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REPORT OF THE NORTH-WESTERN WORKING GROUP

Charlottenlund, 8-12 March 1976

x) General Secretary,
ICES,
Charlottenlund Slot,
DK-2920 Charlottenlund,
Denmark

Contents

		Page
A.	INTRODUCTION	1
1.	Terms of Reference	1
2.	Participants	1
3.	Previous and Present Assessments	1
B.	COD IN DIVISION Va - ICELAND GROUNDS	2
4.	Nominal Catches	2
5.	Spawning and Non-Spawning Fisheries	2
6.	Effort	2
7.	Age Composition of Landings	3
8.	Mean Weight by Age	3
9.	Virtual Population Analysis	4
10.	Stock Biomass	5
11.	Recruitment	7
C.	HADDOCK IN DIVISION Va - ICELAND GROUNDS	8
13.	Nominal Catches	8
13.	Effort and Catch per Unit of Effort 1970-75	8
15.	Catch in Numbers by Age Groups	8
16.	Mean Weight by Age	8
17.	Input Data to VPA	9
18.	Results of VPA	9
19.	Stock Size	9
20.	Yield Curves	9
21.	Biomass of Stock	10
22.	Catch Predictions	10
D.	COD GREENLAND	10
23.	Nominal Catch (ICES Sub-area XIV and ICNAF Divs. 1E-1F)	10
24.	Effort	12
25.	Catch in Numbers by Age Groups	12
26.	Mean Weight by Age	13
27.	Natural Mortality and Emigration	14
28.	Input Data to VPAs of Cod at Greenland	14
29.	Results of the VPAs and Predictions of Stock Size and Catches for 1976-78	14
E.	INTERRELATIONSHIP BETWEEN THE COD STOCKS AT ICELAND AND GREENLAND	15
30.	Introduction	15
31.	Migration of Adult Fish from West to East Greenland and to Iceland	15
32.	Recruitment to the West Greenland Stock of Cod originating from East Greenland and Iceland	17
33.	Management Problems for Cod at Greenland	18
	TABLES 1 - 21	19
	APPENDIX I, II and III (Iceland Haddock)	39
	TABLES 22 - 33	42
	FIGURES 1 - 10	54

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Report of the North-Western Working Group

A. INTRODUCTION

1. Terms of Reference

At the Council's Statutory Meeting in 1975 the following resolution was adopted (C.Res.1975/2:29):

"It was deciced, that

(i) the North-Western Working Group should meet at Charlottenlund from 19-23 January 1976 (postponed to 8-12 March) under the chairmanship of Mr J Møller Christensen in order to:

(a) investigate the interrelationship between the cod at East and West Greenland and adjacent waters, and

(b) report separately on the state of the stocks of cod and haddock in Icelandic and adjacent waters.

(ii) ICNAF should be invited to participate in the discussions under Item (a), and that

(iii) this report be made available to the STACRES of ICNAF."

2. Participants

A C Burd	U.K. (England)
Sv. Aa. Horsted*	Denmark
J Jakobsson	Iceland
J S Joensen	Faroe Islands
B W Jones	U.K. (England)
R Jones	U.K. (Scotland)
P Kanneworff	Denmark
J Møller Jensen	Denmark
J Møller Christensen (Chairman)	Denmark
S A Schopka	Iceland
A Schumacher*	Germany, Fed.Rep.of
Ø Ulltang	Norway

* also representing ICNAF.

3. Previous and Present Assessments

At its meeting in 1970 the North-Western Working Group made assessments of the stocks of cod and haddock in ICES Division Va (Iceland Grounds). It also made an estimate of the migration of mature cod from East Greenland to Iceland.

The assessments of the cod stocks in these areas were reviewed by the Joint ICES/ICNAF Working Group on Cod Stocks in the North Atlantic in 1972.

At the present meeting the North-Western Working Group made new assessments of the cod and haddock stock at Iceland Grounds (Sections B and C). The Group also made further analyses of the interrelationship between the cod stocks at Iceland and at Greenland (Section E) and assessed the cod stock at Greenland (ICES Subarea XIV and ICNAF Divisions 1E and 1F) (Section D).

B. COD IN DIVISION Va - ICELAND GROUNDS

4. Nominal catches

4.1 Data used

In Table 1 the nominal catches by country for each year of the period 1955-75 are presented. The data are in part taken from "Bulletin Statistique" while others are from national statistics. For comparison, the total catch reported in "Bulletin Statistique" is given in the table. It is seen that the differences between the two sets are small.

4.2 Trends in catches

In the period under review the annual catches of cod have fluctuated between a minimum catch in 1967 of about 345 000 tons to a maximum catch of about 540 000 tons in 1955. Within the period, there have been a number of fluctuations. The catches from 1955 declined until 1961, followed by a recovery to a maximum in 1964. Again the catches declined to a minimum in 1967, followed by yet another recovery reaching a maximum in 1970. Since then the catches have again decreased, the provisional catch in 1975 of about 370 000 tons is similar to the catch in 1974. These recent catches are about 13% below the 20-year average of 424 000 tons.

5. "Spawning" and "non-spawning" fisheries

Reference is made in this report to "spawning" and "non-spawning" fisheries for cod at Iceland. These terms distinguish between the "spawning" fishery exploiting primarily the spawning aggregations in the spring season to which non-Icelandic vessels do not have access, and the "non-spawning" fishery which includes all the other fisheries. These terms are used for convenience only, but can be misleading because the "spawning" fishery catches a proportion of immature fish as well as mature adults and conversely the "non-spawning" fishery exploits the whole age range including mature adult fish.

6. Effort

6.1 Data used

The data on English effort (trawling hours) are based on "Bulletin Statistique" for the respective years. The data on Icelandic effort (trawling hours or days absent) are based on "Bulletin Statistique" for 1972 and later years and on unpublished national statistics supplied by the Fisheries Association of Iceland for 1970 and 1971.

6.2 Effort and catch per unit of effort 1970-75 - Non-spawning fisheries

Total numbers of hours' trawling for the English trawlers, separated into steam and motor trawlers are given in Table 2.a. The steam and motor trawlers had about the same catch per hour trawling. Hours' trawling for the two categories were therefore summed to give an estimate of total English effort. This increased from 1970 to 1972 and then gradually decreased again to 1975. Catch per hour trawling showed a total decrease of about 30% from 1970 to 1975.

The English catch per effort data have been used to derive a measure of the total international effort in the non-spawning fisheries. This effort increased by 28% from 1970 to 1971 and then gradually decreased to 1974. In 1975 it increased rather sharply again to about 30% above the 1970 level. The English effort raised to the total catches gives an estimate of the total effort in English units which would be needed to take these catches.

Icelandic data on trawl effort (Table 2.b, c and d) were separated into trawlers bigger than 500 BRT (Table 2.b), Icelandic multigear boats (Table 2.c) and the new

Icelandic stern trawlers smaller than 500 tons (Table 2.d). The effort figures given are the total trawling effort regardless of species sought.

The contribution of cod to the total catches has varied between years and categories. Without knowing the proportion of the effort which has been directed towards cod, the total Icelandic trawling effort on cod cannot be estimated in the way in which it was done for English effort. Tables 2.b - 2.d, however, give indications of what changes there have been in effort during the period 1970-75.

Effort of big trawlers and multi-gear boats has been rather constant during the period, while there has been a big increase in effort of stern trawlers (300-500 BRT). There is no special trend in the catch per hour trawling for big trawlers (> 500 BRT) and stern trawlers (300-500 BRT) during the period. Catch per day absent for multi-gear boats shows, however, a rapid decrease with time.

6.3 Effort and catch per unit of effort 1970-75 - Spawning and mixed fisheries

Icelandic data for effort in the gillnet fisheries (Table 2.e), long-line fisheries (Table 2.f) and hand-line fisheries (Table 2.g) show some increase in effort for gillnet and hand line during the period and a rather stable level for long line. There is a rather consistent and considerable decrease in catch per unit of effort for the three categories.

6.4 Conclusions

In both the non-spawning and the spawning fisheries there has been an increase in total effort from 1970 to 1975. There has been a considerable decrease in catch per unit of effort in the spawning fisheries. There has also been some decrease in catch per unit of effort in the non-spawning fisheries.

7. Age composition of the landings

Age compositions of national landings were available as numbers landed in each age group in each year for the main countries involved in the fishery - Iceland, England and Federal Republic of Germany - for the period 1955-75.

For Icelandic landings age compositions were presented for the non-spawning and the spawning fisheries separately. Many of the data have been revised since the last meeting of the Working Group.

To obtain the age compositions for the total fishery in each year, the age compositions of England, the Federal Republic of Germany and the Icelandic non-spawning fishery were first summed. This total was then raised by the ratio of the landed weights:

$$\frac{\text{England \& Germany (Fed.Rep.) \& Iceland "non-spawning" \& other Countries}}{\text{England \& Germany (Fed.Rep.) \& Iceland "non-spawning"}}$$

This gave the age compositions of the total landings from the non-spawning fishery. The age composition of the Icelandic spawning fishery was then added to give the age composition for the total fishery (Table 3).

8. Mean weight by age

Mean weight by age is required in order to convert into biomass the stock sizes in number derived from VPA. Neither in the Icelandic material nor in the English data have measurements been made routinely on weight per age group.

From both countries, data are available for mean length per age. These have been converted to weight by means of weight/length regressions. The parameters of these regressions are given at the bottom of Table 4. When the

Icelandic data were examined over the period 1965-75 it was seen that there was no trend with time, Tables 5.a and b. It was decided to use mean values for the period 1970-74 for further use in calculating biomasses.

When the weights at age given in Table 4 are applied to the catches in number at each age for the three major fisheries, i.e. non-spawning Icelandic and English and spawning Icelandic, the sum of products is within 5% of the observed catches.

The mean weights to be applied to the total stocks have been derived in the following manner. The Icelandic non-spawning values were taken as representative of the catches in the non-spawning Icelandic fishery and the German fishery. The English data were applied to the English catches and all other countries. The Icelandic spawning data were applied to that fishery. Weighted means were taken which are presented in the final column. (Table 4).

The sum of products of the stock numbers and relevant mean weights at age give tonnages close those observed in the period 1970-74.

9. Virtual Population Analysis

9.1 Input data

The age compositions used for the VPA were derived as described in Section 7, and these are given in Table 3. Natural mortality has been taken as M = 0.2. The values of the fishing mortality coefficient for 1975 which are used to initiate the computation were based on the values calculated for 1970 in a preliminary VPA run. For this preliminary run any error on the calculated F values associated with incorrect assumptions of F in 1975 will be minimal for 1970 as the errors become reduced as calculations proceed backwards in time. Thus, the calculated F values for 1970 from the preliminary run have been accepted as valid. Analysis of fishing effort data (Section 6, Table 2.a) indicated that for the non-spawning fishery the effort in 1975 had increased by 30% compared with 1970. Three trial runs were, therefore, made taking as input F values for 1975 the values for 1970 increased by 20%, 30% and 40% respectively. Initially, however, some adjustments and smoothing were made to the 1970 F values as indicated in Table 6 where the actual input values for F in 1975 used in the three runs are given in Columns (C), (D) and (E).

Table 7 gives the calculated F values for 1970 for each of the three trial runs. This shows clearly how little these 1970 F values are influenced by variation in input values for 1975.

9.2 Results

As a check on the suitability of the input F values for 1975, the trend in fishing mortality estimates from the VPA for the years 1970-75 have been compared with the trend in estimated fishing effort over the same period. This is illustrated in Figure 1, where the average F, weighted by stock size, for age groups 4-6 relative to the 1970 value are plotted against the estimated relative fishing effort in the non-spawning fishery calculated in English trawling hours. The VPA run using F_{1970} + 40% for the 1975 F input values was adopted by the Working Group as the basis of the assessment of the state of the cod stock. Estimates of F values and stock size in each year from this VPA run are given in Tables 8 and 9.

As a further means of obtaining some independent check on these fishing mortalities, the weighted means obtained from VPA have been plotted on the mean total mortalities obtained from English catch per effort data, Figure 2.

Assuming the natural mortality component in the total mortality to be M = 0.2 as used in the VPA, a line has been drawn through this point on the X-axis and the coordinates of the mean values of X and Y. This line has been used to predict the VPA fishing mortalities for 1973-74. These values are of the same order as those used as VPA inputs for these age groups in 1975, giving some independent support to their use.

The F values calculated in the Iceland VPA will be biassed to some extent by immigration of cod from Greenland. This would be expected to show as lower estimates of F in the younger age groups. In fact, if the F values on age groups 4-6 are examined year class by year class, it is clear that the year classes with the lowest calculated F values are those which are recorded as most abundant at East and southern West Greenland. This inverse correlation between Greenland cod year class strength and calculated F from the Iceland VPA are illustrated in Figure 10, Section E.

10. Stock Biomass

10.1 Total stock

For the age groups 3 years and older the total biomass was calculated by multiplying the stock size in numbers (Table 9) in each age group with the corresponding mean weight of that age group using the mean weights in Table 4. During the period 1955-75 the stock biomass was at the highest level in the first year of observation (1955) (Table 10). In that year the stock was 2.6 million tons. The overall increase in F in the late 1950s and early 1960s combined with poorer or an average recruitment resulted in a decline. The total biomass decreased in the stock to a minimum of 1.5 million tons in 1965. From 1966 to 1969 it increased again following an increase in year class strength at Iceland due to better recruitment there (the 1964 year class) and an immigration of the abundant 1961-63 East Greenland year classes. Since 1970 there has been a very rapid decline in the total biomass so that in 1974 the total stock biomass was at the lowest level in the whole period of just above one million tons. This decline was again connected with somewhat poorer recruitment at Iceland, lack of Greenland immigrants, and further increases in fishing mortality, particularly on the younger age groups.

10.2 Spawning stock

The changes in the spawning stock biomass (cod 7 years and older) have shown similar trends in the total stock biomass, but these fluctuations have been of much greater magnitude (see Figure 3). The spawning stock (1 January each year) reached a maximum of 1.2 million tons in 1957 when the strong 1950 year class recruited to the stock. The spawning stock then declined from year to year to a minimum of 237 thousand tons in 1967. Combined with the overall increase in the total stock biomass in the late 1960s the spawning stock increased again to a peak of 673 thousand tons in 1970 due to the immigration of mature cod from Greenland waters. Since 1971 the spawning stock has declined very rapidly and in 1975 it was estimated at the lowest recorded level of only 230 thousand tons.

10.3 Yield per recruit and spawning stock biomass per recruit

Figure 4 shows the change in biomass with age (age 3 to 15) in an unexploited year class, assuming M = 0.2 and using the mean weights at age given in Table 4. The biomass increases considerably from age 3 to age 5 and is at a maximum at age 6-7. It then decreases as the annual increment in weights is not sufficient to counterbalance the loss due to natural mortality. The shape of the curve in Figure 4 from age 8 onwards is probably somewhat distorted because of the large variance in mean weights in these age groups due to sampling problems.

Figure 5 shows the yield per recruit of the cod at Iceland under the present exploitation pattern, as well as stock biomass per recruit with varying fishing mortalities. The exploitation pattern assumed is shown in the text table below:

Age	3	4	5	6	7	8	9-15
Relative F	.13	.41	.48	.51	.53	.67	1

The present situation and the position of $F_{0.1}$ are indicated with arrows. The relationship between various combinations of fishing mortality, stock biomass and yield per recruit is summarised in the following text table:

Present situation	Y/R	% of Y/R max	S/R	$S/R \times R_{55-70}$
of F = 1.05	1.59	99	0.7	154 000 tons
F = 0.6	1.61	100	2.0	440 000 tons
F = 0.40	1.56	97	3.6	792 000 tons
F = 0.20(F 0.1)	1.40	87	6.5	1 430 000 tons

This shows that the present fishing mortality is about 5 times the $F_{0.1}$ advocated as a guide to optimum exploitation of fish stocks. Assuming an average recruitment and unchanged exploitation rate the spawning stock will stabilise at about 150 000 tons or at a level of about 11% of that resulting from fishing at $F_{0.1}$. The fishing mortality giving the maximum yield per recruit is 0.6. However, the curve is flat-shaped and the Y/R does therefore not change significantly over a wide range of F.

The above comments relate to the yield per recruit curve for the present exploitation pattern. Alternative exploitation patterns might give greater yield per recruits.

The sharp increase in biomass between ages 3 to 5 (Figure 4) reflects the relatively high growth rates at these ages. Thus restriction of fishing mortality in these age groups could considerably increase the yield per recruit under certain fishing patterns.

11. Recruitment

From the VPA reliable estimates of recruitment may be obtained only as far as 1973 (1970 year class). The estimates of stock of 3 year olds from VPA for Iceland and East and West Greenland (IE-F) are shown in Table 11. In the latter series there is a marked decline in recruitment in recent years which has partly been associated with a climatic change. The Icelandic data show no such trend but fluctuate about a mean of 220 million fish.

From catches per effort, estimates of the year class strengths up to 1975 may be derived. Abundance indices from the English trawler catch per effort of 3 year old fish have been correlated with the estimates of the numbers of 3 year old fish from VPA in Figure 6 for the period 1961-73. The regression is significant at p = .02 and could be used as an aid to check input data for the VPA and catch predictions. It might be concluded that the 1971 and 1972 year classes approach the average.

As a check on this relation which might be biassed by the concentration of trawlers, the relation between VPA recruitment as 4 year olds and the corresponding abundance as catch per effort is also shown (Figure 7). From this it would seem that in relation to the 1970 year class the 1971 year class is about half that strength.

The only information available for more recent year classes is that derived from 0-group surveys off Iceland. These are given in Figure 8, together with their estimates of abundance as 3 year olds in the English catches. For comparison the mean for the 1958-69 year classes is shown.

Since the International 0-Group Surveys started in 1970 there are reasonably good estimates for two year classes from VPA, the 1970 and the 1971 year classes. These appear in the same ratio in both sources of information. Judging by these two year classes, it could be inferred that the results of these surveys could also be of some use in checking VPA input data and making catch predictions.

12. Summary and Conclusions - Cod at Iceland

12.1 The recent fishing mortality levels given by the VPA analyses show a considerable increase from 1970 to 1971 followed by a reduction in 1972 and 1973. This is in quite good agreement with the effort data. If the effort data can be taken as a reliable indicator, the fishing mortality has increased again in 1974 and 1975.

12.2 Total stock biomass and spawning stock biomass have been declining in recent years (see Figure 3 and Table 10).

12.3 During the period 1955-73, year class strength at 3 years old has fluctuated (see Table 11). No stock/recruitment relationship could be established. There is no evidence of recruitment failure up to the 1970 year class which is the last year class for which the abundance can be established with reasonable confidence.

It should be noted that the present spawning stock is only about 30% of the level in 1970.

12.4 Catch predictions have been prepared using the VPA fishing mortality input values for 1975 and assuming that this exploitation pattern and level of fishing mortality is maintained until 1978.

The starting stock size at 1 January 1975 was as follows:

Age Group	Numbers in Millions
3	248.7
4	90.2
5	122.5
6	33.0
7	28.3
8	9.1
9	3.7
10	1.4
11	1.9
12	0.8
13	0.1
14	+

Recruitment of 3 year old fish for the years 1976-78 has been assumed to be equal to long-term average (220 millions) with an alternative calculation, where these year classes have been assumed to be the lowest recorded year class strength for the year classes 1952-70 (140 millions).

12.5 The results of these calculations give the following catches in thousands of tons:

	1976	1977	1978
R_3 = 220 million	359	355	352
R_3 = 140 million	349	309	274

The corresponding spawning stock biomass in thousand tons for these three years will be:

180 (1976), 217 (1977) and 155 (1978).

It should be noted that these estimates of spawning stock size are independent of the assumptions of recruitment made above, because these recruits will not contribute to the biomass of spawners by those years.

12.6 The present fishing mortality is far above the level needed to give maximum yield per recruit with the present exploitation pattern. If fishing mortality was reduced to $F = 0.6$ (F_{max}) this would in the long term almost double the catch rate and give the possibility for trebling the spawning stock biomass, although the yield per recruit will be increased by only 1%.

There will be many advantages if fishing mortality was reduced slightly below $F_{max} = 0.6$. The yield per recruit will be virtually unchanged, the total stock size and the spawning stock size would increase, and the risk of recruitment failure would be reduced.

A further reduction of F to about 0.4 would give 97% of the maximum yield per recruit and a spawning stock biomass of about five times that corresponding to the present level of exploitation.

C. HADDOCK IN DIVISION Va - ICELAND GROUNDS

13. Nominal Catches

13.1 Data used

As with the cod, the catch data used in the report for assessment are presented by countries in Table 12. Again it is seen that the annual total catch seems in close agreement with the "Bulletin Statistique" figures.

13.2 Trends in catches

The catches reached a maximum in 1962 with a catch of about 120 000 tons. Since then the catch has declined to a level of about 44 000 tons in 1975. This latter catch represents a decrease of 35% from the 20-year average of about 68 000 tons. While this decrease has taken place the Icelandic share of the catch has increased from 38% for the 5-year period 1955-59 to 75% in the period 1970-74.

14. Effort and Catch per Unit of Effort 1970-75

A large proportion of the haddock catch is taken as a by-catch in the cod fisheries by Icelandic vessels. Because of this, it was thought that for this species, the catch per unit effort data and the estimates of total fishing might prove misleading. No effort and catch per unit effort data have been tabulated therefore.

15. Catch in Numbers by Age Groups

Numbers landed at each age have been estimated for the period 1962-75 (Table 13). Age composition data were supplied by Iceland, Germany (Fed. Rep.), England and Scotland. For Iceland the data provided for the previous meeting of the Working Group have been revised and updated. The data were combined annually and raised by weight to provide estimates of the total international landings for each age group for the entire period.

16. Mean Weight at Age

Table 14 shows estimates of mean weight at age from Icelandic data. These were determined from length at age data, converted to weights using the relationships shown in Table 14. Unlike the cod data, it is seen that there is a marked increase in weight in recent years. Means have been taken for the period 1971-75 for use in calculating biomass. Fish of 10 years and older have been raised using the mean weight for 10 year olds.

17. Input data to VPA

Input values of F were required for the oldest age group (≥ 10 years) and for each age group for 1975. Three trial sets of input values were adopted and these are shown in Table 15. Input set A was chosen to represent the probable "average" situation. Input sets B and C were chosen with 1975 values that were likely to be too high (set B) or too low (set C). The natural mortality rate was assumed to be constant, and a value of M = 0.2 was adopted.

18. Results of VPA

Table 16 shows the values of F obtained using one of the three sets of input data tabulated in Table 15 (set B). Comparison of the three sets showed that in the period 1962-71 in spite of the wide variations in the input values of F for 1975 reasonably consistent values of F were obtained. For 1973 and 1974, the values of F were found to be sensitive to the input values used.

19. Stock size

Table 17 shows the corresponding estimates of stock size obtained from the same VPA run. It was noted that, as in the case of the estimates of F, the values obtained for the four most recent years were sensitive to the input values of F adopted for 1975.

20. Yield curves

Yield per recruit curves were calculated for various changes in effort and exploitation pattern. Because little reliance could be placed on the estimates of F from VPA for the years 1972-75, a reference exploitation pattern was determined for the period 1967-71. For this period, a mean value of F was calculated for each age. Data for earlier years were not included, since the cod end mesh size was increased from 120 to 130 mm in January 1967. The values of F obtained in this way are given in Table 18, column A. These values were used for determining the equilibrium yield per recruit for the conditions pertaining to the period 1967-71 using the method of computation given in Appendix I. The long-term effect on this yield per recruit of various percentage changes in fishing effort was then calculated. An example of the computation method is given in Appendix II. The results are plotted in Figure 9, which also shows the results of similar calculations for different exploitation patterns.

Curve A in Figure 9 shows the effect of changes in effort using the exploitation pattern for the period 1967-71. Curve B shows similar results assuming an increase of 0.5 years in the mean age of first exploitation. Curve C shows similar results with the mean age of first exploitation increased by 1 year. Intervals of 0.5 and 1.0 years were adopted since these represent the approximate times required for haddock to grow from the 50% retention length of a 130 mm cod end to the 50% retention length of cod ends of 140 mm and 150 mm respectively. The exploitation pattern used in the assessment are tabulated in Table 18. These results indicate that in the long term:

1) a reduction in the F values from the 1967-71 level could increase the yield per recruit by up to 5%. An increase in F values, such as may have occurred in the years since 1971, could have led to a decrease in the yield per recruit. An increase in F values of 30% for example, would decrease the yield per recruit by 5%.

2) An increase in the age of first capture equivalent to one year would lead to increases in the yield per recruit. At the 1967-71 level of F for example, the increase would be 12%. It is assumed that the stated increases in the age of first capture refer to all gears equally.

21. Biomass of stock

Table 19 shows estimates of the biomass of the stock and of the spawning stock from 1962-75. The results show that there has been a significant decline for both stock components.

22. Catch predictions

Predictions have been made of haddock catches for the period 1976-78 (Table 21). The method of computation is illustrated in Appendix III. Input data consisted of:

1) numbers landed at each age in 1975;
2) mean weights at age, based on averages for the period 1971-75 (Table 14);
3) a natural mortality rate (assumed M = 0.2);
4) values of F at each age. Calculations were done using two of the sets of F-at-age for 1975 given in Table 15; and
5) estimates of year class strengths for the 1974-76 year classes as 2 year old fish.

Values of haddock year class strengths from the VPA results are given in Table 20 and for each of the three input sets of F used in these analyses. These show that the estimates of year class strength at age 2 years were effectively independent of the input F values for the year classes 1960-70. For these year classes the mean value was 64 million fish and this value has been used for the sets of predictions in Table 21.A.

A second sets of predictions (Table 21.B) were made assuming 30 million fish for the 1974-76 year class strength, this being the lowest year class strength observed in the 1960s.

For each of the assumptions made about the F values in 1975, catches are expected to decline in 1976 and 1977. Estimates for 1978 depend on the values assessed for the strengths of the 1974-76 year classes. It should be noted that the further ahead the forecasts are made, the more depend the predictions on estimates of the recruiting year class strength. For example, a large proportion of the predictions given for 1978 in Table 21 are due to the values adopted for strengths of the 1974-76 year classes.

In view of the relatively high variability of year class strengths in practice, the confidence limits for these estimates and for the 1978 estimates in particular, are likely to be large.

D. COD - GREENLAND

23. Nominal catch (ICES Sub-area XIV and ICNAF Divs. 1E-1F)

23.1 Data used

The catches of cod in Greenland waters are reported nationally through the STATLANT system to ICNAF and ICES for West Greenland (ICNAF Subarea 1) and East Greenland (ICES Sub-area XIV), respectively. The ICNAF Subarea 1 is further split into six divisions (Divs. 1A-1F) whereas no further breakdown of the ICES Sub-area XIV exists at present.

In its present report the North-Western Working Group has as far as cod is concerned confined itself to analyses of the stocks at Iceland, at East Greenland and off the southern part of West Greenland (ICNAF Divs. 1E-1F), The inclusion in the analyses of only part of the ICNAF Subarea 1 creates some difficulties since some countries have reported part of their catch or even their total catch at West Greenland as Div. 1NK, i.e. without a breakdown on statistical divisions. It has, therefore, been necessary to allocate such unspecified catches by divisions. The allocation here adopted is the one used by the Greenland Fisheries Institute (Horsted, unpubl.), and which is also used in analyses by ICNAF (Horsted, ICNAF Res.Doc. 75/31). The allocation is made partly on various assumptions, e.g. that unspecified catches from one country are distributed like specified catches from the same country, and partly on observations on fishing activities at Greenland. A full list of the allocations and the principles followed is available in the Greenland Fisheries Institute, but is not given here.

In order to show the magnitude of the problem, the unspecified catches (Div. 1NK) are given in Table 22 together with the total amount of these catches which is allocated to Divisions 1E and 1F and added to the specified Divs.1E-1F catches to give the best estimate of the actual nominal catch from these divisions. The figures for which a part or the total amount of catch has been based upon allocation from Division 1NK are marked with an asterisk in the table. It will be seen that of the annual totals for Divisions 1E-1F cod catches up to about 40% of the total have been allocated from unspecified catches, 1974 being the only year for which all catches were reported by divisions.

The nominal catches for the fisheries at East Greenland (Sub-area XIV) are readily available in ICES "Bulletin Statistique". For 1975, members of the Working Group supplied provisional data at the meeting. Sub-area XIV covers a wide area, and although the cod fisheries in that area are known to occur between Cape Farewell and the Dohrn Bank it is not possible to break catches down by smaller units. The problem of a probable break-down of Sub-area XIV was discussed briefly by the Working Group but referred to the ICES Statistics Committee.

23.2 Trends in catches

23.2.1 Nominal catches of cod in ICNAF Divisions 1E-1F, 1960-74

As explained in Section 23.1, the nominal catches for Divisions 1E-1F as set out in Table 22 contain part of some catches reported as West Greenland unspecified (ICNAF notation: Div. 1NK).

In the course of the late 1960s the cod fisheries at West Greenland (ICNAF Subarea 1) had a tendency to concentrate more on the southern Divisions (Divs. 1E-1F) than previously, and by 1970 about half the West Greenland catch was taken in those Divisions. Whereas the overall Subarea 1 cod catches reached a maximum in 1962, the Divisions 1E-1F fishery obtained its highest catch in 1968. However, since then, this part of Subarea 1 has also faced the same drastic decline as the Subarea 1 fishery as a whole, and the relative importance of the Division has dropped again to about $\frac{1}{4}$ of the total of West Greenland (Table 25). The catch in Divisions 1E-1F by 1974 was only about 12% of the catch in the peak year 1968.

Catches for 1975 are not yet known by Division, but the overall Subarea 1 catch seems to have had a further small decline from 1974.

The fishery in Subarea 1 as a whole has been under quota regulation since 1974, but neither in 1974 nor in 1975 has the total allowable catch been taken. The TAC for 1976 is 46 thousand tons.

23.2.2 Nominal catches of cod off East Greenland (ICES Sub-area XIV) 1960-75

The fishery off East Greenland is almost entirely due to trawling, with a few nations participating, primarily the Federal Republic of Germany and Iceland. The target species are cod and redfish, and although fishing can be directed to one of these species the by-catch of the other species is normally so high that it seems proper to speak of a mixed fishery of the two species. Up to 1969 redfish made up the major part of the fishery but since 1970 cod is the predominant species.

In the period 1960-72 the total catch of cod in the area (Table 23) has fluctuated between 13 and 36 thousand tons (1960-72, mean: 22 100 tons), with 1964 and 1971 as the peak years (35 600 and 31 500 tons, respectively). A drastic decline in the catches has occurred after 1972 with a provisional figure for 1975 of only 3 400 tons or 15% of the 1960-72 level. This decline is closely combined with a decline in effort seen in Section 24.

23.2.3 Nominal catches of cod at East Greenland and off Southwest Greenland as a whole (ICES Sub-area XIV and ICNAF Divisions 1E-1F), 1960-74

The cod catches in ICES Sub-area XIV and ICNAF Divisions 1E-1F mentioned in the preceding sections are combined in Table 24. For the combined area the cod catches have fluctuated between 74 and 130 thousand tons in the period 1960-71, the mean for the period being 99 thousand tons. Peak years are 1963 and 1968, both with 130 thousand tons. A drastic decline is observed after 1971, and the 1974 catch is only about 20 thousand tons or 20% of the 1960-71 level.

24. Effort

24.1 Data used

Both ICES and ICNAF request countries to report fishing effort. For East Greenland (ICES Sub-area XIV) the effort figures as set up in Table 26 were obtained from the German research reports to ICNAF (by A Meyer). This effort is an effort directed partly to cod and partly to redfish or to both species combined. The catch per unit effort as a measure of cod abundance must, therefore, be taken with great reservation.

For ICNAF Divisions 1E-1F no attempt was made by the Working Group to set up a table of an overall effort for the area. Such an exercise would, of course, also contain the same problem of allocation as with the nominal catches.

24.2 Trends in effort

Due to the complexity of the fisheries at West Greenland and the problem of allocating unspecified catches no attempt has been made recently to obtain effort-unit figures for ICNAF Divisions 1E-1F separately.

As explained in para. 24.1 some effort figures can be given for the fisheries off East Greenland (Table 26). These clearly demonstrate a decrease of effort after 1972, so that the level of effort by 1974 is 1/4 - 1/5 of the high lev[illegible] in the mid-1960s. The catch-per-unit of effort figures vary considerably, being highest in 1971. The c.p.u.e. level in 1974 falls within the same range as the figures in the 1960s. However, due to the mixed nature of the fisheries, no definite conclusions are drawn from these c.p.u.e. figures, nor has it been considered appropriate to use these figures to obtain an overall effort for ICES Sub-area XIV and ICNAF Divisions 1E-1F combined. However, the low catch figures for Divisions 1E-1F in recent years do suggest that effort has declined also in these Divisions and hence also in the combined Sub-area XIV-Divisions 1E-1F area.

25. Catch in Numbers by Age Groups

25.1 ICNAF Divisions 1E-1F

The numbers by age groups for the cod catches in ICNAF Divisions 1E-1F for the period 1960-75 are given in Table 27. These figures are taken from ICNAF Res.Doc.75/31 (by Sv. Aa. Horsted) for the years 1965-73, and for the years 1974-75 they are preliminary estimated by Horsted. For the years prior to 1969 (including 1960-64) the basic material is submitted by the Federal Republic of Germany (Schumacher and Meyer, unpubl.), and adjusted to the total catches for Divisions 1E-1F as they occur after allocation of unspecified West Greenland catches (see para.23.1). The German method of raising samples to catches has generally been based on the observed weight of the total sample, whereas Horsted's figures are based on samples for which a total weight has been calculated by applying mean weights for each age group. This latter method may lead to more heavily biassed figures than the former, but the method has been the only possible one since few samples with observed total weight exist for recent years. For the years 1974 and 1975 it has even been necessary to use samples from catches containing a mixture of fish from various divisions. The figures given for 1974 and 1975 are, therefore, very uncertain, although the 1968 year class has the expected very strong predominance.

25.2 East Greenland (ICES Sub-area XIV)

The numbers by age group for the cod catches off East Greenland as given in Table 28 are based on figures for the German (Fed.Rep. of) catches made available to the Working Group by A Meyer. The raising of numbers in samples to numbers in catches is based on observed total weight of the samples. The figures supplied by A Meyer have been raised to total Sub-area XIV cod catches by the Working Group. Since German catches account for the major part of the Sub-area XIV catch, the possible bias by this latter raising seems to be very small. However, due to the wide statistical area, it is not clear whether great variation in catch composition exists between the northern part (the Dohrn Bank) and the southern part (close to Cape Farewell), nor to judge whether the whole area, if fished, is covered by the sampling.

25.3 ICES Sub-area XIV plus ICNAF Divisions 1E-1F

The numbers by age group for the overall southwest and East Greenland cod catches as given in Table 29 are simple sums of figures given in Tables 27 and 28.

26. Mean Weight by Age

The mean weight by age for Greenland cod is known to vary considerably between years and between year classes. In the present analyses the following values taken from ICNAF Res.Doc.75/31 were used:

Age	Mean Weight (kg)
3	0.65
4	0.99
5	1.68
6	2.77
7	3.84
8	4.72
9	5.34
10	5.34
11	5.48
12	5.39
13	8.70
14+	10.00

These figures were checked on the only sample available from Division 1E at present (a length sample from U.K. supplied to the ICNAF Assessment Meeting, April 1976 and broken down in age groups by means of a Danish age/length key for Divisions 1C-1E, 1975). The same sample was converted to weight by means of German length/weight data (A Meyer, ICNAF Res. Doc.66/18). This exercise showed that the weight figures as given above correspond reasonably well both with the weight obtained by German data and with the actual observed total weight for the U.K. sample.

27. Natural Mortality and Emigration

Natural mortality has been taken as M = 0.20, the value used throughout all previous analyses of Greenland cod. However, apart from this mortality (and the fishing mortality) the VPA analyses should also take into account the "mortality" due to emigration. The emigration has been adopted as being 25% annually for mature cod (see para. 30.2). This corresponds to a coefficient (instantaneous rate) of 0.29. Taking the age of emigration as knife-edge at age 7, the VPA analysis for the combined stocks in ICES Sub-area XIV and ICNAF Divisions 1E-1F has been made with a value of M = 0.20 for age groups to and including six years. From seven years onwards the M value is taken as 0.49, treating emigration as a component of the natural mortality.

28. Input Data to Virtual Population Analyses of Cod at Greenland

The basic input figures for VPA analyses are the catch in numbers and the mortality rates. Nominal catches and catch by numbers have already been considered in the previous Sections, and so have the natural mortality and the emigration parameter. For estimating forecasts, figures for mean weight by age are needed. These are also dealt with above.

The most critical input is the terminal figure for fishing mortality rate, F. In the analysis carried out it has been assumed that F in 1975 is the same for East Greenland as for ICNAF Divisions 1E-1F. At the same time it has been taken into account that catches and effort in 1975 are very much lower than in the years prior to 1974. The actual 1975 catches seem to be close to those predicted (for Divisions 1E-1F) in forecasts by an F value of 0.20 (ICNAF Res.Doc.75/31). A value of 0.22 was then chosen for the analyses, but other values of the same order might as well have been considered.

29. Results of the VPA and Predictions of Stock Size and Catches for 1976-78

The VPA analyses (Tables 30 and 31) carried out for the ICES Sub-area XIV and ICNAF Divisions 1E-1F combined show, as expected from the fisheries themselves, that there has been an overall decline in the stock over the last five years. Taking only the spawning stock, i.e. cod of age 7 and older, the numbers (in millions) at the beginning of each year are as follows:

Year	1960	1961	1962	1963	1964	1965
Nos. x 10^{-6}	161.2	101.8	65.3	91.5	89.4	70.3

Year	1966	1967	1968	1969	1970	1971
Nos. x 10^{-6}	39.7	45.2	82.0	76.0	96.4	64.7

Year	1972	1973	1974	1975
Nos. x 10^{-6}	28.3	13.2	7.3	21.4

This reflects the very poor general recruitment to the stock since year class 1963 recruited. The only year class of average strength since then is the 1968 year class. The recruitment of this year class to the spawning stock may have led to some increase in spawning stock in 1975. If no good year classes enter the stock in the next few years, a further decline is to be expected.

There seems to be evidence that the 1973 year class is of some importance. Rather arbitrarily it is here judged to be somewhat stronger than other year classes since 1963 and about 1/3 of the 1963 year class, i.e. in round figures about 70 million individuals by the age of 3. The following 1974 year class has not shown any signs of importance and is set at 10 million by age 3.

On the basis of this a prediction of stock size and catches has been made for the area considered for 1976-77, using values of F corresponding to the input F in 1975 in the VPA (F = 0.22) and $F_{0.1}$ = 0.45 (ICNAF Res.Doc. 75/31). The results are set out in Table 32.

The predictions show that for both F values a slight improvement in the total stock could be expected from 1975 to 1978. However, this improvement is mainly due to the above-mentioned optimistic judgment of the incoming 1973 year class. Figures in brackets in the table reflect that part of the predicted catches and stock which is dependent on the incoming year classes 1973 and 1974. If the 1973 year class is overestimated, catches and stock size will remain at the present very low level.

E. INTERRELATIONSHIP BETWEEN THE COD STOCKS AT ICELAND AND AT GREENLAND

30. Introduction

Throughout the period when investigations of cod in Greenland waters have been made, i.e. since the 1920s, it has been known that part of the stock of cod at West Greenland migrates to East Greenland and Iceland when reaching maturity. This has been demonstrated mainly by tagging experiments at Greenland, but also other studies confirm this migration.

As would be expected the migration to East Greenland and Iceland has been most pronounced for cod tagged in the southernmost part of West Greenland, i.e. ICNAF Divisions 1E and 1F. Tagging off East Greenland has shown a considerable migration from these waters to Iceland but only a small-scale migration to West Greenland. Tagging at Iceland has revealed a negligible number of recaptures at Greenland thus confirming that once the cod have migrated from Greenland to Iceland they will remain at Iceland.

However, the interrelationship between the stocks is not only a matter of adult cod migrating and mixing but also a matter of recruitment of young cod to one area originating from spawning in another area. As far as this question is concerned, there seems to be some feed-back of fry from East Greenland to West Greenland and from Iceland to East Greenland, and possibly even to West Greenland.

These two separate aspects of the interrelationship between cod at Greenland and Iceland are described in further details in the following.

31. Migration of Adult Fish from West to East Greenland and to Iceland

Although it has been known that cod from Greenland waters contribute to the fisheries at Iceland no quantitative estimates of this contribution have been made until the North-Western Working Group tried to carry out such analyses at its last meeting in 1970. At that meeting the Working Group based its analyses partly on tagging experiments and partly on analyses of stock size and composition of stock and catches at Iceland and Greenland.

31.1 Estimates from tagging experiments

Based upon tagging experiments at Greenland the Working Group in 1970 concluded that the actual overall proportion of mature fish at East Greenland and in the southern part of West Greenland (ICNAF Divisions 1E-1F) emigrating to Iceland was about 25% per year.

Since then only few fish have been tagged at Greenland. Danish tagging experiments at West Greenland in the years 1966-72 were presented to the Working Group at its present meeting. They reconfirmed that from the northern divisions at West Greenland (Divisions 1B-1D) the migration to East Greenland and Iceland is insignificant, whereas tagged cod released in the southern part of the area (Divisions 1E-1F) revealed several recaptures at East Greenland and at Iceland. Considering only fish that were 70 cm or bigger at the time of tagging, the total recaptures from the 1966-72 experiments in Divisions 1E-1F amount to 7.6% (25 recaptures, 329 fish tagged). 44% of the recaptures came from East Greenland or Iceland. The overall recapture rate from these experiments is lower than in previous experiments, but the decrease is mainly due to a lower recapture rate at West Greenland than in previous experiments, although also the recapture rate at Iceland and at East Greenland has decreased somewhat. However, the material is so limited and fishermen's reporting rate of tags so uncertain that the Working Group did not find itself in a position to change the conclusions from the meeting in 1970.

From Icelandic tagging experiments at East Greenland in the years 1971-74, only 2% has been returned, probably due to a high tagging mortality. 2/3 of the recaptures came from East Greenland and 1/3 from Icelandic waters. Again, these experiments do not allow any revision of former conclusions.

31.2 Estimate of emigrants from Greenland to Iceland

Since no new information on the number of cod of age 7 and older emigrating from Greenland to Iceland is available, the percentage of emigrants (25% annually) given in the previous report of the Working Group was used. This figure corresponds to an instantaneous emigration rate of 0.29, which was applied to the number of cod from age 7 and onwards in each year and age group derived from VPA (using the parameters outlined in Sections 27 and 28) for ICNAF Divisions 1E-1F and ICES Sub-area XIV combined. In estimating the number of cod emigrating from Greenland, F and M values have also been taken into account (see Section 27).

The annual contribution of Greenland cod to the Icelandic spawning stock (Table 33 and Figure 10) varies according to the size of the year classes and F values at Greenland, ranging from 34.7×10^6 cod in 1960 to 1.3×10^6 in 1974. From 1971 onwards there was a steady decline of emigration from Greenland from 12.1×10^6 in 1971 to 1.3×10^6 in 1974, when the very poor year classes 1965, 1966 and 1967 entered the spawning stock. In 1975, when the about average 1968 year class was expected to emigrate, the number increased slightly to 4.4×10^6 . The average over the period 1960-69 of 7 year old fish (8.0×10^6 fish) is of the same order as the estimate given in the previous report (7.3×10^6).

31.3 Some observations on the use of VPA for the Icelandic/Greenland cod stock

The Group discussed the difficulties of obtaining valid estimates of F and stock size from VPA when dealing with two stocks with interchange between them.

A VPA using only catches made at Iceland would tend to overestimate stock sizes at Iceland, especially among the younger age groups. This is because these estimates might include a proportion of fish that had commenced life in Greenland waters. A VPA using only catches made at East Greenland might underestimate stock sizes at East Greenland if no account has been taken of fish that commenced life at East Greenland but were caught at Iceland. To take account of this, the effective value of M on the older age groups could be increased to take account of an instantaneous coefficient of emigration, and the result of a trial made in this way is given in Tables 30 and 31.

A VPA using catches from Iceland and East Greenland would be useful since this should provide estimates of total stock sizes but without any indication of how this should be distributed between the two areas.

For all the VPAs it was recognised that values of F were liable to be biassed. All assessments depending on VPA Fs were, therefore, regarded as provisional and subject to revisions.

It was recommended that further work be done on a simulation of the Iceland/Greenland situation with a view to obtaining better estimates of F, stock sizes and coefficient of emigration from Greenland to Iceland.

32. Recruitment to the West Greenland Stock of Cod Originating from East Greenland and Iceland

32.1 Distribution of cod at Greenland

The recruitment to the cod stock off West Greenland is dependent on fluctuations in the environment not only at West Greenland, but also at East Greenland and Iceland. These fluctuations in the environment lead to fluctuations in the strength of the cod year classes.

The distribution of cod at West Greenland depends on whether the year classes originate from West Greenland or from East Greenland-Iceland. A year class originating from West Greenland seems to come from the spawning area in the northern part of ICNAF Division 1E and Division 1D. The main nursery grounds are in ICNAF Divisions 1B-1D. Seasonal spawning/feeding migrations occur between various areas.

A year class originating from East Greenland-Iceland has a more southerly distribution at West Greenland than a West Greenland year class. A year class from East-Greenland-Iceland is normally observed in ICNAF Divisions 1E and 1F at an age of one year. They grow up in this area and at an age of 7-8 years old they begin to migrate from West Greenland to the spawning grounds in ICES Sub-area XIV and Division Va. Some migration back to West Greenland may occur from the southern part of East Greenland.

The following year classes which were and some of which still are important for the fishery originate from West Greenland: 1947, 1950, 1953, 1957, 1960, 1961 and 1968. Of East Greenland origin the following were important or relatively important for the fishery at West Greenland: 1945, 1956, 1958, 1961, 1962, 1963, 1964 and 1968. The 1956 and the 1961 year classes were the most important.

32.2 Distribution of cod eggs and larvae

The ICNAF NORWESTLANT Survey 1963 showed that cod eggs in April 1963 were distributed in a continuous belt from Iceland to East Greenland, along East Greenland, round Cape Farewell and over the banks at West Greenland. Concentrations of larvae were, however, only found in two areas. One at West Greenland (ICNAF Divisions 1B-1D) which is the normal area of distribution for cod larvae of West Greenland origin. The other concentration was found from Iceland to East Greenland over the ridge. Thus, the distribution of larvae was disrupted into two parts compared to the more continuous distribution of the eggs.

If the occurrence of eggs in April 1963 reflects the general picture of distribution of eggs in April shortly after spawning, then the contribution of cod from East Greenland-Iceland to West Greenland may depend upon how successful the spawning is in the various areas off East Greenland and at Iceland, and of course upon the size of the spawning stock.

Icelandic investigations have shown that the incubation time for cod eggs off East Greenland is 20-30 days. The speed of the East Greenland Current is known to be 4.5-9.5 nautical miles per day. Thus, eggs from the South East Greenland area can be transported to South West Greenland before hatching.

In 1963 no larvae were found at South West Greenland (Divisions 1E and 1F). This indicates that there may have been a spawning failure in an area at East Greenland from Angmagssalik Bank to Cape Farewell. As the year class 1963 was relatively important for the fishery at West Greenland, and as the West Greenland component of that year class contributed very little to the fishery, it seems likely to assume that these catches consisted of cod originating from the larvae concentrations found in July between Iceland and East Greenland.

The International 0-Group Surveys in the Iceland-East Greenland area in the years 1970-74 found no 0-group cod along East Greenland from 64°N to 60°N. Only in the year of 1973 was a dense concentration of 0-group cod found over the Dohrn Bank. This year class was found at West Greenland in ICNAF Division 1F as 1 year old and also as 2 and 3 years old in Divisions 1E and 1D. These 1-3 year old cod from the year class 1973 may have originated from the concentration over the Dohrn Bank like the year class 1963 did.

These observations indicate that in some years not only the spawning areas off East Greenland are important to the fishery at West Greenland, but also spawning grounds rather close to Iceland.

33. Management Problems for Cod at Greenland

Apart from the problems of adequate data and parameters for analyses of the state of stocks and for forecasts of stocks and catches, management of the cod stocks round Greenland is faced with another problem.

The Working Group observed that a quota regulation is applied to the ICNAF part of the Greenland area. It is also observed that while for practical reasons the ICNAF Subarea 1 cod quota is not split up in areal sections, the analyses on which the scientific advice to ICNAF are based consider the stocks in Divisions 1A-1D and Divisions 1E-1F separately.

In recent years the ICNAF scientists have advised that due to the very low stock size and a possible danger of failure in recruitment due to low spawning stock size, fishing should be kept at the lowest practical level. In this context the scientists have also pointed out that the recruitment to West Greenland stocks is depending partly upon the spawning stock at East Greenland.

The present report confirms that there is a strong interrelationship between cod in ICNAF Divisions 1E-1F and cod at East Greenland and partly at Iceland. Although the migration of adult cod is mainly from West Greenland to East Greenland and to Iceland, the Working Group considers that the cod fisheries at West Greenland are depending to a certain degree on spawning stocks at East Greenland and possibly even at Iceland.

The Working Group also considers that for cod in ICNAF Divisions 1E-1F the interrelationship with the East Greenland cod is just as pronounced as the interrelationship with cod in Divisions 1A-1D. It therefore seems proper to consider East and West Greenland as a unit management area. If a break down for management purposes is to be considered, it may be as proper to combine Divisions 1E-1F with East Greenland (ICES Sub-area XIV) as with ICNAF Divisions 1A-1D.

Table 1. Nominal catch of Cod. ICES Division Va (Iceland Grounds). In thousand tons. 1955-75 (Bulletin Statistique).

Species: COD Country	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975*
Belgium	9.0	7.0	6.7	9.9	5.5	5.6	5.4	8.2	6.3	3.1	3.7	3.0	2.3	3.4	2.7	3.0	3.0	2.5	1.1	1.1	1.0
Denmark	+																				
Faroe Isl.	18.7	16.2	20.9	17.9	7.7	11.8	10.6	8.7	6.3	6.9	5.2	3.4	2.8	4.3	2.6	4.3	8.6	11.1	14.2	12.1	9.6
France							0.1	0.1				0.1	0.4	0.1	0.1	1.9	1.5	-	-	0.2	-
Germany (Fed.Rep.)[1]..	48.2	30.0	23.3	37.8	35.6	37.9	21.8	34.2	33.0	19.3	15.3	9.9	15.4	29.6	19.4	24.7	27.3	11.7	6.6	5.5	2.2
German.Dem.Rep.[2]							0.3	0.5	0.9	0.5	0.5	0.3	0.4	0.9	0.5	2.7	0.7	0.7			
Iceland	315.4	292.6	247.1	284.4	284.3	295.7	233.9	221.8	232.8	273.6	233.5	224.0	193.4	227.6	281.7	302.9	250.3	225.4	234.9	238.3	266.8
Netherlands			+				0.1	0.5	0.7	0.7	0.5	0.1			+						
Norway	7.1	4.6	8.2	6.8	5.5	3.4	4.2	4.7	3.5	2.7	0.4	0.5	0.2	0.3	0.4	0.4	0.3	0.6	0.1	0.2	0.1
Poland[2]				+					0.2	0.1						1.6	0.3	0.2			
U.K.(England & Wales)	138.7	127.8	144.3	150.5	112.7	109.4	96.5	105.1	123.2	122.2	128.1	109.0	126.6	111.6	95.4	125.2	157.7	144.2	121.3	115.4	91.0
U.K.(Scotland)	1.0	2.5	1.4	1.2	1.3	1.2	2.1	3.1	3.2	4.6	6.8	4.8	3.6	2.8	4.0	5.3	4.1	3.0	1.0	2.1	1.6
U.S.S.R.[2]											0.2	2.0	0.3	1.4	0.2	+	0.1	+			
Total	538.1	480.7	451.9	508.5	452.6	465.0	375.0	386.9	410.1	433.7	394.2	357.1	345.0	382.0	407.0	472.0	453.9	399.4	379.2	374.9	372.3
Bull.Stat. Total	536.8	482.2	453.0	510.5	454.2	465.0	375.6	386.4	409.4	434.5	393.6	357.4	344.0	379.5	405.2	470.8	453.0	398.5	379.9	375.0	

The national statistics used in the table (see footnotes 1 and 2) differ slightly from those given in Bulletin Statistique. The order of magnitude of these discrepancies is shown by comparison of the total catches at the bottom of the table.

* Provisional.

1) From national statistics from Bundesforschungsanstalt f. Fischerei, Hamburg.

2) From national statistics.

\+ = less than 0.1 thousand tons.

Note: Due to a mistake during the preparation of the table minor discrepancies (less than 2 thousand tons) occur between the total given in the table and the catch data used in the assessment for the years 1966 (2 000 tons), 1967 (300 tons), 1968 (1 400 tons), 1969 (200 tons) and 1971 (100 tons).

Table 2. Effort and catch per unit of effort 1970-75.

a) English effort

Year	Hours trawling			Tons/hours trawling	Effort raised to total catches (non-spawning)
	Steam	Motor	Total		
1970	59 159	140 365	199 524	0.628	491 222 (1.00)
1971	89 237	211 430	300 667	0.525	627 835 (1.28)
1972	98 937	220 673	319 610	0.451	606 184 (1.23)
1973	82 913	194 971	277 884	0.437	594 369 (1.21)
1974	68 770	164 612	233 382	0.495	545 297 (1.11)
1975			212 608	0.428	640 889 (1.30)

b) Icelandic big trawlers (>500 GRT)

Year	Hours trawling	Cod catch (1 000 tons)	Tons/hours trawling
1970	59 941	25.7	0.429
1971	62 406	14.5	0.232
1972	61 328	11.8	0.192
1973	55 909	7.9	0.141
1974	63 752	20.9	0.328
1975	65 629	(20)*)	(0.305)*)

*) Splitting of catch between big trawler and stern-trawler estimated.

c) Icelandic multigear boats (less than 500 GRT)

Year	Days absent when trawling	Catch (1 000 tons)	Tons/day absent
1970	39 103	74.2	1.90
1971	38 669	58.2	1.49
1972	39 041	29.8	0.76
1973	28 379	20.3	0.71
1974	30 306	17.9	0.59

/...

Table 2 (Continued)

d) Icelandic stern trawlers (300 - 500 GRT)

Year	Hours trawling	Cod catch (1 000 tons)	Tons/hours trawling
1970	1 266	0.4	0.326
1971	13 942	6.6	0.472
1972	18 939	8.1	0.431
1973	57 302	25.5	0.445
1974	111 814	51.5	0.461
1975	146 866	(78.6)*)	(0.535)*)

*) Splitting of catch between big trawler and stern trawler estimated.

e) Icelandic long lines

Year	Days absent	Cod catch (1 000 tons)	Tons/days absent
1970	28 629	43.7	1.528
1971	30 442	not available	
1972	31 486	33.9	1.076
1973	29 831	34.7	1.162
1974	27 570	28.9	1.049
1975		22.7	

f) Icelandic gill nets

Year	Days absent	Cod catch (1 000 tons)	Tons/days absent
1970	20 460	132.5	6.48
1971	22 834	not available	
1972	27 801	114.3	4.11
1973	30 451	119.9	3.94
1974	28 817	99.9	3.47
1975		94.4	

g) Icelandic hand lines

Year	Days absent	Cod catch (1 000 tons)	Tons/days absent
1970	17 901	23.5	1.31
1971	22 143	not available	
1972	25 932	20.8	0.80
1973	23 418	19.7	0.84
1974	25 423	15.6	0.61
1975		16.4	

Table 3. Iceland Cod.
Age compositions of catches 1955-75 used as input data for Virtual Population Analysis (thousands of fish).

Age	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964
1	0	0	0	0	0	0	0	0	0	0
2	169	219	781	2 938	1 945	1 581	1 840	996	1 356	2 268
3	3 981	6 318	15 967	25 694	20 329	13 434	14 665	12 309	14 884	16 284
4	24 277	16 112	23 354	30 535	44 478	30 544	19 971	28 867	29 298	28 590
5	33 115	28 249	17 250	16 012	22 953	29 000	19 680	19 718	22 390	20 312
6	25 328	22 879	18 212	11 501	6 693	12 105	18 826	15 786	11 586	10 882
7	9 749	14 945	12 627	15 304	4 760	8 681	7 617	12 424	17 508	7 482
8	4 545	4 551	12 927	14 876	7 561	5 967	6 502	4 243	8 295	17 182
9	5 757	3 433	3 734	7 466	11 698	6 512	3 633	7 852	2 640	5 169
10	18 172	1 983	2 197	1 982	7 221	12 136	2 962	2 614	6 063	1 763
11	2 548	14 391	1 327	1 492	979	3 661	6 181	1 866	1 410	3 315
12	1 380	1 475	8 020	6 001	981	911	1 230	3 007	946	768
13	2 083	1 679	531	1 192	223	221	90	386	1 396	463
14	186	980	740	663	1 203	219	126	68	204	969

/...

Age	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	0	0	3	0	0	0	0	28	0	0	0
2	2 922	3 852	5 189	772	140	315	820	3 685	2 406	2 320	1 445
3	22 039	16 957	27 444	11 514	9 828	10 670	13 303	8 664	37 583	14 211	29 522
4	30 535	30 039	25 937	49 731	23 168	50 014	35 932	27 765	25 602	58 770	28 786
5	21 562	19 791	24 063	22 280	43 262	24 737	45 939	30 861	26 338	22 632	44 057
6	11 002	12 338	11 953	16 072	16 968	27 188	21 275	23 346	16 048	15 183	12 421
7	9 050	6 196	7 807	17 478	12 826	15 497	17 443	11 190	12 011	9 640	11 118
8	6 228	7 118	2 838	5 657	17 411	12 066	12 334	10 596	3 607	6 140	4 202
9	11 670	2 305	4 142	1 728	1 881	14 581	6 885	11 243	5 893	1 705	2 212
10	1 694	5 862	1 279	3 169	578	516	4 710	4 298	7 853	3 059	867
11	974	526	2 017	526	498	175	360	1 281	1 452	2 162	1 146
12	587	281	95	598	101	99	108	83	261	293	466
13	131	374	40	57	63	43	57	33	11	108	83
14	246	54	153	53	29	18	18	3	1	31	19

Table 4. Cod.
Division Va. . Mean weight at age.
Average of the period 1970-74.

Age	English data	Icelandic data		Stock
		Non-spawning	Spawning	
1		0.22		0.22
2	0.69	0.78	0.43	0.64
3	0.91	1.19	1.30	1.12
4	1.32	1.80	2.78	1.93
5	1.84	2.63	4.51	2.92
6	2.73	3.47	5.40	3.80
7	3.86	4.12	6.17	4.65
8	4.69	4.55	6.60	5.25
9	4.96	4.82	6.78	5.48
10	5.55	5.33	7.30	6.01
11	6.61	6.72	8.37	7.18
12	9.69	7.31	9.68	8.93
13	11.41	9.29	12.82	11.14
14	15.40	12.11	18.10	15.14
15^+	13.41	11.17	23.95	15.90

Length/weight regression parameters: $l_n\, w = al + b$

		(a)	(b)
Non-spawning:	England :	3.000	11.6183
"	Iceland	2.551	9.7361
Spawning	Iceland	3.072	11.8913

Table 5.a. Cod at Iceland.
Non-spawning fishery. Mean weight (kg) at age.

Age/Year	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	-	-	0.41	-	-	-	-	0.22	-	-	-
2	1.18	1.06	1.29	0.75	0.69	0.58	0.65	0.63	1.32	0.74	1.00
3	1.59	1.61	1.64	1.40	1.28	1.04	1.14	1.12	1.40	1.26	1.32
4	2.62	2.33	2.36	1.57	1.92	1.60	1.80	1.81	1.83	1.94	1.87
5	2.98	3.34	3.16	2.56	2.66	2.59	2.54	2.59	2.79	2.62	2.74
6	3.94	4.10	4.11	3.28	3.45	3.47	3.49	3.36	3.40	3.61	3.48
7	4.63	5.09	4.94	4.25	4.20	4.10	4.16	3.99	4.20	4.14	4.49
8	5.31	5.77	6.21	4.37	4.53	4.31	4.15	4.54	4.67	5.09	4.92
9	5.55	5.18	6.04	6.39	5.41	4.78	4.41	4.85	5.07	5.03	5.32
10	7.07	5.57	7.10	6.77	5.27	6.45	4.93	4.59	5.13	5.56	6.79
11	8.39	6.67	6.81	7.74	6.38	9.09	7.79	5.47	5.34	5.89	7.04
12	7.58	8.94	9.70	7.21	9.82	9.44	8.62	7.27	5.37	5.87	7.77
13	13.39	8.43	9.22	11.41	10.40	6.71	9.79	11.90	11.88	6.16	8.61
14	10.86	9.92	12.09	10.32	9.51	-	13.04	-	-	11.17	-
15+	11.67	11.56	13.66	16.26	18.49	-	11.17	-	-	-	15.20

Table 5.b. Cod at Iceland.
Spawning fishery. Mean weight (kg) at age.

Age/Year	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1											
2	-	-	0.55	0.42	-	0.33	-	-	0.52	0.44	0.53
3	2.08	1.55	1.72	2.00	1.22	0.95	1.07	0.99	1.59	1.92	1.38
4	3.80	3.22	3.53	3.47	2.87	2.47	2.42	2.70	2.80	3.51	3.49
5	4.37	4.92	5.04	4.52	3.87	4.68	4.44	4.19	4.66	4.56	4.92
6	5.15	5.56	6.10	5.68	4.78	5.30	5.45	5.15	5.30	5.79	5.26
7	5.91	6.69	6.85	5.62	5.32	5.45	6.39	6.08	6.29	6.66	6.14
8	6.57	7.08	8.21	7.41	6.50	6.01	6.04	6.52	7.05	7.38	7.16
9	7.18	7.74	7.49	8.40	6.47	6.51	6.53	6.21	6.66	7.97	8.04
10	9.02	8.44	9.61	8.66	7.90	8.52	6.87	6.60	6.73	7.79	8.79
11	12.52	11.66	9.89	10.65	7.94	10.55	8.59	7.43	7.14	8.14	8.82
12	10.09	14.25	13.54	11.80	9.52	12.20	10.73	8.63	7.86	8.97	10.09
13	9.92	12.36	10.91	15.99	14.78	11.33	16.04	11.02	13.50	12.24	11.28
14	16.13	14.22	15.32	16.32	14.43	21.73	16.94	31.12	-	20.69	12.68
15	18.22	14.98	-	-	-	28.00	18.63	15.44	-	-	-
15+	21.39	20.76	20.20	18.34	21.80	28.00	29.70	-	-	-	-

Table 6. Cod at Iceland.
VPA input values of F for 1975

	(A)	(B)	(C)	(D)	(E)
Age	F 1970 from prelimin-ary run	Adjusted F 1970	(B)x1.2	(B)x1.3	(B)x1.4
1	0.00	0.001	0.001	0.001	0.001
2	0.00	0.01	0.01	0.01	0.01
3	0.06	0.10	0.12	0.13	0.14
4	0.31	0.31	0.37	0.40	0.43
5	0.36	0.36	0.43	0.47	0.50
6	0.38	0.38	0.46	0.49	0.53
7	0.26	0.40	0.48	0.52	0.56
8	0.50	0.50	0.60	0.65	0.70
9	1.00				
10	0.55				
11	0.67	0.75	0.90	0.98	1.05
12	0.83				
13	0.73				

Table 7. Cod at Iceland.
Derived values of F for 1970 (see Table 6).

Age	(C)	(D)	(E)
3	0.06	0.06	0.06
4	0.31	0.31	0.32
5	0.36	0.36	0.36
6	0.38	0.38	0.38
7	0.26	0.26	0.26
8	0.50	0.50	0.51
9	1.00	1.00	1.00
10	0.55	0.56	0.56
11	0.68	0.68	0.68
12	0.84	0.84	0.84
13	0.77	0.75	0.82

Table 8. Iceland Cod.
Estimates of fishing mortality coefficients for 1955-75 calculated by VPA for age and year.

Age	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.00	0.01
3	0.03	0.04	0.10	0.12	0.08	0.10	0.09	0.10	0.11	0.06
4	0.15	0.17	0.18	0.30	0.30	0.16	0.22	0.25	0.36	0.30
5	0.17	0.26	0.27	0.18	0.38	0.33	0.14	0.35	0.32	0.46
6	0.26	0.17	0.26	0.29	0.10	0.35	0.36	0.16	0.35	0.25
7	0.39	0.24	0.13	0.37	0.19	0.19	0.39	0.44	0.28	0.40
8	0.29	0.32	0.34	0.22	0.31	0.37	0.21	0.40	0.59	0.48
9	0.30	0.36	0.48	0.34	0.27	0.49	0.41	0.42	0.47	0.94
10	0.40	0.16	0.42	0.51	0.65	0.50	0.43	0.58	0.68	0.66
11	0.42	0.65	0.15	0.57	0.51	0.84	0.52	0.53	0.73	1.04
12	0.29	0.46	0.97	2.03	0.94	1.38	0.78	0.52	0.56	1.23
13	0.65	0.68	0.30	0.36	0.37	0.57	0.45	0.60	0.49	0.60
14	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75	0.75

Age	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.01	0.01	0.03	0.00	0.00	0.00	0.01	0.01	0.02	0.01	0.01
3	0.10	0.07	0.09	0.07	0.04	0.06	0.08	0.07	0.15	0.13	0.14
4	0.16	0.19	0.14	0.24	0.21	0.32	0.31	0.24	0.30	0.36	0.43
5	0.40	0.15	0.23	0.17	0.34	0.36	0.53	0.49	0.38	0.48	0.50
6	0.50	0.42	0.13	0.23	0.19	0.38	0.61	0.58	0.51	0.39	0.53
7	0.34	0.58	0.51	0.28	0.30	0.26	0.45	0.79	0.67	0.67	0.56
8	0.70	0.50	0.58	0.87	0.49	0.51	0.34	0.54	0.64	0.91	0.70
9	0.70	0.62	0.62	0.87	0.82	1.00	0.61	0.59	0.66	0.72	1.05
10	0.98	0.98	0.86	1.53	0.84	0.56	1.14	1.02	1.14	0.89	1.05
11	0.98	1.01	1.19	1.16	1.20	0.68	1.01	1.22	1.29	1.24	1.05
12	0.51	0.88	0.49	1.73	0.73	0.84	1.28	0.69	0.91	1.06	1.05
13	0.72	0.72	0.28	0.62	0.92	0.82	2.39	2.90	0.18	1.39	1.05
14	0.75	0.75	0.75	0.75	0.75	0.75	1.05	1.05	1.05	1.05	1.05

Table 9. Iceland Cod.
Estimates of stock size at beginning of year 1955-75 calculated by VPA (thousands of fish).

Age	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964
1	264 785	386 714	458 889	229 164	284 501	214 518	243 737	438 848	388 094	437 131
2	246 532	216 787	316 614	375 706	187 622	232 929	175 632	199 554	359 297	317 744
3	146 263	201 691	177 292	258 516	304 949	151 856	189 278	142 133	162 481	292 943
4	193 883	116 155	159 427	130 756	188 490	231 330	112 214	141 740	105 268	119 607
5	237 875	136 862	80 586	109 493	79 606	114 343	161 878	73 898	90 080	59 880
6	120 581	164 924	86 644	50 465	75 223	44 572	67 561	114 799	42 793	53 632
7	32 788	75 943	114 418	54 558	30 977	55 552	25 622	38 411	79 768	24 631
8	20 045	18 095	48 731	82 296	30 928	21 076	37 665	14 142	20 306	49 566
9	24 630	12 325	10 726	28 287	53 990	18 527	11 898	24 984	7 771	9 205
10	60 008	14 991	7 009	5 435	16 453	33 683	9 333	6 482	13 412	3 996
11	8 129	32 824	10 487	3 767	2 675	7 018	16 705	4 984	2 968	5 565
12	6 033	4 370	14 013	7 390	1 749	1 313	2 484	8 141	2 410	1 171
13	4 746	3 699	2 256	4 342	797	559	270	936	3 972	1 126
14	384	2 024	1 528	1 369	2 485	452	260	140	421	2 001

Age	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	513 056	270 268	387 258	284 339	281 503	211 458	456 807	191 024	374 214	195 673	1 104
2	357 892	420 054	221 276	317 058	232 796	230 474	173 127	374 001	156 372	306 380	160 203
3	258 098	290 378	340 432	176 480	258 888	190 471	188 412	141 003	302 878	125 854	248 747
4	225 147	191 437	222 440	253 970	134 102	203 088	146 316	142 258	107 627	214 108	90 231
5	72 230	156 826	129 686	158 743	163 190	88 938	121 331	87 504	91 490	65 106	122 523
6	30 818	39 787	110 565	84 523	109 897	94 751	50 605	58 204	43 988	51 263	33 022
7	34 122	15 374	21 506	79 748	54 740	74 696	53 169	22 407	26 764	21 640	28 344
8	13 452	19 808	7 043	10 614	49 576	33 288	47 217	27 890	8 367	11 182	9 104
9	25 182	5 453	9 840	3 227	3 652	24 987	16 445	27 579	13 347	3 626	3 691
10	2 938	10 197	2 403	4 353	1 104	1 314	7 500	7 307	12 522	5 662	1 447
11	1 696	900	3 137	829	770	389	614	1 964	2 164	3 288	1 912
12	1 612	523	269	781	212	189	162	182	473	487	778
13	279	794	178	135	114	83	67	37	75	155	138
14	508	112	316	109	60	37	30	5	2	52	32

Table 10. Cod at Iceland.
Total stock biomass and spawning stock biomass (thousands of tons).

Year	Total stock biomass age groups 3 and older	Spawning stock biomass age groups 7 and older
1955	2 615	924
1956	2 429	952
1957	2 208	1 138
1958	2 089	1 036
1959	2 006	783
1960	1 868	748
1961	1 745	587
1962	1 635	550
1963	1 505	694
1964	1 480	543
1965	1 474	422
1966	1 592	288
1967	1 846	237
1968	1 959	487
1969	1 994	551
1970	1 899	673
1971	1 677	637
1972	1 371	462
1973	(1 319)*)	337
1974	(1 183)*)	(244)*)
1975		(231)*)

*) Values sensitive to VPA input values of F for 1975.

Table 11. Estimated year class strengths of Cod from the three VPA's (3 years old, number in 10^{-6}).

Year Class	Iceland	E. Greenland + W. Greenland 1 E & F	E. Greenland + W. Greenland 1 E & F + Iceland
1952	146		
1953	202		
1954	177		
1955	259		
1956	305		
1957	152	81	232
1958	189	71	260
1959	142	16	158
1960	162	53	215
1961	293	151	444
1962	258	78	336
1963	290	135	425
1964	340	42	382
1965	176	12	188
1966	259	13	275
1967	190	8	200
1968	188	6	220
1969	141	4	151
1970	303	13	342

Average 1952 - 1970 year classes 220

Table 12. Nominal catch of Haddock. ICES Division Va (Iceland Grounds). In thousand tons. 1955-75 (Bulletin Statistique).

Species: HADDOCK Country	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975*
Belgium	7.1	6.1	6.6	5.7	2.4	5.2	4.2	4.2	1.9	0.9	1.2	0.7	0.9	1.1	1.0	1.1	1.3	0.8	0.9	0.9	0.8
Denmark	+																				
Faroe Isl.	0.4	0.6	1.2	1.4	1.0	1.3	0.8	0.9	2.1	1.2	1.0	1.0	0.5	0.3	+	0.6	0.7	0.6	0.8	1.0	1.2
France							0.1	0.2				+	0.9	+		0.1	1.2		0.6		
Germany, Fed. Rep.[1]..	7.2	8.8	7.8	6.3	3.8	6.2	4.1	4.0	3.1	2.1	1.8	1.1	1.5	2.6	1.6	1.7	2.0	0.7	1.8	1.2	1.2
German Dem. Rep.[2] ..												0.1	+	0.4		+					
Iceland	21.7	22.1	31.3	28.6	26.5	42.0	51.4	54.3	51.8	56.6	53.5	36.0	39.0	34.0	35.0	31.8	32.4	29.3	34.6	34.2	35.4
Netherlands			+				+	0.2	0.2	0.2	0.1	+			+						
Norway									+	+	+							+	+		
Poland[2]										+											
UK (England & Wales)[2]	27.9	23.7	28.7	27.5	30.0	31.8	47.2	51.9	39.5	33.3	37.6	19.7	17.4	11.9	7.8	7.4	7.7	7.7	6.8	4.4	4.5
UK (Scotland)........	0.7	1.0	1.1	1.0	0.8	0.9	2.3	4.0	3.8	4.9	3.8	1.5	1.0	1.4	1.1	1.7	0.8	0.4	0.3	0.7	1.2
U.S.S.R.[2]												0.1	0.2								
Total	65.0	62.3	76.7	70.5	64.5	87.4	110.1	119.7	102.4	99.2	99.0	60.2	60.4	51.7	46.5	44.4	46.1	39.5	45.8	42.4	44.3
Bull. Stat. Total ...	64.3	61.9	76.4	70.2	63.7	86.4	108.3	119.6	102.6	99.2	99.0	60.1	60.5	51.2	46.6	44.5	46.1	39.3	45.7	42.6	

The national statistics used in the table (see footnotes 1 and 2) differ slightly from those given in Bulletin Statistique.
The order of magnitude is shown by comparison of the total catches at the bottom of the table.

* Provisional

1) From national statistics from Bundesforschungsanstalt f. Fischerei, Hamburg.

2) From national statistics.

\+ = less than 0.1 thousand tons.

Table 13. Iceland Haddock.
Age compositions of catches 1962-75 used as input data for Virtual Population Analysis (thousands of fish).

Age	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	357	52	19	22	76	52	1	80	1	2	5	41	1	1
2	4 282	3 833	4 170	2 490	1 380	3 375	2 681	1 893	908	486	2 301	2 463	1 078	581
3	6 683	18 005	27 409	25 817	13 802	18 613	7 153	9 624	4 220	4 613	4 431	9 634	3 565	6 732
4	14 920	5 447	14 125	17 820	13 192	16 002	10 239	5 522	11 095	5 794	9 386	4 922	11 641	8 395
5	45 797	10 401	4 133	17 999	4 885	4 790	5 079	7 757	3 867	9 026	4 527	4 512	4 625	7 528
6	9 975	25 018	4 097	1 857	5 308	1 308	2 522	1 450	4 093	3 431	2 321	2 599	2 180	1 614
7	840	5 301	9 517	1 364	696	1 617	1 571	611	1 015	1 951	381	1 614	736	764
8	67	464	2 198	2 460	488	161	1 173	359	347	302	207	470	421	156
9	193	36	234	437	547	50	237	485	321	55	41	290	84	91
10	176	90	88	82	202	211	673	131	356	168	41	69	38	30

The last group is a plus group

Table 14. Haddock at Iceland.
Mean weight at age. (kgs)

Age	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	Mean 1971-75
1	0.33	0.40	0.32	-	-	0.44	-	0.22	-	0.19	0.40	0.23	-	-	0.27
2	0.42	0.73	0.77	0.70	0.62	0.58	0.60	0.46	0.29	0.61	0.78	0.44	0.69	0.59	0.62
3	0.84	0.97	1.09	1.02	0.99	0.87	0.90	0.95	0.73	0.89	1.19	0.79	1.00	0.95	0.96
4	1.01	1.34	1.49	1.40	1.43	1.44	1.14	1.49	1.23	1.32	1.59	1.40	1.38	1.38	1.41
5	1.45	1.51	2.04	1.71	2.04	2.02	1.98	2.37	1.91	1.77	2.07	2.22	2.11	1.98	2.03
6	2.12	1.77	2.17	2.33	2.23	2.49	2.61	3.15	2.68	2.40	2.70	3.42	3.13	2.91	2.91
7	2.81	2.22	2.45	2.81	2.81	2.27	3.31	3.77	3.49	3.62	3.21	4.08	3.92	4.18	3.80
8	2.35	2.24	3.11	3.10	3.41	3.69	3.66	3.65	4.31	4.54	3.80	5.12	4.44	4.88	4.56
9	3.84	4.52	2.92	3.11	3.64	2.96	4.41	4.20	4.32	-	5.06	5.03	4.40	4.40	4.72
10	2.76	3.28	3.69	5.74	3.58	3.69	4.00	5.05	4.89	4.07	6.81	4.52	7.55	5.72	5.73
11	5.46	-	-	-	-	4.52	5.14	4.52	5.35	3.59	5.73	-	6.54	5.04	
12	3.94	2.57	-	-	-	5.47	4.16	4.63	4.49	-	-	5.47	6.54	5.47	
13	-	-	-	-	-	-	-	-	-	6.54	-	-	-	-	
14	-	-	-	-	-	-	-	-	5.78	4.52	-	-	-	-	5.58
15+	-	-	-	-	-	3.69	-	-	-	-	-	-	-	-	

Length/weight regression parameters: $l_n w_a = al + b$

$a = 3.0259$

$b = - 11.6350$

Table 15. Iceland Haddock.
Input values of F used in VPA assessments.

For oldest age groups

	1962	63	64	65	67	68	69	70	71	72	73	74	75
A	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7
B	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.9	0.9	0.9
C	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.7	0.45	0.45	0.5

For 1975

Age	A	B	C
1	0.05	0	0
2	0.10	0.05	0.05
3	0.50	0.25	0.20
4	0.70	0.50	0.45
5	0.70	0.80	0.45
6	0.70	1.00	0.45
7	0.70	1.00	0.45
8	0.70	1.00	0.45
9	0.70	1.00	0.45

Table 16. Iceland Haddock.
Estimates of fishing mortality coefficients for 1962-75 calculated by Virtual Population Analysis, and values assumed for 1975.

Age	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.04	0.05	0.06	0.04	0.02	0.09	0.05	0.06	0.03	0.02	0.04	0.07	0.03	0.05
3	0.29	0.25	0.55	0.61	0.35	0.40	0.29	0.24	0.19	0.17	0.23	0.25	0.13	0.25
4	0.47	0.42	0.32	0.86	0.75	0.88	0.41	0.38	0.47	0.42	0.62	0.42	0.53	0.50
5	0.64	0.70	0.65	0.86	0.61	0.69	0.80	0.62	0.51	0.89	0.68	0.70	0.91	0.80
6	0.64	0.91	0.67	0.69	0.67	0.32	1.00	0.56	0.81	1.24	0.60	1.12	0.91	1.00
7	0.57	0.88	1.17	0.50	0.61	0.44	0.80	0.71	1.02	1.27	0.41	1.17	1.23	1.00
8	0.29	0.73	1.24	1.21	0.33	0.27	0.67	0.42	1.24	1.03	0.41	1.40	1.22	1.00
9	0.91	0.25	1.09	0.92	1.03	0.05	0.81	0.67	0.84	0.66	0.36	1.87	1.11	1.00
10+	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.70	0.90	0.90	0.90

Table 17. Iceland Haddock.
Estimates of stock size 1962-75 calculated by Virtual Population Analysis (thousands of fish).

Age	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
1	111 679	97 355	80 005	93 470	50 990	78 739	43 419	49 310	36 471	75 222	51 717	51 383	16 042	1 104
2	114 061	91 113	79 660	65 485	76 507	41 679	64 419	35 548	40 299	29 859	61 585	42 337	42 032	13 133
3	28 762	89 520	71 137	61 457	51 367	61 393	31 080	50 322	27 396	32 175	24 007	48 344	32 441	33 440
4	43 793	17 541	57 095	33 706	27 231	29 660	33 563	19 015	32 541	18 630	22 187	15 668	30 914	23 347
5	105 490	22 481	9 474	34 053	11 723	10 524	10 036	18 292	10 612	16 697	10 055	9 773	8 413	14 886
6	22 920	45 434	9 118	4 063	11 848	5 229	4 338	3 689	8 040	5 224	5 634	4 188	3 972	2 772
7	2 106	9 850	14 934	3 805	1 668	4 958	3 106	1 310	1 722	2 934	1 239	2 537	1 123	1 312
8	291	973	3 345	3 791	1 894	743	2 609	1 142	527	508	676	673	646	268
9	351	178	382	792	925	1 112	464	1 088	613	124	148	367	136	156
10+	226	116	113	105	260	271	865	168	458	216	53	84	46	37

Table 18. Iceland Haddock.
Exploitation patterns used in the yield/recruit assessments.

Age	A	B	C
1	0	0	0
2	0.05	0	0
3	0.26	0.15	0.05
4	0.51	0.35	0.30
5	0.7	0.60	0.47
6	0.82	0.72	0.69
7	0.84	0.72	0.72
8	0.72	0.72	0.72
9	0.72	0.72	0.72
10	0.72	0.72	0.72

A = Mean values of F for the period 1967-71 from VPA

B = Age of first capture increased by 0.5 years

C = Age of first capture increased by 1.0 years.

Table 19. Iceland Haddock.
Stock biomass and spawning stock biomass (thousands of tons).

Year	Stock biomass (age groups 2 and older)	Spawning stock biomass (age groups 4 and older)
1962	453	355
1963	388	246
1964	318	201
1965	264	165
1966	214	118
1967	192	107
1968	181	111
1969	161	91
1970	157	105
1971	140	91
1972	138	77
1973	(142)	(69)
1974	(138)	(80)
1975	-	(78)

Figures in brackets sensitive to VPA input values of F for 1975.

Table 20. Iceland Haddock.
Year class strengths from VPA (in million of fish aged 2 years).

Year class	A	B	C
1960	114	114	114
1961	91	91	91
1962	80	80	80
1963	66	65	66
1964	77	77	77
1965	42	42	42
1966	65	64	65
1967	36	36	36
1968	41	40	43
1969	31	30	35
1970	64	62	76
1971	35	42	45
1972	(24)	(42)	(51)
1973	(6.7)	(13)	(13)
Mean year classes 1960-70	64	64	66

A 1975 F values for ages $\geq 4 = 0.7$

B 1975 F values for ages $\geq 6 = 1.0$

C 1975 F values for ages $\geq 4 = 0.45$

Table 21. Iceland Haddock.
Catch predictions 1976-78 ('000 tons).

A. Assuming 64×10^6 2 year old fish in the 1974-76 year classes.

	1976	1977	1978
C	32	37	44
D	40	39	43

B. Assuming 30×10^6 2 year old fish in the 1974-76 year classes.

	1976	1977	1978
C	30	26	25
D	39	32	28

C - Using F values for ages $\geq$ 4 years = 0.7
D - Using F values for ages $\geq$ 6 years = 1.0

} see Table 15

APPENDIX I

Iceland Haddock

Derivation of stable age compositions of catches per 1 000 recruits.

Age	F[1]	Z	S[2]	N[3]	F(1-S)/Z	Catch[4]	$\bar{W}$ kg	Yield[5] (kg)
1	0	0.2	0.819	1 000	0	0	0.27	0
2	0.05	0.25	0.779	819	0.044	36	0.62	22
3	0.26	0.46	0.631	638	0.209	133	0.96	128
4	0.51	0.71	0.492	403	0.365	147	1.41	207
5	0.70	0.90	0.407	198	0.461	91	2.03	185
6	0.82	1.02	0.361	81	0.514	42	2.91	122
7	0.84	1.04	0.353	29	0.523	15	3.80	57
8	0.72	0.92	0.399	10	0.470	4.7	4.56	21
9	0.70	0.90	0.407	4.1	0.461	1.9	4.72	9.0
10	0.70	0.90	0.407	1.7	0.461	0.8	5.73	4.6

1) Means from VPA for the period 1967-71.

2) S = exp-Z

3) e.g. 638 = 819 (0.779)

4) Catch = NF(1-5)/Z

5) Yield = $\bar{W}$ catch (kg per 1 000 recruits)

APPENDIX II

Iceland Haddock

Worksheet for calculating effect of change in fishing effort - using conversion factors at each age.
Example: effort increased by 20%.

Age	F[1]	ΣF[2]	0.2ΣF	A exp.-0.2ΣF	B Old yield[3]	New yield[4]
1	0	0	0	1.0	0	1.2
2	0.05	0.02	0.004	0.996	22	26
3	0.26	0.18	0.036	0.965	128	148
4	0.51	0.56	0.112	0.894	207	222
5	0.7	1.17	0.234	0.791	185	176
6	0.82	1.93	0.386	0.680	122	100
7	0.84	2.76	0.552	0.576	57	39
8	0.72	3.54	0.708	0.493	21	12
9	0.7	4.25	0.850	0.427	9.0	4.6
10	0.7	4.95	0.990	0.372	4.6	2.1
					756	731 (- 3%)

[1] Mean values for the period 1967-71.

[2] Values of F summed to middle of age group, e.g. 0.18 = 0 + 0.05 +(0.26)/2.

[3] In kg/1 000 recruits.

[4] New yield at each age = 1.2 A.B

General formula for conversion factor at each age

$= (1 + x/100)\ (\text{old yield})\ \exp.-\left[(x/100)\Sigma F\right]$

where x = % change in effort (note if effort is decreased, x becomes negative).

APPENDIX III

Iceland Haddock

Worksheet for predicting catches 1976-78

M = 0.2

Age	1975* Catch	F*	A e^{-Z}	B $F(1-e^{-Z})/Z$	C 1975 stock	D 1976 stock	E 1976 catch	F 1977 stock	G 1977 catch	H 1978 stock	I 1978 catch	$\overline{W}$ (kg)*
2	581	0.10	0.7408	0.0864	6 725	(64 000)	(5 529)	(64 000)	(5 529)	(64 000)	(5 529)	0.62
3	6 732	0.50	0.4966	0.3596	18 722	4 982	1 791	47 412	17 049	(47 412)	(17 049)	0.96
4	8 395	0.70	0.4066	0.4616	18 188	9 297	4 291	2 474	1 142	(23 544)	(10 867)	1.41
5	7 528	0.70	0.4066	0.4616	16 310	7 395	3 413	3 780	1 745	1 006	464	2.03
6	1 614	0.70	0.4066	0.4616	3 497	6 631	3 061	3 007	1 388	1 537	709	2.91
7	764	0.70	0.4066	0.4616	1 655	1 422	656	2 696	1 244	1 222	564	3.80
8	156	0.70	0.4066	0.4616	338	673	311	578	267	1 096	506	4.56
9	91	0.70	0.4066	0.4616	197	137	63	274	126	235	108	4.72
10	30	0.70	0.4066	0.4616	65	80	37	56	26	111	51	5.73
Weights of Catch 000's tons	42.8						31.5		35.7		43.4	
Corrected weight	44						32.3		36.6		44.5	

Input data: * 1975 catch (000's); exploitation pattern (F's); mean weights ($\overline{W}$); value of M; and year class strength.

"Stocks" refer to numbers at the beginning of the stated years.

e.g.
Column C = (1975 catch)/B
Column D = A x C displaced by one age group e.g. 4 982 = (0.7408) (6 725) etc.
Column F = A x D displaced by one age group
Column H = A x F displaced by one age group.
Column E = B x D
Column G = B x F) Catches in numbers
Column I = B x H

Weights of catches are sums of products of catches x $\overline{W}$.
Corrected weights are weights of catches adjusted in proportion to the actual 1975 catch which was 44 000 tons.

New year classes are introduced at the top of Columns D, F and H (assumed constant) = 64 000 annually in this example.
Values dependent on year class strength inputs are shown in brackets.

Table 22. Nominal catch of Cod.
ICNAF Divisions IE and IF in thousand tons 1960-1975 (Statistical Bulletin).

COD	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Faroe Islands	13.0*)	16.3*)	28.5*)	22.7*)	17.7*)	19.3*)	22.6*)	20.5*)	12.7*)	5.1*)	2.7*)	6.4*)	2.8*)	2.1*)	2.0
France	0.1	0.2	0.2	0.7	1.0	0.9	2.0	1.3	7.7	3.2	0.5	0.5	0.3		
Germany, Fed.Rep.	7.7	20.4	31.1	44.9	27.9	20.5	21.7	32.3	55.6	38.4	31.0	26.2	6.8	4.0	0.8
German Dem.Rep.	+			2.2	1.7	0.5x)	1.8	1.1	4.7	1.7	3.4*)	0.1			
Greenland	10.2	15.9	17.2	12.1	7.2	7.9	7.1	8.6	10.0	8.2x)	8.6*)	7.1x)	6.9*)	6.0	7.6
Iceland	2.8*)	3.6*)	0.5	1.7	1.2	0.7	0.6	0.1							
Norway	14.3*)	13.7*)	3.4*)	9.2*)	11.6*)	8.2*)	10.2*)	13.7*)	10.7*)	5.8*)	1.6*)	1.5*)	6.3*)	4.2*)	1.8
Poland	+		0.3	0.2		+	0.1	+	+	0.1					
Portugal	5.4	0.4	2.6	1.5		+	0.2	+	6.4	5.8	1.4	+	+	+	0.4
Spain	0.1	+	0.4	0.1	0.2		+	3.0	1.0	2.2	1.0	0.6	0.6	0.6	+
U.K. (England & Wales)	8.1	2.7	6.6	10.7	13.4	6.1	11.2	5.2	4.7		2.9	1.4	0.4	0.5	0.8
USSR	0.1			1.0					0.5		0.3			+	
Total	61.7	73.1	90.8	106.9	81.9	64.1	77.7	85.8	114.0	70.5	53.5	43.8	24.0	17.4	13.4
Division INK x)	76.2	88.0	115.9	99.7	84.3	99.2	95.1	95.9	68.6	35.9	23.0	26.4	20.1	1.1	0
IE-IF Allocated x)	25.2	26.5	31.0	29.8	25.9	26.1	32.2	30.9	20.3	10.8	8.2	9.2	7.3	0.7	0

x) Catches reported as Division INK (West Greenland unspecified) are given two lines above. Parts of these catches have been allocated (by the Greenland Fisheries Institute) to Divisions IE-IF as given in the last line.
The countries for which the catch or part of the catch was reported as Division INK are marked with an asterisk.

Table 23. Nominal catch of Cod.
ICES Sub-Area XIV in thousand tons 1960-1975 (Bulletin Statistique).

COD	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975[1)]
Faroe Islands	0.4	1.2											0.9	0.2	0.7	0.3
Germany, Fed.Rep.	19.1	15.0	14.3	13.9	30.6	11.0	7.8	12.1	8.3	12.6	13.9	25.6	21.6	9.3	2.3	1.5
German Dem.Rep.														+	+	0.3
Greenland	1.6	1.2	0.9	0.9	1.1	0.9	0.9	0.7	0.6	0.6	0.5	0.5	0.3	0.2	+	0.2
Iceland	2.5	1.4	0.3	1.8	2.9	4.7	4.0	10.5	6.7	4.5	5.5	4.6	3.2	1.4	3.0	0.8
Poland											0.8	0.4	0.3	+	+	+
U.K.	0.3	0.9	1.8	0.8	1.0	0.9	0.2	1.4	+		0.1	+	0.2	0.7	0.5	0.4
USSR				5.7				+		+	+	0.3	0.1			
Total	23.9	19.7	17.3	23.1	35.6	17.5	12.9	24.7	15.7	17.8	20.9	31.5	26.6	11.8	6.6	3.4

[1)] Preliminary figures based on verbal information by the Working Group.

Table 24. Nominal catch of Cod.
ICES Sub-Area XIV and ICNAF Divisions IE and IF in thousand tons 1960-1974.
(Bulletin Statistique and Statistical Bulletin).

COD	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Faroe Islands	13.4*)	17.5*)	28.5*)	22.7*)	17.7*)	19.3*)	22.6*)	20.5*)	12.7*)	5.1*)	2.7*)	6.4*)	3.7	2.3	2.7
France	0.1	0.2	0.2	0.7	1.0	0.9	2.0	1.3	7.7	3.2	0.5	0.5	0.3		
Germany, Fed.Rep.	26.8	35.4	45.4	58.8	58.5	31.5	29.5	44.4	63.9	51.0	44.9	51.8	28.4	13.3	3.1
German Dem.Rep.	+			2.2	1.7	0.5*)	1.8	1.1	4.7	1.7	3.4*)	0.1		+	+
Greenland	11.8	17.1	18.1	13.0	8.3	8.8	8.0	9.3	10.6	8.8*)	9.1*)	7.6*)	7.2*)	6.2	7.6
Iceland	5.3*)	5.0*)	0.8	3.5	4.1	5.4	4.6	10.6	6.7	4.5	5.5	4.6	3.2	1.4	3.0
Norway	14.3*)	13.7*)	3.4*)	9.2*)	11.6*)	8.2*)	10.2*)	13.7*)	10.7*)	5.8*)	1.6*)	1.5*)	6.3*)	4.2*)	1.8
Poland	+		0.3	0.2		+	0.1	+	+	0.1	0.8	0.4	0.3	+	+
Portugal	5.4	0.4	2.6	1.5		+	0.2	+	6.4	5.8	1.4	+	+	+	0.4
Spain	0.1	+	0.4	0.1	0.2		+	3.0	1.0	2.2	1.0	0.6	0.6	0.6	+
U.K.	8.4	3.6	8.4	11.5	14.4	7.0	11.4	6.6	4.7		3.0	1.4	0.6	1.2	1.3
USSR	0.1			6.7				+	0.5	+	0.3	0.3	0.1	+	
Total	85.6	92.8	108.1	130.0	117.5	81.6	90.6	110.5	129.7	88.3	74.4	75.3	50.6	29.2	20.0
Division INK x)	76.2	88.0	115.9	99.7	84.3	99.2	95.1	95.9	68.6	35.9	23.0	26.4	20.1	1.1	0
IE-IF Allocated x)	25.2	26.5	31.0	29.8	25.9	26.1	32.2	30.9	20.3	10.8	8.2	9.2	7.3	0.7	0

x) Catches reported as Division INK (West Greenland, unspecified) are given two lines above. Parts of these catches have been allocated (by the Greenland Fisheries Institute) to Divisions IE-IF as given in the last line. The countries for which the catch or part of the catch was reported as Division INK are marked with an asterisk.

Table 25. Nominal catches of Cod in ICNAF Divisions IE-IF compared to the total catch of Cod in ICNAF Sub-Area I.

Year	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974
Sub-Area I (tons x 10^{-3})	243	345	451	406	350	360	366	430	394	215	113	121	111	63	48
Divisions IE-IF (tons x 10^{-3})	61.7	73.1	90.8	106.9	81.9	64.1	77.7	85.8	114.0	70.5	53.5	43.8	24.0	17.4	13.4
Divisions IE-IF as % of Sub-Area 1	25.4	21.2	20.1	26.3	23.4	17.8	21.2	20.0	28.9	32.8	47.3	36.2	21.6	27.6	27.9

Table 26. Cod. East Greenland.
Estimates of total effort (Germany, Fed.Rep. of days fished used as unit).

Year	Germany, Fed.Rep. catch[b]	Germany, Fed.Rep. effort[a]	Germany, Fed.Rep. c.p.u.e.	Total catch	Total effort
1962	14 299	1 660	8.61	17 295	2 008
1963	13 877	2 182	6.36	23 057	3 625
1964	30 623	3 287	9.32	35 577	3 819
1965	10 965	2 734	4.01	17 497	4 363
1966	7 786	1 827	4.26	12 870	3 020
1967	12 117	2 157	5.62	24 732	4 403
1968	8 323	1 361	6.12	15 701	2 567
1969	12 635	2 164	5.84	17 771	3 044
1970	13 930	1 532	9.09	20 907	2 299
1971	25 644	1 737	14.8	31 516	2 135
1972	21 592	1 732	12.5	26 629	2 136
1973	9 262	931	9.95	11 752	1 181
1974	2 309	312	7.40	6 553	885
1975[c]	1 526			3 435	

a) Germany, Federal Republic of, research reports to ICNAF.

b) Bulletin Statistique Sub-Area XIV.

c) Provisional.

Table 27. Cod. ICNAF Divisions IE-IF 1960-75.
Catch in numbers per age group (1 000 fish).

Age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
3	-	11	435	33	77	-	1 180	49	8	-
4	2 214	283	2 022	534	562	2 447	1 996	1 070	994	142
5	798	7 745	4 879	7 710	1 061	5 336	19 836	3 211	10 713	3 167
6	935	1 860	11 631	8 201	8 239	1 889	4 597	14 391	9 972	15 355
7	5 233	1 343	1 415	11 852	5 550	5 110	1 588	5 800	11 520	6 595
8	1 541	4 741	1 291	912	4 823	3 965	3 018	583	2 236	4 662
9	752	945	2 676	248	542	1 662	2 232	369	182	731
10	1 469	604	475	996	245	223	707	917	123	43
11	220	1 203	308	178	733	158	79	55	314	75
12	394	129	737	178	81	552	56	28	23	146
13	1 425	245	47	443	48	22	186	36	5	27
14+	712	1 220	1 303	751	256	129	128	107	56	4

	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Total	15 693	20 329	27 219	32 036	22 217	21 493	35 603	26 616	36 146	30 947
corresponding catch (tons)x)	61 705	73 086	90 789	106 882	81 942	64 137	77 661	85 751	114 001	70 476
$\overline{w}$ (kg)	3.93	3.60	3.34	3.34	3.69	2.98	2.18	3.22	3.15	2.28

Age	1970	1971	1972	1973	1974	1975xx)
3	-	-	1	4	56	59
4	171	66	2 944	60	145	304
5	1 496	1 118	952	5 133	235	531
6	3 323	2 064	2 218	980	2 664	184
7	8 763	3 274	737	1 005	206	2 587
8	2 989	6 054	1 482	254	240	160
9	1 874	1 266	1 611	742	105	54
10	647	657	293	373	107	27
11	88	207	173	63	205	21
12	33	10	60	36	128	7
13	97	24	4	10	53	3
14+	27	44	26	10	16	3

	1970	1971	1972	1973	1974	1975
Total	19 508	14 784	10 501	8 670	4 160	3 940
corresponding catch (tons)	53 530	43 837	23 970	17 438	13 447	11 300
$\overline{w}$ (kg)	2.74	2.97	2.28	2.01	3.23	2.87

x) Including estimates of catches reported as Division INK.
xx) Including estimates of catches for countries other than Germany, Fed.Rep. of (4 652 tons), U.K. (92) and Denmark (G) (3 186) and partly using samples from Divisions north of Divisions IE-IF. 1975 sampling very poor.

Table 28. Cod. East Greenland.
ICES Sub-Area XIV 1960-1975. Catch in numbers per age group (1 000 fish).

Age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
3	-	23	4	-	1	-	28	-	-	-	-	-	-	4	4	25
4	78	87	64	61	26	131	21	145	104	31	66	25	27	25	63	25
5	144	240	113	419	108	35	470	302	630	252	76	171	85	197	22	149
6	255	203	974	743	933	91	89	2 346	502	849	500	159	254	126	488	38
7	1 321	215	344	2 555	2 281	879	137	564	2 505	770	1 539	1 051	295	250	176	344
8	525	1 080	151	419	3 682	661	1 071	210	238	2 103	1 060	3 785	1 299	82	185	68
9	475	377	1 050	70	383	1 484	359	1 292	62	170	1 715	1 580	3 184	710	52	36
10	1 636	244	298	648	64	59	418	492	144	38	237	1 326	818	959	329	9
11	409	719	132	154	443	27	23	371	69	82	32	171	470	222	259	29
12	60	184	362	96	74	139	3	37	27	68	63	19	136	72	65	23
13	487	64	60	190	35	29	27	17	5	24	48	4	26	19	11	7
14	16	192	15	23	146	41	18	49	10	7	16	9	22	-	-	2
15	83	23	143	12	31	80	2	2	9	10	2	5	24	-	-	
16	-	76	-	71	8	1	5	2	-	10	5		7	3	2	
17	-	-	64	12	102	2	2	16	-	1	3			1		
18	39	-		18	-	37	-	-	4	-	-			-		
19		37			29	1	-	-	-	3	-			3		
≥20						16	9	12	2	5	1					
Total	5 528	3 764	3 774	5 491	8 346	3 713	2 682	5 857	4 311	4 423	5 363	8 305	6 647	2 673	1 656	755
Corresponding catch (tons)	23 914	18 597	17 295	23 057	35 577	17 497	12 870	24 732	15 701	17 771	20 907	31 516	26 629	11 752	6 553	3 435

Table 29. Cod.
ICES Sub-Area XIV plus ICNAF Divisions IE-IF 1960-1975. Catch in numbers per age group (1 000 fish).

Age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975x)
3		34	439	33	78		1 208	49	8				1	8	60	84
4	2 292	370	2 086	595	588	2 578	2 017	1 215	1 098	173	237	91	2 971	85	208	329
5	942	7 985	4 992	8 129	1 169	5 371	20 306	3 513	11 343	3 419	1 572	1 289	1 037	5 330	257	680
6	1 190	2 063	12 605	8 944	9 172	1 980	4 686	16 737	10 474	16 204	3 823	2 223	2 472	1 106	3 152	222
7	6 554	1 558	1 759	14 407	7 831	5 989	1 725	6 364	14 025	7 365	10 302	4 325	1 032	1 255	382	2 931
8	2 066	5 821	1 442	1 331	8 505	4 626	4 089	793	2 474	6 765	4 049	9 839	2 781	336	425	228
9	1 227	1 322	3 726	318	925	3 146	2 591	1 661	244	901	3 589	2 846	4 795	1 452	157	90
10	3 105	848	773	1 644	309	282	1 125	1 409	267	81	884	1 983	1 111	1 332	436	36
11	629	1 922	440	332	1 176	185	102	426	383	157	120	378	643	285	464	50
12	454	313	1 099	274	155	691	59	65	50	214	96	29	196	108	193	30
13	1 912	309	107	633	83	51	213	53	10	51	145	28	30	29	64	10
≥14	850	1 548	1 525	887	572	307	164	188	81	40	54	58	79	17	18	5
Total	21 221	24 093	30 993	37 527	30 563	25 206	38 285	32 473	45 457	35 370	24 871	23 089	17 148	11 343	5 816	4 695
Corresponding catch (tons)	85 619	91 683	108 084	129 939	117 519	81 634	90 531	110 483	129 702	89 247	74 437	75 353	50 599	29 190	20 000	14 735

x) Provisional figures.

Table 30. Cod. ICES Sub-Area XIV plus ICNAF Divisions IE-IF.
Fishing mortalities by year and age.

Age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
3	0.00	0.00	0.02	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.02	0.00	0.03	0.03	0.01	0.02	0.02	0.01	0.02	0.02	0.02	0.01	0.07	0.03	0.02	0.02
5	0.04	0.08	0.06	0.14	0.08	0.11	0.18	0.05	0.10	0.10	0.19	0.14	0.18	0.17	0.12	0.09
6	0.06	0.12	0.17	0.15	0.24	0.20	0.14	0.22	0.22	0.21	0.16	0.45	0.45	0.30	0.14	0.15
7	0.11	0.13	0.17	0.35	0.22	0.28	0.30	0.32	0.33	0.27	0.23	0.31	0.46	0.50	0.18	0.22
8	0.16	0.19	0.23	0.26	0.52	0.28	0.43	0.31	0.28	0.36	0.32	0.52	0.47	0.37	0.45	0.22
9	0.12	0.19	0.24	0.10	0.41	0.52	0.34	0.45	0.20	0.21	0.47	0.56	0.78	0.71	0.42	0.22
10	0.19	0.15	0.23	0.22	0.18	0.29	0.52	0.45	0.16	0.13	0.47	0.77	0.66	0.76	0.71	0.22
11	0.09	0.23	0.15	0.20	0.33	0.21	0.22	0.54	0.29	0.18	0.40	0.55	0.95	0.50	1.03	0.22
12	0.06	0.08	0.28	0.18	0.18	0.47	0.13	0.30	0.15	0.37	0.23	0.22	0.94	0.58	1.18	0.22
13	0.39	0.08	0.05	0.36	0.10	0.11	0.36	0.23	0.09	0.31	0.67	0.13	0.52	0.48	1.36	0.22
14	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.22
Mean $F \geq 7$	0.14	0.18	0.22	0.31	0.32	0.32	0.38	0.36	0.31	0.30	0.29	0.48	0.63	0.61	0.50	0.22

The last group is a plus group.

Table 31. Cod. ICES Sub-Area XIV plus ICNAF Divisions IE-IF.
Stock in numbers at beginning of year.

Age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
3	135 469	103 633	25 548	82 807	210 123	116 737	191 570	60 170	15 000	16 137	10 362	60 481	3 786	13 246	25 472	42 172
4	144 361	110 912	84 817	20 521	67 767	171 963	95 576	155 753	49 219	12 273	13 212	8 484	49 518	3 099	10 838	20 801
5	24 790	116 123	90 473	67 558	16 264	54 952	138 464	76 430	126 423	39 305	9 892	10 603	6 864	37 861	2 461	8 686
6	21 321	19 446	87 870	69 568	47 986	12 261	40 148	95 075	59 405	93 277	29 097	6 684	7 520	4 686	26 197	1 783
7	78 457	16 382	14 062	60 588	48 899	31 035	8 256	28 647	62 776	39 209	61 783	20 378	3 479	3 940	2 842	18 607
8	17 966	43 009	8 835	7 261	26 111	23 943	14 423	3 737	12 683	27 732	18 375	29 942	9 174	1 346	1 461	1 447
9	14 042	9 416	21 871	4 305	3 428	9 541	11 123	5 722	1 683	5 874	11 823	8 160	10 877	3 506	568	571
10	22 965	7 656	4 752	10 540	2 392	1 395	3 458	4 834	2 242	843	2 906	4 515	2 843	3 062	1 054	229
11	9 435	11 681	4 037	2 318	5 194	1 228	638	1 265	1 889	1 168	454	1 109	1 276	903	874	317
12	9 254	5 295	5 681	2 134	1 165	2 283	610	313	452	864	595	187	393	302	337	190
13	7 384	5 318	3 002	2 638	1 097	594	873	328	142	238	366	291	92	94	103	63
14	1 683	3 065	3 020	1 756	1 133	608	325	372	160	79	107	115	156	34	36	16

Table 32. Prediction of catch and biomass for Cod in ICES Sub-Area XIV and ICNAF Divisions IE-IF.

1975	1976			1977			1978
Biomass x) Age ≥ 4 (1 000 tons)	Biomass x) Age ≥ 4 (1 000 tons)	$F_{(\geq 7)}$	Predicted x) catch (1 000 tons)	Biomass x) Age ≥ 4 (1 000 tons)	$F_{(\geq 7)}$	Predicted x) catch (1 000 tons)	Biomass x) Age ≥ 4 (1 000 tons)
126	136	0.22	13.9 (0.08)	187 (57)	0.22	16.5 (0.9)	203 (85)
					0.45	30.5 (0.9)	185 (83)
		0.45	26.2 (0.2)	174 (56)	0.22	14.7 (0.9)	196 (85)
					0.45	27.1 (0.9)	178 (83)

x) The biomass is given by 1 January and therefore includes only fish 4 years and older at that time. During the year 3-year-old fish will recruit, and some of these are included in the catch figures.

The figures in brackets reflect that part of the predicted catches and stock which is dependent on the incoming year classes.

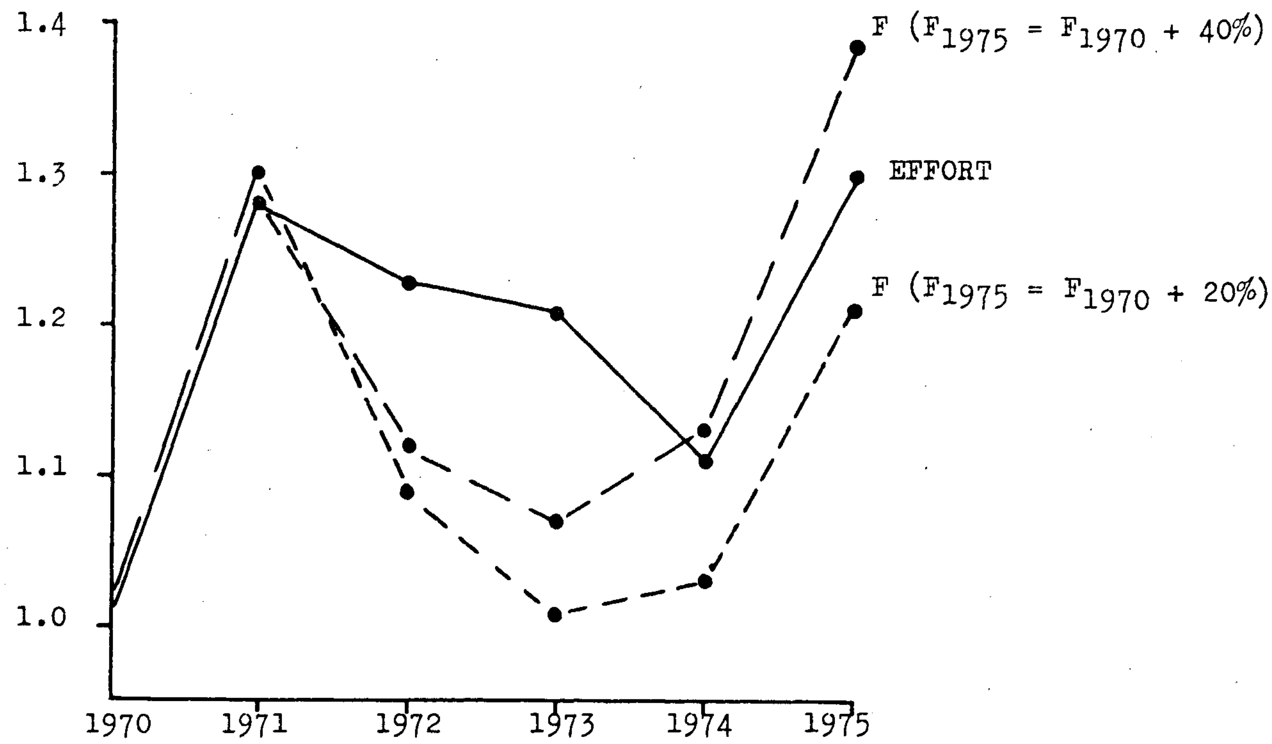
Table 33. Numbers of Cod emigrating from Greenland (ICES Sub-Area XIV and ICNAF Divisions IE-IF) to Iceland (ICES Division Va) in Nos. x 10^{-6}.

Age / Years	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
7	17.1	3.5	3.0	11.9	10.2	6.3	1.7	5.7	12.4	8.0	12.8	4.1	0.7	0.7	0.6	3.9
8	3.8	9.0	1.8	1.5	4.8	4.8	2.7	0.7	2.6	5.4	3.7	5.5	1.7	0.3	0.3	0.3
9	3.1	2.0	4.6	0.9	0.7	1.7	2.2	1.1	0.4	1.2	2.2	1.5	1.8	0.6	0.1	0.1
10	4.8	1.6	1.0	2.2	0.5	0.3	0.6	1.0	0.5	0.2	0.5	0.7	0.5	0.5	0.2	-
11	2.1	2.4	0.9	0.5	1.0	0.3	0.1	0.2	0.4	0.2	0.1	0.2	0.2	0.2	0.1	0.1
12	2.1	1.2	1.1	0.5	0.2	0.4	0.1	0.1	0.1	0.2	0.1	-	0.1	0.1	-	-
13	1.4	1.2	0.7	0.5	0.2	0.1	0.2	-	-	-	0.1	0.1	-	-	-	-
14	0.3	0.6	0.6	0.3	0.2	0.1	0.1	0.1	-	-	-	-	-	-	-	-
Total	34.7	21.5	13.6	18.3	17.8	14.0	7.7	8.9	16.4	14.2	19.5	12.1	5.0	2.4	1.3	4.4

Age/Year Classes	1953	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968
7	17.1	3.5	3.0	11.9	10.2	6.3	1.7	5.7	12.4	8.0	12.8	4.1	0.7	0.7	0.6	3.9
8	9.0	1.8	1.5	4.8	4.8	2.7	0.7	2.6	5.4	3.7	5.5	1.7	0.3	0.3	0.3	
9	4.6	0.9	0.7	1.7	2.2	1.1	0.4	1.2	2.2	1.5	1.8	1.6	0.1	0.1		
10	2.2	0.5	0.3	0.6	1.0	0.5	0.2	0.5	0.7	0.5	0.5	0.2	-			
11	1.0	0.3	0.1	0.2	0.4	0.2	0.1	0.2	0.2	0.2	0.1	0.1				
12	0.4	0.1	0.1	0.1	0.2	0.1	-	0.1	0.1	-	-	-				
13	0.2	-	-	-	0.1	0.1	-	-	-	-						
14	0.1	-	-	-	-	-	-	-	-							
Total	34.6	7.1	5.7	19.3	18.9	11.0	3.1	10.3	21.0	13.9	20.7	6.7	1.1	1.1	0.9	(3.9)

Figure 1. Iceland Cod.

Trends in estimates of fishing effort and of weighted F values (age groups 4-6) from two VPAs, all expressed relative to the 1970 value.



	Z	F		Z	$\hat{F}$
1961	.570	.224	1973	.880	0.52
1962	.550	.269	1974	.930	0.55
1963	.805	.311			
1964	.755	.368			
1965	.770	.420			
1966	.690	.231			
1967	.285	.211			
1968	.345	.213			
1969	.540	.283			
1970	.610	.338			
1971	.730	.529			
1972	.910	.560			
$\bar{x}$	.630	.312			

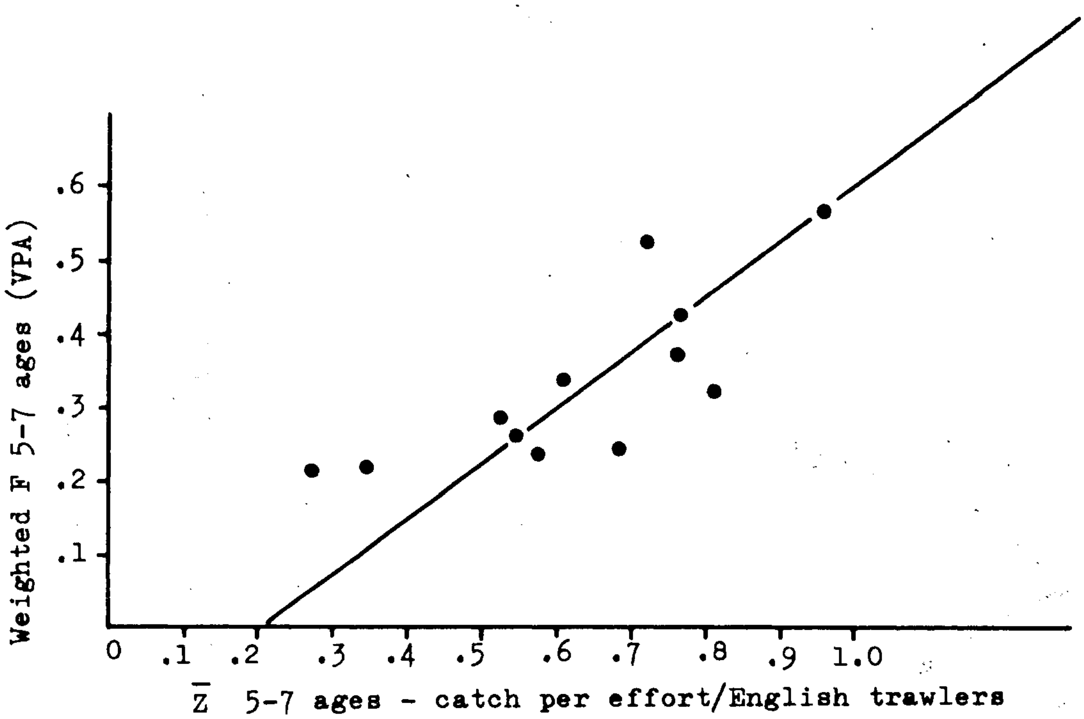


Figure 2. Iceland Cod.
The relation between fishing mortality from VPA and total mortality based on English trawler catch per effort.

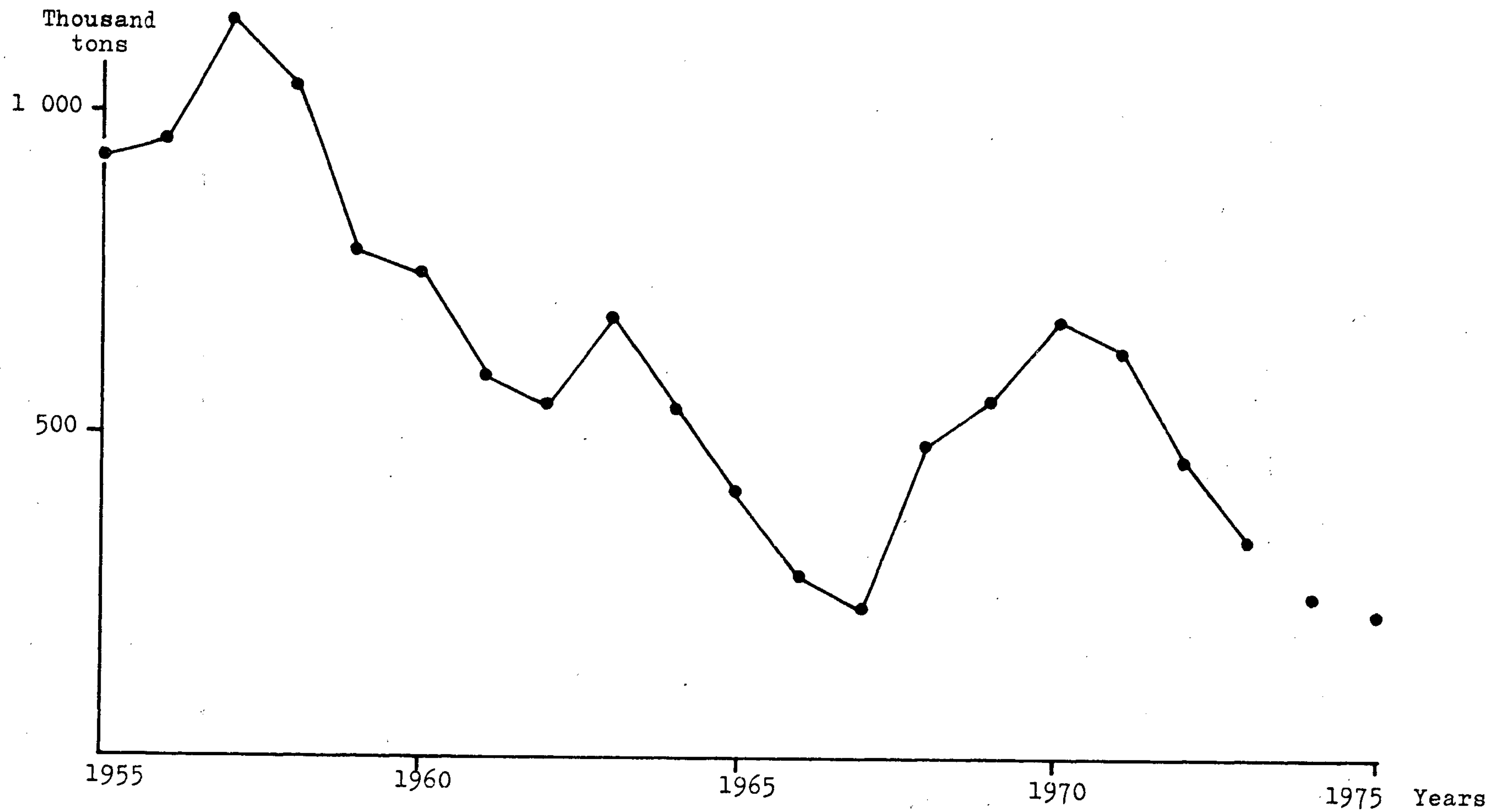


Figure 3. Iceland Cod.
Spawning stock biomass (age groups 7+) estimated from VPA.

Figure 4. Iceland Cod.
Change in biomass with age in an unexploited year class.

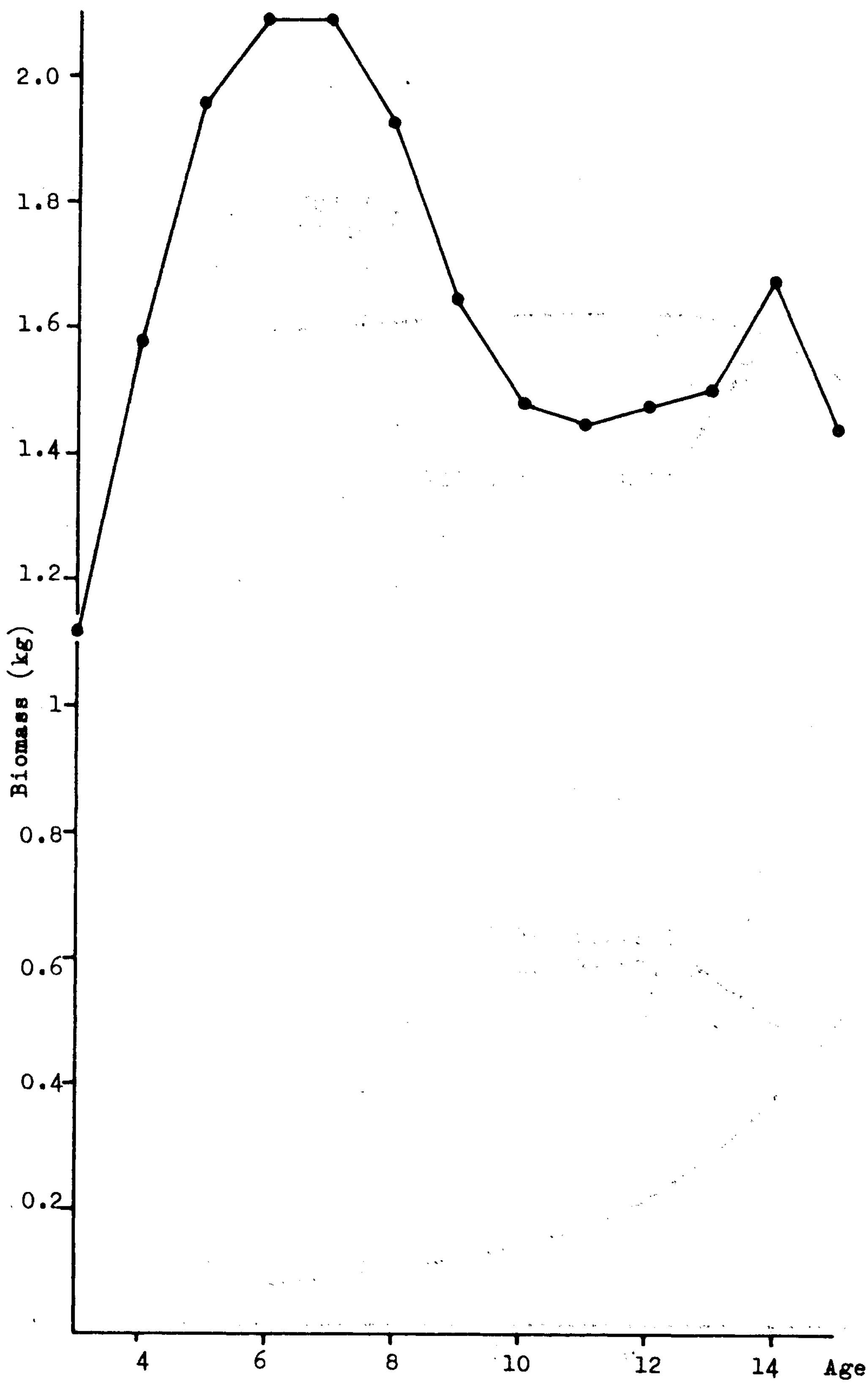


Figure 5. Iceland Cod.
Yield per recruit and spawning stock per recruit under the present exploitation pattern.

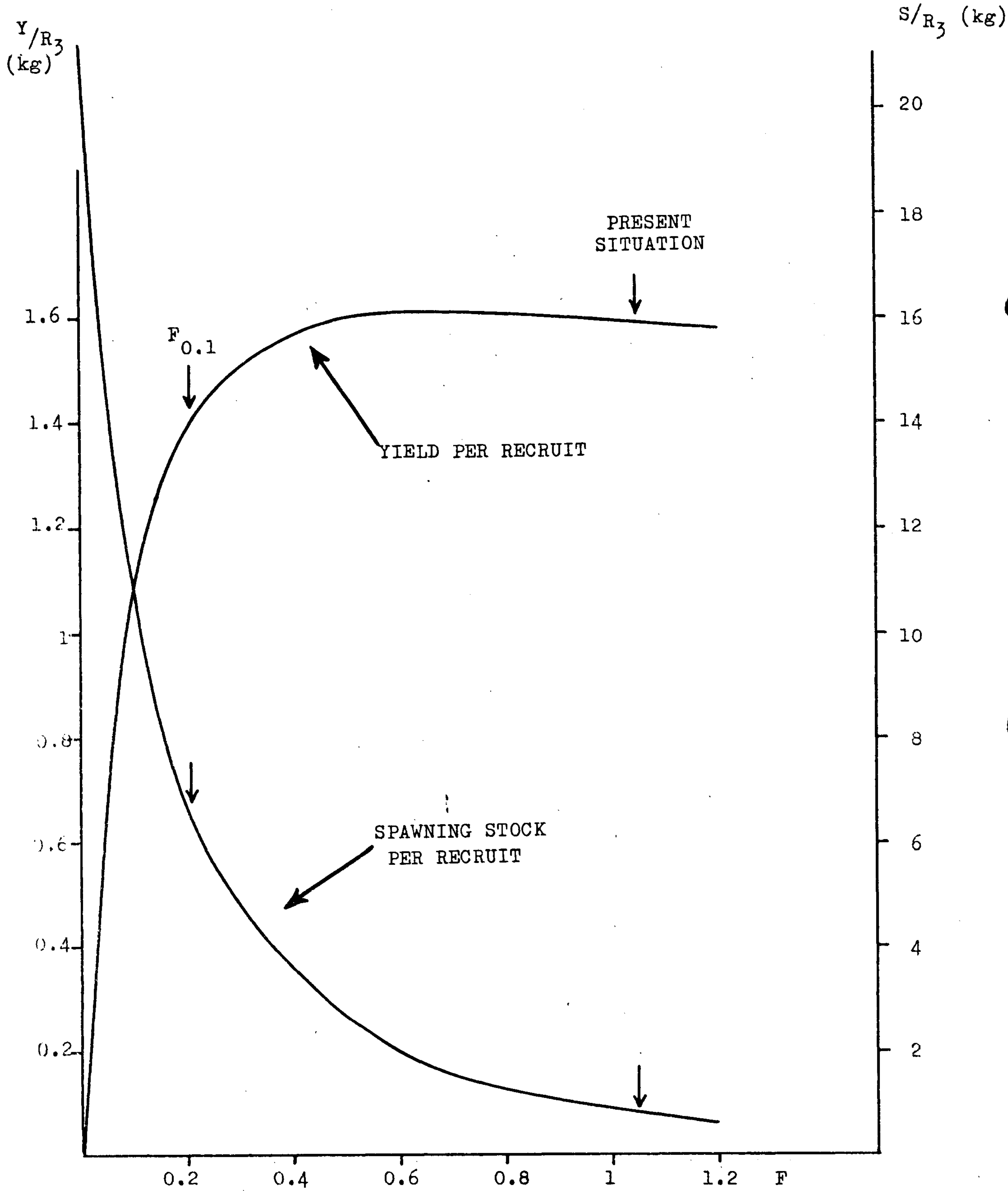
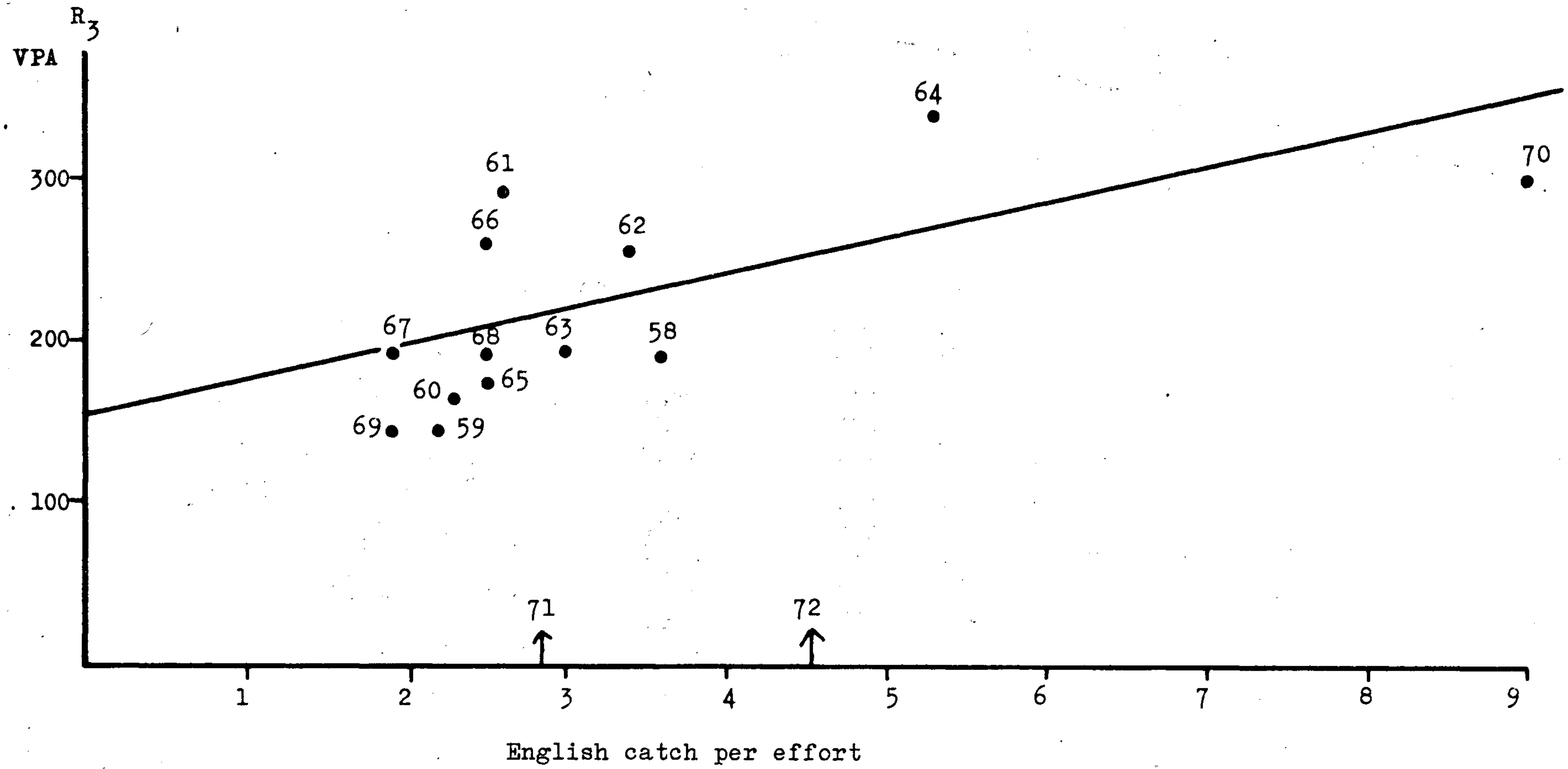


Figure 6. Iceland Cod.
Relationship between stock size of 3 year olds and catch per effort of 3 year olds by English trawlers.



- 59 -

Figure 7. Iceland Cod.
Relationship between stock size of 4 year olds and catch per effort of 4 year olds by English trawlers.

				Year class	x	y		x	$\hat{R}_3$
		b	17.8783	1957	4.1	112			
		a	53.2780	1958	5.2	142			
		Sxy	37.4695	1959	4.8	105			
				1960	4.2	120	1970	12.8	282
		Si	5.3913	1961	5.6	225	1971	5.2	146
				1962	6.4	192			
$\bar{x}$	6.08	Σx	79.0	1963	5.4	222			
y		$S(x-\bar{x})^2$	48.3031	1964	11.1	254			
				1965	5.7	134			
$\bar{y}$	162	Σy	2105	1966	9.5	203			
		$S(y-\bar{y})^2$	3.0883	1967	5.9	146			
				1968	5.6	142			
		$r = .7071$	$p.<.001$	1969	5.5	108			
				n =	13				

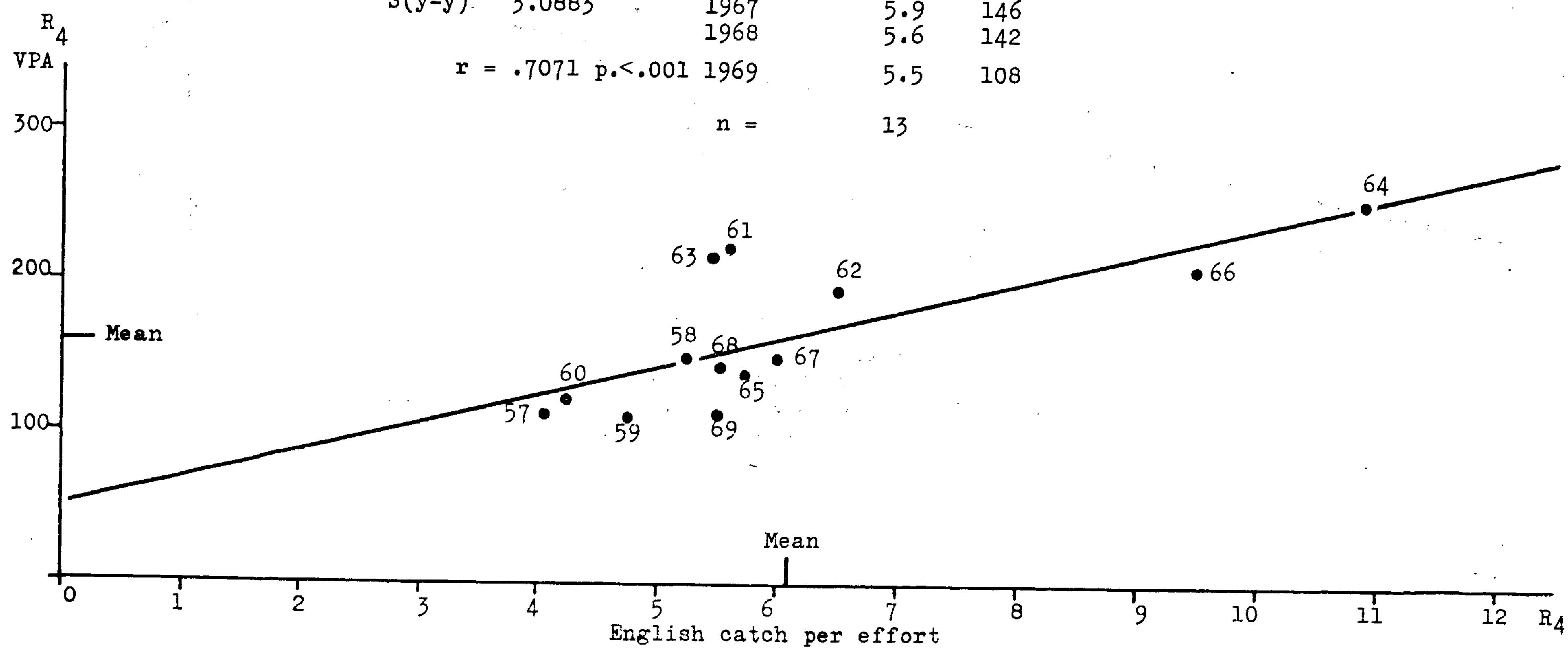


Figure 8. Iceland Cod.
Relationship between English catch per effort of 3 year old cod and estimates from international 0-group surveys.

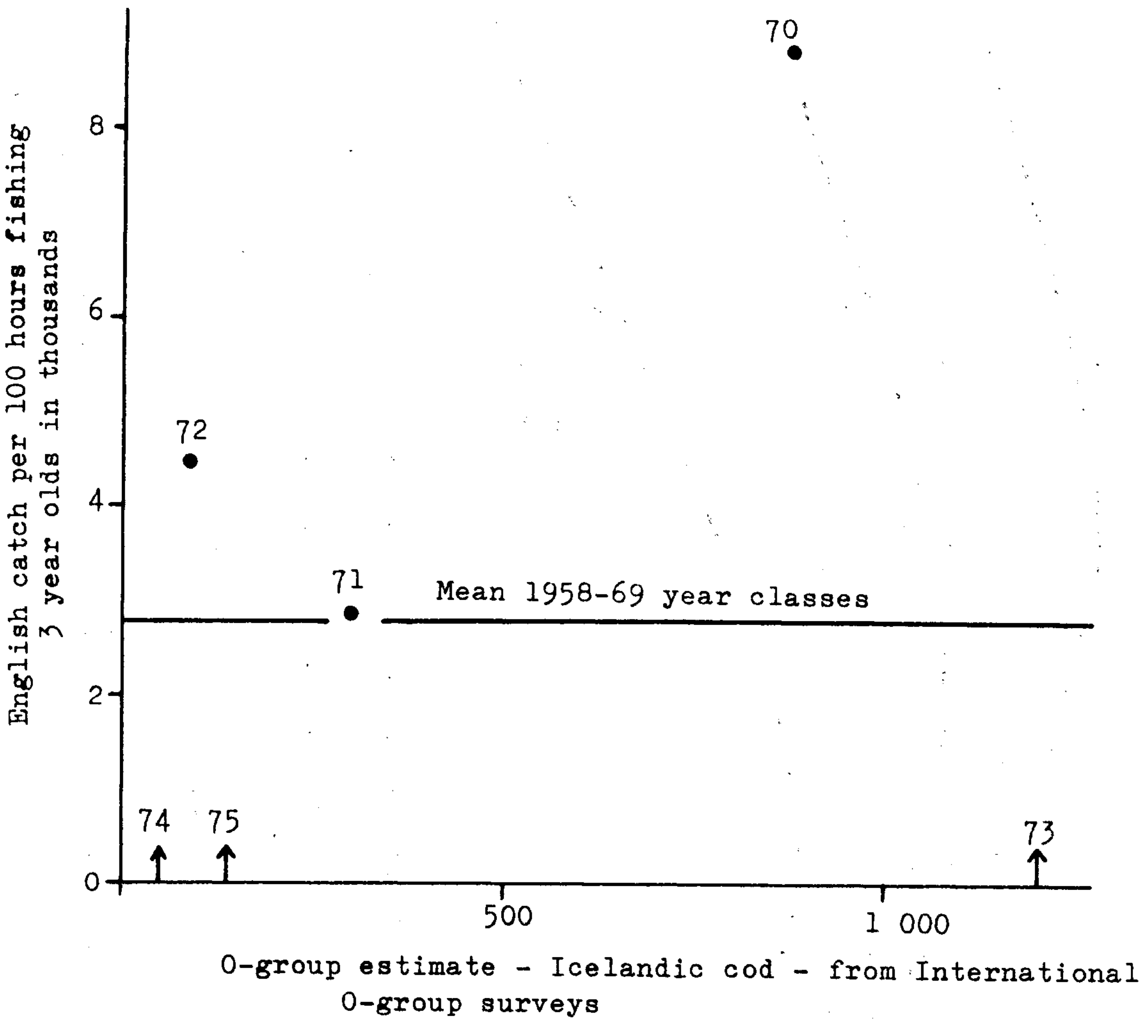
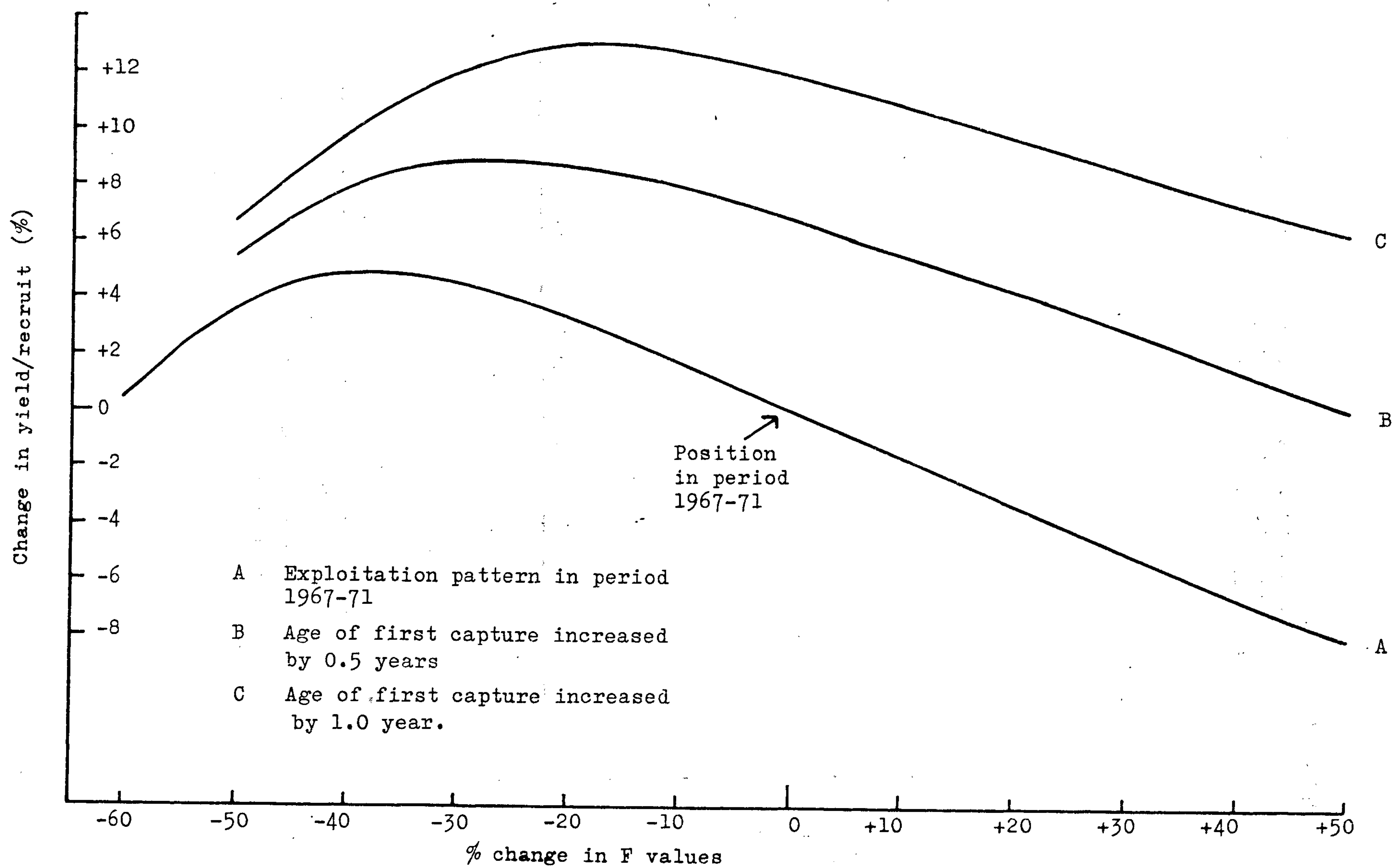


Figure 9. Iceland Haddock.
Effect of changes in fishing mortality (F values) relative to situation in the period 1967-71. M = 0.2.



<u>Figure 10.</u> The dependence of the estimated fishing mortalities at Iceland (4-6 years old) on the numbers of 7-year old fish at Greenland (B) and emigration numbers of emmigrants from Greenland (A).