country / Year	Sub-area I		Sub-area II	
	Norway	England	Norway	England
	t/tonne-hour x 10^{-3}	t/tonne-hour x 10^{-4}	t/tonne-hour x 10^{-3}	t/tonne-hour x 10^{-4}
1972	0.34	.047	0.40	.055
1973	0.53	.057	0.34	.043
1974	0.93	.079	0.70	.028
1975	0.78	.077	0.54	.033
1976	0.72	.060	0.79	.035
1977	0.90	.052	0.68	.044
1978	0.54	.062	0.58	.037

Table 7 COD. Catch in numbers by year and age (thousands)

AGE	1962	1963	1964	1965	1966	1967
1	1	1	103	1	1	1
2	1713	4	675	2522	869	151
3	42416	13196	5298	15725	55937	34467
4	170566	106984	45912	25999	55644	160048
5	167241	205549	97950	78299	34676	69235
6	89460	95498	58575	68511	42539	22061
7	28297	35518	19642	25444	37169	26295
8	21996	16221	9162	8438	18500	25139
9	7956	11894	6196	3569	5077	11323
10	2728	3884	3553	1467	1495	2329
11	2603	1021	783	1161	380	687
12	1647	1025	172	131	403	316
13	392	498	387	67	77	225
14	280	129	264	91	9	40
15	103	157	131	179	70	14
TOTAL	537399	491579	248803	231604	252846	352331
SPAWNING STOCK (AGE >= 8)	37705	34829	20648	15103	26011	40073

AGE	1968	1969	1970	1971	1972	1973
1	1	1	1	38	1	1
2	1	275	591	2210	4701	8277
3	3709	2307	7164	7754	35536	294262
4	174585	24545	10792	13739	45431	131493
5	267961	238511	25813	11831	26832	61000
6	107051	181239	137829	9527	12089	20569
7	26701	79363	96420	59290	7918	7248
8	16399	26989	31920	52003	34885	8328
9	11597	13463	8933	12093	22315	19130
10	3657	5092	3249	2434	4572	4499
11	657	1913	1232	762	1215	677
12	122	414	260	418	353	195
13	124	121	106	149	315	81
14	70	23	39	42	121	59
15	46	46	35	25	40	55
TOTAL	612681	574302	324384	172315	196324	555874
SPAWNING STOCK (AGE >= 8)	32672	48061	45774	67926	63816	33024

AGE	1974	1975	1976	1977	1978
1	115	1	706	1	3
2	21347	1184	1908	11288	789
3	91855	45282	85337	39594	78393
4	437377	59798	114341	168609	44286
5	203772	226646	79993	136335	86786
6	47006	118567	118236	52925	55930
7	12630	29522	47872	61821	24841
8	4370	9353	13962	23338	32238
9	2523	2617	4051	5659	9118
10	5607	1555	936	1521	1228
11	2127	1928	558	610	915
12	322	575	442	271	449
13	151	231	139	122	750
14	83	15	26	92	64
15	62	37	53	54	48
TOTAL	829347	497311	468560	502240	335838
SPAWNING STOCK (AGE >= 8)	15245	16311	20167	31657	44810

Table 8 COD. Preliminary relative fishing pattern used for VPA input in 1978.

$\bar{F}_{8-12} = 1.00$

Age	Fishing Pattern
3	0.13
4	0.30
5	0.52
6	0.63
7	0.69
8	0.95
9	1.11
10	1.08
11	1.05
12	0.83
13	0.87
14	0.73
15	0.75

Table 9 COD. Fishing mortalities by year and by age (M = 0.20)

AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967
1	.000	.000	.000	.000	.000	.000	.000	.000	.000
2	.003	.007	.002	.003	.000	.001	.001	.001	.001
3	.053	.054	.056	.066	.031	.017	.023	.040	.030
4	.256	.226	.271	.305	.236	.144	.111	.103	.153
5	.509	.347	.493	.648	.738	.352	.389	.211	.181
6	.510	.460	.515	.823	1.002	.480	.447	.380	.202
7	.523	.433	.527	.606	.963	.572	.397	.467	.428
8	.495	.483	.684	.654	.868	.718	.520	.564	.672
9	.603	.386	.732	.793	.934	1.031	.694	.694	.831
10	.698	.711	.767	.963	1.260	.832	.742	.717	.820
11	.600	.877	.919	.777	1.334	.980	.731	.430	.884
12	.655	.680	1.019	.791	.833	.866	.420	.612	.783
13	.598	.515	.879	.707	.592	.912	1.060	.470	.852
14	.358	.515	1.036	.756	.535	.737	.563	.375	.478
15	.500	.410	.780	.610	.490	.810	.960	.370	.750

MEAN F FOR AGES >= 8 AND <= 12 (NOT WEIGHTED BY STOCK IN NUMBERS)

	.610	.627	.824	.796	1.046	.885	.621	.603	.798

AGE	1968	1969	1970	1971	1972	1973	1974	1975	1976
1	.000	.000	.000	.000	.000	.000	.000	.000	.001
2	.000	.001	.001	.002	.002	.014	.028	.002	.006
3	.023	.022	.040	.021	.039	.191	.206	.077	.147
4	.207	.212	.138	.101	.166	.196	.479	.201	.283
5	.409	.480	.360	.221	.290	.351	.525	.492	.450
6	.466	.538	.570	.218	.367	.378	.503	.671	.519
7	.399	.767	.621	.517	.284	.393	.422	.692	.639
8	.522	.918	.834	.834	.665	.544	.437	.641	.855
9	.775	1.141	.936	.921	1.138	.994	.313	.512	.645
10	.718	.983	.993	.728	1.188	.745	.940	.324	.346
11	.579	1.101	.606	.672	1.050	.539	1.011	1.061	.184
12	.372	.919	.411	.527	.779	.459	.536	.864	.758
13	.841	.782	.641	.439	1.004	.404	.793	.960	.524
14	.718	.358	.630	.571	.785	.509	.963	.160	.254
15	.740	.680	.540	.340	.910	.310	.700	.860	.430

MEAN F FOR AGES >= 8 AND <= 12 (NOT WEIGHTED BY STOCK IN NUMBERS)

	.593	1.012	.772	.736	.964	.656	.647	.680	.558

AGE	1977	1978
1	.000	.001
2	.021	.002
3	.169	.200
4	.480	.290
5	.642	.490
6	.612	.600
7	.570	.660
8	.759	.670
9	1.098	.780
10	.539	.760
11	.399	.740
12	.128	.560
13	.485	.610
14	.807	.510
15	.400	.530

MEAN F FOR AGES >= 8 AND <= 12 (NOT WEIGHTED BY STOCK IN NUMBERS)

	.584	.706

Table 10 COD. Stock in numbers at beginning of the year (thousands)

AGE	1962	1963	1964	1965	1966	1967
1	506916	1162673	2364064	1931250	263794	171611
2	579995	415027	951915	1935439	1581173	215976
3	730267	473312	339792	778752	1582325	1293770
4	711706	559619	375601	273414	623389	1245002
5	382651	429397	361913	266142	200410	460209
6	173583	163820	168121	208344	147624	132867
7	68054	62390	49256	85152	109145	82679
8	50009	30410	19497	22751	46883	56043
9	15824	21287	10452	7783	11070	21828
10	4791	5862	6847	3053	3185	4529
11	5247	1497	1361	2440	1191	1273
12	3282	1974	323	418	962	634
13	843	1218	703	111	225	427
14	575	341	552	231	32	115
15	137	221	163	216	108	18
TOTAL	3233880	3329048	4650560	5515498	4571515	3686981
SPAWNING STOCK (AGE >= 8)	80708	62810	39898	37005	63655	84867

AGE	1968	1969	1970	1971	1972	1973
1	300014	607470	1540140	2781637	820051	1031350
2	140502	245630	497353	1260959	2277377	671400
3	176690	115032	200856	406664	1030390	1860312
4	1028130	141312	92097	157980	325947	811532
5	875112	684594	93602	65677	116953	225937
6	314433	476058	346750	53456	43123	71631
7	88921	161478	227495	160556	35191	24452
8	44106	48841	61413	100047	78350	21693
9	23426	21425	15971	21838	35573	32979
10	7781	8836	5603	5129	7119	9336
11	1632	3106	2708	1699	2027	1777
12	431	749	846	1116	711	580
13	237	243	245	459	540	267
14	149	84	91	105	242	162
15	58	60	48	40	49	90
TOTAL	3001622	2514917	3085218	5017364	4773643	4763500
SPAWNING STOCK (AGE >= 8)	77821	83344	86924	130434	124611	66885

AGE	1974	1975	1976	1977	1978
1	1023811	419534	725453	532148	3312
2	844397	838122	343484	593313	435685
3	542221	672060	685127	279498	475570
4	1258123	361241	509384	484035	193168
5	546031	638087	241922	314245	245191
6	130198	264569	319346	126345	135423
7	40182	64487	110684	155565	56114
8	13515	21569	26432	47829	72044
9	10305	7146	9299	9204	18339
10	9998	6170	3507	3993	2514
11	3629	3198	3654	2030	1907
12	849	1081	906	2490	1115
13	300	407	373	348	1794
14	146	111	127	181	175
15	80	46	78	81	66
TOTAL	4423785	3297827	2979776	2551304	1642416
SPAWNING STOCK (AGE >= 8)	38822	39728	44376	66155	97954

THE LAST GROUP IS A PLUSGROUP

Table 11 COD. Estimates of spawning stock and year class strength
Estimates from VPA ($M = 0.2$)

Year	Weight correction factor	Spawning stock biomass tonnes x 10^{-3} at beginning of year		Year class	Year class strength at 3 years old (millions)
		age groups 8+	corrected		
1946	0.67	4 078	1 442	1946	498
1947	0.57	3 322	1 501	1947	705
1948	0.61	2 323	1 045	1948	1 097
1949	0.66	1 855	731	1949	1 192
1950	0.78	1 463	418	1950	1 593
1951	0.88	1 390	407	1951	645
1952	0.75	1 161	354	1952	273
1953	0.84	909	328	1953	441
1954	0.78	833	451	1954	805
1955	0.82	875	424	1955	498
1956	0.85	1 000	394	1956	685
1957	0.84	935	420	1957	791
1958	0.88	1 034	452	1958	919
1959	0.86	864	519	1959	730
1960	0.88	602	429	1960	473
1961	0.91	515	304	1961	340
1962	0.77	475	184	1962	779
1963	0.78	378	183	1963	1 582
1964	0.82	244	125	1964	1 294
1965	0.90	213	95	1965	177
1966	0.94	340	111	1966	115
1967	0.88	459	172	1967	201
1968	0.96	437	221	1968	407
1969	0.87	472	211	1969	1 030
1970	0.97	470	456	1970	1 860
1971	1.12	680	762	1971	542
1972	1.08	680	734	1972	672
1973	1.14	407	464	1973	(685)
1974	1.03	254	262	1974	(274)
1975	0.90	242	218	1975	(476)
1976	1.02	260	265	1976	(310)
1977	0.99	366	362	1977	(310)
1978	0.99	527	522	1978	
1979		(387)			
1980		(245)			

( ) Provisional figures.

Table 12 COD. Parameters used in Catch Predictions (M = 0.20)

Age	Stock size at the beginning of 1979 in thousands	Exploitation pattern ($\bar{F}_{8-12}$ = 1.00)			Mean weights (kg)
		1978 1979 1980	1980 ※→135 mm	1980 ※→150 mm	
3	310 000	0.28	0.03	0.02	0.65
4	318 784	0.41	0.17	0.08	1.00
5	118 340	0.69	0.55	0.40	1.55
6	122 982	0.85	0.80	0.77	2.35
7	60 849	0.93	0.93	0.93	3.45
8	23 745	0.95	0.95	0.95	4.70
9	30 183	1.11	1.11	1.11	6.17
10	6 883	1.08	1.08	1.08	7.70
11	962	1.05	1.05	1.05	9.25
12	745	0.83	0.83	0.83	10.85
13	511	0.87	0.87	0.87	12.50
14	798	0.73	0.73	0.73	13.90
15	118	0.76	0.76	0.76	15.00

Table 13 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	Virtual Population No. of 3 year olds x 10^{-6}*
	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		730
1960	9	19	13	Poor		473
1961	2	2	2	Poor		340
1962	7	4	6	Poor		779
1963	21	120	76	Rich		1 582
1964	49	45	46	Rich		1 294
1965	<1	<1	<1	Very poor	6	177
1966	2	<1	1	Very poor	<1	115
1967	1	<1	1	Very poor	34	201
1968	7	1	5	Poor	25	407
1969	11	6	9	Poor	93	1 030
1970	74	86	76	Rich	606	1 860
1971	37	24	32	Average	157	542
1972	53	17	40	Average	140	672
1973	74	5	46	Rich	684	685
1974	6	1	4	Poor	51	279
1975	93	4	62	Rich	343	476
1976	(2)	(<1)	(2)	Poor	43	310
1977	(2)	(1)	(2)	Poor	173	310
1978	(1)	(2)	(1)	Poor	106	

( ) = estimated.

*USSR Murman cod included for 1974-77.

Table 14 COD. Management options for 1980 assuming a catch of 700 000 tonnes in 1979. Weights in 1 000 tonnes.

Stock biom.	Spawning stock biomass	F	Catch	Management Option for 1980	1980 Stock biom.	1980 Spawn. stock biom.	1980 F	1980 Catch	1981 Stock biom.	1981 Spawn. stock biom.
1 590	387	.95	700	$F_{1980} = F_{1978}$	1 188	245	.71	405	1 090	210
				$F_{1980} = F_{1979}$			.95	501	970	166
	Present exploitation pattern			$F_{1980} = 0.8\ F_{1979}$			.76	425	1 065	200
				$F_{1980} = F(max)$			.25	170	1 395	333
				$F_{1980} = F_{0.1}$			.15	107	1 477	365
				F_{1980} → Sp.Biom.1981 = 1979 level			.09	67	1 525	387
				F_{1980} → Sp.Biom.1981 = 1980 level			.56	337	1 180	245
1 590	387	.95	700	$F_{1980} = F_{1978}$	1 188	245	.71	334	1 195	210
				$F_{1980} = F_{1979}$			.95	415	1 097	166
				$F_{1980} = F_{1979} \times 0.8$			.76	350	1 170	200
				$F_{1980} = F(max)$			.29	157	1 413	322
	※ 135 mm in 1980			$F_{1980} = 0.1$			.17	97	1 490	360
				F_{1980} → Sp.Biom.1981 = 1979 level			.09	53	1 548	387
				F_{1980} → Sp.Biom.1981 = 1980 level			.56	277	1 265	245
1 590	387	.95	700	$F_{1980} = F_{1978}$	1 188	245	.71	305	1 235	210
				$F_{1980} = F_{1979}$			.95	375	1 150	166
				$F_{1980} = 0.8\ F_{1979}$			.76	320	1 220	200
				$F_{1980} = F(max)$			.32	158		312
	※ 150 mm in 1980			$F_{1980} = F_{0.1}$			.18	94	1 494	357
				F_{1980} → Sp.Biom.1981 = 1979 level			.09	49	1 550	387
				F_{1980} → Sp.Biom.1981 = 1980 level			.56	254	1 298	245

Stock biomass = fish age 3 to 15
spawning stock biomass = fish age 8 to 15

Table 15 COD. Management options for 1980 assuming a catch of 500 000 tonnes in 1979. Weights in 1 000 tonnes.

Stock biom.	Spawning stock biomass	F	Catch	Management Option for 1980	1980 Stock biom.	1980 Spawn. stock biom.	1980 F	1980 Catch	1981 Stock biom.	1981 Spawn. stock biom.
1 590	387	.60	500	$F_{1980} = F_{1978}$	1 438	347	.71	510	1 250	295
				$F_{1980} = F_{1979}$			.60	450	1 325	328
	Present exploitation pattern			$F_{1980} = 0.8\ F_{1979}$			.48	375	1 418	370
				$F_{1980} = F_{(max)}$			.25	213	1 625	462
				$F_{1980} = F_{0.1}$			.15	133	1 725	508
				F_{1980} → Sp.Biom.1981 = 1979 level			.43	342	1 460	38[illegible]
				F_{1980} → Sp.Biom.1981 = 1980 level			.54	412	1 370	347
1 590	387	.60	500	$F_{1980} = F_{1978}$	1 438	347	.71	433	1 357	295
				$F_{1980} = F_{1979}$			.60	380	1 420	328
				$F_{1980} = 0.8\ F_{1979}$			.48	318	1 497	370
				$F_{1980} = F_{(max)}$			.29	207	1 630	443
	※135 mm in 1980			$F_{1980} = F_{0.1}$			.17	127	1 727	500
				F_{1980} → Sp.Biom.1981 = 1979 level			.43	290	1 530	387
				F_{1980} → Sp.Biom.1981 = 1980 level			.54	350	1 460	347
1 590	387	.60	500	$F_{1980} = F_{1978}$	1 438	347	.71	397	1 400	295
				$F_{1980} = F_{1979}$			.60	348	1 460	328
				$F_{1980} = 0.8\ F_{1979}$			.48	292	1 530	370
				$F_{1980} = F_{(max)}$			.32	205	1 635	433
	※150 mm in 1980			$F_{1980} = F_{0.1}$			.18	125	1 735	493
				F_{1980} → Sp.Biom.1981 = 1979 level			.44	270	1 557	387
				F_{1980} → Sp.Biom.1981 = 1980 level			.55	325	1 490	347

Stock biomass = fish age 3 to 15
spawning stock biomass = fish age 8 to 15

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*	69 426	926	23 674	94 026

* Provisional figures.

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*	32	1 075	369	1 518	39 275	2	5 767	45 895 1)	93	94 026

* Provisional figures.

1) Murman haddock included.

Table 18 HADDOCK. Catch per unit effort and estimated total international effort.

Year	Sub-area I		Division IIb		Division IIa		Estimated total international effort in U.K. units Total catch in t x 10^{-3} / t/100 tonne-hours in Sub-area I
	Norway1)	U.K.2)	Norway1)	U.K.2)	Norway1)	U.K.2)	
1960		33		2.8		34	4.7
1961		29		3.3		36	6.7
1962		23		2.5		42	8.2
1963		13		0.9		33	11.3
1964		18		1.6		18	5.5
1965		18		2.0		18	6.6
1966		17		2.8		34	9.4
1967		18		2.4		25	7.6
1968		19		1.0		50	9.6
1969		13		2.0		42	10.0
1970		7		1.0		31	12.4
1971		8		3.0		25	9.8
1972	0.06	14	0.02	23.0	0.09	18	19.0
1973	0.35	22	0.18	20.0	0.39	20	14.5
1974	0.27	20	0.09	15.0	0.51	74	11.1
1975	0.26	15	0.06	4.0	0.44	60	11.7
1976	0.27	10	+	3.0	0.24	38	13.7
1977	0.11	4	+	0.2	0.14	16	27.5
1978*	0.13	5	0.01	4.0	0.14	15	18.8

* 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.
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	0-group survey index	Virtual population No. of 3 year olds x 10^{-6}*
1957	9		242
1958	4		110
1959	14		241
1960	40		276
1961	50		319
1962	3		100
1963	9		241
1964	12		291
1965	<1	7	20
1966	<1	<1	17
1967	13	42	164
1968	<1	8	94
1969	69	82	1 017
1970	33	115	265
1971	3	73	54
1972	9	46	(45)
1973	8	54	(56)
1974	35	147	(116)
1975	96	170	(193)
1976	13	112	(170)
1977	(<1)	116	(100)
1978	(<1)	61	

( ) = estimated.

* USSR Murman haddock included for 1974-77.

Table 20 HADDOCK. Catch in numbers by year and by age (thousands)

AGE	1962	1963	1964	1965	1966	1967
1	1	3	149	1	1	1
2	4536	2151	831	3483	2559	53
3	39604	28567	22305	5911	26157	15918
4	30947	72995	49162	46161	22469	41373
5	49028	19035	30592	40032	62724	13505
6	33922	13627	5800	12578	28840	25736
7	3209	9290	3519	1672	5711	8878
8	1344	1243	2709	970	578	1617
9	1778	561	832	893	435	218
10	243	409	104	122	188	176
11	247	79	206	204	186	155
12	482	84	234	123	25	76
13	20	169	121	14	8	27
14	8	41	67	205	7	7
TOTAL	165369	148254	116631	112369	149888	107740
SPAWNING STOCK (AGE >= 6)	41253	25503	13592	16781	35978	36890

AGE	1968	1969	1970	1971	1972	1973
1	1	1	480	15	133	1
2	33	1058	276	3535	9369	5915
3	657	1520	23004	1979	230229	70204
4	67632	1963	2408	24359	22246	258773
5	41267	44526	1870	1258	42849	24018
6	7748	18956	21995	918	3196	6872
7	15599	3611	7948	9279	1606	418
8	5292	4925	1974	3056	6736	422
9	655	1624	1978	826	2630	1680
10	182	315	726	1043	896	525
11	101	43	166	369	988	146
12	115	43	26	130	538	340
13	18	14	52	27	53	68
14	19	2	19	4	42	13
TOTAL	139319	78601	62922	46798	321511	369395
SPAWNING STOCK (AGE >= 6)	29729	29533	34884	15652	16685	10484

AGE	1974	1975	1976	1977	1978
1	281	1321	3475	184	39
2	3713	4355	7496	18456	1997
3	9684	10037	13989	55967	48187
4	41701	14089	13449	22043	18748
5	88111	33871	6808	7368	4038
6	5827	49712	20789	2586	1245
7	4138	2135	40044	7781	1535
8	382	1236	1247	11043	2546
9	617	92	1349	311	5740
10	2043	131	193	388	147
11	935	500	279	96	253
12	276	147	652	101	3
13	458	53	331	84	72
14	143	92	46	98	65
TOTAL	158309	117771	110147	126506	84615
SPAWNING STOCK (AGE >= 6)	14819	54098	64930	22488	11606

Table 21 HADDOCK. Fishing mortalities by year and by age (M = 0.20)

AGE	1959	1960	1961	1962	1963	1964	1965	1966	1967
1	.001	.007	.001	.000	.000	.000	.000	.000	.000
2	.009	.029	.021	.015	.006	.007	.013	.008	.002
3	.071	.202	.168	.200	.121	.080	.067	.127	.062
4	.171	.379	.486	.591	.680	.314	.236	.388	.303
5	.322	.505	.689	1.060	.920	.690	.457	.578	.428
6	.544	.606	.710	1.037	1.023	.828	.691	.707	.499
7	.534	.502	.711	.627	.941	.828	.607	.801	.491
8	.312	.569	.315	.646	.533	.816	.573	.436	.556
9	.683	.630	.624	.966	.621	.849	.711	.551	.291
10	.266	.525	.277	.398	.615	.218	.277	.312	.452
11	.925	1.021	.769	.202	.216	.738	.865	.887	.459
12	.520	.536	.351	.753	.098	1.902	1.543	.233	1.235
13	.117	.442	1.319	.167	.658	.198	.554	.353	.423
14	.600	.600	.600	.600	.600	.600	.600	.600	.600
MEAN F FOR AGES >= 3 AND <= 6 (NOT WEIGHTED BY STOCK IN NUMBERS)	.277	.423	.513	.722	.686	.478	.363	.450	.323

AGE	1968	1969	1970	1971	1972	1973	1974	1975	1976
1	.000	.000	.000	.000	.002	.000	.003	.008	.012
2	.002	.005	.003	.003	.031	.094	.071	.068	.056
3	.037	.102	.167	.024	.286	.343	.220	.279	.323
4	.401	.149	.234	.268	.393	.601	.353	.569	.738
5	.562	.505	.207	.184	1.054	.989	.421	.541	.602
6	.469	.550	.504	.149	.965	.461	.699	.447	.769
7	.651	.416	.471	.413	.418	.304	.563	.604	.801
8	.618	.438	.423	.333	.601	.183	.504	.324	.889
9	.459	.388	.315	.314	.535	.291	.441	.215	.706
10	.421	.420	.300	.273	.665	.190	.690	.156	.936
11	.512	.165	.409	.245	.449	.210	.604	.355	.572
12	.746	.428	.142	.657	.676	.273	.765	.175	1.110
13	1.223	.182	1.493	.214	.621	.163	.717	.316	.734
14	.600	.400	.400	.400	.600	.300	.600	.300	.500
MEAN F FOR AGES >= 3 AND <= 6 (NOT WEIGHTED BY STOCK IN NUMBERS)	.367	.327	.278	.156	.674	.599	.423	.459	.608

AGE	1977	1978
1	.004	.001
2	.083	.050
3	.742	.320
4	1.286	.600
5	1.288	.890
6	.485	.790
7	.754	.300
8	.537	.600
9	.578	.600
10	.450	.600
11	2.525	.600
12	.419	.600
13	.391	.600
14	.500	.600
MEAN F FOR AGES >= 3 AND <= 6 (NOT WEIGHTED BY STOCK IN NUMBERS)	.950	.650

Table 22 HADDOCK. Stock in numbers at beginning of year (thousands)

AGE	1962	1963	1964	1965	1966	1967
1	479318	150285	364191	438314	29530	25688
2	341843	392432	123040	298040	358860	24176
3	240721	275780	319353	99986	240869	291499
4	75814	161428	200036	241342	76528	173628
5	81374	34387	66962	119598	156059	42489
6	57015	23092	11216	27502	62028	71648
7	7524	16550	6800	4014	11283	25034
8	3085	3291	5286	2431	1791	4146
9	3119	1324	1582	1913	1123	948
10	812	972	583	554	769	530
11	1488	447	430	383	344	461
12	993	996	295	168	132	116
13	143	383	739	36	29	86
14	19	99	162	496	17	17
TOTAL	1293267	1061468	1100676	1234778	939363	660466
SPAWNING STOCK (AGE >= 6)	74197	47154	27093	37498	77517	102986

AGE	1968	1969	1970	1971	1972	1973
1	246723	140450	1522984	408027	88632	72624
2	21031	201999	114989	1246480	334050	72445
3	19746	17189	164427	93896	1017338	265038
4	224294	15574	12702	113899	75039	625938
5	104969	122948	10982	8233	71346	41512
6	22674	49008	60774	7308	5608	20364
7	35604	11619	23156	30054	5156	1749
8	12541	15209	6273	11834	16281	2780
9	1947	5536	8036	3366	6944	7305
10	580	1007	3075	4802	20.3	3330
11	276	312	542	1865	2993	848
12	238	135	217	295	1195	1565
13	28	93	72	154	125	498
14	46	7	63	13	102	55
TOTAL	690698	581084	1928291	1930224	1626871	1116052
SPAWNING STOCK (AGE >= 6)	73935	82926	102207	59689	40416	38494

AGE	1974	1975	1976	1977	1978
1	89062	185266	316763	55337	43051
2	59459	72664	150490	256205	45140
3	53978	45331	55563	116446	193114
4	153938	35478	28089	32922	45394
5	281024	88584	16439	10995	7450
6	12638	151043	42202	7370	2483
7	10512	5144	79088	16009	3717
8	1056	4903	2302	29052	6165
9	1896	523	2904	775	13898
10	4471	999	345	1173	356
11	2254	1836	700	111	613
12	563	1009	1054	324	7
13	975	214	694	284	174
14	346	390	128	273	157
TOTAL	672173	593383	696761	527275	361720
SPAWNING STOCK (AGE >= 6)	34713	166061	129417	55369	27570

Table 23 HADDOCK. Estimates of the spawning stock and the year class strength. Estimated from VPA for M = 0.2

Year	Weight correction factor	Spawning stock biomass tonnes x 10^{-3} at the beginning of the year (age groups 6+)	Year class	Year class strength at 3 years old millions
			1947	67
			1948	552
			1949	63
1950	0.63	270	1950	1 029
1951	0.90	151	1951	127
1952	0.79	95	1952	52
1953	1.01	66	1953	169
1954	0.95	179	1954	53
1955	0.78	156	1955	69
1956	0.82	474	1956	325
1957	0.75	324	1957	242
1958	0.85	202	1958	110
1959	1.09	160	1959	241
1960	1.24	129	1960	276
1961	1.29	105	1961	319
1962	1.17	147	1962	100
1963	1.14	106	1963	241
1964	0.97	67	1964	291
1965	1.14	76	1965	20
1966	1.01	140	1966	17
1967	1.19	193	1967	164
1968	1.21	166	1968	94
1969	1.25	174	1969	1 017
1970	1.04	215	1970	265
1971	1.32	160	1971	54
1972	1.33	125	1972	45
1973	1.35	104	1973	(56)
1974	1.40	100	1974	(116)
1975	1.27	293	1975	(193)
1976	0.83	(286)	1976	(170)
1977	1.09	(143)	1977	(100)
1978	1.32	(86)		
1979		(51)		
1980		(34)		

( ) = Provisional figures.

Table 24 HADDOCK. Parameters used in Catch predictions ($M = 0.20$)

Age	Stock size at the beginning of 1979 (no x 10^{-3})	Exploitation pattern ($\bar{F}_{8-12}$ = 1.00)				Average weights (kgs)
		1979 Present exploit.pattern	1980	1980 ※→ 135 mm	1980 ※→150 mm	
3	170 000	0.54	0.54	0.08	0.03	0.41
4	114 810	1.49	1.00	0.38	0.20	0.62
5	20 397	1.34	1.49	1.02	0.62	0.97
6	2 505	1.33	1.33	1.17	0.89	1.59
7	923	1.00	1.00	0.97	0.85	2.33
8	1 670	↓	↓	1.00	1.00	2.72
9	2 770	↓	↓	↓	↓	3.56
10	6 245	↓	↓	↓	↓	4.41
11	160	↓	↓	↓	↓	5.40
12	275	↓	↓	↓	↓	6.70
13	3	↓	↓	↓	↓	7.40
14	78	↓	↓	↓	↓	8.00

Table 25 HADDOCK. Management options for 1980 assuming a catch of 140 000 tonnes in 1979. Weights in 1 000 tonnes.

Stock biom.	Spawning stock biomass	F	Catch	Management Option for 1980	1980 Stock biom.	1980 Spawn. stock biom.	1980 F	1980 Catch	1981 Stock biom.	1981 Spawn. stock biom.
288	51	.76	140	$F_{1980} = F_{1978}$	219	34	.60	88	208	34
				$F_{1980} = F_{1979}$			.76	103	187	28
	Present exploitation pattern			$F_{1980} = F(max)$			.18	31	283	59
				$F_{1980} = F_{0.1}$			.11	20	298	65
				$F_{1980} \rightarrow$ Sp.Biom.1981 = 1979 level			.30	50	257	51
				$F_{1980} \rightarrow$ Sp.Biom.1981 = 1980 level			.60	88	208	34
288	51	.76	140	$F_{1980} = F_{1978}$	219	34	.60	53	256	40
				$F_{1980} = F_{1979}$			.76	64	243	34
								2		
				$F_{1980} = F(max)$			.25	25	294	58
	※135 mm in 1980			$F_{1980} = 0.1$			.13	14	310	66
				$F_{1980} \rightarrow$ Sp.Biom.1981 = 1979 level			.37	36	280	51
				$F_{1980} \rightarrow$ Sp.Biom.1981 = 1980 level			.77	65	242	34
288	51	.76	140	$F_{1980} = F_{1978}$	219	34	.60	39	276	48
				$F_{1980} = F_{1979}$			.76	47	266	44
				$F_{1980} = F(max)$			.30	22	299	59
	※150 mm in 1980			$F_{1980} = F_{0.1}$			.14	11	314	67
				$F_{1980} \rightarrow$ Sp.Biom.1981 = 1979 level			.51	35	283	51
				$F_{1980} \rightarrow$ Sp.Biom.1981 = 1980 level			1.05	59	250	34

Stock biomass = fish age 3 to 14

Spawning stock biomass = fish age 6 to 14

Table 26 Germany, Federal Republic of. Input parameters in the assessment of the effective mesh size used in the fisheries for COD in Sub-areas I and II.

Fishery	Vulnerability within area of ~~natural~~ national fishery		Discards		Portion of total fishing mortality	Miscellaneous parameters
	≥ 50% range (age)	≥ 75% range (age)	Retention length (cm) 50%	75%		
Sub-area I						
USSR trawl	1.5 - 11.5	2.5 - 10.5	no discards		0.145	F_{total} = 1.00
Norway trawl	4.5 - 11.5	5.5 - 10.5	41.5	43.5	0.071	M = 0.20
UK trawl	3.0 - 11.5	4.0 - 10.5	41.5	43.5	0.048	
Sub-area II						
USSR trawl	2.0 - 16.0	3.0 - 13.5	no discards		0.066	von Bertalanffy parameters: L_∞ = 200 cm K = 0.0677 t_0 = 0.226
Norway trawl	5.0 -	6.5 -	41.5	43.5	0.034	
UK trawl	4.0 -	5.5 -	41.5	43.5	0.028	
Sub-areas I+II						
Germany, Fed.Rep. trawl	3.0 - 7.5	4.0 - 6.0	37.5	40.0	0.016	
Other countries trawl	3.0 -	4.5 -	no discards		0.026	
Danish seine	3.5 -	5.0 -	41.5	43.5	0.007	
Gill-net	7.5 -	8.5 -	41.5	43.5	0.461	
Long- and Hand-line	4.5 -	6.5 -	41.5	43.5	0.098	

Table 27 Best estimate of effective and maximum effective mesh sizes in the fisheries for North East Arctic COD and HADDOCK. The basic data is the average length and age compositions for 1967-1977.

Fishery	COD				HADDOCK	
	Best estimate of effective mesh size		Maximum effective mesh size		Maximum effective mesh size	
	From length comp.	From age comp.	From length comp.	From age comp.	From length comp.	From age comp.
Sub-area I						
USSR trawl	90	103	93	107	92	105
Norway trawl	119	123	133	136	146	127
UK trawl	113	120	122	128	131	124
Sub-area II						
USSR trawl	111	122	114	127	142	153
Norway trawl	120	126	138	142	166	144
UK trawl	113	123	127	136	161	157
Sub-areas I + II						
Germany, Fed.Rep. trawl	113	109	116	113	155	146
Other countries' trawl	98	113	106	115	101	138
Danish seine	107	97	119	108	131	120
Gill-net	218	214	239	244	no fishery	no fishery
Long-and Handline	162	169	192	~ 200	147	126

Table 28 Input parameters on the assessment of the maximum effective mesh size used on the fisheries for North-East Arctic HADDOCK in Sub-areas I and II.

Fishery	Vulnerability within area of natural fishery		Discards		Portion of total fishing mortality	Miscellaneous parameters
	≥50% range (age)	≥75% range (age)	Retention length (cm) 50%	75%		
Sub-area I						
USSR trawl	0 -	0 -	0	0	0.285	F_{total} = 0.69
Norway trawl	0 -	0 -	0	0	0.079	M = 0.20
UK trawl	0 -	0 -	0	0	0.067	
Sub-area II						von Bertalanffy parameters:
USSR trawl	0 -	0 -	0	0	0.031	L_∞ = 125
Norway trawl	0 -	0 -	0	0	0.077	K = 0.076
UK trawl	0 -	0 -	0	0	0.140	t_o = -1.40
Sub-areas I+II						
Germany, Fed.Rep. trawl	0 -	0 -	0	0	0.067	
Other countries' trawl	0 -	0 -	0	0	0.013	
Danish seine	0 -	0 -	0	0	0.030	
Long- & Hand-line	0 -	0 -	0	0	0.211	

TABLE 29 COD. Relative change in yield (by weight) by increase in trawl mesh size from present effective mesh size to 120 mm. No change for Danish seine.

Sub-area / Year after mesh change	USSR	Norway trawl	UK	USSR	Norway trawl	UK	FRG	Others	Norway			Total
	I	I	I	II	II	II	I + II	I + II	Danish Seine I + IIa	Gill-net I + IIa	Hooks I + IIa	
1	-18	0	-3	-6	1	-3	-5	-12	1	0	0	-8
2	-15	4	0	-2	4	1	-0	-9	5	0	3	-5
3	-10	9	5	2	9	5	5	-4	10	1	6	-1
4	-7	13	9	6	13	9	9	-1	14	3	11	3
5	-5	17	12	9	17	13	11	2	17	7	15	6
6	-3	19	14	10	19	15	12	4	19	13	18	8
7	-3	20	15	11	20	16	12	4	20	17	20	10
.												
.												
.												
17	-2	20	15	12	21	17	12	5	21	22	22	11

Table 30 COD. Relative change in yield (by weight) by increase in trawl mesh size from present effective mesh size to 135 mm and to 125 mm for Danish seine.

Sub-area / Year after mesh change	USSR I	Norway trawl I	UK I	USSR II	Norway trawl II	UK II	FRG I + II	Others I + II	Norway Danish Seine I + IIa	Norway Gill-net I + IIa	Hooks I + IIa	Total
1	-29	-9	-15	-19	-8	-13	-21	-22	-8	0	2	-17
2	-23	-2	-8	-12	-1	- 6	-13	-16	0	1	8	-11
3	-15	8	1	- 3	8	3	- 3	- 8	10	3	17	- 3
4	- 9	17	10	5	18	12	4	- 1	18	9	27	5
5	- 4	24	15	10	25	18	8	4	24	20	35	11
6	- 2	28	18	13	29	22	9	7	27	32	41	15
7	- 1	29	20	14	31	23	10	9	29	41	44	18
.												
.												
.												
17	- 0	30	21	15	33	25	10	10	30	50	47	20

Table 31 North-East Arctic COD. Relative change in yield (by weight) by increase in trawl mesh size from present effective to 150 mm and to 135 mm for Danish seine.

Year after mesh change \ Sub-area	USSR I	Norway trawl I	UK I	USSR II	Norway trawl II	UK II	FRG I + II	Others I + II	Norway: Danish Seine I + IIa	Norway: Gill-net I + IIa	Hooks I + IIa	Total
1	-42	-22	-29	-32	-19	-25	-38	-35	-14	0	3	-26
2	-34	-12	-19	-23	-10	-16	-28	-26	- 2	2	15	-18
3	-23	3	- 6	-11	4	- 3	-15	-15	13	9	31	- 7
4	-13	17	6	- 0	18	10	- 6	- 4	26	22	48	5
5	- 6	27	14	8	29	19	- 0	4	34	41	61	15
6	- 3	32	19	12	36	25	2	9	40	60	70	21
7	- 1	35	21	14	39	28	3	11	42	74	75	25
.												
.												
.												
17	- 0	36	22	16	42	30	3	13	45	87	79	27

Table 32 COD. Relative change of discarded fish (by weight) by increase in effective trawl and Danish seine mesh sizes.

Change in mesh size \ Sub-area	USSR I	Norway trawl I	UK I	USSR II	Norway trawl II	UK II	FRG I + II	Others I + II	Norway Danish Seine I + IIa	Norway Gill-net I + IIa	Hooks I + IIa	Total
Present/ 120 mm 1)	0	- 2	-32	0	5	-33	-33	0	5	0	5	-16
Present/ 135 mm 2)	0	-63	-74	0	-60	-72	-73	0	-70	0	6	-55
Present/ 150 mm 3)	0	-85	-88	0	-85	-91	-93	0	-85	0	8	-69

1) No change in Danish seine mesh size

2) Change in Danish seine mesh size from 107 mm to 125 mm

3) Change in Danish seine mesh size from 107 mm to 135 mm

Table 33 HADDOCK. Relative change in yield (by weight) by increase in trawl mesh size from present effective to 120 mm. No change for Danish seine.

Year after mesh change \ Sub-area	USSR I	Norway trawl I	UK I	USSR II	Norway trawl II	UK II	FRG I + II	Others I + II	Norway: Danish seine I + IIa	Norway: Hooks I + IIa	Total
1	-32	0	- 5	- 9	1	- 2	- 3	-22	2	1	-15
2	-28	3	- 1	- 4	3	0	0	-18	6	3	-12
3	-24	8	5	1	8	5	5	-14	12	7	- 7
4	-20	14	10	6	14	11	11	-10	18	12	- 2
5	-17	20	15	10	20	17	17	- 6	23	18	2
6	-16	24	18	13	25	21	21	- 4	26	23	5
7	-15	27	19	14	28	24	24	- 3	28	27	7
8	-14	29	21	15	30	26	25	- 2	29	29	8
.											
.											
16	-14	31	22	17	32	28	27	- 1	31	32	9

Table 34 HADDOCK. Relative change in yield (by weight) by increase in trawl mesh size from present effective to 135 mm and to 125 mm for Danish seine

Year after change in mesh size \ Sub-area	USSR I	Norway trawl I	UK I	USSR II	Norway trawl II	UK II	FRG I + II	Others I + II	Norway: Danish seine I + IIa	Norway: Hooks I + IIa	Total
1	-49	-11	-22	-26	- 9	-11	-14	-38	-10	2	-28
2	-44	- 5	-15	-20	- 3	- 5	- 7	-33	- 2	9	-22
3	-38	5	- 6	-12	7	4	2	-26	8	18	-14
4	-32	16	3	- 4	18	14	12	-19	18	30	- 6
5	-28	25	10	3	28	25	22	-14	27	41	1
6	-26	33	15	8	37	33	29	-10	32	51	6
7	-24	38	18	11	42	38	34	- 8	36	57	10
8	-24	41	20	13	46	41	37	- 6	38	62	12
.											
.											
16	-23	45	23	15	50	46	41	- 4	41	68	14

Table 35 HADDOCK. Relative change in yield (by weight) by increase in trawl mesh size from present effective to 150 mm and to 135 mm for Danish seine.

Sub-area / Year after change in mesh size	USSR I	Norway trawl I	UK I	USSR II	Norway trawl II	UK II	FRG I + II	Others I + II	Norway		Total
									Danish seine I + IIa	Hooks I + IIa	
1	-65	-27	-40	-44	-23	-26	-29	-54	-20	5	-41
2	-59	-18	-32	-37	-15	-17	-20	-48	- 8	18	-34
3	-53	- 6	-22	-28	- 2	- 5	- 8	-40	6	35	-24
4	-46	8	-11	-18	13	10	6	-32	21	54	-13
5	-41	22	- 1	- 9	28	25	19	-25	33	73	- 3
6	-38	33	6	- 2	40	36	29	-19	41	88	5
7	-36	40	11	3	49	45	36	-16	47	98	10
8	-35	45	14	6	54	50	41	-13	50	105	13
.											
.											
16	-35	51	18	10	62	57	47	-10	55	115	17

Table 36 HADDOCK. Relative change of discarded fish (by weight) by increase in effective mesh size.

Change in mesh size for trawlers \ Sub-area	USSR I	Norway trawl I	UK I	USSR II	Norway trawl II	UK II	FRG I + II	Others I + II	Norway: Danish seine I + IIa	Norway: Hooks I + IIa	Total
Present effective/ 120 mm 1)	-0	13	-18	0	21	-12	-12	0	14	17	- 2
Present effective/ 135 mm 2)	0	-44	-62	0	-46	-53	-55	0	-50	22	-44
Present effective/ 150 mm 3)	0	-73	-82	0	-75	-79	-80	0	-70	24	-62

1) No change in Danish seine mesh size
2) Change in Danish seine mesh size from 107 mm to 125 mm
3) Change in Danish seine mesh size from 107 mm to 135 mm

Table 37 Calculation of total international effort on cod and haddock. English cpue data of total cod and haddock catches by conventional trawlers

Area	I			IIa			IIb		
Year	English cpue t/t-hx10^{-4}	Total internat. catch tx10^{-3}	Effort	English cpue t/t-hx10^{-4}	Total internat. catch tx10^{-3}	Effort t-hx10^{-7}	English cpue t/t-hx10^{-4}	Total internat. catch tx10^{-3}	Effort t-hx10^{-7}
1950	.243	447	1.84	.248	242	0.98	.290	175	0.60
1951	.164	495	3.02	.228	307	1.35	.201	146	0.73
1952	.160	628	3.93	.148	267	1.80	.207	110	0.53
1953	.153	548	3.58	.150	165	1.10	.191	106	0.55
1954	.171	724	4.23	.146	152	1.04	.208	108	0.52
1955	.183	988	5.40	.181	199	1.10	.260	164	0.63
1956	.168	951	5.66	.209	273	1.31	.251	333	1.33
1957	.111	487	4.39	.126	161	1.28	.150	268	1.79
1958	.101	466	4.61	.136	181	1.33	.127	234	1.84
1959	.110	444	4.04	.121	205	1.69	.123	246	2.00
1960	.105	401	3.82	.100	183	1.83	.105	94	0.90
1961	.106	575	5.42	.093	179	1.92	.129	223	1.73
1962	.115	710	6.17	.108	165	1.53	.135	223	1.65
1963	.098	672	6.86	.099	138	1.39	.099	119	1.20
1964	.076	286	3.76	.087	124	1.43	.095	127	1.34
1965	.085	340	4.00	.084	119	1.42	.111	104	0.94
1966	.092	416	4.52	.100	170	1.70	.081	59	0.73
1967	.101	431	4.27	.078	157	2.01	.109	121	1.11
1968	.129	783	6.07	.106	202	1.91	.174	270	1.55
1969	.126	768	6.10	.136	296	2.18	.137	263	1.92
1970	.104	663	6.38	.097	271	2.79	.104	87	0.84
1971	.064	369	5.77	.087	342	3.93	.074	57	0.77
1972	.061	418	6.85	.073	377	5.16	.074	35	0.47
1973	.079	777	9.84	.063	235	3.73	.074	101	1.36
1974	.099	882	8.91	.102	171	1.68	.121	270	2.23
1975	.092	684	7.43	.093	164	1.76	.104	157	1.51
1976	.070	621	8.87	.073	275	3.77	.084	110	1.31
1977	.056	610	10.89	.060	285	4.75	.056	120	2.14
1978	.067	491	7.33	.052	267	5.13	.048	28	0.58

Table 38 English cod and haddock catch by conventional trawlers.

Year	English total cod and haddock catch x 10^{-3} t			Weighted cpue t/t-h x 10^{-4}
	I	IIa	IIb	
1950	185	27	107	.259
1951	162	37	109	.185
1952	164	43	65	.169
1953	81	29	53	.165
1954	88	25	67	.181
1955	110	33	115	.217
1956	91	41	170	.220
1957	53	36	98	.134
1958	56	36	84	.121
1959	67	32	103	.118
1960	102	39	45	.104
1961	101	29	68	.112
1962	106	38	69	.120
1963	76	29	44	.098
1964	31	31	46	.087
1965	35	31	41	.095
1966	58	46	18	.093
1967	51	39	10	.093
1968	81	53	6	.122
1969	74	75	13	.132
1970	55	38	8	.101
1971	18	26	1	.076
1972	10	15	2	.069
1973	17	10	9	.073
1974	30	15	7	.103
1975	26	12	2	.096
1976	13	8	3	.073
1977	32	17	17	.057
1978	5	7	1	.057

Fig. 1 Catchability coefficient, q, for gill-nets and hand-line in the Lofoten spawning fishery for COD 1960-1979

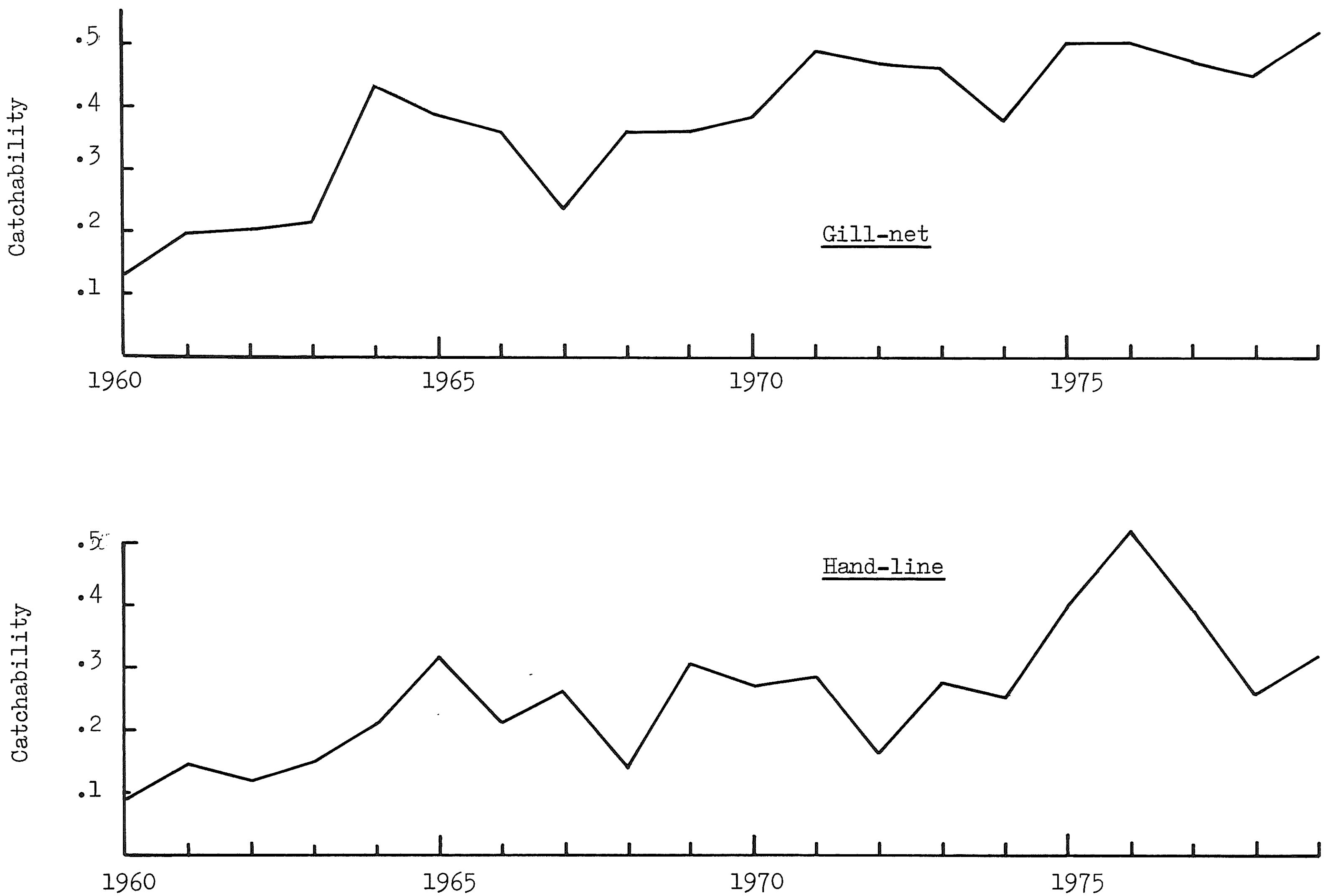


Fig. 2 Catchability coefficient, q, for long-line in the Lofoten spawning fishery for COD 1960-1979

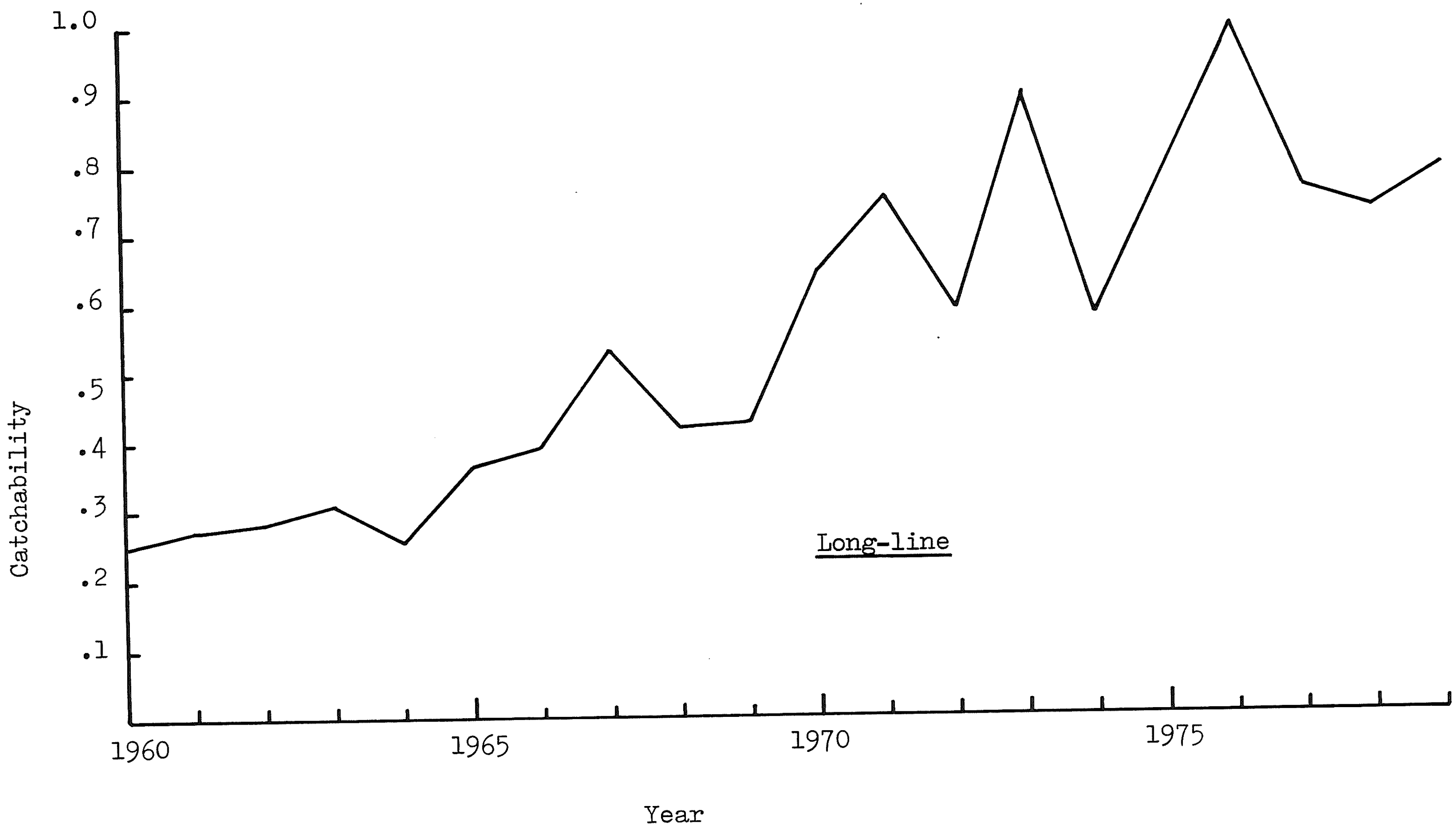


Fig. 3a Catchability coefficient, q, from UK cpue of fish 8 years and older

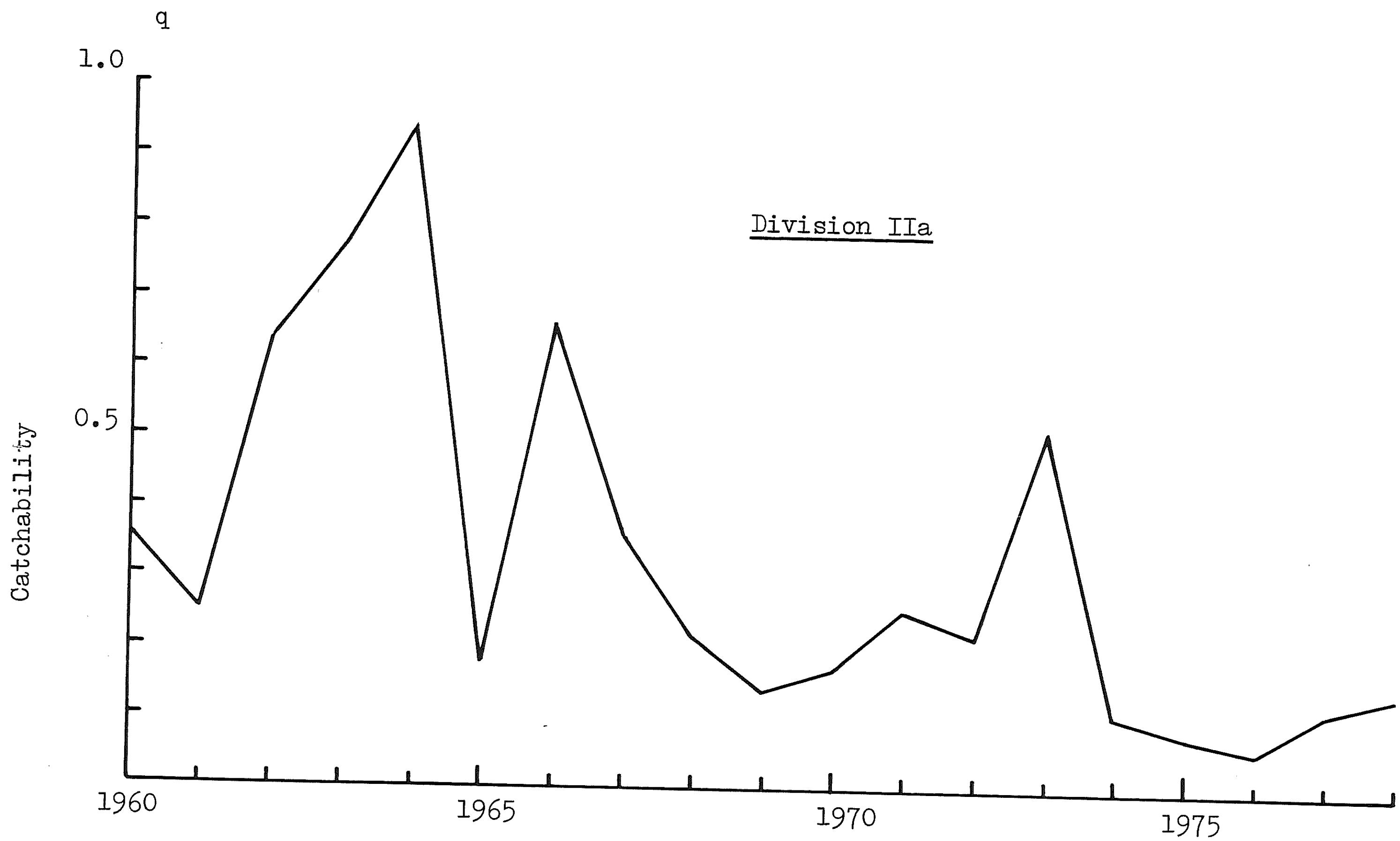


Fig. 3b Catchability coefficient, q, from UK catch per unit effort on 4 to 7 years old fish.

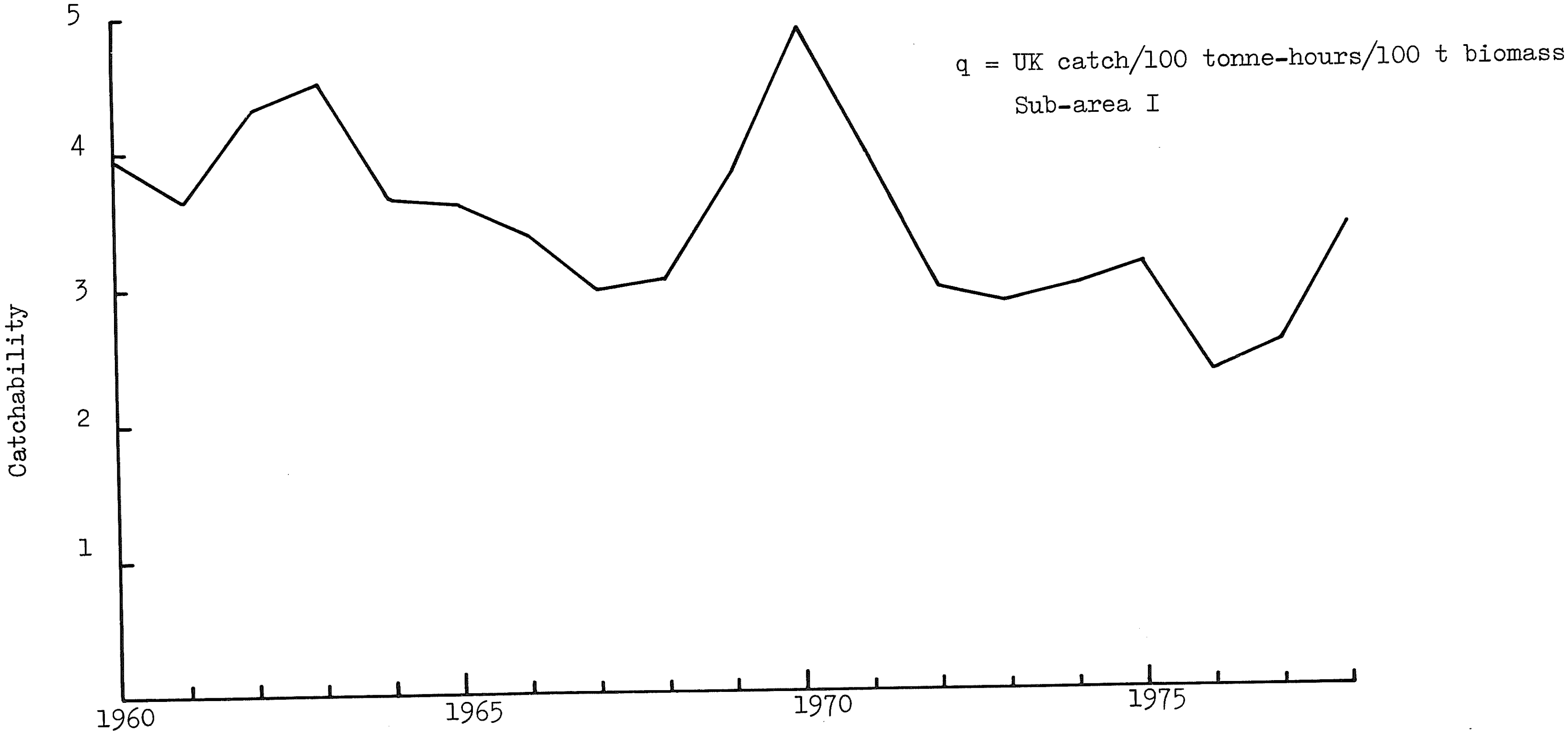


Fig. 4 Relation between English cpue data and Norwegian cpue data (from trawlers)

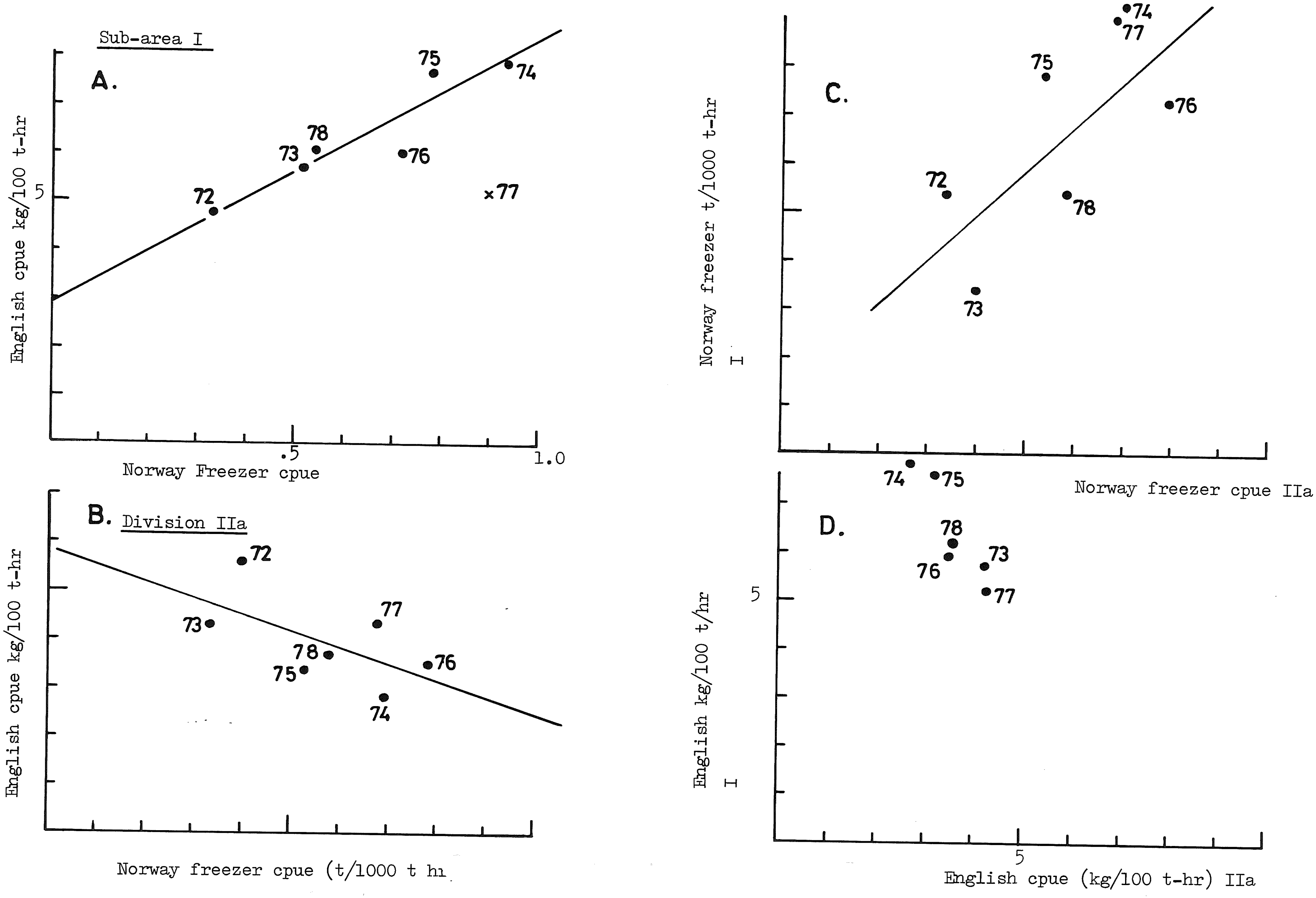


Fig. 5 The correspondence between catch per unit effort of 4 to 7 years old cod (tonnes per 100 tonne-hour trawling) by English trawlers in Sub-area I, and the estimated stock size of 4-7 year old cod.

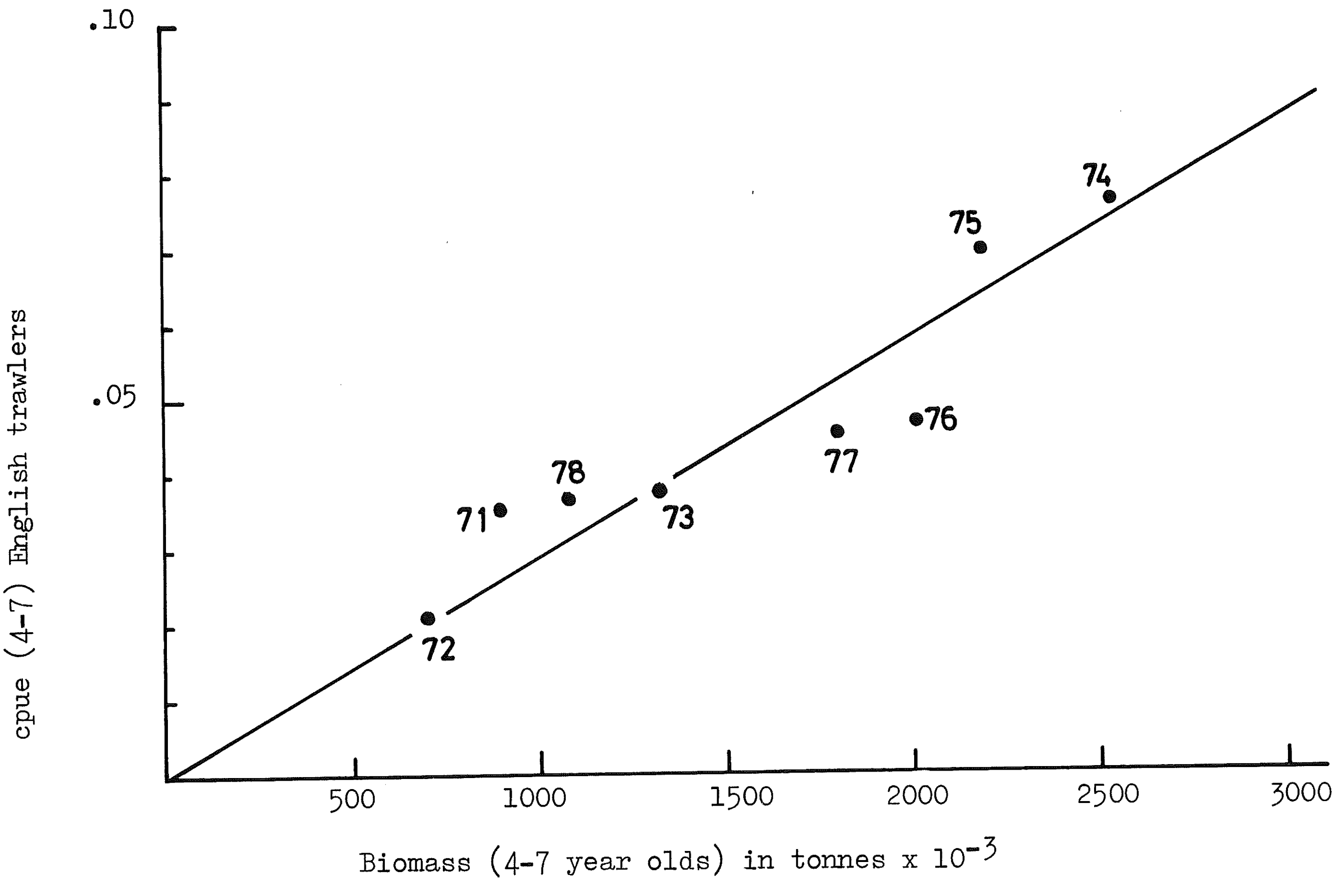


Fig. 6 The average fishing mortality on 4 to 7 year old cod versus the total international effort (in UK units)

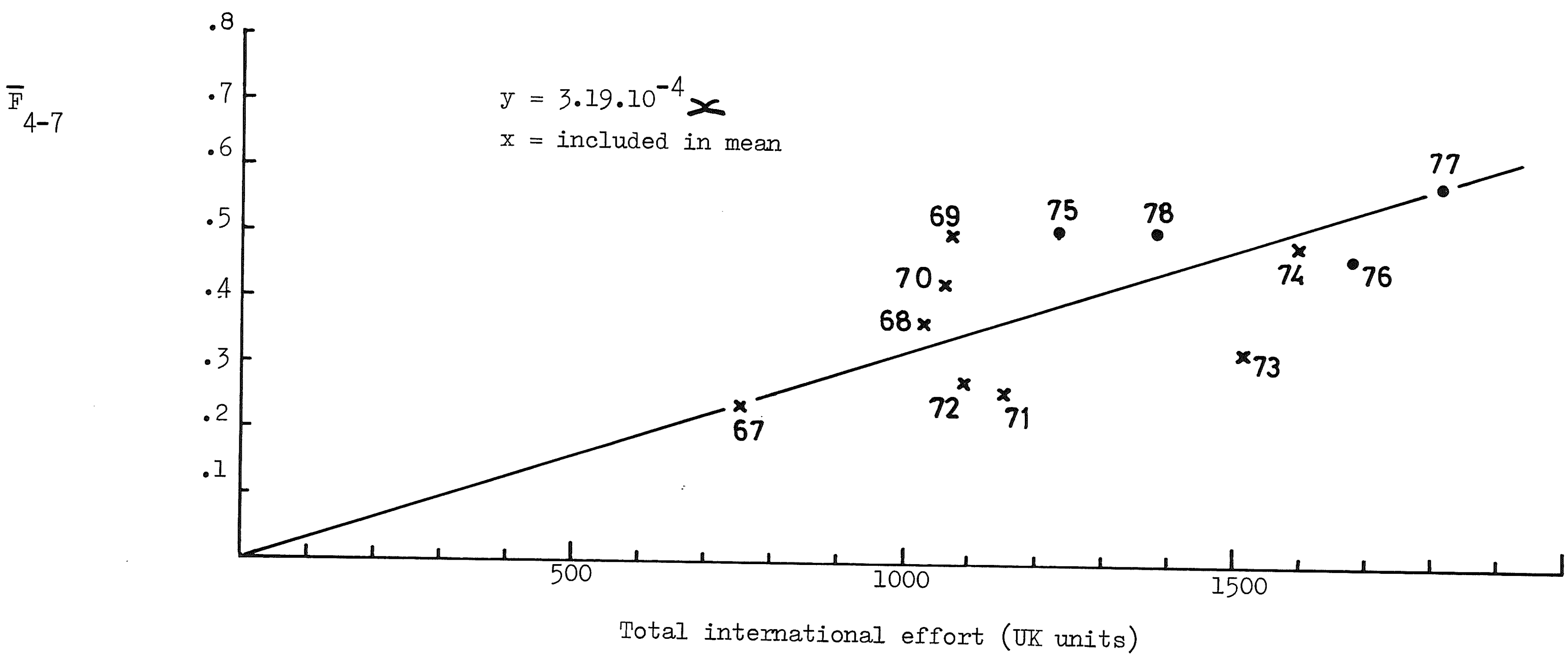


Fig. 7 Number of 3 year olds versus catch per unit effort of 3 year olds by UK trawlers in Sub-area I.

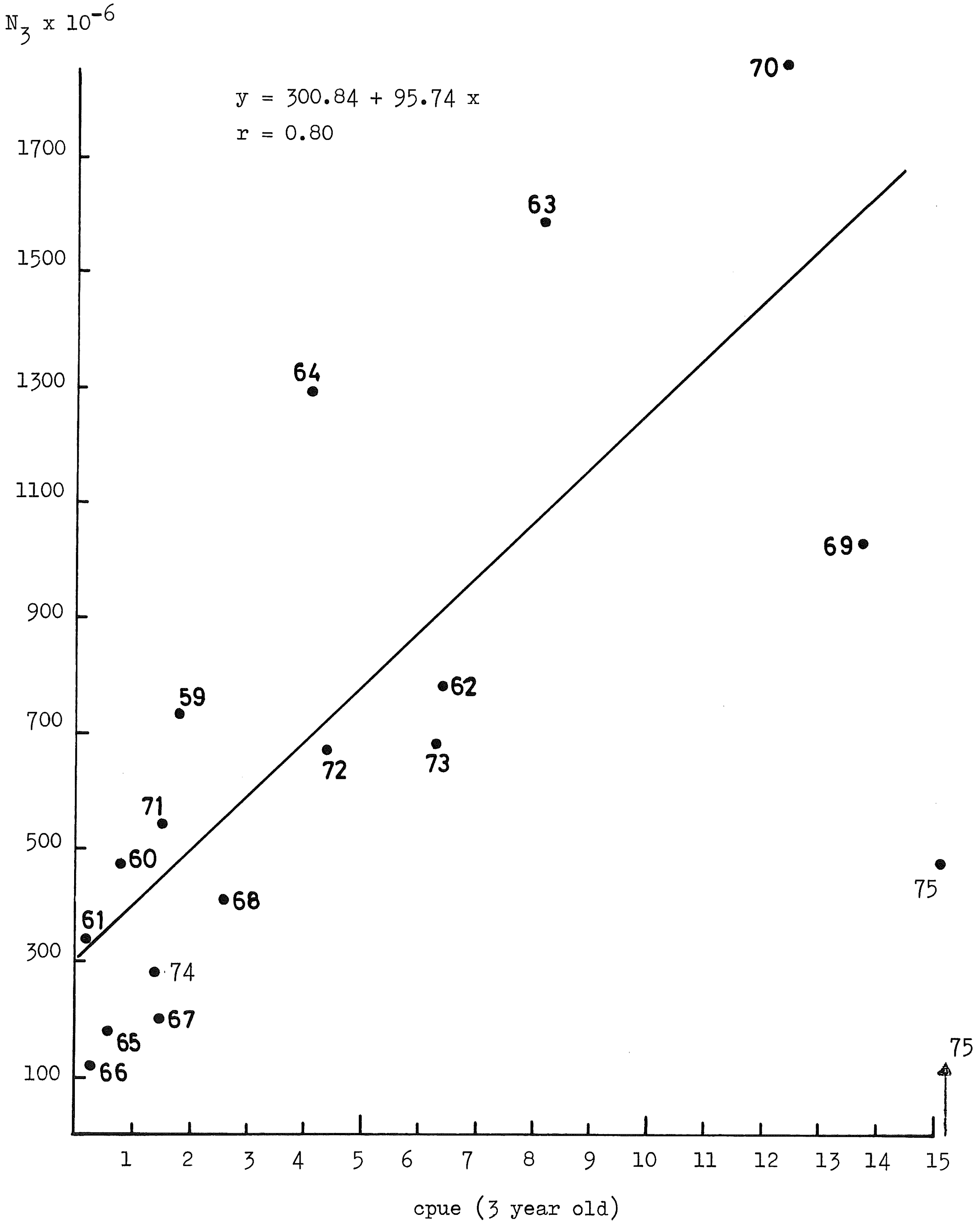


Fig. 8   Number of 4 year olds versus catch per unit effort of 4 year olds by UK trawlers in Sub-area I.

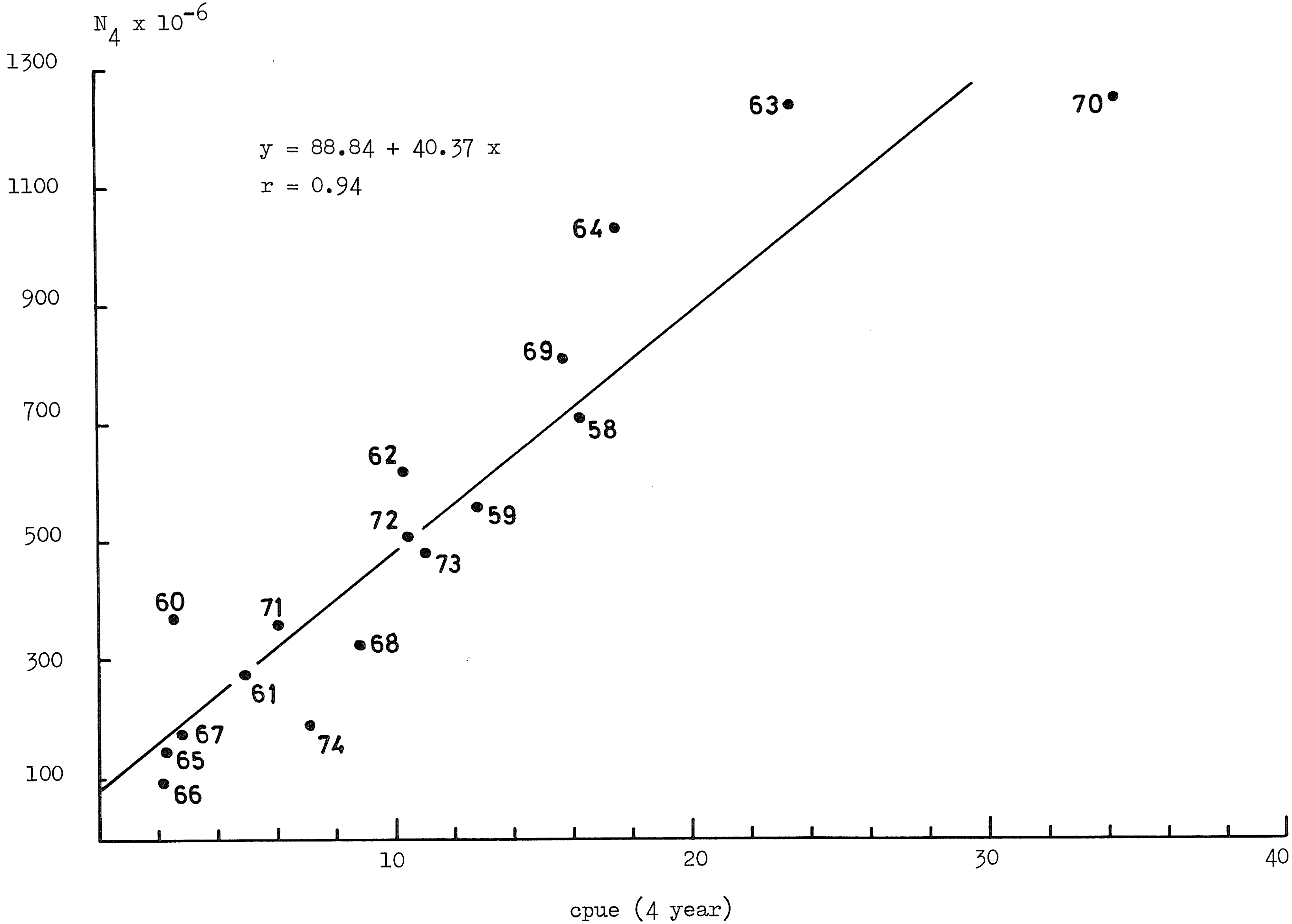


Fig. 9 Number of 5 year olds versus catch per unit effort of 5 year olds by UK trawlers in Sub-area I.

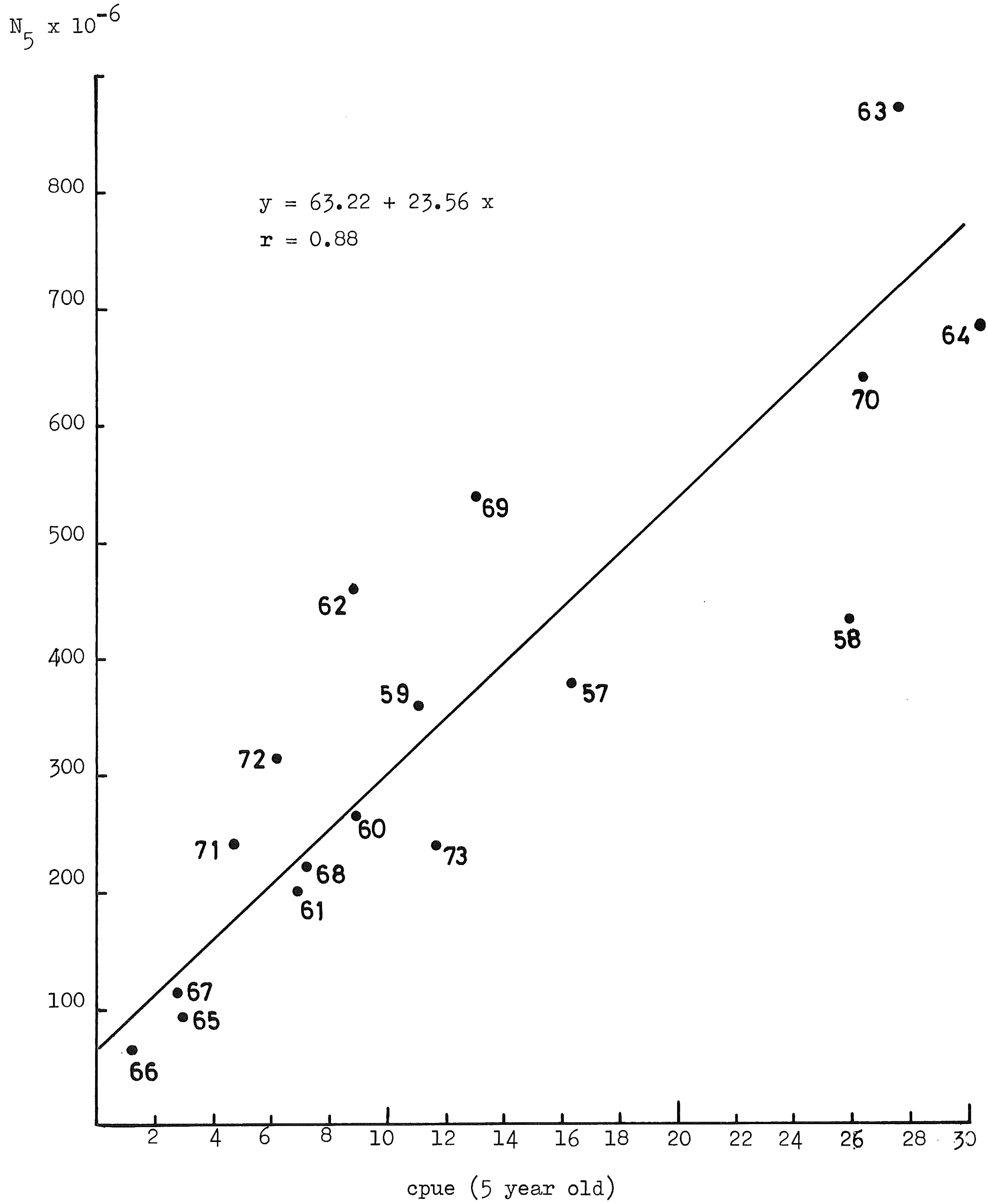


Fig. 10 COD. Recruitment at age 3, and relative fishing mortality on 3 year olds ($= F_3 / \overline{F}_{8-12}$)

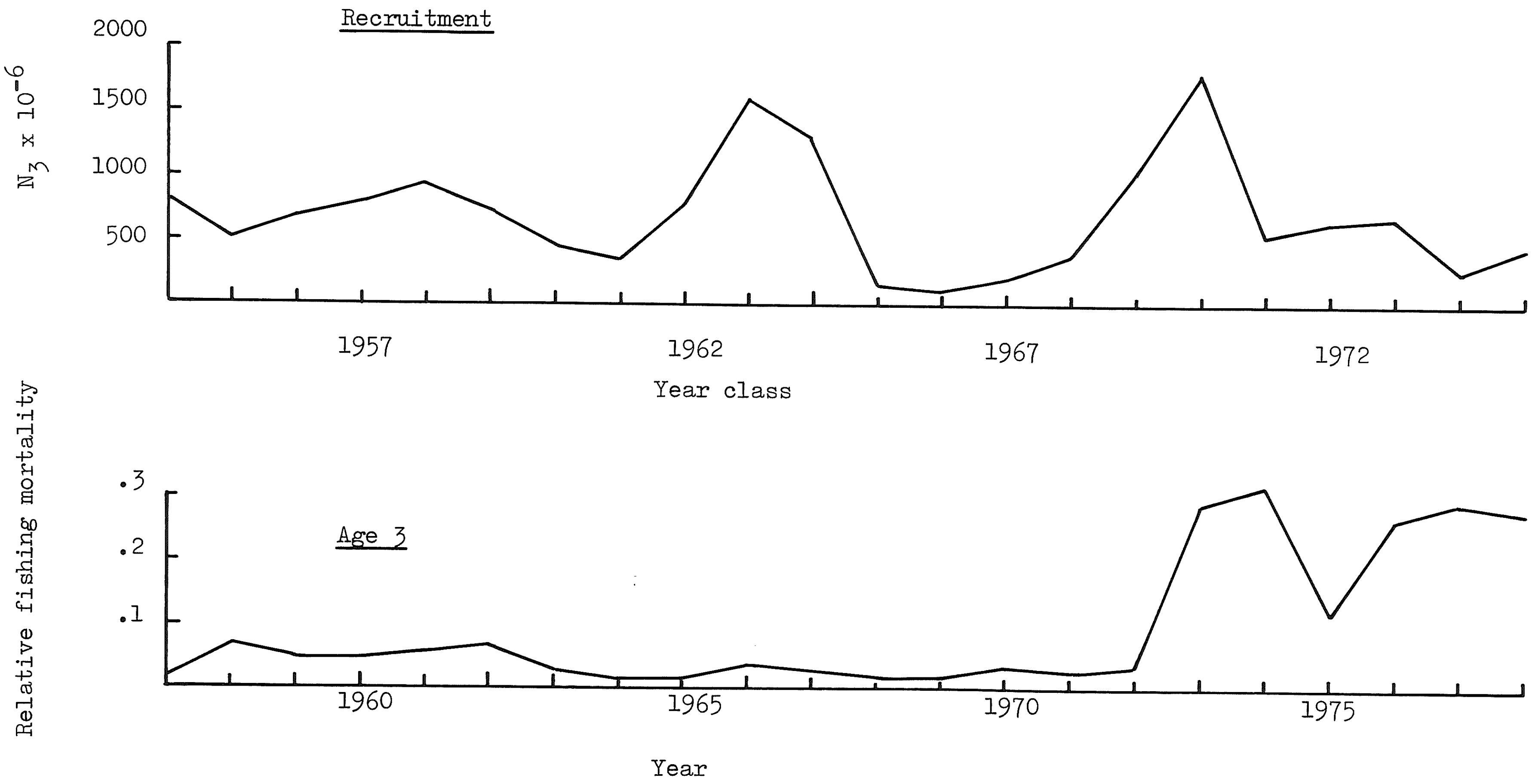


Fig. 11 North-East Arctic COD. Recruitment versus spawning stock (1946-1975 year class)

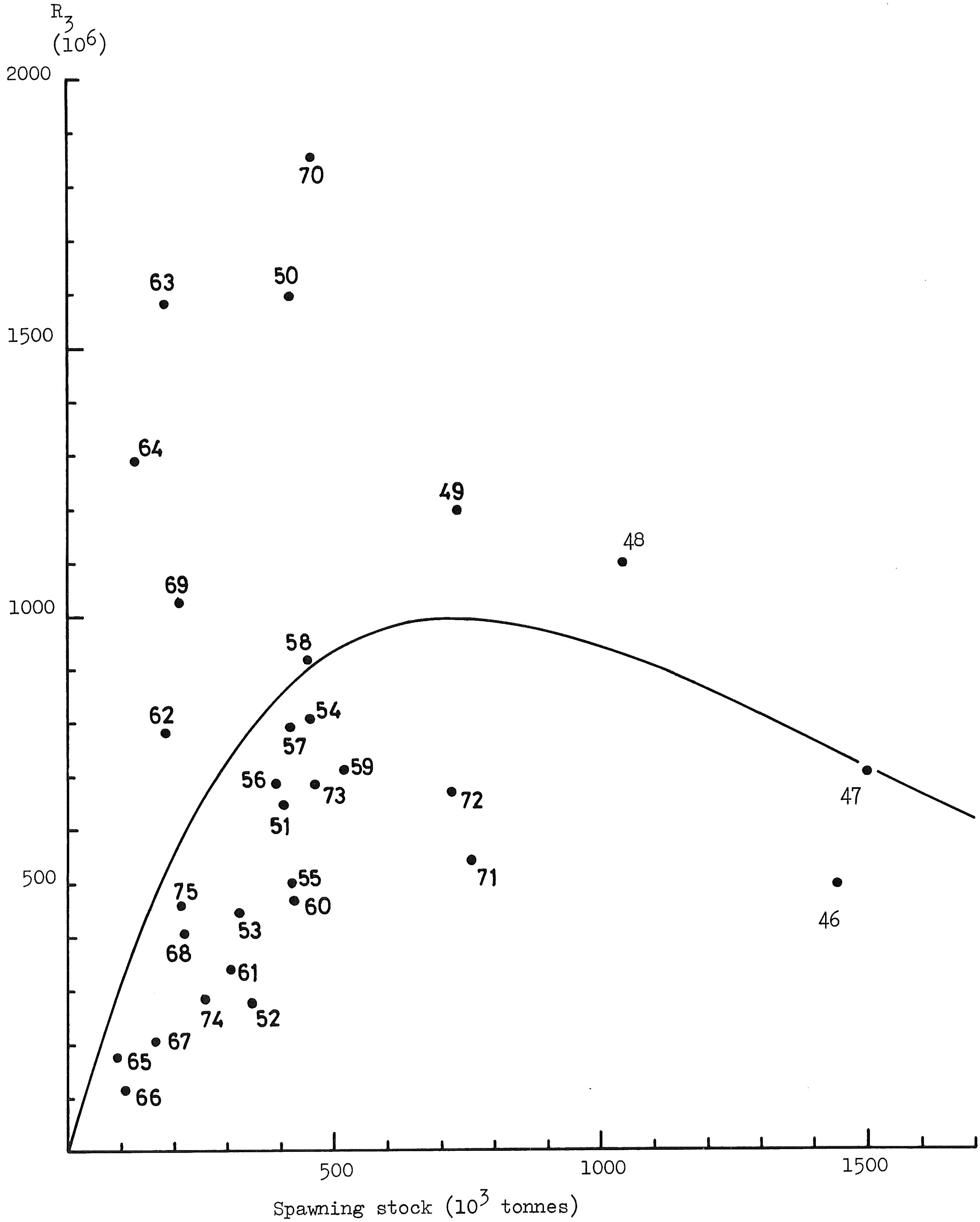


Fig. 12 COD. Correlation of VPA recruitment estimates on USSR young fish survey for 1957-1974. 1975 year class is not included in the regression

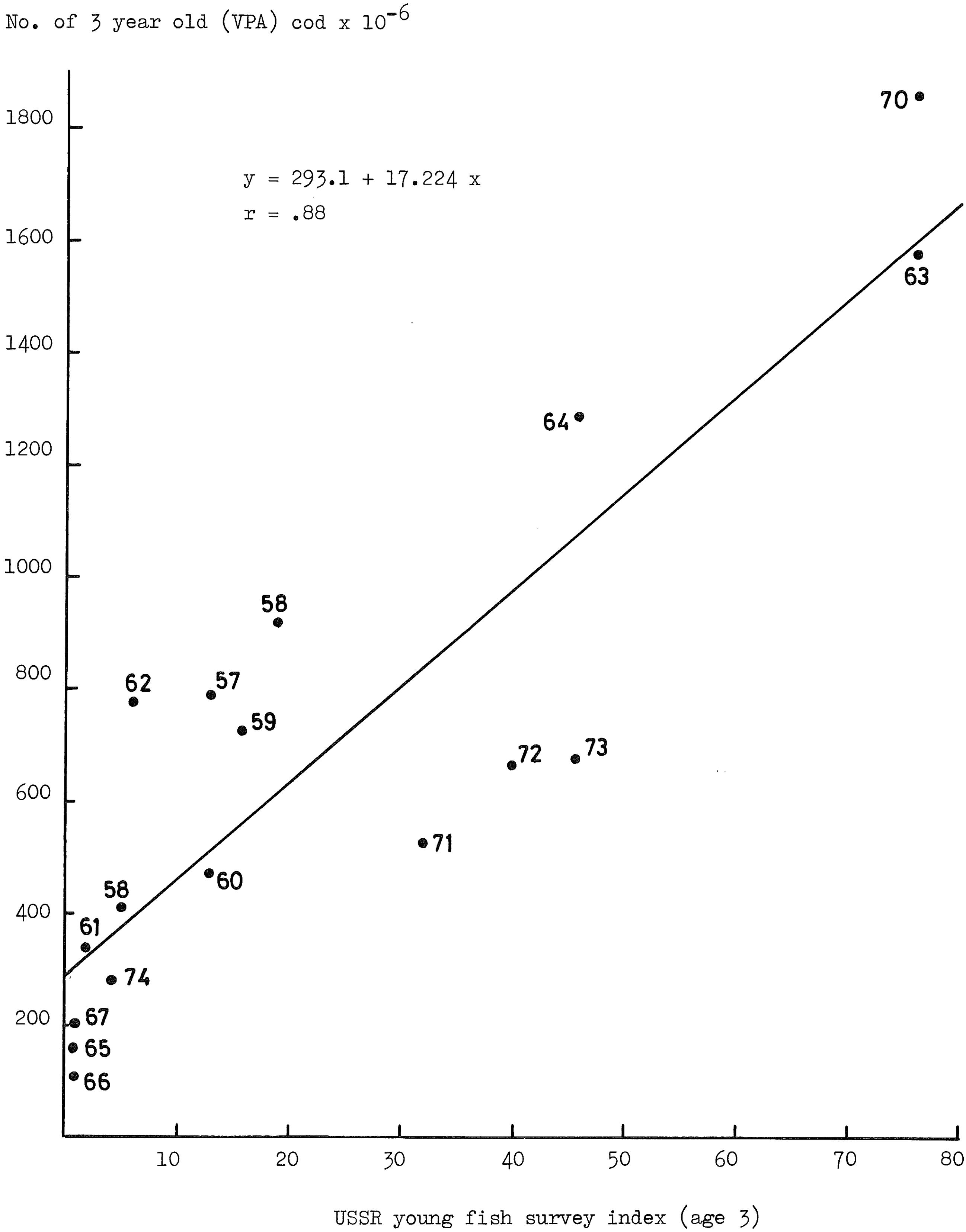


Fig. 13 COD. Yield per recruit (at age 3) versus the average fishing mortality on 8 to 12 year olds

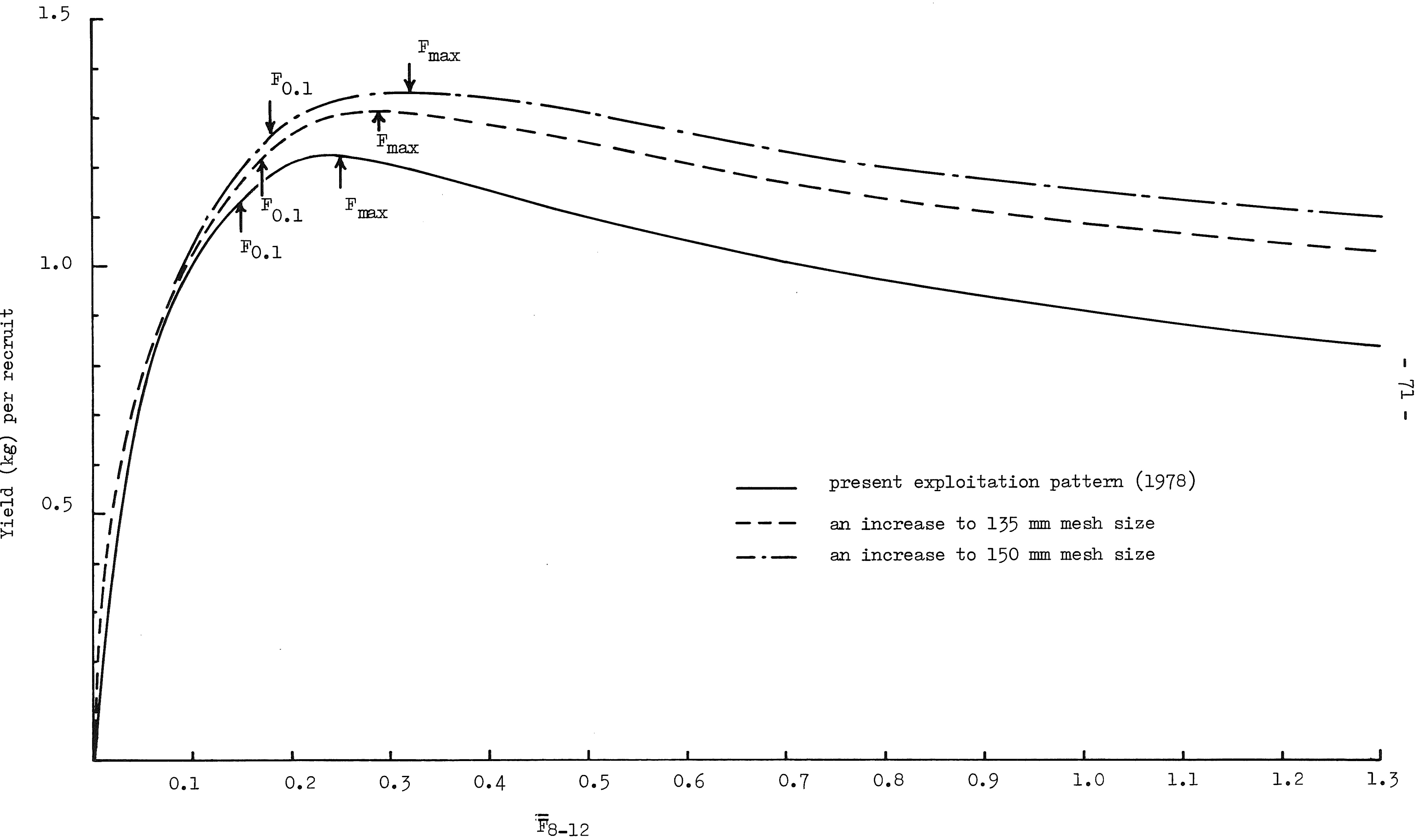


Fig. 14 COD. Spawning stock biomass per recruit (at age 3) versus average fishing mortality on 8 to 12 year olds.

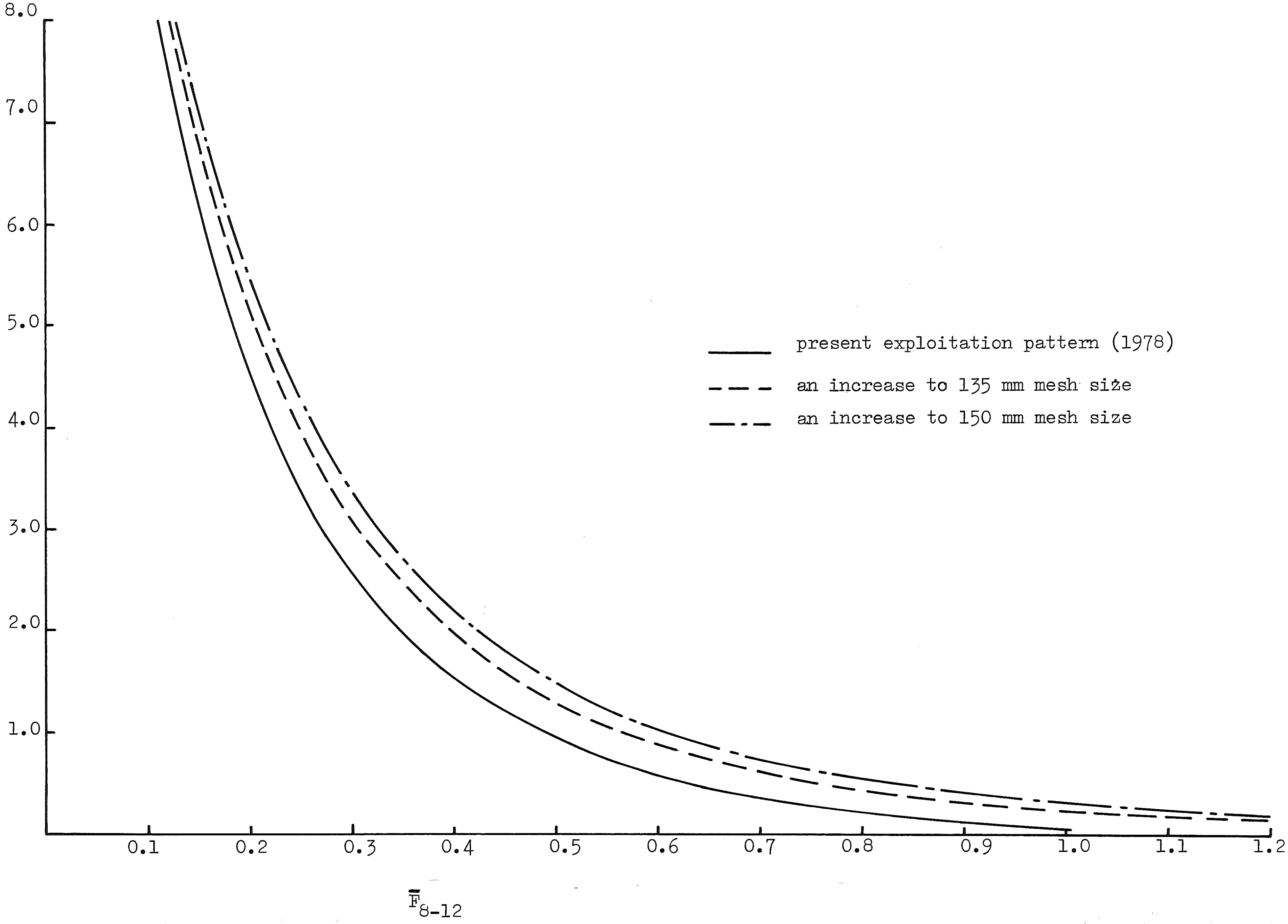


Fig. 15 HADDOCK. Average fishing mortality on 3 to 6 year olds versus the total international effort (in UK units). 1965-1975 from a preliminary VPA run, 1976-1978 from the final VPA run.

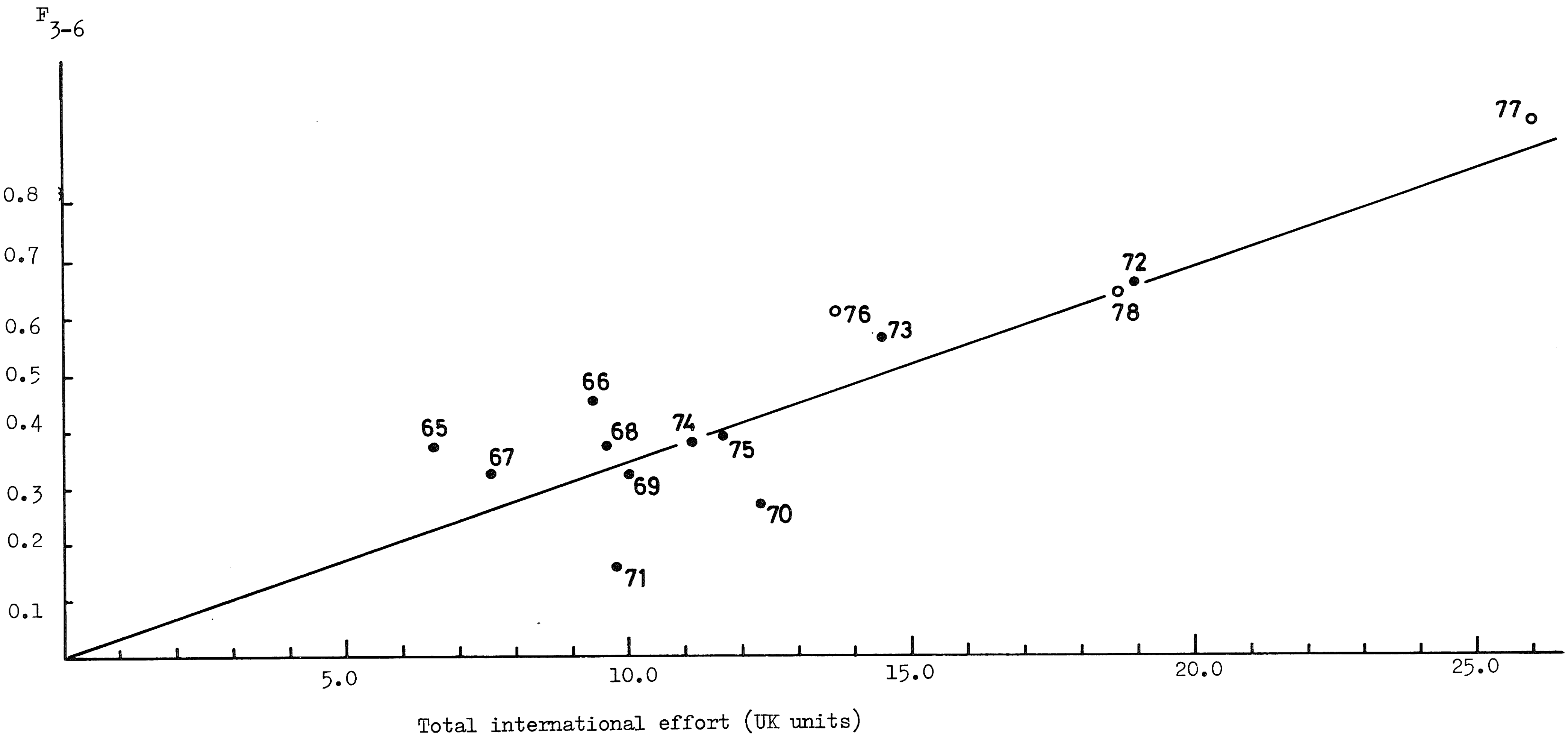


Fig. 16 HADDOCK. Correlation of numbers of 3 year olds (from VPA) and USSR young fish surveys for the year classes 1957-1974.

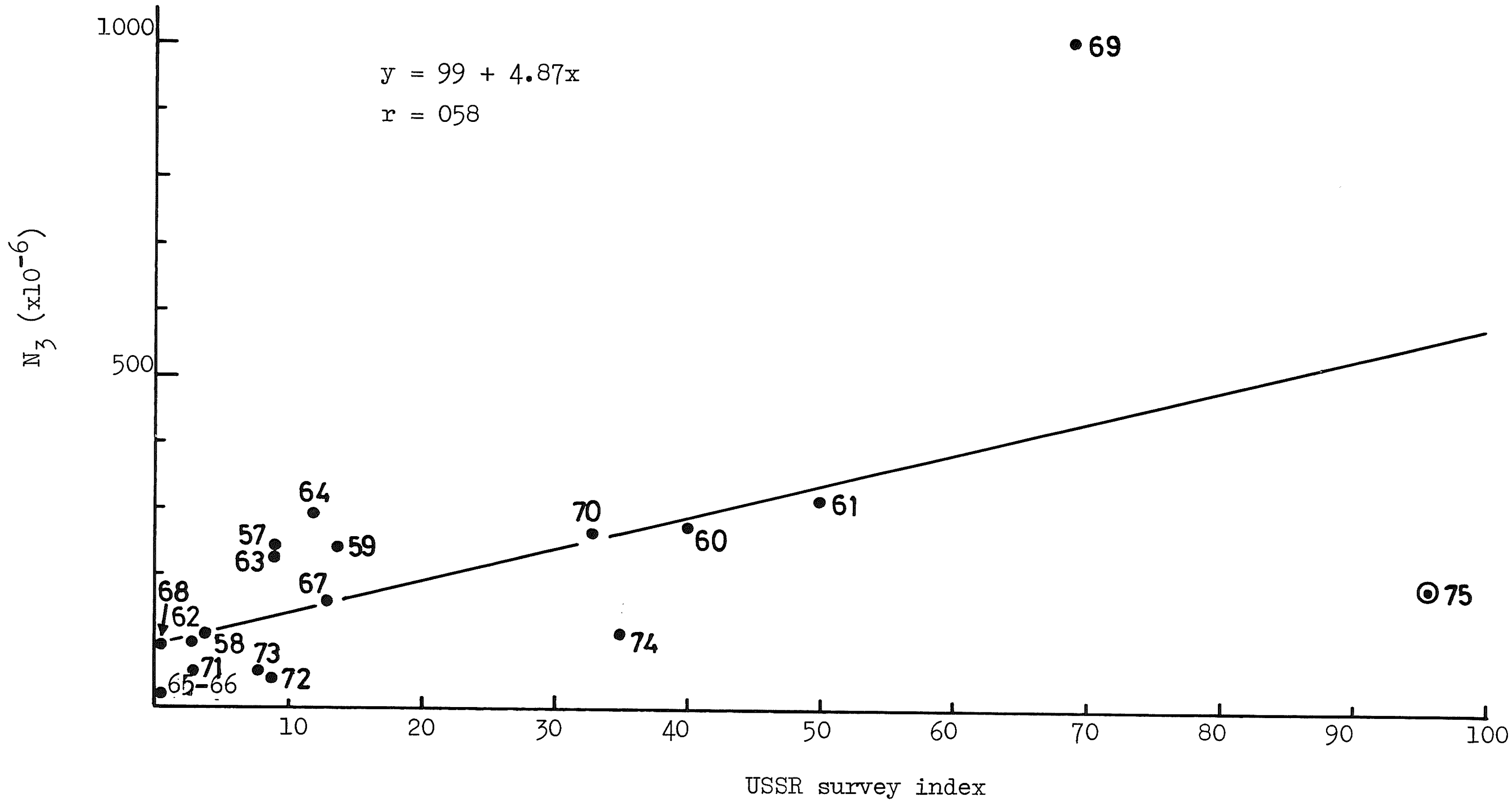


Fig. 17 HADDOCK. Recruitment versus spawning stock (1950-1875 year class)

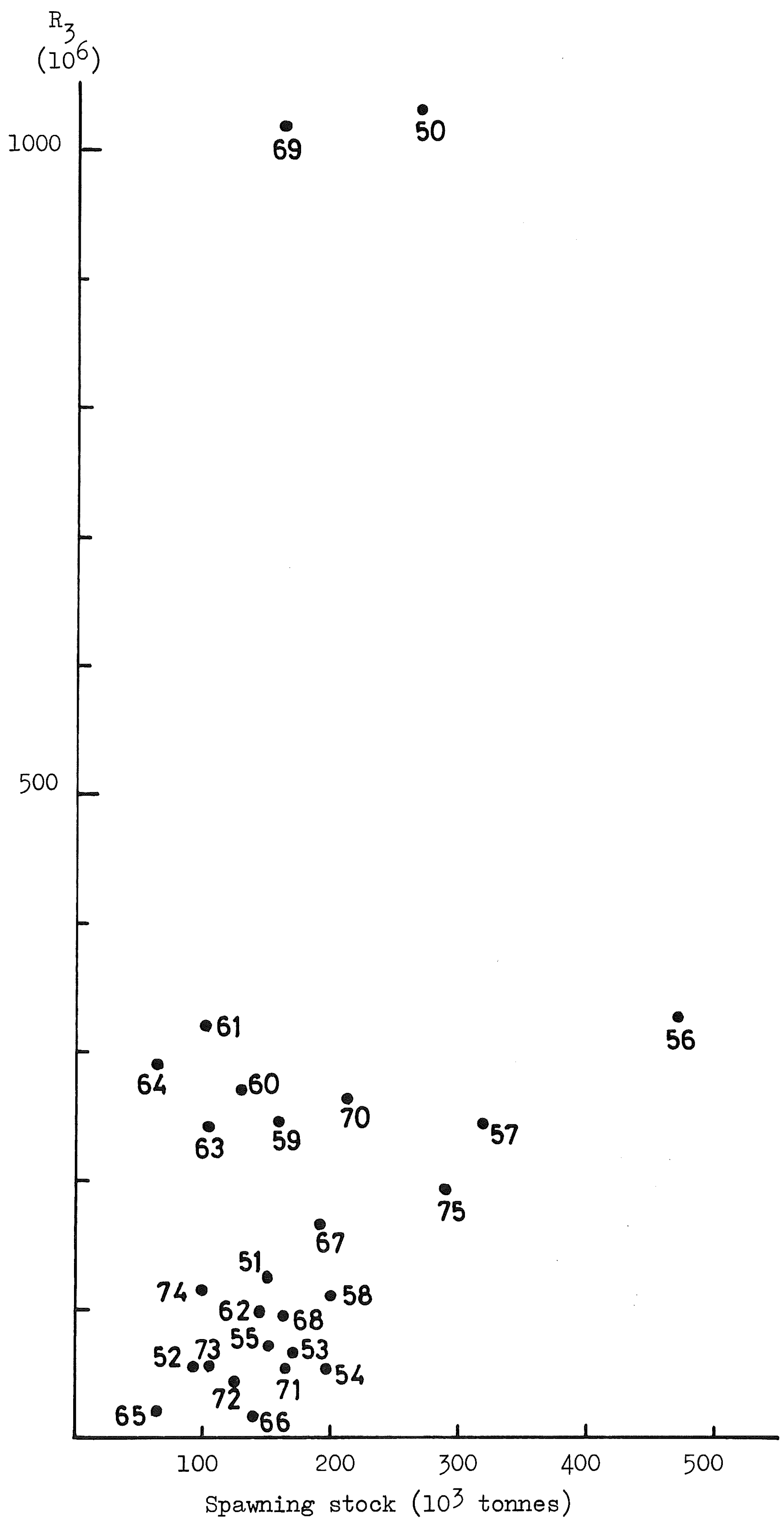


Fig. 18 HADDOCK. Yield per recruit (at age 3) versus fishing mortality on 7 years and older fish.

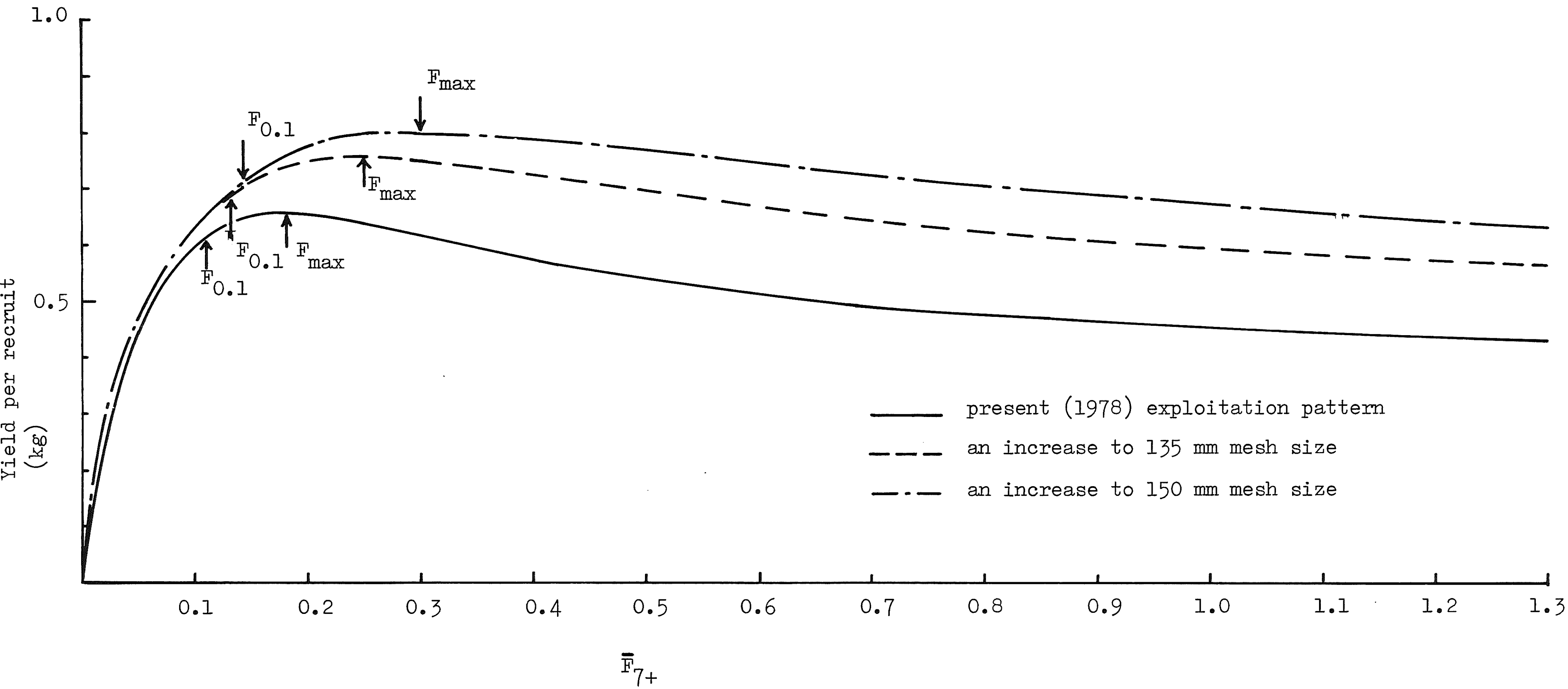


Fig. 19 HADDOCK. Yield per recruit (at age 3) versus fishing mortality on 7 years and older fish

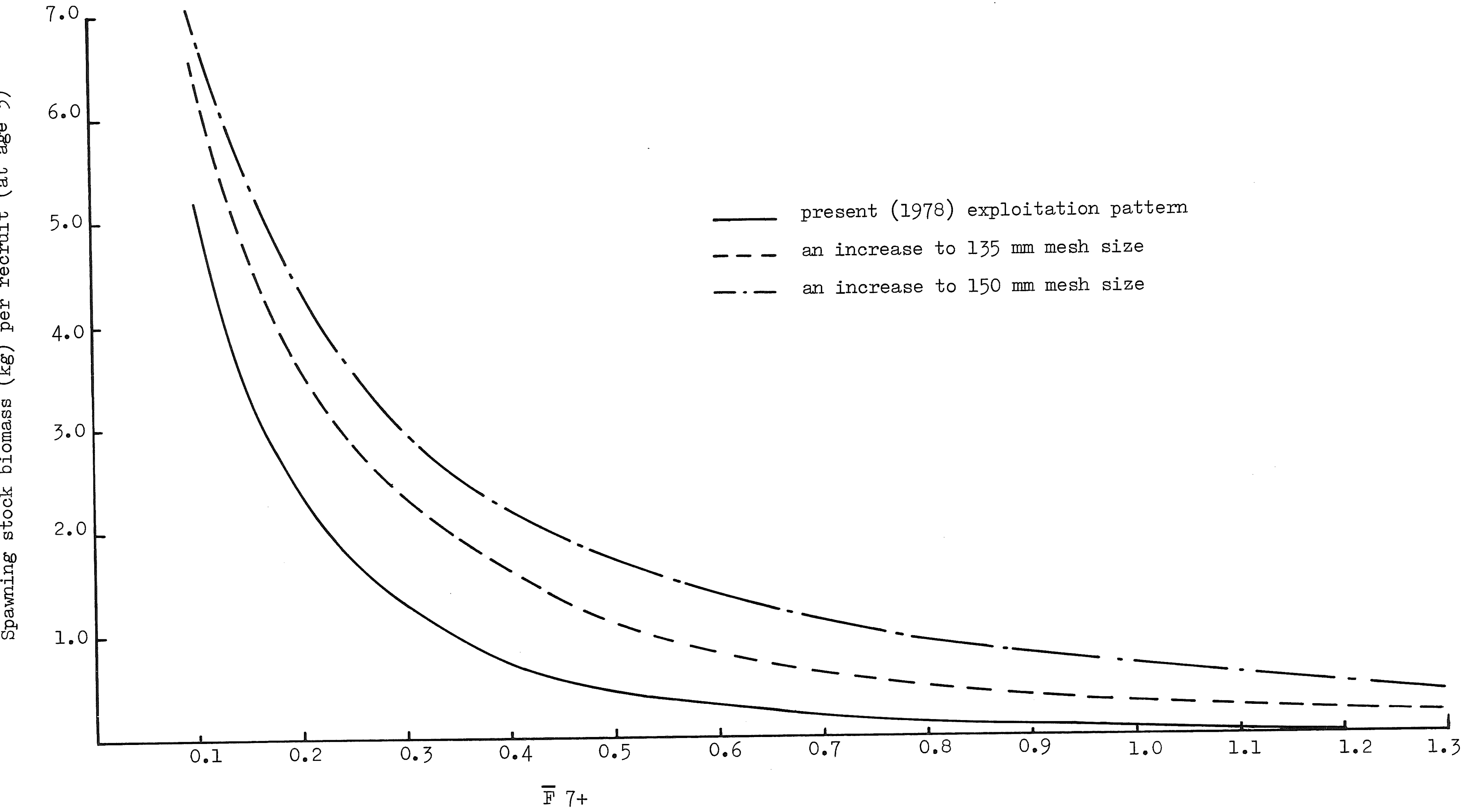


Fig. 20 Weight correction factor versus the proportion of 3 to 5 year olds in the catches (by number).

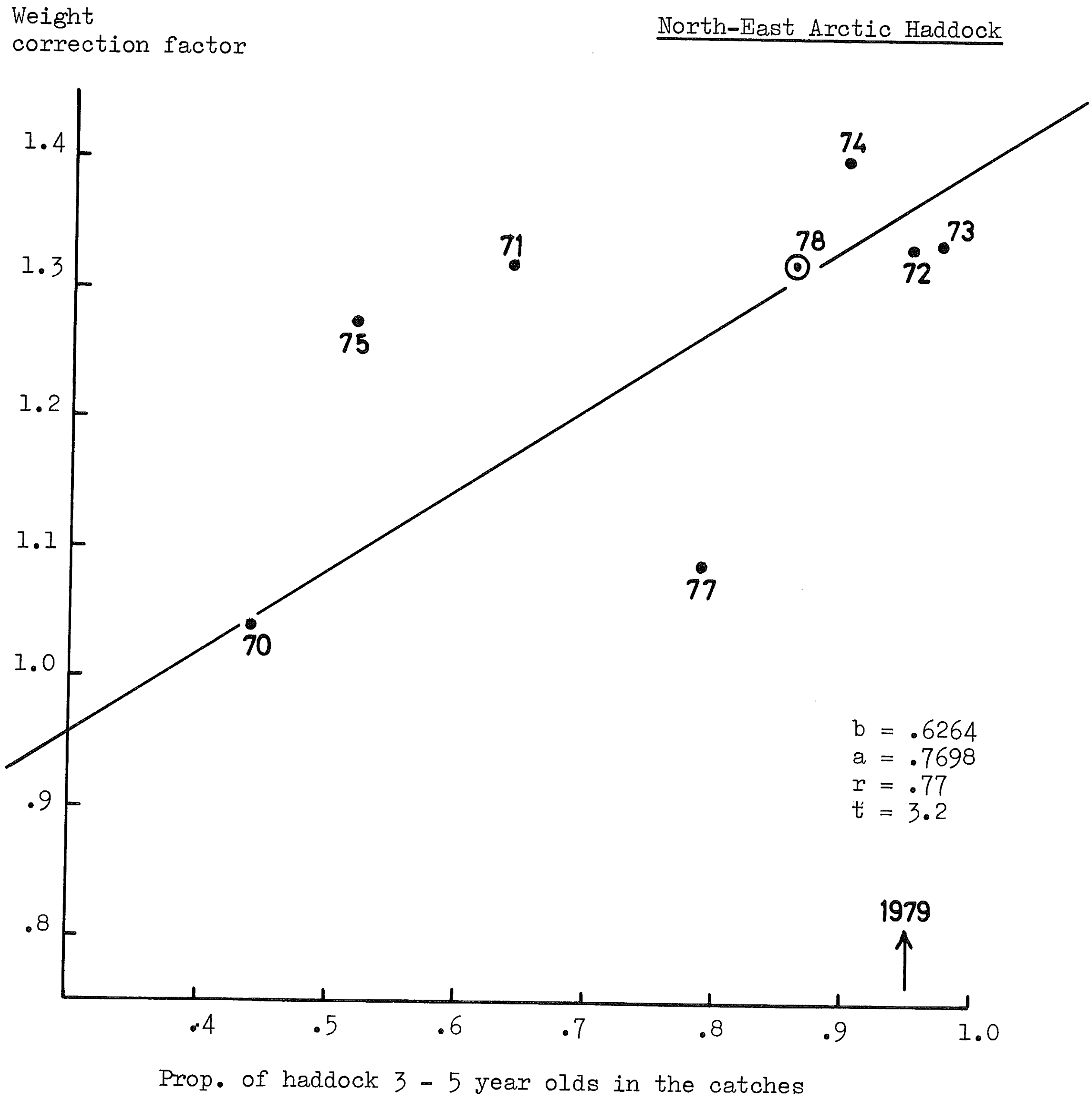
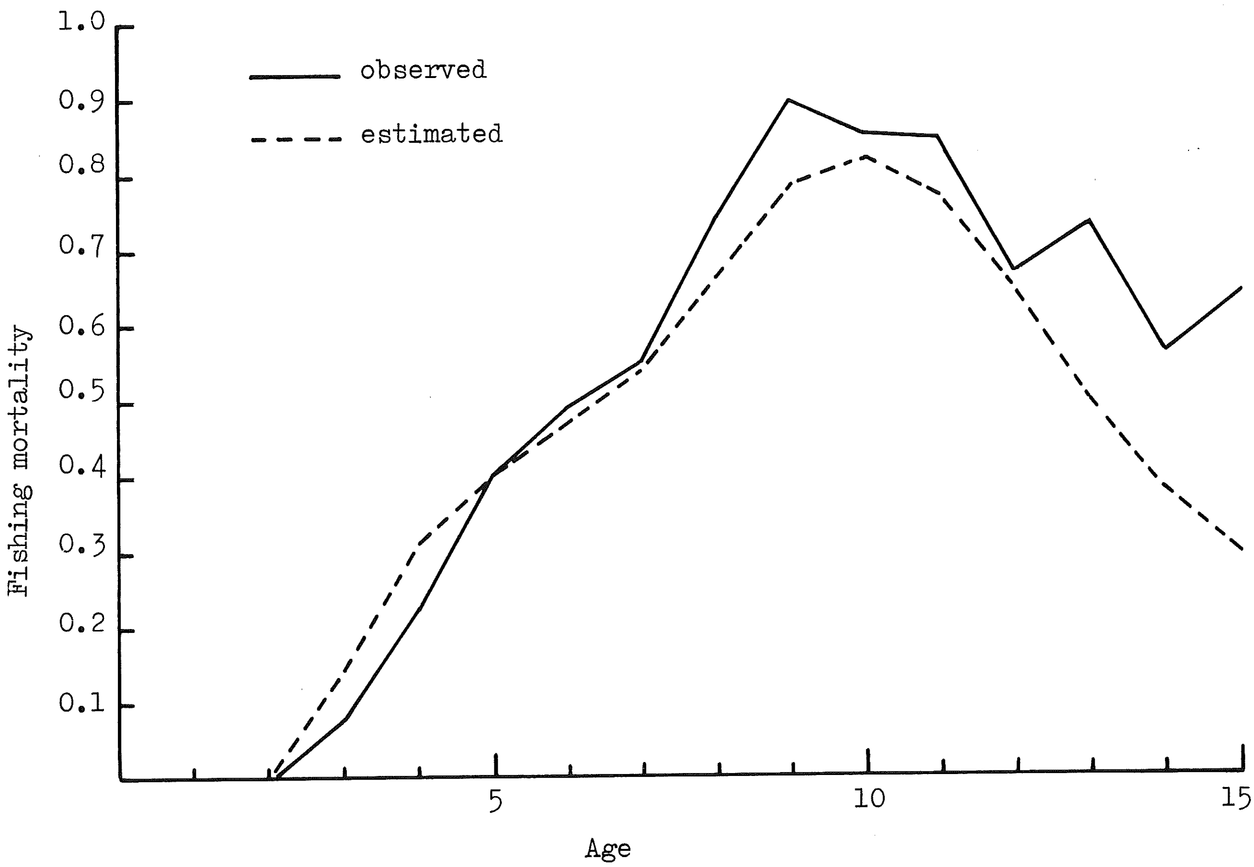


Fig. 21 Fishing mortalities on cod 1967-1977. Estimated fishing mortalities are generated by the effective mesh sizes as estimated from the length distribution of cod 1967-1977.



<u>Fig. 22</u> Total biomass of cod and haddock 1950-1978, and total international effort in 1946-1978 on cod and haddock (UK units).

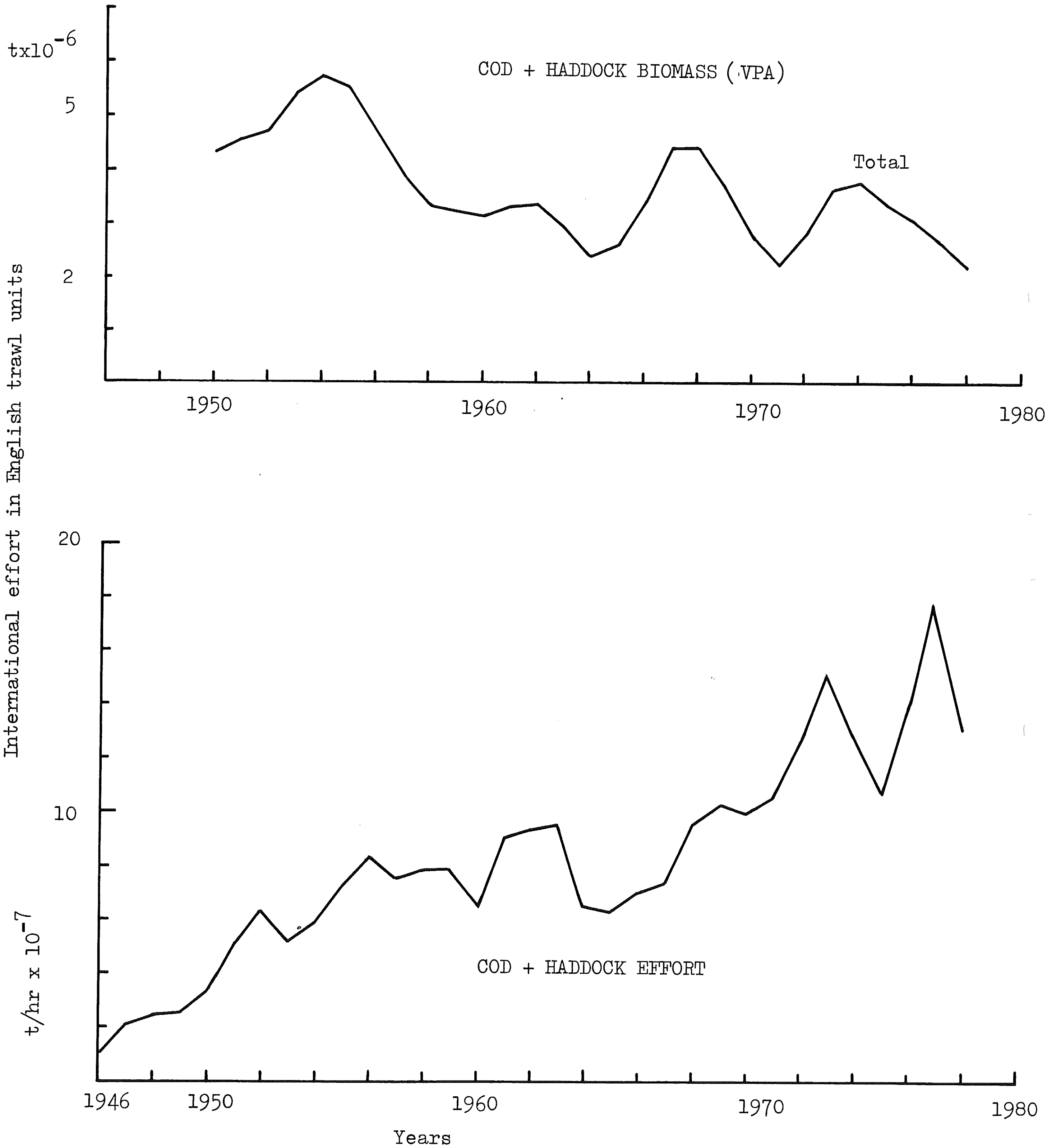


Fig. 23 Total international effort on cod and haddock split on Sub-area I, and Divisions IIa and IIb.
The spawning stock biomass of the cod and haddock is drawn together with the effort in Division IIa.

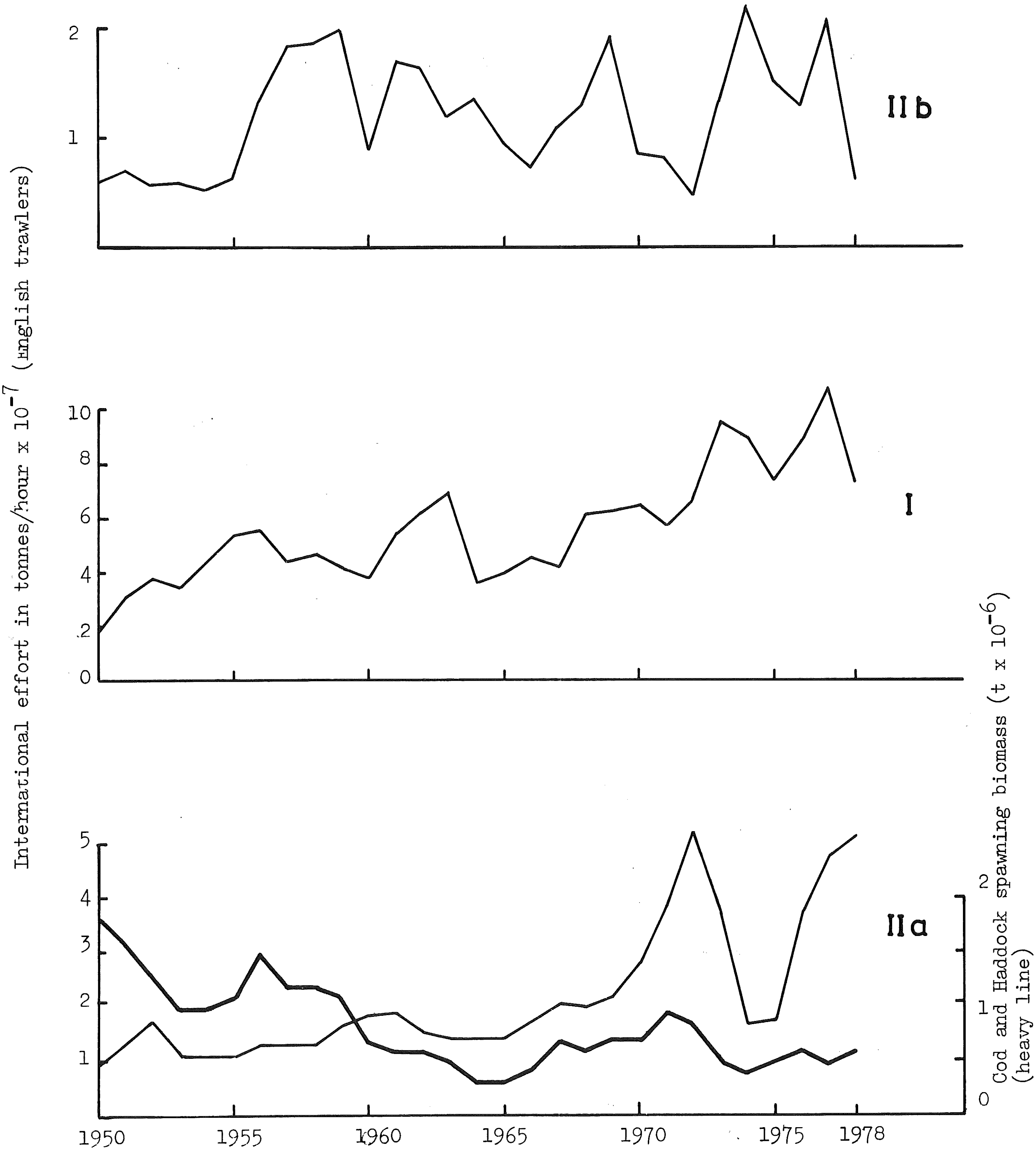


Fig. 24 Cod and Haddock. Catch per unit effort versus the biomass of recruited fish (4 years and older).

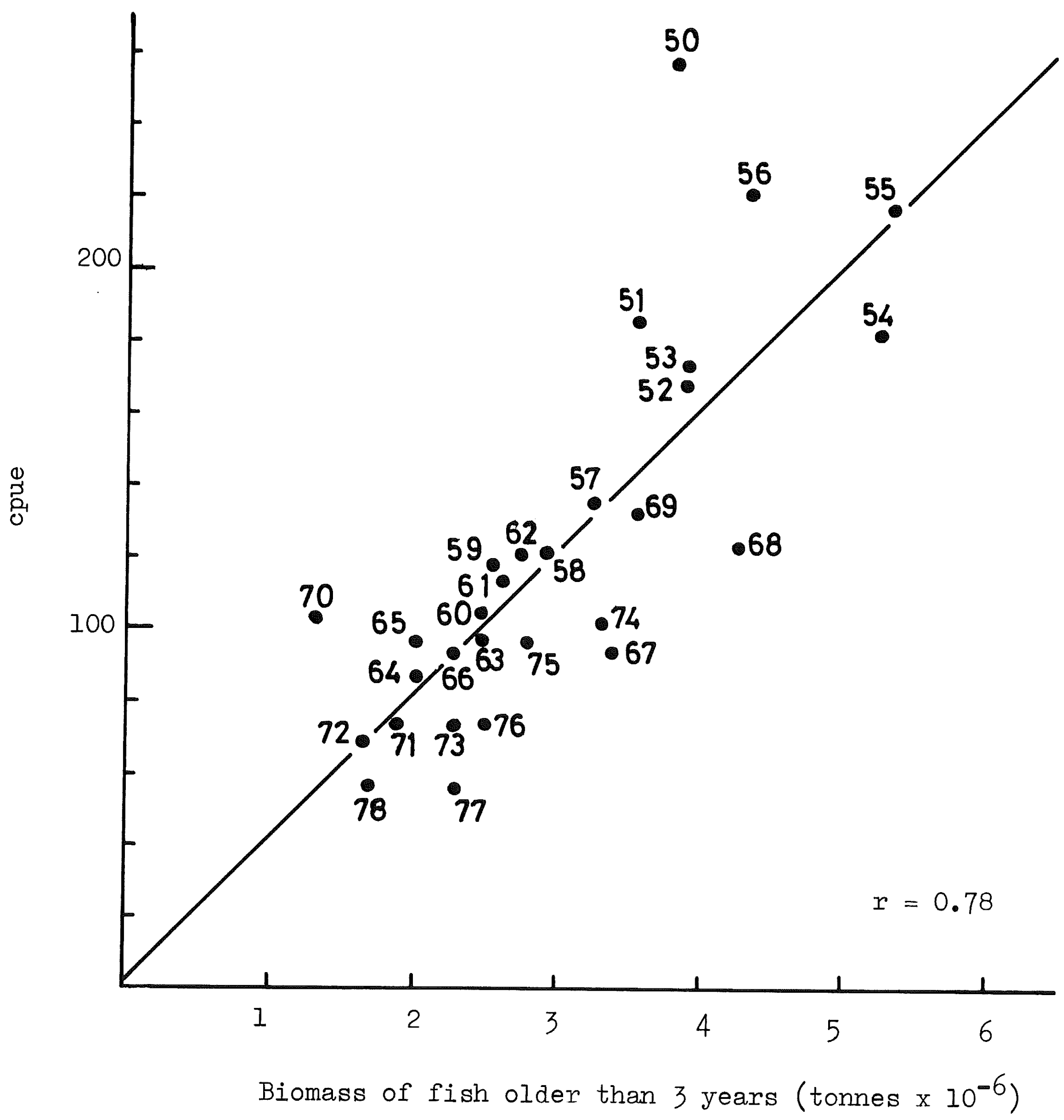
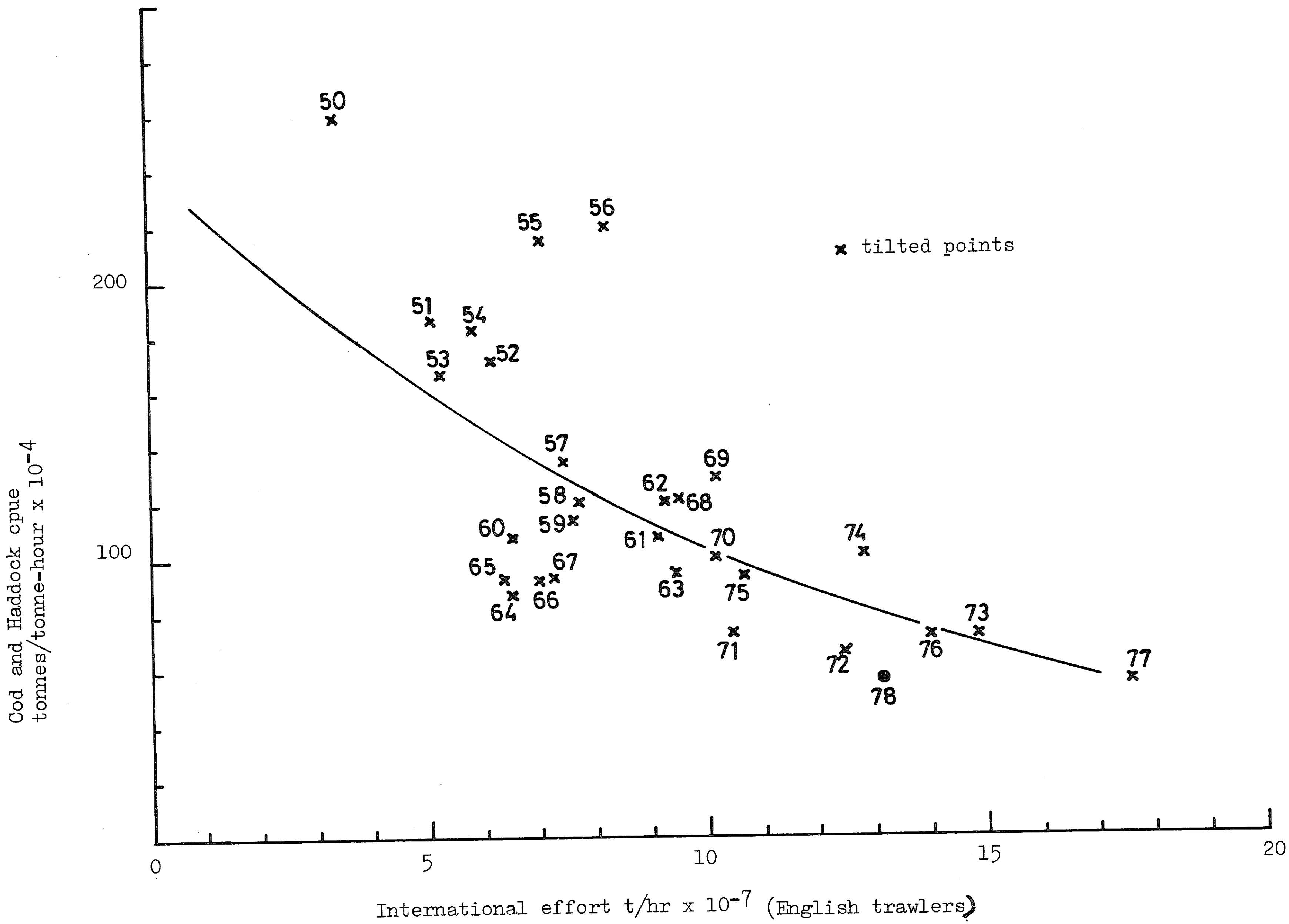


Fig. 25 Cod and Haddock. Catch per unit effort versus total international effort.



APPENDIX I

DET KONGELIGE FISKERIDEPARTEMENT

POSTBOKS 8118 DEP, OSLO 1, TELEFON (02) 56 36 80

International Council for the Exploration of the Sea
Mr. H. Tambs-Lyche,
Secretary General,
Charlottenlund Slot,
2920 Charlottenlund,
DENMARK.

Deres ref.	Vår ref. (bes oppgitt ved svar)	Dato
	utg./78 GU/SG	December 1978

Dear Sirs,

Reference is made to the last report of the Advisory Committee on Fisheries Management Section A.1.1 Arctic cod. On advice from The Institute for Marine Research, The Ministry of Fisheries would make some observations regarding this part of the report which we would like to put before the Council.

The stock of Arctic cod has been TAC-regulated since 1975 with the aim, as a first objective, of rebuilding the spawning stock to the 1970-72 level (about 600 000 tons) by 1977/78 and further to 800 000 - 1 000 000 tons in 1978/79 and reducing the fishing mortality towards the F_{max}-level. The last reports from ICES Advisory Committee on Fisheries Management and the North-East Arctic Fisheries Working Group show that the spawning stock in 1979 is expected to be only 240 000 tons. The reports also show that in 1978 the fishing mortality was about three times the F_{max}-level.

Although nominal catches have slightly exceeded the advised TAC's for the years 1975-1978, this cannot explain the complete failure in reaching the aims which were set for the management of this stock. Nor can the management failure be ascribed to recruitment failure in the stock since the build-up was expected to derive from survival of fish of year classes whose high abundance had already been well established.

The result of the last assessment has come as such a shock that there are now serious doubts that a management policy consisting merely in continued and strongly reduced TAC's as recommended in the last report from ICES, will improve the situation. ICES is therefore asked to try to answer the following questions:

1. What has caused the major difficulties in the assessment of the Arctic cod stock? In particular: How is the data base for calculation of catch in number by age groups in the various areas and fisheries? To what extent have wrong assumptions about exploitation pattern invalidated past assessments and particularly past prognoses? What kind of data should be collected in order to improve the precision of the assessments?

2. What is the effective mesh size in use in the various trawl fisheries (as estimated from reported age and length compositions)?

3. What gains in yield per recruit can be expected if the exploitation pattern is changed towards a more optimum pattern, and fishing mortality is reduced to F_{max} or $F_{0.1}$? What would be the long term effect on the size of the spawning stock. Within what range should the spawning stock be kept, i.e. what is considered to be the optimal range? How could an improved exploitation pattern be achieved?

The ICES advice on a long-term scheme for rebuilding the stock given in the last report of the Advisory Committee on Fisheries Management is based on a maintenance of the present exploitation pattern. We find it difficult to accept this scheme in its present form since the Council in previous submissions of advice on the management of this stock has strongly recommended a change of the existing exploitation pattern. (Cfr. Liaison Committee Reports 1971, 1972, 1973, 1974, 1975, 1976). When advising on a TAC for 1980 and designing a new scheme for rebuilding the stock, ICES is asked to do this for exploitation patterns which are considered more optimal.

Yours faithfully,

G.H. Gundersen
Director General

Trond S. Paulsen