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REPORT ON THE 1985 ICES-COORDINATED HERRING ACOUSTIC SURVEY IN THE NORTHERN NORTH SEA

by

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Summary

This paper describes the results of an ICES coordinated acoustic survey of herring stocks in the northern North Sea carried out by Scottish and Norwegian research vessels in July 1985. Results in terms of the total numbers of herring in ICES statistical rectangles or quarter rectangles are given for the individual countries in Figures 3 and 7 and the combined results in Figure 8, based on methodology established in previous years. The numbers of herring at age and the biomass of herring likely to spawn in 1985 are given for subareas within the survey area in Tables 6, 7, 11 and 13 and estimates of mean length, weight and percentage mature at age in Tables 15, 16 and 17.

The total estimated biomass in the entire survey area was 572 000 tonnes of which 453 000 tonnes were maturing fish. Corresponding spawning stock biomasses for the area covered in 1984 and 1985 were 466 000 and 414 000 t in the two years respectively. An estimated 70% of 2-ringers were mature.

Estimates of sampling error due to survey coverage based on the delta distribution indicate confidence intervals of ±25% around the mean for the Scottish survey.

Introduction

In accordance with Council Resolution 1982/2:26 an acoustic survey of herring stocks was carried out in the northern North Sea in July 1985. The area covered was from 5°W to 7°E and from 56°30' to 61°N. This paper consists of two separate reports on the surveys carried out by the two participating countries followed by a section combining data from the two surveys and presenting a complete estimate for the area surveyed, and for ICES Division IVa.

REPORT ON SURVEYS BY NORWEGIAN RESEARCH VESSELS JULY 1985

Methods

During the period 16-28 July R/V "Eldjarn" and R/V "GO Sars" covered the North Sea plateau north of 57°N. The survey grid and stations are shown in Figure 1. A dense survey grid was worked along the east coast of Shetland and the Orkneys, while an open grid was worked in the south eastern part of the area. The cruises were planned with several objectives, and only the results from the herring survey are included in this report.

Technical data and settings of acoustic equipment are given in Table 1. Key data about the trawls used are given in Table 2. An instrument constant obtained from calibration with a standard target was applied in the echo integrator program to get outputs expressed as scattering cross section in square meters per square nautical mile. Then the area density of fish D_A is given by

$$D_A = S_A/\bar{\sigma}$$

where S_A is the measured scattering cross section.

$\bar{\sigma}$ is the average back-scattering cross section per fish and is given by:

$\bar{\sigma} = 9.5.\bar{L^2}.10^{-7}$ m² which follows from the recommended target strength equation:

$$TS = 20 \log L - 71.2$$

where L is fish length in cm.

The echo integrator values were averaged over intervals of five nautical miles. The contributions from pelagic traces identified as herring were separated directly during daily scrutinizing of the echo recordings. In some areas herring occurred in mixed recordings on the bottom. Then the nearest bottom trawl catches were used to calculate

$$\frac{\Sigma L^2 \text{ (herring)}}{\Sigma L^2 \text{ (total catch)}}$$

which was used as an estimate of the echo fraction of herring.

From each catch of herring 50-100 fish were sampled for length, weight, maturity stage and age. Those data were averaged within subareas defined in Figure 2. The average length distribution in each sub-area was used to calculate L^2 and TS.

Results

Figure 3 shows the estimated number of herring within each statistical rectangle or quarter statistical rectangle.

Most of the herring occurred in schools of moderate size 10-30 m off bottom at bottom depths from 80 to 130 m (Fig. 4a). In sub-areas G, H and I the herring tended to stay in very small schools mixed with other fish on the bottom (Fig. 4b) and some echo integrator contribution might have been lost in the dead zone along the bottom. The smallest herring (1-group and 0-group) were found in small schools in shallower water in sub-areas D, F and J (Fig. 4c). During darkness the herring tended to scatter and it was more difficult to distinguish them from plankton and other fish.

The trawl catches are listed in Tables 3 and 4. Many hauls were made to obtain samples of bottom fish and 0-group gadoids. Therefore the catches do not reflect the occurrence of herring.

Average length distributions, weights and target strengths of herring are shown for each sub-area in Table 5. The average age distributions within sub-areas were used to distribute the estimated abundance on age-groups (Table 6). In sub-area L no herring sample was obtained. Here the length distribution of a sample from a commercial purse seine catch taken in statistical square 44F6 (Fig. 2) on 4 July was applied and the age distribution was obtained by using the age-length key based on all herring samples from the survey (1615 age readings).

The number of fish per age-group within combined sub-areas is shown in Table 7.

The number of spawners per sub-area was found by considering all fish in maturity stage 3 or higher as spawners. Nearly all fish older than 2 rings were then spawners, while both the size and maturity of 2-ringers showed large geographical variations. In sub-areas A and B the average length of 2-ringers was 26.4 cm and 97.5% were spawners, compared to about 23 cm and 50-60% in sub-areas C, D and K.

The maturity staging does not seem to be significantly changed by freezing. Among 397 frozen 2-ringers 74.3% were classified as spawners, while among 291 fresh 2-ringers 72.6% were classified as spawners.

The number of spawners were converted to biomass by applying the average weight of 2 year and older fish. This tends to be slightly lower than the average weight of the spawners.

REPORT OF THE SURVEY BY FRV "SCOTIA" JULY 1985

Methods

The acoustic survey on "Scotia" was carried out using synchronised EK400 38 and 120 kHz sounders. The 38 kHz system was used for quantitative analysis and the 120 kHz sounder was used for comparative purposes. Echo integration was carried out using an Aberdeen Echo Integrator. Table 8 shows the equipment settings and performance data. Two calibrations of the acoustic equipment were carried out during the survey, and the results of these are included in the table. The survey track and positions of trawl hauls are shown in Figure 5.

The part of the echo integration value attributable to herring was extracted in the way described in Anon. (1982). Increments on an analogue-accumulating output were associated with specific shoal shapes on the echo sounder paper and these were compared with the results of nearby trawl hauls. Three levels of classification were used, "Herring", "Probably Herring", "Fish Probably Not Herring". The first two categories were used to provide the stock estimates. During the hours of darkness fish traces dispersed and usually became mixed with plankton layers. Allocation to species at this time was regarded as unreliable and only data from 0230 to 2200 GMT were used for analysis. The identity of fish echo traces were investigated using a Jackson mid-water trawl fitted with a 20 mm mesh codend. The catches were sampled for length frequency of herring (300 fish or more when available), and for age, sex and maturity, at five per ½ cm with an additional five from 22 to 25.5 cm inclusive from each trawl haul. In addition, 12 catches of herring were sampled for vertebral number (VS) and number of keeled scales (K_2), 50 fish being selected at random from the catch.

Results

A total of 111 quarter statistical rectangles were covered with 501 half hour periods of acoustic data and 31 trawl hauls. Of the trawls 25 provided samples of the echo traces and 20 of these had significant proportions of herring. Sprat, mackerel, haddock and blue whiting were also caught and sandeels and 'O' group Norway pout were often meshed in the tunnel. Details of the trawls are given in Table 9 with length compositions of herring which were used to define the sub-areas used in the analysis in Table 10. Sprats were found in the Moray Firth, O-group Norway pout west of Orkney, and a single haul of Argentina silus was made west of Shetland in deeper water at a depth of 150 m.

In order to determine target strengths for each part of the area surveyed the length distributions from trawl hauls with more than 4 kg of herring were considered. The complete area surveyed was divided into five regions or sub-areas by combining length frequency data from each haul with equal weighting. The target strength of herring for each sub-area was calculated from the mean length frequency distribution using the formula recommended by the Acoustic Survey Planning Group (Anon., 1983).

$$TS = 20 \log L - 71.2 \text{ dB}$$

where TS is the target strength of individual fish in dB and L in cm.

The mean target strength for each sub-area (Fig. 6) was calculated by obtaining the scattering cross-section at each length and obtaining an average value using the mean fractional length frequency as a weighting factor. The values for each sub-area are given in Table 10.

Fish weight is calculated using the weight-length equation derived from fish weighed at sea throughout the survey.

$W = 1.508\ E^{-3}\ L^{3.519}$ where W is in g and L in cm

The estimated number of herring in each quarter statistical rectangle is shown in Figure 7. These values are based on the arithmetic mean integrator output within each quarter statistical rectangle, and the number of ½ hour integrals is shown in the upper left hand corner of each rectangle. The breakdown by age and area is shown in Table 11.

In addition to the usual method of calculating the stock estimate for each quarter statistical rectangle, by taking the arithmetic mean of the half-hourly integrator outputs, the data were also processed in the manner described by MacLennan and

MacKenzie (1985). For completeness a brief description is included here, but for a more detailed argument of the procedure reference must be made to the above paper.

For each quarter statistical rectangle the following estimators were used. If X is a non zero observation (half hour intervals of integration), Y = ln(X), n = number of observations of which m are greater than zero.

Then if the mean = c, estimated variance = d and estimated variance of the sample mean = e.

Case 1	$m = 0$	$c = 0$
		$d = 0$
		$e = 0$
Case 2	$m = 1$	$c = X/n$
		$d = X^2/n$
		$e = X^2/n^2$
Case 3	$m>1$	s = variance of Y values
		$\bar{y}$ = mean of Y values
		$c = e^{\bar{y}}\, G(S/2)\, m/n$
		$d = e^{2\bar{y}}\, (G(2s) - ((m-1)/(n-1))\, G\, ((m-2)/(m-1)))\, m/n$
		$e = (e^{\bar{y}}\, G\, (S/2)\, m/m)^2 - e^{2\bar{y}}\, G\, ((m-2)S/(m-1))\, m\, (m-1)/(n(n-1)$

G (t) is calculated by the following subroutine.

```
10 LET A = 1 + (m-1)t/m:  LET T = (m-1)³ t²/2/m²/(M+1)
20 j = 3
30 IF T < 1 E-6 THEN G (t) = A+T: RETURN
40 LET A = A+T:  LET T = T (m-1)²t/m/(m+2j = 3)/j
50 LET j = j+1:  GOTO 30
```

This method of estimation assumes that the non-zero values are a good fit to the log normal distribution and the complete distribution is a delta distribution of the form

$$P[X>=x] = 1 - p \text{ for } x = 0$$
$$= p\, F(x) \text{ for } x > 0 \qquad F(x) \text{ is log normal distribution}$$

In addition to this the data are assumed to be uncorrelated. The Kolmogorov-Smirnoff test has been used to check for log normal distribution and the auto-correlation function calculated to test for correlation.

The values for five sub-areas are shown in Table 12 for arithmetic and delta distributions along with 95% confidence limits calculated from the delta distributions. The confidence levels for this survey calculated by the above method are $\pm$ 25% which compares well with the value of $\pm$ 23% calculated for 1984.

Combined Survey

The survey area and track density were chosen to make the best use of the three vessels available. A small amount of overlap was arranged and the whole survey was designed with the intention of providing a combined result for the whole area.

The acoustic data from each survey were converted to numbers of fish using TS values shown in Tables 5 and 10 and then combined giving equal weight to each half hour or five mile section of survey track. The data were combined on quarter statistical rectangles where these were available and on full statistical rectangles where track density was lower (Fig. 8). The biological data for the survey were combined from original trawl data and the age structure of the stock was calculated on an area basis by weighting the data by the number of otoliths taken from each haul. The areas are shown in Figure 9. The number and biomass for the total (Table 13) and mature fish (Table 14) are shown along with mean weight (Table 15), mean length (Table 16) and percentage mature for 1, 2, 3 and 4 ring fish (Table 17). In addition Tables 13 and 14 show the number and biomass calculated from the mean weight (Table 15) and the results for ICES area IVa east to 2°E. The total estimate for the north western North Sea (the area shown in Fig. 9) is 551 thousand tonnes with a small additional population east of 4°E and south of 58°N which is not included in these tables. Details of this population can be found in Table 6 area L.

Biological Data

On both the Norwegian and Scottish surveys in 1985, the predominant age group of herring was 2-ringers of the 1982 year class. In terms of percentage age composition by area given in Table 13, however, this year class was not uniformly distributed over the survey area. In the areas west of the Orkneys and south of Shetland - Buchan it made up 60-80% of the total in number, whereas to the east and west of Shetland, it constituted only 30-40%. In the latter two areas older herring were significantly more abundant both in terms of percentage contribution and absolute abundance, and it is estimated that 80% of all 4-ringers and older were in areas I and II in Figure 9.

Major quantities of immature 1-ringers were found only in two small areas to the north and east of the Orkneys (Areas V and VII in Fig. 9, cf Table 13).

Despite the major component of 2-ringer recruits in the herring population in July 1985 the results do not indicate that the total biomass had changed significantly since July 1984 (Anon., 1985a). The estimated total biomass of herring at maturity stages III and higher (ie fish likely to spawn the same year) in the area covered in both years was 466,000 t in 1984 and 414,000 t in 1985.

On the 1984 survey the proportion of 2-ringers that were mature was estimated to be 72 and 90% of the total on the Scottish and Norwegian surveys respectively. In 1985 the overall proportion was 70%, while an estimated 94% of 3-ringers were mature.

At the 1985 meeting of the Herring Assessment Working Group (Anon., 1985b), it was suggested that a proportion of 2-ring herring in ICES Division IVa in July belonged to populations that spawn further south in Division IVb. This was based on variation in the mean-length at age over the survey area. The possibility of heterogeneity in terms of stock composition within the survey area in 1985 was tested once again by examining mean lengths at age in each area but in addition 12 samples of herring were examined for numbers of vertebrae (VS) and keeled scales (K_2), and for the back-calculated length at age 1 (L_1) based on otolith measurements (for haul positions, see Table 10).

Mean lengths at age in each area (Table 16) indicate that the largest herring at age were present in the northern parts of the survey area. The meristic and L_1 data do not present any clear pattern and the results of this investigation will be presented elsewhere after further analysis.

References

Anon. 1982. Report on the 1982 Herring Acoustic Survey in the Northwestern North Sea. ICES CM 1982/H:47.

Anon. 1983. Report of the 1983 Planning Group on ICES-Coordinated herring and sprat acoustic surveys. ICES CM 1983/H:12.

Anon. 1985a. Report on the 1984 Herring Acoustic Survey in the Northern North Sea. ICES CM 1985/H:34.

Anon. 1985b. Report of the Herring Assessment Working Group for the area south of 62°N. ICES CM 1985/Assess:12.

MacLennan, D.N. and MacKenzie, I.G. 1985. Precision of results from acoustic surveys. ICES CM 1985/B:17.

Table 1 Technical data and settings of acoustic equipment

	R/V "GO Sars"	R/V "Eldjarn"
Echo sounder	Simrad ES 400	Simrad ES 400
Frequency	38 kHz	38 kHz
Receiver gain	- 10 dB	- 10 dB
Time varied gain	20 logR + 2.0.008·R	20 logR + 2.0.008·R
Pulse length	1.0 ms	1.0 ms
Bandwidth	3.3 kHz	3.3 kHz
Transducer	30 x 30 cm	30 x 30 cm
Effective beam angle (10 log ψ)	-19.6 dB	- 19.6 dB
Basic range	150 m	150 m
Source level + Voltage response	135.9 dB	136.7 dB
Integrator	NORD-10 computer	NORD-10 computer
Integrator gain	40 dB	40 dB
Integrator threshold	17 millivolts	17 millivolts
Instrument constant (C_1) for survey settings	0.33	0.29
Date of calibration	16 July 1985	16 July 1985

Table 2 Technical data of trawl equipment

	R/V "GO Sars"		R/V "Eldjarn"	
	Pelagic	Bottom	Pelagic	Bottom
Trawl type	Fotø (Mod 84) herring trawl	Campelen shrimp trawl	Capelin trawl	Campelen shrimp trawl
Vertical opening (typical)	15 m	5 m	15 m	5 m
Mesh size front (stretched)	6400 mm	80 mm	200 mm	80 mm
Mesh size cod end (stretched)	11 mm	6 mm	10 mm	6 mm
Bridle length	100 m	40 m	80 m	40 m
Door shape	Circular		Rectangular	
Door weight	500 kg		1700 kg	
Door area	4.6 m²		8 m²	

Table 3 Trawl catches R/V "Eldjarn" 16-28 July 1985
P = pelagic trawl, B = bottom trawl

ST NO	DATE	GMT	POSITION N	POSITION E/W	CATCH (number of fish) Herring	Whiting	Haddock	N.pout	Others	TOTAL kg
B 376	18	0047	60°45'	E02°49'	-	13	102	11	83	69
B 377	18	0644	60°44'	E01°52'	-	190	173	-	40	+
B 378	18	0900	60°45'	E01°17'	-	30	118	68	74	110
P 379	18	1909	61°05'	W00°35'	-	11	1	-	-	+
B 380	18	2259	61°38'	W00°23'	-	-	42	263	268	164
B 381	19	1059	61°35'	E01°25'	-	3	2	-	479	525
B 382	19	1646	61°33'	E00°13'	-	1	12	540	195	107
P 383	19	2310	61°21'	E01°06'	-	59	44	-	-	+
B 384	20	0652	61°05'	E02°32'	-	10	16	395	76	124
P 385	20	1130	61°04'	E01°18'	-	153	51	-	-	+
B 386	20	1656	60°57'	E00°01'	39	34	79	802	287	620
P 387	20	1916	60°54'	E00°01'	-	-	1	-	6	+
P 388	20	2120	60°45'	E00°06'	1278	-	-	-	6	326
B 389	21	0038	60°34'	E00°32'	-	29	77	490	52	37
B 390	21	0513	60°35'	E01°58'	-	6	81	282	56	117
P 391	21	0931	60°36'	E02°57'	-	43	114	-	1	2
B 392	21	1440	60°17'	E03°05'	-	-	70	-	415	454
P 393	22	2036	60°19'	E01°30'	-	1450	1740	30	20	32
P 394	23	0515	60°05'	E01°20'	-	640	455	-	82	+
P 395	23	1401	59°49'	E03°24'	-	-	-	-	20000	32
B 396	23	1643	59°49'	E03°06'	-	-	2	-	625	538
P 397	23	2334	59°50'	E01°20'	-	1173	450	-	21	4
B 398	24	0525	59°35'	E00°17'	36	17	162	116	211	121
P 399	24	0852	59°35'	E01°08'	-	108	55	5	-	+
B 400	24	1250	59°37'	E02°01'	-	6	267	8	73	110
P 401	25	1303	59°13'	E00°10'	-	1	4	-	-	+
P 402	25	1647	59°03'	E00°36'	-	8	2	1	5	2
B 403	25	1858	59°05'	E00°57'	495	43	300	910	277	261
P 404	25	2333	59°06'	E02°12'	-	1110	270	-	-	+
B 405	26	0230	59°04'	E03°06'	-	20	7	16	1957	1258
P 406	26	1138	58°50'	E02°06'	-	4	1	-	-	+
P 407	26	1448	58°51'	E01°27'	-	1	1	-	2	1
B 408	26	1712	58°50'	E00°52'	210	17	173	150	76	86
P 409	26	2332	58°37'	E00°44'	-	111	18	-	12	+
B 410	27	0454	58°35'	E02°07'	-	6	66	+	52	22
B 411	27	1645	58°20'	E03°41'	-	3	24	35	28	51

Table 4 Trawl catches R/V "G.O.Sars" 16-28 July 1985
P = pelagic trawl, B = bottom trawl

ST NO	DATE	GMT	POSITION N	POSITION E/W	CATCH (number of fish) Herring	Whiting	Haddock	N.pout	Others	TOTAL kg
B 328	17	0112	59°15'	E03°27'	-	-	-	498	82	151
P 329	17	0630	59°17'	E02°19'	-	6	38	-	1	3
B 330	17	0915	59°17'	E02°00'	-	-	95	-	18	60
P 331	17	1407	59°17'	E00°57'	-	44	145	-	1	2
B 332	17	1850	59°17'	W00°05'	390	2	85	441	16	106
P 333	18	0200	59°17'	W01°30'	-	-	-	-	6	1
P 334	18	0335	59°17'	W01°33'	103	2	-	-	-	5
P 335	18	0900	59°16'	W02°12'	573	55	60	-	1	22
B 336	18	1425	59°08'	W01°17'	1	5	1	12	6	2
B 337	18	1547	59°07'	W01°22'	208	83	119	557	112	112
B 338	18	2120	58°53'	W01°34'	154	58	27	23	7	36
P 339	19	0238	58°38'	W02°14'	2350	91	-	-	145	88
P 340	19	0700	58°38'	W01°09'	-	-	-	-	99	146
P 341	19	1040	58°52'	W00°44'	-	109	66	-	1	1
B 342	19	1618	59°24'	W01°12'	-	1	8	12	35	7
B 343	19	1736	59°23'	W01°12'	6	10	9	35	20	8
P 344	19	2040	59°24'	W01°55'	65	16	13	-	973	16
P 345	20	0009	59°31'	W02°09'	-	156	45	25	1027	6
P 346	20	0332	59°38'	W02°42'	2	26	22	1	2476	6
B 347	20	1240	59°47'	W01°41'	-	420	192	2464	237	299
P 348	21	0000	59°36'	W01°25'	-	743	480	7000	21	13
P 349	21	0407	59°45'	W01°09'	6117	-	-	-	-	630
B 350	21	0725	59°45'	W00°28'	-	23	118	707	121	81
P 351	21	1130	59°56'	W01°05'	-	33	180	-	-	1
P 352	21	1640	60°25'	W00°37'	30000	-	-	-	-	6000
P 353	22	2337	60°15'	W00°28'	-	103	299	1394	-	12
P 354	23	0453	59°43'	W00°14'	-	208	459	-	18	2
P 355	23	0900	59°15'	W00°22'	-	17	15	-	1	2
B 356	23	1150	58°58'	W00°25'	120	-	4	197	4	32
B 357	23	1520	58°29'	W00°24'	50	4	90	1403	123	109
P 358	23	2005	58°13'	E00°21'	900	51	72	-	4	138
B 359	24	1350	57°46'	E01°58'	3	5	157	5	40	42
P 360	24	1700	57°45'	E01°09'	-	122	28	-	4	1
B 361	24	1920	57°45'	E00°37'	168	77	287	300	14	82
P 362	25	0115	57°45'	W00°55'	2	89	91	-	5	1
P 363	25	0620	57°12'	W01°24'	1170	15	28	1	1357	15
B 364	25	1340	57°00'	W00°11'	84	21	167	50	7	65
P 365	25	1915	57°00'	E01°04'	-	28	16	-	2	+
B 366	25	2252	57°01'	E01°26'	4	-	-	4100	6	148
P 367	26	1920	57°00'	E04°26'	-	-	-	-	1	1
P 368	27	0035	57°00'	E05°17'	-	371	7	-	3920	17
P 369	27	1802	57°32'	E06°00'	-	17	18	-	1	1

Table 5 Mean length distribution (%), mean weight ($\bar{w}$) and mean target strength ($\bar{TS}$) within sub-areas. $\bar{w}_{2+}$ is mean weight of 2 year and older fish. Nos. measured is the number of fishes measured both for length, age and maturity. (Norwegian survey). Subareas are shown in Figure 2.

Sub-area	A	B	C	D	E	F	G	H	I	J	K	L
Length (cm)												
<14										100[1)]		
14						6.0						
15				8.3		34.0					1.2	
16				18.5		40.0					1.2	
17				30.2		18.0					3.5	
18			2.4	19.6		1.0	.5		.4		18.8	
19			3.7	8.7		1.0			1.6		32.9	
20			7.3	7.5					4.0		14.1	
21			9.8	4.2	.5		2.5		5.2		5.9	
22			30.5	.8	5.6		8.5	5.1	10.8		1.2	1.0
23			25.6	1.5	9.2		6.5	11.0	7.6		2.4	3.0
24	2.0	1.0	18.3	.4	14.8		19.6	32.1	13.1		5.9	14.0
25	11.0	11.0	2.4	.4	26.5		27.6	26.6	15.5		2.4	32.0
26	18.0	13.0			23.0		19.1	16.0	19.9		1.2	26.0
27	17.0	15.0			11.7		6.5	7.2	14.3		4.7	10.0
28	22.0	20.0			6.1		5.0	1.3	6.8		4.7	8.0
29	18.0	22.0			1.5		3.0		.8			4.0
30	6.0	13.0			1.0		1.0					
31	4.0	4.0										2.0
32	1.0							.4				
>32	1.0	1.0						.4				
No of samples	1	1	1	3	2	1	2	3	3	1	1	1
No measured	100	100	82	265	196	100	199	237	251	100	85	100
w (gram)	218	220	97	40	145	32	138	138	118	5	74	160
w_{2+} (gram)	218	220	106	94	145	-	138	138	123	-	125	160
TS(dB)	-42.4	-42.2	-43.8	-45.8	-43.1	-46.7	-43.2	-43.0	-43.4	-53.3	-44.7	-43.0

1) 0-group herring with mean length 7.9 cm and standard deviation 0.4 cm

Table 6. Number of herring per age group, total number and spawning stock (No= number, Bm= biomass) by sub-areas. All number in millions and biomasses in 1000 tonnes. (Norwegian survey).

Sub-area		A	B	C	D	E	F	G	H	I	J	K	L
Age													
0											73.5		
1				34.0	104.0	4.0	167.1	20.0	.3	82.7		26.3	.3
2		61.7	67.7	130.0	4.9	179.0		293.9	14.7	425.8		9.4	87.9
3		144.9	64.1			75.4		113.6	9.3	232.8		4.2	58.1
4		49.3	33.0			4.0		11.1	2.5	21.4		.0	9.1
5		24.7	11.0			1.3		2.2	.0	3.1		.0	2.4
6		21.6	.0			.0		2.2	.1	3.1		.0	1.8
7		.0	.0			.0		.0	.0	.0		.0	.0
8		3.1	1.8			.0		.0	.1	.0		.0	.5
9+		3.1	5.5			.0		.0	.1	.0		.0	.2
Total	No	308.4	183.1	164.0	108.9	263.8	167.1	443.1	27.2	768.9	73.5	39.9	160.3
Spawning	No	305.3	175.8	65.6	2.9	179.4	.0	363.3	24.2	561.3	.0	10.4	128.2
stock	Bm	66.6	38.7	7.0	.3	26.0	.0	50.1	3.3	69.0	.0	1.3	20.5

Table 7. Number of herring per age group, total number and spawning stock (No= number, Bm= biomass) by combined sub-areas. All numbers in millions and biomasses in 1000 tonnes. (Norwegian survey).

	Age	Shetland/ Orkneys, sub-areas A-G	Fladen/ Buchan, sub-areas H-K	Total area surveyed, sub-areas A-L
	0		73.5	73.5
	1	329.1	109.3	438.7
	2	737.2	449.9	1275.0
	3	398.0	246.3	702.4
	4	97.4	23.9	130.4
	5	39.2	3.1	44.7
	6	23.8	3.2	28.8
	7	.0	.0	.0
	8	4.9	.1	5.5
	9+	8.6	.1	8.9
Total	No	1638.4	909.5	2708.2
Spawning stock	No	1092.3	595.9	1816.4
	Bm	188.7	73.6	282.8

Table 8 Technical data at Acoustic System Settings ("Scotia")

Echo Sounder	EK400	EK400
Frequency	38 kHz	120 kHz
Receiver Gain	-10 dB	- 10 dB
TVG	20 log R + 2αR	20 log 12 + 2αR
V	.008 dB/m	.0366
Pulse Length	1.0 ms	1.0 ms
Bandwidth	3.3 kHz	3.3 kHz
Range	200 m	200 m
Transducer	15 by 30	19 element circular
Equivalent Beam Angle	-17.78 (measured)	-17.5 (measured)
Integrator	Aberdeen	Aberdeen
Threshold (effective)	20 mv	20 mv

Source level and voltage response referred to 1 m on TVG function, measured twice for 38 kHz system

13 July 1985	+ 54.39 dB//1 VRMS
23 July 1985	+ 54.23 dB//1 VRMS

VR + SL used for survey 54.31 dB measured using 38.1 mm diameter tungsten carbide ball TS = -42.36 dB.

Table 9. Trawl Catches Scottish Survey (numbers of fish)

Haul No	Shooting Pos Lat	Shooting Pos Long	Time Bst	Date	Herring	Whiting	Mackerel	Norway Pout	Haddock	Sprat	Blue Whiting	Others	Comments
210	58°41N	04°14W	14.44	13 Jul	32	3	-	-	6	79	-	43	"Others" is Gurnards. Small Sandeels meshed in tunnel Cyanea in codend.
211	59°18N	04°30W	14.10	14 Jul	2,064	-	-	-	6	-	102	-	A few small gadoids meshed.
212	59°25.21N	04°22W	20.58	14 Jul	173	1	-	-	2	59	-	7	Numerous norway pout meshed.
213	59°11.33N	03°24.59W	09.12	15 Jul	55	-	10	-	5	-	-	-	Large numbers of Norway pout meshed in tunnel.
214	59°29.1N	03°12.80W	18.55	15 Jul	29	-	43	-	1	-	-	1	Large numbers of 0 group pout meshed i in tunnel;
215	59°50.71N	03°24.95W	08.35	16 Jul	3,257	-	226	-	-	3	-	6	
216	59°25.4N	02°[illegible]0W	15.10	16 Jul	985	30	-	-	10	24	-	-	Numerous O-group sandeels meshed.
217	60°09.55N	02°25.85W	09.48	17 Jul	42,700	-	-	-	-	-	-	-	
218	60°24.1N	02°[illegible]3.8W	16.09	17 Jul	-	-	2	-	-	-	-	503	"Others" is <u>Argentina silus</u>
219	60°25.62N	02°30.80W	08.50	18 Jul	1,800	12	-	-	9	-	-	9	
220	60°55.22N	01°11.26W	19.10	18 Jul	426	-	1	-	14	-	72	8	
221	60°46.05N	00°24.56W	09.48	19 Jul	1,505	3	-	-	5	-	-	5	
222	60°46N	00°25W	12.23	19 Jul	-	-	2	-	-	-	-	-	
223	60°54.11N	00°17.48W	19.50	19 Jul	630	5	6	-	2	-	-	6	
224	60°54.20N	00°11.30W	21.00	19 Jul	1,764	-	-	-	-	-	-	1	
225	60°34.95N	00°27.55W	08.40	20 Jul	7,700	-	-	-	-	-	-	-	
226	60°10.19N	02°13.07W	10.10	21 Jul	421	-	14	-	2	-	6	10	1½ baskets N. pout meshed in tunnel
227	60°2N	02°21.5W	16.00	21 Jul	-	-	-	-	-	-	-	-	
228	59°15.52N	01°52.86W	09.30	24 Jul	49	3	5	-	22	135	-	7	Belly out. Large no O-group N. pout meshed in tunnel.
229	58°56.72N	01°16.20W	17.15	24 Jul	47,880	-	-	-	-	270	-	-	
230	58°53.39N	01°30.37W	08.20	25 Jul	43,400	-	-	-	-	5,067	66	-	
231	58°46'N	02°48.8W	15.28	25 Jul	-	-	-	-	-	-	-	-	O-group sandeels and a few O-group sprat meshed in tunnel; 1 basket Cyanea in codend and a few O-group haddock
232	58°30.44N	01°32.28W	09.25	26 Jul	14	-	-	-	-	1,045	-	1	
233	58°31.32N	01°27.49W	10.55	26 Jul	-	-	-	-	-	-	-	-	Cyanea; numerous O-group haddock and Whiting meshed in net
234	58°15.58N	00°46.15W	08.50	27 Jul	2,818	1	-	-	-	-	-	1	
235	58°12N	02°20W	15.08	27 Jul	785	-	-	-	-	2,331	-	-	
236	57°54.4N	01°01.48W	08.50	28 Jul	23,900	-	-	-	-	-	817	-	
237	57°57.33N	02°17.46W	20.20	28 Jul	4	-	-	-	1	234	36	-	
238	57°22.29N	01°29.81W	20.25	29 Jul	-	-	-	-	-	-	-	-	Basket of Cyanea; One or two <u>Ammodytes marinus</u> in belly.
239	56°57N	01°46.5W	17.25	30 Jul	19	2	-	-	-	300	32	-	
240	56°12N	00°42E	13.10	31 Jul	-	-	-	-	-	-	1	-	

Table 10 Percentage length composition, Target Strength, number otolithed (o) and measured (m) by trawl and by area (Fig. 6) from the Scottish survey. Hauls marked with an asterisk were also sampled for meristic characters.

L in cm	AREA 1 221*	223*	224	225*	Mean	AREA 2 217*	219*	220	226*	Mean	AREA 3 215*	216	228	Mean	AREA 4 210	211*	212	213	214	Mean	AREA 5 229*	230*	234*	236*	Mean
15																								0.1	
												4.8		1.6										0.1	
16											0.4	12.5		4.3										0.5	0.1
												16.3	4.1	6.8	6.3	0.4				1.3				1.2	0.3
17											5.5	11.9	8.2	8.5	9.4	0.8			3.4	2.7				1.3	0.3
											8.5	14.3	30.6	17.8	6.3	1.6				1.6				1.1	0.3
18											15.8	14.6	20.4	17.0	3.1	0.4			10.3	2.8	0.6	0.2		1.3	0.5
							0.2			0.1	11.4	10.2	10.2	10.6	3.1				10.3	2.7	0.2	0.2		1.8	0.6
19									1.2	0.3	14.4	8.6	10.2	11.1		0.8	1.2			0.4	0.4	0.9		2.4	0.9
											9.6	3.6	4.1	5.7			1.2	1.8		0.6	0.4	1.2		2.0	0.9
20									0.5	0.1	6.6	2.0	2.0	3.6			0.6			0.1	1.5	0.5	0.2	2.0	1.0
									1.4	0.4	3.7	1.2		1.6	3.1		0.6			0.7	1.9	0.9	0.5	0.8	1.0
21									3.8	1.0	2.9		2.0	1.7			0.6			0.1	2.3	1.4	0.5		1.0
									5.2	1.3	2.2			0.7	3.1					0.6	3.0	1.8	0.9	0.2	1.5
22						0.2			12.6	3.2	1.8			0.6		0.8		3.6		0.9	3.2	1.2	0.2	0.4	1.2
						0.5	0.2		24.0	6.2	1.9			0.6		0.8		3.6		0.9	3.9	2.5	0.9	0.2	1.9
23		0.3			0.1		1.1		18.8	5.0	2.0			0.7		1.3		7.3		1.7	3.9	4.1	0.9	1.3	2.6
						0.7	1.6		14.0	4.1	2.1			0.7	12.5	1.6	2.9	1.8	6.9	5.2	5.6	5.1	1.4	1.5	3.4
24		2.5		1.0	0.9		3.6		9.5	3.3	1.8			0.6	15.6	7.4	11.0	12.7	6.9	10.7	6.8	3.7	3.7	4.0	4.5
	0.7	5.1		1.9	1.9	1.6	2.4		3.8	2.0	1.3		2.0	1.1	18.8	16.1	9.8	9.1	3.4	11.4	7.9	10.4	4.2	7.3	7.4
25	0.4	14.1		2.3	4.2	0.7	3.6	0.5	2.9	1.9	0.8			0.3	6.3	16.9	12.1	14.5	17.2	13.4	8.5	8.3	7.6	10.0	8.6
	1.1	18.6	3.1	6.5	7.3	2.1	3.3		0.7	1.5	0.9			0.3	6.3	18.5	11.0	5.5	10.3	10.3	11.8	10.8	10.9	11.7	11.3
26	5.4	18.4	2.0	6.5	8.1	2.3	2.4	0.5	0.7	1.5	0.8		2.0	0.9		12.8	7.5	10.9	10.3	8.3	9.0	8.5	10.1	12.3	10.0
	4.4	11.7	6.1	6.8	7.3	0.9	3.3	0.7	0.5	1.4	0.4			0.1	3.1	4.1	9.8	3.6	6.9	5.5	5.8	9.7	12.5	7.7	8.9
27	6.2	7.8	8.5	6.5	7.3	0.9	4.4	0.9		1.6	0.4			0.1		4.1	3.5	5.5		2.6	5.8	5.8	9.7	6.1	6.8
	6.6	5.9	10.5	10.1	8.3	3.5	3.3	1.9	0.2	2.2	0.6			0.2		4.9	5.2	5.5		3.1	4.1	5.1	10.4	6.3	6.5
28	9.8	2.2	12.9	13.0	9.5	6.6	6.2	3.3		4.0	1.0			0.3		2.5	4.6	5.5		2.5	4.1	6.0	6.7	4.8	5.4
	8.4	2.2	10.2	11.0	8.0	7.3	8.0	6.8		5.5	1.0			0.3		0.8	4.6	3.6		1.8	2.8	4.4	6.9	3.8	4.5
29	9.5	1.4	11.2	7.5	7.4	9.6	10.4	9.2		7.3	0.9			0.3	3.1	0.8	2.9	1.8	3.4	2.4	1.5	3.5	4.6	3.6	3.3
	9.5	2.2	11.2	7.5	7.6	11.0	10.7	11.3		8.2	0.4			0.1		2	6.4		6.9	3.1	1.9	1.4	4.2	2.1	2.4
30	7.7	1.4	8.2	5.2	5.6	10.1	9.8	7.0	0.2	6.8	0.4			0.1		0.4	2.9	1.8	3.4	1.7	1.3	1.2	1.4	1.0	1.2
	8.4	1.4	4.8	3.2	4.5	9.8	4.4	10.6		6.2	0.2			0.1			0.6			0.1	0.9	0.7	0.9	0.6	0.8
31	5.1	1.6	4.1	2.6	3.3	7.0	6.0	11.7		6.2							1.2			0.2	0.4	0.5	0.5	0.2	0.4
	5.1	0.8	1.7	4.5	3.0	6.3	4.4	8.9		4.9	0.1		4.1	1.4				1.8		0.4	0.4	0.2	0.2		0.2
32	4.4	0.6	2.0	1.0	2.0	5.2	2.7	6.3		3.5	0.1												0.2		0.1
	2.5	0.3	1.4	1.3	1.4	2.8	1.8	4.5		2.3															
33	1.1	0.3	.7	0.6	0.7	3.3	1.1	3.1		1.9															
	1.1		1.0	0.3	0.6	1.4	1.1	4.5		1.7															
34	0.7	0.3			0.3	3.7	1.8	4.2		2.4														0.2	0.1
	1.5	0.3			0.4	0.9	1.1	2.3		1.1															
35	0.4			0.3	0.2	1.2	0.2	1.6		0.8															
		0.3	0.3	0.3	0.2	0.2	0.4	0.2		0.2															
36							0.2			0.1															
37																									
TS	-41.8	-42.6	-41.9	-42.1	-42.1	-41.6	-41.9	-41.4	-43.9	-42.1	-45.0	-46.2	45.5	-45.5	-44.0	-43.1	-42.8	-43.0	-43.4	-43.2	-43.1	-42.9	-42.6	-43.0	-42.9
No O	89	105	80	98		118	148	90	94		179	54	34		32	96	100	54	0		162	153	117	162	
M	274	358	294	308		427	450	426	271		595	336	49		32	243	173	55	29		532	433	434	618	

Table 11. Number, mean length, mean weight and biomass for totals and mature fish **by age** and by area (Fig. 6) from the Scottish survey

AREA	AGE	Total				% Immature		Mature			
		No $x10^6$	L cm	W gm	Biomass Tonnes $x10^3$	by No	by Wt	No $x10^6$	L cm	W gm	Biomass Tonnes $x10^3$
1	1										
	2	169.9	26.3	152	25.8	15.2	13.8	144.1	26.4	154	22.2
	3	183.1	28.6	203	37.1	0.9	0.5	181.5	28.6	203	36.9
	4	60.3	30.4	251	15.1			60.3	30.4	251	15.1
	5	25.9	31.0	269	6.9			25.9	31.0	269	6.9
	6	8.8	32.2	307	2.7			8.8	32.2	307	2.7
	7	6.2	32.0	302	1.8			6.2	32.0	302	1.8
	8	4.4	33.5	354	1.5			4.4	33.5	354	1.5
	9	2.0	33.9	371	0.7			2.0	33.9	371	0.7
	10	4.2	34.2	379	1.5			4.2	34.2	379	1.5
	Total	465.2	28.3	201	93.5	5.9	4.0	437.8	28.5	205	89.8
2	1	11.4	21.6	76	0.8	100.0	100.0				
	2	102.3	23.8	108	11.0	68.3	61.9	32.4	25.1	130	4.1
	3	101.0	29.0	214	21.6	1.5	1.1	99.4	29.1	215	21.4
	4	63.8	30.6	257	16.4			63.8	30.6	257	16.4
	5	25.2	31.1	272	6.8			25.2	31.1	272	6.8
	6	9.8	32.3	312	3.0			9.8	32.3	312	3.0
	7	7.7	33.7	359	2.7			7.7	33.7	359	2.7
	8	16.4	33.1	341	5.6			16.4	33.1	341	5.6
	9	6.9	34.3	385	2.6			6.9	34.3	385	2.6
	10	4.7	34.1	377	1.7			4.7	34.1	377	1.7
	Total	349.7	28.2	208	72.7	23.7	10.9	266.7	29.9	243	64.8
3	1	649.3	18.2	42	27.5	100.0	100.0				
	2	41.4	23.7	107	4.4	65.7	57.8	14.2	25.2	131	1.8
	3	11.9	27.6	180	2.1	10.9	9.1	10.6	27.8	184	1.9
	4	8.2	30.4	256	2.1			8.2	30.4	256	2.1
	5	3.3	31.2	275	0.9			3.3	31.2	275	0.9
	6	0.4	29.2	218				0.4	29.2	218	
	7	2.4	31.7	290	0.7			2.4	31.7	290	0.7
	8	0.1	32.2	307				0.1	32.2	307	
	9										
	10										
	Total	717.4	19	53	38	94.5	79.7	39.5	28	195	7.7
4	1	44.0	18.2	42	1.8	100.0	100.0				
	2	214.8	24.9	126	27.0	28.4	25.0	153.8	25.3	132	20.2
	3	59.2	27.4	177	10.4	2.1	1.2	57.9	27.5	178	10.3
	4	8.0	28.8	210	1.6			8.0	28.8	210	1.6
	5	9.9	29.9	238	2.3			9.9	29.9	238	2.3
	6	3.7	29.9	237	0.8			3.7	29.9	237	0.8
	7										
	8										
	9										
	10										
	Total	339.8	24.8	130	44.3	31.3	19.7	233.6	26.2	152	35.5
5	1	327.1	18.9	49	16.0	100.0	100.0				
	2	700.5	25.0	129	90.0	29.0	22.8	497.2	25.7	140	69.5
	3	257.0	27.9	187	48.1	1.9	1.4	252.0	28.0	188	47.5
	4	42.1	29.2	218	9.1			42.1	29.2	218	9.1
	5	17.9	30.0	239	4.3			17.9	30.0	239	4.3
	6	0.6	30.2	245	0.1			0.6	30.2	245	0.1
	7	1.2	31.2	276	0.3			1.2	31.2	276	0.3
	8	0.6	30.2	245	0.1			0.6	30.2	245	0.1
	9										
	10										
	Total	1347.3	21.3	125	168.4	39.7	22.1	812.0	26.7	162	131.2
Total	1	1031.9	18.5	45	46.3	100.0	100.0				
	2	1229.1	25.0	129	158.3	31.5	25.4	841.9	25.7	140	118.1
	3	612.4	28.2	195	119.6	1.7	1.2	601.7	28.3	196	118.1
	4	182.6	30.1	244	44.5			182.6	30.1	244	44.5
	5	82.4	30.7	260	21.4			82.4	30.7	260	21.4
	6	23.5	31.8	295	6.9			23.5	31.8	295	6.9
	7	17.7	32.6	324	5.7			17.7	32.6	324	5.7
	8	21.7	33.1	341	7.4			21.7	33.1	341	7.4
	9	9.0	34.2	382	3.4			9.0	34.2	382	3.4
	10	8.9	34.1	378	3.3			8.9	34.1	378	3.3
	Total	3219.6	24.2	130	417.2	44.4	21.1	1789.7	27.6	184	329.1

Table 12 Comparison of Arithmetic and delta means with 95% confidence limits for the Scottish survey

Area	Arithmetic Mean	Delta Mean	Confidence Interval %	Difference %
1	465.2	413.4	33.5	-11.8
2	349.7	332.04	37.6	-5.2
3	717.4	711.0	53.5	-0.9
4	339.9	337.4	45.5	-0.7
5	1347.4	1427.5	47.1	+5.8
Total	3219.6	3221.4	25.3	-0.1

Table 13. Total numbers (10^6) at age by area (Fig. 9) from the combined surveys, including biomass totals for the complete area and IVa

AREA \ AGE	1	2	3	4	5	6	7	8	9+	TOTAL
I		275.5	275.4	102.6	42.8	15.5	4.8	5.1	7.8	729.4
II	8.8	118.1	109.5	70.2	23.8	9.3	7.8	17.7	11.6	376.9
III	0.4	15.6	9.8	2.7		0.1		0.1	0.1	28.8
IV	36.5	139.4								175.9
V	268.5	83.7	14.4	3.6	1.3	0.6				372.1
VI	3.1	139.3	58.7	3.1	1.0					205.3
VII	219.8	8.0		.2			0.2			228.2
VIII	10.4	264.7	51.3	4.4	6.2	2.7				339.7
IX	26.8	485.5	144.4	19.4	3.4		0.4			679.9
X	74.7									74.7
XI	62.2	431.9	195.8	23.4	5.8	1.7	0.1	0.4		721.3
XII	23.0	8.2	3.7							34.9
TOTAL	734.2	1969.9	862.9	229.6	84.4	30.0	13.3	23.4	19.5	3967.1
TOTAL IVA	705.1	1806.6	829.2	227.0	80.8	28.4	13.3	23.4	19.5	3733.2
BIOMASS TOTAL	34.6	250.5	160.8	55.4	22.0	8.7	4.4	8.1	7.3	551.7
TOTAL IVA	33.2	230.1	155.1	54.8	21.1	8.4	4.4	8.1	7.3	522.6

Table 14. Mature fish (10^6) at age by area (Fig. 9) for the combined survey

AREA \ AGE	1	2	3	4	5	6	7	8	9+	TOTAL
I		208.8	258	102.6	42.8	15.5	4.8	5.1	7.8	645.4
II		73.3	105	70.2	23.8	9.3	7.8	17.7	11.6	318.8
III		13	9.6	2.7		0.1		0.1	0.1	25.6
IV		70.8								70.8
V		23.1	13.6	3.6	1.3	.6				42.2
VI		88.4	46.1	3.1	1.0					138.6
VII		4.4		.2			0.2			4.9
VIII		195.5	50.9	4.4	6.2	2.7				259.7
IX		347.3	136.8	19.4	3.4		0.4			507.3
X										0.0
XI		352	187.4	23.4	5.8	1.7	0.1	0.4		570.8
XII		5.3	3.7							9.0
TOTAL		1381.9	811.1	229.6	84.4	30.0	13.3	23.4	19.5	2593.0
TOTAL IVA		1262.0	777.6	227.0	80.8	28.4	13.3	23.4	19.5	2431.9
BIOMASS TOTAL		177.4	151.2	55.4	22.0	8.7	4.4	8.1	4.9	432.1
TOTAL IVA		162.5	145.5	54.8	21.1	8.4	4.4	8.1	4.9	409.6

Table 15. Mean weight at age from the combined survey

AREA	AGE 1	2	3	4	5	6	7	8	9+
I		156	203	253	269	298	297	343	365
II	60	131	198	255	267	315	358	349	380
III	112	125	145	164		210		255	495
IV	64	106							
V	49	104	184	219	235	218		307	
VI	97	126	173	200	260				
VII	38	98		290			290		
VIII	43	126	168	207	237	239			
IX	75	125	177	209	230		268		
X	32								
XI	63	124	175	199	219	221	379	245	
XII	47	97	189						

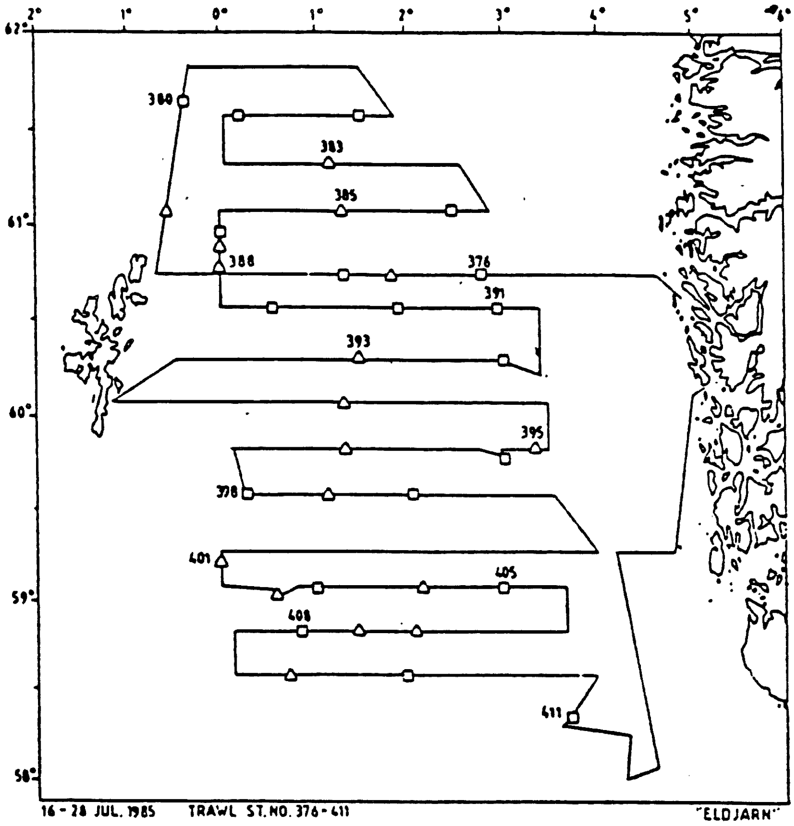
Table 16. Mean length at age from the combined survey

AREA	AGE 1	2	3	4	5	6	7	8	9+
I		26.4	28.4	30.3	30.7	31.7	31.9	32.8	34.2
II	20.1	25.2	28.3	30.5	31.0	32.5	33.6	33.4	34.3
III	23.8	24.5	25.8	26.7		28.5		32.5	37.5
IV	20.6	23.3							
V	19.1	23.6	27.7	29.2	29.9	29.2		32.3	
VI	22.5	25.0	27.3	28.5	30.5				
VII	21.1	25.1	27.3	29.0	30.5		31.8		
VIII	18.9	25.0	27.1	28.8	29.9	30.0			
IX	21.6	24.9	27.6	28.9	29.6	30.5	31.0		
X	16.3								
XI	20.4	25.1	27.4	28.4	29.5	29.2	34.3	30.3	
XII	19.1	22.5	27.8						

Table 17. Percentage mature at age from the combined survey

AREA	AGE 1	2	3	4
I		75.8	93.7	100
II	0	62.1	95.9	100
III	0	83.6	97.5	100
IV	0	50.8		
V	0	27.6	94.5	100
VI	0	63.4	78.6	100
VII	0	55.7	100	
VIII	0	73.8	99.3	100
IX	0	71.5	94.7	100
X	0			
XI	0	81.5	95.7	100
XII	0	65	100	

a



b

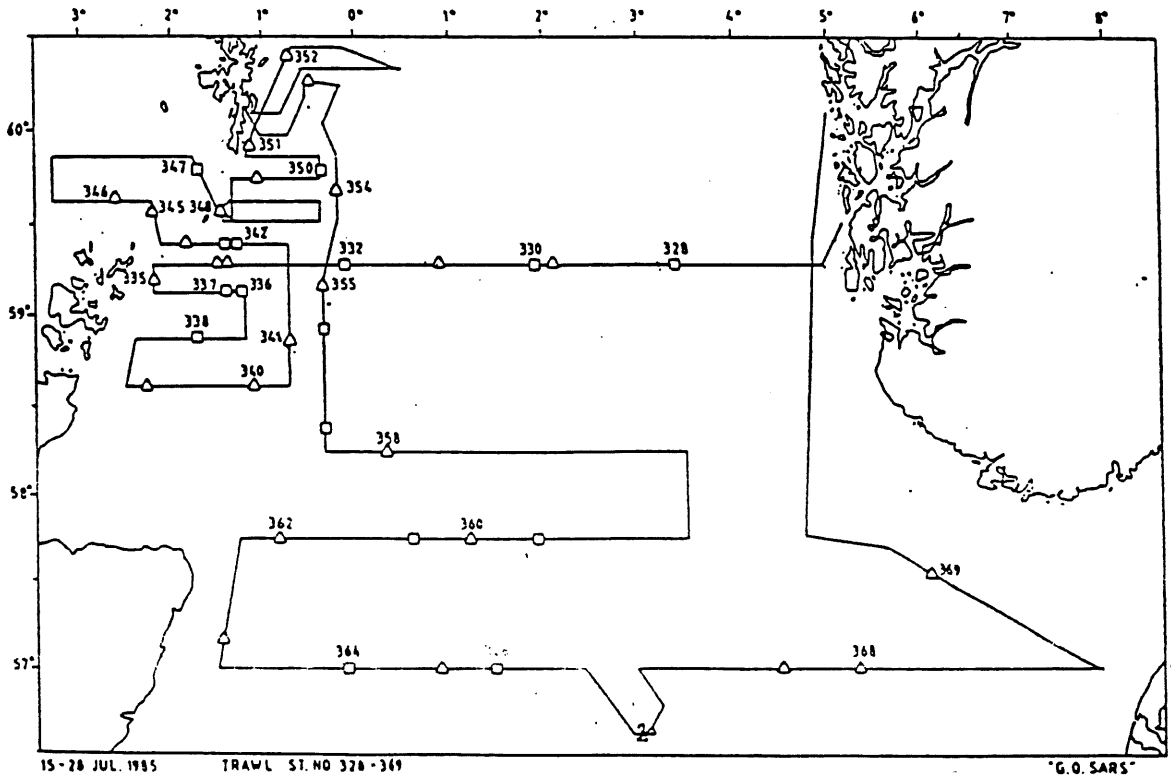


Figure 1. Survey grid and stations 16-28 July 1985
△ : Pelagic trawl, □ : Bottom trawl
a : R/V "Eldjarn"
b : R/V "G.O.Sars"

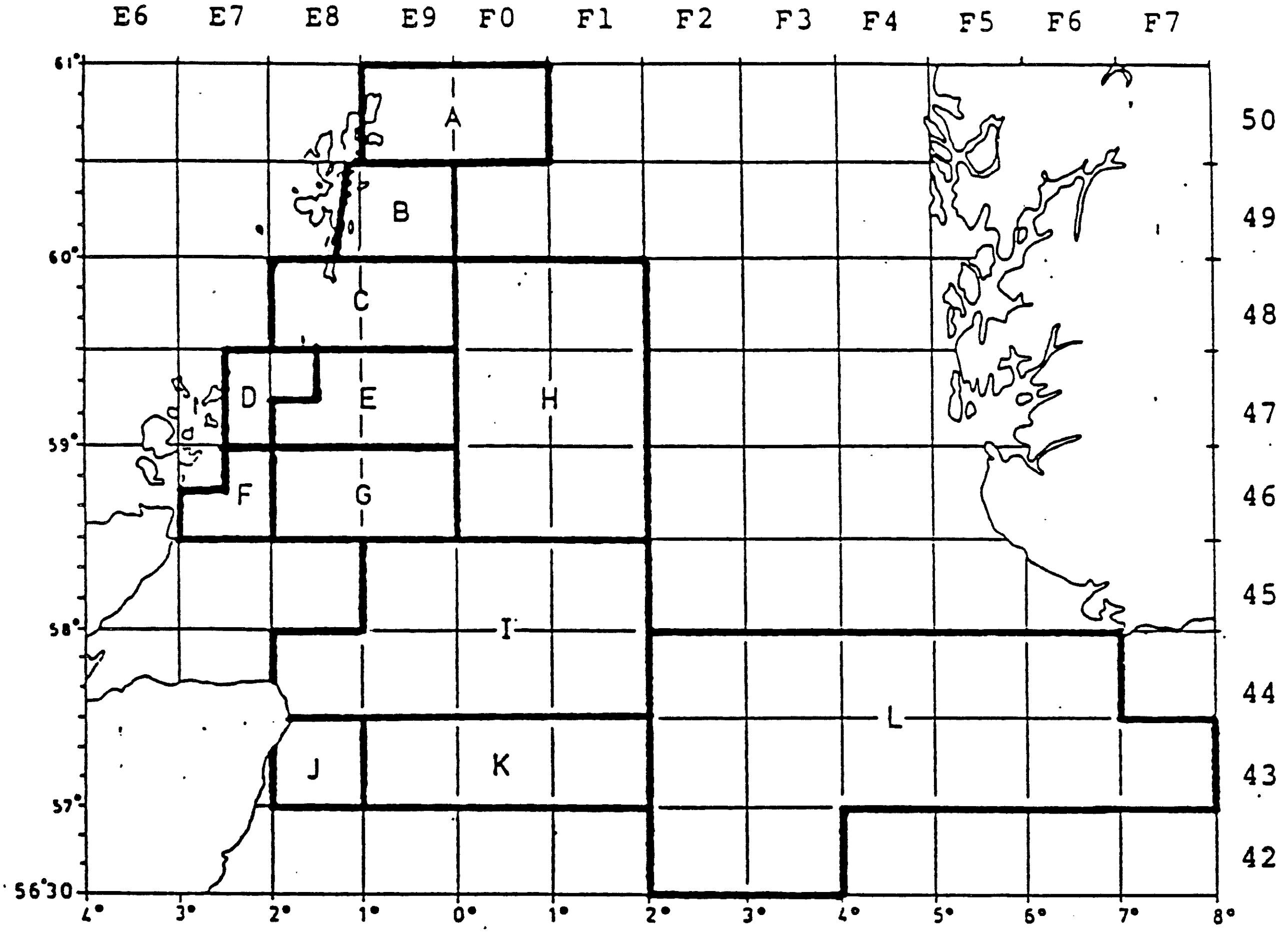


Figure 2. Definition of subareas

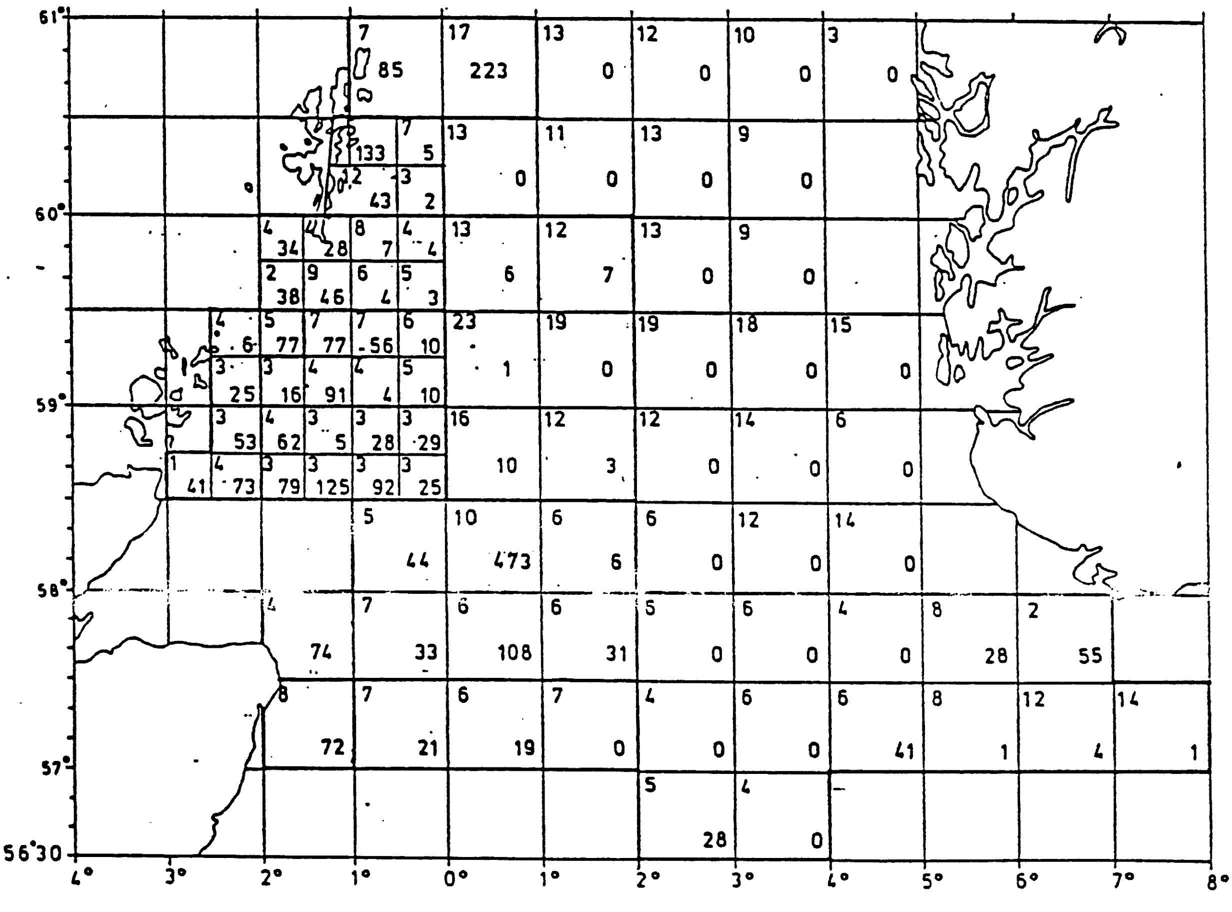


Figure 3. Estimated number of herring (millions) within statistical squares or quarter statistical squares. Number of five mile integrals is given in upper left corners. (Norw. survey)

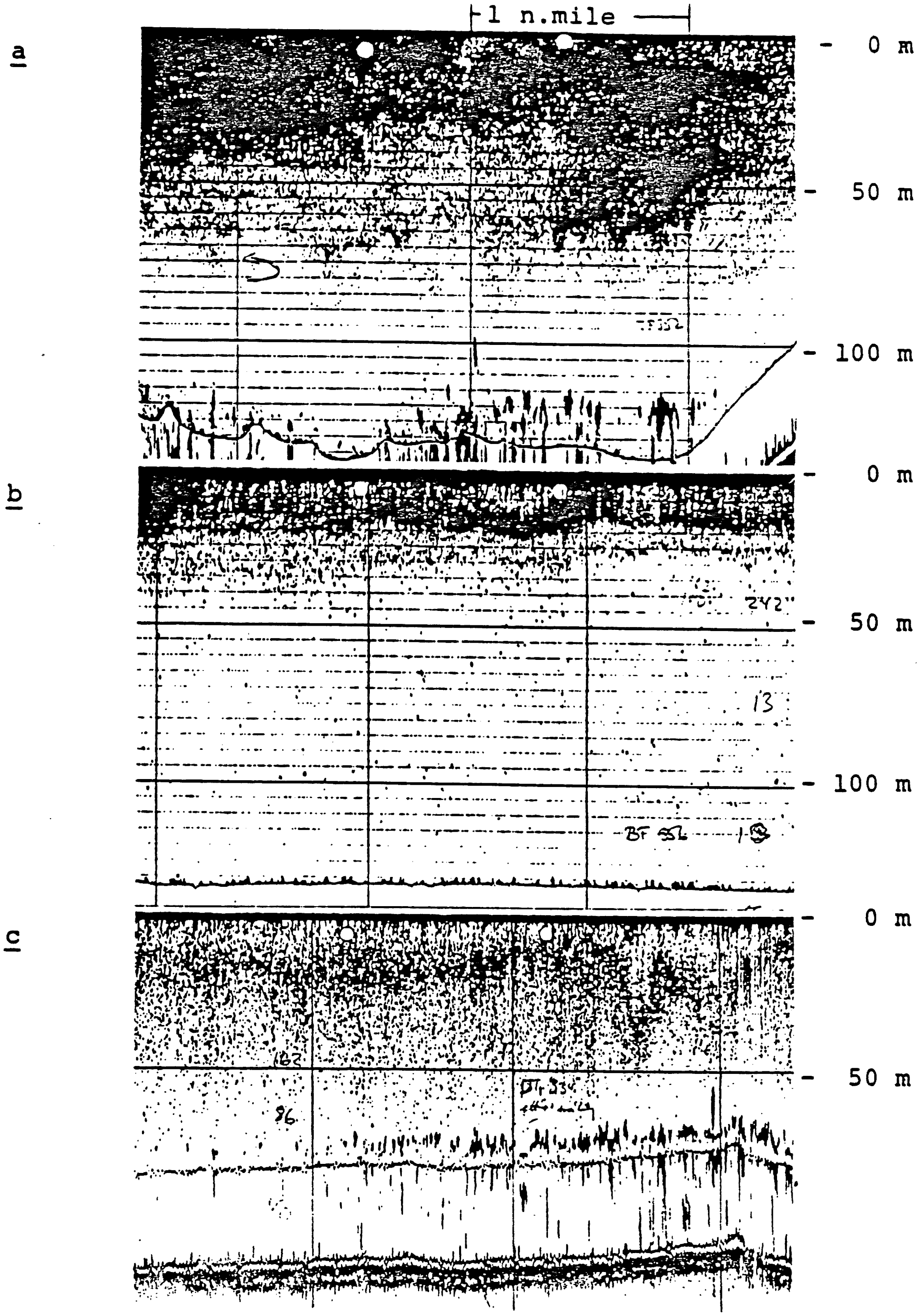


Figure 4. Typical echo recordings

a: schools of adult herring 10-20 m above bottom

b: adult herring mixed with other fish on the bottom

c: 1-gr herring in small schools 5-15 m above bottom

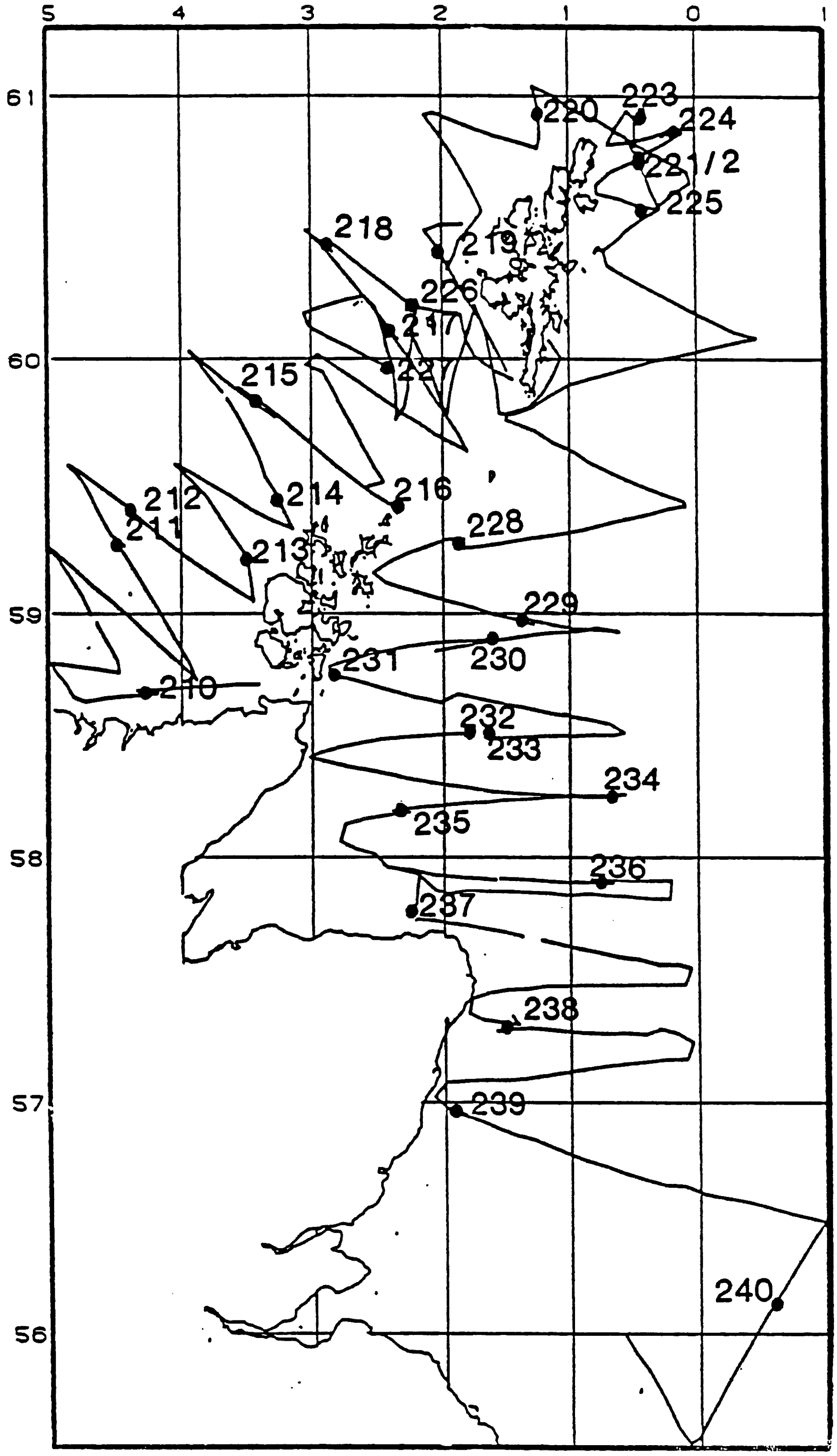


Figure 5. Cruise track and trawl positions for the Scottish survey

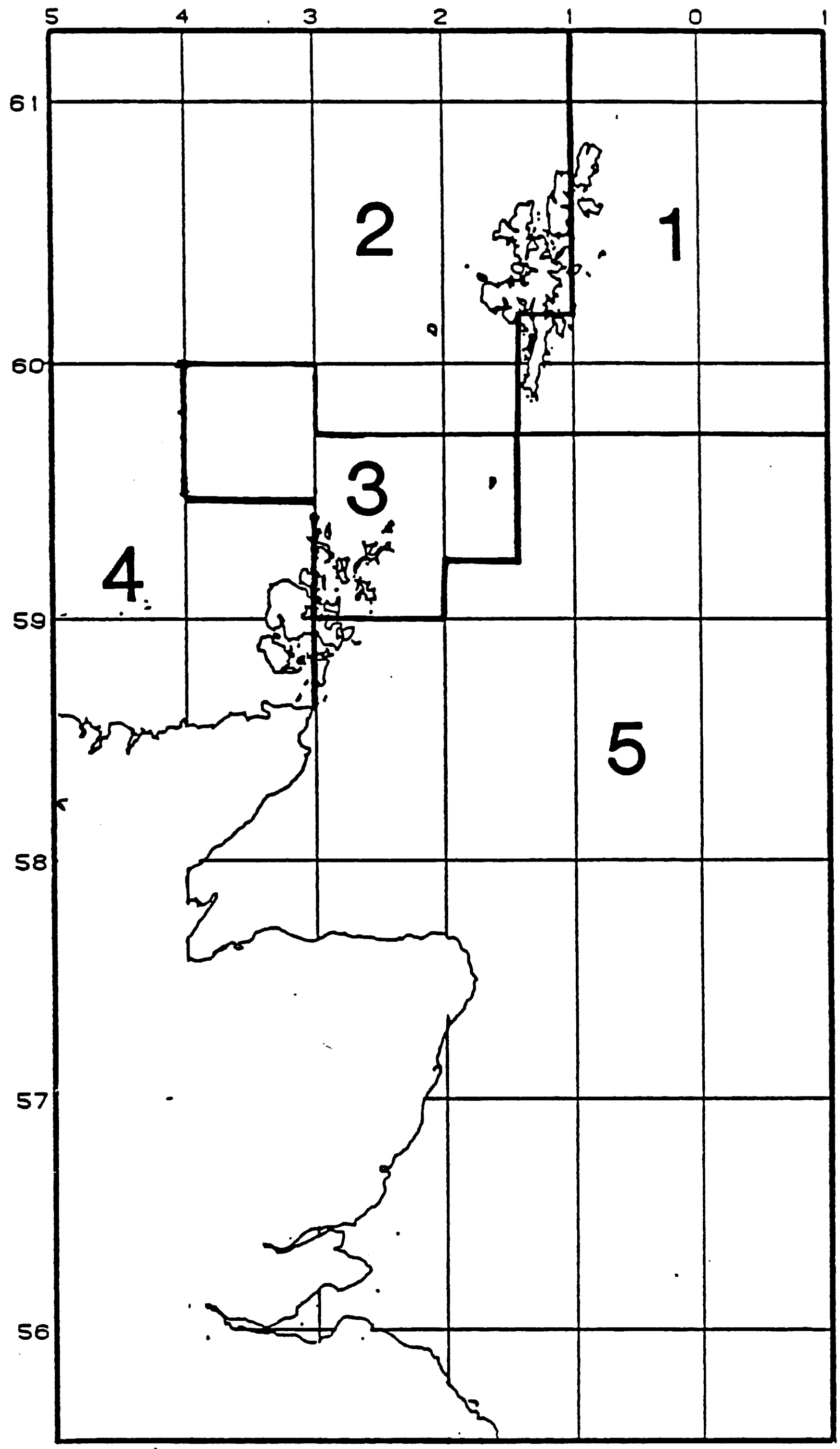


Figure 6. Chosen sub areas for target strength, length and weight data from trawls for the Scottish survey

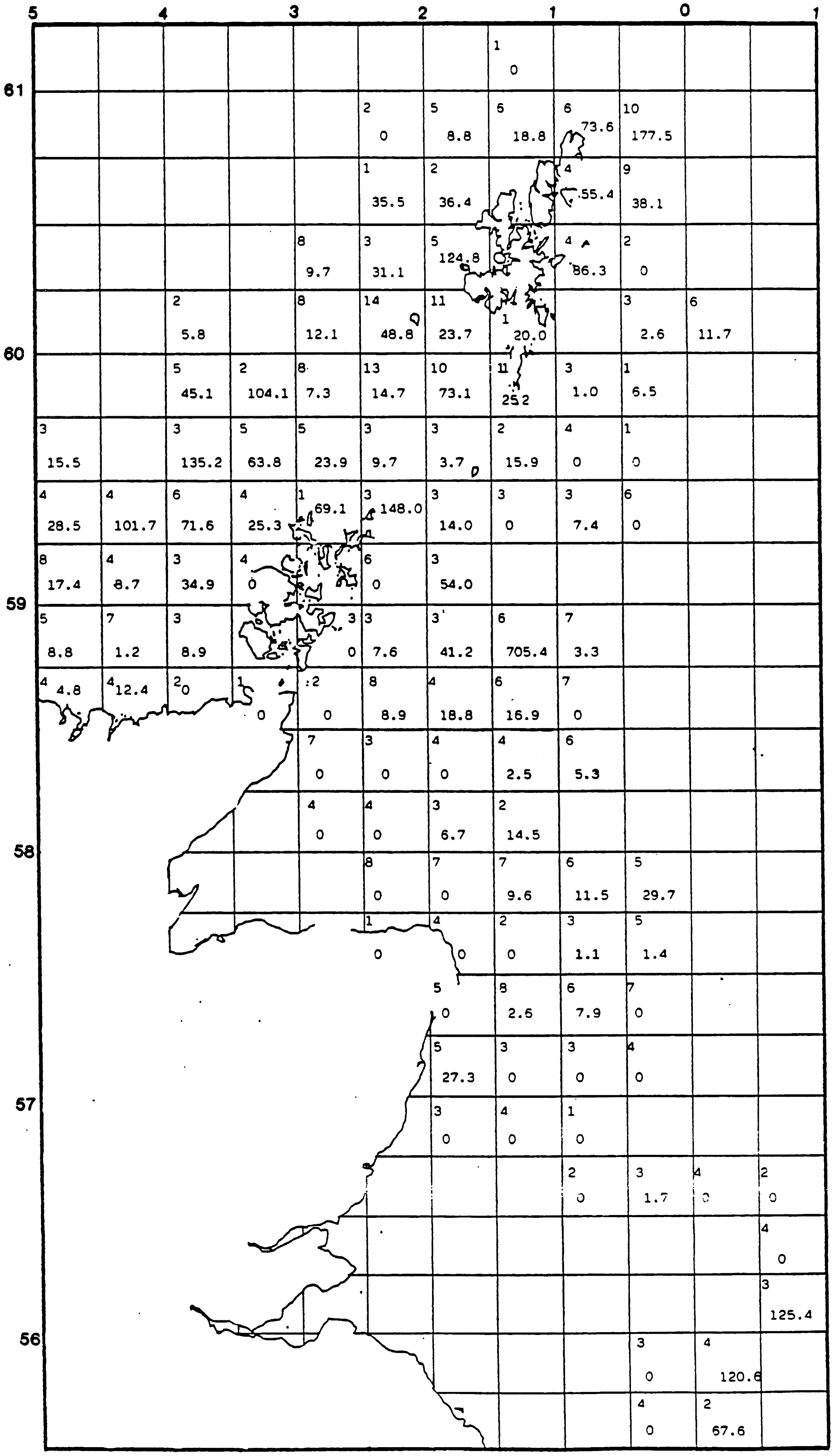


Figure 7. Number of fish (10^6) in quarter stat rectangles from the Scottish survey with number of half hour data periods shown in the top left hand corner of each rectangle

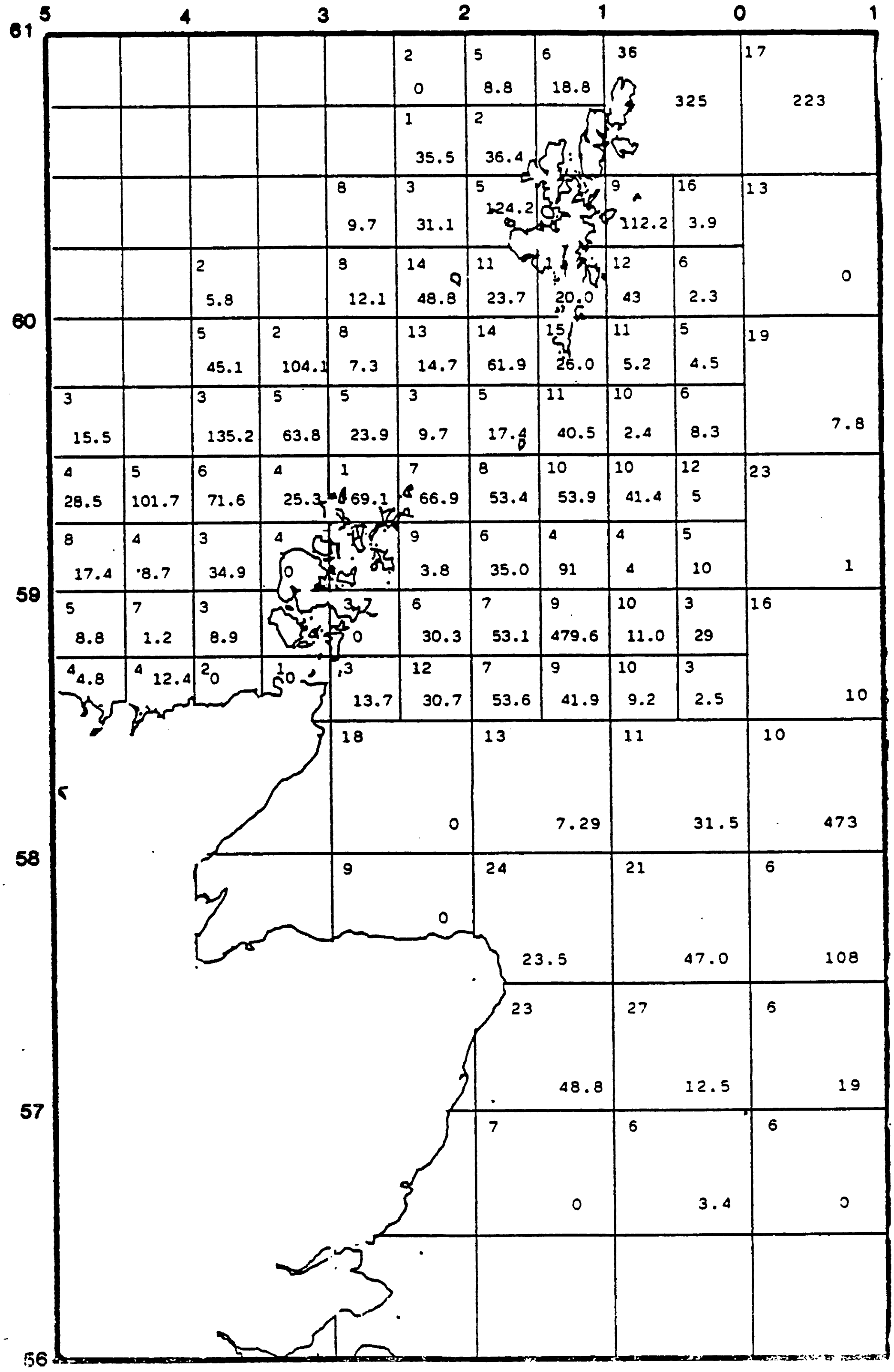


Figure 8. Number of fish (10^6) from the combined survey with the number of 5 mile/half hour data periods shown in the top left corner

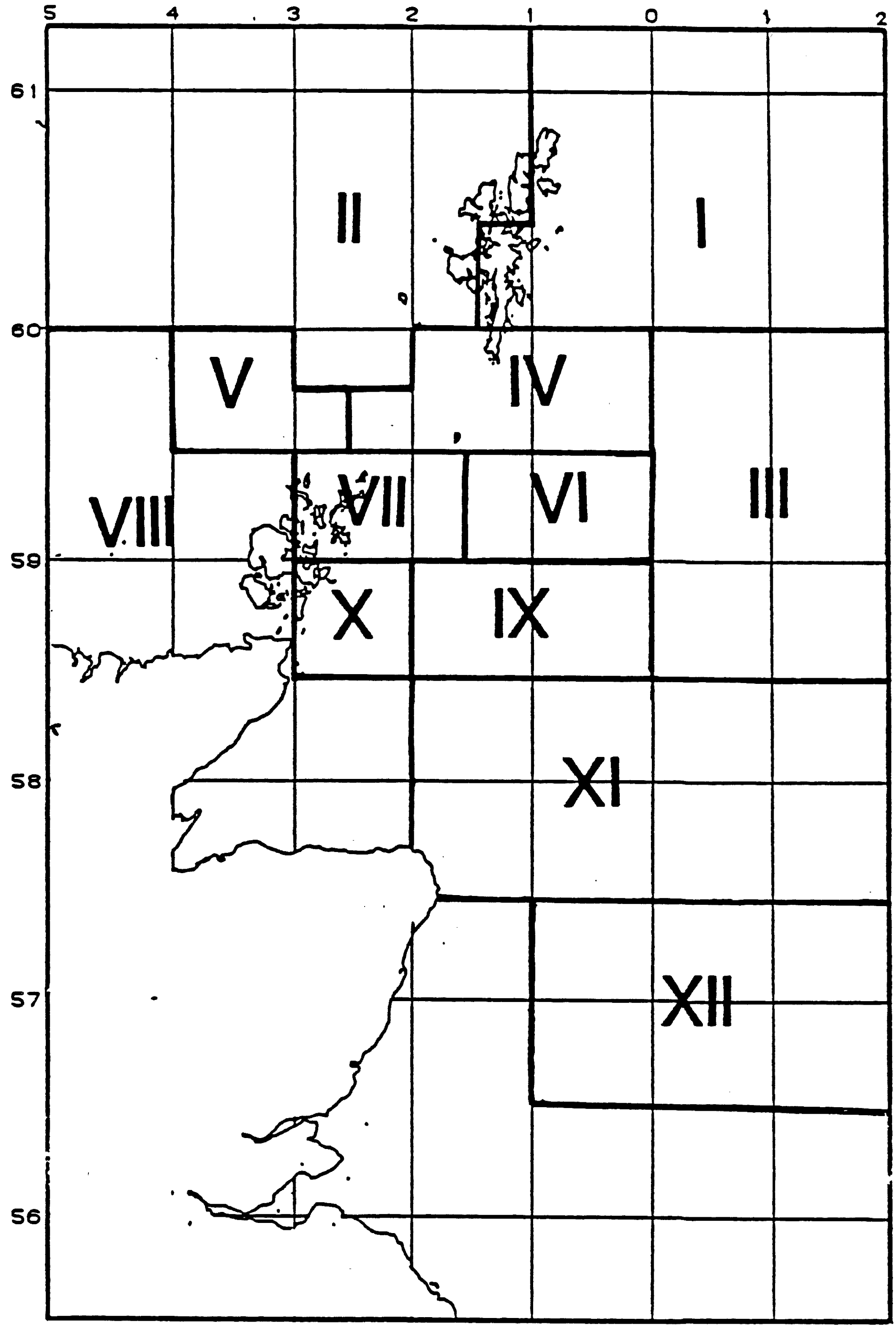


Figure 9. Selected areas for the combined survey