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Demersal Fish Committee

REPORT OF THE WORKING GROUP ON GREENLAND HALIBUT IN REGION 1

Charlottenlund, 27 February - 3 March 1978

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REPORT OF THE WORKING GROUP ON GREENLAND HALIBUT IN REGION 1

1. PARTICIPANTS

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E Smidt	Denmark
B Vaske (Chairman)	German Democratic Republic

V M Nikolaev, ICES Statistician, also attended the meeting.

2. TERMS OF REFERENCE

At the 65th Statutory Meeting of ICES it was decided (C.Res.1977/2:24) that the Working Group on Greenland Halibut in Region 1 should meet at Charlottenlund, 27 February to 3 March 1978 to:

a) assess TACs for 1979. To facilitate this, participants are urged to bring to the Working Group all relevant data;

b) identify and specify in detail shortcomings and gaps in data required for stock assessment work;

c) review and update the "Review of Fish Resources" given in the Appendix to the 1977 Working Group Report (Doc. C.M.1977/F:4 APPENDIX).

3. NOMINAL CATCHES

The total nominal catches for the main fishing areas are given in Table 1 for the period 1967-77, including correct USSR catch figures for Greenland halibut in Sub-area V for 1967-69.

From 1967 to 1977, the total catch of Greenland halibut in Region 1 was in the range of a minimum catch of 42 119 tons in 1976 and a highest catch level of 123 307 tons in 1970. The preliminary reported total catch in Region 1 for 1977 amounts to 43 923 tons.

Tables 2, 3, 4, 6, 7 and 8 present the nominal catches by country for each fishing area. In Tables 5 and 9 the catches are summarised for Sub-areas I and II as well as for Sub-areas V and XIV, respectively.

The preliminary catch for 1977 in Sub-areas I and II is 28 903 tons, representing a drop of 7 171 tons from the amount taken in 1976. The 1977 total catch for Sub-areas V and XIV increased from 6 045 tons in 1976 to the level of 15 020 tons, which is still lower than for the period 1967 to 1975.

4. GREENLAND HALIBUT IN SUB-AREAS I AND II

4.1 Catch per Unit Effort and Effort Data

Updated catch figures per hour trawling were presented by the USSR representative for the period 1965 to 1977 (Table 10). Since the 1977 Working Group meeting, these data were adjusted in order to take into account changes in the effectiveness of the trawls.

Using the total catches and the catch per unit effort values in the USSR trawl fishery, the effort for the total fishery was estimated (Table 10).

The USSR trawl fishery shows a considerable decrease in the catch per
unit effort in 1977 compared with the period before. According to
information from the USSR representative, this decrease resulted
probably from the combined effect of several factors, i.e., the
decline in the biomass of the stock, a higher concentration of the
vessels on the fishing grounds and changes in the construction of the
trawls used. Without the second and third factor, the c.p.u.e. for
1977 could be expected to be above the actual 1977 level and somewhat
lower than the 1976 catch per unit effort.

Figure 1 shows the trend in the c.p.u.e. (1965-77) and in the total
catches from 1950-77.

4.2   Virtual Population Analysis (VPA)

4.2.1 Age composition of landings

For the period 1970 to 1976, an additional age composition for the
Norwegian long-line catch in 1976 was presented. The other age
compositions remained unchanged.

For 1977, age compositions were available for the German Democratic
Republic, the USSR and the Norwegian long-line catch, accounting for
86% of the total landings in Sub-areas I and II.

To obtain the age composition for the total trawl fishery in 1977, the German
Democratic Republic and the USSR age compositions were raised to the
total trawl landings.

The total age compositions for 1970-77 are given in Table 11.

4.2.2 Choice of input fishing mortalities for 1977

Since there were some doubts whether the total effort in 1977 was over-
estimated or not, 2 alternative approaches were chosen.

Alternative 1:   the total effort in 1977 is disregarded.

The input F on age groups 7 to 16 in 1977 was chosen so that the cal-
culated mean F (F_{8-13}) in 1976 fitted with the linear regression between
unweighted mean F values and total effort for the period 1970-74. This
assumes that the 1976 total effort is correct. The fishing mortalities
on age groups 3 to 6 were chosen so that the estimated stock composition
for these age groups in 1977 was near the average for 1970-74. The
relation between F_{8-13} and the total effort is shown in Figure 2A.
The estimated fishing mortalities and stock sizes are given in Tables
12 and 13.

Alternative 2:   the total effort in 1977 is correct.

The input fishing mortalities in 1977 were chosen so that the total
effort and the corresponding F_{8-13} in 1977 fit with the regression line
between the same set of values for 1970-74. The relationship between
fishing mortality and effort is shown in Figure 2B. This figure shows
that the consequence of accepting the total effort in 1977 is that
the total effort in 1975 and 1976 are underestimated. The results of
the VPA are given in Tables 14 and 15.

4.3   Yield and Spawning Stock per Recruit

The two sets of yield and spawning stock per recruit curves shown in
Figure 3 are based on the average fishing pattern in 1970-71 and the
present fishing pattern for 1977. Both fishing patterns are derived
from the results of Alternative 1 in Section 4.2.2., and the mean
weights given in Table 17. The same set of curves based on the
results from Alternative 2 were omitted, since they will be between
those two shown in Figure 3. The two yield per recruit curves show

that the increasing proportion of the younger age groups in the
catches have decreased the maximum yield per recruit from 0.64 kg to
0.60 kg. Whether this change is mainly due to changes in the stock
composition or to different fishing strategy is not clear.

For the present exploitation pattern the $F_{0.1}$ and the F_{max} values
correspond to 0.12 and 0.20, respectively. Therefore, if Alternative 1
is right, the 1977 fishing mortality (F_{8-13} = 0.19) was very close
to F_{max}. However, if Alternative 2 is right, the 1977 fishing mortality
(F_{8-13} = 0.39) was nearly twice the fishing mortality corresponding to
F_{max}.

For the present fishing mortality, $F_{0.1}$ and F_{max} the corresponding
sustainable yield and equilibrium spawning stock biomass were cal-
culated assuming two different levels of average recruitment at age 3:

$$R_{1970-74} = 54 \times 10^6 \text{ fish (from Alternative 1)}$$

$$R_{1970-74} = 39 \times 10^6 \text{ fish (from Alternative 2)}.$$

The results are given in the following text table:

R	F	Y/R (kg)	Sustainable yield (tons)	S/R (kg)	Spawning stock biomass (tons)
54×10^6	$F_{77}=0.19$	.60	32 400	2.4	130 000
	$F_{0.1}=0.12$	.56	30 200	4.2	227 000
	$F_{max}=0.20$	.60	32 400	2.3	124 000
39×10^6	$F_{77}=0.39$	.56	21 800	0.8	31 000
	$F_{0.1}=0.12$	.56	21 800	4.2	164 000
	$F_{max}=0.20$	.60	23 400	2.3	90 000

Assuming that Alternative 2 is correct, it appears that the high present
F compared with F_{max} will not affect yield per recruit much. The spawning
stock, however, will be reduced to one third of the F_{max} level. This
reduction could have serious effects on recruitment. The spawning stock
at the beginning of 1978 is estimated to be about 44 000 tons, using
Alternative 2.

Under Alternative 1, the spawning stock at the F_{max} level is about
120 000 tons, while the present spawning stock is about 100 000 tons.

4.4   State of the Stock

Figure 4 shows the development in biomass of the total stock and the
spawning stock from 1970 to the beginning of 1978 for the two alter-
natives.

Figure 5 shows the relation between biomass of the total stock and
catch per hour trawling under the two alternatives. The fit of the
1970-74 values is slightly better for estimates based on Alternative 1
(r^2 = 0.95) than on Alternative 2 (r^2 = 0.89). Table 16 gives the same
data as Figure 4 and in addition the estimated stock size from 1965-77
calculated from the relationship as shown in Figure 5 for Alternative 1.

The Working Group felt that Alternative 1 was likely to be more correct than Alternative 2. It was recognised, however, that if Alternative 2 was in fact correct, continuously high catches could have serious consequences for the stock.

The mean surplus production of the stock in 1972-1977 is estimated by:

$$\left[\sum_{i=1972}^{1977} c_i - \left(B \left(N_{4+} \right)_{1972} - B \left(N_{4+} \right)_{1978} \right) \right] \quad /6$$

This gives an average surplus production of 34 300 tons in the case of Alternative 1, and 23 200 tons in the case of Alternative 2. The average catch in the same period was 35 652 tons.

Thus, if the total effort in 1977 is not biased compared with the total effort estimates in 1970-74, the stock is seriously overexploited. If the whole TAC of 40 000 tons in 1978 is taken, the situation will be even worse. In last year's report it was concluded that the stock had been in equilibrium with the catch since 1972. This is also the consequence of Alternative 1.

4.5 Total Allowable Catch (TAC)

Table 17 gives the input parameters in the catch prediction. It was further assumed that the quota of 40 000 tons in 1978 would be taken. The estimate of the total catch in 1977 from the age composition of the catch (Table 11) and the mean weights (Table 17) had to be adjusted by 7% to the reported 1977 catch. In accordance with this, the estimated catches from the catch prediction were increased by 7%.

The catch predictions in 1979 were based on:

a) F equal to F_{max} (= 0.20), and

b) F equal to $F_{0.1}$ (= 0.12).

The results are given in Table 18.

Under both alternatives, these fishing mortalities would improve the spawning stock from 1979 to 1980. However, the predicted catches varied from 8 142 tons to 31 247 tons.

The average of the two catch predictions under Alternative 1 is 25 000 tons.

If Alternative 2 is right, a TAC of 25 000 tons is slightly higher than the sustainable yield of 23 400 tons estimated from the yield per recruit curve (Section 4.3) or the estimated surplus production of 23 200 tons (Section 4.4). If the latter two figures are increased by 7%, they are very close to 25 000 tons.

Because of this, and Alternative 1 being believed to be more correct than Alternative 2, the Group felt that a TAC of 25 000 tons for 1979 is acceptable.

Therefore, the Working Group recommends that the TAC for Greenland halibut in Sub-areas I and II for 1979 should be set at 25 000 tons.

5. GREENLAND HALIBUT IN SUB-AREAS V AND XIV

5.1 Catch per Unit Effort and Effort Data

Catch per unit effort data were available for the USSR trawl fishery in Division Va for the period 1967 to 1974. These data and the total landings from Sub-areas V and XIV were used to calculate the total effort (Table 19). Furthermore, an attempt was made to fit these data by a general production model (Schaefer-type). However, the number of years for which the data were available was too limited to produce a reliable yield curve, since at least a 5-year running average of effort was considered necessary.

5.2 Yield per Recruit

Yield per recruit curves were calculated for different ages at first capture t_c (Figure 6). The age of recruitment to the stock (t_r) and the maximum age (t_λ) were taken as 4 and 18 years, respectively. The growth parameters (W_∞, K, t_0) correspond to a calculated growth equation for the Iceland area, which is given in Doc. C.M.1975/F:24 by Krzykawski.

From Figure 6 it can be seen that the F_{max} point is very dependent on the value of t_c used: 0.30 for $t_c = 6$, 0.45 for $t_c = 8$ and 0.75 for $t_c = 10$. Additionally, $F_{0.1}$ was estimated for each yield per recruit curve as follows: 0.18, 0.20 and 0.25 for $t_c = 6$, 8 and 10, respectively.

5.3 Cohort Analysis Based on Length Composition Data

5.3.1 Input data

For the Greenland halibut in the Iceland and East Greenland areas (Sub-areas V and XIV) no age composition data which would allow the cohort analysis by age groups were available. Therefore, the Working Group made an attempt to estimate the average fishing mortality and stock size on the basis of the length compositions of the catches.

Length compositions of the catches were only available from the German Democratic Republic for the years 1970, 1971 and 1975. Since the cohort analysis based on length composition data requires an average length composition over several years of sampling, these three available years were combined to obtain an average length composition. This procedure assumes a relatively stable situation in the period 1970-75. The average length composition is included in Table 20.

The natural mortality was chosen at $M = 0.15$ which corresponds with the value for Sub-areas I and II.

Since the choice of the terminal F/Z for starting the cohort analysis based on length has no critical influence on the results, a value of $F/Z = .80$ ($F = .60$) was assumed.

The following growth parameters considered to be representative were taken from Doc. C.M.1975/F:24:

$$L_\infty = 144 \qquad K = 0.05 \qquad t_0 = -0.93$$

Mean weight at length values were derived from the relationship $w = 0.004 \times L^{3.198}$ which was calculated from the German Democratic Republic samples in 1975.

5.3.2 Results of the cohort analysis

The results of the cohort analysis based on length composition are given in Table 20. The catch in weight is in quite good agreement with the average catches for the three years (Table 9) on which the analysis is based.

The stock size in number given per 2-cm groups in Table 20 is the estimated stock size at the beginning of the year, and not the number of fish which attain a given length during the year. The weighted and unweighted mean Fs are given at the bottom of Table 20. For Greenland halibut, equal to and bigger than 52 cm or 8 years old, both the unweighted and weighted mean Fs are between the $F_{0.1}$ and F_{max} found from the yield per recruit curve with t_c = 8 years (Figure 6).

5.4 Total Allowable Catch (TAC)

From the cohort on length the number of 8 year old fish in the stock is found, assuming that 8 year old fish are within a range from 7.5 years to 8.5 years. The number in stock for that age is: 19 714 x 10^{-3}. From the yield per recruit curve (Figure 6) with t_c = 8 years, the corresponding yield to $F_{0.1}$ = 0.2 is 0.68 kg. Using this figure (0.68) and the number of 8 year old fish in the stock, the sustainable yield amounts to 13 405 tons.

It should be noted, that the result is based on many assumptions and a very limited data base. However, taking into account the catches in the previous 10 years (Table 9) and the c.p.u.e. data in Table 19, a catch of 15 000 tons seems to be acceptable.

Therefore, the Working Group recommends the TAC for Greenland halibut in Sub-areas V and XIV for 1979 of 15 000 tons.

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

The Working Group reviewed the quality of data available for Greenland halibut stock assessments and identified the following shortcomings and gaps:

a) age composition data are required for the catches from Sub-areas V and XIV (by sex, if possible);

b) more length composition data (by sex, if possible) are required for Sub-areas I and II as well as for Sub-areas V and XIV. The countries should use the uniform length grouping and method of length measurement;

c) no recruitment information has been available to indicate the strength of incoming year classes. The 0-group surveys are not very useful to derive the strength of year classes;

d) more effort and catch per unit effort data are needed. Firstly, it would be desirable to have estimates of the c.p.u.e. for different parts of the same fishing fleet. Secondly, c.p.u.e. data from different fleets fishing on the same stock are needed.

7. REFERENCE

Krzykawski, S., 1975. "Age and growth rate of the Greenland halibut, Reinhardtius hippoglossoides (Walb.), from the northern Atlantic". ICES, Doc. C.M.1975/F:24 (mimeo.).

Table 1. Greenland Halibut.
        Total nominal catch by main fishing areas (metric tons).

Year	Sub-area I	Division IIb	Division IIa	Division Va	Division Vb	Sub-area XIV	Total catch
1967	2 198	6 712	15 357	30 657	442	200	55 566
1968	2 488	8 935	14 745	21 036	647	189	48 040
1969	8 393	25 010	10 386	23 141	906	280	68 116
1970	4 011	70 523	14 950	30 001	–	3 822	123 307
1971	5 413	62 764	10 857	15 049	11	13 913	108 007
1972	8 549	18 873	15 633	10 666	417	15 389	69 527
1973	5 667	16 081	8 190	7 386	358	12 719	50 401
1974	5 251	24 660	7 852	7 866	325	28 089	74 043
1975	6 495	28 511	3 166	3 308	560	19 627	61 667
1976[*]	2 479	29 610	3 985	5 448	324	273	42 119
1977[*]	2 134	22 481	4 288	14 523	285	212	43 923

[*] preliminary.

Table 2. Greenland Halibut.
        Nominal catch (metric tons) in Sub-area I.

Country	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977[*]
German Dem.Rep.	21[1]	23[1]	256[1]	–[1]	14[1]	1[1]	–	–	5	–	–
Germany, Fed.Rep.of	13	–	–	–	–	–	25	22	6	2	1
Norway	1 312	1 488	689	1 675	1 951	3 116	2 947	2 167	2 160	1 203	1 108
Poland	–	–	5 314	–	7	117	–	1	–	9	–[2]
UK (Eng. & Wales)	–[1]	–[1]	–	–	–	949	995	732	550	665	665[2]
USSR	852[1]	977[1]	2 134	2 336	3 441	4 366	1 700	2 329	3 774	600	360
Total	2 198	2 488	8 393	4 011	5 413	8 549	5 667	5 251	6 495	2 479	2 134

[*] preliminary.   [1] from national statistics.   [2] assumed value equal to the 1976 nominal catch.

Table 3. Greenland Halibut.
        Nominal catch (metric tons) in Division IIa.

Country	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977[*]
Faroe Islands	-	-	-	44[1]	-	-	-	-	-	2	...
German Dem.Rep.	928[1]	1[1]	501[1]	2 131[1]	353[1]	1 069[1]	52	656	172	354	1 641
Germany, Fed.Rep.of	25	+	+	-	3	3	+	49	41	17	22
Norway	14 404	14 744	9 885	6 408	4 974	11 715	7 861	6 593	2 265	3 490	2 462
Poland	-	-	-	6 291	5 036	2 643	137	499	66	31	95[2]
UK (Eng. & Wales)	-	-	-	-	-	182	118	55	107	48	48[2]
USSR	-	-	-	76	491	21	22	-	515	43	20
Total	15 357	14 745	10 386	14 950	10 857	15 633	8 190	7 852	3 166	3 985	4 288

Table 4. Greenland Halibut.
        Nominal catch (metric tons) in Division IIb.

Country	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977[*]
German Dem.Rep.	15[1]	233[1]	3 031[1]	16 598[1]	2 582[1]	563[1]	3 902	5 258	8 295	8 601	6 545
Germany, Fed.Rep.of	-	-	71	-	-	-	34	17	47	12	125
Norway	1 812	6 282	4 282	7 788	2 541	1 152	3 181	31	433	1 312	870
Poland	-	-	-	12 971	7 234	5 221	2 003	4 646	3 579	3 526	129[2]
UK (Eng. & Wales)	-	-	-	-	-	131	122	79	74	222	222[2]
USSR	4 885[1]	2 420[1]	17 626	33 166	50 407	11 806	6 839	14 629	16 083	15 940	14 590
Total	6 712	8 935	25 010	70 523	62 764	18 873	16 081	24 660	28 511	29 613	22 481

[*] preliminary. [1] from national statistics. [2] assumed value equal to the 1976 nominal catch.

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Table 5. Greenland Halibut.
   Nominal catch (metric tons) in Sub-areas I and II, 1967-1977.
   (Data for 1967-1976 from Bulletin Statistique.)

Country	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977[*]
Faroe Islands	–	–	–	44[1]	–	–	–	–	–	2	...
German Dem.Rep.	964[1]	257[1]	3 788[1]	18 729[1]	2 949[1]	1 633[1]	3 954	5 914	8 472	8 955	8 186
Germany, Fed.Rep.of	38	–	71	–	3	3	59	88	94	31	148
Norway — Trawl catch	–	–	–	1 638	2 309	9 656	10 217	4 656	1 686	4 030 (1975)	2 747 ⎱ 4 440
Norway — Long-line catch	17 528	22 514	14 856	14 233	7 157	6 327	3 772	4 135	3 172	1 693	1 693 ⎰
Poland	–	–	5 314	19 262	12 277	7 981	2 140	5 146	3 645	3 566	224
UK (Eng. & Wales)	–	–	–	–	–	1 262	1 235	866	731	935	935[2]
USSR	5 737[1]	3 397[1]	19 760	35 578	54 339	16 193	8 561	16 958	20 372	16 580	14 970
Total	24 267	26 168	43 789	89 484	79 034	43 055	29 938	37 763	38 172	36 074	28 903

Table 6. Greenland Halibut.
   Nominal catch (metric tons) in Division Va.

Country	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977[*]
Faroe Islands	–	–	–	4 122[1]	1 316[1]	1 180[1]	188	41	2	373	...
German Dem.Rep.	5 064[1]	6 247[1]	7 768[1]	14 958[1]	3 317[1]	159[1]	320	388	–	–	–
Germany, Fed.Rep.of	3 890	1 253	1 488	–	882	1 119	826	1 786	887	1 719	4 541
Iceland	1	1	5 856	7 343	5 020	4 640	2 115	2 842	1 212	1 687	9 982
Norway	–	–	54	338	369	186	–	–	–	–	–
Poland	–	–	–	1 127	899	31	–	485	–	–	–
UK (Eng. & Wales)	–	–	–	–	–	2 223	3 648	2 314	1 207	1 669	...
USSR	21 102[1]	13 535[1]	7 975[1]	2 113	3 246	1 128	289	10	–	–	–
Total	30 657	21 036	23 141	30 001	15 049	10 666	7 386	7 866	3 308	5 448	14 523

[*] preliminary.   [1] from national statistics.   [2] assumed value equal to the 1976 nominal catch.

Table 7. Greenland Halibut.
Nominal catch (metric tons) in Division Vb.

Country	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977[*]
Faroe Islands	$-^{1)}$	$-^{1)}$	$-^{1)}$	-	-	-	-	7	6	2	...
German Dem.Rep.	$218^{1)}$	$68^{1)}$	$855^{1)}$	-	-	-	-	147	91	-	-
Germany, Fed.Rep.of	224	579	51	-	11	405	287	163	437	309	285
Norway	-	-	-	-	-	-	-	-	7	7	-
Poland	-	-	-	-	-	-	9	-	18	-	-
UK (Eng. & Wales)	-	-	-	-	-	12	61	8	+	6	...
USSR	-	-	-	-	-	-	1	-	-	-	-
Total	442	647	906	-	11	417	358	325	559	324	285

Table 8. Greenland Halibut.
Nominal catch (metric tons) in Sub-area XIV.

Country	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977[*]
German Dem.Rep.	-	-	$42^{1)}$	$2\ 981^{1)}$	$3\ 491^{1)}$	$7\ 328^{1)}$	8 806	25 266	16 872	-	
Germany, Fed.Rep.of	200	187	183	-	270	5	7	+	64	191	212
Greenland	-	2	+	-	2	3	4	2	1	1	-
Iceland	-	-	24	2	+	-	3	1	+	2	-
Poland	-	-	-	732	7 910	7 847	3 122	1 057	1 054	-	-
UK (Eng. & Wales)	-	-	-	-	-	1	1	1	2	5	...
USSR	-	-	31	107	2 240	205	776	1 762	1 634	74	-
Total	200	189	280	3 822	13 913	15 389	12 719	28 089	19 627	273	212

[*] preliminary.   [1] from national statistics.

Table 9. Greenland Halibut.
Nominal catch (metric tons) in Sub-areas V and XIV, 1967-77.
(Data for 1967-76 from Bulletin Statistique.)

Country	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977[*]
Faroe Islands	-	-	-	4 122[1]	1 316[1]	1 180[1]	188	48	8	375	...
German Dem.Rep.	5 282[1]	6 315[1]	8 665[1]	17 939[1]	6 808[1]	7 487[1]	9 126	25 801	16 963	-	-
Germany, Fed.Rep.of	4 314	2 019	1 686	-	1 163	1 529	1 120	1 949	1 388	2 219	5 038
Greenland	-	2	+	-	2	3	4	2	1	1	-
Iceland	1	1	5 880	7 345	5 020	4 640	2 118	2 843	1 212	1 689	9 982
Norway	-	-	-	338	369	186	-	-	7	7	-
Poland	-	-	-	1 859	8 809	7 878	3 131	1 542	1 072	-	-
UK (Eng. & Wales)	-	-	-	-	-	2 236	3 710	2 323	1 209	1 680	...
USSR	21 702[1]	13 535[1]	8 006[1]	2 220	5 486	1 333	1 066	1 772	1 634	74	-
Total	31 298	21 872	24 237	33 823	28 973	26 473	20 463	36 280	23 494	6 045	15 020

Table 10. Greenland Halibut in Sub-areas I and II.
Total effort and catch per unit effort.

Year	USSR catch/hour trawling (tons)	Hours trawling (USSR effort)	Total effort (raised to the total catch)
1965	0.80	20 853	43 558
1966	0.77	12 587	34 084
1967	0.70	8 196	34 667
1968	0.65	5 226	40 258
1969	0.53	37 283	82 621
1970	0.53	67 128	168 838
1971	0.46	118 128	171 813
1972	0.37	43 765	116 365
1973	0.39	21 951	76 764
1974	0.40	42 395	94 408
1975	0.39	52 236	97 877
1976	0.40	41 458	90 185
1977[*]	0.26	57 577	111 165

[*] preliminary. [1] from national statistics.

Table 11. Greenland Halibut in Sub-areas I and II.
Input data-catch in numbers by year and by age (thousands).

AGE	1970	1971	1972	1973	1974	1975
3	0.0	0.0	0.0	0.0	0.0	22.0
4	34.0	0.0	461.0	19.0	276.0	334.0
5	526.0	80.0	1109.0	212.0	917.0	840.0
6	2792.0	4486.0	3521.0	1117.0	2519.0	2337.0
7	10464.0	12712.0	9605.0	3923.0	6204.0	6520.0
8	18562.0	12283.0	6438.0	3515.0	3838.0	4118.0
9	10034.0	6130.0	2775.0	2551.0	1834.0	2265.0
10	6671.0	4339.0	1734.0	1919.0	1942.0	1654.0
11	2517.0	2703.0	1368.0	1536.0	1622.0	1857.0
12	1250.0	1660.0	1234.0	1127.0	1338.0	1536.0
13	616.0	1044.0	675.0	716.0	734.0	1122.0
14	1104.0	300.0	200.0	251.0	531.0	600.0
15	266.0	123.0	40.0	70.0	137.0	270.0
16	15.0	20.0	40.0	56.0	79.0	98.0

AGE	1976	1977
3	0.0	60.0
4	98.0	742.0
5	830.0	2002.0
6	2982.0	3191.0
7	5824.0	4112.0
8	5002.0	2482.0
9	3000.0	1590.0
10	1350.0	1089.0
11	915.0	1044.0
12	1212.0	844.0
13	698.0	585.0
14	526.0	377.0
15	254.0	91.0
16	104.0	85.0

Table 12. Greenland Halibut in Sub-areas I and II.
           Fishing mortalities by year and by age (Alternative 1).

AGE	1970	1971	1972	1973	1974	1975	1976	1977
3	0.00	0.00	0.00	0.00	0.00	.00	0.00	.00
4	.00	0.00	.01	.00	.01	.01	.00	.02
5	.01	.00	.03	.01	.03	.02	.02	.06
6	.06	.12	.12	.04	.08	.09	.10	.09
7	.26	.37	.37	.17	.29	.31	.30	.19
8	.67	.52	.31	.21	.24	.30	.38	.19
9	\56	.45	.20	.18	.16	.21	.34	.19
10	.57	.46	.21	.19	.19	.20	.18	.19
11	.46	.45	.25	.28	.23	.27	.15	.19
12	.46	.59	.36	.32	.39	.34	.27	.19
13	.60	.83	.48	.35	.34	.61	.24	.19
14	1.41	.63	.34	.31	.44	.49	.62	.19
15	1.69	.52	.15	.18	.26	.40	.37	.19
16	.50	.50	.30	.30	.30	.29	.25	.19

MEAN F FOR AGES >= 8 AND <= 13 (NOT WEIGHTED BY STOCK IN NUMBERS)

| .55 | .55 | .30 | .26 | .26 | .32 | .26 | .19 |

AGES-NATURAL MORTALITIES

3	4	5	6	7	8	9	10	11	12	13	14	15	16
.15	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15

Table 13. Greenland Halibut in Sub-areas I and II.
Stock in numbers (thousands) at beginning of year (Alternative 1).

AGE	1970	1971	1972	1973	1974	1975
3	52213.5	53508.5	49306.1	53113.3	64168.7	54489.4
4	46607.0	44940.6	46055.2	42438.2	45715.0	55230.6
5	50734.7	40083.5	38680.7	39212.8	36509.3	39091.5
6	54056.0	43180.3	34426.0	32265.3	33554.3	30574.2
7	48950.0	43940.4	33013.8	26372.0	26736.2	26548.1
8	40698.4	32464.3	26091.8	19553.9	19070.3	17282.2
9	24976.6	17966.3	16630.6	16513.0	13581.0	12867.4
10	16375.8	12261.9	9814.0	11748.4	11853.8	9992.7
11	7306.6	7955.3	6555.9	6844.0	8337.5	8407.0
12	3634.7	3969.2	4355.9	4378.7	4471.9	5677.2
13	1452.4	1976.4	1889.0	2610.5	2728.4	2614.8
14	1545.2	683.4	743.3	1003.9	1586.1	1670.9
15	344.0	324.0	312.3	455.1	632.4	875.7
16	40.8	54.4	165.6	231.8	327.0	417.7

AGE	1976	1977
3	52029.0	53875.2
4	46879.1	44781.8
5	47227.8	40258.4
6	32868.0	39880.2
7	24151.6	25529.3
8	16829.9	15409.5
9	11072.1	9871.5
10	8981.2	6761.1
11	7071.5	6481.7
12	5520.6	5240.0
13	3468.8	3632.0
14	1218.5	2340.6
15	885.4	565.0
16	504.7	527.7

Table 14. Greenland Halibut in Sub-areas I and II.
Fishing mortalities by year and by age (Alternative 2).

AGE	1970	1971	1972	1973	1974	1975	1976	1977
3	0.00	0.00	0.00	0.00	0.00	.00	0.00	.00
4	.00	0.00	.01	.00	.01	.01	.00	.02
5	.01	.00	.04	.01	.04	.04	.03	.07
6	.06	.14	.15	.05	.11	.13	.18	.13
7	.28	.42	.46	.23	.36	.42	.50	.39
8	.69	.58	.37	.29	.34	.41	.63	.39
9	.58	.48	.23	.23	.23	.32	.57	.39
10	.58	.51	.22	.24	.26	.31	.31	.39
11	.47	.46	.28	.30	.30	.39	.26	.39
12	.46	.61	.38	.37	.44	.50	.45	.39
13	.58	.82	.50	.37	.41	.76	.42	.39
14	1.42	.60	.33	.33	.48	.65	.95	.39
15	1.76	.53	.14	.18	.28	.46	.60	.39
16	.56	.56	.31	.27	.29	.32	.30	.39

MEAN F FOR AGES >= 8 AND <= 13 (NOT WEIGHTED BY STOCK IN NUMBERS)
    .56   .58   .33   .30   .33   .45   .44   .39

AGES-NATURAL MORTALITIES

3	4	5	6	7	8	9	10	11	12	13	14	15	16
.15	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15	.15

Table 15. Greenland Halibut in Sub-areas I and II.
Stock in numbers (thousands) at beginning of year (Alternative 2).

AGE	1970	1971	1972	1973	1974	1975
3	43171.9	42152.6	34089.8	31453.8	45760.6	43756.8
4	37956.7	37158.4	36281.1	29341.3	27072.5	39386.5
5	43730.6	32638.1	31982.6	30800.2	25236.7	23045.8
6	49188.8	37151.8	28017.8	26500.2	26313.5	20871.9
7	45804.9	39751.4	27826.1	20857.5	21774.2	20316.6
8	39927.5	29759.7	22493.2	15098.5	14326.3	13017.0
9	24261.9	17306.6	14311.5	13420.1	9749.1	8788.4
10	16190.4	11649.2	9247.8	9753.4	9193.0	6696.0
11	7234.0	7796.4	6030.2	6356.9	6621.5	6118.3
12	3652.6	3906.9	4219.5	3926.7	4053.1	4201.4
13	1487.5	1991.8	1835.6	2493.3	2339.9	2255.1
14	1538.8	713.5	756.4	958.1	1485.4	1337.1
15	338.5	318.6	338.1	466.4	593.0	789.3
16	37.4	49.9	161.0	254.0	336.7	383.8

AGE	1976	1977
3	40817.4	43106.5
4	37641.4	35131.9
5	33590.7	32307.4
6	19057.5	28142.8
7	15802.0	13645.3
8	11475.0	8236.3
9	7406.5	5276.3
10	5473.3	3613.8
11	4236.1	3464.4
12	3553.3	2800.7
13	2201.3	1941.3
14	910.7	1251.0
15	599.2	302.0
16	430.5	282.1

Table 16. Greenland Halibut in Sub-areas I and II.
The biomass of the recruited stock $B(N_{4+})$ and the biomass of the spawning stock $B(N_{9+})$, estimated from two alternative VPA runs. B_{LR} (N_{4+}) is the biomass of the recruited stock as estimated by linear regression between the USSR catch per hour trawling and $B(N_{4+})$ in Alternative 1 (Figure 5).

Year	Alternative 1		Alternative 2		B_{LR} (N_{4+}) 10^{-3} tons
	$B(N_{4+})$ 10^{-3} tons	$B(N_{9+})$ 10^{-3} tons	$B(N_{4+})$ 10^{-3} tons	$B(N_{9+})$ 10^{-3} tons	
1965					473
1966					455
1967					413
1968					383
1969					311
1970	316	126	299	124	311
1971	265	106	243	103	270
1972	229	96	200	89	216
1973	221	106	182	93	228
1974	226	110	175	89	234
1975	227	111	164	82	228
1976	219	103	146	67	234
1977	213	98	129	52	150
1978	221	101	124	44	

Table 17. Greenland Halibut in Sub-areas I and II.
The input parameters in the catch prediction.
(In addition, the catch figures of 1977 were used. An
average recruitment was used for 1978 and 1979.)

Age	Mean weights	Fishing pattern 1977	
		Alternative 1	Alternative 2
3	0.19	0.0068	0.0038
4	0.419	0.095	0.059
5	0.539	0.29	0.177
6	0.700	0.47	0.333
7	1.025	1.00	1.00
8	1.350	1.00	1.00
9	1.756	1.00	1.00
10	2.167	1.00	1.00
11	2.743	1.00	1.00
12	3.085	1.00	1.00
13	4.087	1.00	1.00
14	4.684	1.00	1.00
15	5.477	1.00	1.00
16	5.993	1.00	1.00
Average recruitment at age 3 ('000)		54 000	39 000
Fishing mortality on the fully exploited age groups in 1977		0.19	0.39

Table 18. Greenland Halibut in Sub-areas I and II.
Catch predictions for 1979 with the stock composition at the beginning of 1978 according to Alternatives 1 and 2 (Section 4.2.2.).

	Year	Catch	F	Biomass (in tons)	
				Total stock	Spawning stock
Alternative 1	1977	28 903	0.19	213 000	98 000
	1978	40 642	0.26	221 000	101 000
	1979	) 31 247	0.20 $(=F_{max})$	216 000	100 000
		) 19 422	0.12 $(=F_{0.1})$		
	1980			) 216 000	105 000
				) 229 000	113 000
Alternative 2	1977	28 903	0.39	129 000	52 000
	1978	39 930	0.60	124 000	44 000
	1979	) 13 110	0.20 $(=F_{max})$	108 000	31 000
		) 8 142	0.12 $(=F_{0.1})$		
	1980			) 118 000	37 000
				) 123 000	40 000

Table 19. Greenland Halibut in Sub-areas V and XIV.
USSR c.p.u.e. in Division Va and total effort in Sub-areas V and XIV.

Year	USSR catch/hour trawling (Va)	Total effort in Sub-area V and XIV (raised to total catch)
1967	1.7	18 058
1968	1.6	13 670
1969	1.3	18 644
1970	1.5	22 548
1971	2.3	12 597
1972	0.7	37 819
1973	1.2	17 052
1974	1.7	21 341

Table 20. Greenland Halibut in Sub-areas V and XIV.
Cohort analysis based on length composition (1970-71-75).

M = 0.150   K = 0.0500   M/K = 3.000   L(INF) = 144.00   TERM F = 0.600
A = 004   B = 3.198

LENGTH GR	CATCHNO	CATCHWT	STOCKNO	STOCKWT	DELTA T	F	Z
38 - 39	3	1	11134	5022	0.381	0.000	0.150
40 - 41	10	5	10718	5696	0.388	0.001	0.151
42 - 43	16	10	10308	6403	0.396	0.002	0.152
44 - 45	54	39	9904	7139	0.404	0.006	0.156
46 - 47	106	88	9491	7887	0.412	0.012	0.162
48 - 49	203	193	9066	8632	0.421	0.023	0.173
50 - 51	382	414	8610	9340	0.430	0.046	0.196
52 - 53	560	689	8087	9945	0.440	0.073	0.223
54 - 55	572	794	7497	10403	0.450	0.080	0.230
56 - 57	573	896	6913	10779	0.460	0.088	0.238
58 - 59	656	1144	6345	11064	0.471	0.110	0.260
60 - 61	642	1248	5749	11174	0.482	0.119	0.269
62 - 63	604	1304	5175	11169	0.494	0.125	0.275
64 - 65	692	1653	4632	11066	0.506	0.161	0.311
66 - 67	412	1086	4059	10699	0.520	0.108	0.258
68 - 69	440	1276	3643	10565	0.533	0.130	0.280
70 - 71	625	1989	3223	10256	0.548	0.214	0.364
72 - 73	714	2486	2715	9452	0.563	0.297	0.447
74 - 75	672	2554	2170	8248	0.580	0.356	0.506
76 - 77	532	2202	1664	6889	0.597	0.370	0.520
78 - 79	626	2815	1256	5647	0.615	0.619	0.769
80 - 81	334	1629	802	3709	0.635	0.505	0.655
82 - 83	274	1446	544	2870	0.656	0.637	0.787
84 - 85	170	969	333	1897	0.678	0.653	0.803
86 - 87	114	701	198	1215	0.702	0.767	0.917
88 - 89	65	430	106	699	0.727	0.843	0.993
90 - INF	55	391	69	487	******	0.600	0.750

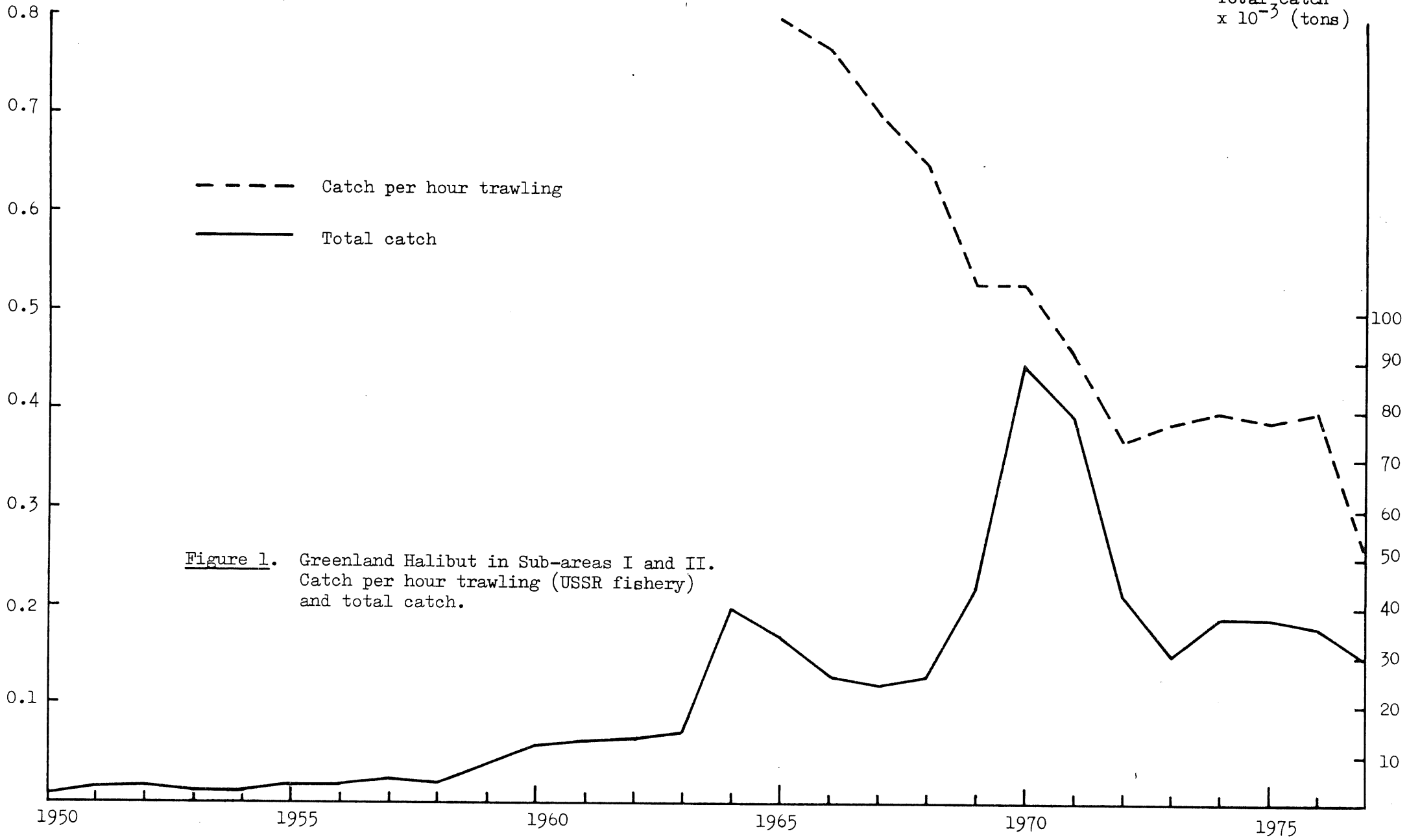|			SUMS			AVERAGES	
ALL	10108	28453	134411	198553		0.083	0.233
=> 52	9334	27013	65179	148434		0.159	0.309
=> 60	6971	22931	36336	106244		0.217	0.367

Unweighted $\bar{F}$

> 52   0.329
> 60   0.394

Figure 1. Greenland Halibut in Sub-areas I and II.
Catch per hour trawling (USSR fishery)
and total catch.

Figures 2 A-B. Greenland Halibut in Sub-areas I and II.
The relation between the mean fishing mortalities on
age groups 8 to 13 and the total effort in thousand
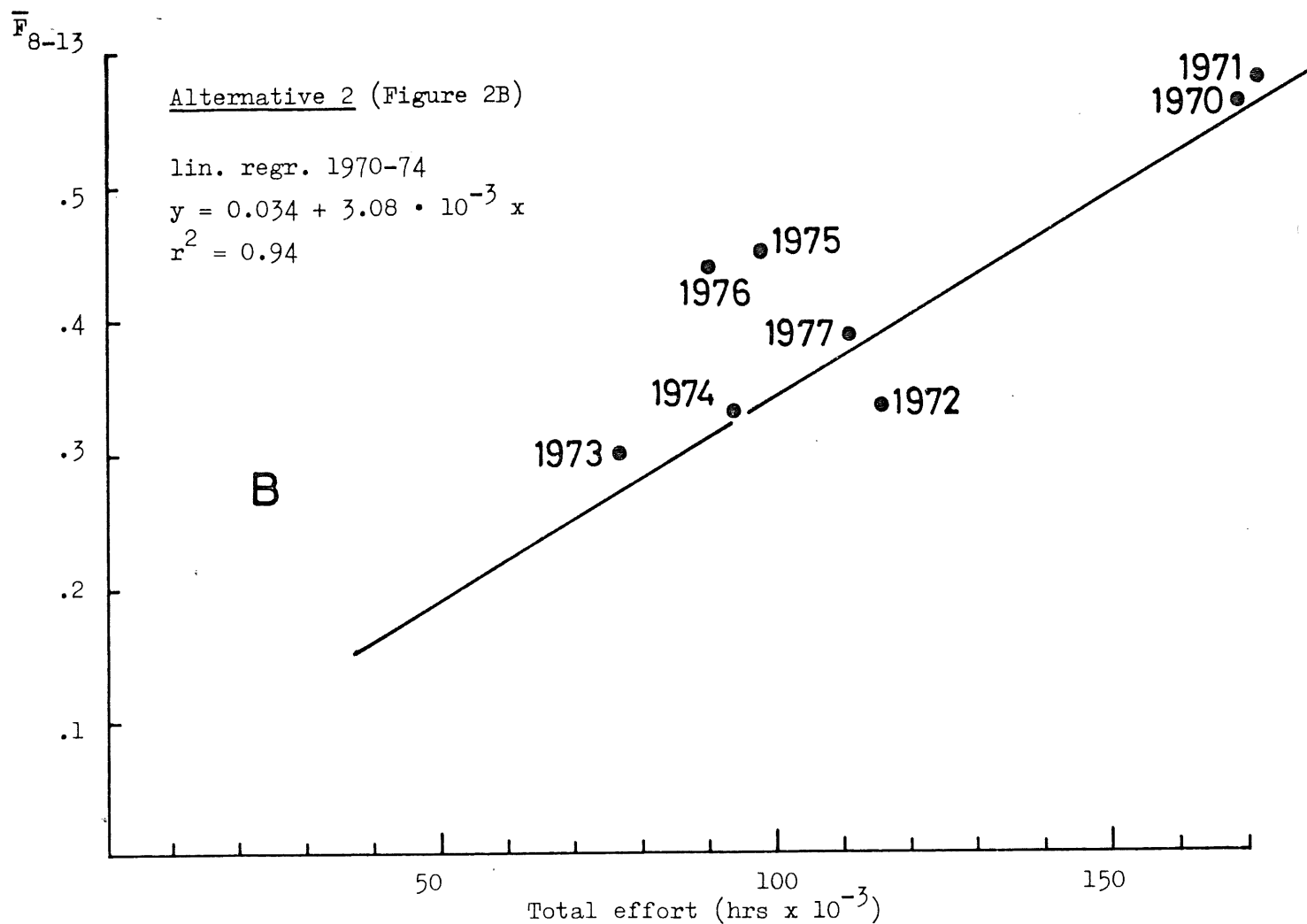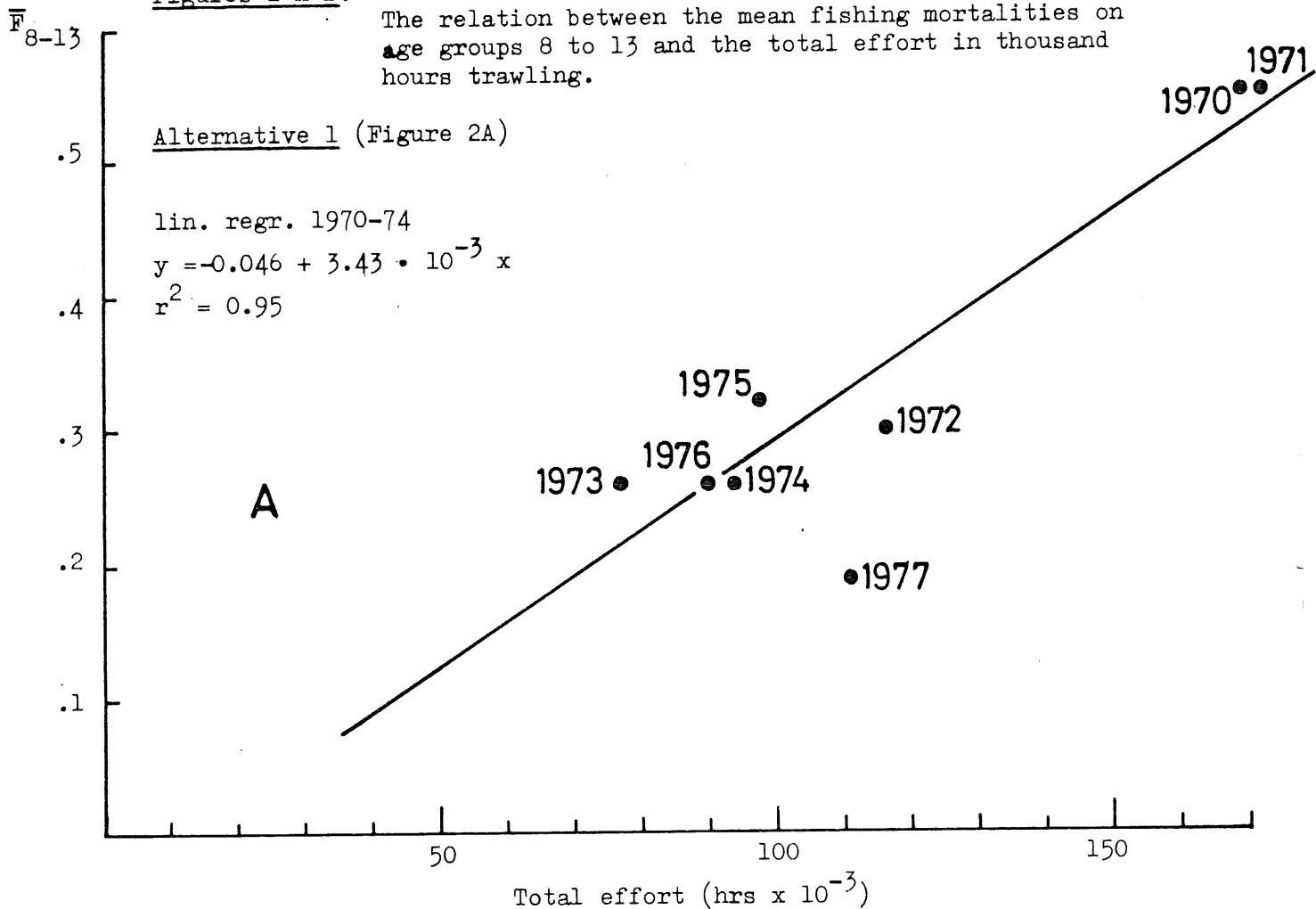hours trawling.

Alternative 1 (Figure 2A)

lin. regr. 1970-74
$y = -0.046 + 3.43 \cdot 10^{-3} x$
$r^2 = 0.95$

Alternative 2 (Figure 2B)

lin. regr. 1970-74
$y = 0.034 + 3.08 \cdot 10^{-3} x$
$r^2 = 0.94$

Figure 3. Greenland Halibut in Sub-areas I and II.
Yield and spawning stock per recruit curves. Based on Alternative 1 (Section 4.2.2.).
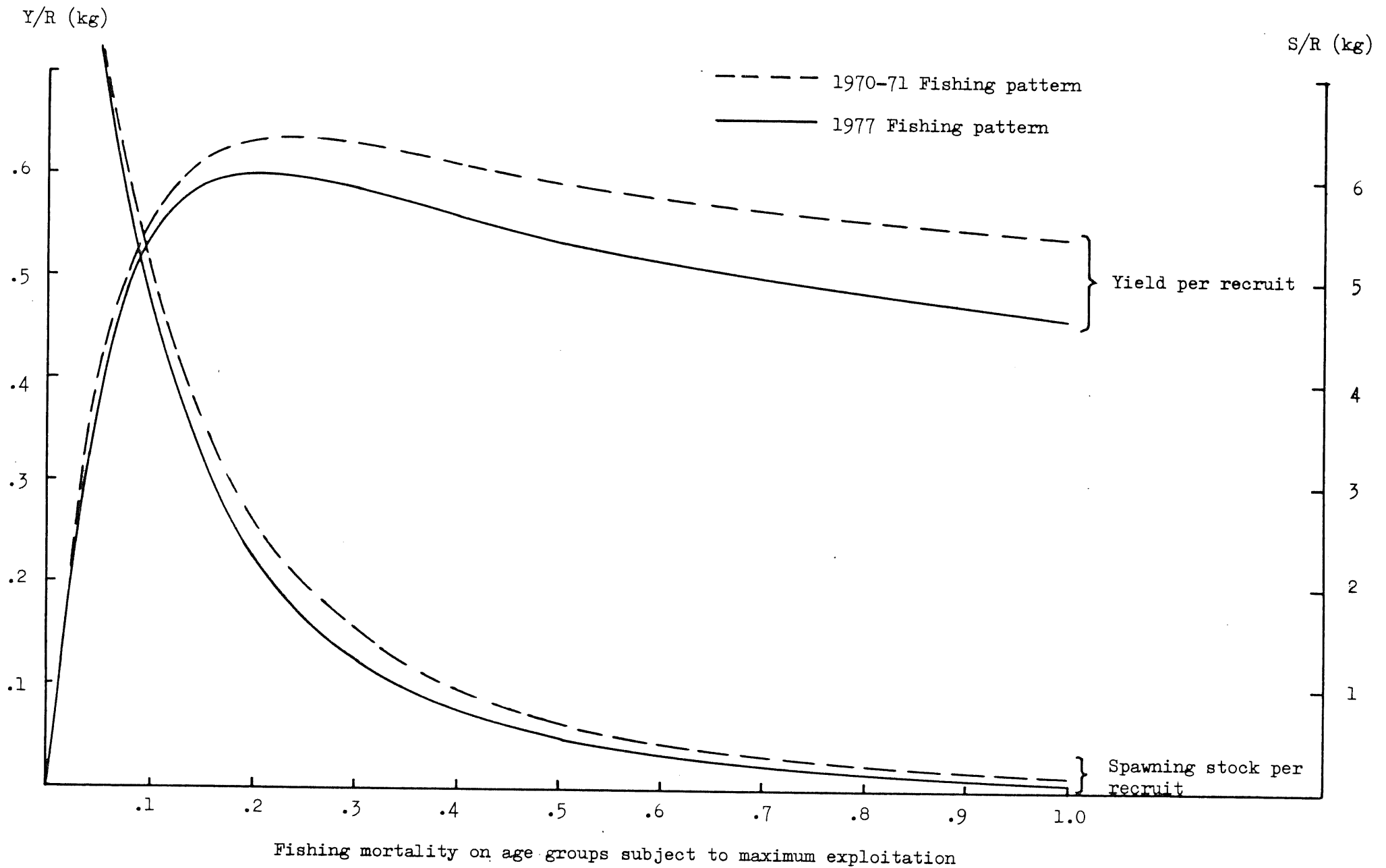
Figure 4. Greenland Halibut in Sub-areas I and II.
The stock size (4 years and older) and the
spawning stock (9 years and older) 1970-78.
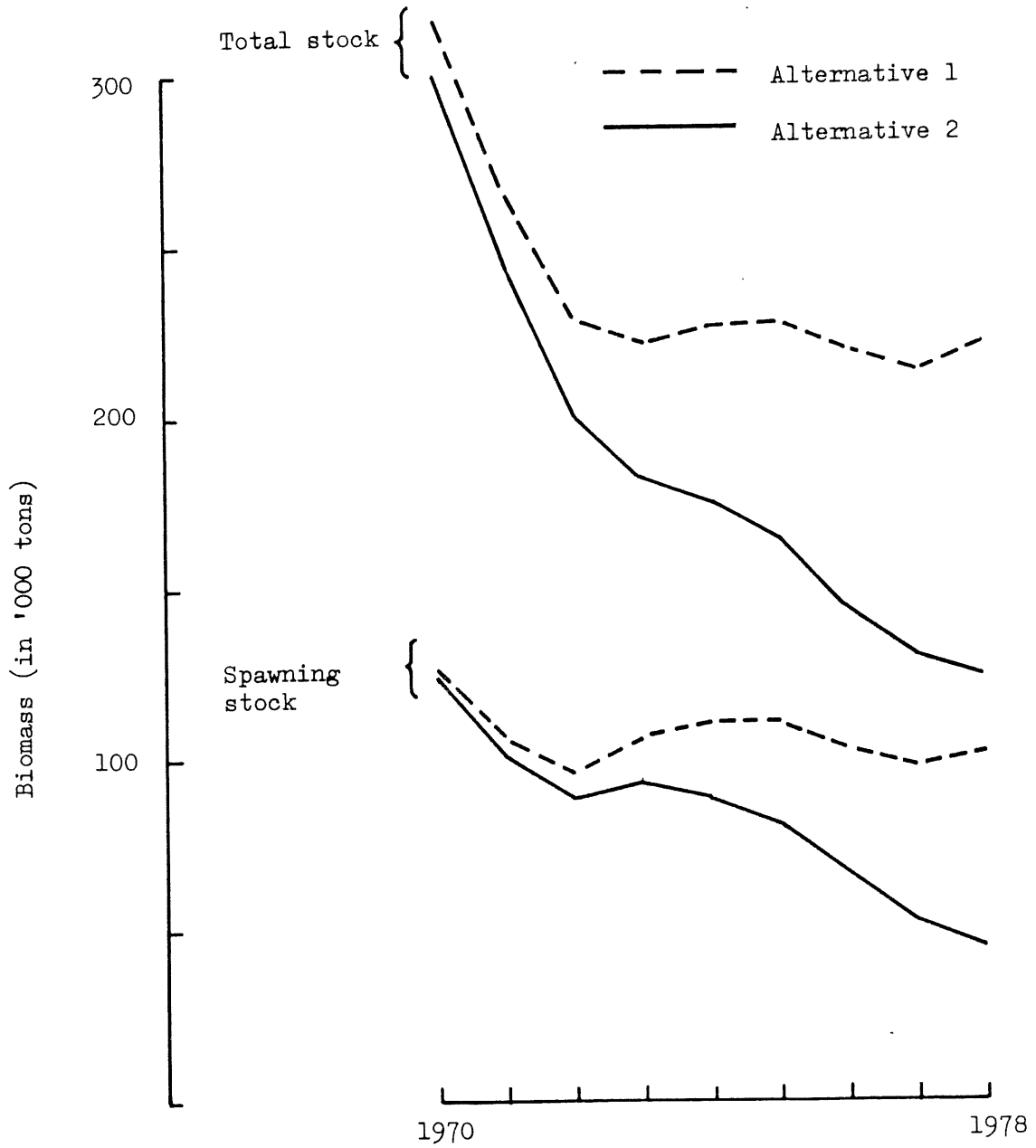
Figure 5. Greenland Halibut in Sub-areas I and II.
The relation between catch per hour trawling in the USSR
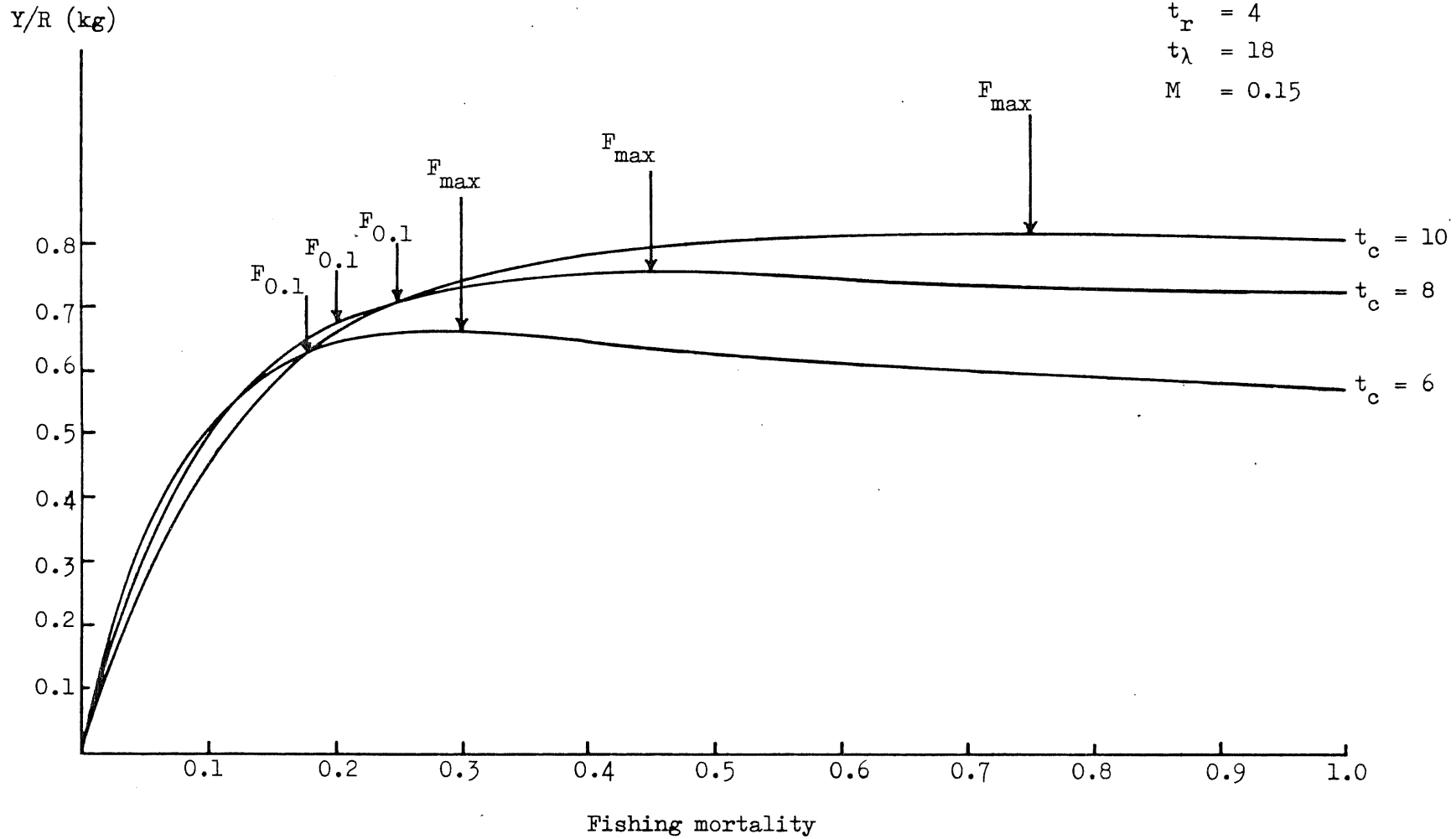fishery and the estimated stock size of 4 years and older
fish from the VPA.

Stock size
(in '000 tons)

Catch per hour trawling

Alternative 1

$$y = -6 + 599 \; x$$
$$(r^2 = 0.95)$$

Alternative 2

$$y = -100 + 745 \; x$$
$$(r^2 = 0.89)$$
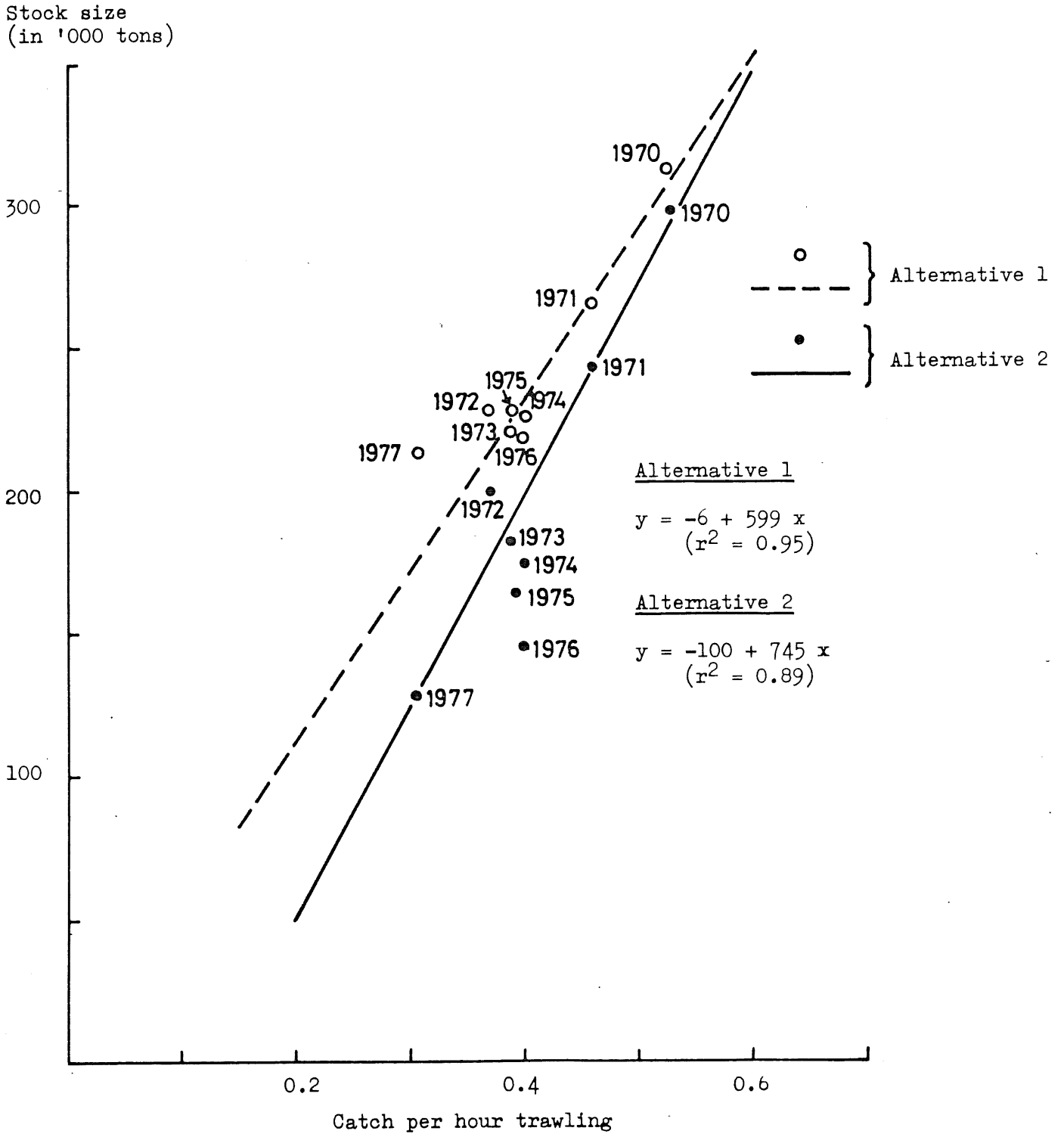
Figure 6. Greenland Halibut in Sub-areas V and XIV.
Yield per recruit curves at different age at first capture (t_c).

APPENDIX

ADDITIONS TO DOC. C.M.1977/F:4/APPENDIX: "REVIEW OF SOME FISH STOCKS WITHIN THE NEAFC CONVENTION AREA".

The following points should be noted in addition to the previous Appendix Report of the Working Group (Doc. C.M.1977/F:4/APPENDIX):

Greenland Halibut in Sub-areas I and II

#### Fisheries

The last paragraph in Chapter 1.1.2 is to be replaced by:

> The Norwegian long-line fishery is a seasonal one which usually starts in April/May and ends in August/September (Lahn-Johannessen, 1972). The directed trawl fishery is conducted mainly in the autumn. Since 1969 the fishery on Greenland halibut has been mainly concentrated in Division IIb. In the period 1969 to 1977 on the average 68% of the total catches in Sub-areas I and II were taken in Division IIb. The largest concentrations are found on the slope of the continental shelf in the western Barents Sea at a depth of 350 to 700 m.

### Greenland Halibut in Sub-areas V and XIV

Life history

Greenland halibut spawn at the continental slope west of Iceland between Reykjanes ridge and Dohrn bank, especially south of 65°N (Figure 1). (On the spawning of Greenland halibut in Icelandic waters, by A Sigurdsson, ICES, Doc. C.M.1977/F:28).

Males of Greenland halibut seem to be recruited to the Icelandic long-line fishery at the ages of 6-8 years and dominate in the catches until they are 10 years old. The females on the other hand seem to be recruited to the same fishery at the ages of 6-11 years. They dominate in the catches of 11 years and older fish (Figure 2).
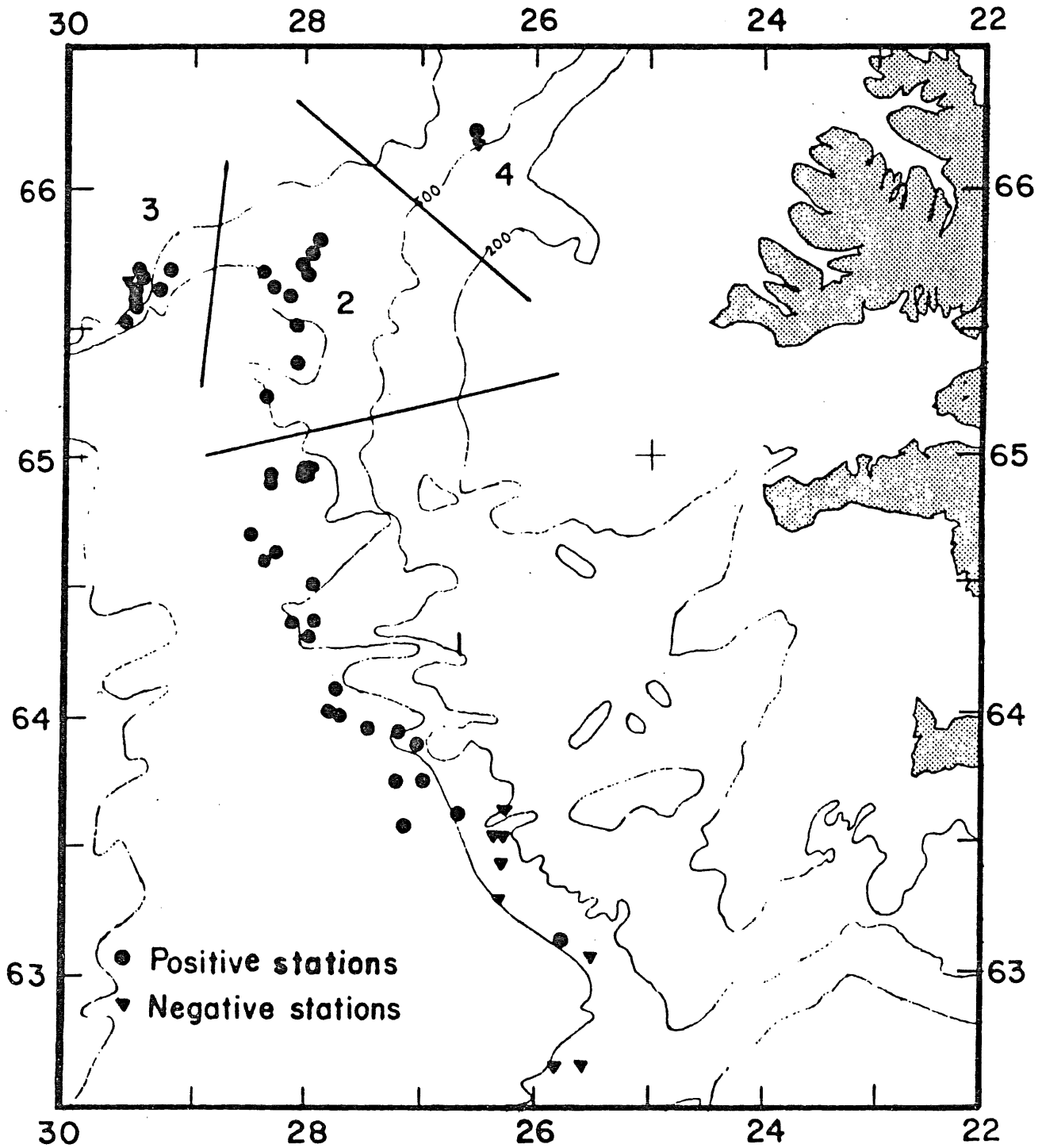
Appendix Figure 1. Trawl stations taken in March 1977. The area is divided into four sub-areas.
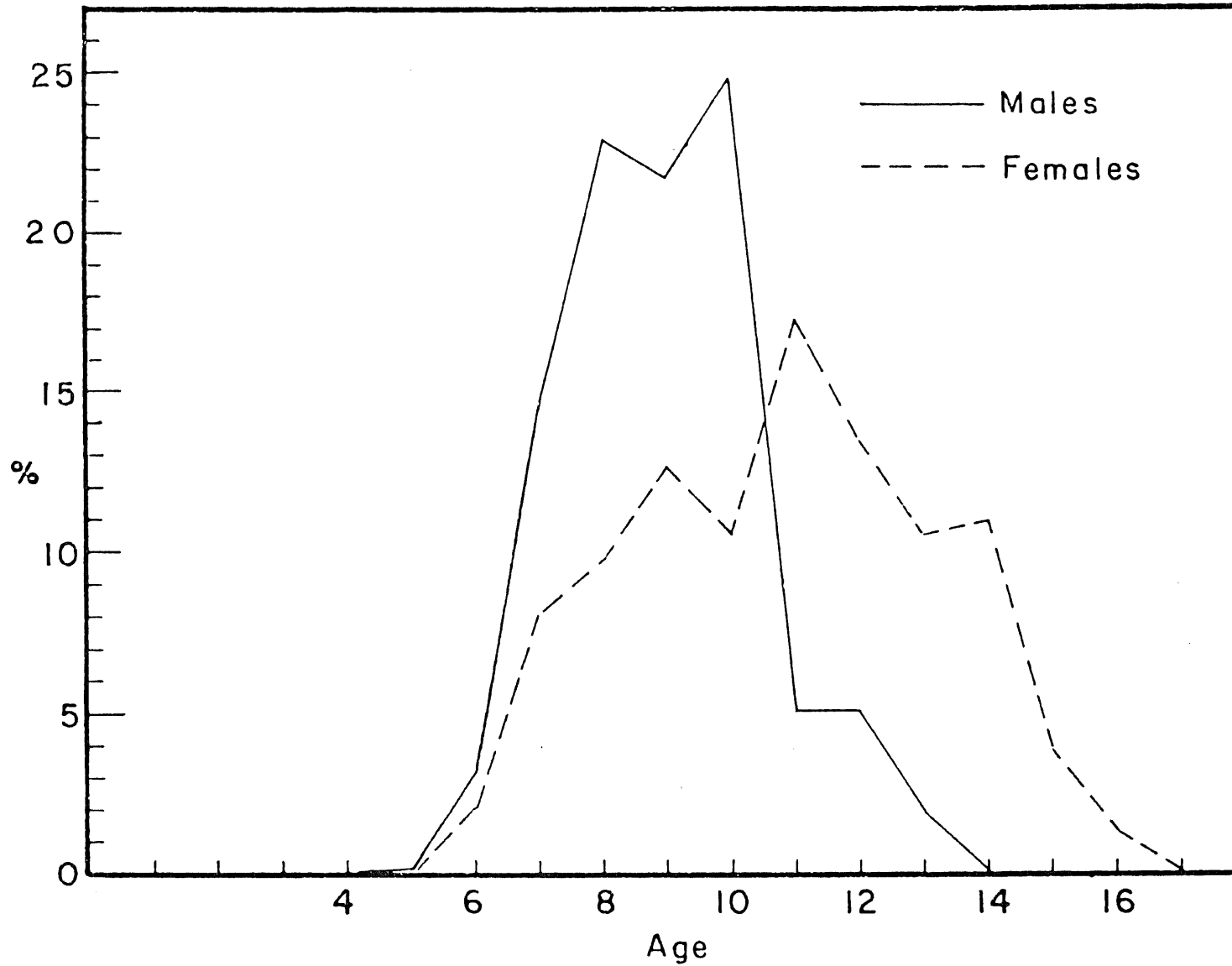
Appendix Figure 2. Greenland halibut in Division Va.
The age distribution in the Icelandic
long-line catches in 1976.