International Council for the
Exploration of the Sea

C.M.1977/F:7
Demersal Fish (Northern) Committee

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

Charlottenlund, 28 February - 4 March 1977

---

* General Secretary
ICES
Charlottenlund Slot
DK-2920 Charlottenlund
Denmark

TABLE OF CONTENTS

	Page
1. Introduction	1
1.1 Participants	1
1.2 Terms of Reference	1
1.3 Species Considered	1
2. Assessment of Norway pout in the North Sea	1
2.1 Material and Methods	1
2.2 Catch and Effort	2
2.3 Age Composition	2.
2.4 Mortality Estimates	2
2.5 Growth	3
2.6 Yield per Recruit	4
2.7 Recruitment	4
3. Assessment of the North Sea Sandeel Stock	5.
3.1 Catch and Effort	5
3.2 Mortality	6
3.3 Growth	7
3.4 Yield per Recruit	8
4. Summary and Conclusions	8
4.1 Norway Pout	8
4.2 Sandeel	8
5. References	9
Tables 2.2.1-3.3.1	10-19
Figures 2.2.1 - 3.4.2	20-37

-o-o-o-o-o-

Note: See also Doc. C.M.1977/F:7 - Appendix.

Report of the Working Group on Norway Pout and Sandeels in the North Sea

1. Introduction

1.1 Participation

Dr R.S. Bailey	United Kingdom
Mr A.C. Burd	United Kingdom
Mr J. Lahn-Johannessen	Norway
Mr H. Knudsen	Denmark
Mr K. Popp Madsen (Chairman)	Denmark
Mr C.J. Rørvik	Norway

1.2 Terms of Reference

The Working Group on Norway Pout and Sandeels in the North Sea was established at the 64th Statutory Meeting of ICES (C.Res.1976/2:7) and was given the following task : "to assess the state of the stocks of Norway pout and sandeels at the meeting in Charlottenlund from 28 February to 4 March 1977. Also, as a result of a request from NEAFC, the Group was asked by the Chairman of the ICES Liaison Committee to provide information on the distribution, biology and state of exploitation of the above-mentioned species in the NEAFC area with reference to 200 mile fishery zones.

1.3 Species Considered

Undertaking an assessment of two fish species which have hitherto been neglected in that respect necessitated a thorough screening of catch data and other basic information at the Working Group's meeting. Parts of the material have been tabulated in this report for future reference, but a more detailed data base could not be established in the short time available.

Apart from the Norway pout (Trisopterus esmarkii (Nilsson, 1855)), the report only considers one species of sandeel: Ammodytes marinus, (Raitt, 1934). Five or six species of sandeels occur in the North-Eastern Atlantic, but only A. marinus is of economic importance. In the main fishing area, the North Sea, A. marinus accounts for about 95-100% of the commercial sandeel landings.

2. Assessment of Norway pout in the North Sea

2.1 Material and Methods

Owing to the short life-span of Norway pout, conventional methods of assessment using virtual population analysis were considered to be inappropriate. Instead, trends in landings and effort were examined using age composition and catch per unit effort data over the development of the fishery.

Information for the period 1973-1976 is based on extensive sampling of commercial landings carried out by Denmark, Norway and Scotland. For the earlier period from 1960 onwards, data are available from Scottish research vessel surveys carried out over a regular grid of stations approximately the same time in the autumn of each year.

2.2 Catch and Effort

The landings of Norway pout recorded in "Bulletin Statistique" contain a bycatch of other species. From data available to the Working Group, a corrected table of landings was prepared for the North Sea (Table 2.2.1). This shows that landings have fluctuated markedly, but with a steady underlying increase since 1966. A peak catch of 736 000 tonnes was taken in 1974.

During the past few years there has been some change in the distribution of catches which are shown in Figures 2.2.1-5 for the years 1972-1976. Catches to the east of 2°E have fluctuated more than those west of 2°E, and catches south of 57°30'N in Area IVb have become negligible

No direct effort data are available for the Norway pout fishery. To estimate changes in effort, the total catches since 1959 were divided by the catch per hour taken by the Esbjerg fleet. The results are given in Table 2.2.2. The effort values for the period prior to 1965 show considerable fluctuation and may not be very reliable. Since 1965, however, there has been a clear increase in effort up to a peak in 1974.

2.3 Age Compositions

Percentage age compositions since 1960 are given in Table 2.3, based on both research vessel and commercial fishery sampling, The life span of Norway pout in the North Sea is very short, indicating either a very high mortality rate or a high rate of emigration. On average, the percentage of 0-group is lower than that of 1-group, indicating that recruitment to the fishery is not complete until after the fish become 1-group at a real age of 9-10 months (the birthday is taken as 1 January).

The series of research vessel data show no obvious trend in age composition since the beginning of the fishery, although there have been considerable year-to-year fluctuations caused by marked changes in recruitment (see Section 2.7).

2.4 Mortality Estimates

The mortality rate of each year class has been estimated from catch in numbers per unit effort in successive years (Table 2.4a). Since the fishery extends through most of a year, estimates cannot be derived from numbers at age pooled over the whole year. Instead, mortality estimates were made between the same period in two successive years on either a monthly or a quarterly basis. Since the Scottish research vessel surveys were made at approximately the same time each year, mortality rates estimated from them between each year can be treated as annual mortality rates. Recent estimates, however, are based on rather inadequate sampling and at a time when the ship used for the surveys has been replaced, necessitating the use of correction factors. The estimates since 1970 must therefore be treated with caution.

Since recruitment is not complete as 0-group, the values from 0-1 years of age are not valid estimates for mortality. In both the Danish and Scottish data, the mortality estimates from 1-2 years of age based on data collected early in the year are lower than those based on the data collected in the second half of the year. The only simple interpretation of this is that recruitment to the fishery is not complete until they are rather more than one year old. A similar trend is not seen in the mortality rates estimated for fish older than two years.

Estimates of mortality rates of fish older than two years tend to be greater than those from 1-2 years of age. If the mean values from 1-2 years old, however, are biassed downwards by incomplete recruitment as 1-group in the first half of the year, this may not be a genuine increase in mortality rates. Excluding the mortality estimates from age 1-2 based on the first half of the year, the trend with age is less apparent.

Estimates of recent mortality rates from age 1-2 based on fishery data, vary from 1.74 to 2.72, the mean of the four estimates being 2.09. Considering mortality of all ages from one-year-olds onwards, the estimates are 1.93-2.16, with a mean of 2.08. A recent total mortality rate of approximately 2.1 is therefore indicated for the fully-recruited age groups.

Although variation in recruitment can have a marked effect on mortality rates estimated from catch curves, such estimates were made for 1973-76 from the Scottish commercial fishery data (Table 2.4b). The estimates ranged from 2.16-2.48 with a mean of 2.37, that is a little higher than estimates based on catch per unit effort.

The recent mortality estimates based on research vessel surveys are on average higher (mean 2.70) but less consistent. Nevertheless, they are the only series that can be used to examine longer term trends. On this evidence, there has been no obvious major increase in mortality rates over the period 1960-75, despite an estimated five-fold increase in fishing effort.

There are a number of possible interpretations of this apparent anomaly:

a) Fishing effort is still a very minor part of the total mortality;

b) Natural mortality has decreased over the same period so that the increase in fishing effort has had no effect on total mortality; or

c) Catch per unit effort in the fishery is not a valid measure of abundance, with the corollary that fishing effort has not increased to nearly the extent indicated in Table 2.2.2. In this case the increase in catches would have been due almost entirely to an increase in stock.

Without direct estimates of fishing effort or independent estimates of abundance, it is impossible to decide between these three alternatives. The evidence from recruitment indices is discussed in Section 2.7.

Raitt (1968a) presented evidence based on length composition data from earlier research vessel surveys for a much lower mortality rate (mean 1.60) in the years before the fishery started. Although this is an estimate of natural mortality (M), or at least rate of loss from the stock, it is not possible to judge its reliability or whether it can be applied to recent data.

2.5 Growth

Recent observations on mean length at age from Scottish and Danish fisheries are given in Table 2.5.

In the Scottish fishery the year class 1972 had consistently higher mean lengths than the more numerous 1973 year class. This is in good accordance with Raitt's (1968b) observations of pronounced density dependent growth in this species. The mean lengths of the 1973 year class observed in the Danish fishery were higher than those in the

Scottish fishery. Whether this is due to a real difference in growth rate within the area or to methodological differences is a question which calls for further study.

2.6 Yield per Recruit

Curves of yield per recruit were constructed using the parameter values W_{∞} = 58 g (corresponding to the mean L_{∞} in Table 2.5), K = 0.6 years^{-1}, and various values of M. 0-group Norway pout are first caught in August, but trends in the values of F shown in Section 2.4 suggest that the year class is still not fully recruited to the fishery in February-March. Therefore, values of mean age at first capture of 0.5 year and 1 year were used. (Figure 2.6a and b).

The true value of the natural mortality is likely to lie somewhere between 1 and 1.6 (see Section 2.4). With a total mortality of about 2.1 this gives a fishing mortality between 0.5 and 1.1.

The yield curves show that recent estimates of fishing mortality are reasonably close to the value giving maximum yield per recruit. Little or nothing could be gained either by increasing or by decreasing it. Using a value of K = 0.8 alters the levels of the curves, but it does not significantly change their shape. The cautious conclusions which can be drawn from Figure 2.6 are thus still valid.

2.7 Recruitment

The fluctuations in the catches of Norway pout and in the age compositions indicate quite clearly that there are large annual variations in recruitment. Since 1-group fish form a high proportion of the catches in most years (Table 2.3), it is surprising that bigger variations in catch per unit effort have not been apparent (see Table 2.2.2).

Independent estimates of year class strength are available from research vessel data. These are based on Scottish surveys in the autumn, and more recently on the International Young Herring Survey in the winter and the pelagic 0-group gadoid surveys in summer. Recruitment indices based on these sources are given in Table 2.7.

The Scottish surveys indicate a ratio between extreme recruitment values of 187:1 based on the 0-group and 54:1 based on the 1-group over a period of 14 years. Although there is some inconsistency between the indices, the 1967 and 1973 year classes appeared to be outstanding; 1961, 1970 and 1971 above average; 1960, 1963 and 1964 below average; and 1965 and 1968 very poor.

There were thus several good year classes in the early sixties, followed by a series of poor broods from 1963-1966. These were followed by an exceptionally strong year class in 1967 and several more strong year classes since. From this it is clear that a considerable component of the variation in total catches, including the recent overall increase, can be attributed to recruitment. It therefore seems likely that average stock size has increased considerably since the 1967 year class entered the fishery, and that this increase is due to increased recruitment. If this is so, then the lack of evidence of any substantial increase in mortality rate may indicate that effective fishing effort has not increased as steeply as Table 2.2.2 suggests.

3. Assessment of the North Sea Sandeel Stock

3.1 Catch and effort

The development of the sandeel fisheries is given in Table 3.1.1. From the start in 1952 until 1970 the main fishing grounds were restricted to the central and southern North Sea and included areas 1A (West Dogger), 4 (Norfolk Banks), 5 (Dutch coastal areas), 6 (German Bight and Horns Reef) and partly 3 (Jutland reef) indicated in Figure 3.1.1. After 1970 an important fishery developed in deeper water in the area between Holmen Ground and Ling Bank (Areas 1 and 2). This development is shown in the text table below and in Figures 3.1.2-3.1.6.

Area	1972	1973	1974	1975	1976
1	32 259	38 271	187 556	69 390	63 601
2	85 224	60 621	177 758	159 540	41 342
3	13 433	8 668	28 965	33 227	50 218
1A	99 503	60 916	54 482	70 446	154 084
2A	24 564	16 465	2 317	12 271	71 823
4	59 770	39 992	29 928	42 906	59 211
5	6 714	9 516	11 789	12 433	9 008
6	28 178	59 896	25 434	19 273	36 810

Catch per unit effort data from the Danish fishery are given in Table 3.1.2 for the period 1958-1975. The total effort figures are calculated from c.p.u.e. in the Esbjerg fleet.

The effort apparently increased from about 116 000 hours in the early sixties to about 218 000 hours in the early seventies. Over the same period the abundance index (c.p.u.e) increased from 1.06 to 1.85 or by the same order as the effort. An increase in fishing power might have taken place in the same period and especially since 1970. To check this possibility, a number of Esbjerg vessels built in 1960-65 were extracted from the data files and their c.p.u.e. were compared with the overall values for each area in 1973-75:

Area	1	2	3	1A	2A	4	5	6
1973	1.69	1.66	0.97	1.58 (1.52)	2.69 (1.26)	1.68 (1.67)	1.45 (1.41)	0.97 (1.04)
1974	4.50 (4.76)	3.86 (4.53)	0.81	1.06 (1.57)	0.69 (1.02)	1.69 (1.61)	2.13 (1.86)	1.07 (1.07)
1975	3.06 (2.66)	2.36 (1.68)	1.15 (0.80)	2.08 (1.67)	1.15 (1.16)	1.89 (1.66)	1.91 (1.69)	0.95 (0.97)

For the southern areas (1A, 2A, 4, 5 and 6) there is no clear evidence that the older vessels fish less efficiently than the average. On these fishing grounds the restricted patches of clean bottom probably negate the effect of larger engine power and gear, success in fishing operations being mainly dependent on precise navigation.

In the northern areas (1, 2 and 3) the tendency is not clear either, but the figures for 1975 could suggest a lower than average performance by the older and smaller vessels.

An average abundance estimate weighted by catch for the southern areas in 1971-75 gives a value of 1.42 tons per hours fishing or an increase of about 35% as compared with the early sixties. Without any obvious increase in fishing power, and with an increase in fishing effort of only 12% it may, at the present stage, be assumed that the sandeel stock in the southern North Sea has not decreased despite 15 years of intensive fishery.

3.2 Mortality

The main sources of information on the total mortality in the sandeel stocks in the North Sea are tagging data from 1958-1963, estimates from growth curves made by Macer (1966) in the early sixties and estimates for the period 1970-75 from Danish and British material.

In the early period the fishing was confined to the southern areas, i.e. all areas except 1 and 2. In 1958, 1959 and 1963 Danish tagging experiments were carried out in all these areas and the results are given below as recaptures per year in percentages of the initial numbers released.

1958	1959	1960	1961	1962	1963	1964	1965	1966	1967	1968	Z
11.6	6.8	1.4	0.7	0.5	0.4	0	0.1				0.67
-	4.4	3.2	1.7	0.1	0.2						0.96
-	-	-	-	-	15.8	1.95	0.65	0.25	0.05	0.15	1.01

From age group frequencies over the years 1960-62 Macer (1966) found Z = 1.07 which is in good agreement with the values estimated from the tagging experiments for the same period.

Unfortunately there are no data available for the late sixties, although there are several estimates from more recent years.

English sampling of British commercial landings from Area 4 took place in 1970-74 and Table 3.2.1 below gives the nos ($x10^{-3}$) caught per age group per one hour's fishing.

Table 3.2.1

Age	1970	1971	1972	1973	1974
1	148.35	196.82	24.40	81.68	8.90
2	21.78	35.87	147.59	11.14	80.86
3	15.72	1.98	19.98	52.41	24.38
4	12.88	0.21	1.79	8.15	20.64
4+	2.18	0.32	1.01	-	6.67

From these figures total mortality rates were calculated for 3 year classes:

Year class 1968	Z = 1.83
Year class 1969	Z = 0.88
Year class 1970	Z = 0.91

An average mean Z weighted by the number of observations gives Z = 1.05.

In 1974-76 extensive age composition material by areas was collected from Danish commercial landings. Total mortality rates estimated from catch curves are given in Table 3.2.2. It is apparent that in the southern areas the estimated Z values are very close to those found in the late fifties and early sixties.

In the northern areas Z appears to be somewhat higher. For these areas there are no estimates available prior to 1974 when the highest catches were taken.

Only one set of data refers to a totally unfished stock, Scottish research vessel data from the east coast of Scotland for the years 1968-71. From a combined catch curve the estimated total mortality rate is Z = 1.07. If this figure is assumed to be an estimate of natural mortality it must either be concluded that fishing mortality is a negligible part of the total mortality and that the sandeel stock in the North Sea is extremely large, or it may be assumed that there are differences between the Northern and the Southern North Sea in respect of natural mortality. The fact that haddock feed heavily on sandeels could indicate a higher natural mortality in the Northern North Sea (Ritchie (1932), Jones (1976)).

Even in an unfished population sandeels hardly reach an age of 10 years according to age compositions recorded in the literature and to the unpublished material available to the Working Group.

Assuming that sandeels with 1 winter ring are fully recruited to the adult stock and that 9-ringers amount to 1% of that stock in numbers, then a minimum estimate of the average instantaneous natural mortality rate is M = 0.5.

Pending an estimate based upon more relevant data, M = 0.5 may be tentatively applied to sandeel stocks in the Southern North Sea from which the oldest fish hitherto are recorded.

In the Northern North Sea any value of M from 0.5 to 1.0 may be assumed.

3.3 Growth

Data on mean length at age were available from the Danish fishery and the recently developed Scottish fishery at Shetland. Monthly samples of length at age were available for some months in 1975 and 1976 at Shetland. Only the April and June samples contained sufficient number of old fish to provide some confidence in the growth parameters. In Figure 3.3.1 the actual mean lengths at age are shown for the two months. Position of L_∞ value is shown in the right-hand margin.

In Table 3.3.1 and 3.3.2 the Danish data for 1975 and 1976 are given by month and by area. The values of L_∞ are shown on a chart in Figure 3.3.2 together with the data from Shetland. There is a tendency for the values to be higher in the northern areas than in the southern.

The highest values were obtained from samples on the Jutland Bank. The data from Shetland appear to indicate a similar growth pattern to that in the north-eastern North Sea.

Considerable seasonal changes take place in mean weight at age. The von Bertalanffy weight at age curve calculated from the Scottish Shetland data are shown in Figure 3.3.3. Values of W_∞ for the three curves are indicated in the right-hand margin. Between April and June there is more than a three-fold increase.

Tables 3.3.1 and 3.3.2 also give data from the Danish fishery by area and month for 1975 and 1976. Maxima in W_∞ tend to appear in May and June when feeding is most intensive. This is perhaps best illustrated in Figure 3.3.4 which shows the variation in mean fat content by month over the period 1964-74.

3.4 Yield per Recruit

Figures 3.4.1 and 3.4.2 show "families" of yield curves constructed from different growth parameters and different values of M.

Figure 3.4.1 refers to sandeel in the Southern North Sea where the maximum obtainable average weight is about 21 grammes, while Figure 3.4.2 refers to the Northern North Sea, where sandeel obtains twice that weight. The maximum sustainable yield is indicated by arrows at each curve having maximum within reasonable values of F.

The curves indicate that in both areas maximum yield per recruit is obtaimed at $Z = 1.6$ assuming $M = 0.5$.

On this basis it may be tentatively concluded that no significant gain in long-term yield would accrue from a change in fishing intensity.

4. Summary and Conclusions

4.1 Norway Pout

The recent increase in catches of Norway pout has not been accompanied by any commensurate increase in mortality rate. It might tentatively be concluded, therefore, that the stock increased as a result of an increase in average recruitment. Since no estimates are available on the proportion of mortality that is attributable to fishing, no estimates of total stock size can be made. Furthermore, no significant gain in long-term yield by changing the present fishing pattern can be demonstrated at present.

4.2 Sandeel

Despite the rapid increase in catch and effort in the North Sea sandeel fisheries, it has not been possible to demonstrate any relation between these and any measure of total mortality currently available. From this evidence, it can be tentatively concluded that there has been an increase in sandeel stock. Furthermore, no significant gain in long-term yield by changing the present fishing pattern can be demonstrated at present.

5. References

JONES, R., 1976. An energy budget for North Sea fish species and its application for fisheries management. ICES Doc.C.M.1976/F:36 (mimeo).

MACER, C.R.,1966. Fishery Invest., London, 24(6).

RAITT, D.F.S., 1968a. The population dynamics of the Norway pout in the North Sea. Mar.Res. 1968, no.5, 24 pp.

RAITT, D.F.S., 1968b. Observations on the population dynamics of the Norway pout in the North Sea. Rapp. Prov. Verb. Réun. Cons. perm. int. Explor. Mer 158:85-90.

RITCHIE, A., 1932. Rapp. Prov. Verb. Réun. Cons. perm. int. Explor. Mer 80 (IIIc).

Table 2.2.1. Landings of Norway pout from the North Sea 1957-76, in thousand tonnes (t).

Year	Belgium	Denmark	Faroes	Netherlands	Norway	Poland	Sweden	UK England+Wales	UK Scotland	USSR	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	0.2	142.1	32.0		63.5				0.2		238.0
71	0.2	178.5	47.2		79.3				0.1		305.3
72	0.2	259.6	56.8		120.5		6.8		0.9		444.8
73	0.4	215.2	51.2		63.0		2.9	0.2	13.0		345.8
74	0.5	464.5	85.0		154.2	2.7	2.1	+	26.7	+	735.9
1975	0.6	251.2	63.6	0.4	218.9		2.3		22.7	+	559.7
76	-	244.9	73.8	+	108.9		-		17.3	-	445.0

Table 2.2.2. Total catch of Norway pout, catch per unit effort and derived effort in the North Sea, 1959-75

Year	Total catch t x 10^{-3}	Catch per unit effort by the Esbjerg fleet t/hour	Derived effort in hours x 10^{-3}
1959	69.3	1.39	49.9
1962	149.7	1.42	105.4
1963	137.8	4.78	28.8
1965	43.2	1.48	29.2
1966	53.0	1.41	37.6
1967	182.6	1.93	94.6
1968	451.8	2.04	221.5
1969	113.5	0.74	153.4
1970	238.0	1.46	163.0
1971	305.3	1.48	206.3
1972	444.8	1.63	272.9
1973	345.8	1.26	274.4
1974	735.9	1.82	404.3
1975	559.7	1.68	333.2

Table 2.3. 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		
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	
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		

Table 2.4 Estimates of Norway pout mortality rates.

2.4a) from catch per unit effort data

1) Danish commercial fishery data:

Period of mortality	Age groups 1/2	
January 1974-75	1.34	
February 1974-75	1.84	mean 1.72
March 1974-75	1.96	
August 1974-75	4.12	mean 3.11
September 1974-75	2.1o	
October 1974-75	2.34	
November 1974-75	3.42	mean 3.45
December 1974-75	4.6o	
	Over all mean	2.72

2) Scottish commercial fishery data:

Period of mortality	Age groups o/1	1/2	2/3	3/4	4/5	1 and over	2 and over
1973-74 Jan.-March	-	o.44	3.94	3.83	-	1.76	
Apr.-June	-	2.6o	3.42	2.49	-	2.83	
July-Sept.	o.69	2.95	3.14	-	-	2.99	
Oct.-Dec.	o.39	o.95	-	-	-	1.o6	
Mean	o.54	1.74	3.5o	3.16	-	2.16	
1974-75 Jan.-March	-	1.12	3.o2	2.56	2.o7	1.23	
Apr.-June	-	1.79	2.77	4.63	-	1.81	
July-Sept.	-o.o2	2.2o	3.15	-	-	2.21	
Oct.-Dec.	1.45	2.49	1.32	-	-	2.45	
Mean	o.72	1.9o	2.57	3.6o	2.o7	1.93	
1975-76 Jan.-March	-	o.88	2.21	2.63	-	1.27	
Apr.-June	-	1.97	1.86	2.94	-	1.94	
July-Sept.	-1.55	3.46	5.o4	2.19	-	3.64	
Oct.-Dec.	o.57	1.69	1.67	2.39	-	1.69	
Mean	-o.49	2.oo	2.7o	2.54	-	2.14	
Over all mean	o.26	1.88	2.92	3.1o	(2.o7)	2.o8	

3) Scottish data - research vessel surveys.

	1/2	2/3		1/2	2/3
196o-1961	3.o1	2.48	197o-1971	1.88	3.85
1961-1962	2.21	2.98	1971-1972	1.76	3.14
1962-1963	2.95	3.78	1972-1973	4.71	3.5o
1963-1964	3.7o	2.26	1973-1974	1.48	1.9o
1964-1965	o.42	o.62	1974-1975	3.5o	-
1965-1966	2.47	3.77	Mean 197o-75	2.67	3.oo
Mean 196o-66	2.46	2.65			

2.4b) from catch curves:

1) Scottish data - commercial fisheries:

	Value of Z calculated from age 1 onwards with s.e.		
1973	2.16 $\pm$	o.45	
1974	2.41 $\pm$	o.16	
1975	2.48 $\pm$	o.43	
1976	2.41 $\pm$	o.45	Mean 2.37

Table 2.5. Mean lengths at age and growth parameters for Norway pout.

	Mean lengths										v.Bertalanffy parameters		
	Age	0.5	1	1.5	2	2.5	3	3.5	4	4.5	L_∞	K	t_o
Shetland fishery 1972 year-class		9.48	10.90	14.70	15.61	17.50	18.00	-	20.00	18.00	20.04	0.65	-0.40
Shetland fishery 1973 year-class		8.79	10.51	14.38	14.69	16.52	16.54	17.88	-	-	19.53	0.59	-0.47
Fladen Ground fishery 1973 year-class		9.93	10.63	14.83	15.41	18.21	17.35	20.42			20.18	0.81	-0.08

Table 2.7. Recruitment indices of Norway pout 1959-1976, as shown by number per hour's fishing on research vessel surveys in areas shown in Figure 2.7.

Year class	Abundance in north-western North Sea in Scottish autumn surveys		Abundance on pelagic 0-group surveys	Abundance on international young herring surveys	
	as 0-group	I-group	0-group	as 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	16.7(12)	328.8(22)	3 347(26)		
1972	36.3(22)	16.6(10)	545(28)		692(40)
1973	224.4(10)	121.6(22)	2 558(28)	37 666(40)	2 148(45)
1974	84.4(22)	9.5(11)	3 237(28)	6 656(45)	312(44)
1975	41.2(11)	-	3 623(28)	6 073(44)	
1976	-	-	10 884(28)		

NB. Number of statistical rectangles sampled shown in brackets.

Table 3.1.1. Landings of sandeel from the North Sea 1952-76, in thousand metric 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	352.1	0	4.9	0	54.0	0.1	13.6	424.8
1976*)	423.5	-	-	-	43.9	-	18.7	(486.1)

*) preliminary data

+ = less than half unit

- = no information

Table 3.1.2. Total catch of Sandeel, catch per unit effort (Danish data) and derived effort in the North Sea.

Year	Catch ('000 tons)	Catch per hour (tons)	Effort ('000 hours)
1958	100.9	1.047	96.4
1959	107.6	0.993	108.4
1960	120.6	-	-
1961	83.2	0.934	89.1
1962	109.3	0.790	138.4
1963	162.3	1.318	123.1
1964	128.0	1.015	126.1
1965	130.6	1.260	103.7
1966	143.1	1.260	113.6
1967	188.7	1.648	114.5
1968	193.7	1.713	113.1
1969	113.3	1.214	93.3
1970	191.4	2.210	86.6
1971	382.1	1.494	255.8
1972	358.5	2.206	162.5
1973	296.9	1.385	214.4
1974	524.8	2.298	228.4
1975	424.8	1.869	227.3

Table 3.2.2. Sandeel. Total mortality rates (Z) estimated from Danish catch curves

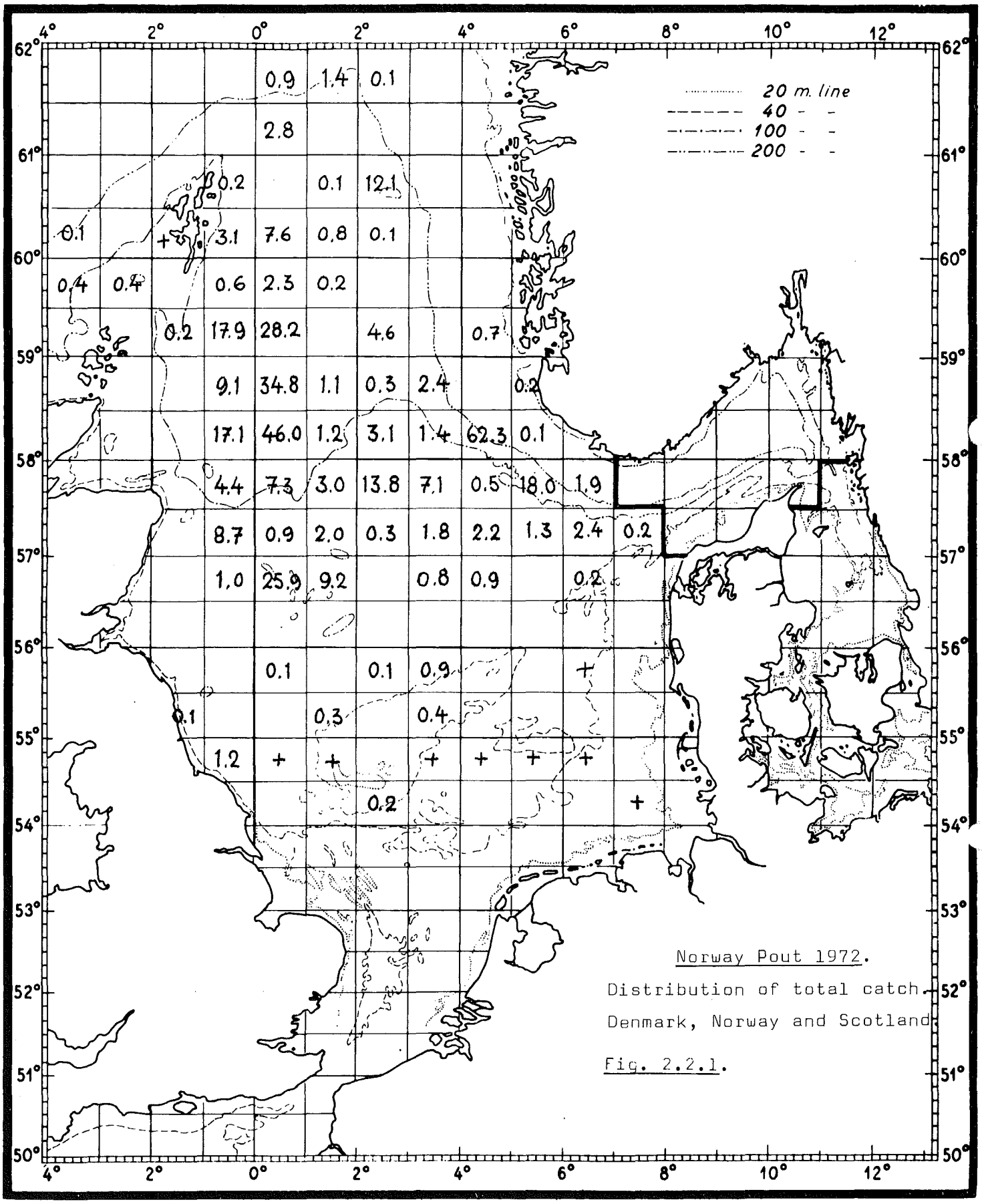
Area	1974	1975	1976	Average 1974 - 1976
1	1.20± .28			1.20
2	1.67± .41	1.39± .26	0.98± .10	1.35
3	1.19± .38	0.97± .01	1.17± .21	1.11
Average	1.35	1.18	1.08	1.20
1A	0.93± .34	0.75± .16	1.15± .23	0.94
2A	0.74± .09	1.35± .14	1.32± .23	1.14
4	0.77± .45	1.01± .18	0.86± .20	0.88
6	0.67± .23	0.63± .31	0.82± .25	0.71
Average	0.78	0.94	1.04	0.92

Table 3.3.1. von Bertalanffy growth parameters. Sandeel 1975.

Month	April			May			June			July		
Length parameters	L_∞	k	t_o	L_∞	k	t_o	L_∞	k	t_o	L_∞	k	t_o
Area 2				27.6	.319	-1.10						
1A	19.8	.425	-0.887				19.4	0.438	-1.39			
3							21.8	0.799	-0.625			
4				17.95	0.556	-0.851						
5							17.65	0.426	-2.57			
6							19.44	0.713	-0.540			
Weight parameters	W_∞	k	t_o	W_∞	k	t_o	W_∞	k	t_o	W_∞	k	t_o
Area 2				51.40	0.425	-0.803						
3							39.40	0.983	-0.216			
1A	18.78	0.431	-0.834									
4				13.48	0.542	-1.046	14.06	0.825	-0.845	25.49	0.352	-2.45
5							15.19	0.723	-1.151			
6							20.72	1.055	-0.174			

Table 3.3.2. von Bertalanffy growth parameters. Sandeel 1976.

Length parameters	L_∞	k	t_o	L_∞	k	t_o	L_∞	k	t_o	L_∞	k	t_o
Area 1	21.19	0.813	-0.067				24.00	0.575	-0.769			
3	25.32	0.421	-0.910	21.65	1.960	1.313	30.52	0.261	-1.896			
4	19.32	0.500	-0.690	18.94	0.576	-0.868				17.85	0.647	-1.135
5	17.75	0.854	-0.376							19.49	0.270	-3.797
6				19.11	0.583	-0.413						
Weight parameters	W_∞	k	t_o	W_∞	k	t_o	W_∞	k	t_o	W_∞	k	t_o
Area 2	22.44	0.943	-0.0075				62.26	0.487	-0.799			
3	50.28	0.384	-1.273	116.26	0.137	-3.240	151.45	0.233	-1.846			
1A	19.24	0.497	-0.727	25.27	0.493	-0.875						
4										17.58	0.539	-1.734
5	14.88	0.934	-0.315							22.44	0.445	-2.184
6				19.51	0.513	-0.818						
1										44.35	0.489	-1.540



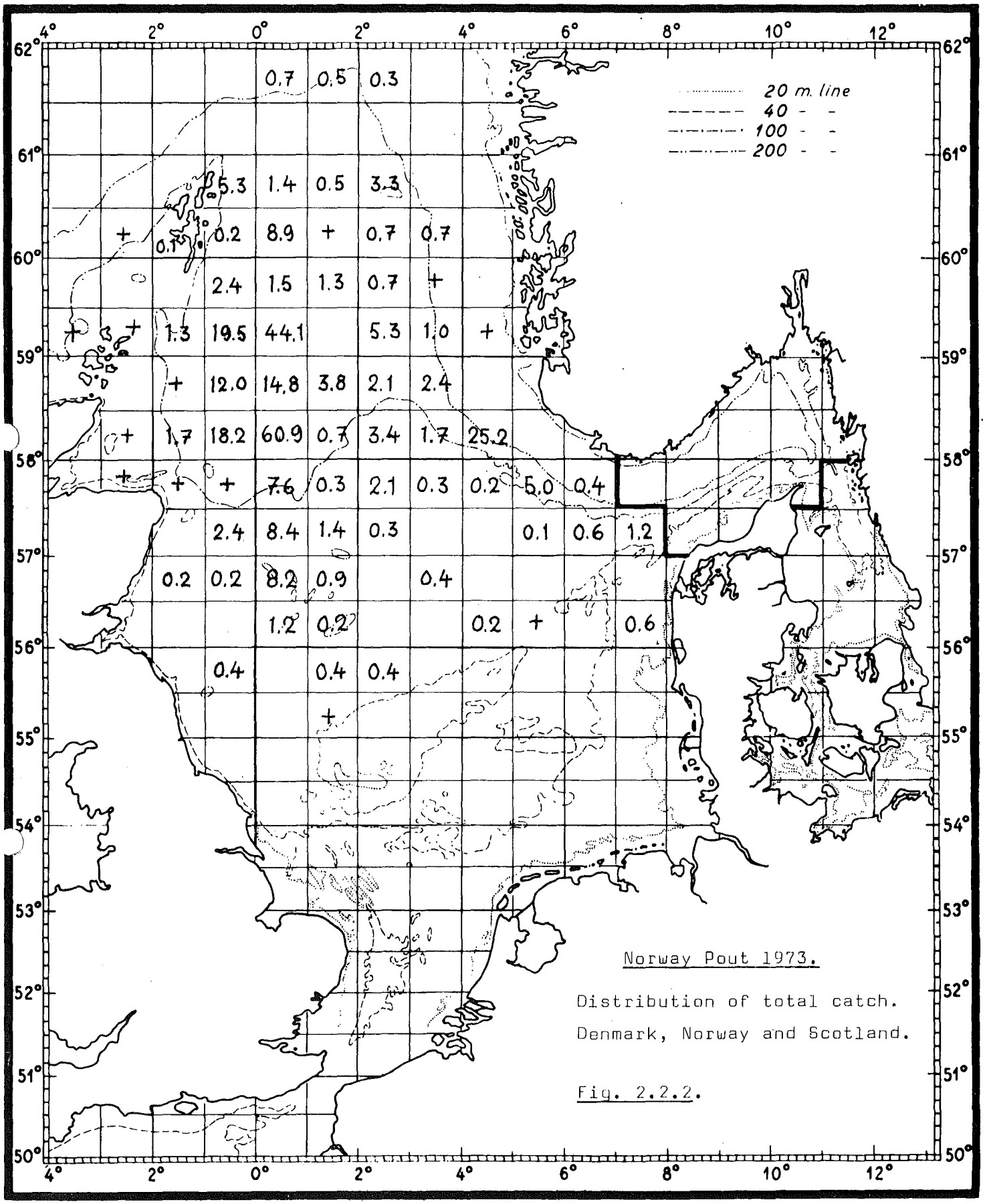
Norway Pout 1972.

Distribution of total catch.

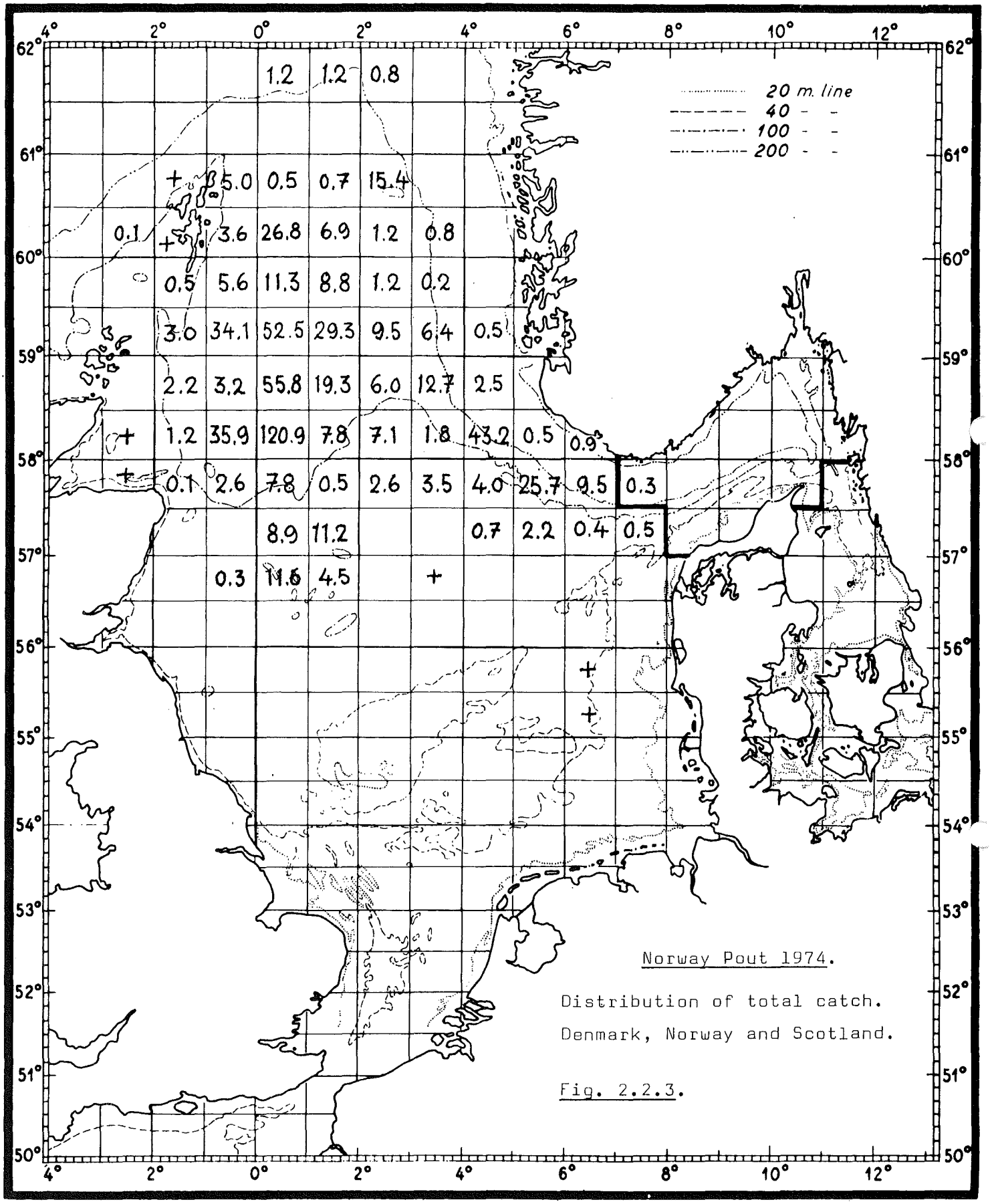
Denmark, Norway and Scotland.

Fig. 2.2.1.

Fm 05-27


20 m. line
40 - -
100 - -
200 - -
4° 2° 0° 2° 4° 6° 8° 10° 12°
62° 61° 60° 59° 58° 57° 56° 55° 54° 53° 52° 51° 50°
0.7 0.5 0.3
5.3 1.4 0.5 3.3
+ 0.1 0.2 8.9 + 0.7 0.7
2.4 1.5 1.3 0.7 +
+ 3 + 1.3 19.5 44.1 5.3 1.0 +
+ 12.0 14.8 3.8 2.1 2.4
+ 1.7 18.2 60.9 0.7 3.4 1.7 25.2
+ + + 7.6 0.3 2.1 0.3 0.2 5.0 0.4
2.4 8.4 1.4 0.3 0.1 0.6 1.2
0.2 0.2 8.2 0.9 0.4
1.2 0.2 0.2 + 0.6
0.4 0.4 0.4
+
Norway Pout 1973.
Distribution of total catch.
Denmark, Norway and Scotland.
Fig. 2.2.2.

Fm 05-27



Norway Pout 1974.

Distribution of total catch.

Denmark, Norway and Scotland.

Fig. 2.2.3.

Fm 05-27

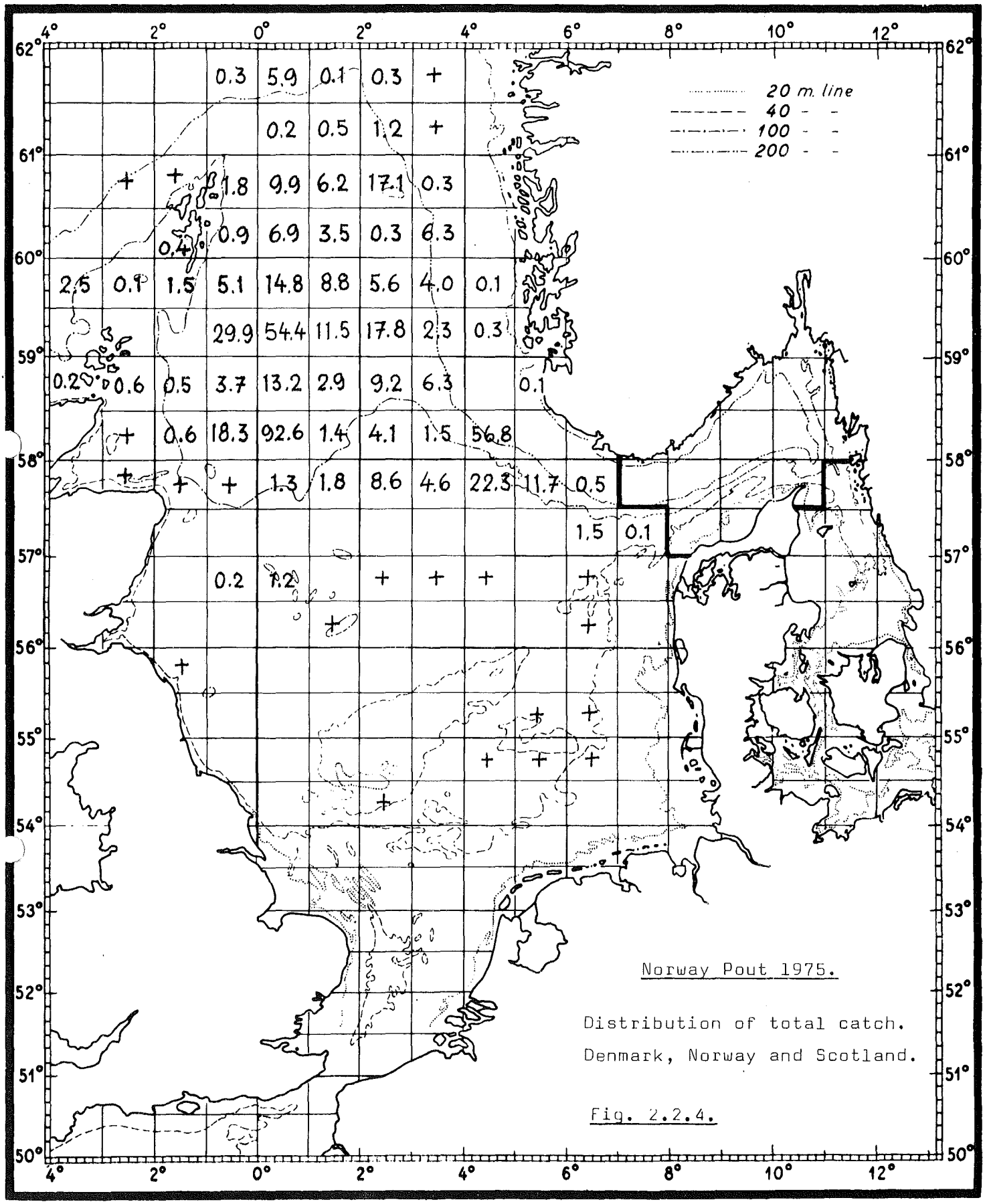

20 m. line
40 - -
100 - -
200 - -
Norway Pout 1975.
Distribution of total catch.
Denmark, Norway and Scotland.

Fig. 2.2.4.

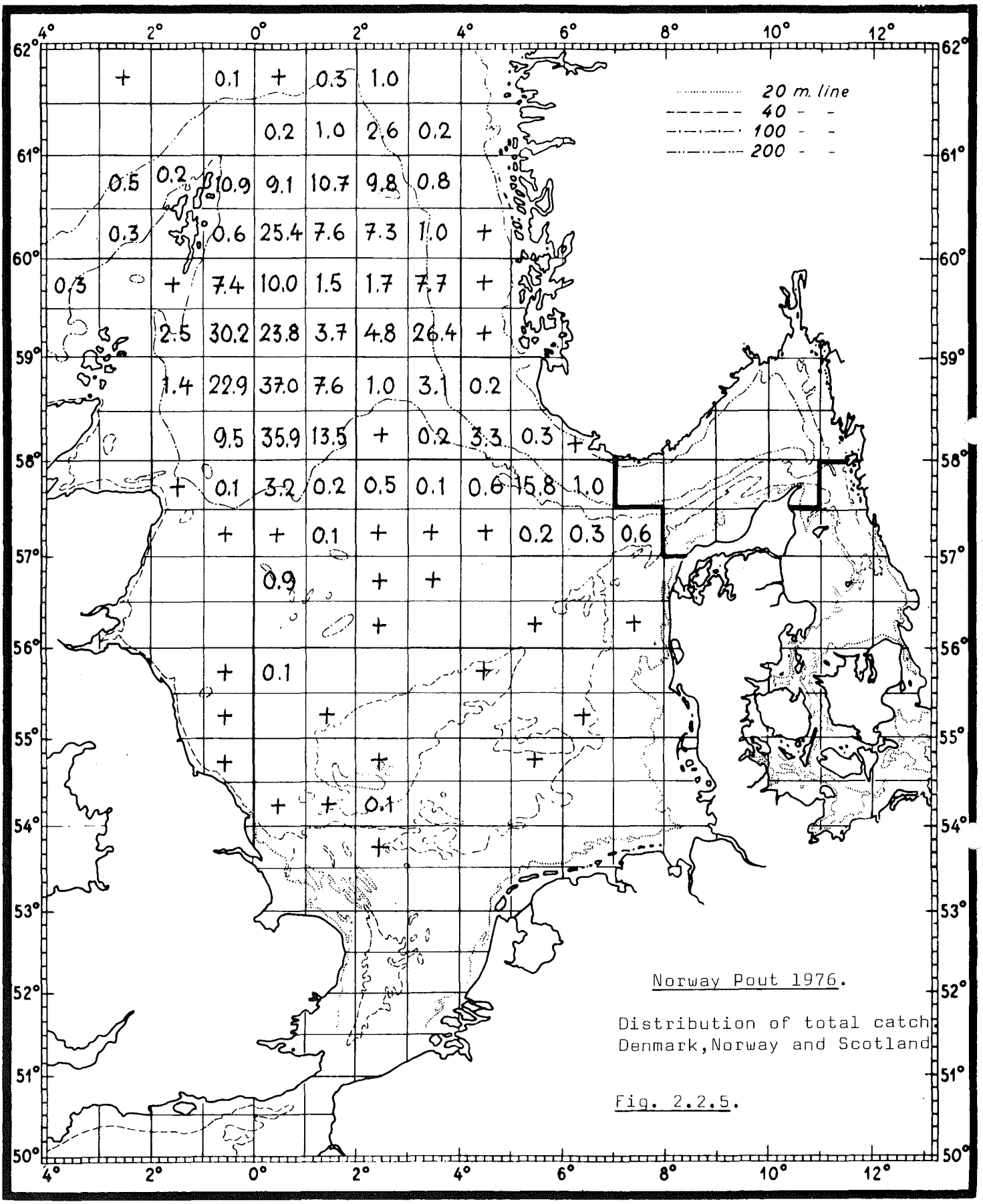


Fig. 2.2.5.

Fm 05-27

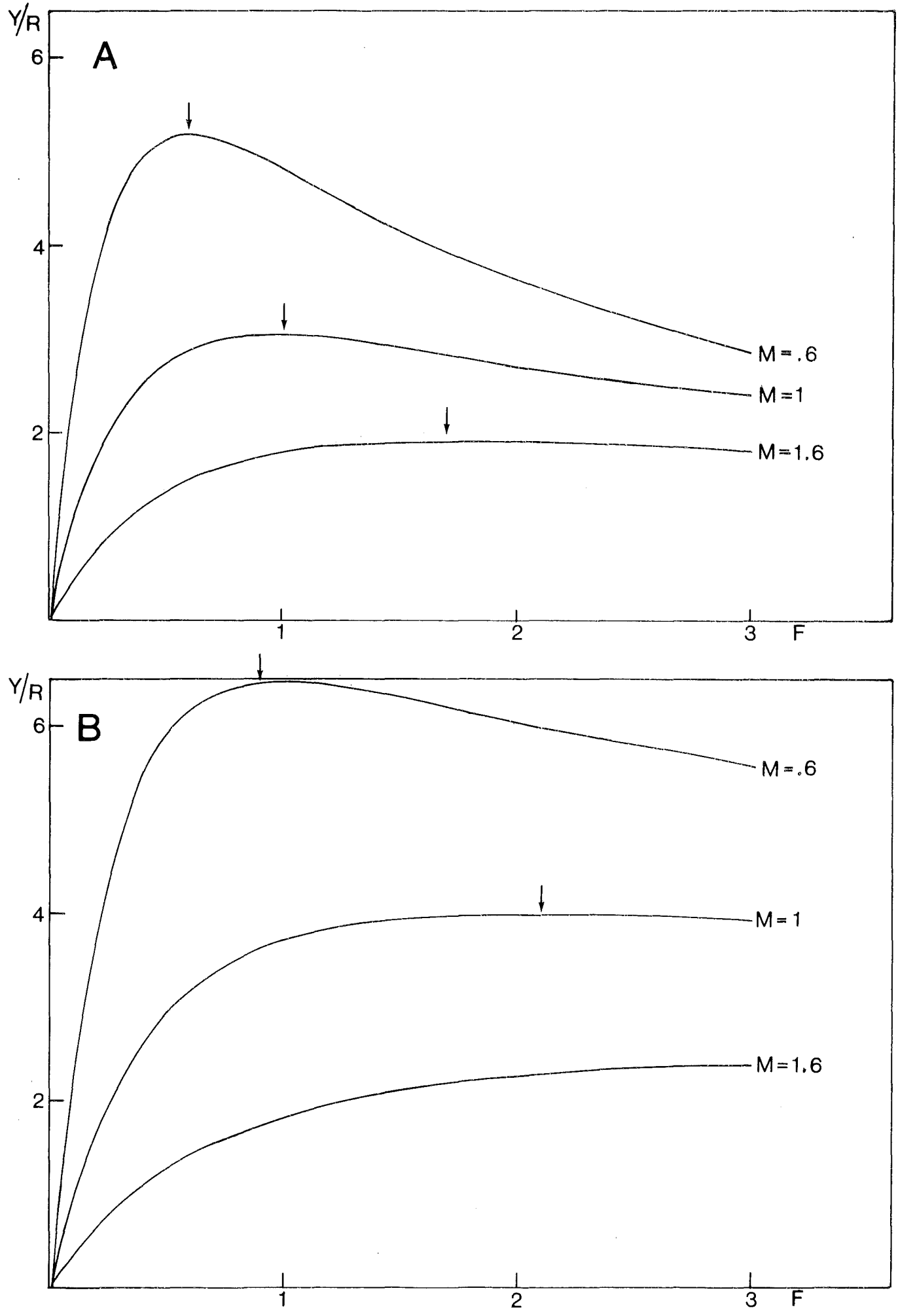


Fig.2.6. Norway pout. Yield per recruit (in grammes) for W_∞ = 58, K = 0.6 t_c = 0.5 (A) and t_c = 1 (B).

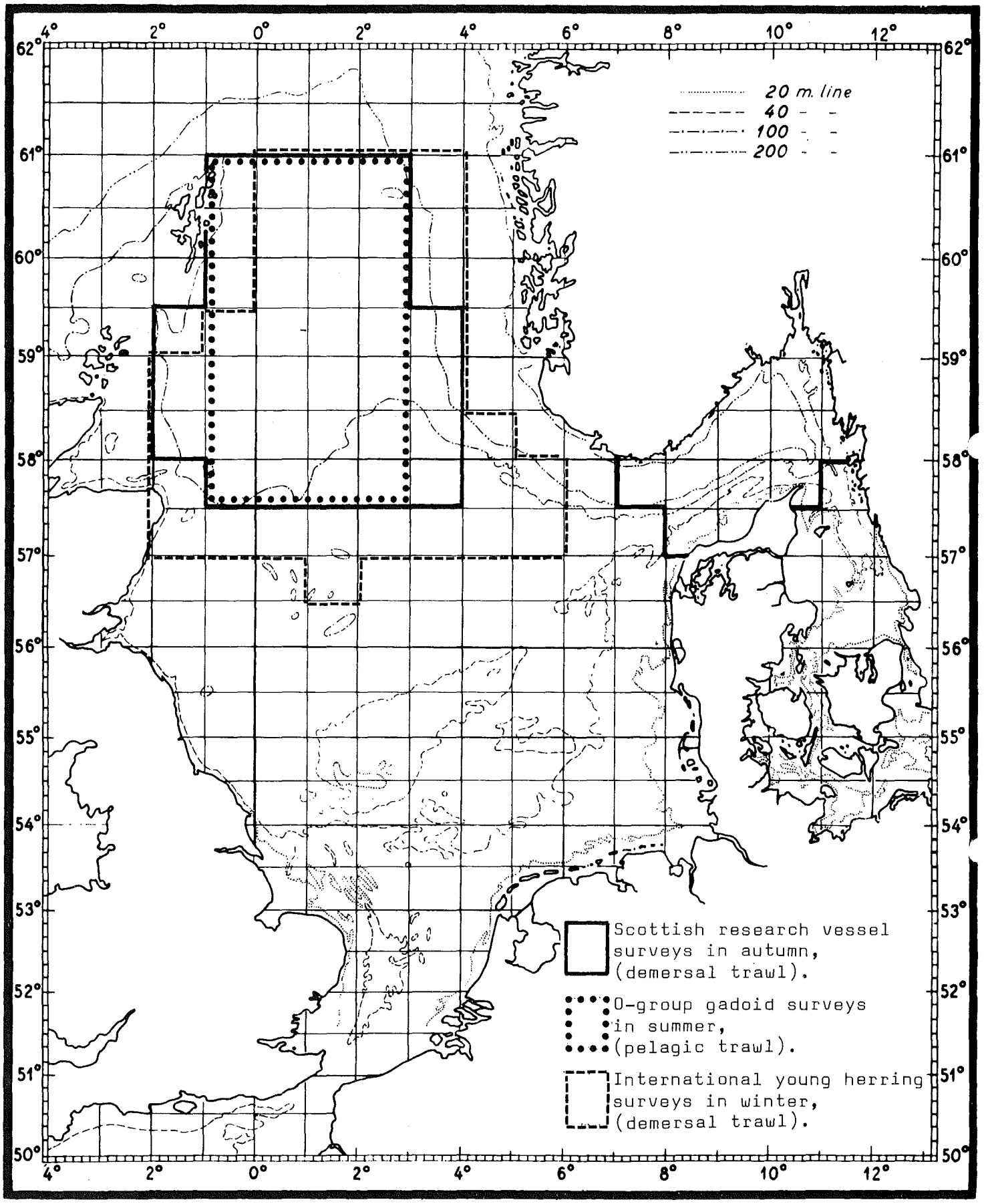


Fig. 2.7. Sampling areas used for recruitment indices of Norway pout, shown in Table 2.7.

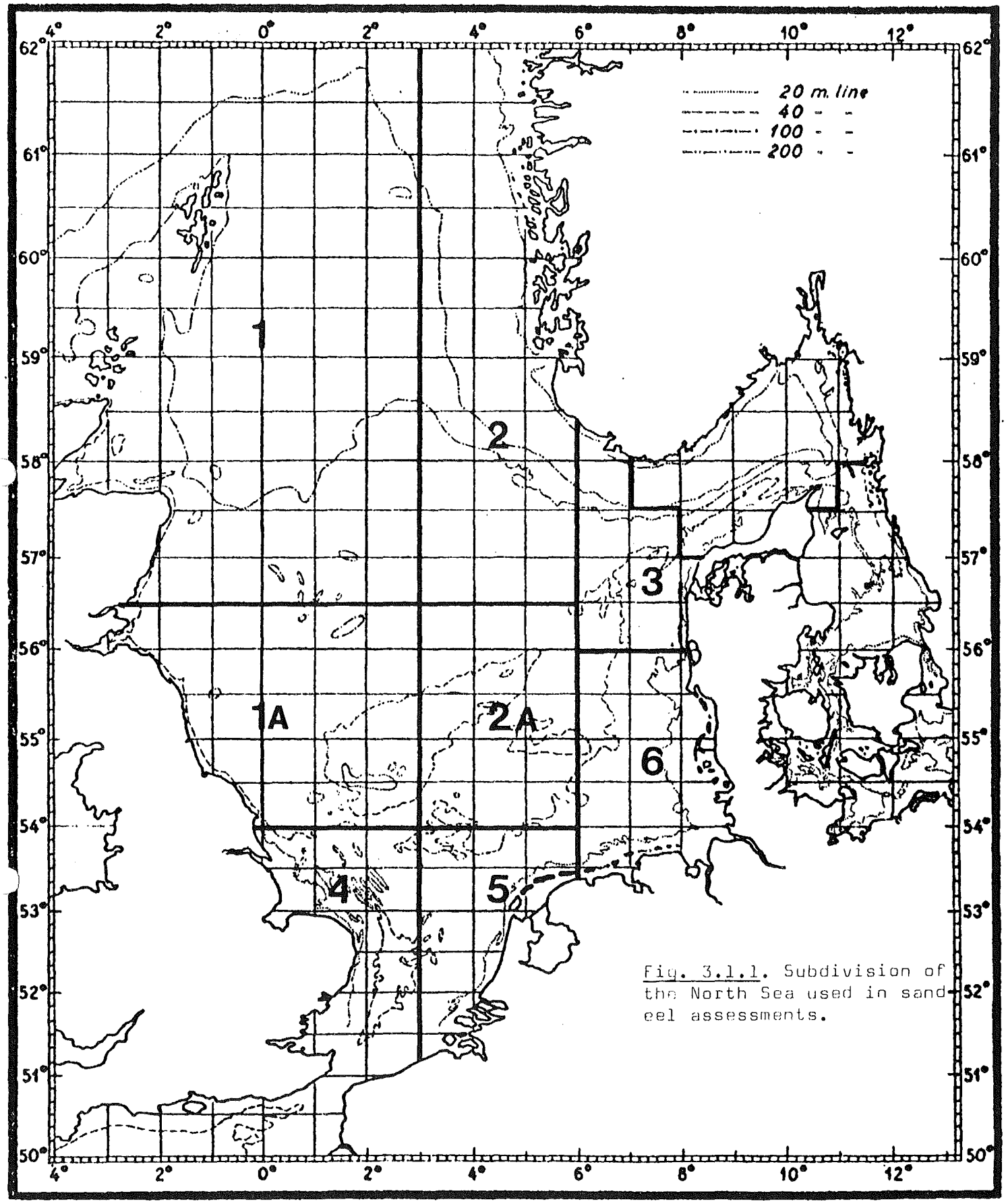
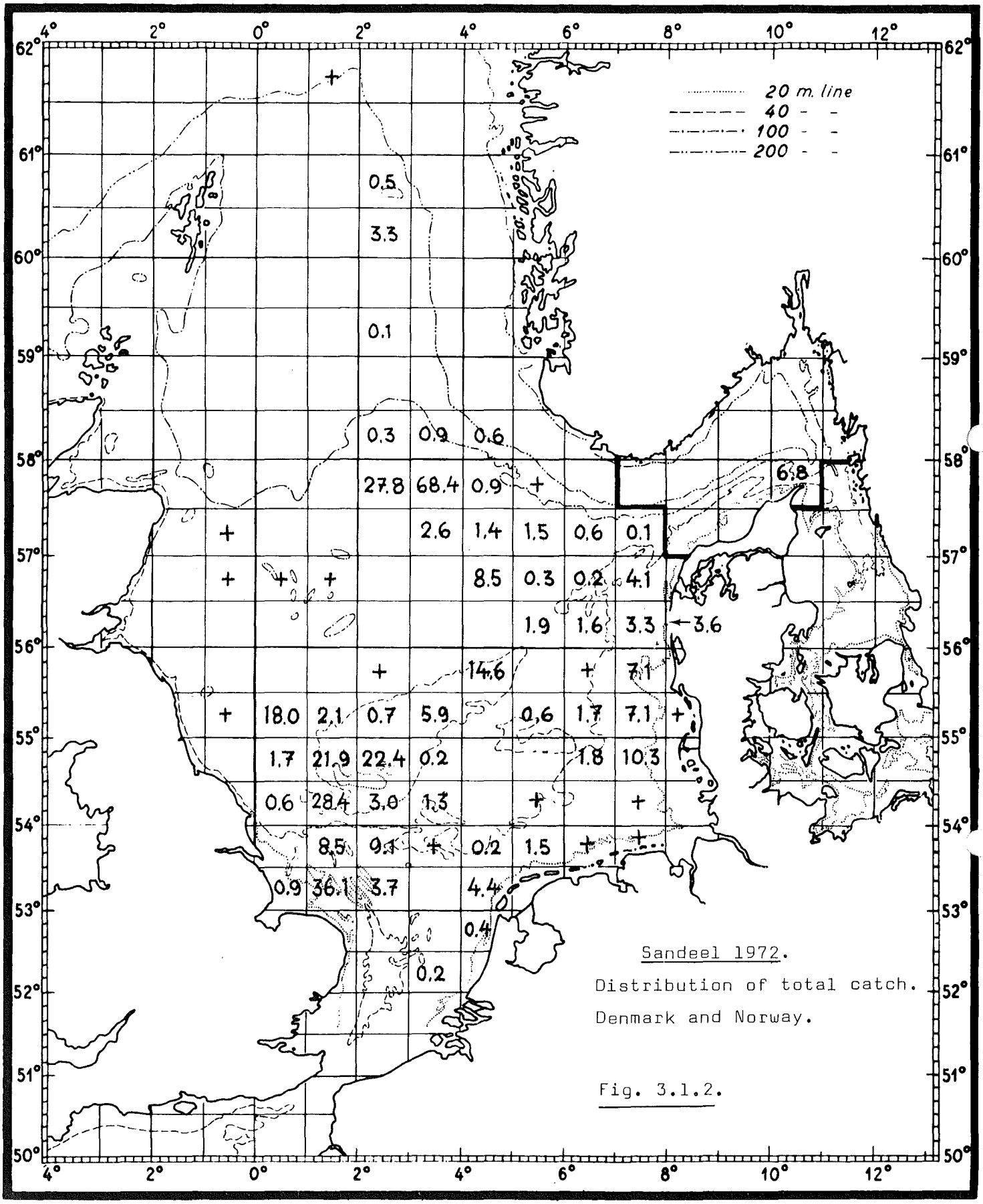


Fig. 3.1.1. Subdivision of the North Sea used in sand eel assessments.



Sandeel 1972.

Distribution of total catch.

Denmark and Norway.

Fig. 3.1.2.

Fm 05-27

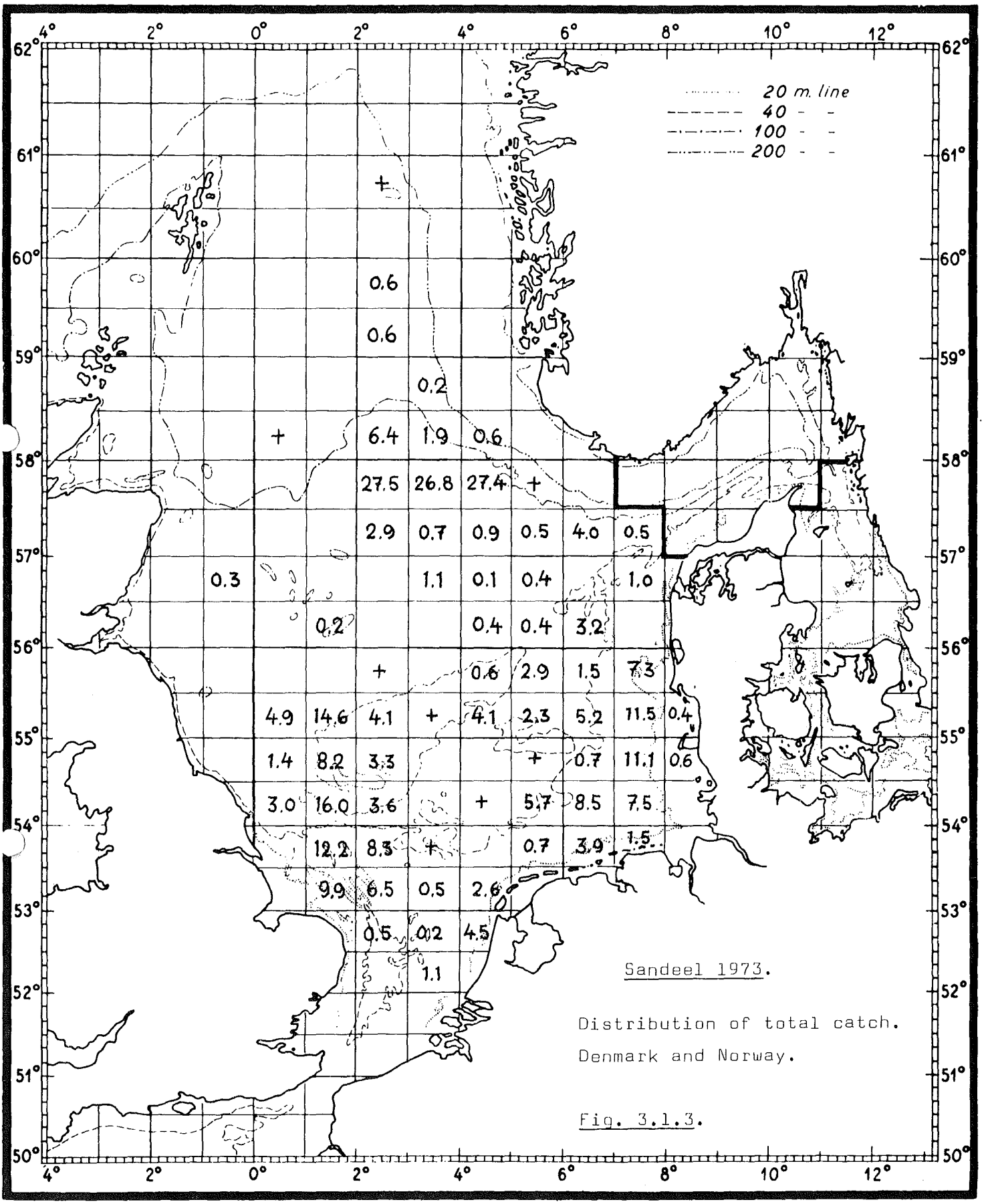
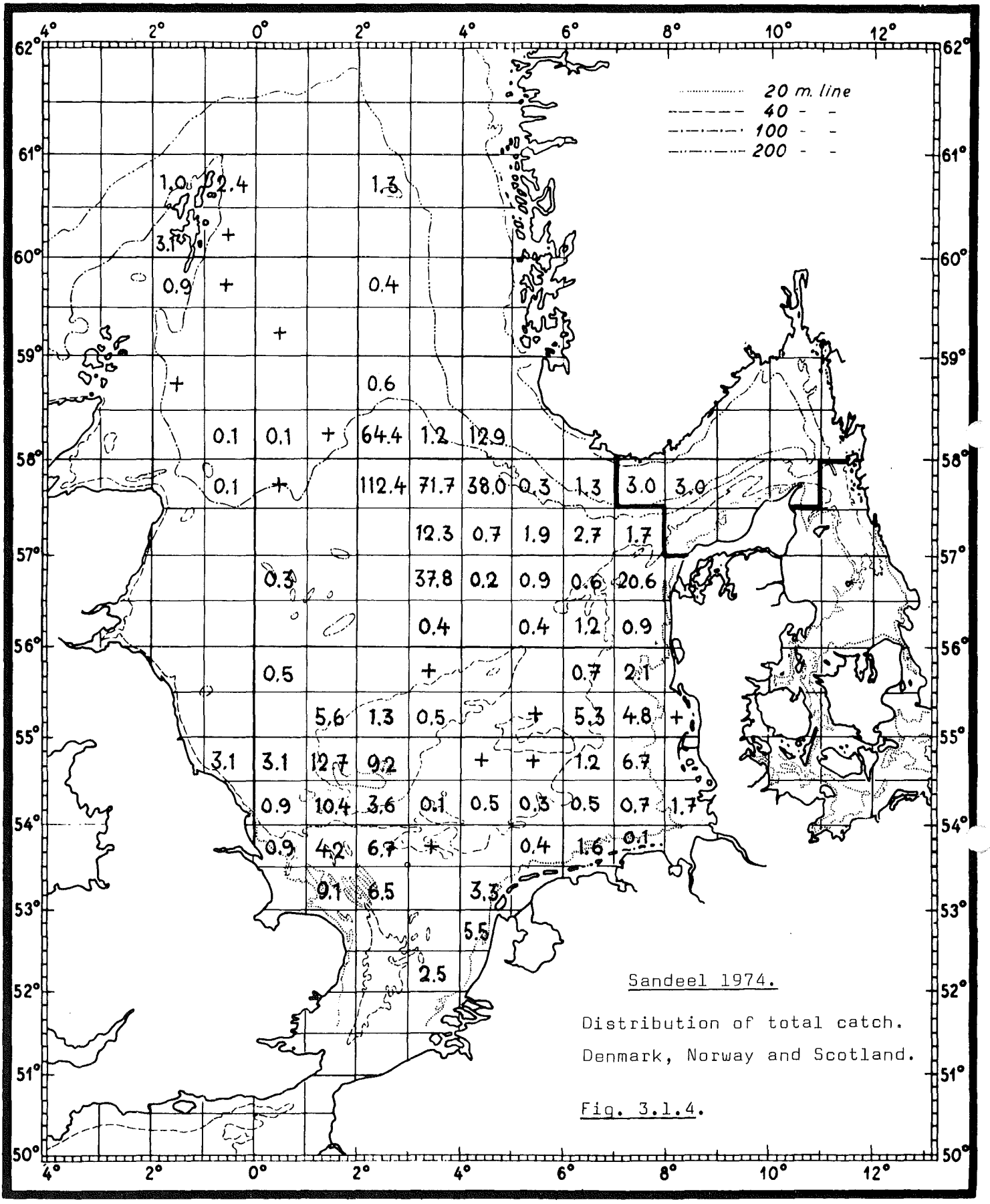


Fig. 3.1.3.

fm 05-27



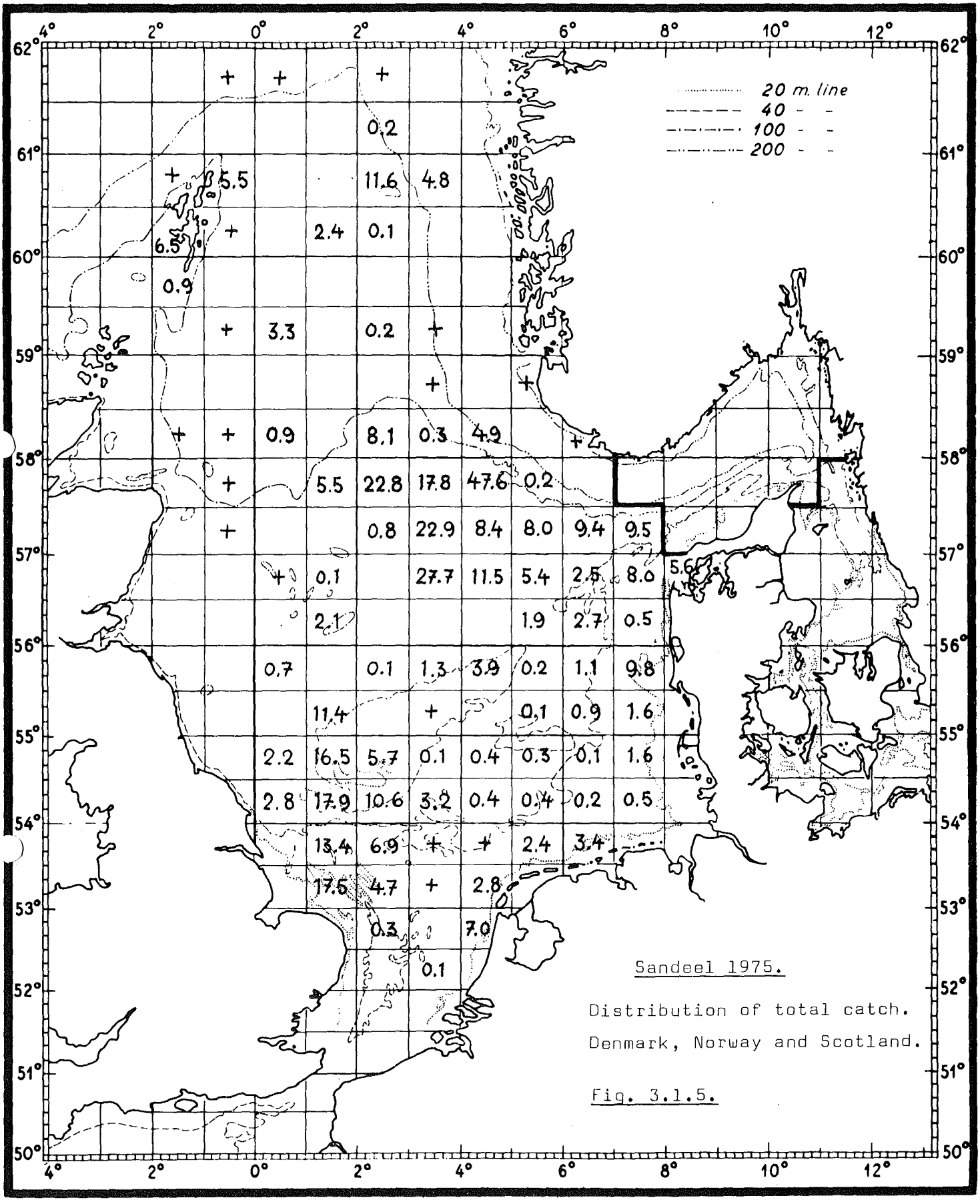
Sandeel 1974.

Distribution of total catch.

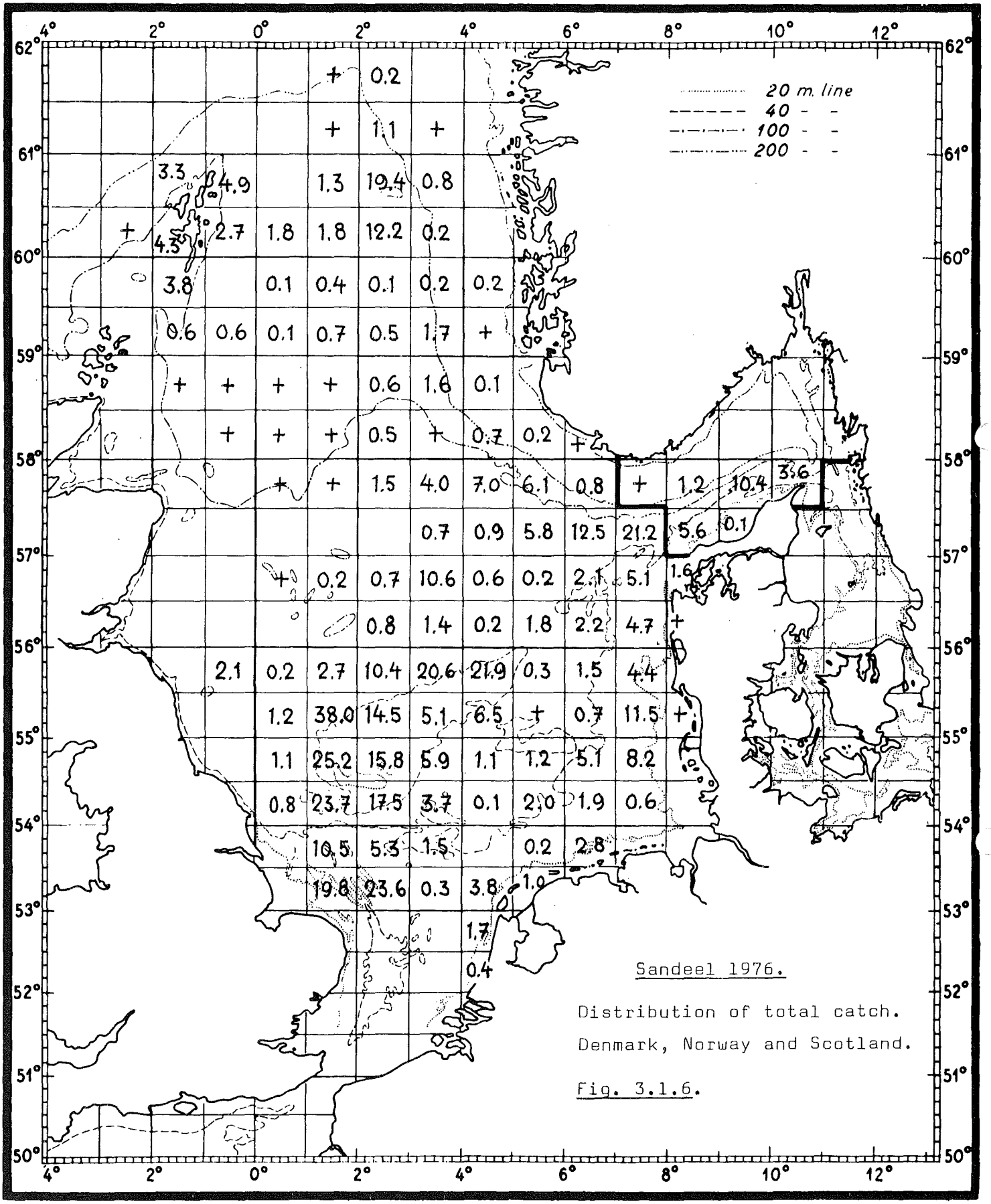
Denmark, Norway and Scotland.

Fig. 3.1.4.

Fm 05-27


20 m. line
40 - -
100 - -
200 - -
4° 2° 0° 2° 4° 6° 8° 10° 12°
62° 61° 60° 59° 58° 57° 56° 55° 54° 53° 52° 51° 50°
+ + + 0.2 + 5.5 11.6 4.8 + 2.4 0.1 6.5 0.9 + 3.3 0.2 + + + 0.9 8.1 0.3 4.9 + + 5.5 22.8 17.8 47.6 0.2 + 0.8 22.9 8.4 8.0 9.4 9.5 + 0.1 27.7 11.5 5.4 2.5 8.0 5.6 2.1 1.9 2.7 0.5 0.7 0.1 1.3 3.9 0.2 1.1 9.8 11.4 + 0.1 0.9 1.6 2.2 16.5 5.7 0.1 0.4 0.3 0.1 1.6 2.8 17.9 10.6 3.2 0.4 0.4 0.2 0.5 13.4 6.9 + + 2.4 3.4 17.5 4.7 + 2.8 0.3 7.0 0.1
Sandeel 1975.
Distribution of total catch.
Denmark, Norway and Scotland.
Fig. 3.1.5.

Fm 05-27



Sandeel 1976.

Distribution of total catch.
Denmark, Norway and Scotland.

Fig. 3.1.6.

fm 03-27

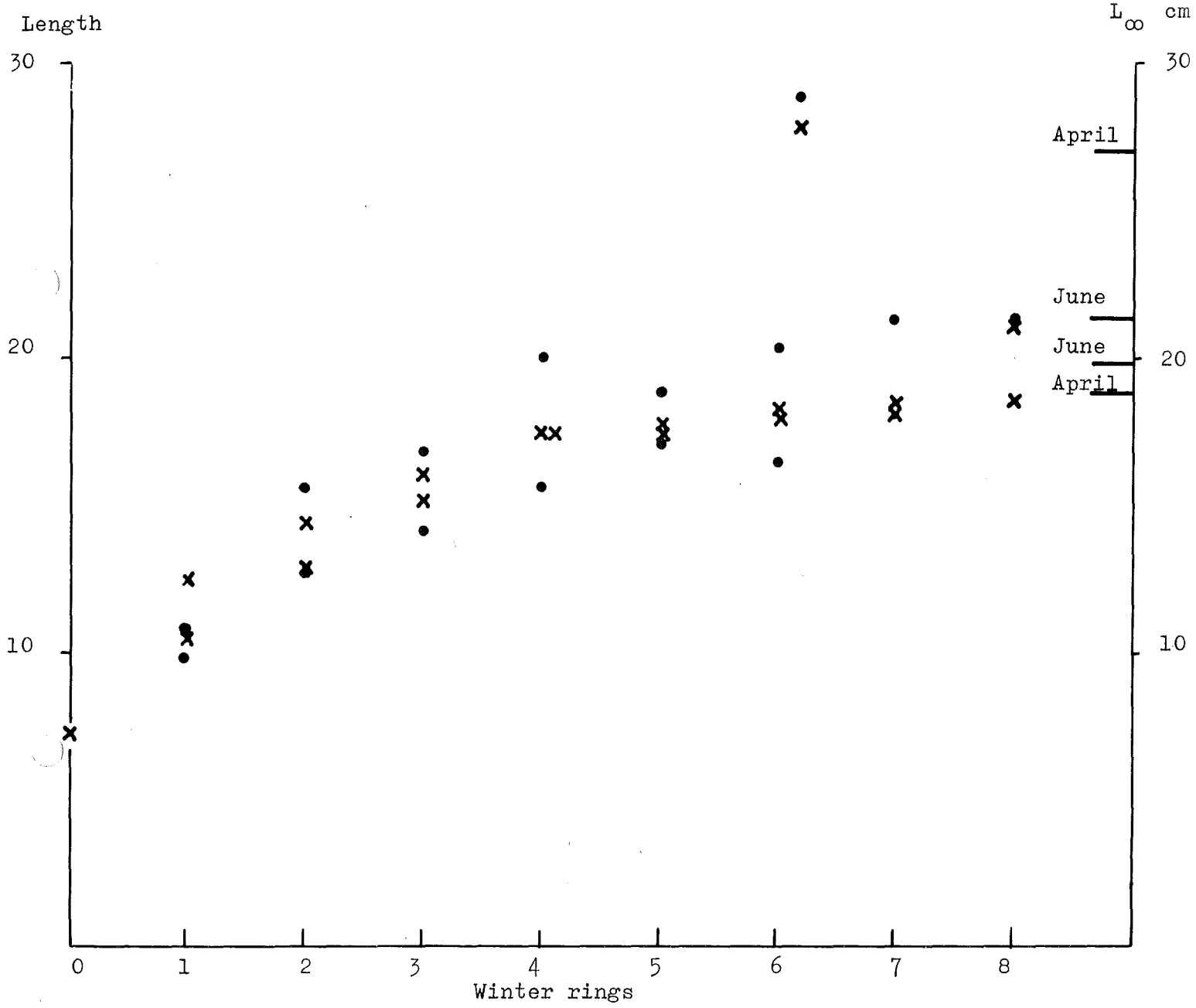


Figure 3.3.1 Length at age in Scottish Sandeel landings from Shetland in 1975-76. (L_∞ indicated in right hand margin).

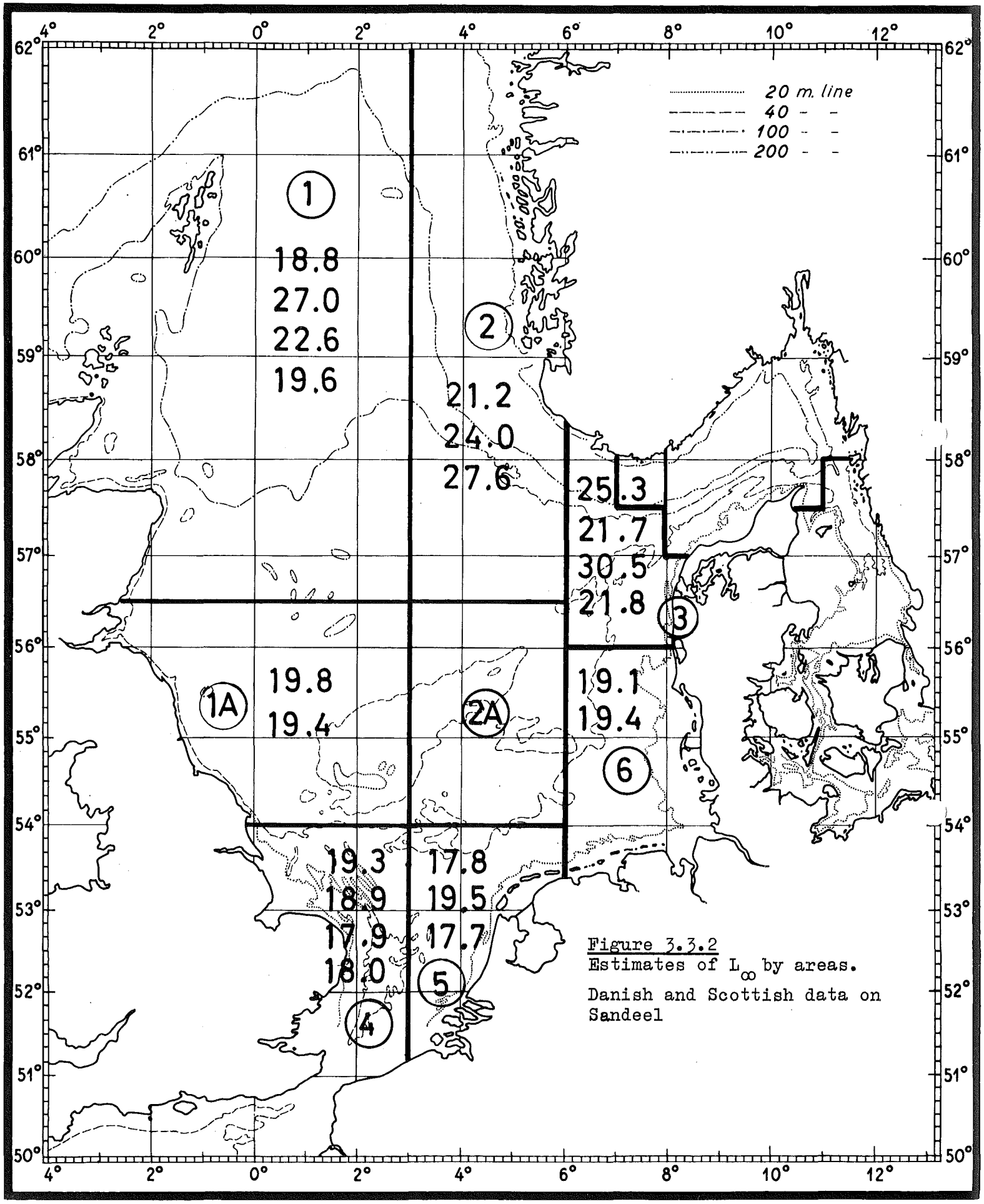


Figure 3.3.2
Estimates of L_∞ by areas.
Danish and Scottish data on Sandeel

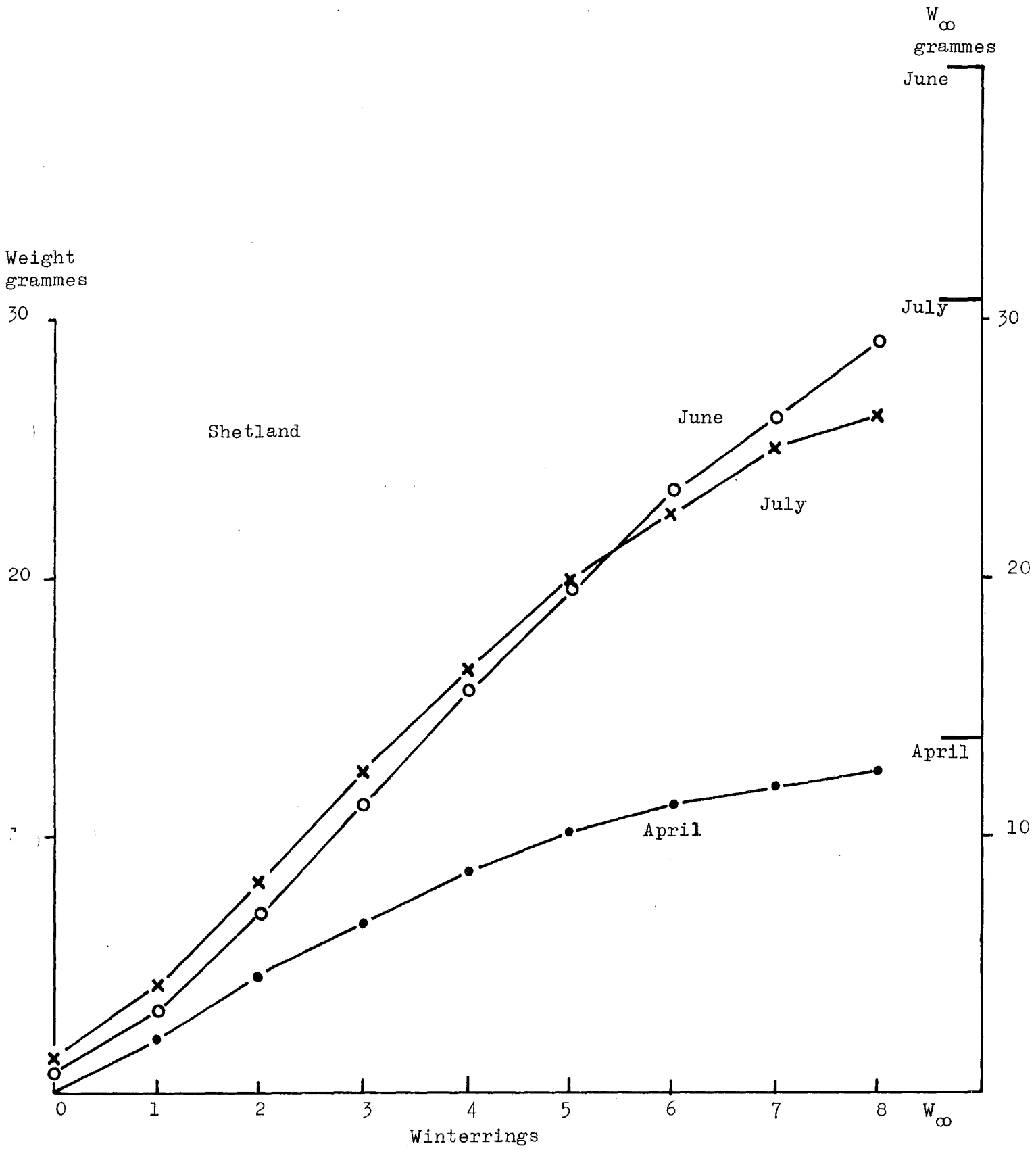


Figure 3.3.3 Weight at age in Scottish Sandeel landings from Shetland in 1975-1976 (W_∞ indicated in right hand margin).

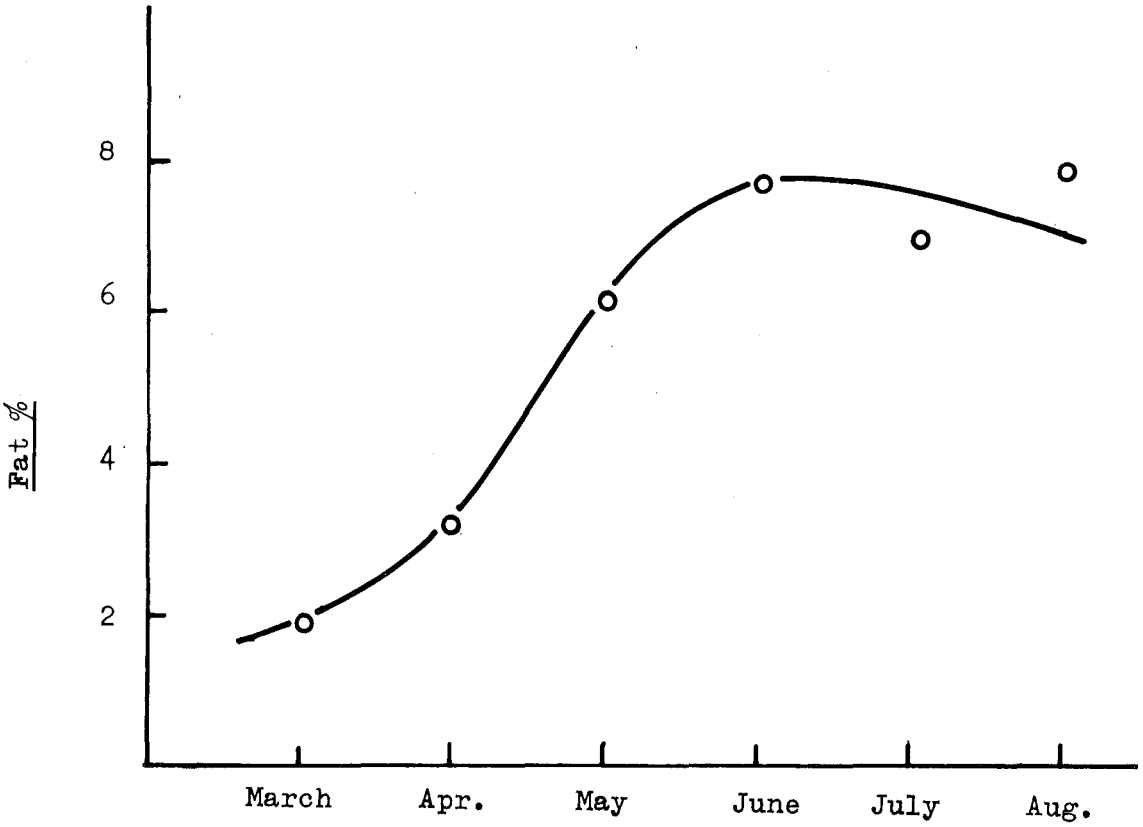


Figure 3.3.4 Sandeel. Monthly average fat percentage 1964-1974

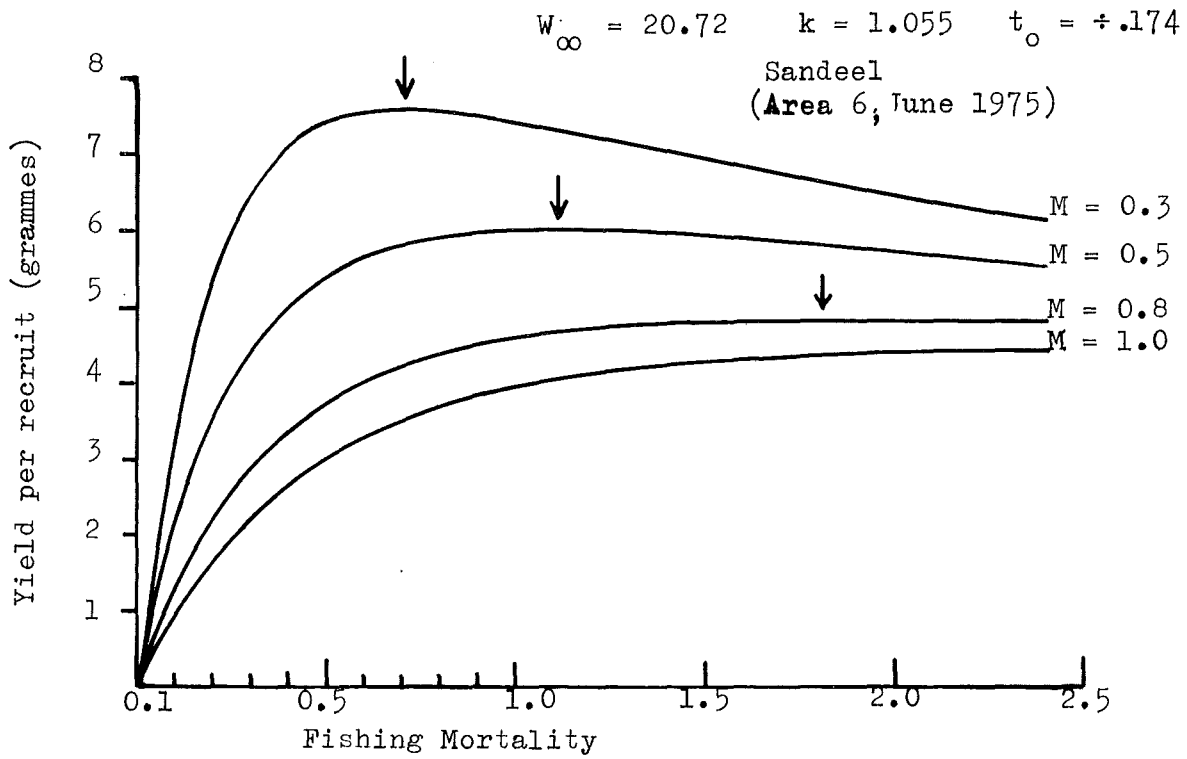


Figure 3.4.1 Yield per recruit curves for Sandeel in southern North Sea

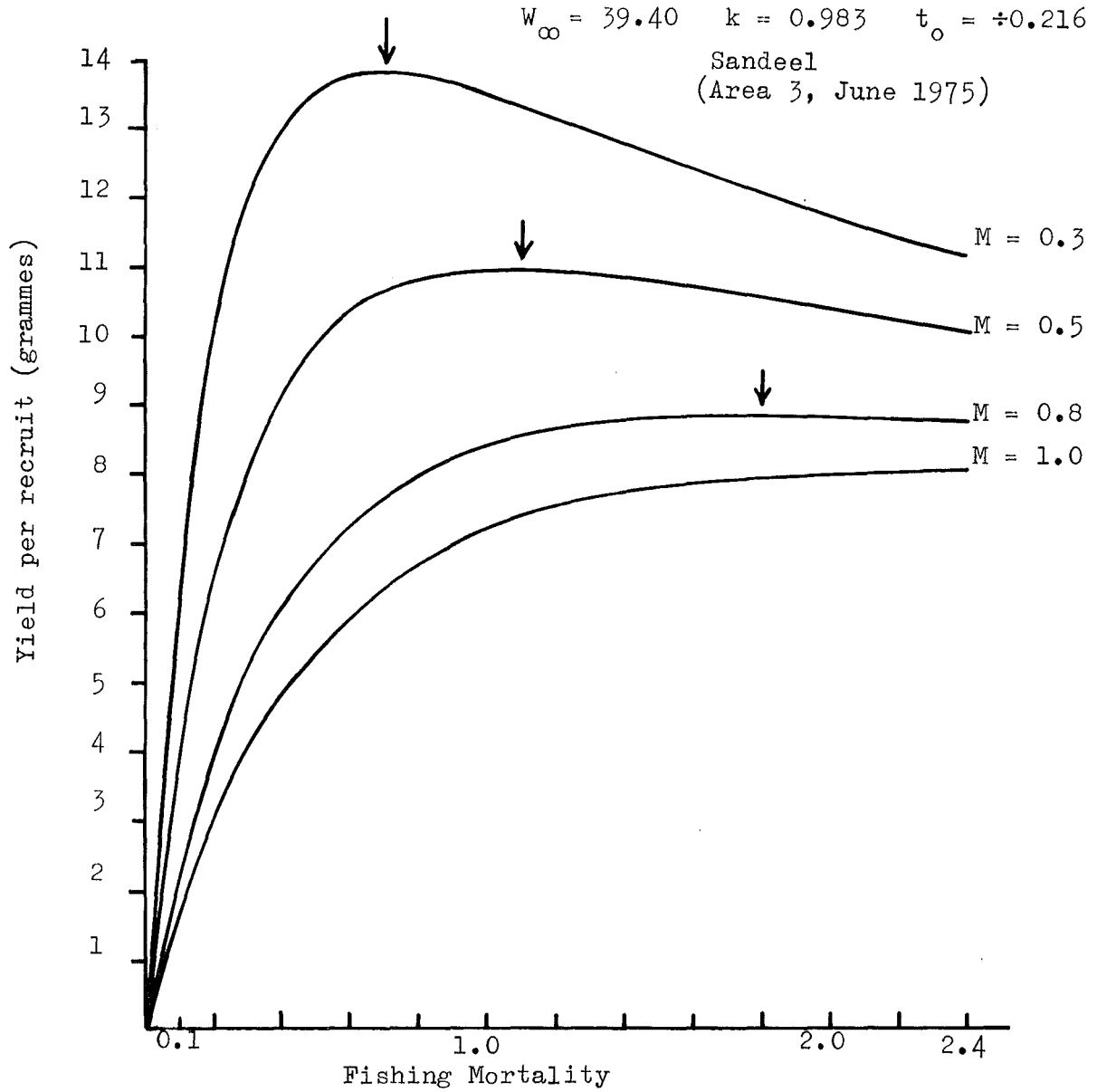


Figure 3.4.2 Yield per recruit curves for Sandeels in northern North Sea