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REPORT OF THE NORTH-EAST ARCTIC FISHERIES WORKING GROUP

Charlottenlund, 27 September - 1 October 1978

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REPORT OF THE NORTH-EAST ARCTIC FISHERIES WORKING GROUP

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2. TERMS OF REFERENCE

The Advisory Committee on Fishery Management decided at its meeting in May 1978 that the North-East Arctic Fisheries Working Group should meet in September 1978 to:

- (a) re-assess the North-East Arctic cod stock and the TAC for 1979 in the light of the data then available from the 1978 fisheries,
- (b) re-calculate a TAC for North-East Arctic haddock in 1979 which takes into account the results of the re-assessment for cod.

3. THE COD

3.1 Status of the Fisheries (Tables 1-5)

All countries fishing in the North-East Arctic have not yet given their final figures for total landings in 1977. However these figures are only missing for 3 countries which are expected to take only a small fraction of the total landing. The total nominal catch in 1977 is updated for those countries which have given their final figures. As a result the total landing in 1977 is 5 930 tons higher than the preliminary figure, making up 890 389 tons. This is 40 389 tons higher than the total TAC of 850 000 tons, Murman cod included.

Compared with 1976, the total landing in Sub-area I and Division IIa increased by 1 845 tons and 21 423 tons respectively. In Division IIb it decreased by 342 tons.

Total international effort (Table 3) increased from 1976 to 1977 in Sub-area I by 16% in United Kingdom units and 33% in USSR units. In Division IIb, the total international effort increased by 44% in United Kingdom and 17% in USSR units. However, the total international effort in USSR units may be biased, because cod was mainly by-catch in the redfish fishery in Division IIb. In Division IIa, the total international effort decreased by 13% in United Kingdom and 16% in Norwegian gillnet units.

Thus, the 1977 catch in Sub-area I and Division IIb was achieved by increased fishing effort. The higher catch in 1977 from Division IIa was caused by a higher stock abundance of mature cod reflected by the increased catch per unit effort (Table 4).

The TAC for 1978 was agreed at 850 000 tons. Table 5 gives the catches reported for the first six months of 1978. Since then a further 70 000 tons have been reported taken up to the end of August.

From projection of these figures and the catch rates reported to the Norwegian authorities, it has been calculated that the total catch in 1978 will reach 890 000 tons. This figure has been used in the catch prediction.

### 3.2 Abundance Indices - cpue

Table 6 gives the catches per unit effort by Norwegian longliners, gillnetters and handliners in the Lofoten fishery for 1960-78 and by United Kingdom trawlers fishing in IIa and in all areas for 1960-77 combined.

The percentage of the total yearly catch in Lofoten taken by gillnetters has fluctuated in the period 1960-77 between 43.3% and 69.7%, on the average 54.6%. The longliners have caught 24.0% on the average in this period (range 17.0-40.3%). The figure for handline is 9.6% with a range of 6.1% to 14.7%. The rest of the catch (on average 6.7%) has been taken by Danish seine (6.3%) and purse seine (0.4%).

In the 1978 Lofoten fishery the catch was 92 000 tons. In relation to the exerted effort this seems to be low, if the spawning stock was 699 000 tons as estimated by the Working Group (Table 18, C.M.1978/G:5).

Assuming the catch of one operation ( $\Delta C$ ) is proportional to the stock density

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

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

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

Catchability coefficients,  $q'$ , have been calculated from the data in Tables 6 and 6A, and the stock biomasses from Table 18 (C.M.1978/G:5).

Figures 1, 2, 3, and 4 show the trend of  $q'$  with time in the Lofoten data, while Figure 5 shows the trend for the United Kingdom trawl data both in the Norway coast fishery (Division IIa) and the United Kingdom fishery in the whole area for the adult part of the catch  $\geq 8$  years. The solid lines refer to the value calculated as described above. The broken lines show the revised values following changes made to input  $F$  values made later in this report.

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 gillnets, 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. Again for long liners changes in length of line or number of hooks or further refinements to the fishing gear are unaccounted. The hand-line remains fairly constant from 1964-74. This gear has during recent years been mechanized, which can account for the increased  $q'$  in 1975 and 1976.

Figure 4 gives the unweighted average for the three gears. In view of what is known of the improvements in fishing techniques it is surprising that all three gears feature an apparent sudden drop in  $q'$  in 1977 and 1978. The question which arises is whether the spawning stock biomasses calculated for 1977 and 1978 are realistic. Both are largely dependent on the assumption regarding input  $F$  in 1977 on 7 years and older fishes.

The trend in  $q'$  for United Kingdom vessels is reversed (Figure 5). Apart from the Norway coast fishery considerable quantities of adult cod are taken in the northern areas. Both graphs follow the same trend and fluctuations. Some variation probably arises from the likelihood that the area fished is not a constant part of the stock distribution. In addition a variety of regulations have been introduced which have affected the areas of operation of the trawlers. However, comparison of Figures 5 and 6 shows that the peaks in  $q'$  follow one another in sequence suggesting that they represent concentration on abundant year classes.

Since 1974 it is seen that  $q'$  has apparently stabilized. Over this period various quota agreements have been observed by United Kingdom vessels and those have led to a more managed fishery in which the areas fished have become less variable. Over this period it is thought that catch per unit effort is a reasonable index of abundance and that the changes in international effort calculated in United Kingdom units are real. As in Figures 1-4 the broken line shows the effect of the changes in input  $F$  made in this report.

Figure 6 shows the changes in  $q'$  for United Kingdom trawlers in Sub-area I. The catch per unit effort refer only to fish of 4-7 years, which form the major part of the catches in this area. In contrast to Figure 5, the values are less variable and with the changes made to the input  $F$  values it is seen that the newly derived values of  $q'$  fit with the general declining trend since 1960.

From Sub-area I catch per unit effort data are also available for Norwegian fresh fish trawlers fishing in the first quarter of the years 1972-78. At this time of the year the mature stock is almost absent from the area and the data can be interpreted in relation to the biomass of 4-7 year olds. These cpue data have been plotted in Figure 7 against biomasses estimated in C.M.1978/G:5. A line has been drawn through the origin and the means for 1973-76. If this line represented the real relation between cpue and biomass, the values for 1977 and 1978 would be too high. Figure 7b shows the adjusted positions of the prints following the changes made to input  $F$  later discussed. The cpue for 1972 refers to a year when the fishery by this group of trawlers had not been completely established.

The data from the United Kingdom trawl fishery have been similarly plotted in Figure 8a and 8b. The line has been drawn through the origin and the means of the cpue and biomasses for 1971-75. From comparisons of annual catches per unit effort with those for the first six months of 1975-77, a projected level of cpue for 1978 is also shown. Figure 8b shows the effects of using the new biomasses derived in this report.

### 3.3 Fishing Mortality

The mean fishing mortalities taken from C.M.1978/G:5 were calculated for 4-7 years old and 8-12 years old. These have been plotted on the estimate of total international effort in United Kingdom units from Table 3. There is no significant correlation for the older fish but Figure 9a shows the plot for the 4-7 years old. The line has again been fitted through the origin and the mean F and effort for 1967-74. The value of F for 1977 deviates far from this point. Figure 9b shows the same plot after re-evaluation of the earlier Working Group's distribution of fishing mortality with age in 1977.

Assuming that  $q'$  is constant over the recent period 1974-77, the total instantaneous mortalities may be calculated from the United Kingdom catch per unit effort data for the young part of the stock and for the spawning stock. The data are given in Table 7 and the mean total mortalities derived were:

<u>Ages</u>	<u>Z</u>	<u>F</u>
4-7	0.67	0.47
8 and older	1.05	0.85

### 3.4 Virtual Population Analysis (VPA)

The preliminary age compositions used for the 1977 landings (C.M.1978/G:5) were adjusted for the new catch figures given in Table 1 and are given in Table 8.

The assessment of stock size has been made previously for both values of natural mortality of 0.2 and 0.3. It was agreed to limit this assessment to the use of  $M = 0.2$ .

As has been shown earlier there are some inconsistencies in the biomasses and mortalities used as input values for 1977. The international effort indicates an increase in F in 1977 over 1976 of some 18% while the input F chosen in March was 0.65 compared with the 1976 value of 0.73 which itself is dependent on the input F.

The Working Group therefore re-examined the assumptions made in the F at age array used to commence the VPA for 1977.

#### a) Fishing mortalities on 8-15 years old

There is no reason to suppose that  $F_{8-12}$  in 1977 should not be of the same magnitude as those in 1975 and 1976. Rather than use a constant F, on all ages above 8, as in March the Working Group decided to use the average fishing pattern in 1970-76, derived from some preliminary VPA runs. The relative distribution of F by age is given below ( $F_{8-12} = 1.00$ ):

<u>Age</u>	<u>Proportion</u>
3	.13
4	.29
5	.51
6	.62
7	.68
8	.95
9	1.10
10	1.08
11	1.05
12	.82
13	.87
14	.72
15	.75

The mean Fs on 8 to 12 year old fish in 1975 derived in these preliminary runs were 0.87 and 0.84. 0.85 was chosen as input F. To account for the declining trend in F on the oldest age groups, the input value of  $F_{15}$  for the years 1950-76 was set equal to ( $F_{13} - 0.1$ ), where  $F_{13}$  was taken from the last preliminary run.

b) Fishing mortalities on 6 and 7 years old cod

The fishing mortalities of the age groups 3-8 have been proportioned to the mean fishing mortality on 8-12 years old calculated from C.M.1978/G:5, Table 11.

These relative fishing mortalities are plotted in Figures 10a, b and c (solid lines). The recruitment at age 3 is also shown in Fig. 10a for comparison (data from Table 12 in C.M.1978/G:5). These figures show how the fishing pattern is continuously changing from year to year as a result of concentrated fishing on the rich year classes. The broken lines in Fig. 10 are based on the new assessment and prognosis.

Increased fishing mortalities on the year classes 1957 and 1958 (and to some extent the 1956 year class) relative to the adjacent year classes can be detected up to age group 7. The same "wave" can be seen generated on the year classes 1963 and 1964.

Concentrated fishing can also be detected on the rich 1970-year class and partly on the 1969-year class. However, for these two latter year classes the "wave" on age group (5), 6, 7 is largely dependent on the input Fs for 1977.

The 1970-year class at age 3 is nearly twice as large as the 1969-year class (Fig. 10a). The Working Group therefore considered it to be more consistent with the development of the fishing pattern in the past to increase the relative F on the 7 years old in 1977 to the same level or larger than the relative F of the 7 years old in 1976. A relative  $F_{7,1977} = 0.9$  was chosen.

The relative F on the 6 years old in 1977 (1971-year class) are likely to be somewhat lower than the F on the same age group in 1976 (1970-year class) for the same reasons as above. However, the relative  $F_{6,1977} = 0.51$  given in C.M.1978/G:5 represents a rather large drop from  $F_{6,1975}$ . A relative  $F_{6,1977} = 0.70$  would be more appropriate since the 1971-year class is an average one, and the preceeding 1970-year class is rich. If the fishing has been partly concentrated on the 1970-year class in 1977, this would probably also generate a relatively high F on the 1971-year class. A relative  $F_6$  of 0.80 was adopted.

c) Fishing mortality on 3, 4, and 5 years old

For the 1955-74 year classes correlations have been made between the new VPA estimates and United Kingdom cpue from Sub-area I (Figures 11, 12 and 13). For the 1969-74 year classes the VPA estimates made in March (C.M.1978/G:5) are also shown.

Figure 11 shows the correlation ( $r = 0.89$ ) at age 5 of the 1955-68 year classes. Two estimates are shown on the 1969-72 year classes derived from the two VPA runs. Figure 12 shows the correlations of the 1957-70 year classes ( $r = 0.93$ ) at 4 years of age. In view of the good agreement shown in these regressions they have been used to set the fishing mortalities for the age groups 4 and 5 in 1977. Stock indices as calculated from the regressions would require fishing mortalities of  $F_4 = 0.30$  and  $F_5 = 0.58$  as opposed to the previous values assumed of  $F_4 = 0.17$  and  $F_5 = 0.26$  (C.M.1978/G:5). These latter generate estimates of stock numbers of the 1972 and 1973 year classes far above the expected levels from Figures 11, 12 and 13.

It has been shown earlier that the relative  $F_3$  for 1970-76 was 0.13. Applying this value to the agreed input  $F_{8-12}$  of 0.85 gives an  $F_{77}$  of 0.11.

The acceptability of this value has been tested by examining the stock size of the 1974 year class derived from the catch in 1977 (Table 8). The estimate of the 1974 year class at age 3 is 419 million fish which is in good agreement with the expected value from Figure 13.

Abundance estimates of prerecruiting year classes are available from the international 0-group survey and the USSR young fish survey (Table 9). Figure 14 shows the correlation between VPA recruit estimates for the year classes virtually not affected by input  $F$  (1957-70) and USSR young fish indices. It is seen that the 1974 year class abundance in the USSR survey also gives a stock size of about  $410 \times 10^6$ .

The input  $F$  values in this new assessment are compared below with those from the March assessment.

Input F 1977

Age	New	Old	Age	New	Old
1	.01	.00	8	.81	.65
2	.01	.01	9	.94	.65
3	.11	.07	10	.92	.65
4	.30	.17	11	.83	.65
5	.58	.26	12	.70	.65
6	.68	.33	13	.74	.65
7	.77	.39	14	.61	.65
			15+	.64	.65

The calculated estimates of fishing mortalities for earlier years resulting from VPA are given in Table 10, and stock size estimates in Table 11. Estimates of spawning stock biomass and year class strength are given in Table 12.

The relative fishing mortalities for the years 1972-77 generated by the chosen  $F$ s in 1977 have been drawn in Figure 10 (broken lines), which shows that the relative  $F$  soon approaches the one estimated from in C.M.1978/G:5.



Furthermore, considering the curves generated by the last assessment, the increased relative F on 4 year olds in 1976 and 1977 compared to 1975 corresponds to the strength of the year classes 1971-73 at age 3 (Figure 10a).

The larger relative F on the 5 year olds in 1977 compared to 1976 also corresponds to a larger 1972 year class compared to the 1971 year class at age 3.

### 3.5 Catch Prediction

#### a) Relative fishing mortalities in 1978 and 1979

The relative fishing mortalities in Figure 10 were used to select the exploitation pattern in 1978 and 1979. The Working Group took into account the rich 1975 year class. Data presented to the Working Group on the composition of the United Kingdom catches in the first half of 1978 indicated that some extra effort might be directed on the 1975 year class and therefore a relative F of 0.20 (0.13 in 1970-76) on the 3 year olds in 1978 was adopted. Expecting concentrated fishing on this year class at age 4 in 1979 the relative F for this age group in 1979 was set at 0.50 (0.30 in 1970-76).

The 1973 year class is also above average and for that reason the relative F on the 5 year olds in 1978 was set equal to 0.60 (0.52 in 1970-76). For the other age groups the average relative Fs in 1970-76 were adopted.

For the period 1980-85 the average fishing pattern for 1970-76 was used.

The parameters used in the catch prediction are given in Table 13.

#### b) Recruitment

Using the new VPA values a revised correlation was made with the USSR young fish survey data (Figure 15).

The 0-group survey indicated that the 1973 year class was more abundant than the outstanding 1970 year class. In the USSR young fish survey it was somewhat lower. The most recent assessment indicates that it might be about 46% less. Abundance indices from both prerecruit surveys indicate that the 1974 and the 1976 year classes are poor. In the 0-group survey the 1975 year class was rich which is also confirmed by the USSR young fish survey. The 1977 year class appears to be average in the 0-group survey, while the USSR young fish survey indicates a poor one. Abundance index from the 0-group survey indicate that the 1978 year class is below average. Absolute strength of the year-classes 1975 used in the catch prediction is estimated from the regression of year class indices at 3 years of age and the absolute year class strength at 3 years taken from the VPA (Fig. 15). The strength of the 1976 and 1977 year classes (1 and 2 years old at the time of the survey) cannot be estimated directly from the regression in Figure 15. Since, however, the preliminary results from this survey are indicating that both year classes are poor ones, the Working Group decided to apply a survey index of 1 as a conservative approach.

#### c) Definition of $F_{max}$ (yield per recruit)

The yield per recruit curve (Figure 16) was calculated for cod using the average exploitation pattern for the period 1970-76 and weight at age data in Table 13. This curve gives  $F_{max} = 0.29$  ( $M = 0.20$ ) compared with  $F_{max} = 0.30$  with the exploitation pattern used in Doc. C.M.1978/G:5.

### 3.6 Management Options

In order to provide advice on management for the North-East Arctic cod fishery nine management options have been developed by the Working Group. In discussing the virtue of the different management options the Working

Group was guided by the following considerations:

- i) The rate of recovery of the spawning stock biomass with a view to maximizing the contribution to the spawning stock of the rich 1973 and 1975 year classes and taking into consideration the weakness of the 1976 and 1977 year classes recruiting to the spawning stock in 1984 and 1985.
- ii) Reduction in fishing mortality from the present high level towards  $F_{max}$ .
- iii) Maximizing the total yield from the stock for the period 1979-81 for which indications of year class strength are available.
- iv) Minimizing disruption of fishing activities.

The options are given in Table 14. It should be noted that the catch figures in the years 1982-85 are based on average recruitment and are therefore of an indicative nature.

Option 1: Fishing mortality stabilized at the present(1978) level

Under this option the disruption of fishing activities will be minimized, but even then the catches are expected to decrease continuously to about 600 000 t in 1982. The total for the three years would be the highest of all the options.

The spawning stock biomass will decline steadily. It will remain below the already low level of 1977, even in those years when the good year classes are recruiting to the spawning stock. Under these conditions the probability of recruitment failure (due to low spawning stock size) is very high. Option 1 can therefore not be seriously considered as a method of management, but it may serve as illustration of the consequences of maintaining the present high rate of exploitation of the stock.

Option 2: Fishing at  $F_{max}$  ( $F = 0.29$ )

Of the options presented this gives the highest rate of recovery of the spawning stock. Already by 1980 the spawning stock biomass exceeds the 1978 level and in 1983, the level of 1 500 000 tons will be reached due to the 1975 year class. However, severe limitation of the fishery would be required with the catches in 1979 and 1980 being reduced below the minimum level recorded in this fishery (except wartime). The Working Group felt that such a disruption of the fishery should be avoided even if the recovery of the spawning stock is to be delayed.

Option 3: Stepwise reduction of fishing mortality to reach  $F_{max}$  in 1981

Under this option the spawning stock biomass will increase continuously to over 1 million tons by 1983. The moderate reduction of catch in 1979, however, is to be followed by further reductions to a level in 1981 comparable to that of the initial period in Option 2. Consequently, the total yield over the years 1979-81 is very low.

Other options

Of the other options 5 and 7 are rejected as they require too severe immediate cut backs in 1979. Both these options produce increased spawning stock biomasses, reaching over 800 000 tons in 1985.

Option 6 gives an even higher biomass in 1985 but requires also a large cut-back in catch in 1979. This option allows a stabilization of catch at 500 000 tons annually.

In both Options 4 and 8 increasing spawning stock biomasses are obtained, reaching levels similar to those in 1970 and 1971. The fishing mortalities in 1985 are still about 50% higher than  $F_{max}$ .

By 1985 it would be preferable if the fishing mortalities were approaching the level of  $F_{max}$ . This is achieved in Options 3, 6, 7, and 9. Option 3 has already been rejected on the grounds of loss of total yield from the fishery (sum of catches from 1979 to 1981 being only 1 396 000 t), and Options 6 and 7 require too high an immediate loss in 1979.

Option 9 appears to offer the best solution; it is achieved with a reduction in fishing mortality of only 35% in 1979 giving a catch of 600 000 tons, and allows a stable catch of 550 000 t for the remaining period. It has a further advantage in that the total yield of 1 700 000 t is 80% of that achievable under the practically unlimited fishing in Option 1, where the spawning stock biomass is eventually reduced to dangerously low levels. Under Option 9 the spawning stock in 1985 reaches a level not seen since 1959 and 1960 and corresponds with the level previously recommended by the Working Group as one of its aims. This level of about 800 000 t (calculated on the basis of  $M = 0.2$ ) is equivalent to 1 million tons calculated using  $M = 0.3$ .

The Working Group recommends that the TAC for North-East Arctic cod for 1979 should be 600 000 tons (including Murman cod).

#### 4. NORTH-EAST ARCTIC HADDOCK

##### 4.1 The Status of the Fisheries (Tables 15-16)

The preliminary figures of nominal catch in 1977 were updated for those countries which had given final figures. Further corrections are only expected from 2 or 3 countries which have only taken small quantities in the past. The new estimate of nominal catch in 1977 was 109 699 tons, compared with the preliminary one of 101 977 tons. This was close to the total allowable catch of 110 000 tons for 1977. Table 17 gives the reported catch up to the end of June 1978; since that time a further 10 000 tons have been reported. The 1978 total catch has been estimated at 125 000 tons.

Data on catch per unit effort (Table 18) show a decrease in all areas from 1974, and the relative decrease is the greatest from 1976 to 1977. This decrease was mainly caused by the declining abundance of the rich 1969 year class and the lower abundance of subsequent year classes.

##### 4.2 Recruitment (Table 19)

The most recent assessment of recruitment indicates that the 1973 year class is a poor one and that the 1974 year class is somewhat above average. Both pre-recruit surveys indicate that the 1975 year class is an abundant one. It may be close to the strength of the 1969 year class which was an outstanding one. The 1976 and 1977 year classes appeared to be rich in the 0-group survey, but this indication has not been confirmed by the USSR young fish survey. The 1978 year class has been recorded as poor in the 0-group survey. Absolute strength of the 1975-77 year classes used in the catch prediction is taken from the North-

East Arctic Fisheries Working Group from March 1978 (C.M.1978/G:5).

#### 4.3 Virtual Population Analysis (VPA)

The preliminary age compositions used for the 1977 landings in Doc. C.M.1978/G:5 were adjusted for the revised catch figures (Table 15). The new catch in number data are given in Table 20.

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

The exploitation pattern used for 1977 in Doc. C.M.1978/G:5 was based on the average for the years 1970-74. This was maintained unchanged for the VPA input fishing mortality values for 1977 (Table 21). Fishing mortality  $F = 0.55$  for age groups subject to maximum exploitation was also taken unchanged.

Calculated estimates of  $F$  in 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.

#### 4.4 Calculation of Total Allowable Catch

Data used to calculate catches and spawning stock biomass for the years 1979 and 1981 are given in Table 24.

At the Working Group meeting in March 1978 these calculations were based on the assumption that the TAC of 150 000 tons would be taken in 1978. Since the catch in 1978 is estimated as 125 000 tons the fishing mortality on the age group subject to maximum exploitation in 1978 is reduced to 0.41 from the level of 0.51 used in March. Consequently, the size of the stock at the beginning of 1979 has increased.

The exploitation pattern for 1978 and 1980 has not been changed from that in the March assessment. For the year 1979, however, the relative  $F$ s for age groups 4 and 5 have been changed expecting the fishery in 1979 to concentrate on the 4 years old fish of the very strong 1975 year class. In doing so the Working Group followed the same approach as applied with cod assessment.

The management objective previously adopted was to reduce  $F$  on the age group subject to maximum exploitation towards  $F_{max} = 0.3$ . Following this concept the Working Group in March recommended a TAC for 1979 based on  $F = 0.45$ , a reduction in  $F$  of 18% compared with 1977. In the present assessment  $F$  for 1978 is estimated to be 0.41, representing a reduction in  $F$  of 25% from the previous year. The Working Group decided to maintain this level into 1979 as the basis for its advice on TAC. This would be expected to yield a catch of 206 000 tons of haddock as indicated in the table below.

	SPAWNING STOCK BIOMASS (1000 tons)	F	CATCH (1000 tons)
1977	200	0.55	110
1978	154	0.41	125
1979	159	0.40	206
1980	253	0.40	203
1981	506		

This TAC will leave a spawning stock biomass of 253 000 tons at the beginning of 1980.

Maintaining this level of catch and F into 1980 would result in a further increase in spawning stock biomass to 500 000 t. This is in part due to the contribution of the spawning stock of the very strong 1975 year class. This level of spawning stock biomass exceeds that of 1956, the highest on past record.

As already pointed out in earlier reports the fishery for haddock in the North-East Arctic cannot be managed as a single species fisheries since considerable amounts of haddock are caught as bycatch in the fishery directed to cod. The proportion of haddock by-catch in the cod fishery is variable depending on the relative abundance of haddock in the area. The situation in 1979 is expected to be comparable to that in 1973 when a very strong year class at age 4 was subject to heavy exploitation. In 1973 the proportion of haddock in the cod fishery of USSR and Federal Republic of Germany vessels was of the order of 30%. Assuming the same bycatch rate in 1979, this would lead to the conclusion that a TAC for cod of 600 000 tons in 1979 would produce a bycatch of 180 000 tons of haddock. Under such circumstances a TAC of 206 000 tons for haddock would cover the expected bycatch and would also allow a limited directed fishery for haddock without endangering the stock.

The Working Group recommends that the TAC for North-East Arctic Haddock for 1979 should be 206 000 tons.

5.

REFERENCE

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

Table 1. COD. Total nominal catch (metric tons)  
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*	528 530	103 191	258 668	890 389

\* Provisional figures.

Table 2. COD. Nominal catch (metric tons, whole weight) by countries (landings of Norwegian coastal cod not included). (Sub-area I and Divisions IIa and IIb combined.)

(Data provided by Working Group members)

Year	Faroe Islands	France	German Dem.Rep.	Germany Fed.Rep.	Norway	Poland	United Kingdom	USSR	Others	Total all countries
1960	3 306	22 321		9 472	231 997	20	141 175	213 400	351	622 042
1961	3 934	13 755	3 921	8 129	268 377	-	158 113	325 780	1 212	783 221
1962	3 109	20 482	1 532	6 503	225 615	-	175 020	476 760	245	909 266
1963	-	18 318	129	4 223	205 056	108	129 779	417 964	-	775 577
1964	-	8 634	297	3 202	149 878	-	94 549	180 550	585	437 695
1965	-	526	91	3 670	197 085	-	89 962	152 780	816	444 930
1966	-	2 967	228	4 284	203 792	-	103 012	169 300	121	483 704
1967	-	664	45	3 632	218 910	-	87 008	262 340	6	572 605
1968	-	-	255	1 073	255 611	-	140 387	676 758	-	1 074 084
1969	29 374	-	5 907	5 343	305 241	7 856	231 066	612 215	133	1 197 226
1970	26 265	44 245	12 413	9 451	377 606	5 153	181 481	276 632	-	933 246
1971	5 877	34 772	4 998	9 726	407 044	1 512	80 102	144 802	215	689 048
1972	1 393	8 915	1 300	3 405	394 181	892	58 382	96 653	166	565 287
1973	1 916	17 028	4 684	16 751	285 184	843	78 808	387 196	276	792 686
1974	5 717	46 028	4 860	78 507	287 276	9 898	90 894	540 801 <sup>1)</sup>	38 453	1 102 434
1975	11 309	28 734	9 981	30 037	277 099	7 435	101 834	343 580 <sup>1)</sup>	19 368	829 377
1976	11 511	20 941	8 946	24 369	344 502	6 986	89 061	343 057 <sup>1)</sup>	18 090	867 463
1977*	9 167	15 414	3 463	12 763	382 407	1 084	86 781	369 876 <sup>1)</sup>	9 434	890 389

\* 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 inter-national effort		National effort		Total inter-national effort		National effort		Total inter-national effort	
	U.K. <sup>1)</sup>	USSR <sup>2)</sup>	U.K. units	USSR units	U.K.	USSR	U.K. units	USSR units	U.K.	Norway <sup>3)</sup>	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	1016	106	46	31	184	41	39	6 583	588	52

\* Provisional figures.

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

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

3) Gill net boat week at Lofoten.



Table 4. COD. Catch per unit effort (metric tons, round fresh)  
in Sub-area I and Divisions IIa and IIb.

Year	SUB-AREA I		DIVISION IIb		DIVISION IIa	
	U.K. <sup>1)</sup>	USSR <sup>2)</sup>	U.K.	USSR	U.K.	Norway <sup>3)</sup>
1960	0.075	0.42	0.105	0.31	0.067	3.0
1961	0.079	0.38	0.129	0.44	0.058	3.7
1962	0.092	0.59	0.133	0.74	0.066	4.0
1963	0.085	0.60	0.098	0.55	0.066	3.1
1964	0.058	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	0.047	0.34	0.051	0.18	0.055	11.5
1973	0.057	0.56	0.054	0.57	0.043	6.8
1974	0.079	0.90	0.106	0.77	0.028	3.4
1975	0.077	0.85	0.100	0.43	0.033	3.4
1976	0.060	0.66	0.081	0.30	0.035	3.8
1977	0.052	0.50	0.056	0.25	0.044	5.0

1) United Kingdom data - tons per 100 ton-hours fishing.

2) USSR data - tons per hour fishing.

3) Norwegian data - tons per gill-net boat week at Lofoten.

Table 5

COD  
Nominal Catch (metric tons) up to the end of June 1978\*  
(Sub-Area I, Divisions IIa and IIb combined)

DDR	2 254
Germany, Fed.Rep.of	3 589
Norway	311 905 <sup>1)</sup>
Poland	445
UK	16 399
USSR	187 276 <sup>2)</sup>
Total	521 868

\* preliminary

1) coastal cod included

2) murman cod included

Table 6 COD. Catch per unit effort. Data from the Lofoten Fishery is given in gutted weight with head off. The UK data is given in round fish weight.

Year	Catch (kg) per man per day worked in the Lofoten fishery (Division IIa)			Catch (kg) per 100 ton-hours by UK trawlers (the whole year)	
	Gillnet	Long-Line	Handline	Division IIa	Sub-area I, Divisions IIa and IIb combined
1960	77.8	148.3	56.7	2.14	8.44
1961	101.5	141.1	75.5	1.29	8.73
1962	94.9	134.4	57.8	3.04	10.19
1963	80.8	116.3	56.2	2.91	33.79
1964	104.5	62.1	51.5	2.30	8.61
1965	81.8	78.3	68.4	0.39	7.70
1966	121.8	131.9	72.6	2.23	6.56
1967	107.9	245.4	120.7	1.66	13.83
1968	158.0	184.6	61.5	0.95	6.89
1969	170.6	200.4	142.8	0.68	4.64
1970	180.3	304.3	127.6	0.79	7.71
1971	334.2	510.7	192.7	1.79	18.99
1972	318.7	400.1	110.2	1.51	18.57
1973	189.7	366.5	112.1	2.09	15.51
1974	96.3	146.4	63.9	0.27	2.62
1975	122.0	188.3	96.1	0.20	5.80
1976	131.4	258.4	134.8	0.15	7.67
1977	173.2	279.6	143.5	0.43	3.43
1978	237.7	381.7	134.6	-	

Table 6a

COD. Catch per unit effort in  
Sub-area I. (Metric tons, round fish)

Year	Catch of 4 to 7 years old per 100 ton-hours fishing UK trawlers. Whole year	Catch per 1000 ton-hours fishing. Norwegian fresh- fish trawlers. 1. Quarter
1960	.064	
1961	.067	
1962	.084	
1963	.082	
1964	.055	
1965	.053	
1966	.056	
1967	.076	
1968	.105	
1969	.110	
1970	.089	
1971	.036	
1972	.021	(1.43)
1973	.038	1.26
1974	.076	2.09
1975	.069	2.21
1976	.047	1.94
1977	.046	2.12
1978	.046*	1.69**

\* Preliminary, for the first half of 1969

\*\* Preliminary

Table 7(a)

COD. Catch (No) of spawners per 100 ton-hours by UK trawlers. (Sub-area I and Divisions IIa and IIb combined)

Year	Age	
	$\geq 8$	$\geq 9$
1974	5.56	3.88
1975	4.11	1.87
1976	3.60	1.43
1977	9.41	1.33

Table 7(b)

COD. Catch by numbers per 100 ton-hours. UK trawlers in Sub-area I.

Year	Age			
	4	5	6	7
1974	34.36	13.10	3.42	.70
1975	6.08	26.42	7.51	1.00
1976	10.65	4.80	8.74	1.15
1977	10.85	6.23	2.07	4.49

Table 8 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

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

AGE	1974	1975	1976	1977
1	115	1	706	1
2	21347	1184	1908	11176
3	91855	45282	85337	39597
4	437377	59798	114341	167244
5	203772	226646	79993	136363
6	47006	118567	118236	53448
7	12630	29522	47872	59509
8	4370	9353	13962	22192
9	2523	2617	4051	5287
10	5607	1555	936	1425
11	2127	1928	558	580
12	322	575	442	243
13	151	231	139	109
14	83	15	26	83
15	62	37	53	47
TOTAL	829347	497311	468560	497304

Table 9

COD.

Year class strength. The 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 <sup>-6</sup> *
	Sub-area I	Division I Ib	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		1 293
1965	<1	<1	<1	Very poor	6	165
1966	2	<1	1	Very poor	<1	110
1967	1	<1	1	Very poor	34	195
1968	7	1	5	Poor	25	407
1969	11	6	9	Poor	93	1 018
1970	74	86	76	Rich	606	1 782
1971	37	24	32	Average	157	527
1972	53	17	40	Average	140	(708)
1973	74	5	46	Rich	684	(959)
1974	6	1	4	Poor	51	(419)
1975	93	(4)	54	Rich	343	(1 200)
1976	(1)	(1)	(1)	Poor	43	(380)
1977	(1)	(1)	(1)	Poor	173	(380)
1978					106	(700)

( ) = estimated.

\*USSR Murman cod included for 1974-77.

Table 10 COD. Fishing mortalities by year and by age (M = 0.2)

AGE	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.00	.00	.00	.00	.00	.00	.00	.01	.00	.00
3	.00	.04	.02	.03	.02	.02	.03	.02	.07	.05
4	.03	.16	.17	.13	.15	.08	.13	.11	.26	.26
5	.12	.26	.37	.23	.27	.29	.45	.21	.36	.51
6	.29	.28	.55	.31	.33	.53	.69	.48	.55	.51
7	.41	.42	.53	.33	.40	.51	.61	.55	.53	.52
8	.35	.40	.43	.35	.25	.59	.68	.63	.45	.50
9	.48	.51	.57	.41	.44	.59	.65	.53	.46	.60
10	.56	.52	.76	.52	.69	.76	.76	.63	.71	.70
11	1.06	.54	1.04	.70	.75	.88	.87	.91	.83	.60
12	1.03	.68	1.33	.64	.74	.67	1.15	.74	.93	.65
13	.77	.77	.91	.60	.81	.67	.97	.81	.32	.59
14	1.03	1.17	1.06	.67	.86	.91	.91	.63	.19	.35
15	.61	.59	.73	.50	.63	.55	.73	.37	.17	.28

MEAN F FOR AGES  $\geq$  8 AND  $\leq$  12 (NOT WEIGHTED BY STOCK IN NUMBERS)  
 .69 .53 .83 .52 .57 .70 .82 .69 .68 .61

AGE	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
1	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00
3	.05	.06	.07	.03	.02	.02	.04	.03	.03	.02
4	.23	.27	.31	.24	.14	.11	.10	.15	.21	.23
5	.35	.49	.65	.74	.35	.39	.21	.18	.41	.48
6	.46	.51	.82	1.00	.48	.45	.38	.20	.47	.54
7	.43	.53	.61	.96	.57	.40	.47	.43	.40	.77
8	.48	.68	.65	.87	.72	.52	.56	.67	.52	.92
9	.39	.73	.79	.93	1.03	.69	.69	.83	.78	1.14
10	.71	.77	.96	1.26	.83	.74	.72	.82	.72	.98
11	.88	.92	.78	1.33	.98	.73	.43	.88	.58	1.10
12	.67	1.01	.79	.83	.87	.42	.61	.78	.37	.92
13	.51	.87	.70	.59	.91	1.06	.47	.85	.84	.78
14	.50	1.02	.73	.52	.74	.55	.37	.48	.72	.36
15	.39	.68	.54	.42	.71	.96	.35	.74	.73	.67

MEAN F FOR AGES  $\geq$  8 AND  $\leq$  12 (NOT WEIGHTED BY STOCK IN NUMBERS)  
 .63 .82 .80 1.05 .89 .62 .60 .80 .59 1.01

AGE	1970	1971	1972	1973	1974	1975	1976	1977
1	.00	.00	.00	.00	.00	.00	.00	.01
2	.00	.00	.00	.01	.03	.00	.00	.01
3	.04	.02	.04	.20	.21	.07	.10	.11
4	.14	.10	.17	.20	.51	.21	.27	.30
5	.40	.23	.30	.35	.53	.55	.47	.58
6	.57	.25	.40	.40	.50	.70	.63	.68
7	.62	.52	.35	.44	.46	.69	.68	.77
8	.84	.83	.67	.75	.52	.74	.84	.81
9	.94	.93	1.13	1.01	.53	.69	.88	.94
10	.99	.73	1.21	.74	.98	.75	.58	.92
11	.69	.67	1.06	.56	1.00	1.18	.67	.89
12	.41	.53	.78	.46	.57	.83	1.00	.70
13	.64	.44	1.01	.41	.81	1.09	.49	.74
14	.64	.57	.79	.51	.98	.17	.32	.61
15	.54	.35	.91	.31	.72	.90	.49	.64

MEAN F FOR AGES  $\geq$  8 AND  $\leq$  12 (NOT WEIGHTED BY STOCK IN NUMBERS)  
 .77 .74 .97 .70 .72 .84 .79 .85



Table 11 COD. Stock in numbers at beginning of year (thousands)

AGE	1962	1963	1964	1965	1966	1967
1	506863	1162324	2364323	1929802	245698	164376
2	579978	414983	951630	1935651	1579387	201159
3	730261	473299	339756	778519	1582499	1292799
4	711706	559614	375590	273384	623198	1245144
5	382651	429397	361909	266133	200386	460053
6	173580	163820	168121	208340	147616	132848
7	68054	62388	49256	85152	109143	82673
8	50010	30410	19495	22751	46883	56041
9	15824	21288	10452	7782	11070	21828
10	4791	5862	6848	3053	3184	4529
11	5252	1497	1361	2441	1191	1272
12	3282	1978	323	419	962	634
13	850	1218	706	111	225	427
14	588	346	552	234	32	115
15	141	232	168	216	110	18
TOTAL	3233832	3328657	4650490	5513988	4552182	3663916

AGE	1968	1969	1970	1971	1972	1973
1	291221	608605	1522321	2664293	797779	1085631
2	134579	238431	498283	1246370	2181304	653165
3	164559	110183	194962	407426	1018445	1781654
4	1027335	131380	88127	153155	326570	801753
5	875228	683944	85477	62427	113003	226447
6	314305	476153	346219	46820	40465	68402
7	88905	161373	227573	160124	29763	22281
8	44101	48828	61328	100110	77998	17256
9	23424	21421	15961	21770	35625	32693
10	7781	8834	5599	5121	7064	9377
11	1632	3106	2706	1697	2020	1733
12	430	749	846	1115	708	575
13	237	242	245	459	539	265
14	149	84	91	105	242	161
15	59	60	48	39	49	90
TOTAL	2973946	2493694	3049786	4871031	4631574	4701484

AGE	1974	1975	1976	1977
1	1432762	627120	1514161	111
2	888839	1172943	513441	1239052
3	527291	708445	959255	418647
4	1193764	349027	539171	708416
5	538030	585608	231929	338602
6	130615	258048	276572	118192
7	37545	64827	105387	120734
8	11743	19417	26708	43524
9	6697	5700	7551	9427
10	9767	3224	2330	2575
11	3662	3012	1252	1070
12	813	1108	757	526
13	296	377	395	227
14	144	108	104	199
15	79	44	75	62
TOTAL	4782048	3799008	4179086	3001363

Table 12 Estimates of spawning stock and  
year class strength for COD.  
Estimates from VPA (M = 0,2)

Year	Spawning stock biomass tons x 10 <sup>-3</sup> at beginning of year (age groups 8+)	Year class	Year class strength at 3 years old Millions
		1947	705
		1948	1 097
		1949	1 192
1950	1 463	1950	1 593
1951	1 390	1951	645
1952	1 161	1952	273
1953	909	1953	441
1954	833	1954	805
1955	875	1955	498
1956	1 000	1956	685
1957	935	1957	791
1958	1 024	1958	919
1959	864	1959	710
1960	602	1960	473
1961	515	1961	340
1962	475	1962	779
1963	378	1963	1 582
1964	244	1964	1 293
1965	213	1965	165
1966	340	1966	110
1967	459	1967	195
1968	437	1968	407
1969	472	1969	1 018
1970	469	1970	1 782
1971	680	1971	527
1972	678	1972	(708)
1973	384	1973	(959)
1974	221	1974	(419)
1975	198	1975	(1 200)
1976	217	1976	(380)
1977	305	1977	(700)
1977	(353)		
1978	(241)		
1979	(307)		
1980			

( ) = provisional figures.

Table 13 COD. Parameters used in catch predictions (M = 0.2)

Age	Stocking size at the beginning of 1979 in thousands	Fishing pattern ( $F_{8-12} = 1.00$ )			Mean weights (kgs)
		1978	1979	1980-1985 (Average 1970-1976)	
3	380 000	0.20	0.13	0.13	0.65
4	812 468	0.35	0.50	0.30	1.00
5	180 282	0.60	0.52	0.52	1.55
6	198 946	0.63	0.63	0.63	2.35
7	69 848	0.69	0.69	0.69	3.45
8	20 839	0.95	0.95	0.95	4.70
9	15 197	1.11	1.11	1.11	6.17
10	4 521	1.08	1.08	1.08	7.70
11	885	1.05	1.05	1.05	9.25
12	254	0.83	0.83	0.83	10.85
13	134	0.87	0.87	0.87	12.50
14	77	0.73	0.73	0.73	13.90
15	82	0.76	0.75	0.75	15.000

Table 14. COD. Management Options.

Year	Spawn. Stock Biom.	$\bar{F}_{8-12}$	Catch	Spawn. Stock Biom.	$\bar{F}_{8-12}$	Catch	Spawn. Stock Biom.	$\bar{F}_{8-10}$	Catch	Spawn. Stock Biom.	$\bar{F}_{8-12}$	Catch	Spawn. Stock Biom.	$\bar{F}_{8-10}$	Catch
	1			2			3			4			5		
1977	305	0.85	890	→											
1978	353	0.95	891	→											
1979	241	0.95	844	241	0.29	311	241	0.62	604	241	0.86	783	241	0.45	460
1980	234	0.95	672	405	0.29	360	307	0.46	448	252	0.77	600	354	0.45	485
1981	273	0.95	619	741	0.29	446	510	0.29	344	336	0.69	549	580	0.45	553
1982	193	0.95	593	851	0.29	517	606	0.29	418	291	0.62	523	590	0.45	599
1983	261	0.95	632	1516	0.29	607	1137	0.29	513	475	0.56	551	980	0.45	670
1984	184	0.95	673	1519	0.29	674	1195	0.29	596	436	0.50	572	889	0.45	719
1985	148	0.95	710	1479	0.29	717	1233	0.29	660	441	0.45	597	805	0.45	755
Total yield 1979-81	2135			1117			1396			1932			1498		
Year	6			7			8			9					
1977	305	0.85	890	→											
1978	353	0.95	891	→											
1979	241	0.50	504	241	0.56	555	241	0.62	604	241	0.62	604			
1980	339	0.48	498	323	0.56	548	307	0.65	599	307	0.59	553			
1981	547	0.42	500	491	0.51	549	438	0.63	605	459	0.54	551			
1982	574	0.37	498	481	0.47	549	389	0.60	594	441	0.50	550			
1983	1021	0.31	502	813	0.41	557	615	0.54	599	738	0.43	550			
1984	1056	0.26	499	787	0.35	551	547	0.48	600	711	0.37	551			
1985	1129	0.22	492	808	0.30	546	523	0.42	597	731	0.32	552			
Total yield 1979-81	1502			1652			1808			1708					

Table 15 HADDOCK. Total nominal catch (metric tons) 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*	71 156	9 168	29 375	109 699

\* Provisional figures.

Table 16

HADDOCK. Nominal catch (in metric tons) 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	49	16 373	15 778	3	78 911
1972	137	-	829	1 433	46 700	1 433	17 166	196 224	2 223	266 145
1973	1 212	3 214	22	9 583	86 767	325	32 408	186 534	-	320 065
1974	925	3 601	454	23 409	66 164	3 045	36 293	78 548 <sup>1)</sup>	8 699	221 138
1975	299	5 191	437	15 930	55 966	1 080	28 661	65 015 <sup>1)</sup>	3 163	175 742
1976	537	4 459	348	16 660	49 492	986	16 954	42 485 <sup>1)</sup>	5 358	137 279
1977*	213	1 510	144	4 798	39 600	-	10 877	52 210 <sup>1)</sup>	347	109 699

\* Provisional figures.

1) Murman haddock included.

Table 17 HADDOCK. Nominal catch (metric tons) up to the end of June 1978\*  
(Sub-area I and Divisions IIa and IIb combined)

DDR	307
Germany, Fed.Rep.of	1 251
Norway	13 879
Poland	1
UK (England)	4 171
USSR	39 681
Total	59 290

\* Preliminary

Table 18

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

Year	Catch per effort (U.K.) Kilos/100 ton-hours			Estimated total international effort in U.K. units
	Sub-area I	Divisions		$\frac{\text{Total catch in tons} \times 10^{-3}}{\text{Tons/100 ton-hours in Sub-area I}}$
		IIa	IIb	
1960	33	34	2.8	4.7
1961	29	36	3.3	6.7
1962	23	42	2.5	8.2
1963	13	33	0.9	11.3
1964	18	18	1.6	5.5
1965	18	18	2.0	6.6
1966	17	34	2.8	9.4
1967	18	25	2.4	7.6
1968	19	50	1.0	9.6
1969	13	42	2.0	10.0
1970	7	31	1.0	12.4
1971	8	25	3.0	9.8
1972	14	18	23.0	19.0
1973	22	20	20.0	14.5
1974	20	74	15.0	11.1
1975	15	60	4.0	11.7
1976	10	38	3.0	13.7
1977	4.2	16	0.2	26.1*

\* Provisional figure.



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 <sup>-6</sup> *
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	18
1967	13	42	165
1968	<1	8	95
1969	69	82	1 044
1970	33	115	291
1971	3	73	(54)
1972	9	46	(58)
1973	8	54	(111)
1974	35	147	(339)
1975	(96)	170	(900)
1976	(13)	112	(270)
1977	( 1)	116	(275)
1978		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

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

AGE	1974	1975	1976	1977
1	281	1321	3475	185
2	3713	4355	7496	18457
3	9684	10037	13989	55921
4	41701	14089	13449	22061
5	88111	33871	6808	7395
6	5827	49712	20789	2537
7	4138	2135	40044	7773
8	382	1236	1247	10938
9	617	92	1349	305
10	2043	131	193	391
11	935	500	279	89
12	276	147	652	88
13	458	53	331	79
14	143	92	46	94
TOTAL	158309	117771	110147	126313

Table 21 HADDOCK. Fishing mortalities by year and by age (M = 0.2)

AGE	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959
1	.00	.00	.00	.01	.01	.00	.00	.00	.00	.00
2	.01	.00	.01	.06	.01	.01	.05	.00	.01	.01
3	.05	.14	.11	.07	.06	.02	.11	.04	.03	.07
4	.59	.22	.55	.37	.24	.13	.17	.25	.17	.17
5	.81	.63	.58	.54	.28	.49	.26	.36	.57	.32
6	.80	.87	.89	.48	.42	.41	.80	.37	.49	.54
7	1.13	.79	.89	.72	.59	1.02	.51	.78	.81	.53
8	.93	.99	1.17	.52	.87	.57	.96	.33	.79	.31
9	.54	1.13	1.29	.45	.80	.44	.35	.67	.44	.68
10	.53	.75	.64	.55	.72	.24	.68	.51	.98	.27
11	.56	.85	.94	1.20	.44	.23	.30	.11	.73	.93
12	2.26	.21	.54	1.27	.70	.18	.47	.01	1.02	.52
13	1.43	3.40	.26	.84	1.55	.32	.27	.52	.88	.12
14	.60	.60	.60	.60	.60	.60	.60	.60	.60	.60

MEAN F FOR AGES  $\geq$  7 AND  $\leq$  12 (NOT WEIGHTED BY STOCK IN NUMBERS)  
 .99 .79 .91 .78 .69 .45 .55 .40 .79 .54

AGE	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
1	.01	.00	.00	.00	.00	.00	.00	.00	.00	.00
2	.03	.02	.01	.01	.01	.01	.01	.00	.00	.01
3	.20	.17	.20	.12	.08	.07	.13	.06	.04	.10
4	.38	.49	.59	.68	.31	.24	.39	.30	.40	.15
5	.51	.69	1.06	.92	.69	.46	.58	.43	.56	.50
6	.61	.71	1.04	1.02	.83	.69	.71	.50	.47	.55
7	.50	.71	.63	.94	.83	.61	.80	.49	.65	.42
8	.57	.82	.65	.53	.82	.57	.44	.56	.62	.44
9	.63	.62	.97	.62	.85	.71	.55	.29	.46	.39
10	.52	.28	.40	.62	.22	.28	.31	.45	.42	.42
11	1.02	.77	.20	.22	.74	.86	.89	.46	.51	.16
12	.54	.35	.75	.10	1.90	1.54	.23	1.24	.75	.43
13	.44	1.32	.17	.66	.20	.55	.35	.42	1.22	.18
14	.60	.60	.60	.60	.60	.60	.60	.60	.60	.40

MEAN F FOR AGES  $\geq$  7 AND  $\leq$  12 (NOT WEIGHTED BY STOCK IN NUMBERS)  
 .63 .59 .60 .50 .89 .76 .54 .58 .57 .38

AGE	1970	1971	1972	1973	1974	1975	1976	1977
1	.00	.00	.00	.00	.00	.00	.01	.00
2	.00	.00	.03	.09	.06	.03	.02	.06
3	.17	.02	.28	.31	.22	.21	.15	.20
4	.22	.27	.39	.57	.30	.58	.49	.37
5	.21	.17	1.04	.96	.39	.43	.61	.55
6	.50	.15	.83	.45	.66	.40	.52	.49
7	.46	.41	.42	.23	.54	.54	.65	.37
8	.42	.33	.60	.18	.35	.30	.71	.37
9	.31	.31	.52	.29	.45	.13	.63	.37
10	.30	.27	.66	.18	.69	.16	.44	.37
11	.41	.25	.45	.21	.57	.36	.59	.37
12	.14	.66	.68	.27	.76	.16	1.12	.37
13	1.49	.21	.62	.16	.72	.32	.64	.37
14	.40	.40	.60	.30	.60	.30	.50	.37

MEAN F FOR AGES  $\geq$  7 AND  $\leq$  12 (NOT WEIGHTED BY STOCK IN NUMBERS)  
 .34 .37 .56 .23 .56 .27 .69 .37

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

AGE	1962	1963	1964	1965	1966	1967
1	479318	150285	365039	438265	29424	27241
2	341843	392432	123040	298734	358820	24090
3	240721	275780	319353	99986	241437	291466
4	75814	161428	200036	241342	76528	174094
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	393	996	295	168	132	116
13	143	383	739	36	29	86
14	19	99	162	496	17	17
TOTAL	1293267	1061468	1101524	1235424	939786	662365

AGE	1968	1969	1970	1971	1972	1973
1	248062	142034	1563302	446922	88075	90817
2	22302	203095	116287	1279490	365895	71989
3	19675	18229	165325	94959	1044365	291110
4	224268	15516	13554	114633	75958	648036
5	105349	122926	10934	8930	71947	42223
6	22674	49318	60756	7269	6178	20847
7	35604	11619	23408	30039	5124	2210
8	12541	15209	6273	12040	16269	2754
9	1947	5536	8036	3366	7112	7295
10	580	1007	3075	4802	2013	3467
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	693591	585036	1971844	2004776	1687351	1183715

AGE	1974	1975	1976	1977
1	171675	517649	430516	204215
2	74354	140302	422622	349338
3	53605	57525	110938	339244
4	175247	35172	38062	78223
5	299013	105999	16190	19112
6	13211	165731	56405	7168
7	10906	5609	91078	27561
8	1433	5224	2681	38783
9	1875	830	3166	1081
10	4463	982	597	1386
11	2366	1829	686	316
12	563	1100	1049	312
13	975	214	768	280
14	346	390	128	333
TOTAL	810032	1038557	1174887	1067353

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

Year	Spawning stock biomass tons x 10 <sup>-3</sup> 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	270	1950	1 029
1951	151	1951	127
1952	95	1952	52
1953	66	1953	169
1954	179	1954	53
1955	156	1955	69
1956	474	1956	325
1957	324	1957	242
1958	202	1958	110
1959	160	1959	240
1960	129	1960	276
1961	105	1961	319
1962	147	1962	100
1963	106	1963	241
1964	67	1964	291
1965	76	1965	20
1966	140	1966	18
1967	193	1967	165
1968	166	1968	95
1969	174	1969	1 044
1970	216	1970	291
1971	161	1971	54
1972	126	1972	(58)
1973	106	1973	(111)
1974	103	1974	(339)
1975	(320)	1975	(900)
1976	(341)	1976	(270)
1977	(200)	1977	(275)
1978	(154)		
1979	(159)		
1980	(253)		

( ) = provisional figures.

Table 24 HADDOCK. Parameters used in the catch prediction (M = 0.2)

Age	Stock size of the beginning of 1979 in thousands	Fishing pattern*		Mean weights (kgs)
		1978 and 1980 (average) (1970-1974)	1979	
3	270 000	.36	.36	.41
4	635 743	.67	1.00	.62
5	141 460	1.00	.90	.97
6	24 036	.89	.89	1.59
7	5 132	.67	.67	2.33
8	2 236	.67	.67	2.72
9	9 696	.67	.67	3.56
10	13 647	.67	.67	4.41
11	380	.67	.67	5.40
12	488	.67	.67	6.70
13	111	.67	.67	7.40
14	208	.67	.67	8.00

\*F = 1,00 for age-groups subject to maximum exploitation

Figure 1 North-East Arctic Cod

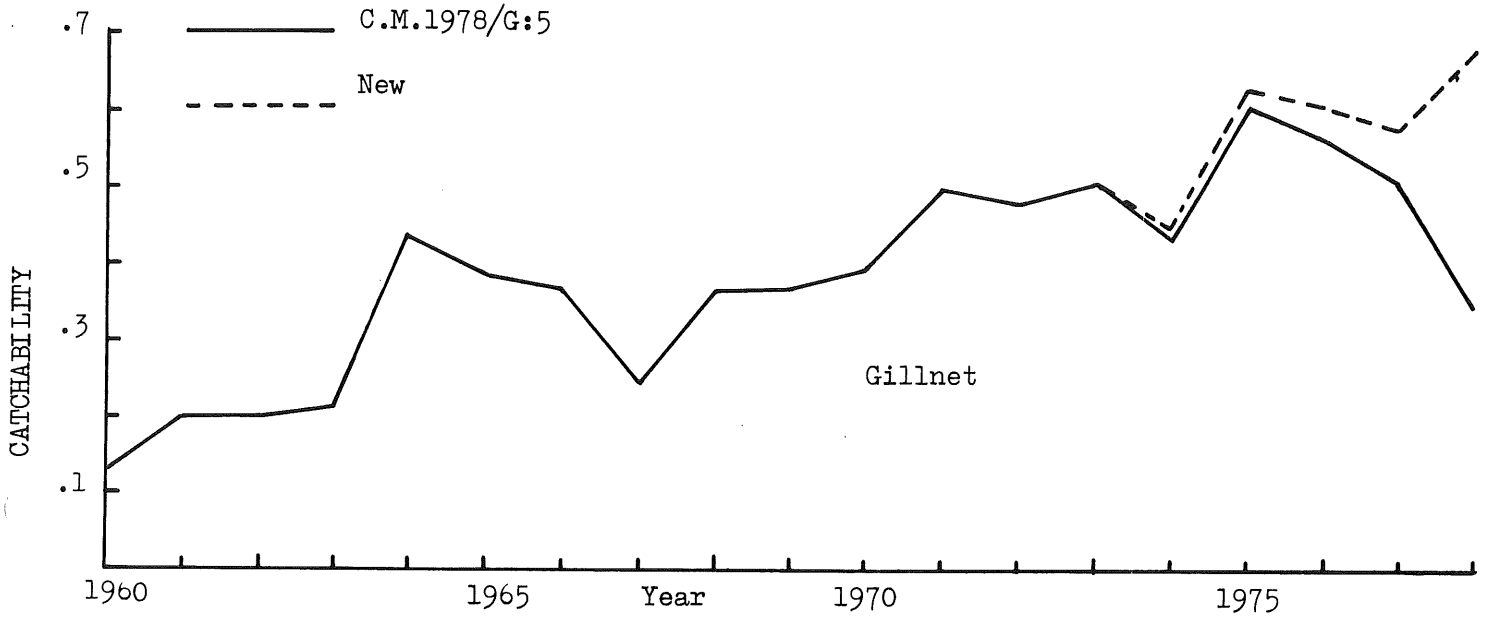
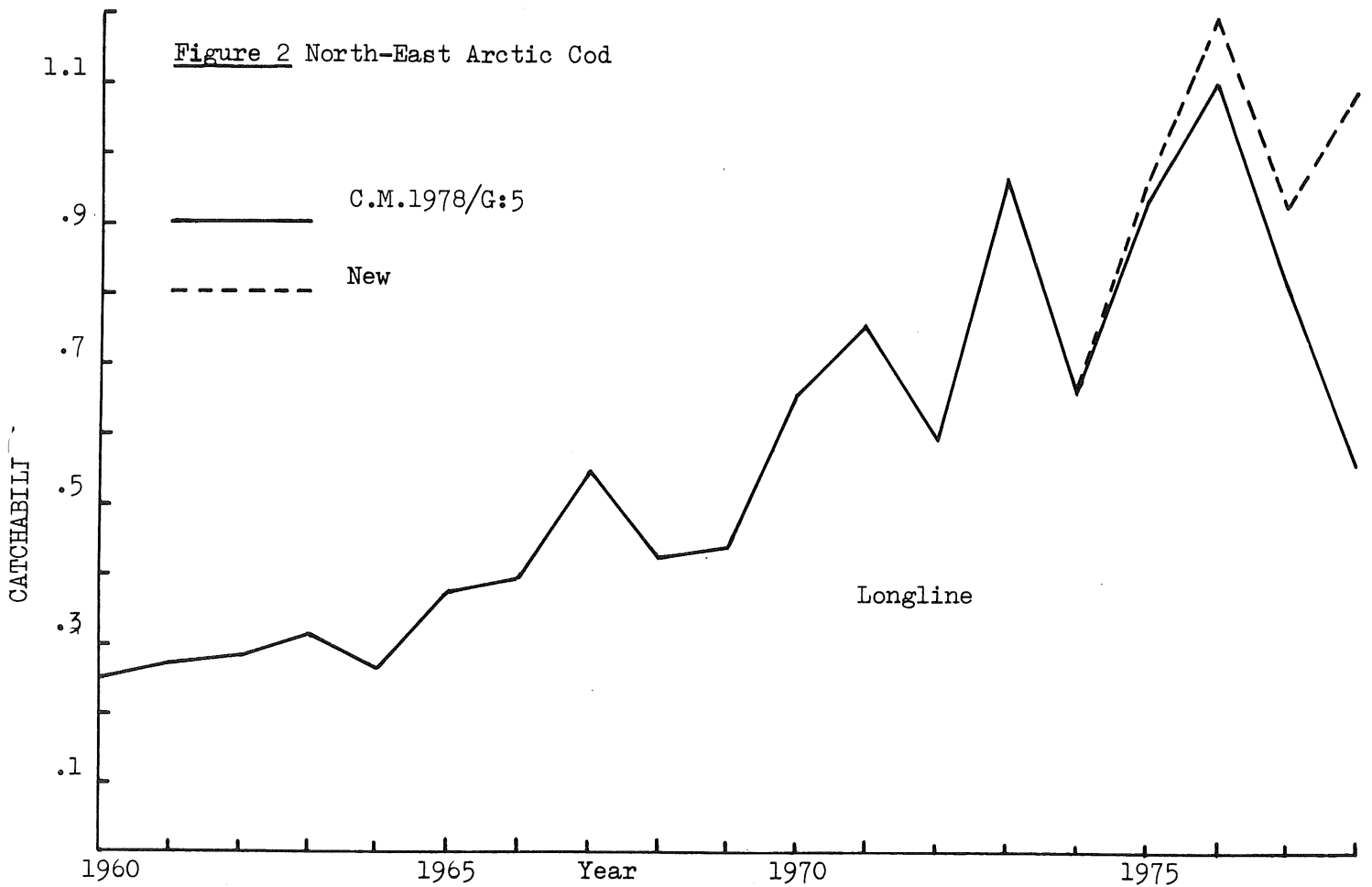


Figure 2 North-East Arctic Cod



Figures 1-2 Catchability for gillnets (Fig. 1) and for longlines (Fig. 2) in the Lofoten spawning fishery for cod 1960-1978.

Figure 3. North-East Arctic Cod

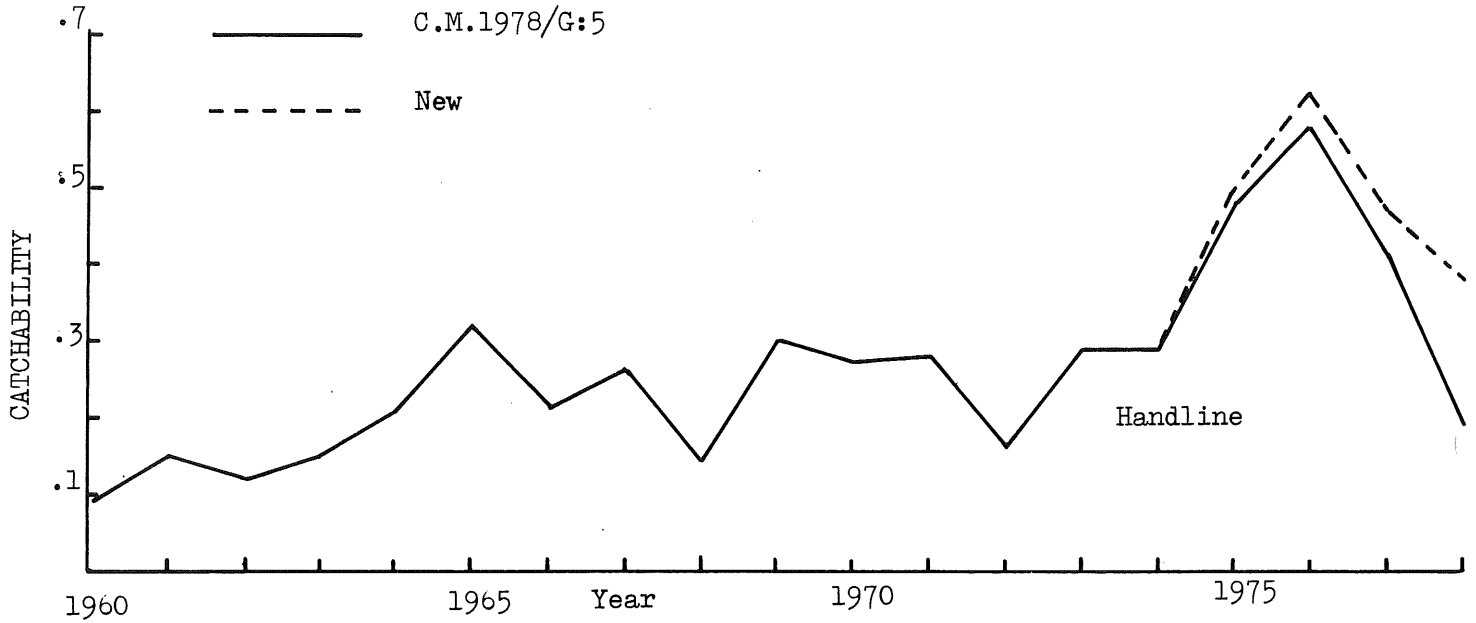
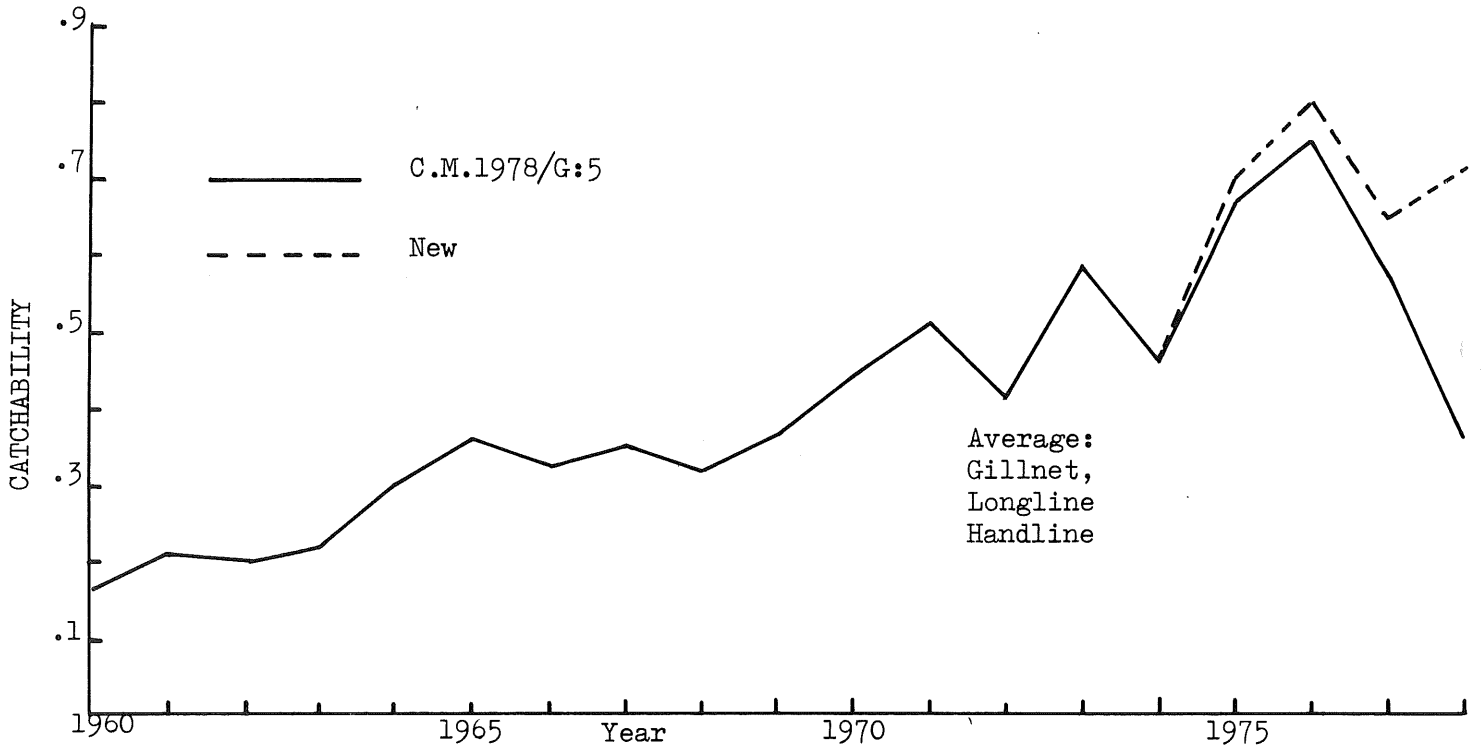


Figure 4 North-East Arctic Cod



Figures 3-4 Catchability for handlines (Fig. 3) and the average catchability of gillnets, longlines and handlines (Fig. 4) in the Lofoten spawning fishery for cod, 1960-1978.



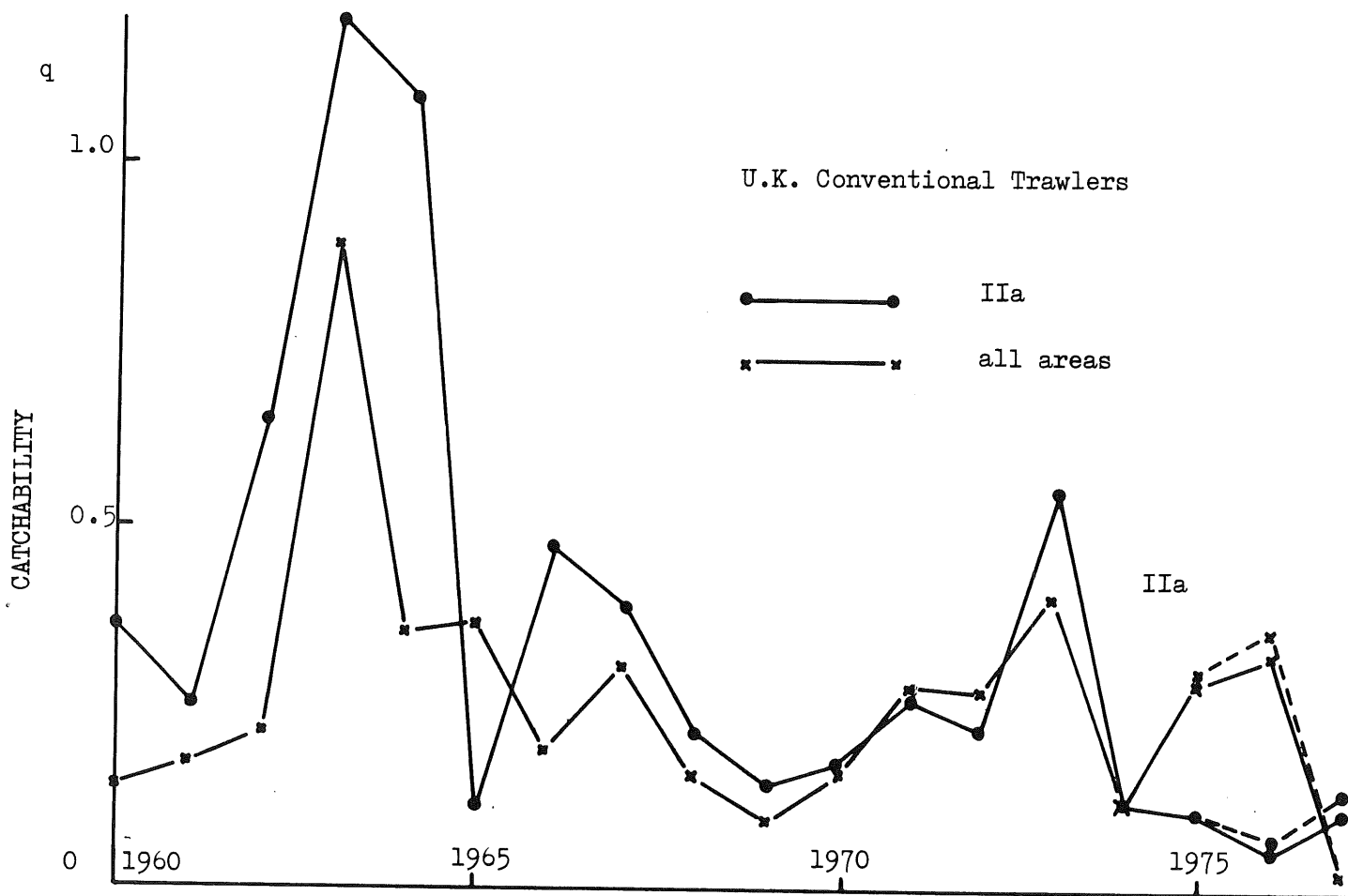


Figure 5 Catchability coefficient  $q$ , from U.K. cpue of fish 8 years or older.

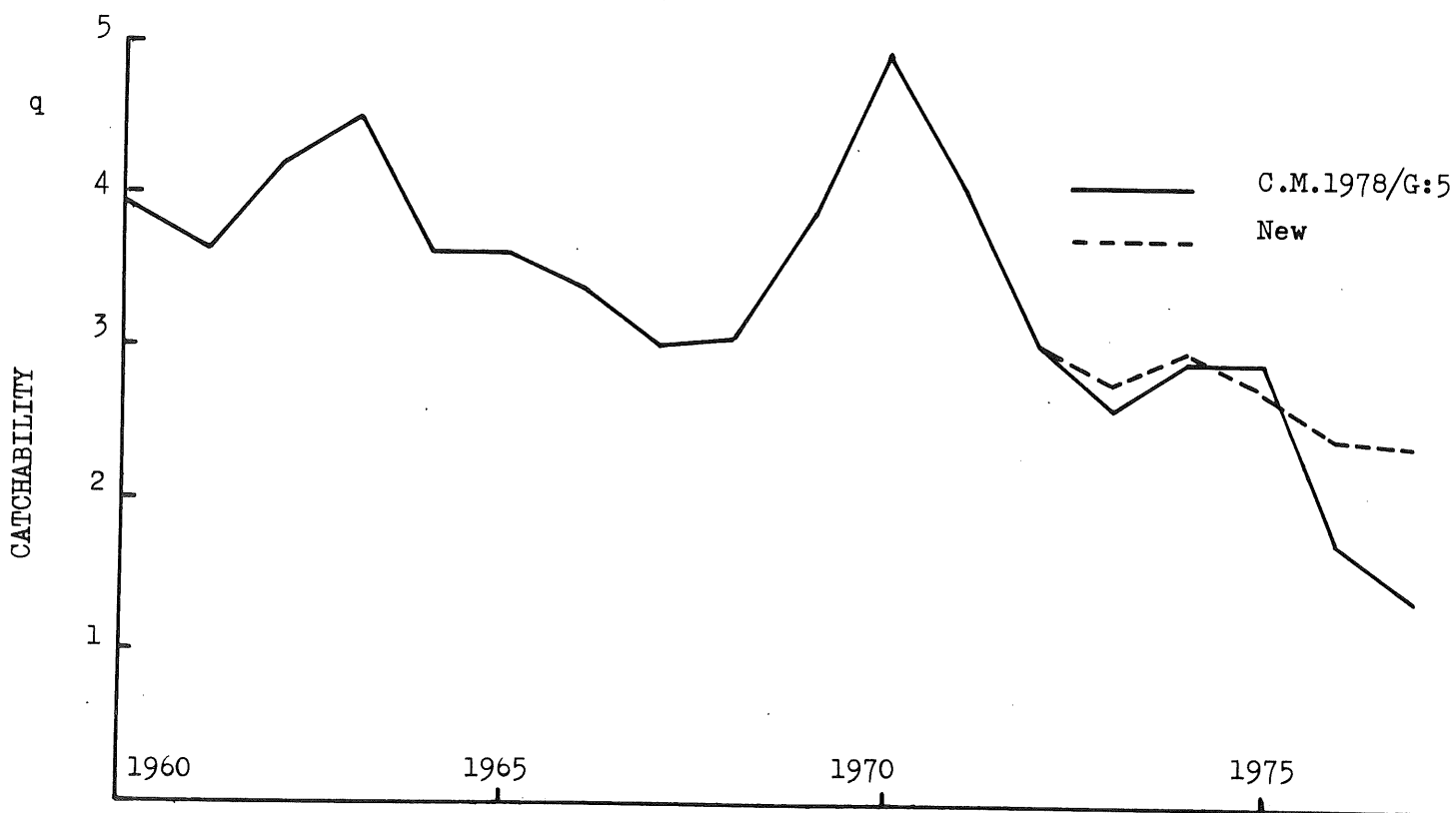
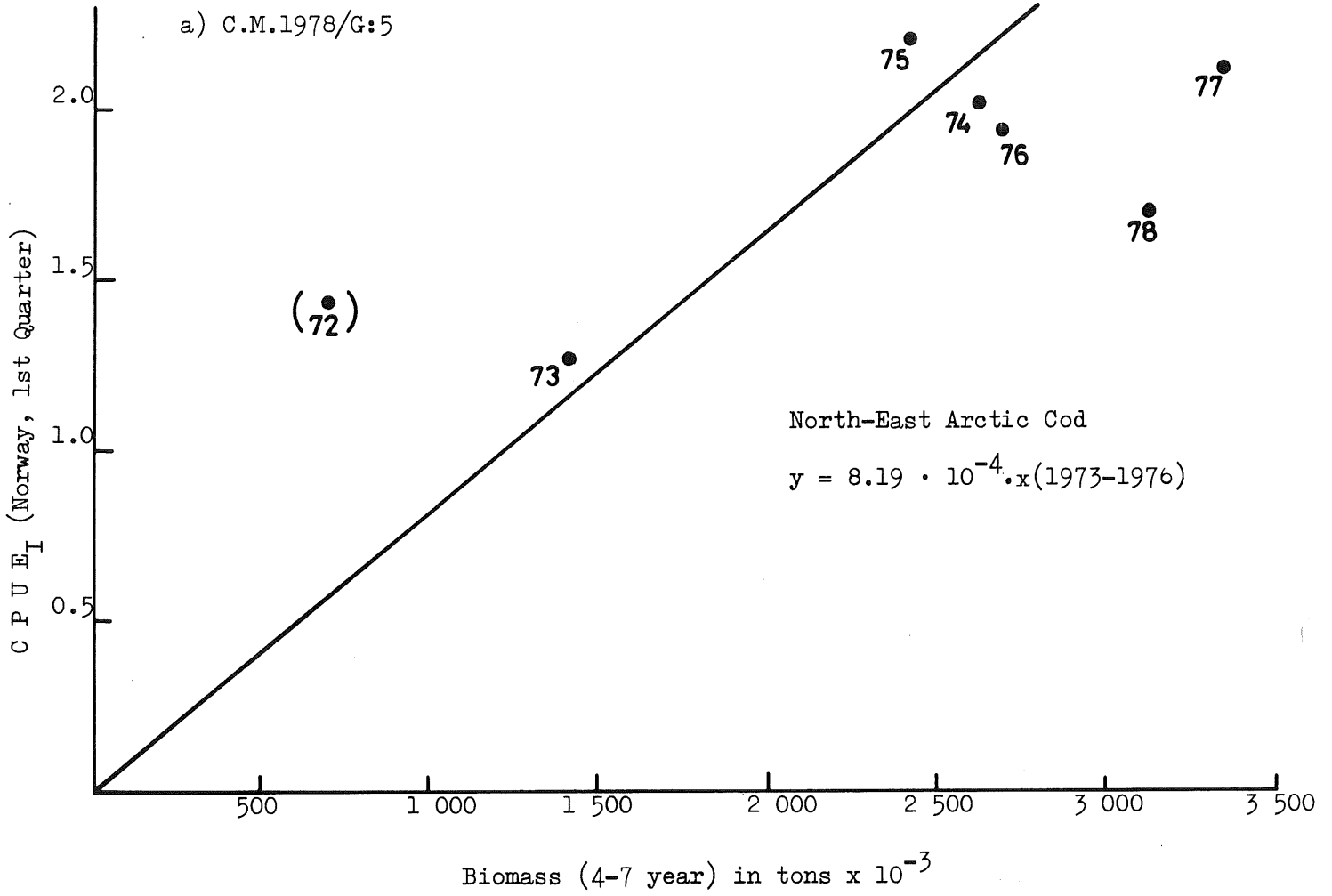


Figure 6 Catchability coefficient  $q$ , from U.K. catch per unit effort on 4 - 7 year old fish.

a) C.M.1978/G:5



b) New

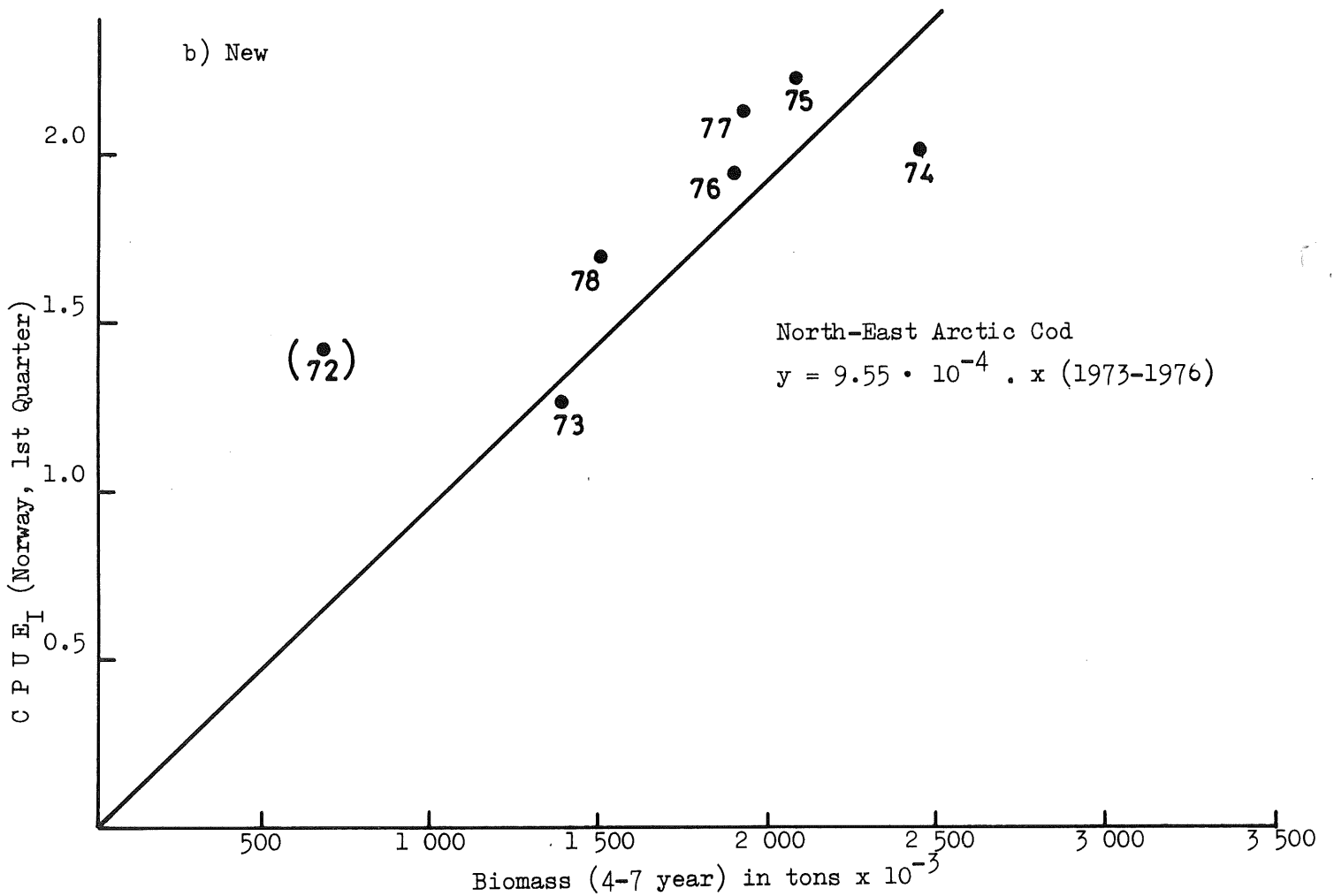
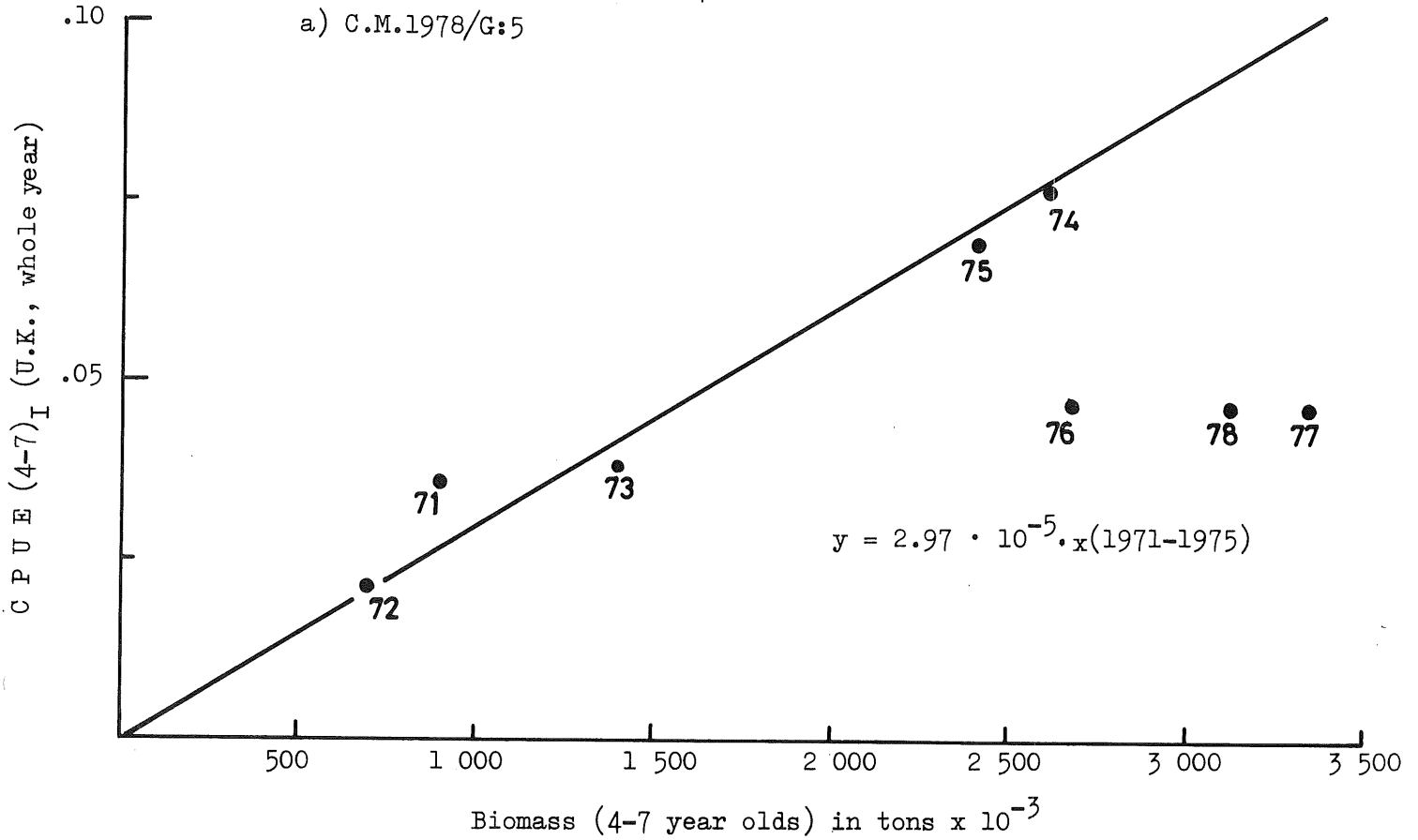
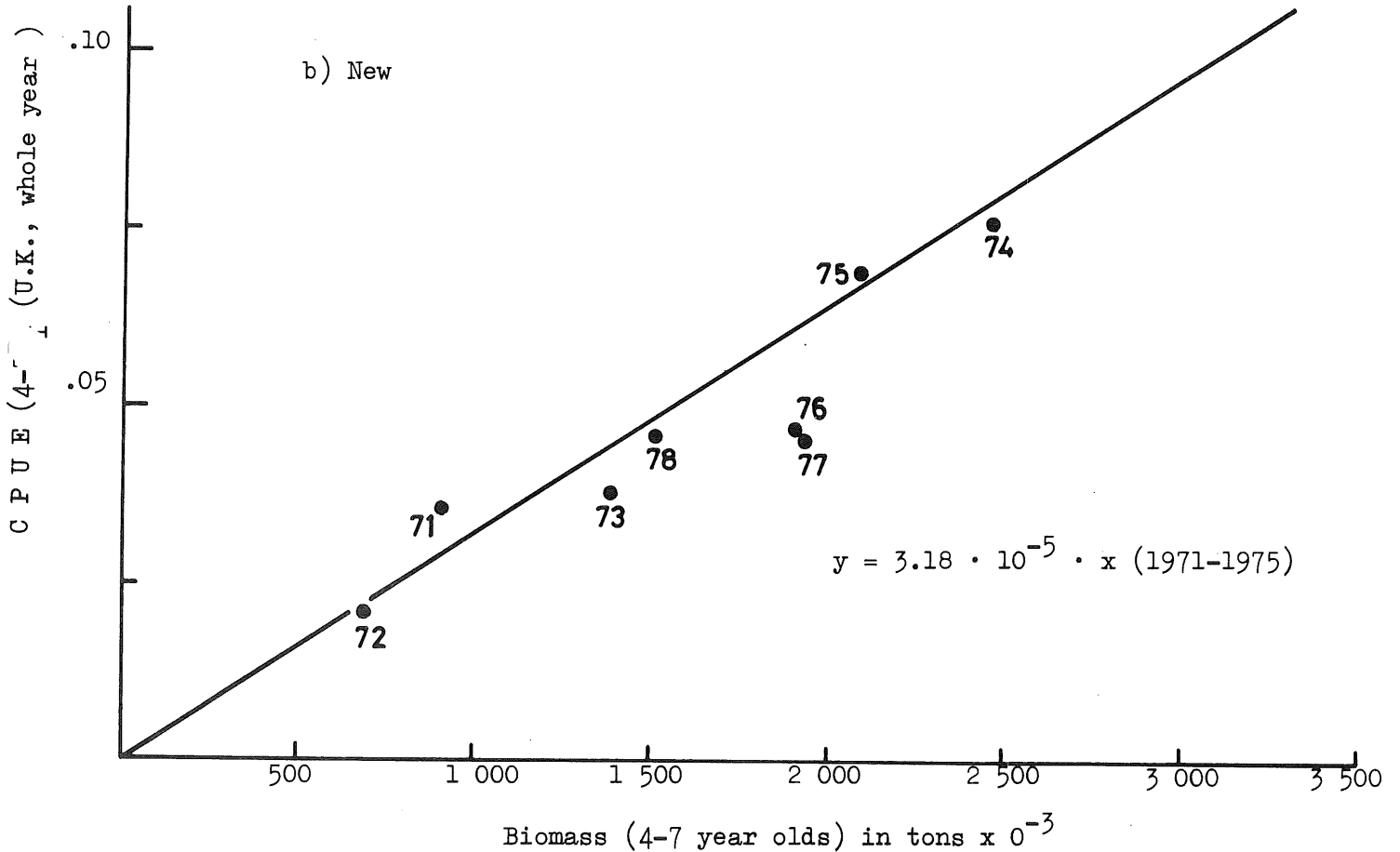


Figure 7 a-b Catch per unit effort in Sub-area I by Norwegian freshfish trawlers in the first quarter of the year versus the biomass of 4 to 7 year olds.

a) C.M.1978/G:5



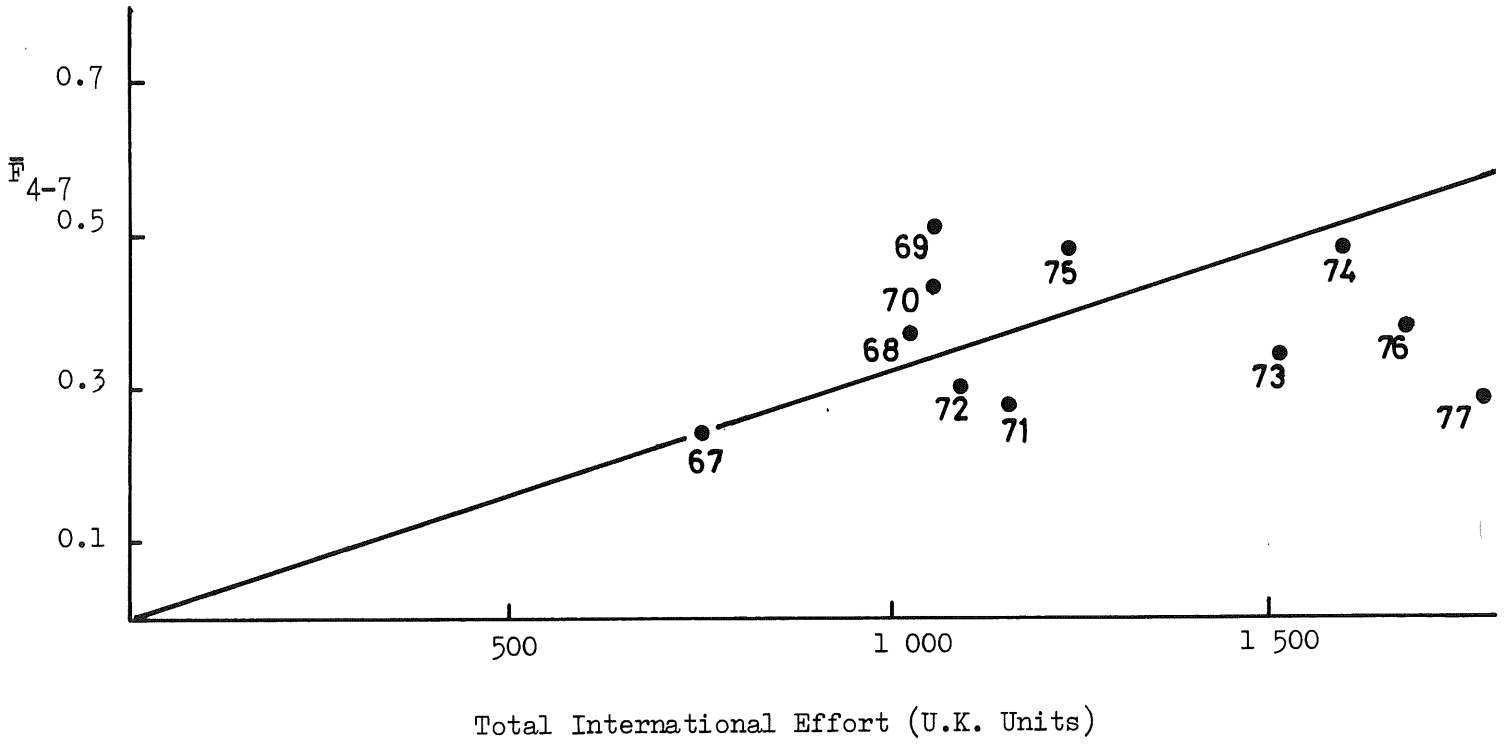
b) New



Figures 8a-b. The correspondence between catch per unit effort of 4 to 7 years old cod (tons per 100 ton-hour trawling) by UK trawlers in Sub-area I, and the estimated stock size of 4-7 year old cod. Stock estimate from C.M.1978/G:5 (Fig.8a) and present (Fig. 8b).

North-East Arctic Cod

a) C.M.1978/G:5  
( $y = 3.19 \cdot 10^{-4} \cdot x$ ,  
based on 1967-1974 averages)



North-East Arctic Cod

b) New  
( $y = 3.19 \cdot 10^{-4} \cdot x$   
based on 1967-1974 averages)

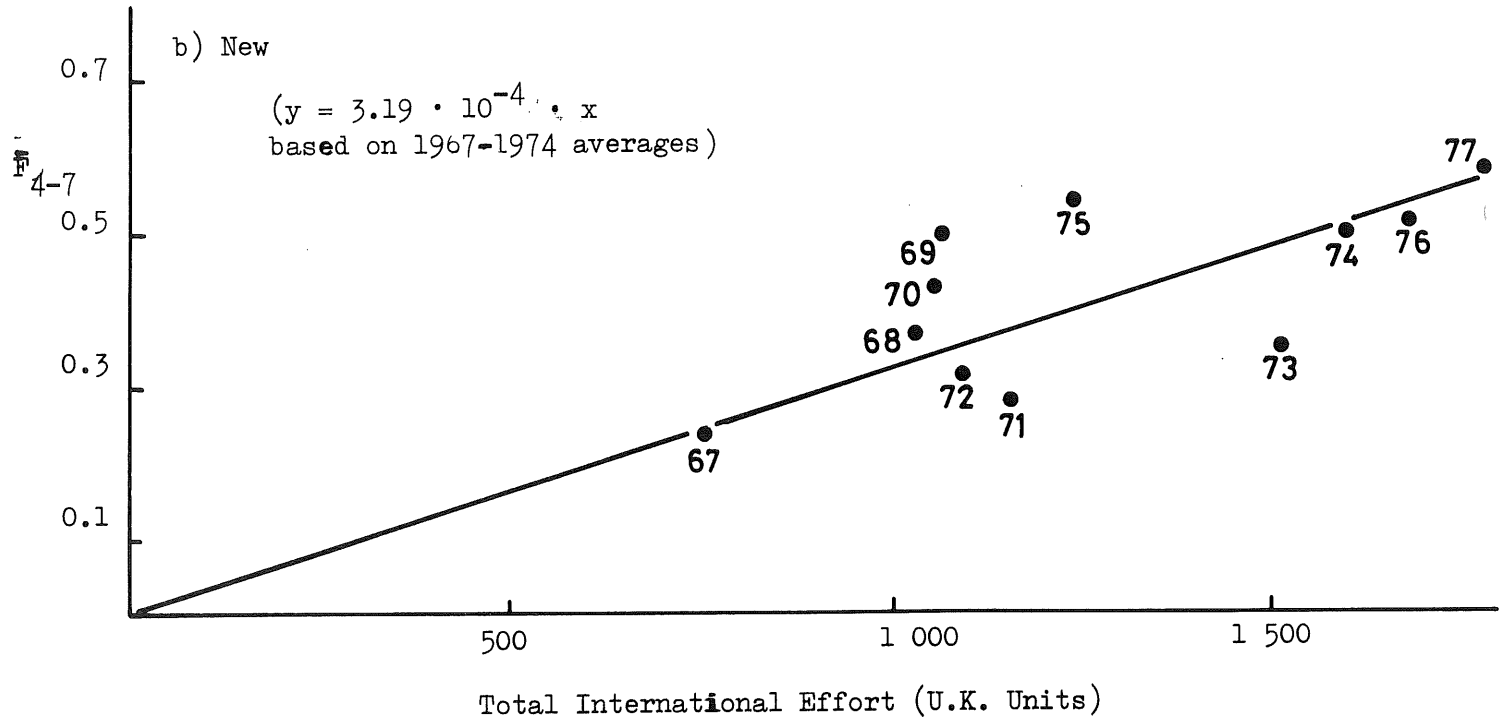


Figure 9 a-b The average fishing mortality on 4 to 7 year old cod versus the total international effort (in U.K. units).

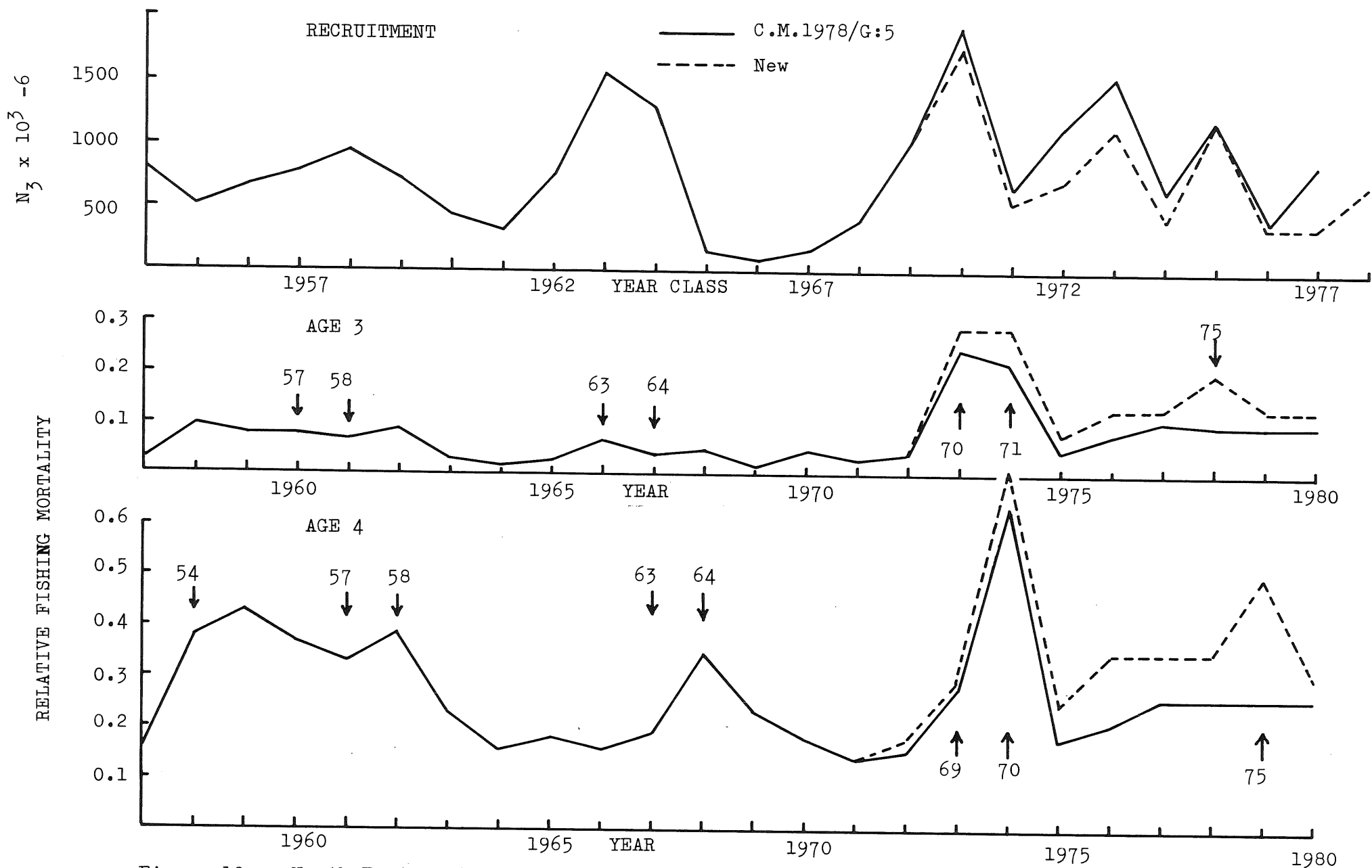


Figure 10a. North-East Arctic Cod. Recruitment at age 3 and relative fishing mortalities on 3 and 4 year olds, with projections of these for 1978-80 as used in the predictions.

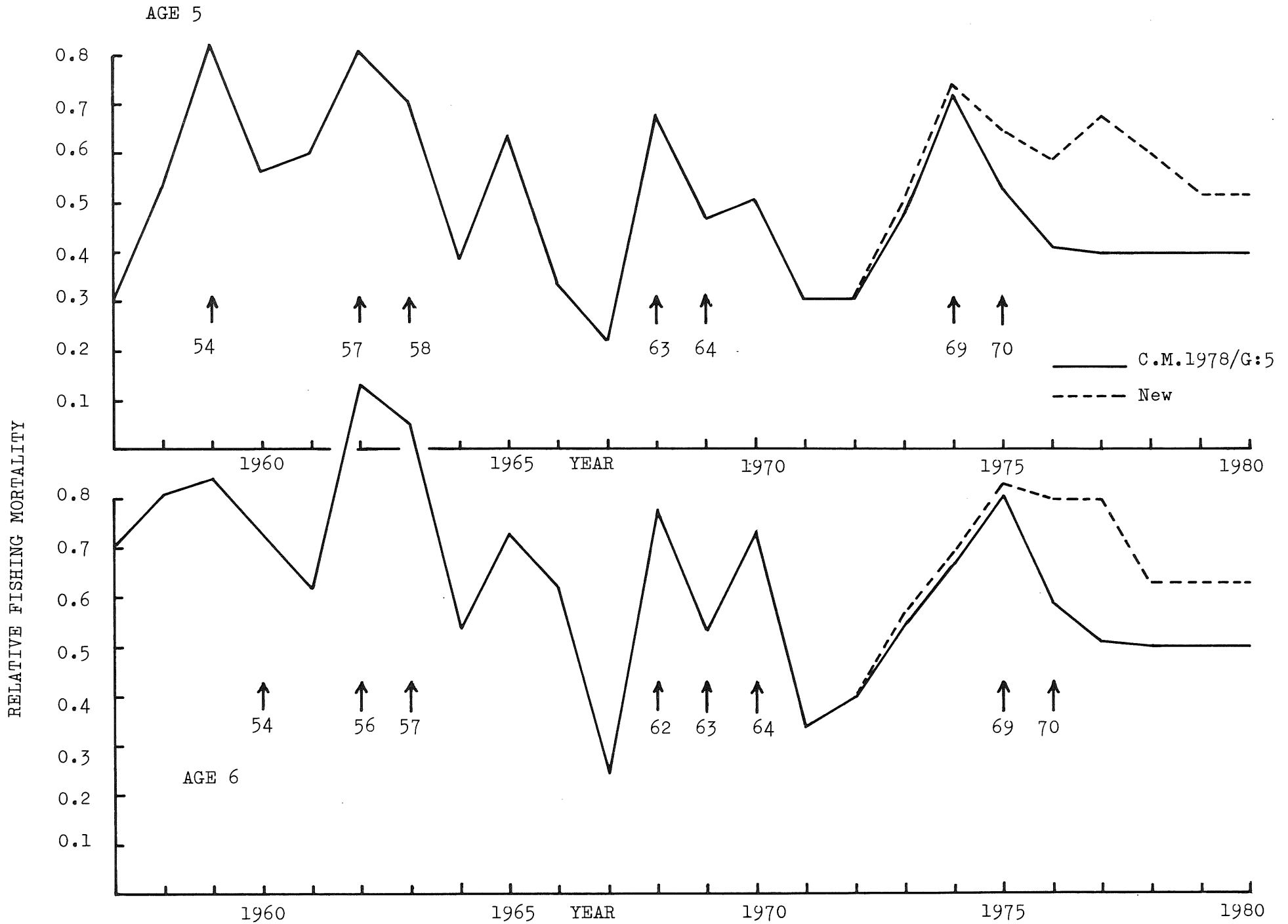


Figure 10b. North-East Arctic Cod. Relative fishing mortalities on 5 and 6 year olds.

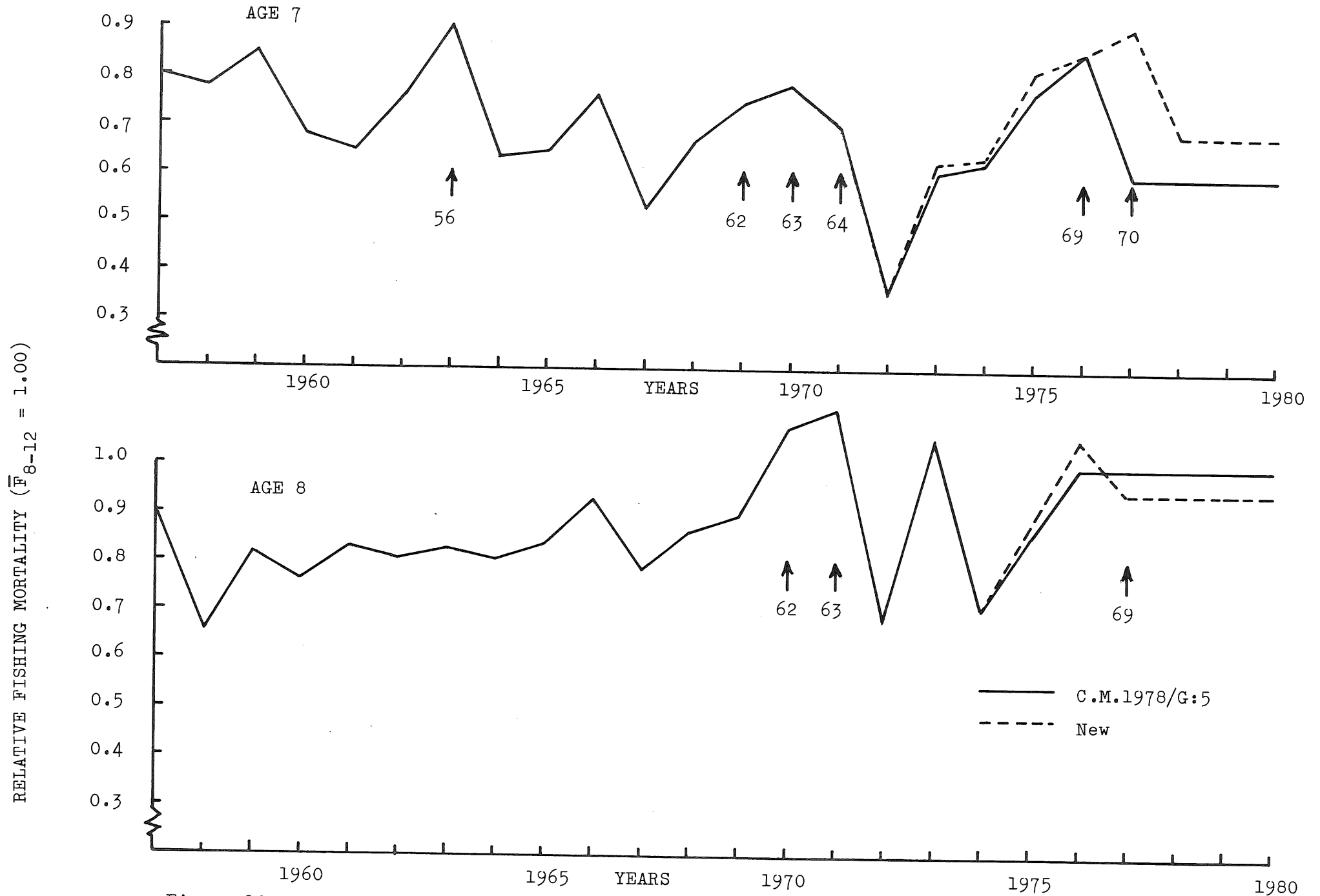


Figure 10.c North-East Arctic Cod. Relative fishing mortalities on 7 and 8 year olds.

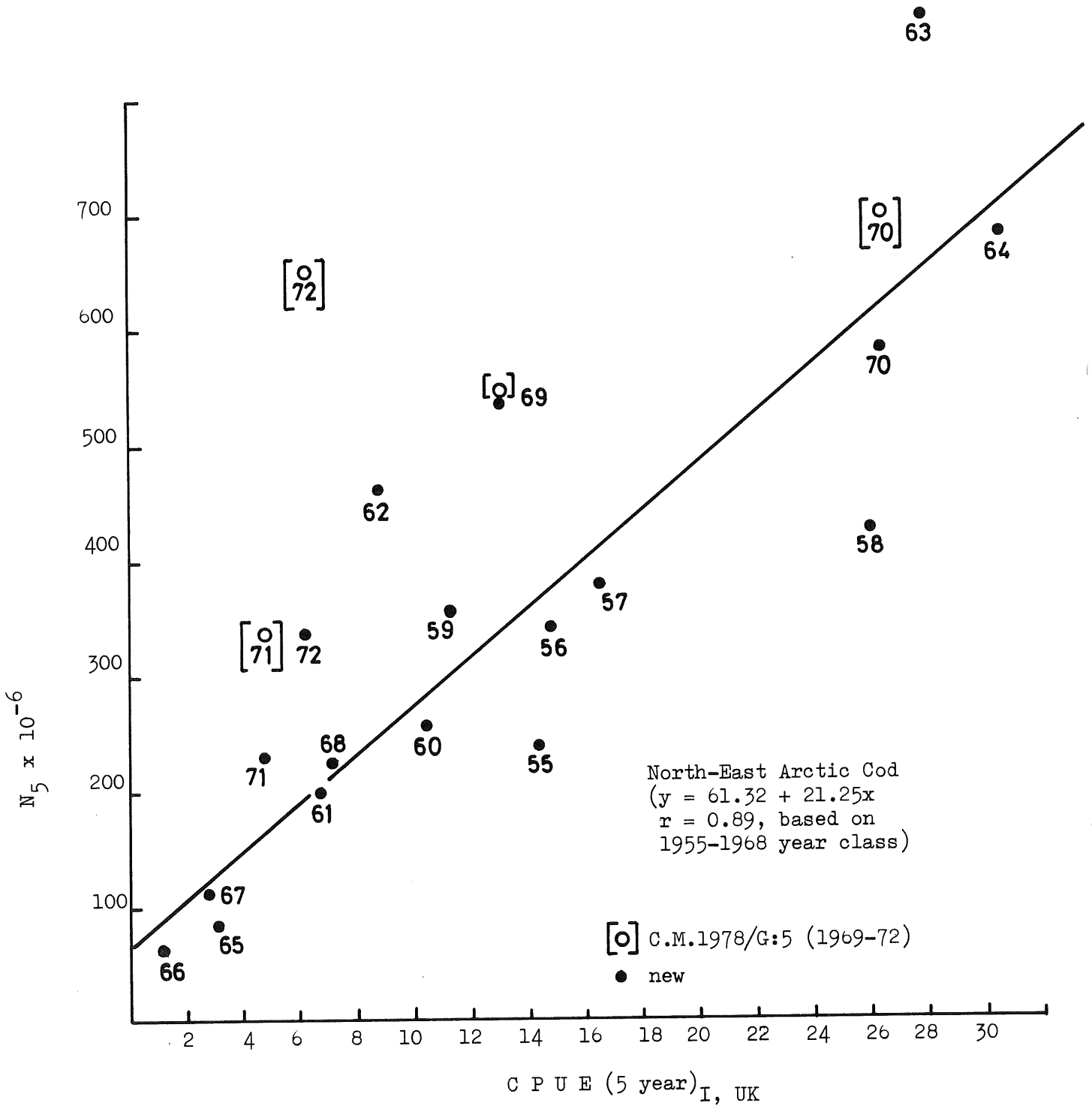


Figure 11 Number of 5 year olds (from the new estimate) versus catch per unit effort of 5 year olds by U.K. trawlers in Sub-area I.



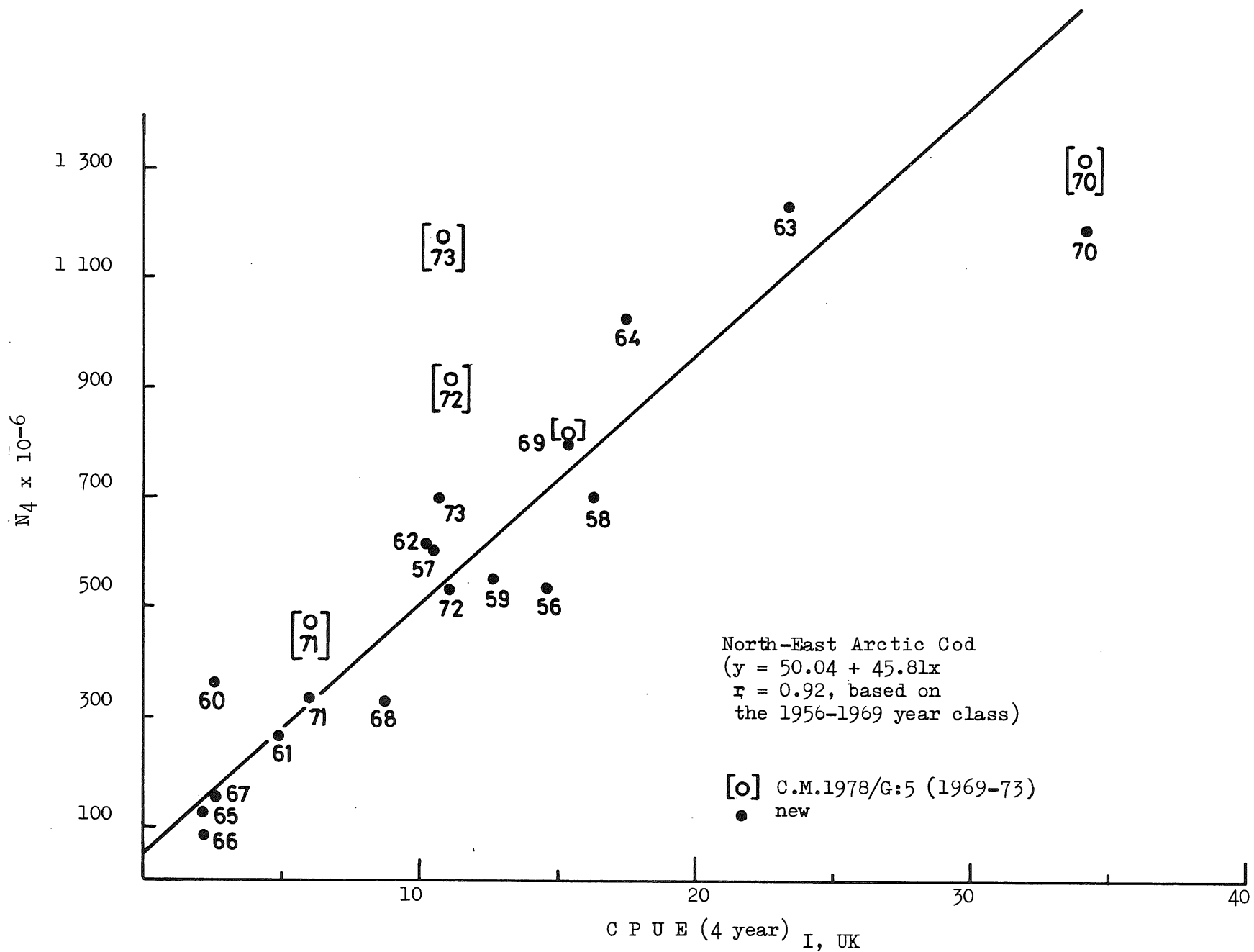


Figure 12 Number of 4 year olds (from the new estimate) versus catch per unit effort of 4 year olds by U.K. trawlers in Sub-area I.

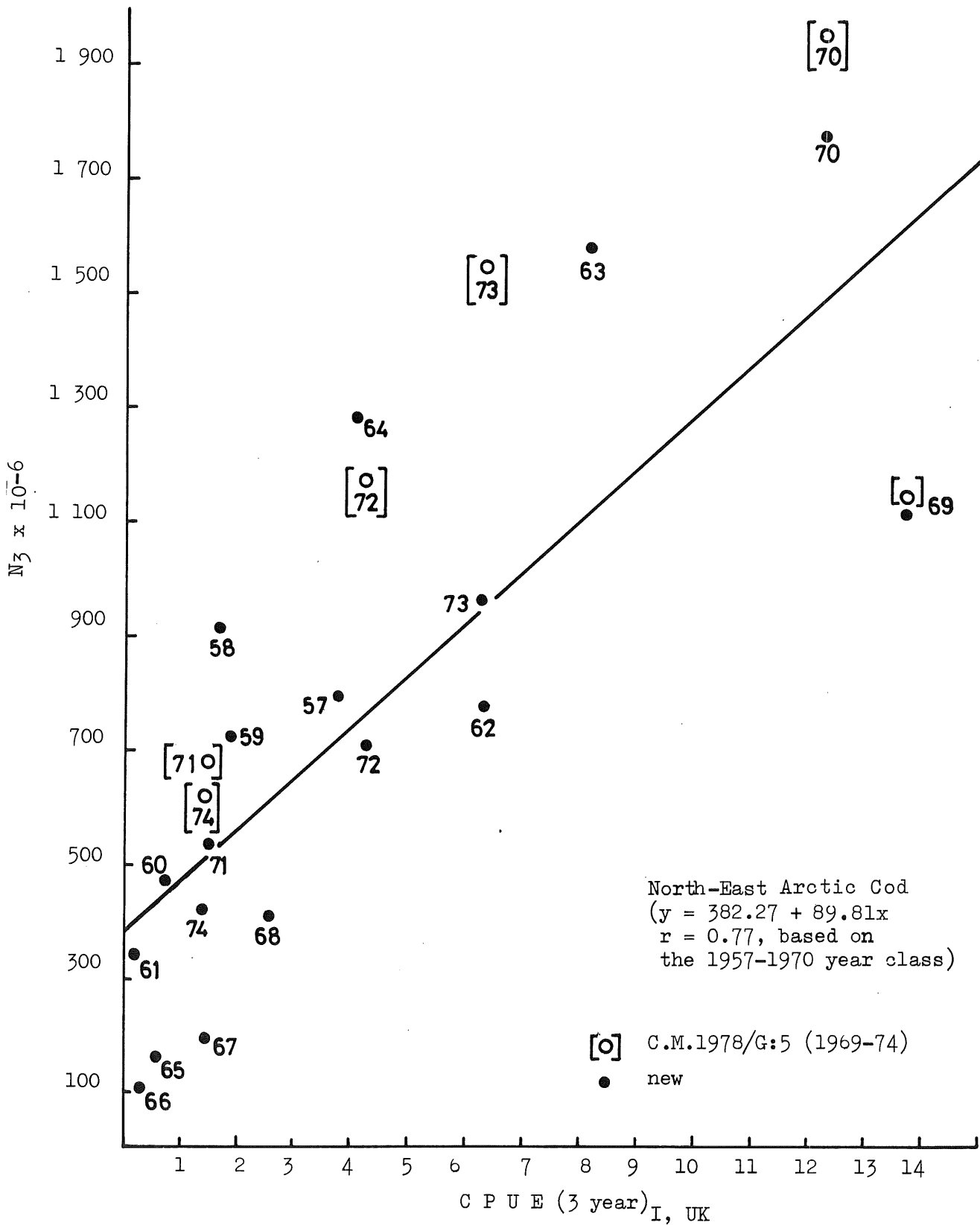


Figure 13 Number of 3 year olds versus catch per unit effort of 3 year olds by U.K. trawlers in Sub-area I. The estimates of the year class strength at age 3 from the VPA adopted in the present paper. (For comparison the estimates in C.M.1978/G:5 are plotted for the 1969-1974 year classes.)

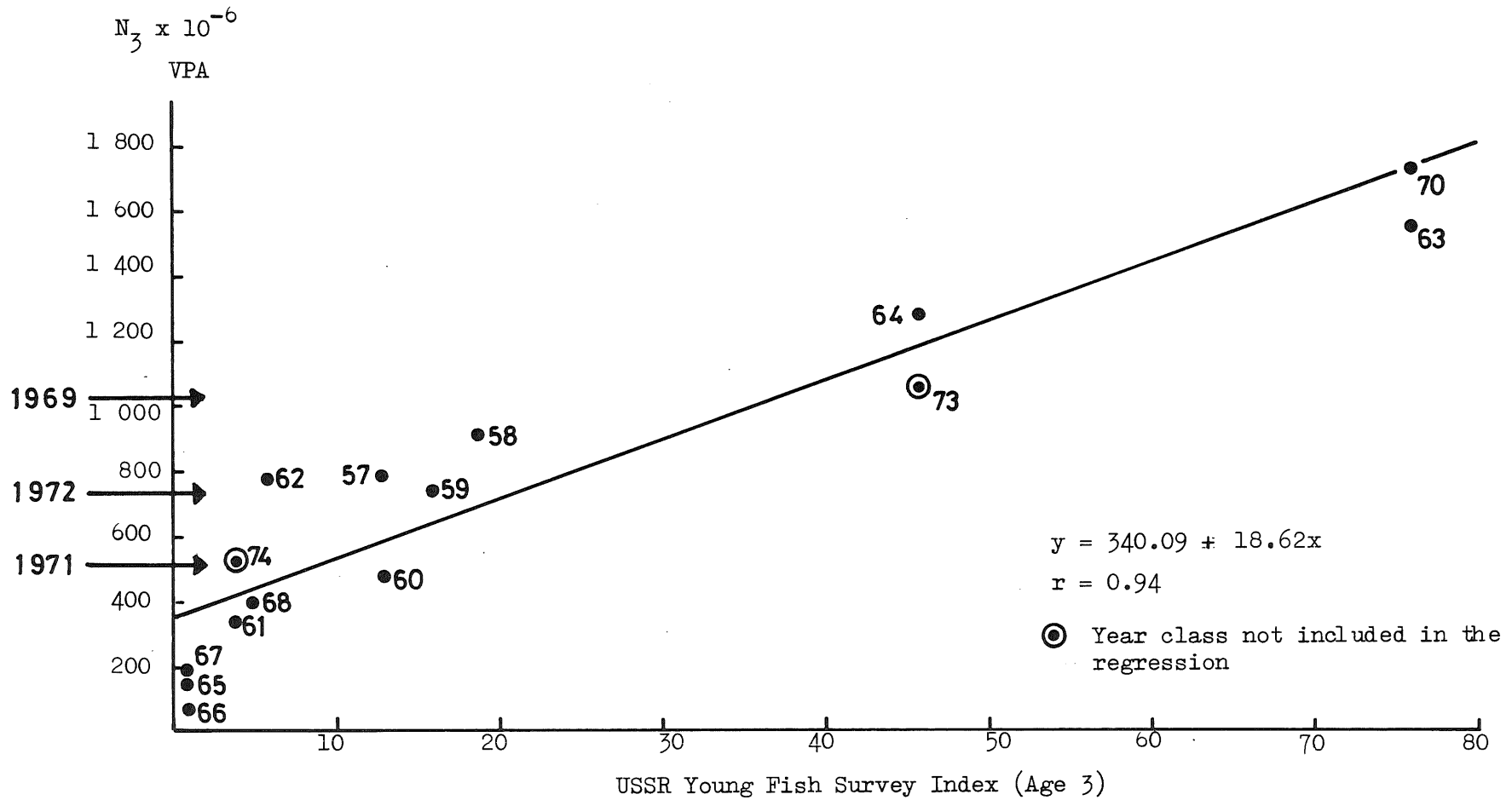


Figure 14 North-East Arctic Cod. Correlation of VPA recruitment estimates on USSR young fish survey for 1957-1970. Recent year classes not included in the regression.

Recruits  
 $N_3 \times 10^{-6}$

VPA

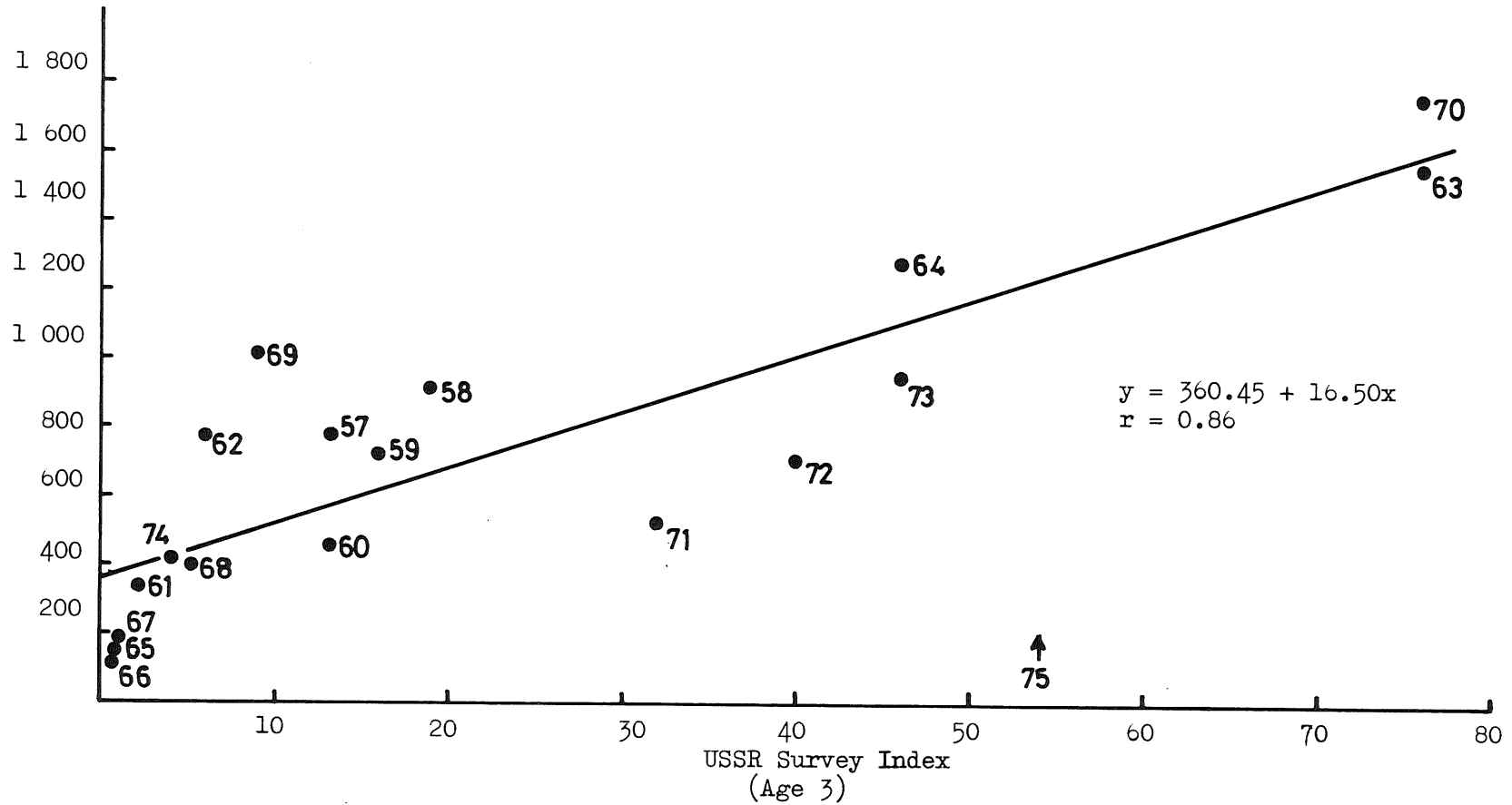


Figure 15 North-East Arctic Cod

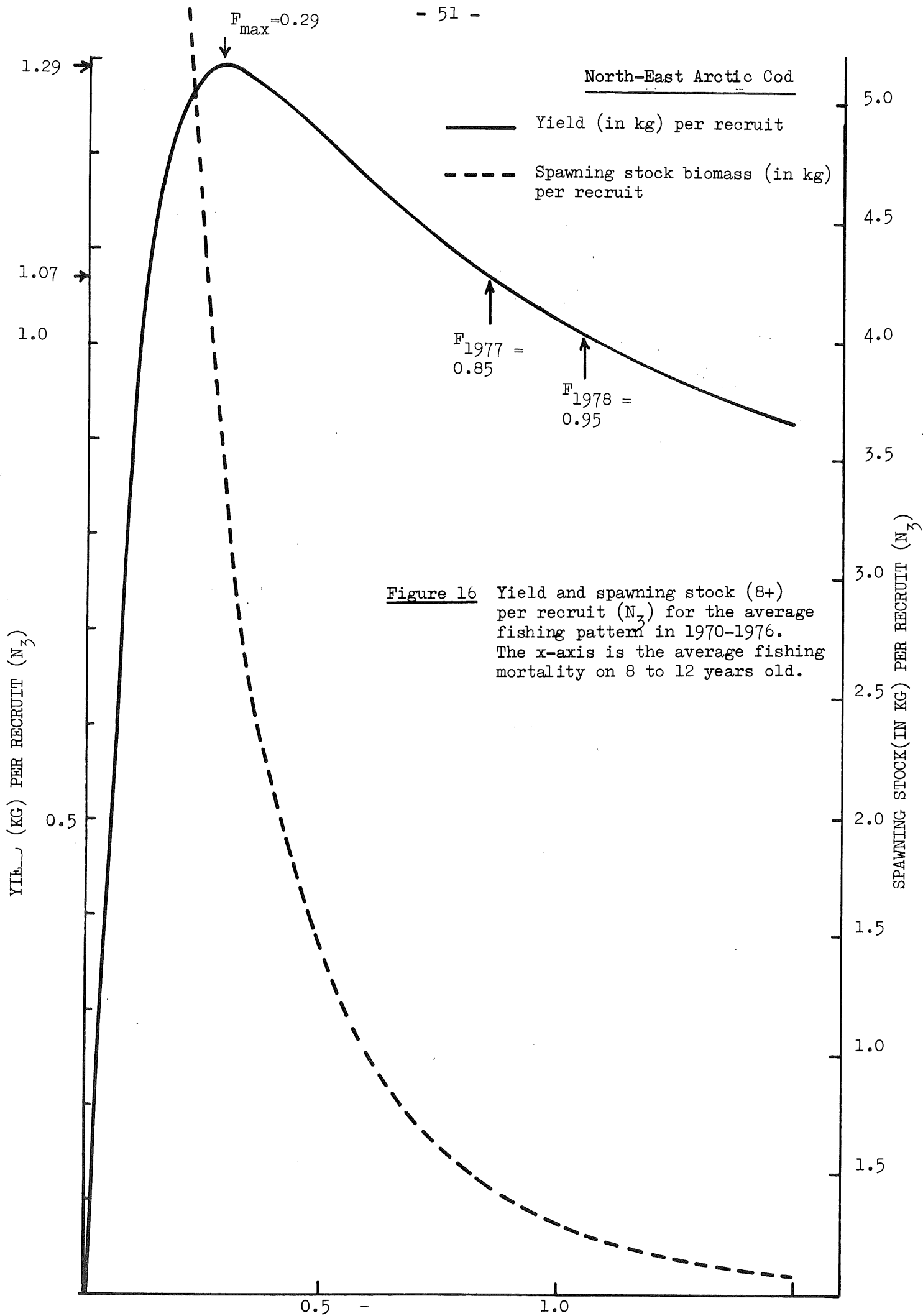


Figure 16 Yield and spawning stock (8+) per recruit (N<sub>3</sub>) for the average fishing pattern in 1970-1976. The x-axis is the average fishing mortality on 8 to 12 years old.