International Council for the
Exploration of the Sea

C.M.1980/H:4
Addendum 1

Revised assessment of Div. IIIa Herring

During the meeting of the Herring Assessment Working Group for the Area South of 62°N, an acoustic estimate of herring in Div. IIIa in September 1979 was presented. A constant factor C was used to convert integrated echo-signals into biomass, and this factor was based on target strength measurements of herring around 100 g (Hagstrøm et al. 1979). A considerable part of the total biomass registered during the survey was other fish, mostly sprat, and herring smaller than those the target strength measurements were based upon. This could lead to a serious overestimate of both total biomass and herring biomass.

If it is assumed that the reflection coefficients are the same function of length for herring and sprat, $\sigma = k_1 l^2$ (Nakken and Olsen, 1973), and also that the weight of herring and sprat are the same function of length, $w = k_2 l^3$, the C value for herring and sprat would be the same linear function of length, $C(l) = kl$

Based on the measured C-value for herring around 100 g or 25 cm, the function $C(l) = kl$, and the sampling data on length compositions available from the survey, a revised acoustic estimate has been calculated after the Working Group meeting.

The difference between the two estimates is shown below:

	Stock in numbers ($\times 10^{-6}$)	
Age	Working Group Report	Revised estimate
0	998.8	577.4
1	1010.8	610.7
2	1638.8	1 067.4
3	116.6	92.8
4	14.3	12.7
5	4.7	3.9

The revised estimates are 28 % lower than those given in the Working Group Report. The difference between a VPA and prognosis based on the revised acoustic estimate and those given in the Working Group report will, however, be rather small due to the fact that the Working Group decided to adjust the acoustic estimate downwards to an extent which made the 1977 year class not stronger than the 1974 year class as 0-group. Accepting the revised acoustic estimate as starting point for the VPA, no such adjustment is necessary since in this case the 1977 year class is estimated to be slightly weaker than the 1974 year class.

The revised VPA is given in Table 1-3. Revised stock at 1 January 1980 is given in the text table below:

W.R.	Stock in number $x10^{-6}$	Stock in tonnes
0	(5000)	-
1	3064	79 700
2	518	31 100
3	946	109 700
4	65	11 400
5	12	2 500
6	4	900
7	+	+
Total	4610	235 300

The corresponding spawning stock biomass in 1980 is 125 000 tonnes. The TAC of 40 000 tonnes for 1980 will generate a fishing mortality on 3-ringers and older of 0.18 compared to 0.7 in 1979. $F_{1980} = \frac{0.18 + 0.7}{2} = 0.44$ will generate a catch of about 90 000 tonnes. Calculated catch in 1981 and spawning biomass in 1982 are plotted against F_{81} in Figure 2 for these two catch levels in 1980.

All calculations are based on continuation of the 1979 exploitation pattern. The yield per recruit curve for this pattern is shown in Figure 2. F_{max} is 0.24, and this F would give a catch of 52 000 tonnes in 1980. $F_{0.1}$ is 0.12.

Addendum 1, Table 1. Division IIIa herring.
Input catch data for VPA 1980.

Age	1974	1975	1976	1977	1978	1979
0	2 499	2 006	433	934	147	457
1	910	1 471	1 474	1 437	876	168
2	375	149	325	329	455	583
3	135	60	28	61	65	70
4	47	57	4	12	10	13
5	26	15	3	6	1	4
6	9	6	1	4	1	0
7	3	1	1	2	0	0
8+	1	1	1	0	0	0

Natural mortality at age:

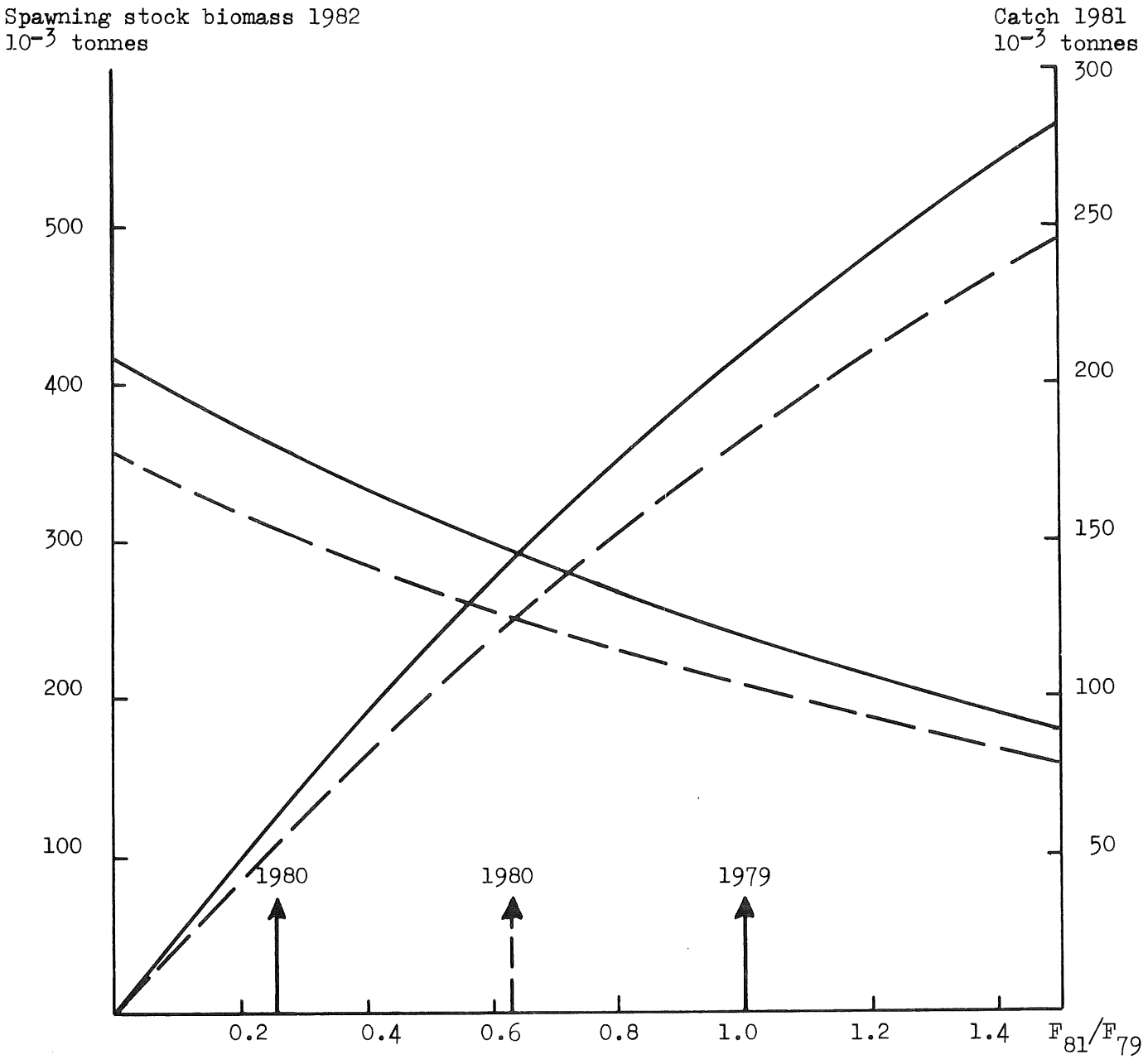
0	1	2	3	4	5	6	7	8
0.30	0.25	0.20	0.10	0.10	0.10	0.10	0.10	0.10

Addendum 1, Table 2. Division IIIa herring.
Fishing mortalities from VPA.

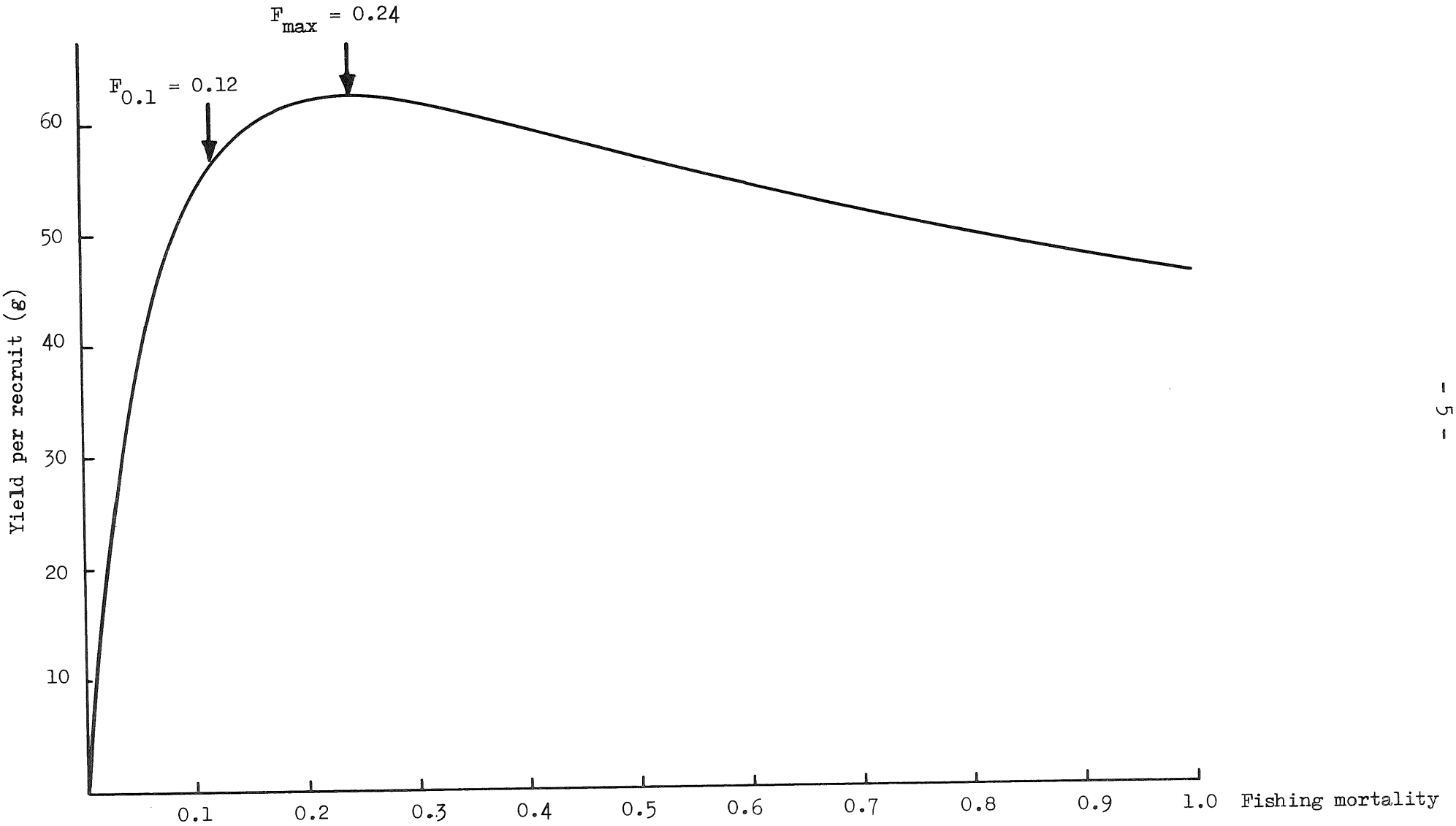
Age	1974	1975	1976	1977	1978	1979
0	0.672	0.565	0.141	0.217	0.137	0.120
1	1.530	1.329	1.299	1.048	0.355	0.250
2	1.677	1.382	1.475	1.382	1.327	0.440
3	1.060	1.716	1.082	1.367	1.184	0.700
4	1.195	2.073	0.415	2.459	0.760	0.700
5	1.464	1.658	0.526	1.852	3.821	0.700
6	1.569	1.863	0.380	5.080	3.821	0.700
7	1.294	0.635	4.473	5.128	0.603	0.700
8	1.500	1.500	1.500	1.500	1.000	0.700
Mean	1.465	1.586	1.402	1.449	1.302	0.464

Addendum 1, Table 3. Division IIIa herring.
Stock size in numbers from VPA.

Age	1974	1975	1976	1977	1978	1979
0	5 817	5 302	3 805	5 511	1 322	4 664
1	1 273	2 202	2 232	2 449	3 286	854
2	496	215	454	474	669	1 794
3	215	76	44	85	97	145
4	70	67	12	14	20	27
5	35	19	8	7	1	8
6	12	7	3	4	1	0
7	4	2	1	2	0	0
8	1	1	1	0	0	0



Addendum 1, Figure 1. Division IIIa herring. Catch in 1981 and spawning biomass in 1982 plotted in different F-values in 1981 relative to F_{1979}. Full-drawn curves based on the assumption that the TAC of 40 000 tonnes is taken in 1980. Hatched curves based on a catch of 90 000 tonnes in 1980.



Addendum 1, Figure 2. Division IIIa herring, yield per recruit. 1979 exploitation pattern.
M = 0.3 on 0-group, 0.25 on 1-group, 0.2 on 2-group and 0.1 on 3-group and older.

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C.M.1980/H:4
Addendum 2

Herring by-catch in Sprat Fisheries

1. The by-catch data of 1979

The Chairman of the ICES Herring Assessment Working Group for the Area South of 62°N circulated a request that data should be submitted on herring by-catches in 1978 and 1979. From the data submitted, it has only been possible to produce some estimate of the by-catches by statistical area for 1979 (Figure 1). The international sprat catches for 1979 by ICES rectangles are shown in Figure 2; the totals exceed those given in Table 2 by 3%. The percentage by-catches derived from Figures 1 and 2 are shown in Figure 3. The estimated annual herring by-catch of about 14 000 tonnes has been derived from data referring to the sprat fisheries only, giving an annual herring by-catch percentage of 3.6. The Working Group Report (C.M.1980/H:4) estimated a total herring by-catch of about 18 000 tonnes.

Considerable care must be taken in interpreting the detailed distribution given in Figure 1. Though data of sprat catches were available by rectangle from the United Kingdom and Norway, the Danish data (whose catch accounted for 71% of the 1979 catch) are derived from catches initially reported by much larger areas. These areas are shown in Figure 4, and in addition the Danish estimated annual percentage by-catch by rectangle derived from these data. The data from Figure 4 were used as a basis for the construction of Figure 1.

From individual data for the rectangles adjacent to the English north-east coast, the combined Danish by-catch percentage of 13.35 compares well with the English annual value of 13.40%. Norwegian purse-seiners, only sampled in United Kingdom ports, gave by-catches of the order of 10%, during the short period in which they were fishing.

The use of annual by-catch percentages or indeed annual area distributions of by-catches are misleading as the sprat fishery is markedly seasonal both in timing and area exploited. Table 1 shows the percentage catch taken in recent years, by quarters. An increasing proportion is taken in the third quarter.

For 1979, Table 2 gives the quarterly breakdown by area and country of the sprat catches, the percentage herring by-catch and the number of samples upon which it was based. Despite the repeated requests by ACFM for adequate sampling of herring by-catch, it is seen that the number of samples are low relative to the size of the catches and there is great variability between quarters and within areas.

There must be considerable doubt as to the reliability of these data in assessing the true by-catch rate in the sprat fishery. In the July to September quarter, 43% of the total sprat catch was taken (Table 1). From Table 2, it is seen that this is almost entirely taken by Denmark. From detailed reports on by-catch levels, they are basically related to Danish Areas I and II (Figure 4). The overall by-catch was 4.7% in Division IVb east, but within Area I 20% of the samples had a mean by-catch of 28%. This area is one which formed a major herring nursery area at the time of the 1969/70 Bløden tagging experiment. It was calculated that the industrial fishery in 1970 generated a fishing mortality on the 1968 year class of 0.33 - 0.46 as 1-ringers. At that time, the industrial fishery was exploiting

herring. It is of importance to note that now under a total ban on directed fishing for herring, the estimated fishing mortality on 1-ringed fish is 0.49 (C.M.1980/H:4, page 12).

It is clear that the areas identified with high by-catches in the sprat fisheries are the well-known herring nursery areas off the English northeast coast and in the continental coastal areas in the German Bight and off the Danish coasts.

2. The "loss" to the adult stock from the juvenile catches

The juvenile catches reported in Table 3.4 (C.M.1980/H:4) for the year classes 1976, 1977 and 1978 are given below:

Year class	No. x 10^6	
	0-ringers	1-ringers
1976	256.1	168.6
1977	130.0	158.8
1978	592.0	?

Assuming that these fish were not caught but were allowed to enter the spawning stock as 2-ringers, and a natural mortality of 0.1 (which is that used conventionally), then the magnitudes of the increment to the spawning stocks are calculated as follows:

Year class	Increment in biomass as 2-ringers
1976	60 000 tonnes in 1979
1977	40 000 tonnes in 1980
1978	80 000 tonnes in 1981

There are considerable objections to this procedure particularly in relation to the choice of natural mortality applied to the 0-group. It is not unlikely that this loss to the North Sea recruitment is not inconsiderable. The increments in spawning stock biomass estimates derived from larval surveys are given below (C.M.1980/H:4, page 11):

Increment	'000 tonnes
1976-1977	36
1977-1978	45
1978-1979	55

The possible increment of biomass lost from the juvenile catch could be of the same order as the annual increment in biomass achieved under the present management policy.

3. Reducing the juvenile herring loss

3.1. Identification of herring nursery areas

The IYFS data for 1978, 1979 and 1980 have been examined to determine the relative abundances of sprat and herring by statistical rectangles. The results are shown in Figures 5-7. The proportions of herring "by-catch" are very much greater than any reported from the commercial fisheries data

for the first quarter of the year. The high by-catches of herring occur in 1978, 1979 and 1980 in the Danish Areas I, II and VIII. In addition, in 1978 and 1979 high catches occurred in Area XII.

By-catch limitation could be achieved by closure in time and space of herring nursery areas if they could be identified with certainty. Variability in relative sprat/herring distributions between years might necessitate such closed areas being large.

The evidence from the IYFS data would identify Danish Areas I, II and XII. Large differences occur in the comparison of the sprat/herring catches in IYFS and in the reported fishery by-catches. For example, in Area VIII the IYFS data give 30.6% herring, while from 13 samples from the fishery the by-catch levels lie between 0-1%. One sample was between 1 and 2%. It has been objected that it is not possible to draw conclusions on the relative abundance of herring and sprat from the IYHS because of the differences in fishing practice from that used in the industrial fishery. However, the industrial fishery also employs high handline bottom trawls as do the research vessels on the IYHS.

3.2. Reduction in by-catch level

If a system of closures were not possible, the loss of potential herring recruitment could be achieved, in the extreme, by closing the sprat fishery or by drastically reducing the sprat TAC.

This would be the only course if sprat could not be caught without also taking herring.

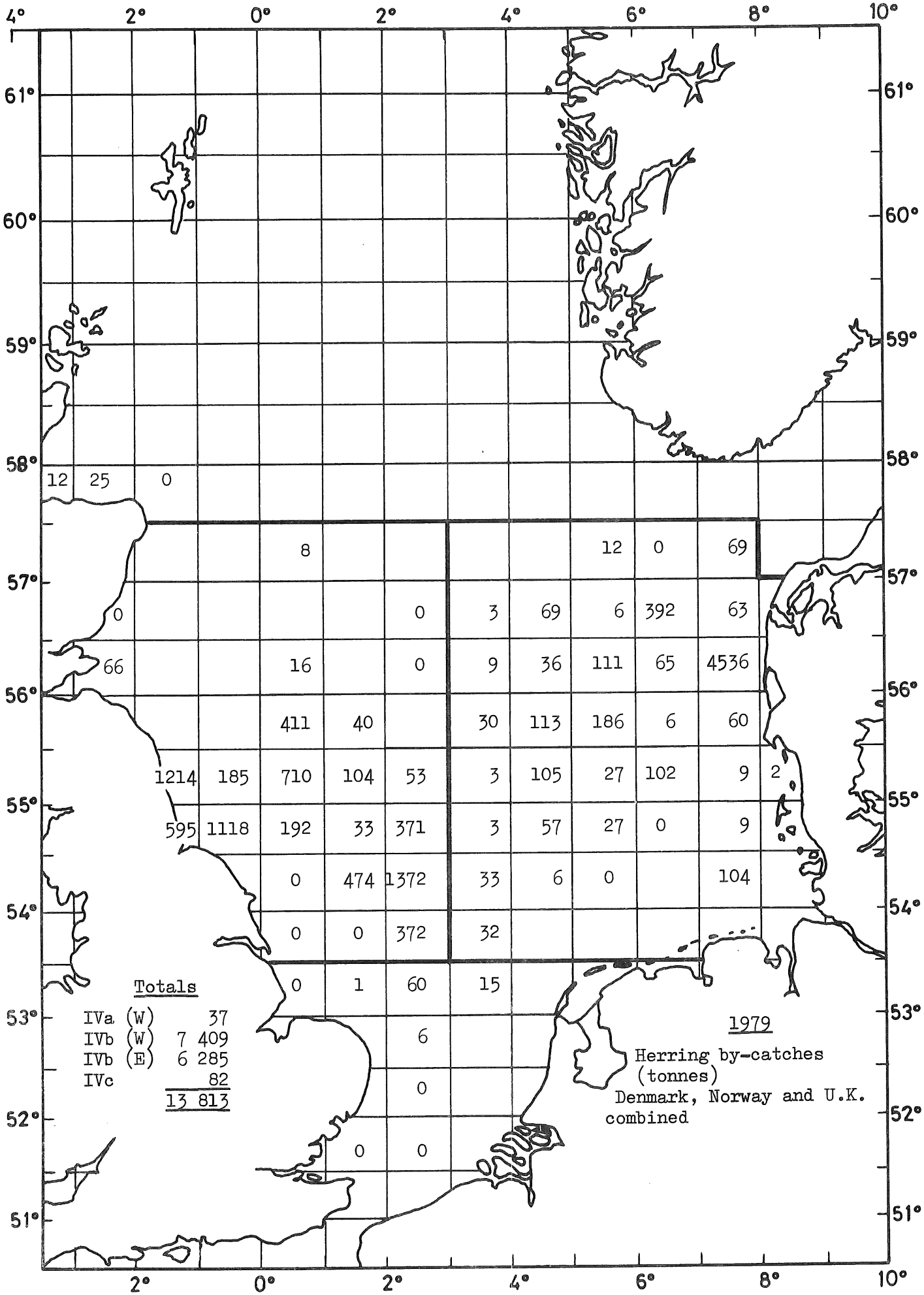
On the other hand, if by a suitable fishing technique a directed sprat fishery could be maintained at certain times or in certain areas, then a change in the allowable by-catch percentage would help to concentrate fishing on sprats. For example, referring to catches onboard ship at any time, a zero or, at the most, 5% herring by-catch might be allowed.

Table 1. Percentage of the North Sea sprat catch taken by quarters.

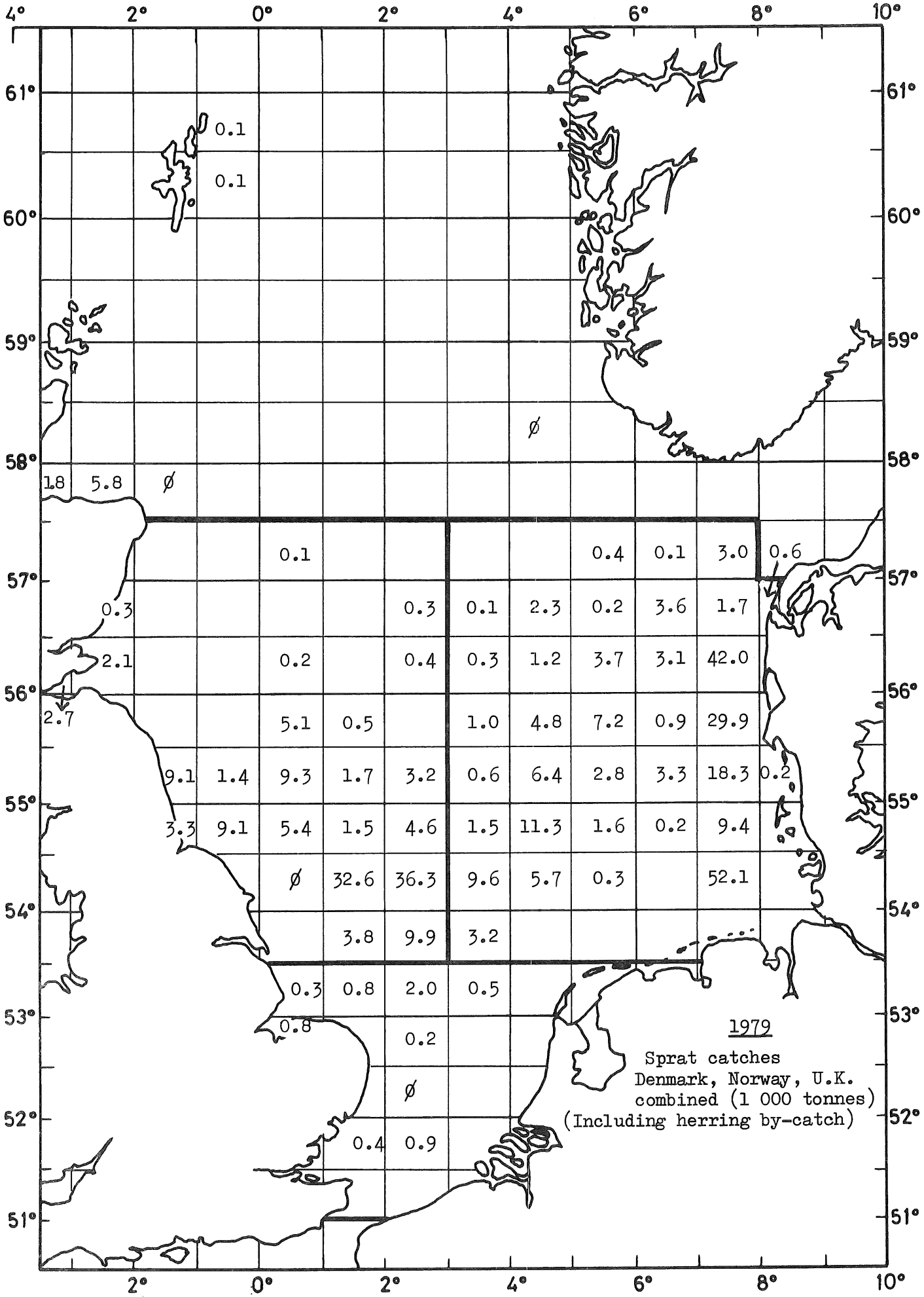
Year	Quarter			
	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
1974	39	9	23	29
1975	37	2	28	33
1976	42	5	26	27
1977	56	4	28	44
1978	24	1	35	40
1979	27	1	43	29

Table 2. 1979 Sprat catch (thousand tonnes) % = % herring, n = no. of samples.

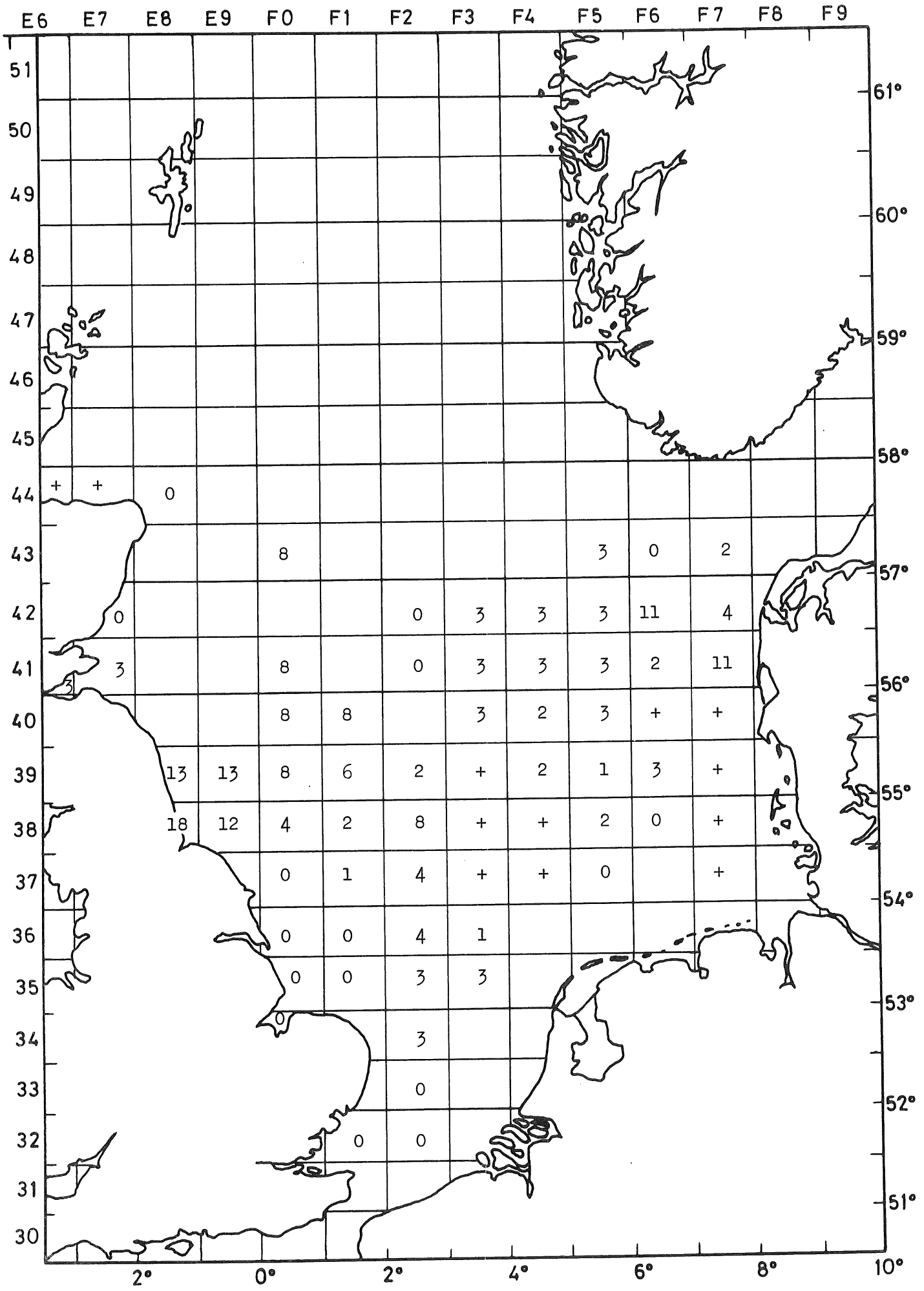
	Country	IVa			IVb						IVc		
		W of 2°E			W of 3°E			E of 3°E					
		C	%	n	C	%	n	C	%	n	C	%	n
Jan.-Mar.	Denmark				27.4	≃1	16	12.5	≃1	11	1.4	<1	4
	England				4.4	5.3	14				-		
	Germany,F.R.				-						-		
	Norway				29.7	5.9	1	18.4	-	-	3.1		
	Scotland	1.7	<1	3	3.9	4.2	10				-		
Apr.-June	Denmark												
	England				1.1			2.8	≃1	2			
	Germany,F.R.							0.8	1.4	1			
	Norway				+			+			+		
	Scotland				0.6								
July-Sept	Denmark							166.5	4.7	84	+		
	England												
	Germany,F.R.							0.9	<1	4			
	Norway												
	Scotland												
Oct-Dec	Denmark				36.4	6.5	18	31.4	≃1	11			
	England				8.5	18.8	21						
	Germany,F.R.												
	Norway				18.2	11.6	3	9.0	-	-			
	Scotland	6.1	<1	15	0.3	2	1						



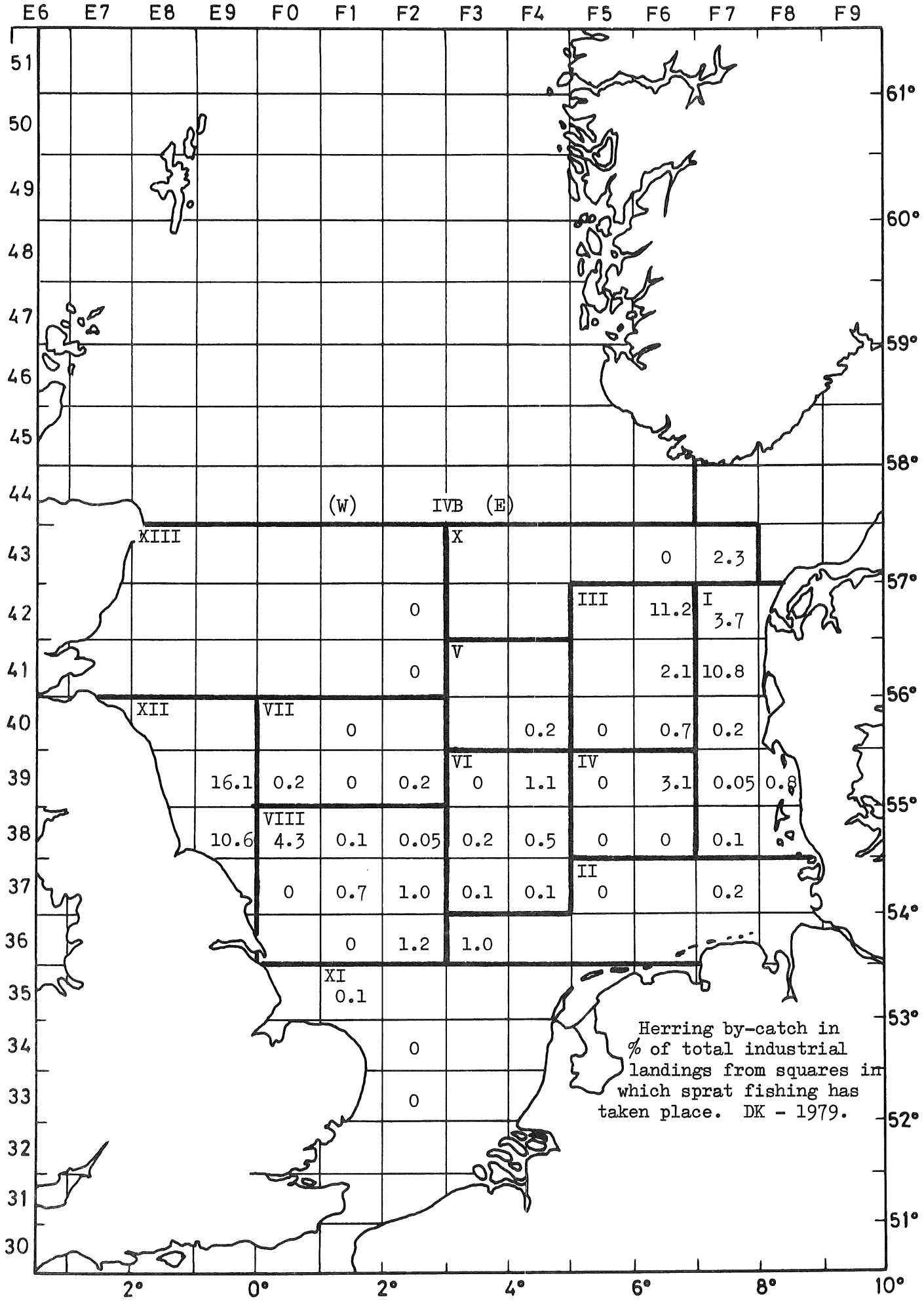
Addendum 2, Figure 1. Estimated herring by-catches in 1979.



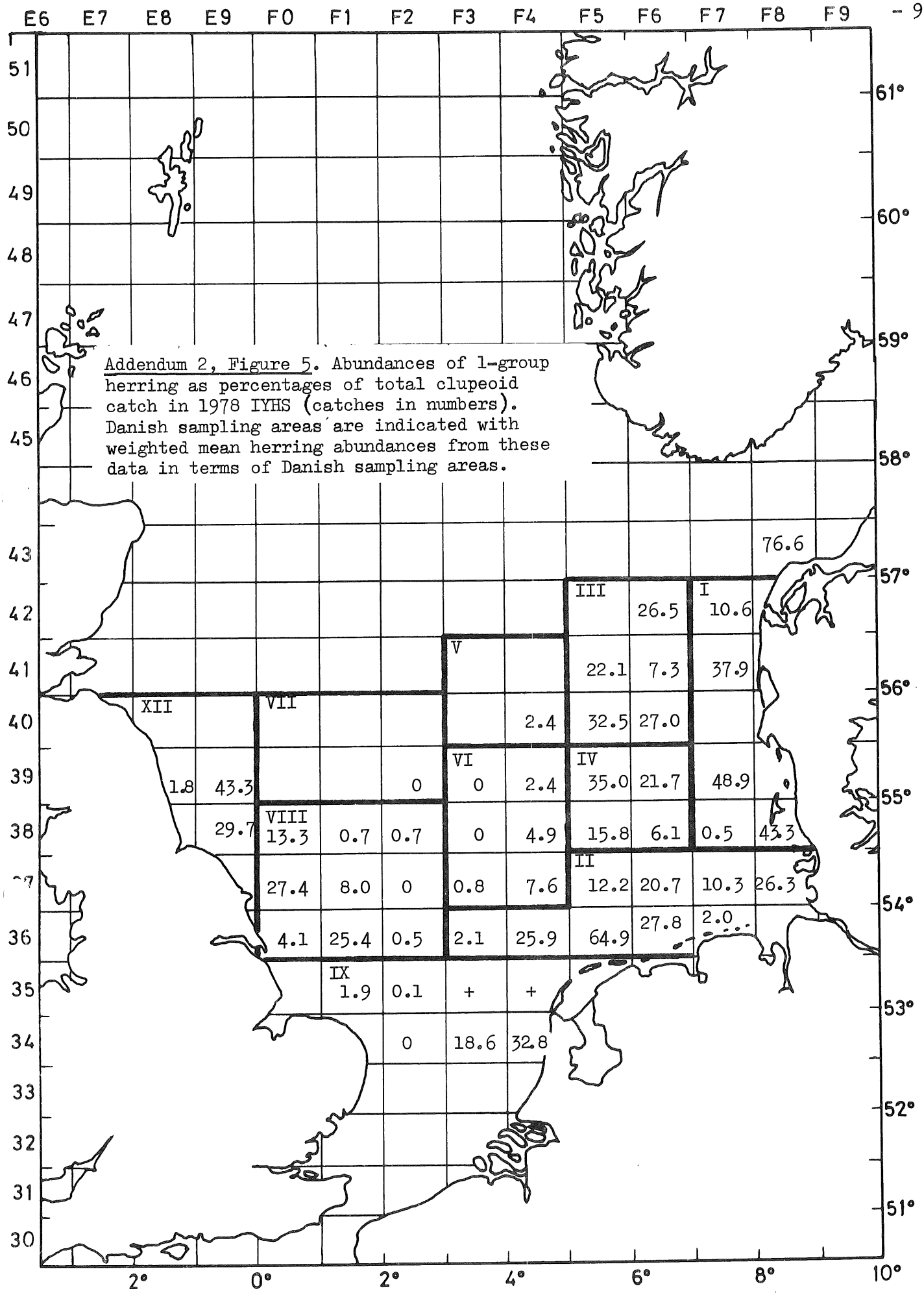
Addendum 2, Figure 2. Estimated sprat catches in 1979.



Addendum 2, Figure 3. Annual % herring by-catches as proportions of the international sprat fisheries.



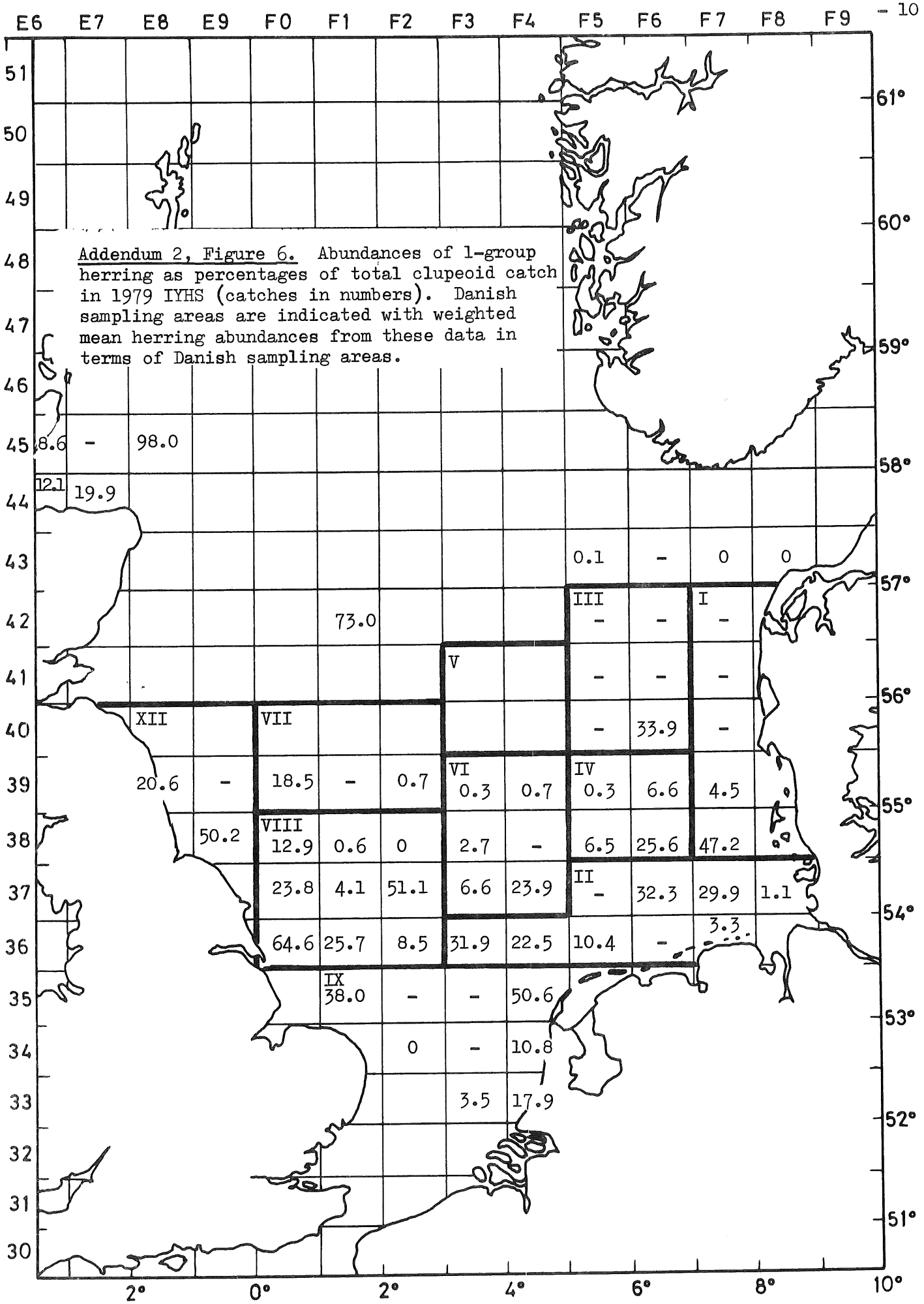
Addendum 2, Figure 4. Danish by-catch percentages and Danish biological sampling areas shown with Roman figures.



Addendum 2, Figure 5. Abundances of 1-group herring as percentages of total clupeoid catch in 1978 IYHS (catches in numbers). Danish sampling areas are indicated with weighted mean herring abundances from these data in terms of Danish sampling areas.

Footnote:

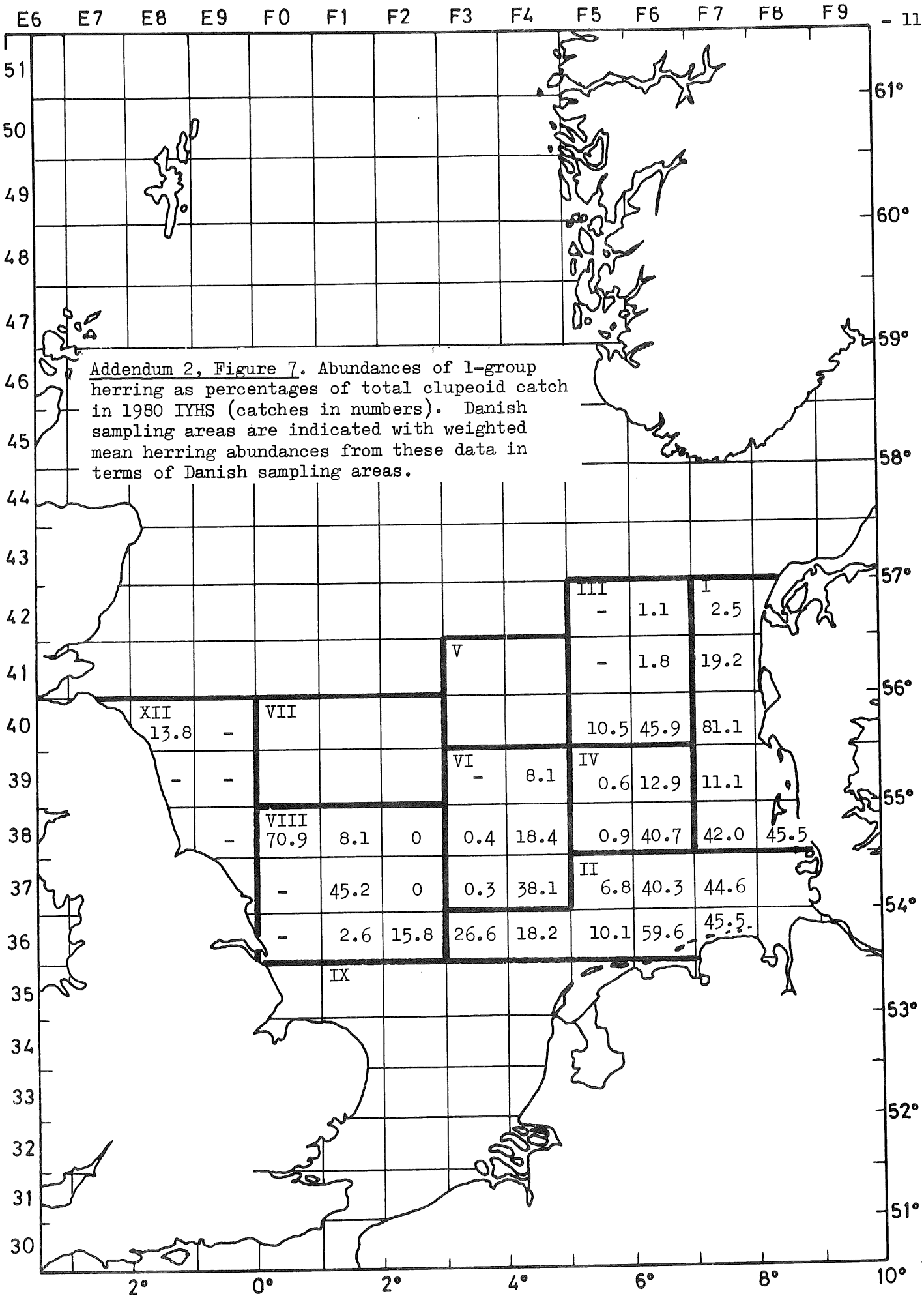
Areas	I	II	III	IV	VI	VIII	IX	XII
%	15.5	14.2	24.1	14.3	5.6	16.4	4.4	16.4



Addendum 2, Figure 6. Abundances of 1-group herring as percentages of total clupeoid catch in 1979 IYHS (catches in numbers). Danish sampling areas are indicated with weighted mean herring abundances from these data in terms of Danish sampling areas.

Footnote:

	Area	I	II	III	IV	VI	VII	VIII	IX	XII
IYFS	%	26.5	16.0	33.9	8.5	3.8	2.2	30.6	11.7	42.5
Danish Catch	no. samples		1			10		13/1		1/1
	%		0-1			0-1		0-1/1-2		0-1/1-2



Addendum 2, Figure 7. Abundances of 1-group herring as percentages of total clupeoid catch in 1980 IYHS (catches in numbers). Danish sampling areas are indicated with weighted mean herring abundances from these data in terms of Danish sampling areas.

Footnote:

Areas	I	II	III	IV	VI	VIII	XII
%	28.9	29.5	9.9	4.0	3.4	15.2	13.8