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Exploration of the Sea

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Demersal Fish (Northern) Cttee.

REPORT OF THE SAITHE (COALFISH) WORKING GROUP

Charlottenlund, 9 - 13 April 1973

1. Participants

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2. Terms of Reference

At the 60th Statutory Meeting of ICES it was resolved (C.Res.1972/2:7) that the Saithe Working Group be re-convened in order to assess the present status of the stocks and the desirability of including saithe in Recommendation 4 fisheries. In addition, the Working Group also considered the likely effects on saithe fisheries of an increased mesh size in the NE Arctic and Iceland areas, a task which was deferred from the Meeting of the North-East Arctic Fisheries Working Group.

3. Trends in Catch, Catch per Unit Fishing Effort and Effort

3.1. Catch

Annual catch data for the main statistical areas are given in Table 1. The Table has been compiled from national data sources where possible, with the remaining data taken from the "Bulletin Statistique".

The total catch from all areas combined has increased steadily from about 200 000 tons in 1950 to 600 000 tons in 1971. The main increase in landings has taken place during the last 10 years. There have been big increases in landings from Division IV and Sub-area Va in recent years, but in most areas there has been a trend of increasing catches.

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3.2. Catch per Unit Fishing Effort

Catch-rate data are available for the English, Icelandic, Scottish and German
trawl fisheries and these are tabulated by statistical areas in Table 2
and are shown graphically in Figure 1. Catch per unit effort data as indices
of stock abundance are of only limited value for the saithe fisheries.
Catch rates in any area will reflect changes in abundance resulting from
natural variations or fishery-induced changes, but they will also be affected
by immigration to, or emigration from, any area. In addition, any systematic
change in emphasis in any of the demersal fisheries, such as fishing specifi-
cally for saithe rather than taking saithe as a by-catch while fishing for
other species, will result in a biassed index of stock abundance. In some
of the fisheries such changes are known to have taken place in recent years.
However, having made these reservations there is no clear indication from
any of the fisheries, with the possible exception of the North Sea, that
catch rates have been reduced as catches have been increasing.

3.3. Fishing Effort

Only very limited data on fishing effort are available. For the English
and Icelandic trawlers there were data of hours fished and average gross
tonnage; for German trawlers days fished were recorded, and for Scottish
vessels there were data for the Faroe area. Total fishing effort for each
area (Table 3) was calculated from the total landings and the English,
German and Scottish catch per unit effort data. For Sub-area IIa the
estimates of effort relate to trawl landings only, but for other areas
they relate to total landings by all gears. These estimates of total
fishing effort must be regarded at the best as being only a guide to the
trend in fishing effort and possible biasses in the catch per effort data
referred to in Section 3.2 will also affect estimates of effort.

The data from Table 3 are presented graphically in Figure 2. The general
impression is one of relatively stable amounts of fishing in the various
areas until recent years. At Faroe, however, there appears to be a long-
term trend of steadily increasing fishing effort. In recent years the data
indicate a rapid increase in the amount of fishing in the North Sea and for
the trawl fisheries on the Norwegian coast.

It is believed, however, that in many areas the amount of fishing for saithe
has been increasing. This has been brought about both by an increased
amount of fishing and also, in some fleets, by a greater proportion of
demersal fishing being directed more to fishing specifically for saithe.

4. Mortality Estimates

Estimates of total mortality coefficients (Z) were calculated from English,
German and Scottish age compositions per unit fishing effort. The results
are tabulated in Table 4. The values of Z shown are averages for the age
groups indicated in the Table. The age groups chosen in each case covered
the range from full recruitment to the age where numbers of fish become too
small to give valid estimates. The age of recruitment varies for the
different fisheries.

The calculated values of Z show considerable variation, both between pairs of years and between estimates from the different fisheries. Any significant migration of fish between fishing areas will affect mortality estimates and the migratory habit of saithe will certainly be contributing to the variability of the mortality estimates. In making comparisons between the estimates of Z from the English and German fisheries it should be remembered that the fisheries are not directly comparable. Normally the English fisheries are generalised demersal fisheries, while from Germany there are specialised fisheries for saithe. German vessels frequently fish in deeper water than the English fleet. Age of recruitment differs for the various fisheries. For example, tagging experiments at Iceland (Jones and Jónsson, 1971) indicated that young saithe recruited first to the Icelandic purse-seine and trawl fisheries, then to the English trawl fishery and finally to the German trawl fishery,

It must be concluded that this method of estimating mortality rates may not provide, for the saithe fisheries, a satisfactory means of determing the exploitation rates for the various stocks.

5. Virtual Population Analysis

The Working Group was of the opinion that the best method of assessing the state of the saithe stocks would be by Virtual Population Analysis. It was the Group's intention to make such an analysis based on the combined catch data for the whole of the North-East Atlantic. This approach would be expected to provide as reliable an indication of the overall intensity of exploitation as the data would permit. In the event the Group had to postpone this aim because it was not possible for all countries to prepare their age-composition data in time for the Meeting. At the ICES Meeting at least one country stated that data preparation could not be completed before June, 1973. The Group was able, however, to assemble most of the data in a form suitable for the analysis. The remaining data will be added as soon as they become available and the analysis can be made and the results circulated to members of the Group. Interpretation of the results could then be made by correspondence or at a further meeting of the Group. It was possible, however, to make Virtual Population Analyses for several of the statistical areas separately, where all the available data were to hand.

5.1. Data Input

The age composition data which were available at the present Meeting are indicated in Table 5. There were no data available from some countries which have important fisheries in the areas concerned. As a result it has had to be assumed that the catches of the countries for which no data were available had the same age composition as the countries for which data were available. For each area for each year the available age distributions of national catches were summed and the resultant age composition was then raised by the ratio of total landed weight of all countries to landed weight of countries for which age compositions were known. In the calculation the coefficient of natural mortality was taken as $M = 0.2$.

5.2. Results

Estimates of stock size and fishing mortality for the years 1960-70 for the North Sea, Faroe, Iceland and the West of Scotland are given in Tables 6 - 9. In interpreting these results it must be remembered that they may be influenced by migration of fish from one area to another. The estimates of stock size in any area will represent the stock in the sea needed to provide the observed catches, but it is possible that part of this stock may have spent part of their lives in another area. The fishing mortality shown is that suffered by the stock of the size given in the Table, but this may not represent the true value of the mortality on that part of the stock that may have been available in the area at a given time.

A better interpretation of these results should be possible when the analysis for all areas combined is completed. However, inspection of the present results suggests that fishing mortality is relatively low in the Iceland and West of Scotland areas. For the North Sea the data show a substantial increase in fishing mortality in recent years, and at Faroe there is a trend of increasing mortality. These results are generally in accord with the trends in the estimates of fishing effort.

Estimates of stock size for the North Sea indicate the year classes 1966-68, especially 1968, to be much more abundant than preceeding year classes. Whether or not these estimates of year class strength reflect the true abundance of these recent year classes is not yet clear.

6. Growth

On examining growth data it was noted that in the English data there was a clear trend of reducing length at age over the past 10-12 years for saithe from Sub-areas IIa, Va and Vb (Figure 1). The rate of reduction of average length has been about 1 cm per year, and over a period of 10 or 12 years this is equivalent to more than a year's growth. A similar but less marked trend is apparent in the German data. The reason for this change is not clear but on the Norway Coast the change appears to have commenced with the 1959 year class which is the first of a series of abundant year classes in that area. This suggests the possibility of a density-related growth change. This could be looked at in more detail when the combined North-East Atlantic Virtual Population Analysis is completed as this will provide a better indication of stock abundance.

7. Summary of the Status of the Fisheries

An earlier report of the Working Group (ICES, Coop.Res.Rep., Ser.A, No.6) summarised our knowledge of the identity of saithe stocks. There are several well-known spawning grounds in various areas of the North-East Atlantic. However, tagging experiments and interpretation of otolith types have shown that, at least from time to time, there are substantial migrations of fish between the different fishing areas. This makes it difficult, if not impossible, to relate catches from the various fisheries to particular well-defined and delimited stocks. For this reason assessment of the state of the fisheries is difficult and results of analyses have to be interpreted with care.

As stated earlier, the Group considers that a Virtual Population Analysis for all areas combined would give as good an assessment of the overall state of exploitation of saithe as the data would permit. However, until this analysis is completed the following provisional conclusions have been reached:

(a) With the possible exception of the North Sea, in none of the fisheries have catch rates been declining as catches have been increasing.

(b) Until recently, fishing effort in the various fisheries appears to have been relatively stable with only short-term fluctuations. At Faroe, however, there appears to have been a long-term trend of increasing fishing effort. In recent years the data indicate an increasing amount of fishing in the North Sea and in the trawl fisheries on the Norwegian Coast.

(c) Estimates of fishing mortality so far available are in reasonable agreement with the trends in estimated fishing effort. Mortality rates have generally been relatively low but have been increasing in the Faroe area and in recent years in the North Sea.

(d) Subject to revision when the combined North-East Atlantic analysis and an analysis for the Norway Coast are completed, the Group concluded that the saithe stocks were moderately exploited.

8. Saithe as a Protected Species

The Working Group discussed the desirability of including saithe in the NEAFC Recommendation 4 species. The effect of including saithe in Recommendation 4 would be that this species would become subject to minimum permitted landing size regulations. The following points are considered relevant:

(a) The Group considered that a degree of natural protection against trawl fishing for the youngest age groups was provided by the distribution of saithe. In the early part of their life the young fish inhabit the inshore areas especially on rocky coasts where it is generally not possible to fish them with trawls. However, it is possible that fisheries might develop using other gears. With a general increase in exploitation for the older age groups, a trend which is likely to continue if the abundance of other demersal species declines, any intensive exploitation of the youngest age groups would be undesirable. The inclusion in Recommendation 4 could prevent such fisheries developing.

(b) Table 10 gives the percentage by weight of saithe less than 30, 35 and 40 cm in the landings from each statistical area for the countries for which length compositions were available. The greatest proportions of small fish were taken in the Norwegian fisheries in the southern part of Sub-area IIa (south of 64°N). These fisheries are exploited mainly by trawlers, for which the minimum legal cod-end mesh size is 80 mm, and by purse-seiners.

(c) Some countries have domestic regulations for their saithe fisheries.
     In Norway it is forbidden to land saithe less than 35 mm total
     length other than for human consumption or for bait. It is also
     forbidden to use saithe larger than 35 cm for production of fish
     meal or to catch them for this purpose. Recent Icelandic regulations
     have banned the exploitation of demersal species by purse-seiners.

(d) If saithe was to be included in Recommendation 4 it would become
     a protected species in the context of Recommendation 2 (mixed industrial
     fisheries). This would have some implications for the Dutch herring
     trawl fisheries in the North Sea. These fisheries employ 3 cm mesh
     nets in a "mixed fishery" on herring, mackerel and roundfish. Up
     till now the proportion of protected species has been relatively
     constant at 30% but the proportion of herring and mackerel has been
     steadily declining over the last ten years in favour of saithe.
     If saithe was to be added to the list of protected species, this
     fishery could hardly claim to be a "mixed fishery" any more, because
     generally more than 60% would consist of protected species.

     In relation to these problems it was pointed out that no discards of
     small-sized saithe occur, because no saithe smaller than 35 cm are
     available to this fishery. This is in contrast with other gadoid
     species (cod, haddock and whiting) of which there certainly are
     discards of undersized juveniles.

(e) Lengths of saithe corresponding to various retention percentages for
     different mesh sizes are given in Table 11 to provide guidance in
     determing a minimum landing size should it be decided to include
     saithe in Recommendation 4 species.

9. <u>Effects on the Saithe Fisheries of an increase in the minimum trawl cod-
    end mesh size in the North-East Arctic and Iceland</u>

Assessments were made of the likely effects of a change in the minimum trawl
mesh size from 130 mm (manila) to 145 mm. The basic method used was that
described by Gulland (1961). The average length compositions of landings by
trawlers are given in Table 12 and the length-weight data used in the assess-
ment are given in Table 13. Selectivity data used were those of Hylen (1969)
who found a selection factor of 3.8 for saithe. Values of M = 0.2 and

$$E = \frac{F}{F + M} = 0.7$$

were used. In the North-East Arctic area Norwegian landings from the southern
part of IIa (south of 64°N) were excluded from the immediate loss calculations
as they are in the 80 mm mesh area and would be unaffected by a mesh change in
the 130 mm area. These fisheries could benefit in the long term from fish
released in the northern trawl fisheries and so they have been included with
Norwegian 'Other Gears' in the calculation of long-term gain.

Results are tabulated in Table 14.

For the Iceland area an increase of mesh size to 145 mm would be expected to have very little effect as the majority of the fish in the landings are outside the selection range. The estimated immediate losses for all fisheries are in the range of 3-5% by weight. The long-term effects are also expected to be very small.

For the North-East Arctic the range of immediate losses for the various trawl fisheries are much larger, in the range of 11-34%. The largest losses would be experienced by the U.S.S.R. trawlers. In the long term the mesh change would be expected to result in losses for all trawl fleets except for the German fleet for which the long-term gain would be about 10%. The long-term losses are estimated as 18% for the U.S.S.R., 4% for Norwegian trawlers, and 1% for England and other countries. Any significant migrations of fish between fisheries would affect the results of these assessments.

10. References

GULLAND, J.A. 1961. The estimation of the effect on catches of changes in gear selectivity. J.Cons.perm.int.Explor.Mer, 26(2):204-214.

HYLEN, A. 1969. Selectivity experiments with a cod-end made of polypropylene splitfibre. Coop.Res.Rep., 1968, Ser.B, pp.51-55. ICES.

ICES, 1965. Report of the Coalfish Working Group. Coop.Res.Rep., Ser.A, No.6.

JONES, B.W. and JONSSON, J. 1971. Coalfish tagging experiments at Iceland. Rit Fiskideildar 5, No.1.

Table 1. Summary of Saithe Landings by Regions Metric Tons Round Fresh Weight

Fishing Area / Year	I	IIa	IIb	IV	VA	Vb	VI	TOTAL
1946	5 557	27 059	506	23 155	41 569	5 325	4 781	107 952
1947	15 498	46 560	958	31 929	43 379	8 759	5 596	152 679
1948	29 754	62 037	861	29 204	114 286	3 569	4 622	244 333
1949	33 551	61 449	357	27 079	87 045	6 114	3 730	219 325
1950	29 236	86 007	647	21 108	55 174	5 367	3 329	200 868
1951	27 028	76 269	1 204	22 217	74 096	8 698	4 362	213 874
1952	14 203	105 058	632	23 227	87 940	6 851	6 701	244 612
1953	18 636	104 915	716	22 791	73 131	7 184	6 206	233 579
1954	11 162	91 277	576	36 224	69 629	6 212	6 646	221 726
1955	13 404	90 807	928	44 942	47 843	7 234	8 687	213 845
1956	15 321	98 409	1 351	51 067	67 860	10 884	11 679	256 571
1957	16 253	112 682	1 353	55 546	62 061	26 858	12 210	286 963
1958	12 306	105 265	1 217	50 372	53 178	12 978	12 780	248 096
1959	17 813	113 511	1 235	51 224	48 478	14 545	9 845	256 651
1960	17 627	117 782	620	31 515	48 120	11 845	8 532	236 041
1961	16 602	92 859	421	35 489	50 826	9 592	6 723	212 512
1962	11 456	110 968	419	24 559	50 514	10 454	7 159	215 529
1963	21 399	126 491	146	30 300	48 011	12 693	6 609	245 649
1964	55 714	141 335	1 061	58 669	60 257	20 550	16 655	354 241
1965	18 676	164 995	877	73 274	60 177	22 071	18 276	358 346
1966	16 963	183 835	1 062	90 940	52 003	24 597	18 509	387 909
1967	15 452	175 331	408	76 759	75 712	23 219	16 034	382 915
1968	10 895	96 100	186	98 179	77 549	19 704	12 504	315 117
1969	19 524	118 851	1 004	115 564	115 853	27 536	16 366	414 698
1970	36 129	223 034	1 249	179 594	116 601	29 148	14 488	600 233
1971	38 448	174 493	720	209 532	134 127	30 867	11 203	599 390

Table 2. Catch per Unit Effort of Saithe by Statistical Area for English and German Trawlers.

English data (E) and Icelandic data (I) tons per million ton-hours.
German data (G) kg per fishing day.

Statistical Area Country	I	IIa		IVa	Va			Vb		VIa
	E.	E.	G.	E.	I.	E.	G.	E.	G.	E.
1946	29	277		73		308		330		147
47	74	552		148		339		403		151
48	93	571		112		287		218		80
49	75	417	2 911	68		208	3 206	273		64
1950	62	110	5 323	60		136	3 647	160		56
51	47	124	6 051	92		123	4 348	237		79
52	39	176	7 379	231		113	3 867	216		108
53	49	148	7 052	495		101	2 115	260		88
54	30	169	9 296	369		99	2 742	227	46	88
55	27	176	8 164	364		76	2 186	245	476	132
56	35	121	6 033	388		77	3 705	259	6 240	187
57	39	164	7 878	315		61	3 416	182	11 507	218
58	36	168	7 310	341		60	2 501	243	3 804	204
59	36	100	6 492	352		56	2 678	202	5 447	180
1960	35	149	7 539	303		54	2 407	161	3 914	153
61	16	89	6 154	253		54	2 851	225	3 579	135
62	14	93	6 932	231	222	51	3 025	186	2 539	142
63	12	103	6 110	281	182	55	2 105	214	2 876	136
64	45	114	5 252	269	211	61	2 269	266	3 801	244
65	38	135	7 772	373	190	64	1 652	342	2 561	293
66	44	189	6 884	344	161	54	1 768	278	3 648	305
67	24	122	7 428	331	186	74	2 411	276	4 456	251
68	27	119	6 410	166	183	90	1 915	398	3 995	233
69	33	129	7 663	229	308	149	3 946	359	7 116	189
1970	51	151	13 542	226	356	92	3 405	411	4 119	285
71	36	134	7 546	136	538	116	4 417	451	2 842	238
72			11 087		440		3 918		2 810	

Table 3. Estimates of Total Fishing Effort on Saithe in English, German and Scottish Units.

Total effort = $\dfrac{\text{National catch per unit effort}}{\text{Total landings}}$

English units : millions of ton-hours.
German units : thousands of days fishing.
Scottish units : thousands of hours fishing.
Icelandic units : millions of ton-hours.

Statistical Area	I	IIa (Trawl)		IV	Va			Vb			VIa
Country	E.	E.	G.	E.	E.	G.	I.	E.	G.	S.	E.
1946	192			317	135			16			33
47	201			216	128			22			37
48	320			261	398			16			58
49	447			398	418	27		22			58
1950	472			352	406	15		34			59
51	351			241	602	17		37			55
52	364			101	778	23		32			62
53	380	174	3.6	46	724	35		28			71
54	372	178	3.2	98	703	25		27	135		76
55	496	239	5.2	123	630	22		30	15		66
56	438	271	5.4	132	881	18		42	1.7		62
57	417	242	5.0	176	1 017	18		118	2.3		56
58	432	205	4.7	148	886	21		53	3.4		63
59	495	283	4.4	146	866	18		72	2.7		55
1960	504	240	4.7	104	891	20		74	3.0		56
61	1 038	309	4.5	140	941	23	217	43	2.7		50
62	818	233	3.1	106	990	17	279	56	4.1	594	50
63	1 783	202	3.4	108	873	23	239	59	4.4	525	49
64	1 238	243	5.3	218	988	27	253	77	5.4	528	68
65	491	273	4.7	196	940	36	374	65	7.8	420	62
66	386	287	7.9	264	963	29	323	88	6.7	470	61
67	644	443	8.1	232	1 023	31	284	84	5.2	329	64
68	404	261	4.8	591	862	41	246	50	4.9	237	54
69	592	379	6.4	505	778	29	218	77	3.9	383	87
1970	708	884	9.9	795	1 267	34	215	71	7.1	261	51
71	1 068	666	11.8	1 541	1 156	30	265	68	10.9	260	47

Table 4. Estimates of Coefficients of Total Mortality for Saithe from German (G) and English (E) and Scottish (S) Age Compositions Per Unit Effort.

Statistical Area	IIa		IV			Va		Vb			VIa
Country	G	E	E	G	S	G	E	G	E	S	E
Age Groups Years	(5-11)	(5-9)	(4-10)	(5-10)	(3-8)	(6-11)	(4-9)	(6-12)	(5-10)	(4-8)	(4-9)
1949-50	-0.40					0.45					
1950-51	0.31					-0.34					
1951-52	0.16					0.92					
1952-53	0.44					1.00					
1953-54	0.52					0.51					
1954-55	0.65					1.17					
1955-56	0.93					0.20					
1956-57	0.91	0.57				0.63		-0.67			
1957-58	0.32	0.45				0.60		0.98	0.57		
1958-59	1.30	1.11				0.79		-0.57	0.57		0.29
1959-60	-0.23	0.61				0.62		0.47	0.80		0.75
1960-61	0.77	1.61				0.70		0.68	0.03		0.50
1961-62	0.59	0.45	1.40			0.31	0.53	0.43	0.61		0.71
1962-63	0.02	1.24	0.65			0.34	0.79	-0.02	0.34		0.89
1963-64	0.33		0.75			1.27	0.77	0.51	0.54		0.57
1964-65	-0.31		1.31	1.66		1.25	0.29	0.24	0.00		0.26
1965-66	0.41	0.20	1.40	-0.90		0.53	0.42	0.04	0.92		1.28
1966-67	0.27	1.12	0.44	0.19		0.45	-0.26	0.06	0.65		0.65
1967-68	0.29	0.75	1.49	0.56		0.63	-0.10	0.63	0.34		0.82
1968-69	0.52	0.81	0.21	-0.56		0.15	-0.38	-0.48	0.87		1.00
1969-70	-0.56		0.53	-0.72		0.40	0.63	0.61	0.14		0.46
1970-71	0.68		1.70	1.24	0.77	0.22	-0.10	1.01	0.75	0.55	0.56
1971-72	-0.18					0.90		0.19			

Table 5. Age Composition Data Available for Virtual Population Analysis (1960 onwards).

Area / Country	I + IIa + IIb	IV	Va	Vb	VI
Germany	1960-1971	1964-1971	1960-1971	1960-1971	
Netherlands		1970-1971			
Norway					
U.K. (England)	1960-1971	1960-1971	1961-1971	1960-1971	1960-1971
U.K. (Scotland)		1969-1971		1970-1971	
U.S.S.R.	1970-1971	1968-1971			

Table 6. Estimates of Stock Size and Fishing Mortality for North Sea Saithe from Virtual Population Analysis (M = 0.2).

Stock Size

Year / Age Group	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
2	45	44	52	67	185	166	175	124	402	438	1 069
3	35	36	36	42	54	147	136	138	98	327	348
4	16	22	26	26	34	39	112	105	106	69	243
5	11	10	12	16	17	23	23	70	76	70	42
6	7	7	6	7	9	10	14	12	47	44	43
7	4	4	4	4	5	6	7	8	8	27	24
8	3	3	2	3	3	4	4	4	4	5	13
9	2	2	2	2	2	2	3	2	1	2	2
10	0.3	1	2	2	1	1	2	1	0.7	0.7	1
11	0.2	0.2	1	1	1	1	1	0.9	0.5	0.3	0.2
12	0.1	0.2	0.1	0.9	1	0.8	0.7	0.5	0.3	0.2	0.1
13		0.1	0.1	0.1	0.7	0.8	0.6	0.3	0.2	0.2	0.1
14			0.1	0.1	0.1	0.5	0.6	0.3	0.2	0.1	0.1

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.5

FISHING MORTALITY

Year / Age Group	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
2	.03	.01	0	.01	.03	0	.04	.03	0	0.03	0
3	.25	.14	.12	.04	.12	.07	.06	.06	.15	.10	.11
4	.28	.43	.28	.23	.16	.31	.28	.12	.22	.30	.38
5	.34	.28	.26	.39	.28	.29	.44	.20	.34	.28	.68
6	.31	.34	.15	.16	.26	.18	.36	.26	.35	.44	.61
7	.10	.28	.06	.07	.19	.21	.49	.57	.26	.51	.37
8	.03	.13	.04	.04	.21	.12	.39	.82	.26	.53	.28
9	0	.13	.03	.06	.26	.06	.45	.82	.33	.58	.32
10	.03	.11	.05	.02	.22	.11	.47	.78	.80	1.04	.41
11	.04	.33	.03	.06	.19	.11	.57	.77	.91	.55	.61
12	0	.50	.19	.05	.12	.07	.67	.54	.55	.42	.77
13		.39	.10	.42	.11	.09	.28	.15	.84	.51	.41
14			.66	.43	1.11	.05	.57	.44	1.42	.50	.50

F_I = Assumed value of F in the last year used to initiate the analysis.

Table 7. Estimates of Stock Size and Fishing Mortality for Saithe at Iceland from Virtual Population Analysis (M = 0.2)

F_I
.01
.10
.20
.30
.30
.30
.30
.30
.30
.30
.30
.30
.50

STOCK NUMBERS (millions)

Age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
2	41	45	115	76	151	116	106	106	219	484	396
3	30	34	36	94	62	124	95	87	87	179	145
4	23	25	24	28	71	48	100	77	70	70	53
5	9	19	17	15	21	48	35	80	60	55	40
6	4	8	11	10	10	14	32	26	60	46	32
7	3	3	5	6	6	6	10	23	17	44	27
8	3	3	2	3	3	4	4	7	14	11	7
9	2	2	2	1	2	2	2	2	4	9	6
10	0.7	1	2	1	0.8	1	1	2	1	3	2
11	0.5	0.6	0.9	1	0.8	0.6	0.7	0.5	0.9	0.9	0.7
12	0.5	0.4	0.4	0.6	0.6	0.6	0.4	0.5	0.3	0.6	0.4
13		0.4	0.2	0.2	0.3	0.4	0.4	0.2	0.3	0.4	0.3
14			0.3	0.1	0.1	0.2	0.3	0.2	0.1	0.2	

FISHING MORTALITY

Age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
2	0	.01	0	.01	0	0	0	0	0	0	0
3	0	.15	.05	.07	.06	.02	.01	.01	.01	.01	.04
4	0	.19	.26	.09	.20	.12	.02	.05	.04	.07	.11
5	0	.33	.29	.21	.21	.19	.11	.08	.07	.12	.18
6	0	.33	.45	.38	.29	.19	.15	.20	.12	.17	.24
7	0	.22	.29	.43	.26	.27	.16	.27	.23	.26	.27
8	0	.14	.24	.38	.22	.22	.24	.22	.26	.32	.33
9	0	.13	.18	.30	.18	.21	.20	.28	.17	.26	.26
10	0	.22	.19	.26	.21	.19	.21	.26	.29	.18	.17
11	0	.27	.19	.30	.15	.22	.23	.23	.27	.13	.33
12	0	.40	.27	.42	.17	.18	.23	.18	.22	.21	.27
13		.06	.16	.42	.22	.22	.33	.66	.32	.02	.31
14			.05	.18	.33	.31	.32	.35	.60	.29	
15											

Table 8. Estimates of Stock Size and Fishing Mortality for Saithe at Faroe from Virtual Population Analysis (M = 0.2)

STOCK NUMBERS (millions)

Age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
2	9.3	14	22	13	18	14	19	14	53	30	25
3	10	7.4	12	18	11	15	12	15	12	43	34
4	6.5	7.0	59	8.9	14	8.3	11	9.1	12	9.1	5.5
5	4.4	5.0	5.4	4.3	7.0	9.9	6.1	8.0	6.8	8.4	4.8
6	3.0	3.2	3.7	3.9	3.3	4.5	6.6	3.9	5.4	4.6	2.5
7	2.2	2.0	2.3	2.6	2.8	2.1	2.8	4.0	2.6	3.5	1.8
8	1.4	1.6	1.5	1.6	1.7	1.8	1.3	1.6	2.3	1.6	0.80
9	1.1	0.97	1.2	1.1	1.1	1.1	1.1	0.74	0.92	1.3	0.54
10	0.56	0.79	0.69	0.84	0.74	0.77	0.59	0.66	0.43	0.53	0.22
11	0.15	0.39	0.57	0.46	0.54	0.48	0.45	0.31	0.39	0.24	0.09
12	0.16	0.09	0.28	0.40	0.29	0.36	0.25	0.23	0.17	0.24	0.11
13		0.10	0.05	0.20	0.18	0.17	0.19	0.13	0.13	0.09	0.04
14			0.0	0.03	0.11	0.11	0.06	0.11	0.07	0.07	0.03

FISHING MORTALITY

Age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
2	0.03	0.01	0.00	0.01	0.01	0.01	0.00	0.01	0.00	0.00	0.06
3	0.19	0.03	0.06	0.04	0.07	0.11	0.05	0.04	0.06	0.03	0.23
4	0.07	0.06	0.11	0.04	0.15	0.12	0.16	0.09	0.16	0.29	0.37
5	0.12	0.11	0.13	0.09	0.25	0.21	0.24	0.19	0.19	0.36	0.41
6	0.18	0.15	0.16	0.13	0.22	0.27	0.31	0.22	0.24	0.41	0.50
7	0.13	0.12	0.15	0.19	0.24	0.30	0.36	0.35	0.26	0.44	0.57
8	0.18	0.09	0.10	0.15	0.29	0.28	0.37	0.35	0.36	0.51	0.56
9	0.17	0.14	0.13	0.19	0.18	0.38	0.32	0.34	0.35	0.67	0.67
10	0.17	0.12	0.20	0.23	0.24	0.34	0.45	0.33	0.38	0.67	0.55
11	0.25	0.14	0.15	0.25	0.21	0.44	0.46	0.37	0.28	0.74	0.82
12	0.22	0.38	0.12	0.61	0.35	0.45	0.50	0.38	0.45	0.60	0.63
13		0.07	0.32	0.41	0.32	0.84	0.35	0.36	0.40	0.57	0.49
14			0.25	0.33	0.33	0.37	0.92	0.11	0.56	0.61	
15+											

F_I
.2
.3
.4
.4
.5
.5
.6
.6
.75
.5
.5
.5

Table 9. Estimates of Stock Size and Fishing Mortality for West of Scotland Saithe from Virtual Population Analysis (M = 0.2).

F_I
.6
.6
.4
.3
.3
.3
.3
.3
.3
.3
.3
.5

STOCK NUMBERS (millions)

Age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
2	7.0	6.9	16	13	23	16	14	19	11	13	11
3	5.4	5.5	5.6	13	11	19	13	11	15	9	5.7
4	2.6	3.3	3.9	3.7	9.1	6.4	12	7.9	7.4	10	4.4
5	3.4	1.3	1.8	2.1	2.4	4.9	2.6	5.8	3.9	4.0	2.0
6	1.3	1.5	0.81	1.0	1.4	1.2	2.5	1.0	3.0	2.1	1.3
7	0.53	0.73	0.80	0.51	0.63	0.80	0.55	1.4	0.59	1.9	1.1
8	0.55	0.31	0.43	0.43	0.35	0.34	0.42	0.32	0.73	0.35	0.20
9	0.46	0.36	0.19	0.27	0.22	0.24	0.20	0.31	0.18	0.49	0.33
10	0.93	0.29	0.19	0.12	0.17	0.12	0.13	0.14	0.21	0.13	0.08
11	0.06	0.72	0.16	0.09	0.10	0.10	0.07	0.10	0.09	0.15	0.11
12	0.03	0.05	0.04	0.11	0.06	0.05	0.04	0.04	0.07	0.06	0.04
13		0.03	0.03	0.02	0.08	0.04	0.04	0.03	0.03	0.05	0.03
14			0.02	0.02	0.01	0.05	0.02	0.03	0.02	0.02	0.03

FISHING MORTALITIES

Age	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969	1970
2	0.04	0.02	0.04	0.01	0.01	0.02	0.01	0.02	0.01	0.03	0.35
3	0.28	0.16	0.20	0.14	0.31	0.21	0.28	0.22	0.19	0.26	0.59
4	0.47	0.40	0.40	0.23	0.42	0.72	0.56	0.51	0.40	0.63	0.58
5	0.62	0.31	0.39	0.19	0.49	0.49	0.73	0.45	0.40	0.49	0.39
6	0.35	0.43	0.27	0.27	0.38	0.61	0.37	0.35	0.25	0.29	0.22
7	0.32	0.33	0.42	0.17	0.41	0.46	0.32	0.44	0.32	0.37	0.22
8	0.23	0.30	0.26	0.48	0.18	0.34	0.11	0.37	0.20	0.38	0.26
9	0.26	0.42	0.23	0.23	0.36	0.38	0.16	0.17	0.18	0.19	0.21
10	0.05	0.40	0.52	0.05	0.33	0.40	0.10	0.25	0.12	0.20	0.30
11	0.05	0.45	0.13	0.33	0.43	0.69	0.22	0.17	0.15	0.13	0.22
12	0.03	0.34	0.48	0.17	0.20	0.14	0.20	0.32	0.12	0.15	0.35
13		0.29	0.31	0.19	0.29	0.45	0.16	0.37	0.18	0.19	0.19
14			0.64	0.38	0.41	1.4	0.34	0.30	0.15	0.28	0.14
15+											

Table 10. Percentages by Weight of Saithe less than 30, 35 and 40 cm in Length in the Landings from the Different Areas[1]

Country	Length	Percentage by Weight				
		I + IIa	IV	Va	Vb	VI
England	30	0	0	0	0	0
	35	<0.1	<0.1	0	<0.1	<0.1
	40	0.4	1.0	<0.1	0.2	0.1
Germany	30	0	0	0	0	
	35	0	0	0	0	
	40	< 0.1	0	<0.1	<0.1	
Netherlands	30		0			
	35		0.1			
	40		1.0			
U.S.S.R.	30	<0.1	0			
	35	0.6	0.2			
	40	6.6	2.8			
Norway (Sub-area I + IIa North of 64°N)	30	0				
	35	1.3				
	40	6.7				
Norway (Sub-area IIa South of 64°N)	30	4.0				
	35	18.0				
	40	45.1				

[1] Germany (except IV), Norway and U.S.S.R. averaged for 1970-72. Germany (Division IV) and England averaged for 1970-71.

Table 11. Lengths of Saithe Corresponding to Different Rates of Retention. Selection Factor: 3.8.

	Mesh Size (mm)			
% Retention	80	110	130	145
5	18.4	29.0	37.4	43.1
25	26.2	37.6	45.2	50.9
50	30.4	41.8	49.4	55.1
75	35.0	46.4	54.0	59.7
95	41.2	52.6	60.2	65.9

Table 11. Lengths of Saithe Corresponding to Different Rates of Retention. Selection Factor: 3.8.

Table 12. Average Length Compositions of Saithe Landings from the North-East Arctic and from Iceland. Total Landings – Thousands of Fish.

Period Length cm.	(a) North-East Arctic					(b) Iceland	
	England[1] 1970-71	Germany[2] 1970-72	Norway[3] (Trawl) 1970-72	Norway[4] (Other Gears) 1970-72	USSR[5] 1970-72	England 1970-71	Germany 1970-72
<30				9 481	48		
30-34	14			24 091	608		
35-39	75	38	24	36 208	4 307	3	1
40-44	219	309	717	40 047	5 367	48	32
45-49	538	607	2 057	25 500	4 178	133	191
50-54	1 041	1 016	1 765	7 554	2 635	235	630
55-59	1 067	1 137	1 412	2 858	1 877	318	1 201
60-64	944	1 321	1 162	1 477	1 526	387	1 557
65-69	619	1 158	879	1 047	1 092	454	1 638
70-74	272	922	632	955	733	562	1 474
75-79	135	619	243	844	560	582	1 254
80-84	86	351	137	1 117	339	549	929
85-89	60	194	76	478	196	450	575
90-94	41	82	30	241	81	274	267
95-99	16	42	19	72	54	144	109
100-104	6	19	4	110	34	52	29
105-109	3	13	4	39	11	23	12
110+	3	7	2	15	11	10	3

1) Division I, Sub-areas IIa and IIb.
2) Sub-area IIa.
3) Division I, Sub-area IIa North of 64°N and IIb.
4) Includes trawl landings from IIa South of 64°N.
5) Sub-area IIa.

Table 13. Length/Weight Relationship for Saithe Based on German Data.

Fitted Relationship: Iceland $W = 1^{3.12} \times 5.4 \times 10^{-6}$

Lofoten $W = 1^{3.15} \times 4.4 \times 10^{-6}$

Length (cm)	Whole Weight (kg)	
	Iceland	Lofoten
32.5	.281	.255
37.5	.440	.400
42.5	.650	.593
47.5	.92	.84
52.5	1.25	1.13
57.5	1.70	1.50
62.5	2.20	1.95
67.5	2.75	2.52
72.5	3.45	3.15
77.5	4.25	3.85
82.5	5.15	4.70
87.5	6.25	5.68
92.5	7.40	6.75
97.5	8.75	8.05
102.5	10.15	9.40
107.5	11.76	10.85
112.5	13.55	12.72

Table 14. Effects of an Increase in the Minimum Trawl Cod-End Mesh Size from 130 to 145 mm in the North-East Arctic and Iceland Areas. $M = 0.2$, S.F. $= 3.8$, $E = 0.7$.

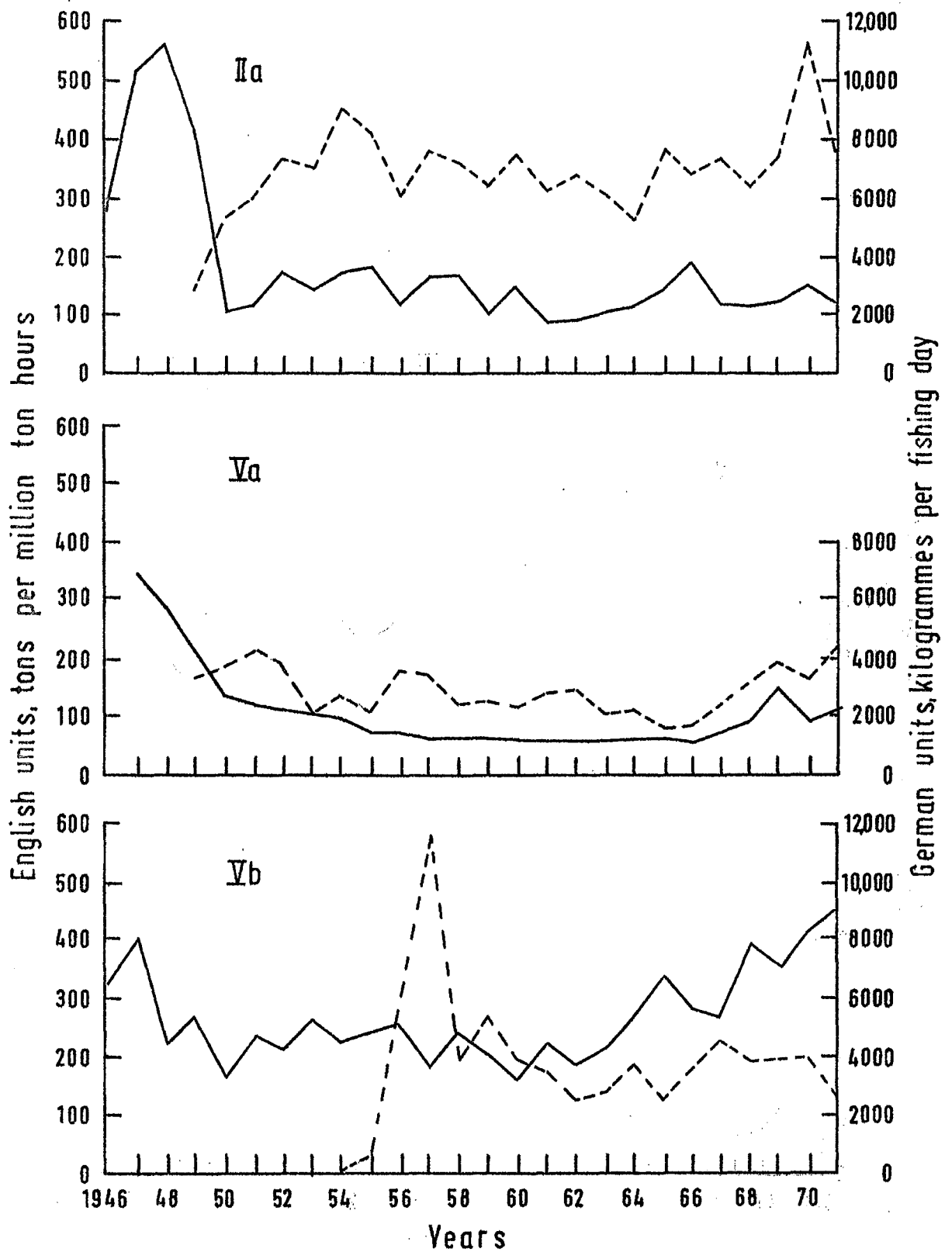|	Immediate Loss %	Long-Term Change %
North-East Arctic		
England	19	-1
Germany	11	+10
Norway (Trawl)	23	-4
U.S.S.R.	34	-18
Others (Trawl)	19	-1
Norway 'Other Gears'	0	+11
Iceland		
England	3	-4
Germany	5	-2
Other Countries	3	-4

Figure 1   Catch per unit effort of saithe by statistical area for English (solid
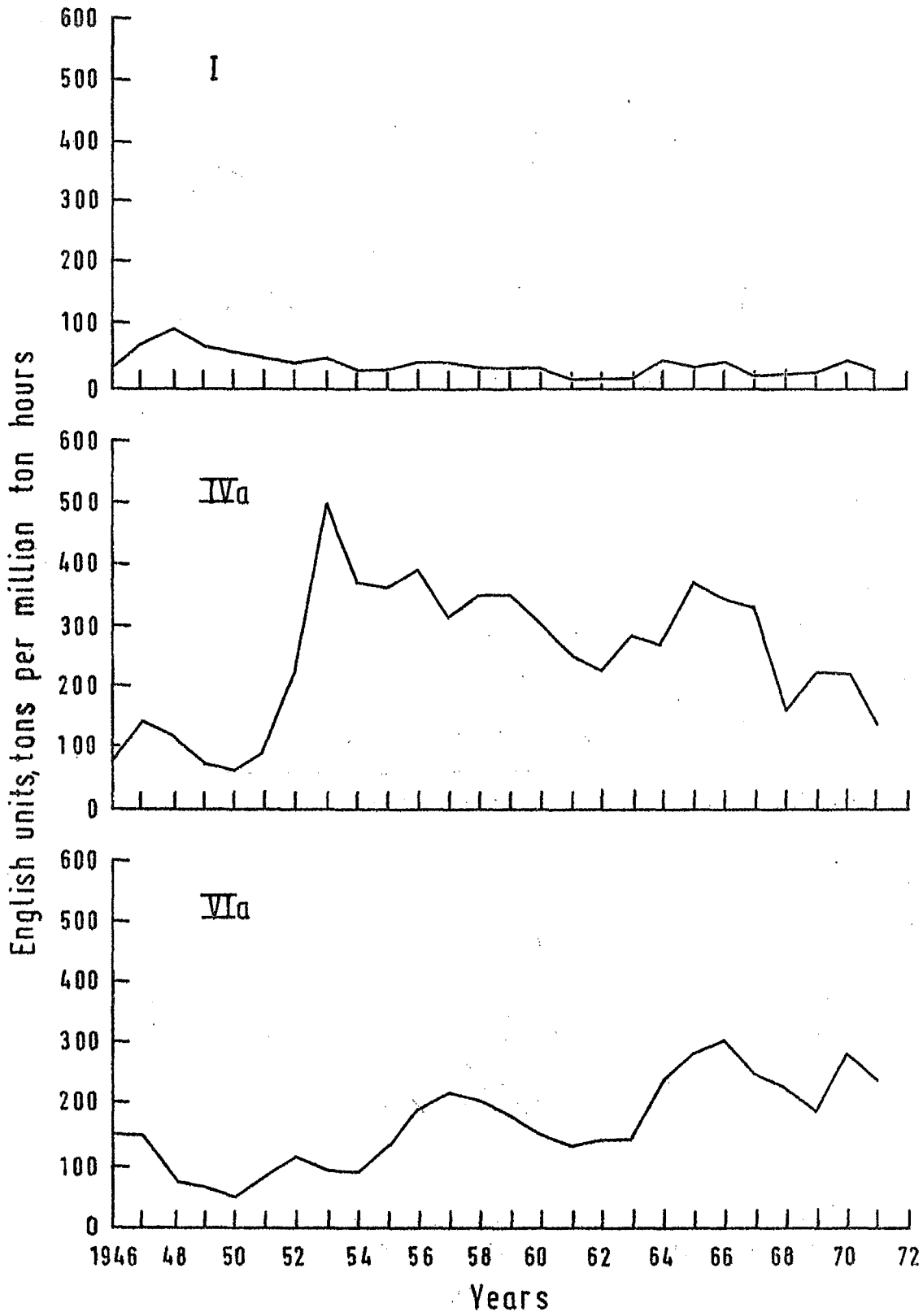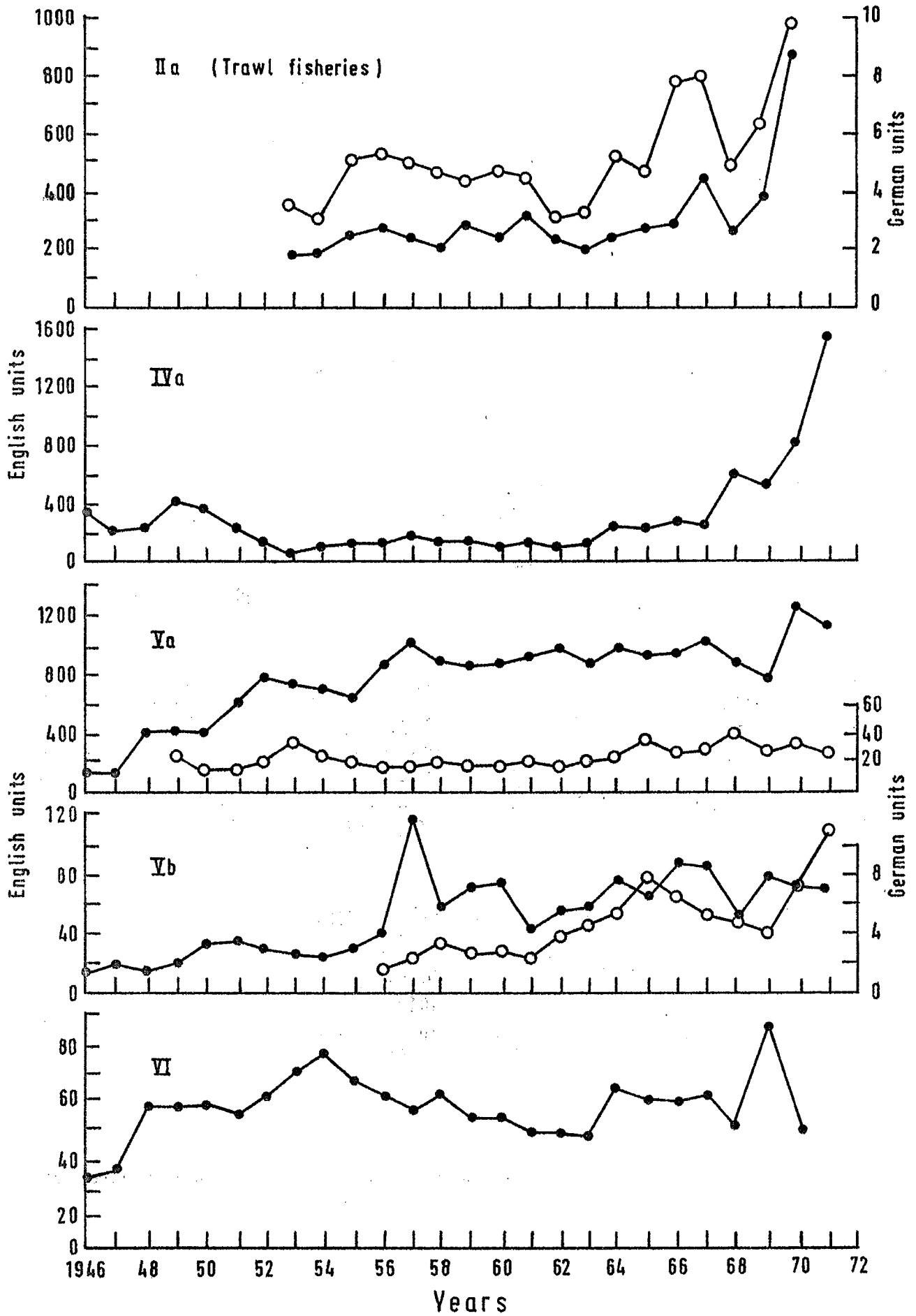lines) and German (broken lines) trawlers.

Figure 1 (continued)

Figure 2   Trends in estimates of total fishing effort on saithe by statistical area.
German units: open circles,
English units : solid circles.

English landings   German landings

Vb Faeroe

Length (cm)

IIa Norway coast

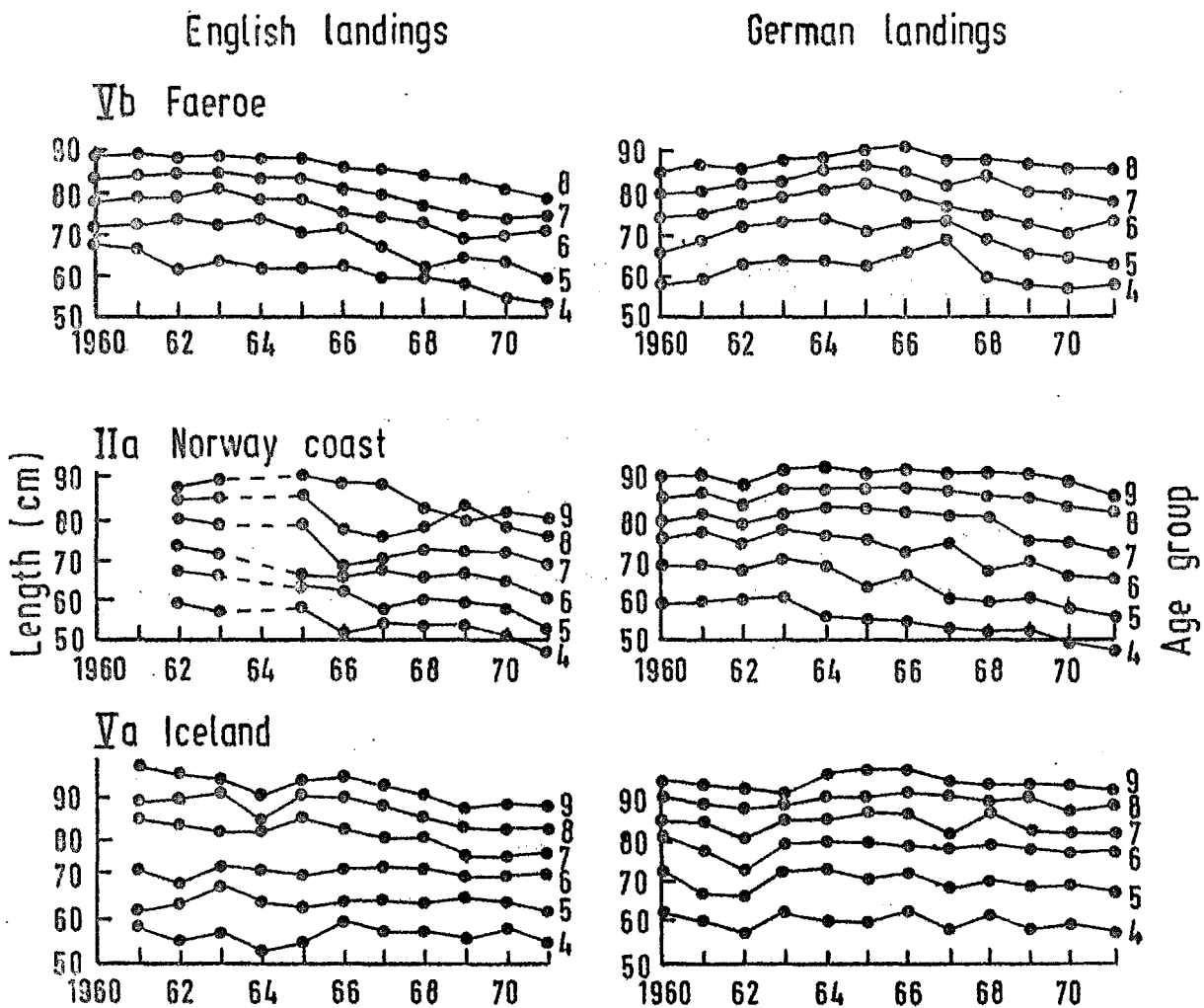Va Iceland

Age group

Figure 3   Mean lengths of age groups of saithe in English and German landings
            from Faroe, Norway Coast and Iceland.