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REPORT OF THE WORKING GROUP ON NORWAY POUT AND SANDEELS IN THE NORTH SEA

Charlottenlund, 23 - 25 April
1979

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1. Introduction.

1.1. Terms of Reference

In accordance with C.Res. 1978/2:37 the Working Group met at ICES headquarters in Charlottenlund 23-25 April 1979. The terms of reference set out in the Council's resolution are shown below:

> "It was decided, that in view of additional information available, and in order to make more effective use of data previously presented, the Working Group on Norway Pout and Sandeels in the North Sea should meet 23-25 April 1979 at ICES headquarters to improve the assessment of the state of these stocks".

1.2. Participation

The following experts took part in the meeting:

T Benjaminsen	Norway
K Hoydal	Faroes
J Lahn-Johannessen	Norway
K Popp Madsen (Chairman)	Denmark
N A Nielsen	Denmark
M G Pawson	United Kingdom
P Sparre	Denmark
K Warburton	United Kingdom
V Nikolaev	ICES's Statistician

1.3. The Report

The Working Group intended to make the present report cover the results obtained during the first 3 meetings of the Group. Because of the very restricted time available this intention could not, however, be carried out to a satisfactory extent. The Working Group recommends, therefore, that the papers: C.M. 1977/F:7, C.M. 1978/G:12 and the present paper be joined into one reference paper with publication in the Cooperative Research Report series in view.

2. Norway Pout

2.1. The Fish

2.1.1. General remarks

The Norway pout is a small gadoid species which is usually found within a few meters of the sea-bed. The largest population is found in the northern North Sea, but there are other populations in adjacent areas. It is mainly distributed between depths of 100 and 250 m.

Norway pout in the North Sea spawn east of Shetland in March - April, and the 0-group begin to recruit to the population on the sea-bed during late summer. The fish spawn at an age of 1 or (mainly) 2 years, and in the North Sea do not normally live for more than 4 years.

The fact that only one main spawning area is known in the North Sea and the general distribution of the species indicate that the Norway pout in this area should be treated as a single stock for management purposes.

2.1.2. Distribution of the 0-group

Data on the distribution are available from the International 0-Group Gadoid Surveys in summer (Figure 2.1.1 and 2.1.2). Compared with the long-term average figures the distribution of the 0-group in 1978 was quite similar to that of recent years, being almost exclusively restricted to the northern North Sea.

2.1.3. Distribution of older Age Groups

The distribution of older age groups in 1978 and preliminary indications of the distribution of the 1978 year class as I-group based upon collections from the International Young Herring Surveys in 1978 and 1979, and long-term average figures for the period 1974-77 are presented in Fig. 2.1.3-9. The distribution of older age groups in 1978 followed the same pattern as in previous years, the main area being the northern North Sea with branches extending south along the British coast and southeast into the Skagerrak. Though incomplete the data available of the 1978 year class suggest a similar distribution (Fig. 2.1.9).

2.2. The Fishery

2.2.1. Landings

From data available to the Working Group a corrected table of annual landings by countries was prepared for the North Sea (Table 2.2.1)

Compared with the previous year the total annual landings in 1978 decreased from about 390 000 to 270 000 tons. The landings from all countries went down; most markedly in the case of Denmark and the Faroes. It should be noted that the Norwegian fishery for Norway pout is also partly directed towards the stock of young blue whiting in the Norwegian Deeps so that variations in the annual landings of Norway pout to some extent depend on the by-catch of blue whiting. Since the peak in 1974, however, the total annual landings of Norway pout have gradually decreased.

A breakdown of landings by month in 1978 is given for the major exploiting countries in Table 2.2.2. The table shows marked fluctuations from month to month. The largest quantities were landed during the third quarter of the year, whereas the comparatively low landings in the second quarter correspond with high landings of sandeel in the same period, thus indicating the relationship of these fisheries.

2.2.2. Distribution of Catch in 1978.

The 1978 complete landing figures were not available in statistical rectangles but were grouped within sub divisions on a quarterly basis as shown in Fig. 2.2.1 and Table 2.2.3. From this table it is seen that the main area of fishing was restricted to the northern North Sea which corresponds with the fishing area in previous years (C.M.1978/G:12). The regulations imposed on the fishery in the Norway pout box (Sub-divisions 1,2 and 3) and Norwegian regulations in the fourth quarter of the year probably reduced the landings considerably, though this loss apparently was somewhat compensated for by the landings from the adjacent sub divisions (mainly 4 and 5A).

2.2.3. Effort

Data on catch per unit effort in the Danish industrial fisheries were available by sub-areas and quarters from 1975 to the first half of 1978. These data excluded the sand eel fisheries but included all other species i.e. Norway pout and by-catches. For each subarea and quarter estimates of total effort were derived from the Danish c.p.u.e. figures and the corresponding total international catch. The results are shown in Table 2.2.4.

2.3. Growth

2.3.1. Length and weight

There are differences in growth between various year classes of Norway pout as shown in Table 2.3.1. The monthly length data (Table 2.3.2

and 2.3.4) indicate that Norway pout only grow during a period of about 3 months, June-August. The trend in the mean monthly individual weights (Figure 2.3.5 and Table 2.3.6) follows that of the corresponding length values. Norway pout increase in weight during the same three month period after which the weight remains more or less constant until the end of the year. The apparent decrease in II-group from January to May could be due to the release of spawning products combined with a general decrease in the fat content.

2.3.2. Growth parameters

From the mean length at age given in Table 2.3.2-2.3.4, the follow ing (unweighted) average values were calculated for half-year periods:

Age	Jan.-Jun-	Jul.-Dec.
0	-	9.94 cm
1	11.79 cm	15.59 cm
2	16.20 cm	18.18 cm
3	18.24 cm	19.78 cm

A von Bertalanffy growth curve fitted to these values (unweighted) had the following parameters:

$$L_\infty = 22.1 \text{ cm} \qquad k = 0.53 \qquad t_o = 0.3 \text{ years}$$

Based on mean weights at age (Table 2.3.1) the von Bertalanffy parameters are:

$$W_\infty = 85 \text{ grms} \qquad K = 0.55 \qquad t_o = 0.6 \text{ years}$$

Y/R curves for various values of M and t_o are shown in Figure 2.3.3. They indicate that assuming constant recruitment and an age at first capture of between 0.5-1.0 years, an asymptote in yield per recruit is reached above fishing mortalities of F = 1.5-2.0.

2.4. Age Distribution

Catch at age data for the northern North Sea were compiled as follows.

Quarterly catches for 1974 to 1977 inclusive in numbers at age were available for Denmark and Scotland to the west of 2^{o}E, and for Denmark and Norway to the east of 2^{o}E. The Danish data for the western area were raised using the ratio of Danish + Norwegian + Faroese catches to the Danish catch in this area, and grouped with the Scottish data. The result was then grouped with the catch in numbers at age in the area to the east of 2^{o}E, obtained by raising the appropriate Danish data (being similar to the corresponding Norwegian data) using the ratio of total Danish + Norwegian +

Faroese catches to the Danish catches. A similar method was used for the 1978 data, but using Norwegian catch in numbers at age for the area to the east of 2°E directly.

Table 2.4.1 shows the catch at age by quarter and year for 1974 to 1978, and Table 2.4.2 shows the final input figures for VPA's carried out on a yearly basis.

Percentage age compositions from different sources are shown in Table 2.4.2. The longest series of years (1960-78) are presented by data from Scottish research vessel surveys in autumn while data from the Scottish and Danish commercial fisheries only cover the period from 1972 and 1974 respectively. The figures indicate rather strong fluctuations in yearclass strength, and the research vessel data also show that only a very small part of a yearclass achieves an age of 3 years, irrespective of whether the stock was lightly or heavily fished.

2.5. Mortality

2.5.1. Estimates from catch per unit effort

Data on total effort derived from Danish c.p.u.e. for the period 1975 to the first half of 1978 (Table 2.2.4) and the catch in numbers at age shown in Table 2.4.1 made new estimates possible in addition to those given in earlier reports.

The new estimates, based on total catch and effort in the North Sea, are shown below:

Period of mortality		Age groups 1/2	2/3	Mean
1975/76	Mean Z	2.18	2.46	2.32
1976/77	"	2.00	3.27	2.64
1977/78	"	1.92	1.60	1.76

The only estimates of Z from a period with much lower effort are those obtained from Scotish research vessel surveys. In the period 1960-1966 these data give estimates ranging from 0.42-3.01 for 1/2-groups and 0.62-3.78 for 2/3-groups. Mean Z values are 2.46 and 2.65 respectively. Compared with the estimates for the most recent years given above there is no apparent effect of the unquestionable increase in effort, which have taken place in the interim period. There are a number of possible explanations of why this is so, but the Working Group had no means by which to point out the most likely one(s).

2.5.2. Estimates from V.P.A.

Using the catch in numbers at age shown in Table 2.4.1 as input figures for a V.P.A. covering the period 1974-78 the following estimates of fishing mortality (F) and of total mortality (Z) were obtained.

Input	M = 1.6 F = 1.0		M = 2.0 F = 0.6		Derived total effort (hours $\times 10^{-3}$)
Year	mean F	mean Z	mean F	mean Z	
1974	1.18	2.78	0.84	2.84	404.3
1975	1.00	2.60	0.67	2.67	379.1
1976	0.68	2.28	0.35	2.35	425.6
1977	(0.62)	(2.22)	(0.34)	(2.34)	323.1

The decreasing trend in calculated F's, irrespective of which input mortality values are chosen, is apparently not in agreement with the derived total effort development in the same period. There are other objections to the application of the V.P.A. technique to such short lived species as e.g. the Norway Pout, but it is quite clear, that without some knowledge on the level of and possible fluctuations in the natural mortality coefficient the exercise is of very doubtful value.

2.6. Stock and Recruitment

2.6.1. Development of the fishery and catch fluctuations, 1959 onwards

The fluctuations in the catch of Norway pout (Table 2.2.1) and in the age compositions (Table 2.4.3) indicate quite clearly that there are large annual variations in recruitment. There is, however, a surprising uniformity in commercial catch per unit effort data during this period. It seems, therefore, that independent estimates of year class strength are required for assessment purposes, and it can be seen (Fig. 2.6.1) that abundance indices of 1 group fish based on Scottish surveys in the autumn have accurately reflected the catch fluctuations until quite recently. Unfortunately these data are only available towards the end of the year in which the one year old Norway pout are being caught, and are of little use for management predictions. 0-group data obtained during these Scottish autumn surveys have generally anticipated the following year's catch, despite the small sample size taken each year.

2.6.2. Recent catch data and recruitment indices

According to the catch at age data presented in this report (Tables 2.4.1 and 2.4.2) the most recent peak in the abundance of Norway pout occurred in the 1973 year class. The 1974 year class was probably about average and was followed by two similar recruitment years. In 1977, however, a very low year class strength is indicated, although this may partly be due to the effect of a box closure. The high 1973 year class strength was well monitored by the Scottish autumn surveys as both 0 and 1 group fish and by the IYHS as 1 groups (Table 2.6.1), although it was not predicted by the 0-group gadoid survey in 1973, due possibly to inadequate coverage of the 0-group's distribution. The latter surveys and the Scottish autumn surveys indicated a very strong year class in 1976 which was not apparent in the catch data or from IYHS results in 1977. The low 1977 year class was well monitored by all but the Scottish autumn surveys. It seems likely that the 1978 year class will be stronger than those of 1974 and 1975.

2.6.3. Recruitment indices and prediction

It appears, then, that the 0-group gadoid surveys and the Scottish autumn surveys provide a useful index of Norway pout abundance upon which to base a tentative assessment for the following year. It is important, however, to be able to adjust this prediction according to the results of the IYHS during the year of capture as 1-group fish. The foregoing indices are all based upon a mean abundance estimate over the sampling areas shown in Figure 2.6.2 and it seems likely that an index based on a depth stratification may be more accurate for 1-group Norway pout in the IYHS.

A bottom depth chart (Fig. 2.6.3) of the northern North Sea (56-61°N by 4°W to 8°E) was produced using soundings recorded on IYHS fishing stations during 1975-1978, and those given on Admiralty chart 2339 (1960). Contours were drawn at 20 m intervals from 40 m downwards. The mean catch per effort (numbers per hour tow using a logarithmic transformation) of 1-group Norway pout were calculated for each year for all hauls. This analysis of catch rates by depth seems justified in view of the consistant trend in abundance with depth, see Figure 2.4.4. The mean catch per effort values for 1-groups at each depth were then weighted by the area of that depth interval (measured by planimetry), and summed to give an index of abundance for each year see Table 2.6.7. It can be seen that although there is considerable variation in the relative abundance by depth between years, an index of the abundance of 1-group Norway pout may be obtained by using the values at depths of between 100 and 160 m. At lesser depths their relative abundance is negligible, and depths of over 160 m are difficult to contour and, probably, sample satisfactorily.

2.7. Management Strategy

In view of the predominance of 1 year old fish in landings of Norway pout and the fluctuations in year class strength, it seems unlikely that any long-term management of Norway pout is possible. Management by yield per recruit considerations is based on the assumption of constant recruitment, and is very sensitive to variations in natural mortality, of which little is known for Norway pout. Consequently the application of yield per recruit curves for the management of this stock is doubtful.

Indices of abundance from 0-group surveys seem to predict the following year's catch with some accuracy, and provided that indications of abundance as 1-group fish from IYHS are made available and acted upon rapidly, it should be possible to adjust annual landings on a year to year basis, if necessary.

Table 2.2.1. Norway pout. Annual landings (in thousand tons) by countries. North Sea 1957-78.

	Denmark	Faroes	Norway	Sweden	U.K.(Scotland)	Others	Total
1957			0.2				0.2
58							
59	61.5		7.8				69.3
1960	17.2		13.5				30.7
61	20.5		8.1				28.6
62	121.8		27.9				149.7
63	67.4		70.4				137.8
64	10.4		51.0				61.4
1965	8.2		35.0				43.2
66	35.2		17.8			+	53.0
67	169.6		12.9			+	182.6
68	410.8		40.9			+	451.8
69	52.5	19.6	41.4			+	113.5
1970	142.1	32.0	63.5		0.2	0.2	238.0
71	178.5	47.2	79.3		0.1	0.2	305.3
72	259.6	56.8	120.5	6.8	0.9	0.2	444.8
73	215.2	51.2	63.0	2.9	13.0	0.6	345.9
74	464.5	85.0	154.2	2.1	26.7	3.3	735.8
1975	251.2	63.6	218.9	2.3	22.7	1.0	559.7
76	244.9	64.6	108.9	+	17.3	1.7	435.4
77	232.2	50.9 x)	98.3	2.9	4.6	1.0	389.9
78	163.4	19.7	80.8	0.7	5.5	–	270.1

x) including VIa

Table 2.2.2. NORWAY POUT National Landings by months, 1978

Months	Denmark	Faroes	Norway	U.K. (Scotland)	Total
January	12 690	927	3 452	939	18 008
February	21 322	2 259	5 096	1 236	29 913
March	13 170	1 674	1 110	441	16 395
April	3 840	745	3 626	-	8 211
May	2 718	1 511	9 198	-	13 427
June	2 236	1 944	13 210	33	17 423
July	21 177	1 500	4 355	-	27 032
August	15 528	2 608	10 366	-	28 502
September	32 274	1 958	14 881	-	49 113
October	18 916	1 821	5 996	952	27 685
November	12 567	1 504	6 028	1 035	21 134
December	6 971	1 255	3 437	371	12 034
Total	163 409	19 706	80 755	5 007	268 877[1)]

1) 698 tons caught by Sweden are not included.

Table 2.2.3. Norway Pout. Landings by quarters and areas in 1978

Quarter \ Sub-division	1+2	3	4	5A	5B	6	Total
1	12 168	3 943	21 275	26 624	235	69	64 314
2	6 466	745	4 769	27 063	-	21	39 062
3	33 873	6 804	22 477	36 822	4 671	-	104 647
4	-	-	44 998 1)	15 559	295	-	60 852
Total	52 507	11 492	93 517	106 068	5 201	90	268 875

1) 5A and B partly included

Table 2.2.4. Estimates of total hours (x 10^{-3}) trawling in industrial fisheries (excluding sandeel). (Based on Danish catch per unit effort data).

Area / Quarter	1975 I	1975 II	1975 III	1975 IV	1976 I	1976 II	1976 III	1976 IV
1	19.2	(4.0)	14.6	23.3	23.6	4.4	28.8	30.4
2	15.7	6.9	51.4	48.2	21.9	5.4	54.8	43.0
3	4.8	2.2	8.8	5.3	5.8	1.9	12.6	8.3
4	7.8	11.0	9.1	13.5	11.4	16.3	13.2	9.5
5A	28.7	46.6	29.7	28.1	24.6	40.2	53.6	15.9
Total	76.2	70.7	113.4	118.5	87.3	68.2	163.0	107.2

Area / Quarter	1977 I	1977 II	1977 III	1977 IV	1978 I	1978 II	1978 III	1978 IV
1	19.8	7.0	26.0	?	0	?	-	-
2	19.0	0.8	34.0	50.0	19.6	13.0	-	-
3	16.7	0.1	4.0	1.7	5.0	?	-	-
4	18.4	4.1	9.8	22.3	28.3	6.1	-	-
5A	28.6	17.2	24.3	20.2	34.9	23.9	-	-
Total	1o2.6	29.2	98.1	94.2	87.8	43.0	-	-

Table 2.3.1. Norway Pout. Mean length and weight by yearclass and age in October/November-January.

Mean length (October-January)

W.R.	0	1	2	3
72	-	-	18.46	-
73	-	15.23	18.07	20.08
74	11.07	16.26	18.93	19.50
75	10.66	15.88	18.19	21.06
76	10.51	15.93	18.33	-
77	10.87	15.83	-	-
78	10.62	-	-	-
Mean length	10.75	15.83	18.40	20.21

Mean weight (November-January)

W.R.	0	1	2	3
72	-	-	48.32	-
73	-	24.70	44.15	53.50
74	9.12	31.09	43.70	-
75	7.17	27.14	46.83	69.82
76	7.25	28.14	44.79	-
77	7.96	27.78	-	-
78	7.14	-	-	-
Mean weight	7.73	27.77	45.56	61.66

Table 2.3.2. Norway pout. Mean length by month and age in the western North Sea, 1974-77. (number of years in brackets).

Age	0	1	2	3	4
Month					
1		11.15 (4)	15.86 (4)	18.11 (3)	(20.25) (1)
2		11.30 (4)	15.90 (4)	18.55 (3)	
3		11.25 (4)	15.88 (4)	17.98 (3)	
4		11.63 (3)	16.02 (3)	17.72 (2)	
5		(11.57)(1)	(16.00)(1)	(18.25)(1)	
6		(13.58)(1)	(17.83)(1)	-	
7	8.39 (2)	14.86 (3)	16.85 (3)	(17.63)(2)	
8	9.11 (4)	15.16 (4)	18.24 (4)	(20.25)(2)	
9	9.85 (4)	15.76 (4)	18.86 (4)	20.32 (3)	
10	10.16 (4)	15.81 (4)	18.17 (4)	19.75 (2)	
11	10.82 (4)	15.86 (4)	18.39 (4)	19.92 (3)	
12	11.22 (2)	15.62 (2)	18.63 (2)	-	

Table 2.3.3. Norway pout. Total North Sea 1978. Mean length by month and age, based on Danish Samples.

Age	0	1	2	3	4
Month					
1	-	11.53	15.72	18.69	21.25
2	-	11.41	15.67	19.04	-
3	-	11.92	15.72	18.39	21.00
4	-	12.42	17.04	-	-
5	-	-	-	-	-
6	-	16.03	19.65	-	-
7	-	15.46	17.94	20.25	-
8	9.05	16.19	18.25	20.86	22.25
9	9.80	16.04	17.89	18.78	-
10	9.74	15.69	17.96	20.25	20.25
11	10.49	16.02	18.02	20.00	-
12	10.91	16.13	18.68	22.75	-

Table 2.3.4. Norway Pout (east of 2^{o} E). Mean length by age and quarter, 1978, based on Norwegian samples.

Age	0	1	2	3	4	No of fish sampled
Quarter						
1	-	11.21	15.37	18.51	21.08	3527
2	-	12.40	14.78	18.14	-	3988
3	-	15.48	18.21	21.18	-	2504
4	10.40	15.98	18.28	20.60	-	1641

Table 2.3.5. Norway pout. Mean weight by month and age in the western North Sea, 1974-77. (Number of years in brackets).

Age	0	1	2	3	4
Month					
1		7.95 (4)	28.77 (3)	42.59 (3)	62.00 (1)
2		8.51 (4)	25.61 (4)	42.49 (3)	
3		8.08 (4)	23.48 (4)	33.77 (3)	
4		8.40 (3)	21.11 (3)	26.72 (2)	
5		8.29 (1)	20.14 (1)	29.00 (1)	
6		15.21 (1)	37.16 (1)	-	
7	3.76 (2)	21.68 (3)	33.23 (3)	38.00 (2)	
8	4.16 (4)	23.14 (4)	43.05 (4)	56.00 (2)	
9	5.45 (4)	27.16 (4)	46.04 (4)	63.00 (3)	
10	6.18 (4)	27.96 (4)	43.85 (4)	55.75 (2)	
11	6.72 (4)	28.25 (4)	45.06 (4)	55.33 (3)	
12	8.76 (2)	27.70 (2)	47.38 (2)		

Table 2.3.6. Norway Pout. Total North Sea 1978. Mean weight by month and age, based on Canish Samples. Number of fish measured in brackets.

Age	1	2	3	4	5	
Month						
1	-	8.93(2200)	25.82(1051)	46.02 (39)	70.50 (2)	
2	-	8.61(2347)	25.72(1234)	48.74 (38)	-	
3	-	9.57(1679)	23.20 (475)	38.59 (21)	60.00 (2)	
4	-	10.19 (362)	26.43 (40)	-	-	
5	-	-	-	-	-	
6	-	27.92	54.57	-	-	
7	-	24.50 (478)	39.18 (246)	54.61 (11)	-	
8	4.36 (42)	28.73 (829)	46.98 (411)	64.12 (13)	81.00 (1)	
9	5.36(388)	30.27(1299)	46.57 (370)	53.19 (19)	-	
10	5.08(376)	27.36(1299)	42.08 (259)	70.50 (1)	70.50 (1)	
11	6.83(550)	28.89 (642)	42.65 (105)	58.28 (2)	-	
12	7.71(586)	29.03 (113)	48.39 (43)	80.00 (1)	-	

Table 2.4.1. Norway pout. Numbers caught at age by quarters (Total North Sea), 1974-78.

Year/Age		0	1	2	3	4	5
	1	-	13 450.43	413.90	26.47	0.51	-
	2	-	7 872.55	193.09	25.65	0.60	-
1974	3	845.54	9 965.92	488.54	144.81	-	-
	4	5 720.21	7 808.59	140.07	4.37	-	-
	1	-	3 741.72	1 726.45	13.19	0.48	0.09
	2	-	7 205.82	383.19	1.81	0.01	-
1975	3	888.60	7 116.60	348.94	0.34	-	-
	4	9 967.65	2 027.44	460.66	1.29	0.15	-
	1	-	4 949.79	589.18	91.35	0.22	-
	2	-	7 580.12	644.55	57.90	0.01	-
1976	3	197.15	5 348.52	589.53	2.32	0.03	-
	4	5 985.85	3 156.96	319.87	15.20	0.08	-
	1	-	9 170.85	949.60	33.41	2.51	0.17
	2	-	3 577.33	367.06	8.14	-	-
1977	3	60.67	3 579.66	860.66	44.93	-	-
	4	1 655.02	3 540.32	236.36	4.73	-	-
	1	-	2 930.84	1 371.23	93.22	3.56	-
	2	-	1 180.51	649.59	193.87	-	-
1978	3	304.38	2 385.07	786.20	29.59	0.37	-
	4	1 225.27	1 400.46	322.14	5.84	-	-

Table 2.4.2. V.P.A. input for catch in nos at age ($\times 10^{-3}$)

W.R.	1974	1975	1976	1977	1978
0	6565.75	10856.25	6182.28	1715.69	1529.65
1	39097.50	20091.60	21035.38	19868.16	7896.88
2	1235.60	2919.24	2143.13	2413.68	3129.16
3	201.33	16.63	166.77	91.21	322.52
4	1.12	0.74	0.34	2.51	3.93
5	0	0.09	0	0.17	0

Table 2.4.2. V.P.A. input for catch in nos at age (x 10^{-3})

W.R.	1974	1975	1976	1977	1978
0	6565.75	10856.25	6182.28	1715.69	1529.65
1	39097.50	20091.60	21035.38	19868.16	7896.88
2	1235.60	2919.24	2143.13	2413.68	3129.16
3	201.33	16.63	166.77	91.21	322.52
4	1.12	0.74	0.34	2.51	3.93
5	0	0.09	0	0.17	0

Table 2.4.3. Percentage age composition of Norway pout.

Year \ Age	0	1	2	3	4	5
Scottish Research Vessel cruises in autumn						
1960	5.19	91.96	2.40	0.45		
1961	43.80	51.13	4.56	0.51		
1962	5.02	94.32	0.59	0.06		
1963	4.65	90.12	4.99	0.24		
1964	42.14	47.52	8.71	1.64		
1965	1.60	93.79	2.71	1.91		
1966	47.92	45.83	5.42	0.83		
1967						
1968	0.74	97.61	1.63	0.03		
1969						
1970	43.63	50.14	5.94	0.29		
1971						
1972	17.49	72.73	9.71	0.08		
1973	75.09	20.37	3.68	0.86		
1974	21.04	76.01	2.67	0.27		
1975	64.77	26.42	8.81	0.00		
1976-77						
1978	55.79	32.45	10.75	0.97	0.04	
Scottish fishery						
1972	31.90	64.39	3.59	0.12		
1973	71.15	18.09	9.76	0.96	0.03	0.003
1974	20.67	75.36	3.52	0.40	0.05	
1975	37.32	41.73	20.51	0.39	0.05	0.006
1976	21.08	64.98	11.42	2.48	0.04	
1977	11.85	68.38	18.47	1.05	0.18	0.06
1978	7.10	61.30	30.13	1.48		
Danish fishery						
1974	15.97	81.07	2.57	0.40		
1975	38.07	53.38	8.51	0.015		
1976	19.02	72.23	8.22	0.52		
1977	8.65	81.51	9.52	0.32	0.01	
1978	13.99	64.92	20.38	0.68	0.02	

Table 2.6.1. Recruitment indices of Norway pout 1959-1978 , as shown by number per hour's fishing on research vessel surveys.

Year class	Abundance on pelagic 0-group surveys	Abundance in northwestern North Sea in Scottish autumn surveys		Abundance on international young herring surveys	
	Arithemetic mean	Geometric mean as		Arithmetic mean as	
	0-group	0-group	I-group	I-group	II-group
1959		-	106.8 (22)		
1960		10.9 (22)	28.1 (14)		
1961		59.6 (14)	181.7 (15)		
1962		25.0 (15)	141.8 (15)		
1963		8.5 (15)	6.6 (14)		
1964		14.0 (14)	18.6 (11)		
1965		1.2 (11)	6.1 (13)		
1966		16.4 (13)	-		
1967		-	243.2 (7)		
1968		4.5 (7)	-		
1969		-	33.1 (4)		
1970		101.7 (4)	111.7 (12)		
1971	3 347 (26)	16.7 (12)	328.8 (22)		
1972	545 (28)	36.3 (22)	16.6 (10)		692 (40)
1973	2 558 (28)	224.4 (10)	121.6 (22)	37 666 (40)	2148 (45)
1974	3 237 (28)	84.4 (22	9.5 (11)	6 656 (45)	312 (44)
1975	3 623 (28)	41.2 (11)	-	6 073 (44)	408 (46)
1976	10 884 (28)	-	131.5 (16)	8 653 (46)	2065 (47)
1977	1 521 (28)	77.7 (16)	83.9 (34)	3 065 (47)	-
1978	2 974 (27)	144.3 (34)		2 211 (36)	

NB. Number of statistical rectangles sampled shown in brackets.

Table 2.6.2.

Year \ Depth(m)	0-60	60-80	80-100	100-120	120-140	140-160	Total
1975	0 (8)	14.3(23)	269.8(15)	6268.0(17)	50077.8(16)	40924.5(9)	97554.4
1976	11.6(13)	81.0(31)	670.5(16)	7355.0(16)	9945.3(17)	37058.9(6)	55122.3
1977	24.4(18)	66.3(29)	739.3(26)	30352.5(26)	6157.8(15)	9436.2(17)	46776.5
1978	0.6(11)	12.0(27)	43.6(22)	1536.3(24)	13011.5(16)	9777.7(11)	24381.7
1979	- (0)	31.9(17)	66.4(18)	589.6(11)	18363.6(8)	17136.4(8)	36187.9
	10517	17921	15091	12468	7992	5720	

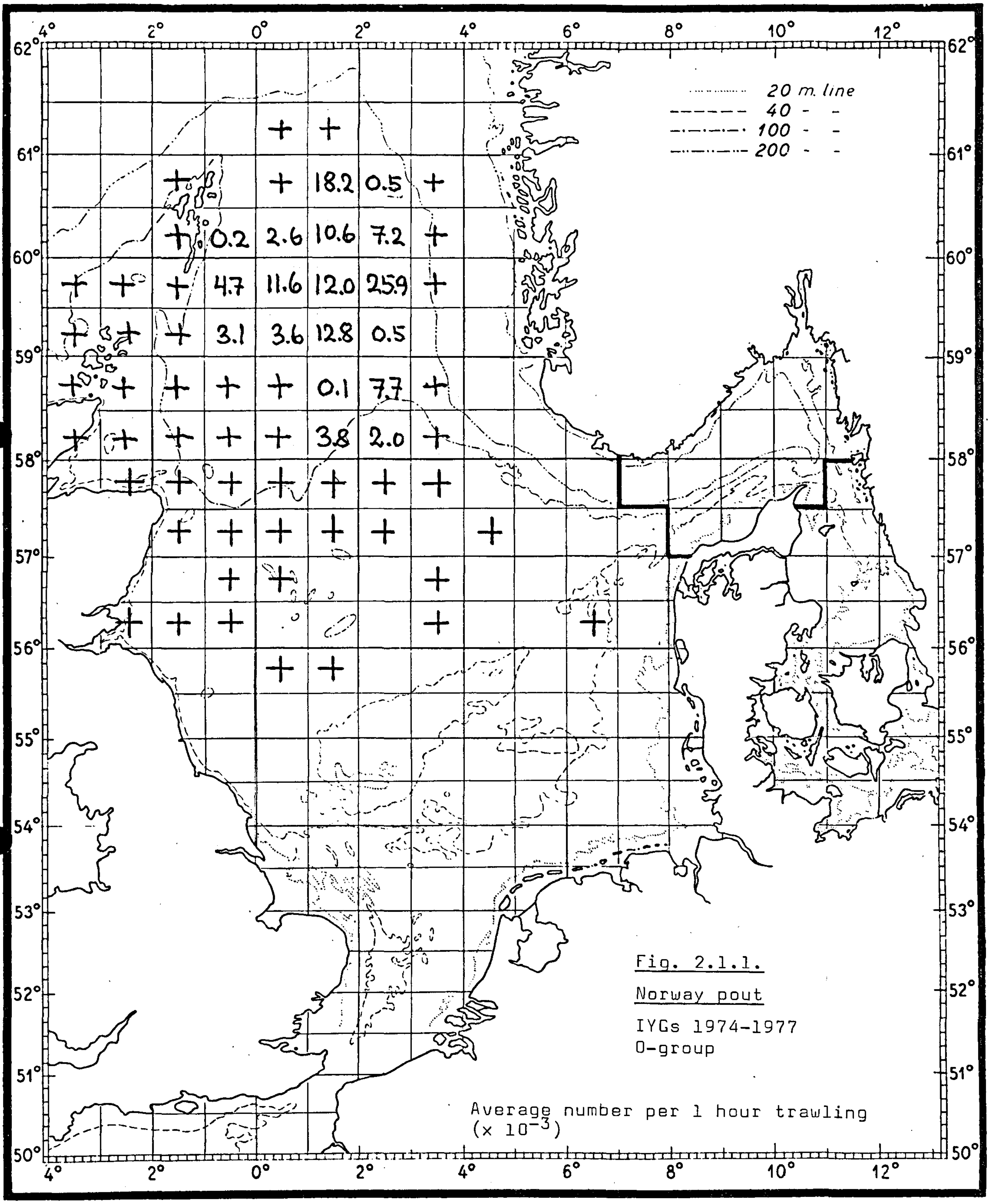


Fig. 2.1.1.

Norway pout

IYGs 1974-1977

0-group

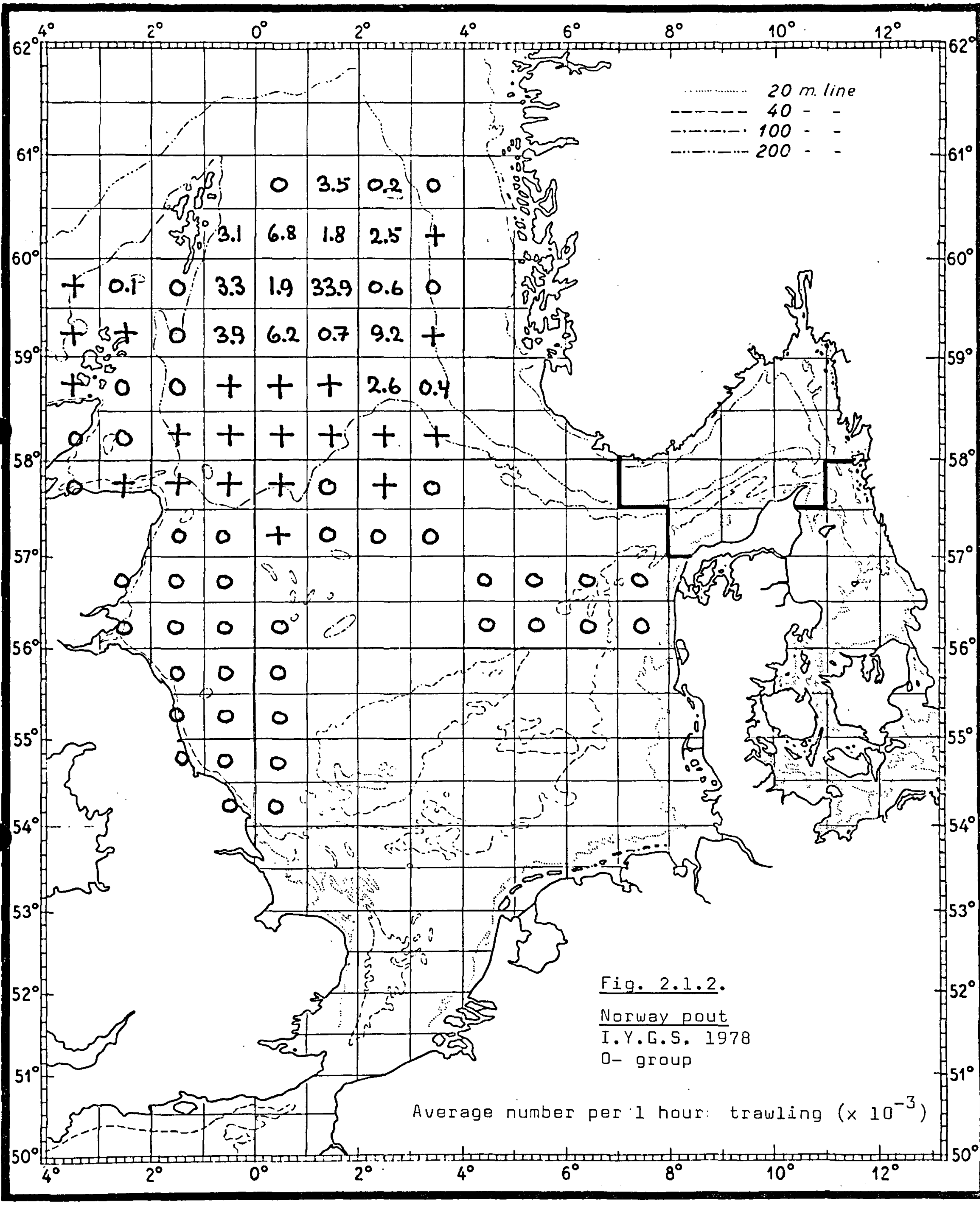


Fig. 2.1.2.

Norway pout
I.Y.G.S. 1978
0- group

Average number per 1 hour trawling ($\times 10^{-3}$)

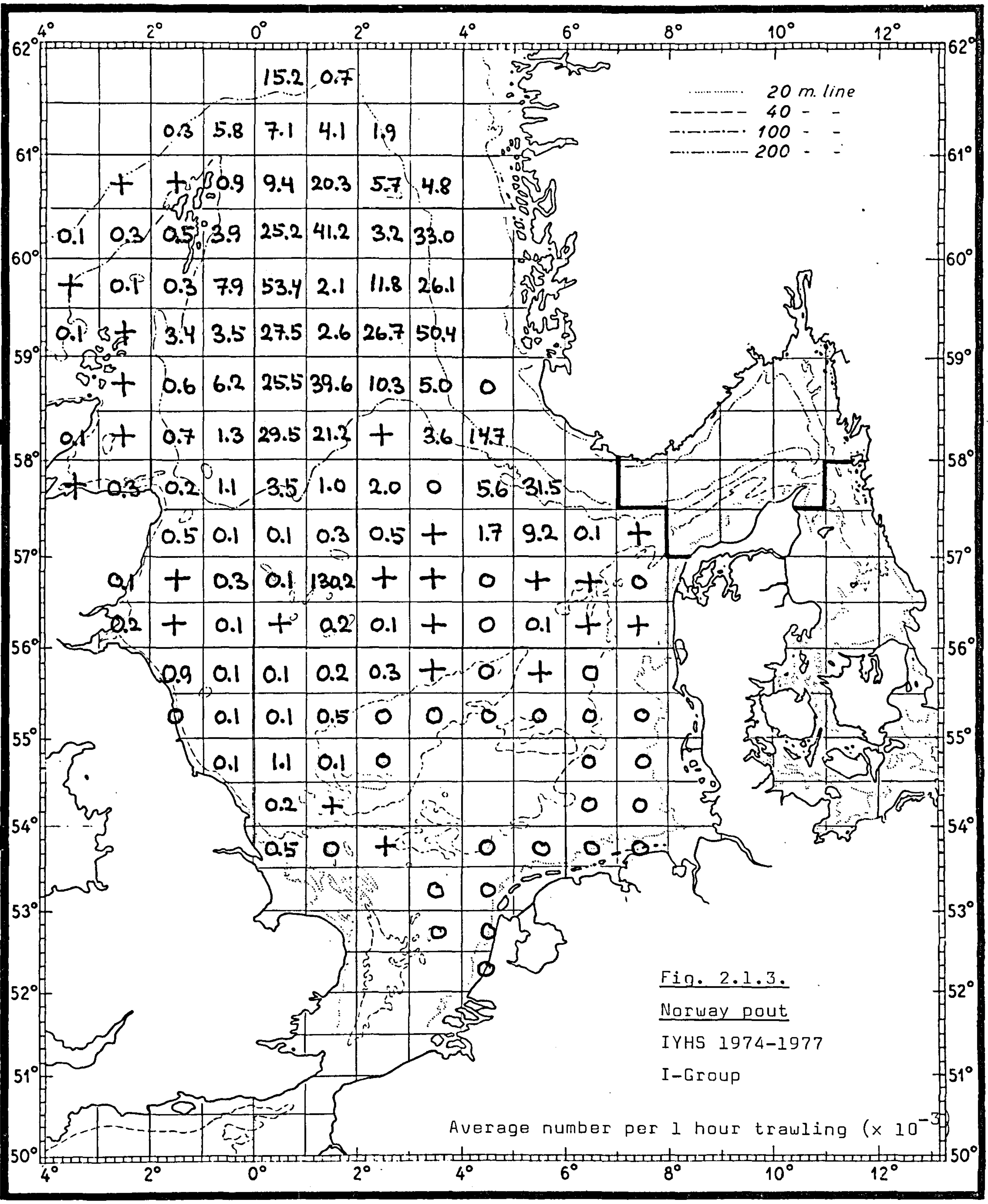
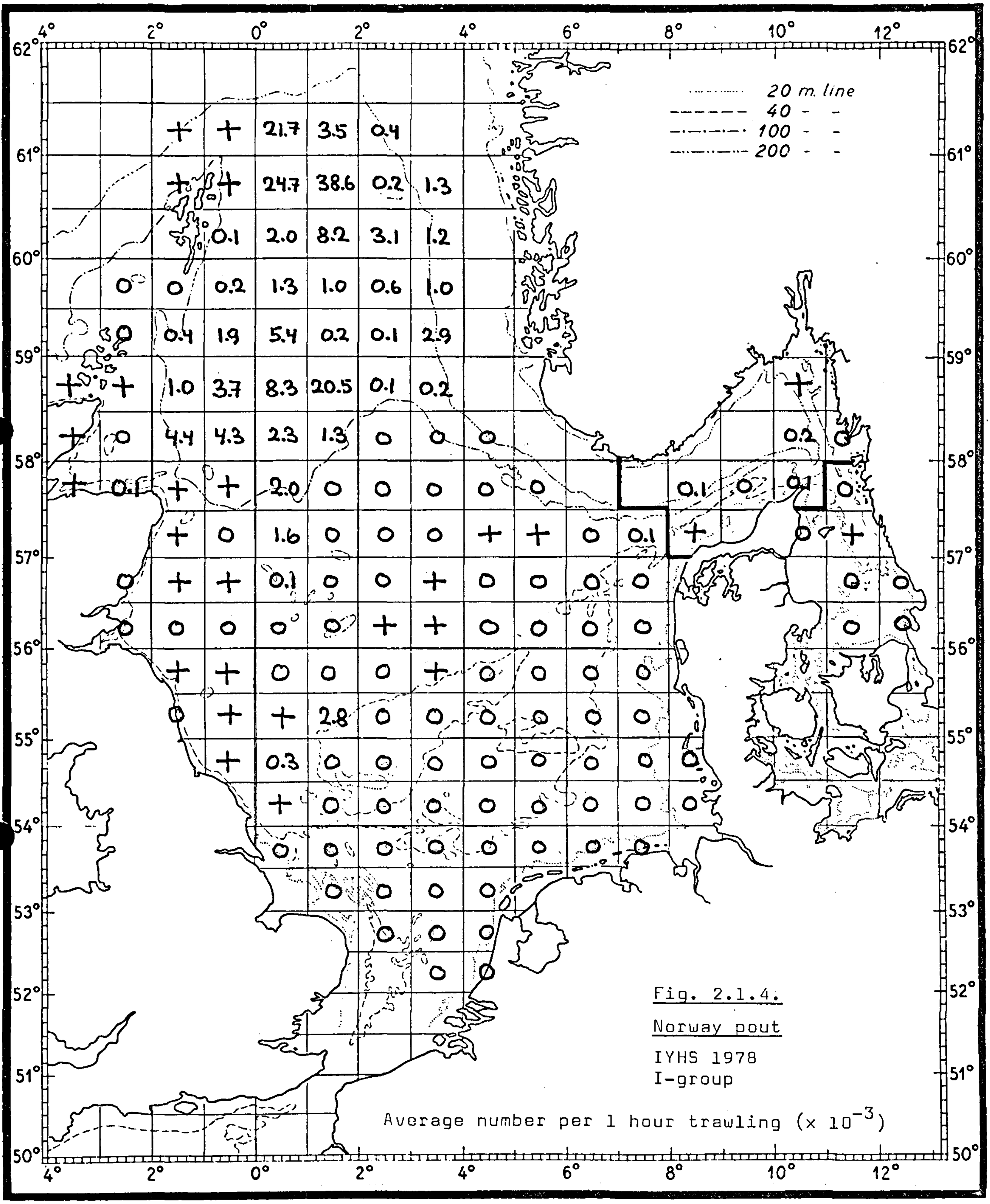


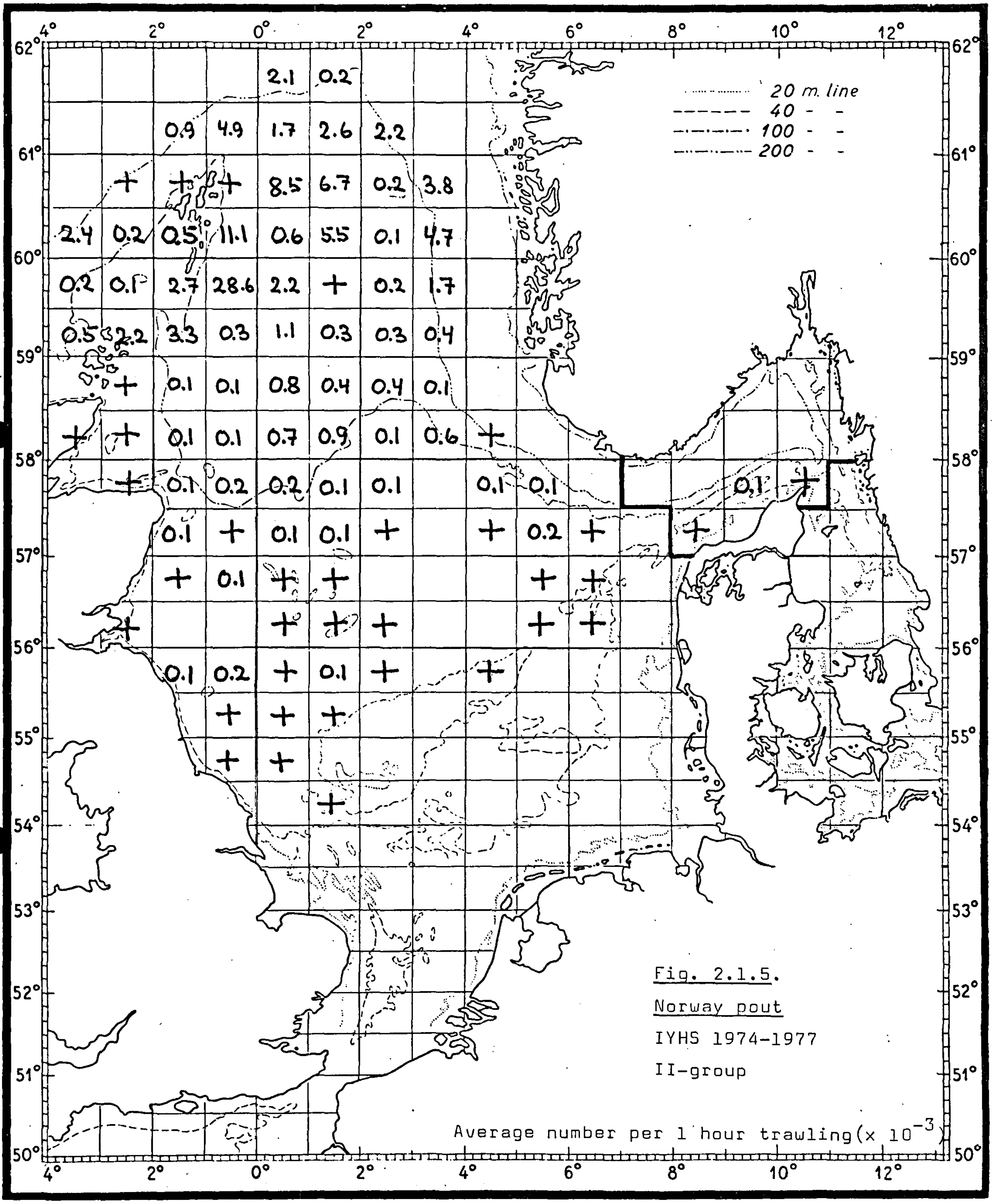
Fig. 2.1.3.

Norway pout

IYHS 1974-1977

I-Group


20 m. line
40 - -
100 - -
200 - -
Fig. 2.1.4.
Norway pout
IYHS 1978
I-group
Average number per 1 hour trawling (x 10⁻³)


20 m. line
40 - -
100 - -
200 - -
Fig. 2.1.5.
Norway pout
IYHS 1974-1977
II-group
Average number per 1 hour trawling (x 10^{-3})
4° 2° 0° 2° 4° 6° 8° 10° 12°
62° 61° 60° 59° 58° 57° 56° 55° 54° 53° 52° 51° 50°
2.1 0.2
0.9 4.9 1.7 2.6 2.2
+ + + 8.5 6.7 0.2 3.8
2.4 0.2 0.5 11.1 0.6 5.5 0.1 4.7
0.2 0.1 2.7 28.6 2.2 + 0.2 1.7
0.5 2.2 3.3 0.3 1.1 0.3 0.3 0.4
+ 0.1 0.1 0.8 0.4 0.4 0.1
+ + 0.1 0.1 0.7 0.9 0.1 0.6 +
+ 0.1 0.2 0.2 0.1 0.1 0.1 0.1 0.1 +
0.1 + 0.1 0.1 + + 0.2 + +
+ 0.1 + + + +
+ + + + + +
0.1 0.2 + 0.1 + +
+ + +
+ +
+

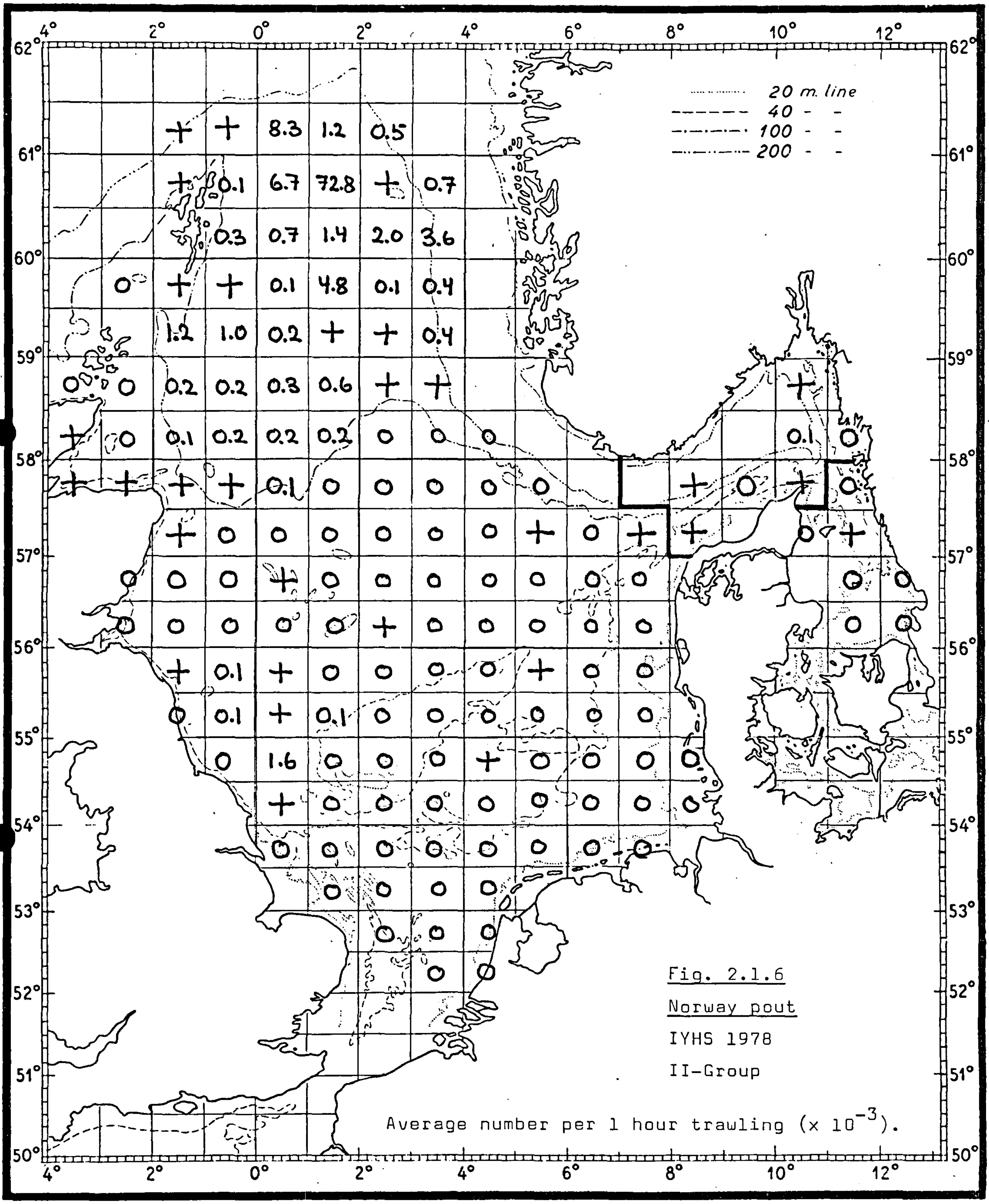


Fig. 2.1.6
Norway pout
IYHS 1978
II-Group

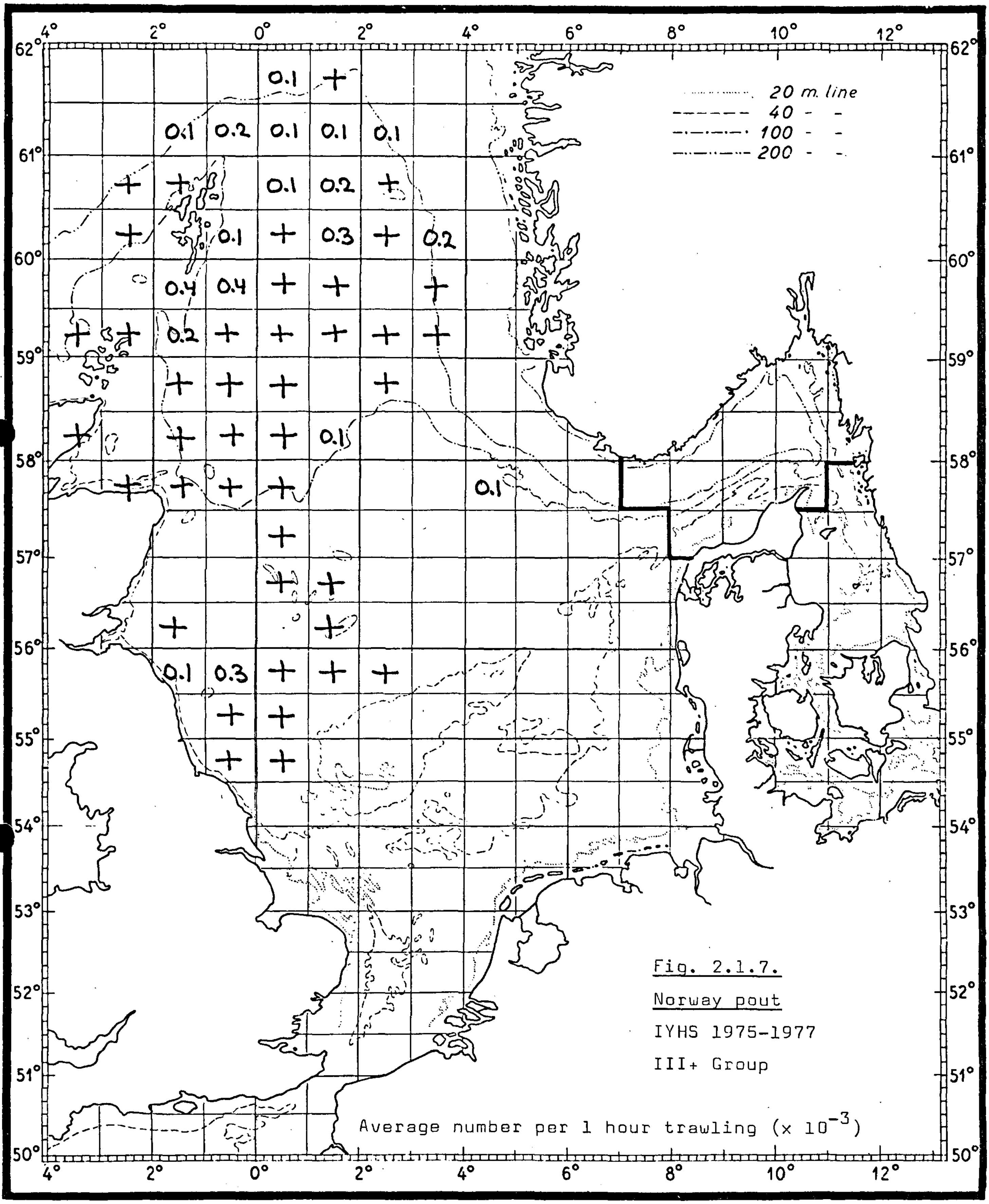


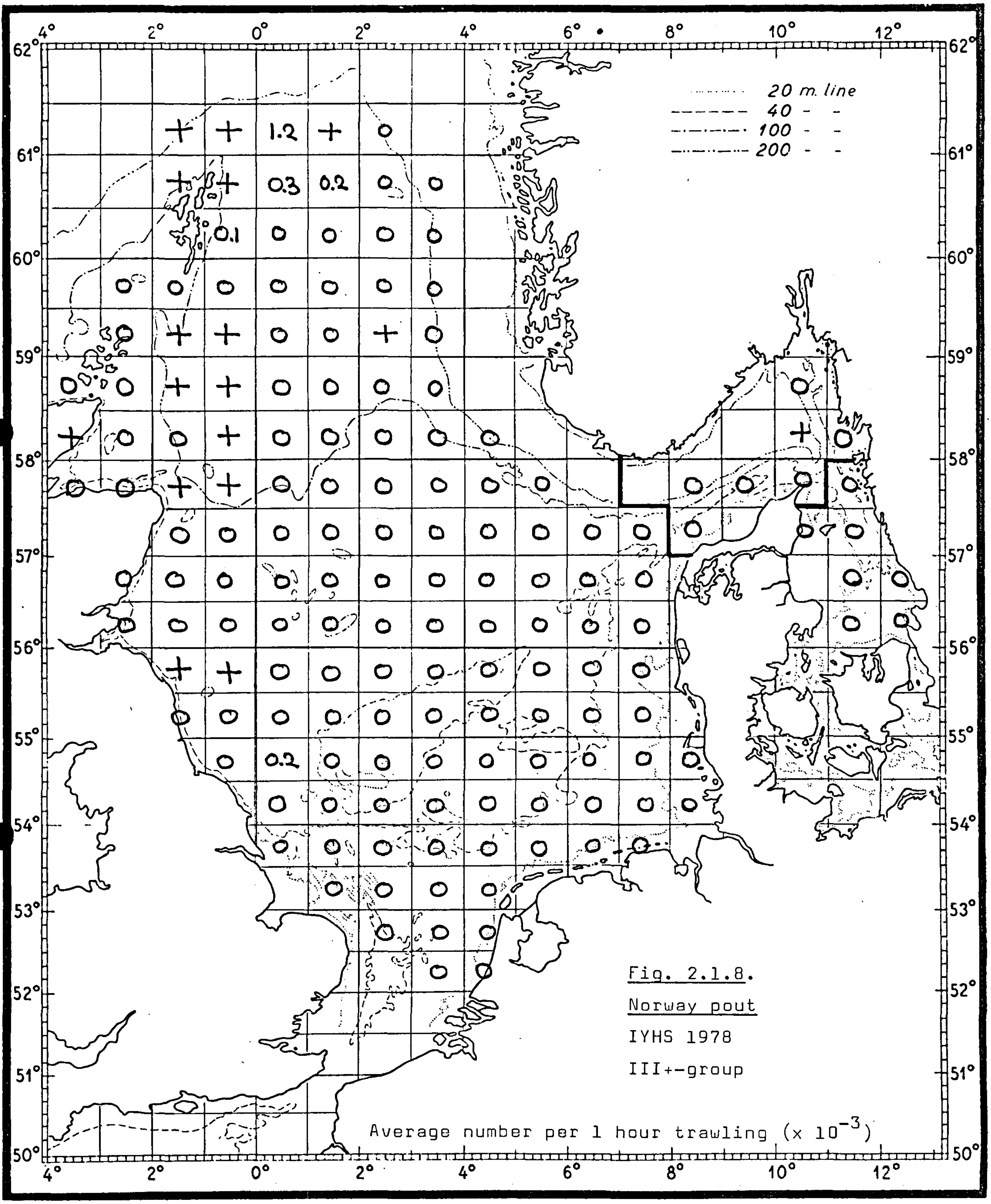
Fig. 2.1.7.

Norway pout

IYHS 1975-1977

III+ Group

Average number per 1 hour trawling (x 10^{-3})


20 m. line
40 - -
100 - -
200 - -
Fig. 2.1.8.
Norway pout
IYHS 1978
III+-group
Average number per 1 hour trawling (x 10^{-3})

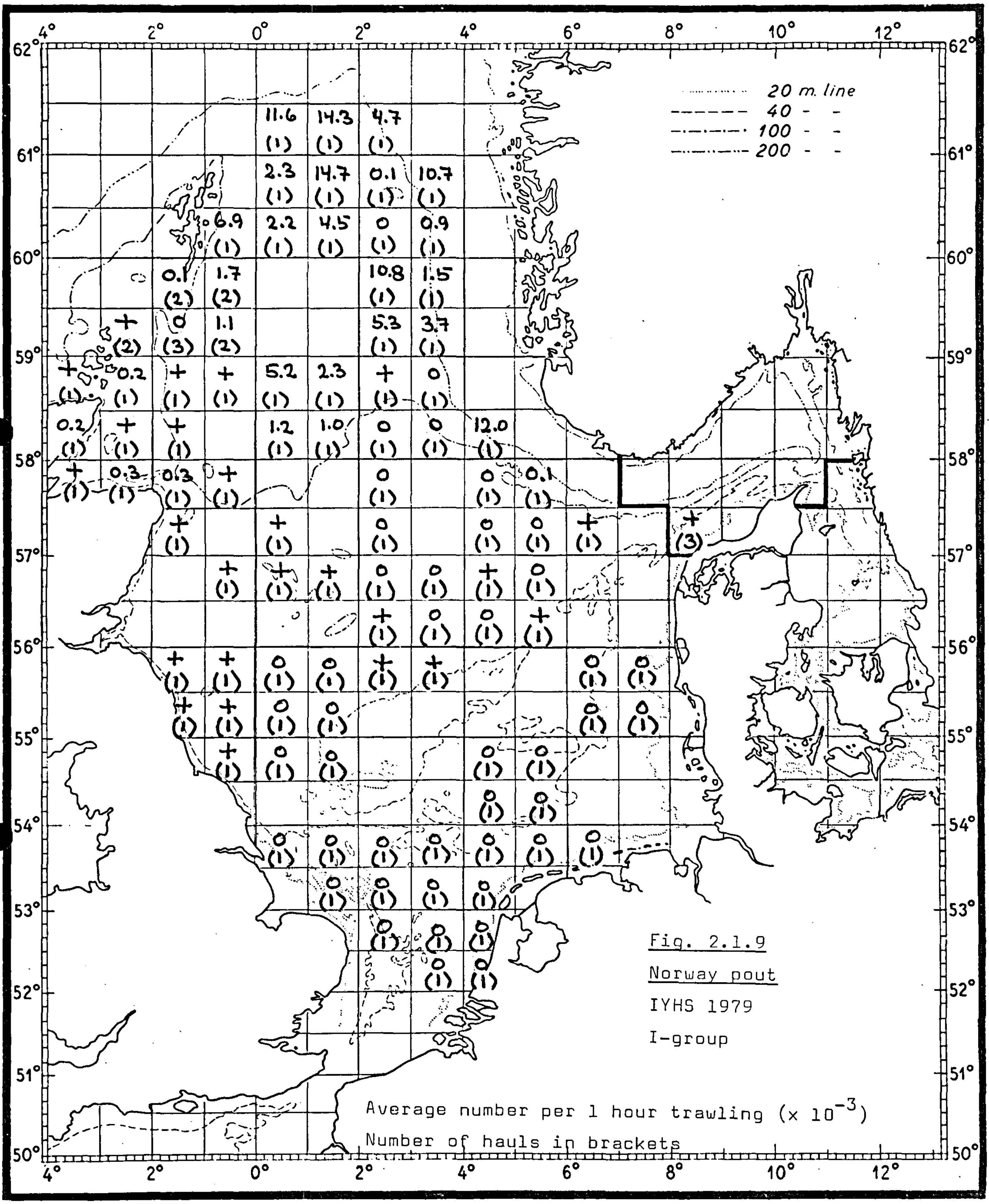


Fig. 2.1.9

Norway pout

IYHS 1979

I-group

Average number per 1 hour trawling ($\times 10^{-3}$)

Number of hauls in brackets

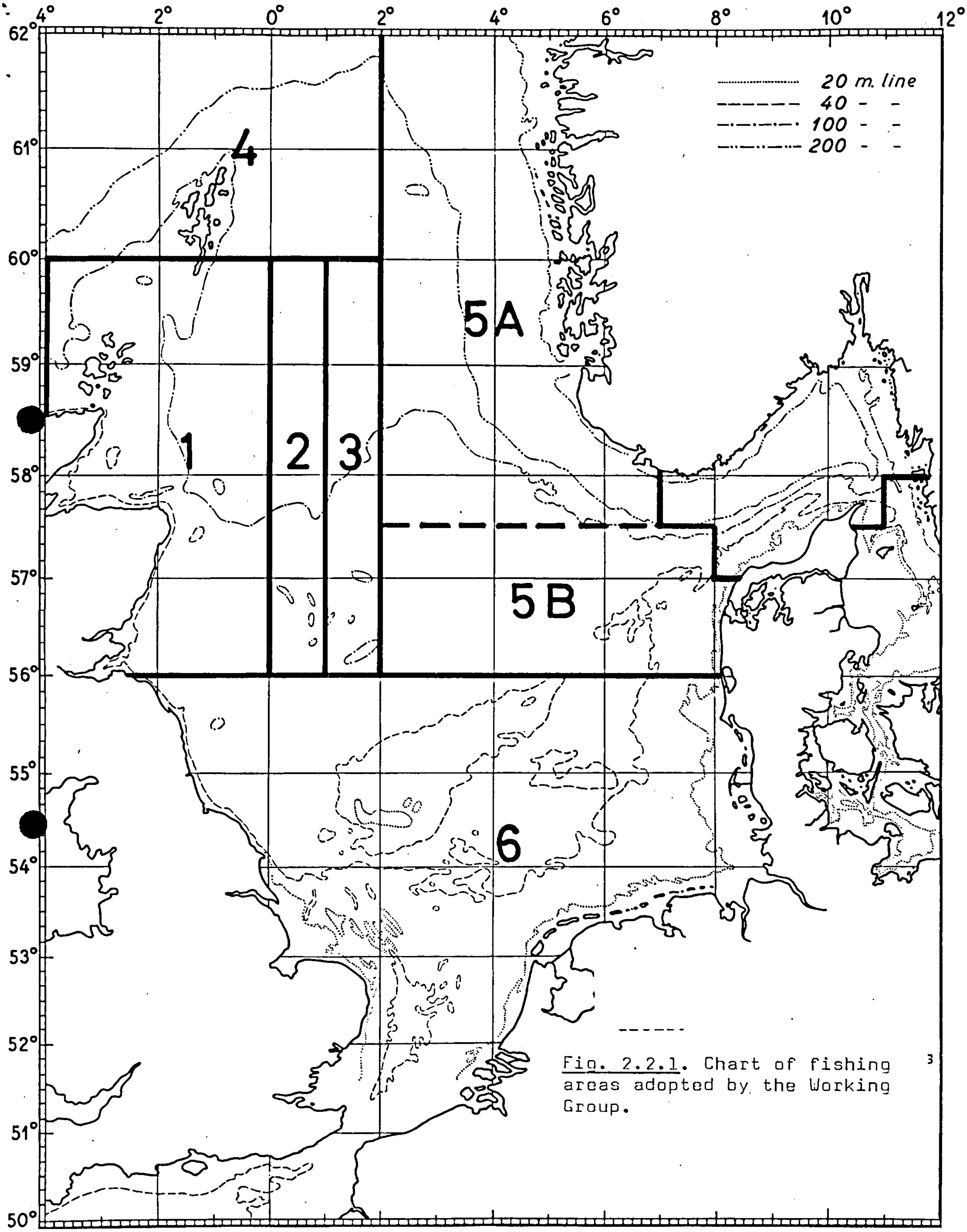
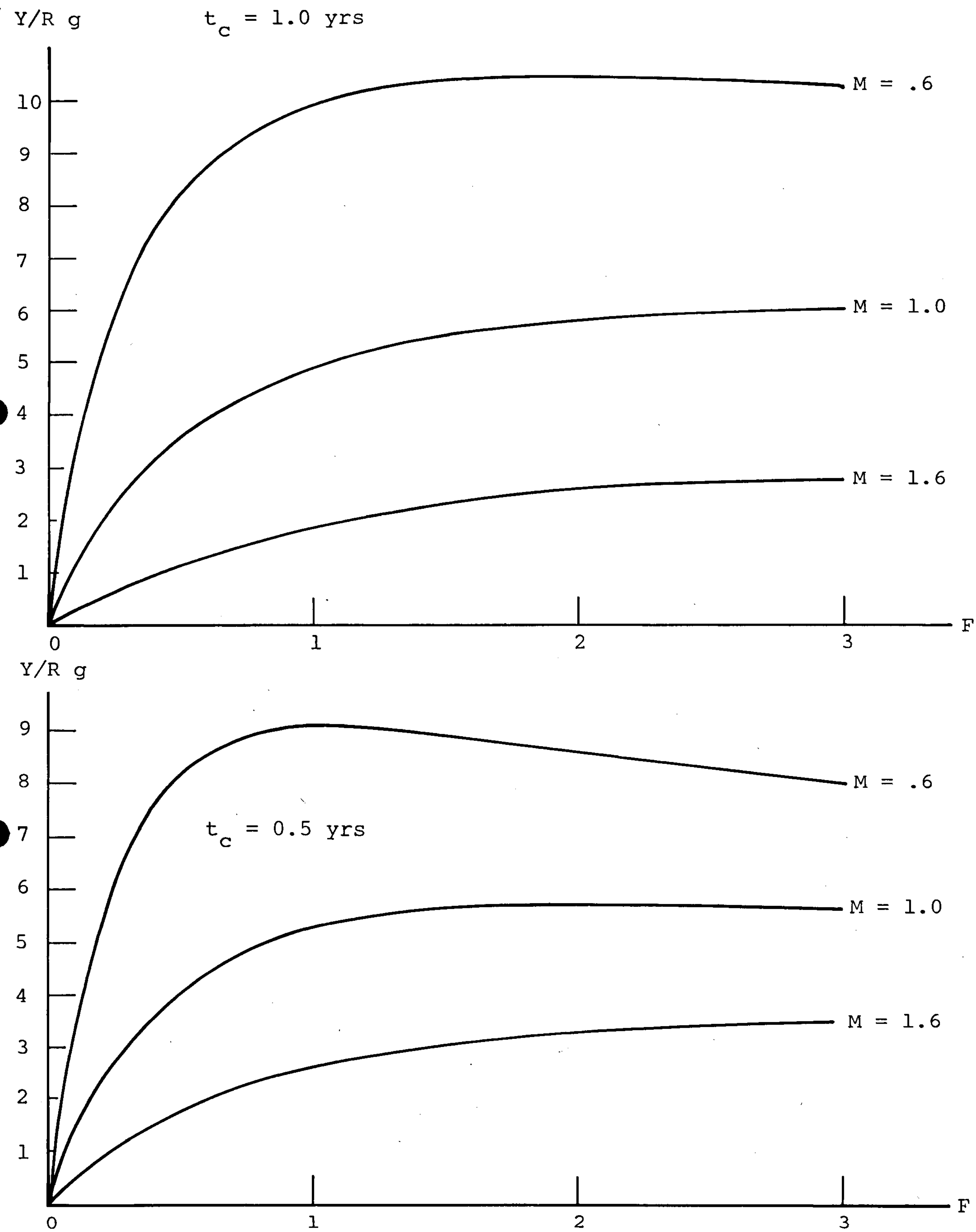


Fig. 2.2.1. Chart of fishing areas adopted by the Working Group.

Fig. 2.3.3.



Yield per recruit curves for Norway pout

W_∞ = 85 g, k = .55, t_o = -.6 yrs. (t_c = age at first capture)

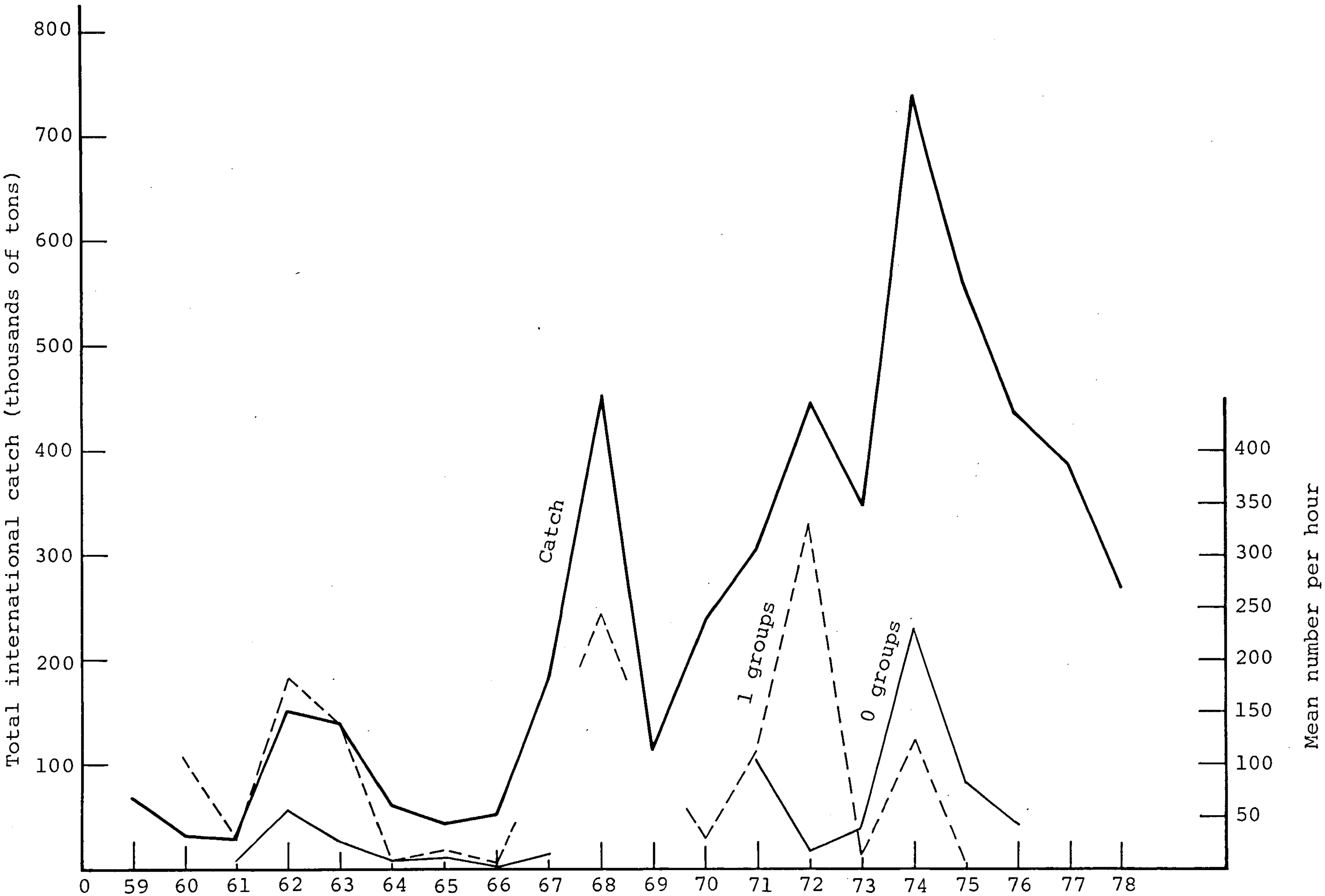


Fig. 2.6.1. Abundance indices of 0- and I-group. Norway pout from Scottish autumn surveys compared with the corresponding total commercial landings.

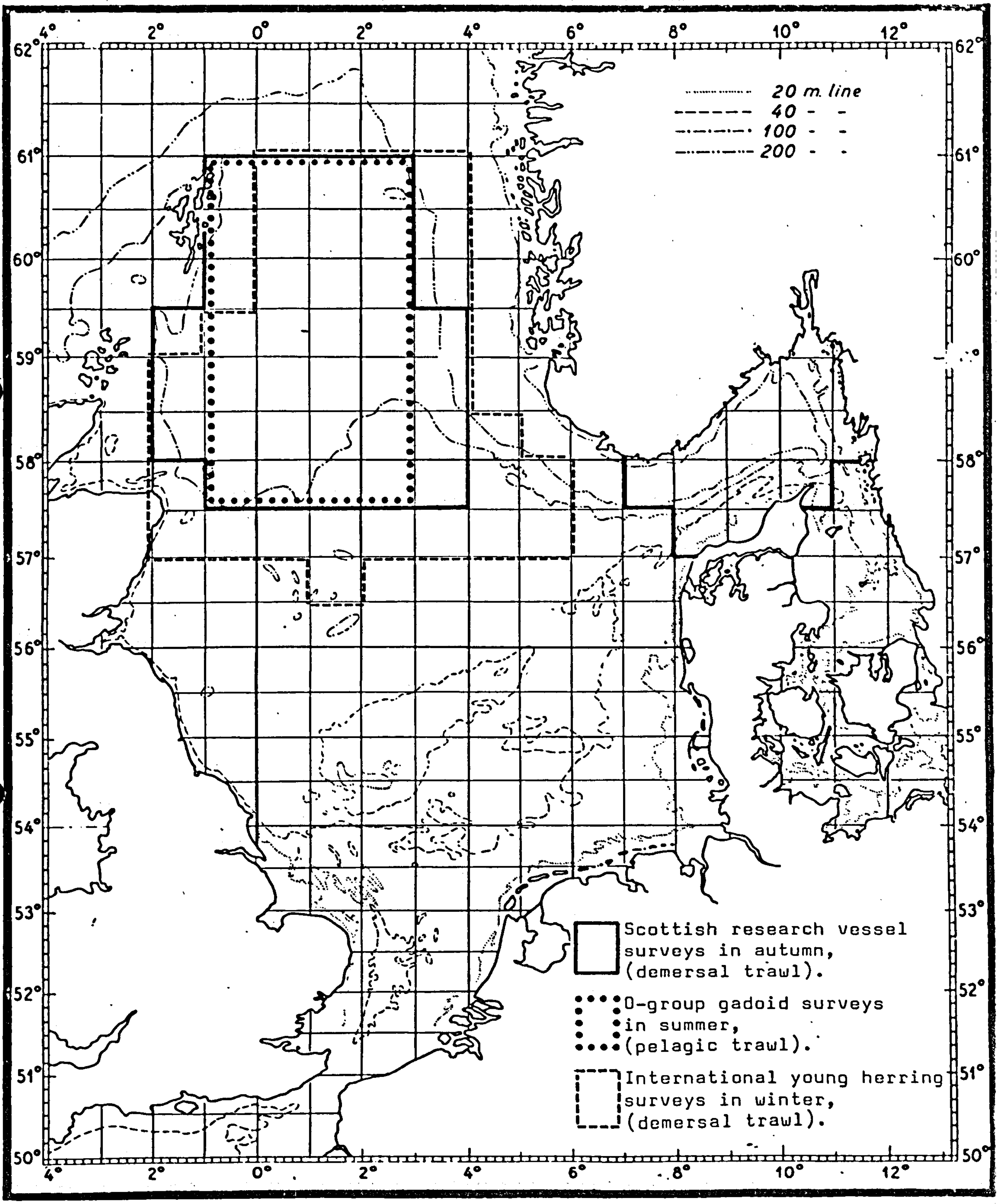


Fig. 2.6.2. Sampling areas used for recruitment indices of Norway pout, shown in Table 2.6.1.

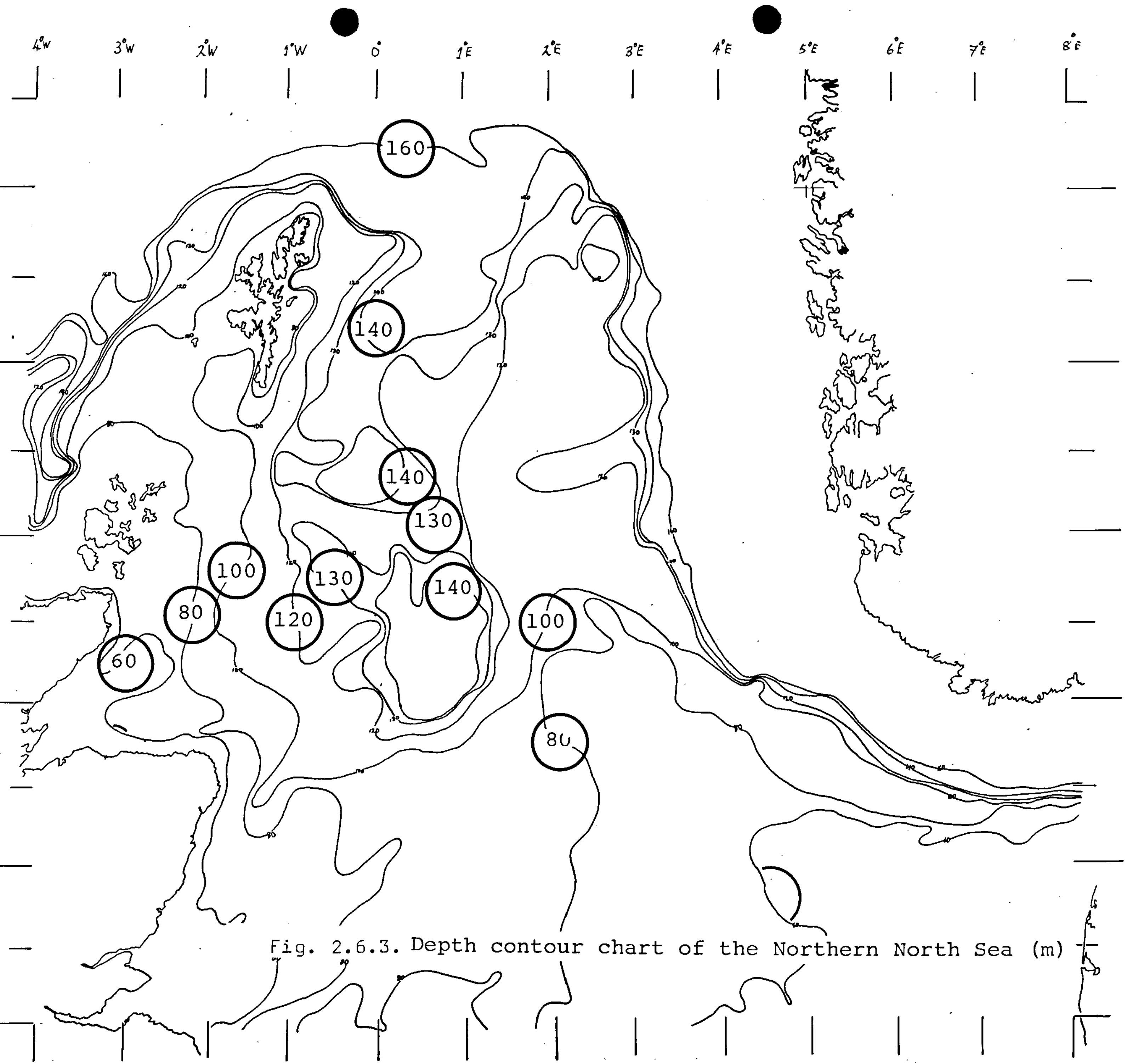
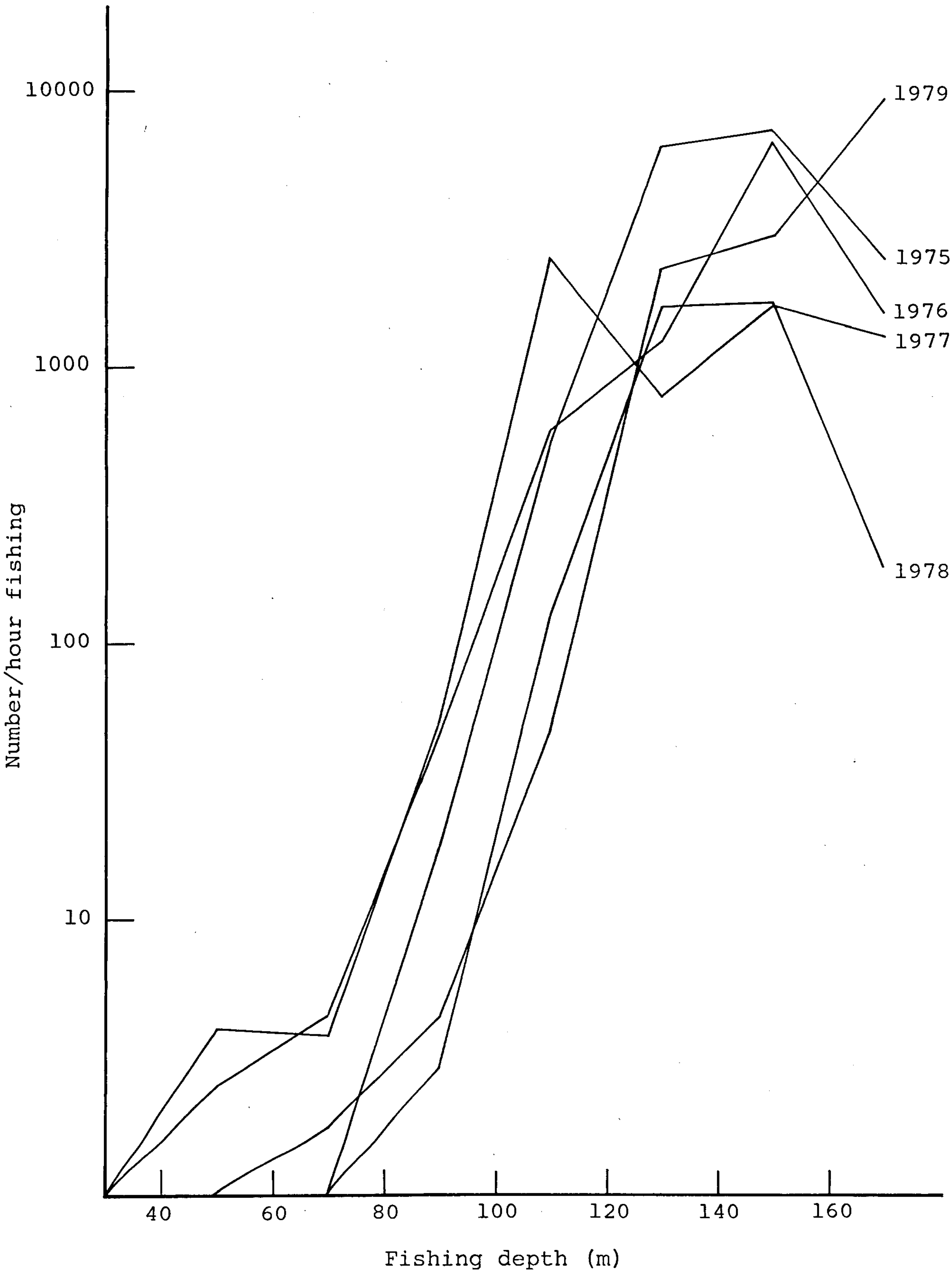


Fig. 2.6.3. Depth contour chart of the Northern North Sea (m)

Fig. 2.6.4. Depth distribution of 1-gr. Norway pout during IYHS 1975-78 (Catch in nos./haul)



3. Sand-eel

3.1. The Fish

3.1.1. General Biology

The lesser sandeel (Ammodytes marinus, Raitt) is by far the most abundant of the five or six species of northeast Atlantic sand-eels. Spawning of A. marinus takes place in late December in the North Sea and perhaps somewhat later in the northern part. The eggs are often buried in the sand by displacement of the bottom material and hatching seems to take place when the eggs are incidentally freed from the substratum by further action of water movements. Despite a rather short breeding season hatching may thus take place over a quite extended period of time and as late as April-May pelagic sandeel larvae in all stages are caught in plankton hauls.

The occurence of the small fry is associated with the distribution of the adult sandeel. As data on the distribution of the demersal eggs are insufficient for any assessment to be made, it might tentatively be concluded that spawning occurs in all parts of the distribution areas of the adult sandeel and is not confined to special spawning grounds, i.e. localities on which the mature fish assemble as the result of an active spawning migration.

3.1.2. Immature distribution

Older larvae are dispersed over the main part of the central and southern North Sea. At about 5 cm of length the young sandeel assumes the demersal habit of the adult and occurs in the same habitats from late summer and onwards.

3.1.3. Adult distribution

The sandeel is common on clean, coarse sand within the loo m depth contour. Dense concentrations often occur in association with relatively high current velocities, e.g. over bank ridges and along edges of shallower ground. Owing to the sandeel's affinity to sandy bottom its distribution is markedly discontenous (See for example Fig. 16 in Coop. Res.Rep. no. 46).

In the southern North Sea A. marinus is most abundant at depths of 20-40 meters. Major concentrations are found on the banks of East Anglia, on the western part of the Dogger Bank, Borkum Riff, Sylt Grounds, Horns Reef and the Jutland Reef. Since 1969 the commercial fisheries have exploited additional areas in deeper waters like Inner Shoal, Ling Bank and the western edge of the Norwegian Deep to Viking Bank. It is not clear whether this recent development is due to an expanded area of distribution of the North Sea sandeel or to a considerable increase in the overall size of the stock.

3.1.4. Migrations

Tagging experiments indicate that the adult sandeel undertake little seasonal migration, at least in the southern North Sea. In the post-larval stages the young sandeel is assumedly capable of active movements towards areas of suitable substratum but there is no evidence of special nursery areas from which an emigration of adolescent sandeel takes place.

3.2. The Fishery

3.2.1. Landings

A table of annual landings by countries from 1952-1978 was prepared for the North Sea (Table 3.1.1). In the years 1952 - 70 the landings were all less than 200 000 tons. In the years after 1970 the landings have increased markedly to a level of 350 000 tons in 1971-73 and 480 000 tons in the years 1974-76. In 1977 and 1978 the landings have increased further to 786 000 tons in 1977 and 787 000 tons in 1978. The distribution of the landings by countries did not change significantly in 1978 compared with 1977.

The monthly breakdown by countries (Table 3.1.2) shows a marked seasonality in landings. The fishery is concentrated in the months April-August with a maximum of 246 000 tons in June 1978. In 1978 the fishery was more concentrated with 90 % of the annual landings in the above-mentioned period, compared with 80 % of the annual landings in 1977.

3.2.2. Distribution of the Catch in 1978

The distribution of the catches by areas 1, 1A, 2, 2A, 3, 4, 5, 6 and Shetland (Fig.3.2.1) in each month made by Denmark, Norway and the United Kingdom is shown in Table 3.2.1. The area of fishing has been changed markedly in 1978 compared with 1977. With the northern area defined as areas 1, 2, and 3 and the southern areas as 1A, 2A, 4, 5 and 6, - 4% of the total landings in 1977 were taken in the Shetland area, 46 % in the northern area, and 50 % in the southern area. In 1978 the landings from the Shetland area are unchanged with 4 % of the total landings. The landings in the northern area in 1978 decreased to 21 % of the total, and the landings from the southern area increased accordingly to 75 % of the total landings in 1978. The main reason for this change in fishing areas is the very high landings from Dogger Bank in April, May and June, together with relatively low landings from Ling Bank in the period June-September (Table 3.2.1.).

The main fishing area for sandeel in 1978 was the Dogger Bank with 66 % of all the landings. Other landings were taken on Ling Bank and Viking Bank and to a smaller extent in the approaches to the Skagerrak and from the area southwest of the Dogger Bank.

In the Shetland area the fishery is extended over a longer season than in the rest of the North Sea, but still without landings of sandeel in November-February.

3.2.3. Distribution of the effort

A table of the fishing effort and the catch per unit effort in the northern and the southern area in the years 1970-78 (Table 3.2.3.) shows an increasing catch in the period. The table is based on Danish effort data and from these a total effort is derived from the total catch. The effort in 1978 is at a level of 261 000 hours of fishing in the southern area and 138 000 hours of fishing in the northern area, which is a re-allocation in fishing effort compared with 1977, where the effort in the southern and northern area was 155 000 hours and 197 000 hours respectively. A possible reason for this change in effort is that the c.p.u.e. in the northern area is 1390 (tons/1000 hours fishing), which is the lowest level in the years 1970-78. For the southern area the c.p.u.e. is 2210 in 1978 compared with c.p.u.e. of 2538 in 1977.

3.3. Growth

3.3.1. Length at age

Length and weight at age were calculated for each month from Danish and Scottish data for three separate areas: 1A, 2A, 4, 5 and 6, offshore grounds in area 1, 2 and 3 and the Shetland area (see Fig. 3.2.1). The results are tabulated in tables 3.3.1-3.3.5).

The salient features are the marked difference in length at age in the three areas, and the marked seasonal fluctuations. Length at age was much higher in the northern North Sea than in the south and that in the Shetland landings was even lower.

In both the southern and northern North Sea, there was a progressive increase in mean length at age during the spring and summer. The following spring, however, the mean lengths of the same year-class show a decrease. This change is difficult to explain, but probably indicates a change in the component of the population fished at different times of the year in each area. By contrast in the Shetland area, the mean length at age decreases even during the fishing season. Whatever the explanation, it is clear that the sandeels living in offshore areas of the northern North Sea grow very much more rapidly than those in the southern North Sea and than those around the Shetlands.

3.3.2. Weight at age.

Weight at age data submitted by Denmark and Scotland show the area and seasonal differences even more markedly than does length at age. The seasonal differences are dependent both on the unexplained differences in length at age and on superimposed changes in condition factor. There is, as a result, an approximate doubling in weight at age between the spring and autumn. This applies to both the southern and northern North Sea although the annual mean weights at age in the two areas are very different. In the Shetland fishery the pattern is less clear.

As a result of the analysis of the growth data described above, it appeared unwise to calculate average growth parameters for the whole of the North Sea. For this reason assessments of yield per recruit were carried out separately for the three areas. Mean weights at age of fish caught in the fishery during the year calculated by weighting each monthly mean in the years 1976-77 and 1978 by the number caught, are given for each main area in Table 3.3.6.

3.3.3. Growth parameters.

From the mean weight at age von Bertalanffy parameters were estimated for all three areas (Table 3.3.7).

The values of W_∞ also clearly indicate that the sandeel achieve a larger size in the northern area than in the southern area. The data do not indicate a different growth coefficient (K-value) in the two areas.

3.3.4. Yield per recruit

From the average figures for W_∞ and K yield per recruit curves were constructed. For values of M between 0.5 and 1.0 the curves are flat topped and reach a maximum at high value of Z. Yield is greater in the northern North Sea than in the south.

3.4. Age Distribution

3.4.1. Catch at age

Catch at age data were constructed for the northern and southern regions as follows. Age distributions for Areas 1, 2 and 3 in Fig. 3.2.1 were available by month from 1970 for Denmark, and from 1974 for Scotland. For the years 1970 and 1971, the area split of catches were not available and consequently no catch at age data were constructed for these two years. For the years 1972-73, Danish age distributions for Areas 1, 2 and 3 were summed for each month. Where one or two areas had not been sampled in a month, the age distribution of the other area(s) was used to give the total Danish catch for all areas. This was then grossed to the total international catch in Areas 1, 2 and 3. Where no samples were available in a month, the distribution for an adjacent month was used and raised to the international catch total. In the years 1974 to 1978, the procedure was similar, except that Scottish catches were first removed from the total international catches and worked up separately. Thus, the final figures are the Scottish age distribution plus the other international catch in the area based on Danish samples.

Table 3.4.1 shows the catch at age by month and year for all ages for the northern region (incl. Shetland).

The same procedure was adopted in constructing catch at age data for the southern areas 1A, 2A, 4, 5 and 6. In the southern region, only Danish catch at age by month distributions were available and these were raised to total international catch using the ratio of the annual total international catch to the annual Danish catch.

Table 3.4.2 shows the catch at age by month and year for the southern region.

Shetland data were analysed twice, first as part of the northern region and then separately. Table 3.5.9 shows the catch at age from 1974 to 1978 for the Shetland area.

3.5. Mortality

3.5.1. Total mortality estimated from tagging data

Danish tagging experiments were conducted in the southern North Sea (all areas except 1 and 2) in 1958, 1959 and 1963. Calculated values of Z ranged from 0.67 to 1.01.

3.5.2. Estimates from catch curves

Age group frequencies obtained from southern fish over the same period supported the above conclusions, indicating a mean mortality rate of 1.07 (Macer, 1966). Further agreement within the southern area was provided by an analysis of the age composition of the Danish commercial sandeel landings in 1974-1976, from which a mean Z of 0.92 was derived. By the mid-1970's, the northern North Sea was also being fished for sandeel, and here total mortality appeared to be higher than in the south (Z = 1.11-1.35; mean 1.20). No estimates of sandeel mortality are available for the northern area during the period before catches reached their peak level in 1974.

3.5.3. Estimates from catch per unit effort data

Macer (1966) examined catch per effort data for individual cohorts of sandeel sampled on the Dogger Bank in successive years in the early 1960's. He quoted a mean Z of 1.39, with a range of 1.02-2.01. Estimates are also available from the English sampling of British commercial landings from area 4 during 1970-1974: these yielded a mean of 1.05 and a range of 0.88-1.83.

An analysis has been performed on Danish commercial catch and effort data over the same period (1970-1975). Overall means for Z for the northern and southern North Sea were obtained from individual comparisons of the mean numbers of sandeel of various year classes taken per hour during the same month in successive years. Negative Z values from ages 0 to 1 were almost certainly caused by incomplete recruitment during the first year of life. Calculated mean mortality rates with standard errors, for the northern and southern areas were respectively 1.01 ± 0.23 and 0.53 ± 0.37. A similarly-derived figure for the Shetland stock over the period of fishing activity (1975-1978) was Z = 1.39 (range 1.17 - 1.81). In summary, there is evidence that mortality within the sandeel stocks increases from the southern North Sea ($Z = 0.97$, mean of means) towards the northern region ($Z = 1.11$) and the Shetland area ($Z = 1.39$).

3.5.4. Natural Mortality

Few data are available concerning the mortality of totally unexploited sandeel stocks in the North-East Atlantic. Following Scottish exploratory surveys in the Moray Firth (Smith Bank) during the period 1968-1971, a combined catch curve was used to derive an estimate of Z of 1.07. Since the stock has never been subjected to fishing pressure, it may be postulated that this figure also represents the rate of natural mortality, M. However, if this assumption is made then either of the following are logical consequences:

a) fishing mortality is still a small fraction of total mortality in the North Sea and the sandeel stocks are very large partly because an (complete unknown) proportion of the population is living outside the restricted fishing localities, or
b) differences exist between the northern and southern North Sea with respect to natural mortality.

In this connection, it is thought that predation by haddock on sandeels might be significantly more intense in the north (Ritchie, 1932, Jones, 1976). Irrespective of the extent of fishing activity, the maximum age of A. marinus appears to be about 10 years, so that assuming that sandeels with one winter ring are fully recruited to the adult stock and the nine-ringers constitute 1 % of the population by number, then a minimum estimate of the average instantaneous mortality rate becomes 0.5. A more theoretical indication comes from the incorporation of mean monthly growth parameter values from 1974 - 1977 into the A_{95} equation of Taylor (1959). This gives mean values of M in the northerly area of 0.57 and 0.90, based on length and weight data respectively, while corresponding values for the southern area are 0.61 and 0.71. For the purposes of VPA, two different mortality rates ($M = 0.5$ and 1.0) were assumed for the northern stock, but only one ($M = 0.5$) for the southern stock.

3.5.5. Mortality estimates from V.P.A.

V.P.A.s were carried out for the Shetland area and for the northern and southern North Sea respectively using the input data given in Tables 3.5.1, 3.5.6 and 3.5.9.

In case of both the Shetland area and the offshore northern North Sea V.P.A. runs were made with M of 0.5 and 1.0 for reasons described in the previous section. For the southern North Sea only one run was made, assuming M = 0.5. The results in terms of calculated stock in numbers and calculated fishing mortalities are shown in tables 3.5.2-3.5.5., 3.5.7-3.5.8 and 3.5.10-3.5.13.

Comparing the calculated fishing mortalities with the derived effort figures shown in table 3.2.3 indicates a clear relationship (see also Fig. 3.5.1). The correlation is highest in case of the southern North Sea and least for the Shetland area, where the period of observations also is the shortest.

3.6. Management

V.P.A. runs carried out for the years 1972-78 indicate a fair agreement between derived effort and calculated fishing mortalities both for the northern and the southern North Sea. In the case of the Shetland sandeel, which probably should be regarded as a separat management unit, the data base covers too short a period for a VPA to furnish useful indications of the historic development in this stock. From the data available the Working Group concluded that until 1977 the sandeel stocks in the North Sea show no sign of overexploitation.

There is no effective method of assessing the present situation. Despite an appriciable increase in effort in the southern North Sea in 1978 the total mortality as assumed by the Working Group do not exceed the F_{max} on the corresponding yield curve.

Catch data indicate that two very strong yearclasses (1977 and 1978) have entered the fishery. It is, however, uncertain to which degree of accuracy the commercial fishery data allows an estimate of recruiting yearclasses. As the Working Group could not envisage any other means by which such an estimate may be obtained, it concluded, that even short term advice on management is without any firm basis at present.

Table 3.1.1. Landings of Sandeel from the North Sea 1952 - 1978, in thousand tons

Year	Denmark	F.R.G.	Faroes	Nether-lands	Norway	Sweden	U.K.	Total
1952	1.6	0	0	0	–	0	0	1.6
1953	4.5	+	0	0	–	0	0	4.5
1954	10.8	+	0	0	–	0	0	10.8
1955	37.6	+	0	0	–	0	0	37.6
1956	81.9	5.3	0	+	1.5	0	0	88.7
1957	73.3	25.5	0	3.7	3.2	0	0	105.7
1958	74.4	20.2	0	1.5	4.8	0	0	100.9
1959	77.1	17.4	0	5.1	8.0	0	0	107.6
1960	100.8	7.7	0	+	12.1	0	0	120.6
1961	73.6	4.5	0	+	5.1	0	0	83.2
1962	97.4	1.4	0	0	10.5	0	0	109.3
1963	134.4	16.4	0	0	11.5	0	0	162.3
1964	104.7	12.9	0	0	10.4	0	0	128.0
1965	123.6	2.1	0	0	4.9	0	0	130.6
1966	138.5	4.4	0	0	0.2	0	0	143.1
1967	187.4	0.3	0	0	1.0	0	0	188.7
1968	193.6	+	0	0	0.1	0	0	193.7
1969	112.8	+	0	0	0	0	0.5	113.3
1970	187.8	+	0	0	+	0	3.6	191.4
1971	371.6	0.1	0	0	2.1	0	8.3	382.1
1972	329.0	+	0	0	18.6	8.8	2.1	358.5
1973	273.0	0	1.4	0	17.2	1.1	4.2	296.9
1974	424.1	0	6.4	0	78.6	0.2	15.5	524.8
1975	355.6	0	4.9	0	54.0	0.1	13.6	428.2
1976	424.7	0	–	0	44.2	–	18.7	487.6
1977	664.3	0	11.4	0	78.7	5.7	25.5	785.6
1978	647.5	–	12.1	–	93.5	1.2	32.5	786.8

+ = less than half unit

– = no information

Table 3.1.2. Sandeel. Monthly breakdown of catches (in tons) by countries

1977	Denmark	Faroes	Norway	Eng.&Wales	Scotland	Total
January	8	-	32	-	-	4o
February	698	430	334	-	-	1462
March	28032	125	1072	-	890	30119
April	55648	50	2145	364	2997	61204
May	200930	4812	30449	1296	2946	240433
June	188826	2553	30226	1396	4950	227951
July	29763	3422	2974	602	4899	41660
August	23961	-	700	-	3062	27723
September	82758	-	6687	-	1602	91047
October	49779	-	4018	-	524	54321
November	1926	-	-	-	-	1926
December	-	-	-	-	-	-
Total	662329	11392	78637	3658	21870	777886

1978	Denmark	Faroes	Norway	Eng./Wales	Scotland	Total
January	0		0			0
February	1		34			35
March	15926	154	60		179	16319
April	110485	3165	2474	600	2496	119220
May	136085	4958	31128	1426	6130	179727
June	202772	2973	32681	2182	4924	245532
July	67881	562	10483	258	3889	83073
August	71389	327	4857		4922	81495
September	19532		2626		4272	26630
October	14951		8112		1245	24308
November	3147		831			3978
December			0			0
Total	642169	12139	93486	4466	28057	780317

Table 3.2.1. Sandeel 1978
Catch (tons) by Month and Area (DK, N, UK).

Area	1	2	3	1a	2a	4	5	6	SH	Total
Jan.	-	0	0	-	0	0	0	0	0	0
Febr.	34	0	0	1	0	0	0	0	0	35
Mar.	60	1626	13	177	14110	0	0	0	179	16165
Apr.	31	1183	1194	21905	73528	15308	0	409	2496	116054
May	24071	10546	14742	27278	81322	2914	5768	1926	6131	174698
June	10033	32051	14117	109683	38255	10421	642	22506	4924	242632
July	2350	14810	460	0	51432	8719	0	851	3889	82511
Aug.	905	7664	3339	341	62522	0	0	1475	4921	81167
Sept.	2839	1378	4963	15	13163	0	0	0	4272	26630
Oct.	9046	1031	534	258	12194	0	0	0	1245	24308
Nov.	789	42	3147	0	0	0	0	0	0	3978
Dec.	0	0	0	0	0	0	0	0	0	0
Total	50158	70331	42509	159658	346526	37362	6410	27167	28057	768178

Table 3.2.3. Sandeel landings (x 10^{-3} tons), Danish c.p.u.e. data (tons per 1000 hours trawling) and derived effort (x 10^{-3} hours).

Year	Catch		C.p.u.e.		Derived Effort	
	N	S	N	S	N	S
1970	100.1	87.7	1 420	1 961	70.5	44.7
1971	201.5	170.1	2 065	1 676	97.6	101.5
1972	130.6	219.1	1 445	1 493	90.4	146.8
1973	107.6	182.6	1 864	1 205	57.7	152.4
1974	394.0	124.2	3 599	1 468	109.5	84.6
1975	266.6	153.1	2 246	1 656	118.7	92.5
1976	155.2	330.9	-	-	-	-
1977	385.0	393.0	1 955	2 538	196.9	154.8
1978x)	191.1	577.1	1 390	2 210	137.5	261.1

x) Only based on March-June (incl.).

Table 3.3.1. Sandeel. Northern area, 1978.
Mean length at age in cm, based on Danish samples (number of fish in brackets).

W.R.	0	1	2	3	4	5	6	7
Jan.								
Feb.								
Mar.		13.47 (300)	17.83 (6)					
Apr.		10.78 (364)	17.06 (8)					
May		12.34 (817)	18.17 (222)	19.99 (127)	24.02 (11)	26.08 (3)	26.25 (1)	
Jun.		12.32 (311)	18.96 (269)	22.64 (19)	24.25 (8)	24.75 (9)	25.75 (4)	
Jul.	7.64 (119)	15.51 (376)	20.10 (161)	23.35 (20)	26.25 (1)			
Aug.	10.41 (705)	16.50 (4)	21.83 (186)	23.67 (6)	23.75 (1)	25.50 (2)		
Sep.	10.32 (440)	16.03 (7)						
Oct.	11.28 (286)	16.25 (1)						
Nov.								
Dec.								

Table 3.3.2. Sandeel. Northern area, 1978.
Mean weight at age in grs. based on Danish samples
(number of fish in brackets).

W.R.	0	1	2	3	4	5	6	7
Jan.								
Feb.								
Mar.		5.45 (300)	13.01 (6)					
Apr.		3.15 (364)	12.04 (8)					
May		5.59 (817)	18.56 (222)	24.73 (127)	41.88 (11)	48.50 (3)	48.50 (1)	
Jun.		8.18 (311)	24.93 (269)	45.70 (19)	57.85 (8)	63.34 (9)	68.81 (4)	
Jul.	1.13 (119)	13.96 (376)	34.48 (161)	53.29 (20)	70.00 (1)			
Aug.	3.13 (705)	15.50 (4)	45.43 (186)	59.91 (6)	61.46 (1)	74.75 (2)		
Sep.	3.32 (440)	15.57 (7)						
Oct.	4.31 (286)	16.00 (1)						
Nov.								
Dec.								
Mean x) weight	3.07	6.98	22.86	32.18	53.28	59.01	63.73	

x) Mean value calculated by weighting each monthly mean by the number caught

Table 3.3.3. Sandeel. Southern area, 1978.
Mean length of age in cm, based on Danish samples
(number of fish in brackets).

W.R.	0	1	2	3	4	5	6	7	8+
Jan.									
Feb.									
Mar.		10.94 (1203)	13.14 (33)	16.38 (4)					
Apr.		11.46 (2545)	13.86 (428)	17.33 (26)	21.38 (4)	21.50 (2)			
May		11.79 (1476)	14.32 (778)	17.18 (80)	17.73 (55)	18.88 (15)	18.88 (4)	17.92 (3)	18.42 (3)
Jun.	9.02 (62)	11.83 (1136)	15.33 (319)	17.39 (46)	17.87 (30)	17.00 (2)			
Jul.	9.77 (499)	11.36 (147)	15.38 (108)	16.32 (32)	16.65 (26)	17.25 (5)	16.25 (14)	18.75 (1)	15.25 (2)
Aug.	10.23 (2186)	11.07 (137)							
Sep.	11.70 (720)	15.33 (62)	18.75 (1)						
Oct.	12.52 (486)	15.60 (77)							
Nov.									
Déc.									

Table 3.3.4. Sandeel. Southern area, 1978.
Mean weight of age in gram, based on Danish samples (number of fish in brackets).

W.R.	0	1	2	3	4	5	6	7	8+
Jan.									
Feb.									
Mar.		3.19 (1203)	5.61 (33)	9.59 (4)					
Apr.		3.76 (2545)	6.92 (428)	13.75 (26)	27.55 (4)	27.67 (2)			
May		4.65 (1476)	8.51 (778)	14.71 (80)	15.80 (55	18.45 (15)	18.78 (4)	15.65 (3)	17.45 (3)
Jun.	1.66 (62)	4.86 (1136)	10.52 (319)	15.16 (46)	16.28 (30)	13.56 (2)			
Jul.	2.53 (495)	4.54 (147)	14.24 (108)	15.77 (32)	17.47 (26)	16.95 (5)	15.76 (14)	16.00 (1)	16.36 (2)
Aug.	3.20 (2186)	4.61 (137)							
Sep.	4.75 (720)	11.83 (62)	21.00 (1)						
Oct.	6.29 (486)	13.57 (77)							
Nov.									
Dec.									
Mean x) weight	3.05	4.42	8.79	14.81	16.71	18.00	17.35	15.77	17.41

x) Mean weight calculated by weighting each monthly mean by the number caught.

Table 3.3.5. Sandeel. Shetland Area. Mean Length at Age (1978)

Mean length (cm)

W.R.	0	1	2	3	4	5	6	7	8+
Jan.									
Feb.									
Mar.		8.45	9.45	10.58					
Apr.		9.16	11.01	14.09	16.00	15.23			
May	4.83	9.51	10.96	15.24	15.05	16.00	18.00	19.38	18.02
Jun.	7.38	10.73	12.23	14.76	15.84	16.94	18.25	18.75	18.75
Jul.	7.01	11.56	13.32	14.36	14.12				
Aug.	9.15	11.44	12.91	14.25	13.75	15.75			
Sep.	9.15	11.44	12.91	14.25	13.75	15.75			
Oct.	10.64	11.02	13.68	14.86	-	18.75			
Nov.									
Dec.									

Mean weight (gram)

W.R.	0	1	2	3	4	5	6	7	8+
Jan.									
Feb.									
Mar.		1.16	2.88	2.61					
Apr.		1.55	2.66	6.06	10.08	8.11			
May	0.25	1.56	2.66	8.85	11.00	14.97	13.97	15.87	
Jun.	1.14	3.56	5.59	11.10	14.07	17.77	25.10	24.50	22.10
Jul.	0.93	4.10	7.06	9.06	8.75				
Aug.	2.23	4.46	6.47	8.00	7.10	10.50			
Sep.	2.23	4.46	6.47	8.00	7.10	10.50			
Oct.	3.86	3.83	8.41	10.49		16.50			
Nov.									
Dec.									

Table 3.3.6. Sandeel. Mean weight in grammes.

Age	Northern area (subarea 1.2.3)		Southern area (subarea 1A, 2A,4,5,6)		Shetland	
	76-77	78	76-77	78	76-77	78
0	3.11	3.07	3.81	3.05	1.32	1.91
1	8.49	6.98	6.88	4.42	2.84	2.14
2	23.78	22.86	10.09	8.79	4.97	3.60
3	37.76	32.18	13.63	14.81	9.30	9.15
4	47.43	53.28	17.06	16.71	12.68	10.97
5	50.01	59.01	17.40	18.00	14.44	14.65
6	48.92	63.73	18.84	17.35	15.68	18.50
7	-	-	20.08	15.77	17.82	18.38

Table 3.3.7. Sandeel. Bertalanffy parameters calculated from Table 3.3.6.

Area	Year	W	K	t_0
Northern North Sea	1976-77	64.48	0.4127	-1.011
	1978	114.25	0.2555	-1.277
The Shetlands	1976-77	27.02	0.2396	-1.801
	1978	78.88	0.1030	-2.923
Southern North Sea	1976-77	22.96	0.3423	-2.296
	1978	20.00	0.4169	-1.668

Table 3.4.1. Catch in numbers (x 10^{-3}). Sandeels. Northern North Sea and the Shetlands. 1978.

Age	0	1	2	3	4	5	6	7	8+
Month									
1									
2									
3	-	119.5	66.1	31.6	2.0	0.9			
4	-	1 529.4	255.8	33.8	3.7	3.2			
5	2.5	6 546.5	1 504.8	456.9	53.3	19.1	6.6	0.2	0.8
6	96.1	2 337.0	1 530.6	120.8	40.3	41.5	16.6	0.6	0.6
7	2 104.8	1 105.8	280.6	76.2	4.8	-			
8	3 974.2	213.1	152.7	6.1	1.6	2.9			
9	3 992.4	240.2	38.5	2.2	1.0	1.5			
10	2 266.8	89.7	4.0	0.6		0.1			
11	911.6	3.2							
12									
Total	13 348.4	12 184.4	3 833.1	728.2	106.7	69.2	23.2	0.8	1.4

Table 3.4.2. Catch in numbers ($\times 10^{-3}$). Sandeels. Southern North Sea.

Age	0	1	2	3	4	5	6	7	8+
Month									
1									
2		0.5	0.1						
3	-	3 966.1	46.1	1.9					
4		20 624.5	5 460.5	322.9	48.1	14.9			
5		12 262.9	6 261.7	592.2	369.9	59.2	20.4	13.3	25.4
6	922.4	21 985.1	5 179.9	876.2	588.0	40.3	1.0	0.3	0.3
7	19 202.3	1 191.5	340.4	113.7	87.6	25.7	17.5	6.5	0.8
8	18 271.4	1 152.7	41.5	10.8	9.2	0.7	8.5	0	1.4
9	2 274.8	195.8	3.2						
10	1 475.6	233.8							
11									
12									
Total	42 146.5	61 612.9	17 333.4	1 917.7	1 102.8	140.8	47.4	20.1	27.9

Table 3.5.1. Sandeel Northern North Sea. Input catch data. V.P.A. Numbers at age in millions.

AGE	1972	1973	1974	1975	1976	1977	1978
0	4929	337	11404	9326	10946	12861	13348
1	4244	4200	21074	11632	8561	30517	12184
2	2044	1724	1486	5969	1659	4080	3833
3	114	856	1460	1627	887	711	728
4	78	89	309	272	148	293	107
5	61	58	82	0	63	52	69
6	60	0	2	7	28	26	23
7	1	1	6	2	1	3	2
TOTAL	11531	7265	35823	28835	22293	48543	30294
SPAWNING STOCK (AGE >= 1)	6602	6928	24419	19509	11347	35682	16946

Table 3.5.2. Sandeel. Northern North Sea. Calculated Fishing Mortality by year and by age (for M = 0.5).

AGE	1972	1973	1974	1975	1976	1977	1978
0	.22	.01	.35	.28	.16	.36	.20
1	.40	.42	.91	1.15	.64	1.43	1.10
2	.61	.40	.36	1.15	.72	1.18	1.10
3	.25	.84	1.08	1.37	.78	1.30	1.10
4	.55	.46	1.47	.91	.61	1.00	1.10
5	1.41	1.90	1.86	.00	.84	.66	1.10
6	3.38	.09	.42	1.50	1.73	2.00	1.10
7	1.10	1.10	1.10	1.10	1.10	1.10	1.10
MEAN F FOR AGES >= 1 AND <= 6 (WEIGHTED BY STOCK IN NUMBERS)	.46	.45	.86	1.16	.66	1.39	1.10

Table 3.5.3. Sandeel Northern North Sea. Calculated stock in numbers (in mill.)

AGE	1972	1973	1974	1975	1976	1977	1978
0	31672	71742	48412	48577	93231	52710	92802
1	16185	15445	43254	20700	22357	48167	22205
2	5573	6599	6186	10579	3992	7133	6986
3	638	1843	2695	2623	2023	1180	1327
4	230	300	481	557	403	565	195
5	97	81	115	67	136	133	126
6	70	14	7	11	40	35	42
7	1	1	9	3	1	4	3
TOTAL	54467	96026	101158	83116	122185	109927	123686
SPAWNING STOCK (AGE >= 1)	22794	24284	52746	34539	28953	57217	30883

Table 3.5.4. Sandeel Northern North Sea. Calculated Fishing Mortality by year and by age (for M = 1.0)

AGE	1972	1973	1974	1975	1976	1977	1978
0	.05	.00	.15	.11	.08	.17	.20
1	.14	.14	.45	.59	.32	.83	.60
2	.27	.18	.15	.57	.38	.66	.60
3	.11	.42	.57	.63	.38	.74	.60
4	.29	.27	.69	.50	.26	.54	.60
5	.58	1.02	1.24	.00	.52	.32	.60
6	2.48	.00	.19	.89	1.06	1.27	.60
7	.60	.60	.60	.60	.60	.60	.60
MEAN F FOR AGES >= 1 AND <= 6 (WEIGHTED BY STOCK IN NUMBERS)	.17	.16	.42	.58	.33	.80	.60

Table 3.5.5. Sandeel. Northern North Sea. Calculated stock in numbers (in mill).

AGE	1972	1973	1974	1975	1976	1977	1978
0	147325	240297	125154	144596	234674	130732	114607
1	51451	51342	88204	39487	47813	80001	40710
2	13553	16485	16470	20625	8069	12736	12807
3	1777	3822	5076	5205	4271	2032	2432
4	481	588	924	1056	1015	1071	358
5	210	133	166	170	236	289	231
6	87	43	18	18	63	52	77
7	3	3	16	5	3	8	5
TOTAL	214885	312712	236028	211161	296144	226921	171226
SPAWNING STOCK (AGE >= 1)	67561	72415	110874	66566	61470	96189	56620

Table 3.5.6. Sandeel. Southern North Sea. Input catch data. V.P.A.
Numbers at age in millions.

AGE	1971	1972	1973	1974	1975	1976	1977	1978
0	0	0	13	749	0	4	15068	42147
1	27967	2064	14706	6237	11322	16581	22459	61613
2	1056	19002	2568	3954	2599	16938	6388	17333
3	198	510	3984	498	2854	1916	7168	1918
4	133	171	188	1978	742	1338	1106	1103
5	123	124	92	205	631	191	509	141
6	105	22	33	22	86	130	276	47
7	48	3	8	11	2	17	141	48
TOTAL	29630	21896	21592	13654	18236	37115	53115	124350
SPAWNING STOCK (AGE >= 1)	29630	21896	21579	12905	18236	37111	38047	82203

Table 3.5.7. Sandeel. Southern North Sea. Calculated Fishing Mortality by year and by age (for M = 0.5).

AGE	1971	1972	1973	1974	1975	1976	1977	1978
0	.00	.00	.00	.01	.00	.00	.07	.20
1	.38	.13	.46	.32	.18	.59	.34	.70
2	.29	.71	.33	.31	.31	.67	.70	.70
3	.27	.31	.45	.14	.55	.56	1.08	.70
4	.32	.58	.25	.63	.44	.81	1.21	.70
5	1.04	.83	1.14	.70	.61	.27	1.44	.70
6	2.73	.79	.83	1.73	1.15	.34	1.24	.70
7	.70	.70	.70	.70	.70	.70	.70	.70
MEAN F FOR AGES >= 1 AND <= 6 (WEIGHTED BY STOCK IN NUMBERS)								
	.38	.52	.44	.33	.24	.63	.48	.70

Table 3.5.8. Sandeel. Southern North Sea. Calculated stock in numbers (in mill.)

AGE	1971	1972	1973	1974	1975	1976	1977	1978
0	35065	81529	46547	140486	76445	161992	268288	293028
1	110761	21268	49450	28222	84632	46366	98250	151147
2	5284	45959	11318	18872	12374	42672	15646	42521
3	1045	2401	13650	4912	8437	5527	13182	4705
4	613	483	1068	5265	2598	2966	1910	2706
5	232	270	164	504	1708	1014	801	346
6	129	50	72	32	152	561	469	115
7	82	5	14	19	3	29	242	82
TOTAL								
	153212	151965	122282	198313	186349	261128	398788	494650
SPAWNING STOCK (AGE >= 1)								
	118147	70436	75735	57827	109905	99136	130500	201622

Table 3.5.9. Sandeel. Shetland Area. Input catch data. V.P.A. Numbers at age in millions.

AGE	1974	1975	1976	1977	1978
0	953.4	9.1	4600.2	6108.5	5528.2
1	840.3	3335.6	2246.3	3354.8	5068.9
2	87.0	1397.0	449.7	816.3	1193.2
3	25.0	282.0	156.5	52.9	117.1
4	26.7	50.9	27.9	70.4	28.1
5	4.9	28.4	14.6	8.3	23.0
6	1.6	18.7	6.3	8.3	2.6
7	6.3	8.6	1.7	3.6	.8
8	.0	5.8	.1	.6	1.4
TOTAL	1945.2	5136.1	7503.3	10423.7	11963.3
SPAWNING STOCK (AGE >= 1)	991.8	5127.0	2903.1	4315.2	6435.1

Table 3.5.10. Sandeel. Shetland Area. Calculated Fishing Mortality by year and by age (for M = 0.5)

AGE	1974	1975	1976	1977	1978
0	.13	.00	.36	.39	.50
1	.23	1.39	.80	.74	1.00
2	.14	1.18	1.14	1.29	1.00
3	.14	1.43	.55	.55	1.00
4	.26	.69	.76	.78	1.00
5	.12	.70	.63	.80	1.00
6	.12	1.57	.47	1.59	1.00
7	.44	3.69	.88	.82	1.00
8	.00	1.00	1.00	1.00	1.00
MEAN F FOR AGES >= 1 AND <= 7 (WEIGHTED BY STOCK IN NUMBERS)	.22	1.32	.83	.81	1.00

Table 3.5.11. Sandeel. Shetland Area. Calculated stock in numbers (in mill.)

AGE	1974	1975	1976	1977	1978
0	9997.7	8258.2	18841.8	23775.7	17491.0
1	5094.9	5333.0	5001.8	7935.4	9787.2
2	844.7	2448.8	801.7	1358.1	2303.9
3	240.3	445.6	458.0	155.2	226.1
4	148.1	126.6	64.9	159.9	54.3
5	52.7	69.5	38.6	18.5	44.4
6	18.4	28.2	20.9	12.5	5.0
7	22.2	9.9	3.6	7.9	1.5
8	.0	8.7	.1	.9	2.1
TOTAL					
	16418.9	16728.4	25231.4	33424.0	29915.4
SPAWNING STOCK (AGE >= 1)					
	6421.2	8470.2	6389.6	9648.3	12424.5

Table 3.5.12. Sandeel. Shetland Area. Calculated Fishing Mortality by year and by age (for M = 1.0)

AGE	1974	1975	1976	1977	1978
0	.06	.00	.19	.26	.50
1	.10	.84	.50	.52	1.00
2	.07	.61	.67	.97	1.00
3	.05	.82	.30	.38	1.00
4	.09	.35	.43	.55	1.00
5	.06	.30	.40	.57	1.00
6	.08	1.00	.24	1.22	1.00
7	.27	3.06	.58	.54	1.00
8	.00	1.00	1.00	1.00	1.00

MEAN F FOR AGES >= 1 AND <= 7 (WEIGHTED BY STOCK IN NUMBERS)

.09	.75	.50	.57	1.00

Table 3.5.13. Sandeel. Shetland Area. Calculated stock in numbers (in mill.)

AGE	1974	1975	1976	1977	1978
0	25076.2	23574.1	41395.3	41331.9	21348.0
1	13868.7	8673.0	8667.1	12592.4	11724.5
2	2163.2	4617.0	1374.9	1932.9	2759.9
3	758.3	747.3	924.2	257.6	270.9
4	495.7	264.5	121.1	251.1	65.0
5	125.1	166.9	68.5	28.9	53.2
6	34.1	43.2	45.3	17.0	6.0
7	41.3	11.6	5.8	13.1	1.9
8	.0	11.6	.2	1.2	2.8
TOTAL	42567.6	38109.1	52602.6	56426.3	36232.2
SPAWNING STOCK (AGE >= 1)	17491.4	14535.0	11207.3	15094.5	14884.2

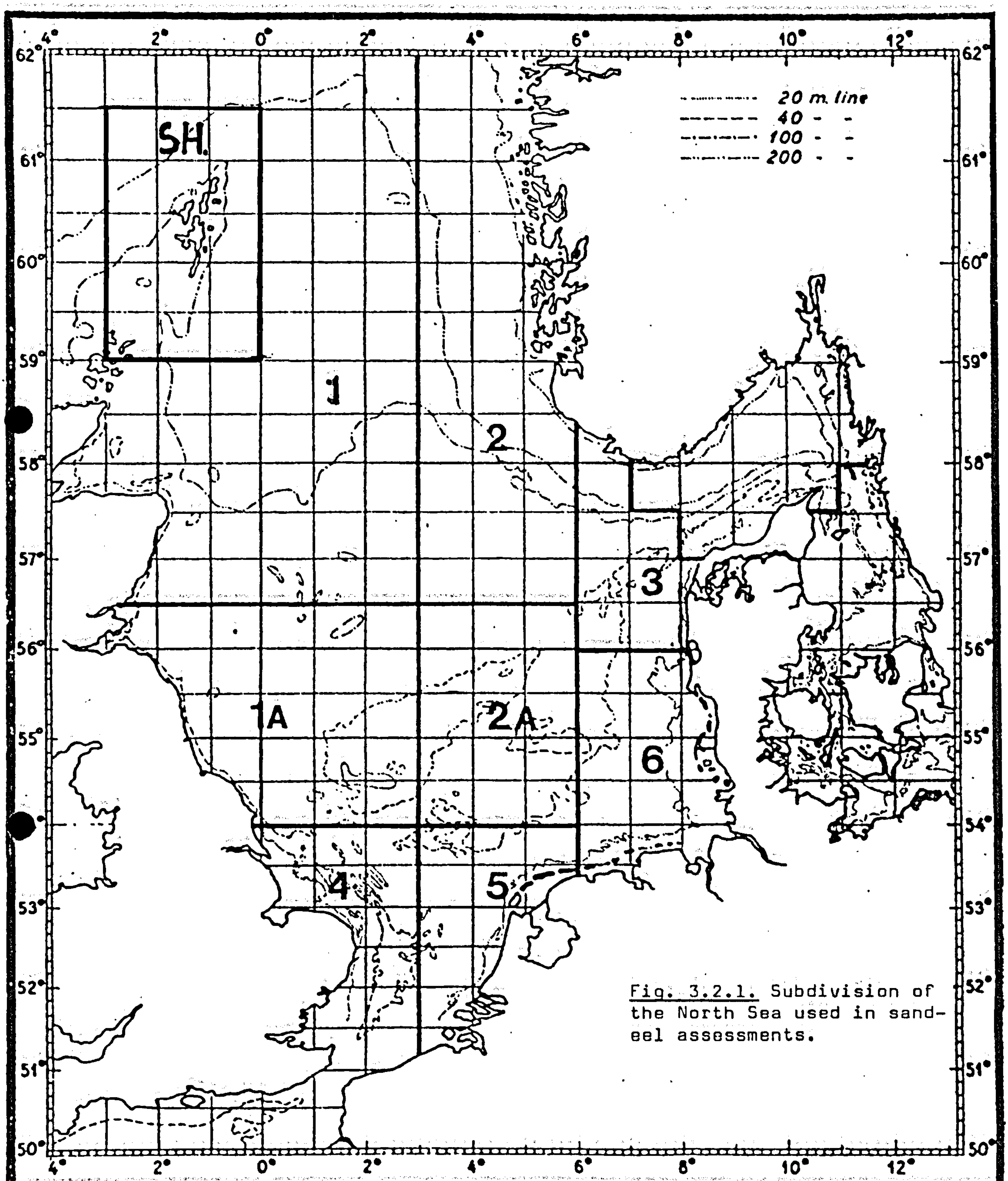


Fig. 3.2.1. Subdivision of the North Sea used in sandeel assessments.

Fig. 3.5.1. SANDEEL. Comparison of fishing effort and fishing mortalities. Estimated from VPA.