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Pelagic Fish
Committee

REPORT ON THE ICES-COORDINATED ACOUSTIC SURVEY OF HERRING STOCKS IN 1980

by

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INTRODUCTION

In accordance with ICES resolution C Res 1979/2:26, a coordinated acoustic survey was carried out in the Orkney-Shetland area of the northwestern North Sea (ICES Division IVa west) in the period 26 June-31 July 1980. Plans for the survey are described in the "Final report on the ICES-coordinated acoustic survey of herring stocks in 1979" (CM 1980/H:3).

The vessels taking part in the survey, their dates and the acoustic and trawling equipment used, are given in Table I. Track charts for each ship and positions of trawl hauls are shown in Figs 1-5. Each ship participating was allocated an area to cover and all ships were requested to survey the statistical rectangle immediately to the south of the Shetland Is. (E848).

This report is compiled from cruise reports provided by participants in the survey.

RESULTS

Distribution of herring

During a preliminary survey of the whole area, SCOTIA found a concentration of herring in the area east and south of Shetland (Fig 5a). East of Fetlar, echotraces were in the form of both midwater plumes (type A) and less intense recordings several metres above the sea bed (type B). The other ships confirmed the area of concentration to the south of Shetland and in addition further concentrations of plume traces were located by THALASSA southwest of Shetland (Fig 1), and by EXPLORER west of Shetland (Fig 4). In the area south-southeast of Shetland, the traces were largely type B. Both TRIDENS and SCOTIA made catches of herring in this area. In other areas, herring echotraces were more patchily distributed either in the form of isolated plumes (type A) or type B traces. The densest concentrations of mostly type B traces recorded by G O SARS towards the end of July were north and northeast of the Orkney Is. There was thus some evidence of a movement during July from the area east of Shetland towards the spawning areas to the north of Orkney and southwest of Shetland.

Identification of echotraces

Positions of both pelagic and bottom trawl hauls are shown in Figs 1-5 and a summary of catches is given in Tables II-VI. With the exception of those made by TRIDENS, catches of herring were generally small. The percentages of herring in each pelagic trawl haul are shown in Fig 6. Despite the variability, this shows an area to the southeast of Shetland in which hauls were predominantly composed of herring and further areas where herring made up a significant proportion of the catches. In some areas echotraces were close to the sea bed over rough ground and trawling was either not possible or resulted in appreciable gear damage.

As in the previous year, echotrace patterns in the survey area were extremely varied. In some areas discrete plume-like records were located (type A) and, in the absence of evidence to the contrary, it is assumed that these were caused by herring shoals. In the area to the east of northern Shetland where this type of trace was seen, the research vessel G A REAY, pelagic trawling for other purposes, made repeated large hauls of herring. In other areas where similar traces occurred, eg to the west of Shetland, confirmation of their identification was not obtained.

The results of trawling given in Tables II-VI demonstrate that herring were not confined to areas where plume echotraces were found. More frequently, they were associated with more dispersed echotraces lying from 5-20m above the sea bed. Trawl hauls through traces of this type contained a variety of species in addition to herring (notably whiting, but also mackerel, squid and Norway pout). Both TRIDENS and G O SARS, however, reported that echotraces in which herring were caught were consistently denser and further from the sea bed than those yielding other species. It is clear from the complexity of traces, nevertheless, that identification of echotraces by inspection is likely to give rise to considerable errors and for this reason the biomass attributable to herring in this type of echotrace has also been estimated using the results of pelagic trawling.

The complexity of echotraces recorded in this year's survey is very similar to that found the previous year and the results confirm the inherent difficulty experienced in identifying individual echotraces in this area. Furthermore, the difficulty experienced by four of the five participating vessels in sampling herring in any quantities raises the possibility that trawling may not in all cases have provided a representative sample of the echotraces investigated.

At night there was some evidence of dispersal of herring shoals but usually they remained within about 30m of the sea bed. In no area was there a well-defined vertical migration to the surface. Catches of herring made by EXPLORER using a bottom trawl (Table V) were small and it is therefore likely that only a small proportion of the herring population was distributed below the working depth range of the echointegrators.

Biological data

Length compositions of herring for each statistical rectangle sampled are given in Table VII. Herring caught ranged from 23-37cm, most being rather large herring from 26-34cm in length. Mean values for each rectangle showed little variation, although fish to the south of 59°30'N (ie south of the latitude of Fair Is) were on average about 1cm shorter than those further north. A combined length composition for samples taken by G O SARS, not given here, is very similar to those shown in Table VII.

Age compositions are not yet available from all surveys, but the results from G O SARS are shown in Fig 7. Three-ringers (1976 year-class) were the predominant age group, and there were very few two-ringers. The length compositions of the fish in other samples indicate that most of the herring were three ringers and older and that there were relatively small numbers of the recruiting 1977 year-class.

Available maturity data are summarised in Table VIII. From 27 June-4 July, most fish were at stages 3 or 4, whereas later in the survey from 23-31 July, most were at stages 5 or 6. The small percentage of fish at stage 8 were mostly large fish and were probably spring spawners.

Herring biomass estimates

Four of the five vessels participating in the survey carried out echointegration. On each ship calibrations were performed against standard targets of known target strength. For comparative purposes all biomass estimates were standardised assuming a target strength of herring and other fish of -34dB/kg. The results from each vessel's surveys are given below, and are summarised in Fig 8.

a) G O SARS

The track and positions of trawl stations are shown in Fig 4. Integrator values in eight depth channels were allocated to four categories: herring; bottom fish (ie those less than 20m from the sea bed); other fish; and plankton (including O-group fish).

Average integrator values for herring ($\bar{M}_H$) were calculated for the four subareas shown in Fig 9 in two separate ways. In the first, the echotraces were divided into those judged to be herring and those judged to be other fish on the basis of trawl hauls and the appearance of the traces. In the second, the densities of herring and bottom fish combined were subdivided into their components purely on the composition of trawl catches (given in Table IV). In both cases average densities of herring ($\bar{D}_H$) were calculated using two different assumptions about target strength, namely that the target strength of a unit weight of fish was independent of length of fish or alternatively introducing a length-dependent target strength relationship. The appropriate formulae were as follows

1) $\bar{D}_H = 0.15\bar{M}_H$ tonnes/km^2, assuming that the average target strength for all sizes of fish is -34dB/kg;

2) $\bar{D}_H = \frac{0.15}{24}\,\bar{L}_H.\bar{M}_H$ tonnes/km^2, assuming that -34dB/kg is the average target strength for a fish of 24cm length and that the average target strength per kg decreases with 10log L. $\bar{L}_H$ is the mean length of herring in trawl catches in that sub area, and the values used are shown in Fig 9.

Equivalent calculations were carried out for each subarea for herring and bottom fish combined, again making the same two assumptions about target strength and allocating the biomass densities in proportion to the composition of trawl hauls in that subarea (details are given in Table IV). Four alternative estimates of herring biomass in each subarea were thus obtained. Average densities for each subarea are given in Fig 9 and contoured levels of herring density are given in Fig 10.

Estimates of herring and bottom fish biomass for each subarea calculated in the ways described above are given in Table IX. There is good agreement between the estimates made assuming length-dependent and length-independent target strength values and this is largely because of the small length range of herring sampled. The values based on trawl haul data only are smaller than those based on a more subjective allocation of echotraces. A possible explanation for this is that herring were underrepresented in trawl catches because of their greater ability to avoid the trawl. The range of herring biomass estimates obtained by the four methods is 13 000-24 000 tonnes.

Part of the survey area was covered twice during the survey (Fig 3), and the herring biomass estimates on each differed by only 15% of the mean. This indicates that, despite possible systematic errors, the survey gave a reasonably reliable index of abundance.

b) THALASSA

The track and trawl haul positions are shown in Fig 1. Four areas of echotrace concentrations were found, but in only the easternmost of these was there evidence of any appreciable quantities of herring. By night the shoals in this area were large (up to 20-30m high and 250-300m across). By day they were less numerous but denser and were in the form of plumes (20m high and 50m across).

For each statistical rectangle surveyed an estimate of total fish biomass was made assuming an average target strength of -34dB/kg. Trawling by THALASSA provided insufficient evidence to allocate echotraces to species (Table II) but, using trawl haul data from the other ships and by examination of the echotraces, an estimate was made of the proportion of herring. The results are shown in Fig 8 and the estimate of the herring population in the six statistical rectangles covered was 9 000 tonnes out of a total of 95 000 tonnes fish biomass.

c) EXPLORER

The track and trawl haul positions are shown in Fig 4. The proportion of echointegrator readings attributable to herring was estimated in two ways. First, the contribution of distinct plume traces, the positions of which are shown in Fig 4, was calculated and the entire value was allocated to herring. Second, other fish traces within 30m of the sea bed were allocated from the mean percentage of herring in pelagic trawl hauls in the respective statistical rectangle, or where appropriate in areas smaller than a rectangle. Estimates of herring biomass thus consisted of two components, that present in plume traces, and that in more dispersed traces near the sea bed. Figure 8 shows for each rectangle the estimated total biomass of herring. The estimate for the whole Orkney-Shetland area was approx. 270 000 tonnes of fish, of which 150 000 tonnes was estimated to be herring (100 000 tonnes in the form of plumes).

d) SCOTIA

The track chart and midwater trawl haul positions are shown in Fig 5. After the survey ended, it became apparent that non-linearity in the relationship between input and output voltage in the echointegrator had resulted in considerable under-recording of dense echotraces. This was shown by a wide disparity in the average densities of total biomass (fish and plankton combined) recorded on the SCOTIA and EXPLORER surveys. In retrospect this fault is impossible to rectify, but to provide a rough estimate of herring biomass, the SCOTIA values have been raised by a factor of 6.4, which is the ratio between EXPLORER and SCOTIA mean biomass densities for all species combined (including plankton).

Using the adjusted densities, the fish biomass was allocated to herring and other species in the way described above for the EXPLORER survey. The results for the two halves of the SCOTIA survey are shown in Fig 8. The estimated total of herring for the first survey of the whole Orkney-Shetland area was 210 000 tonnes of which 55 000 tonnes was in the form of recognisable plume traces. On the second survey which covered a smaller area the total was about 70 000 tonnes of herring. It should be stressed, however, that because of the dubiety about the validity of the raising factor mentioned above, these results should be treated with great caution.

DISCUSSION

Since it was not possible for the Planning Group to meet to evaluate these surveys, this discussion is limited to a few comments made in the reports of the participants.

From the vertical distribution of herring found during the survey, it seems likely that most herring were available for echointegration. A far more serious difficulty was that of identifying echotraces in the area surveyed. Only one of the four ships carrying out midwater trawling was able to sample herring in reasonable quantities with any reliability and the composition of most trawl hauls is therefore likely to give a biassed estimate of the composition of mixed traces. The method using trawling to distinguish herring traces from those caused by other species, and allocating the biomass to species from the appearance of the traces, is thus likely to give a more nearly correct estimate. This method has a subjective element, however, and the resulting identifications are likely to be subject to considerable error.

The other unresolved problem is the correct target strength to use for herring and whether it is length dependent. What evidence there is from cage experiments suggests that -34dB/kg may be rather low (Edwards, 1980, ICES CM 1980/B:19), but on the other hand avoidance behaviour of herring in the path of the ship (either sideways or downwards) might result in a lowering of effective target strength by a factor of unknown proportions.

The herring biomass estimates in rectangles covered by more than one ship (Fig 8) indicate considerable variation between the results of the different ships taking part. Excepting the somewhat dubious results from SCOTIA, however, the quantities of herring in the total area south of Shetland appeared to be low on most surveys. On the assumption of target strength used, the total biomass of herring in the Orkney-Shetland area is not likely to have been more than 150-200 000 tonnes.

Table I Vessels participating in the 1980 survey with details of equipment used:

Vessel	Survey dates	Acoustic equipment	Trawling gear
THALASSA	15-25 July	Simrad EKS38 sounder Simrad QM MK II integrator.	Pelagic trawl 11m vertical opening; semi pelagic trawl 7m vertical opening; bottom trawl 6m vertical opening.
TRIDENS	8-17 July	Vertical echosounder.	Engel trawl
G O SARS	23-31 July	Simrad EK38 sounder with NORD-10 computer for echo-integration. Ceramic transducer.	Pelagic trawl 45 x 15m mouth; Bottom trawl 47 x 6m mouth
EXPLORER	10-28 July	Simrad EK38 sounder with Aberdeen echointegrator. Magnetostrictive transducer.	GOV bottom trawl
SCOTIA	26 June-14 July	Simrad EK38 sounder with Aberdeen echointegrator. Ceramic transducer.	Blue whiting midwater trawl; "Delagic" trawl

Table III Catches in pelagic trawl hauls made by TRIDENS:

Haul No.	Position	Date	Shooting time GMT + 2	Duration (min)	Catches in kg
1	59.43N 01.10W	9/7	13.15	60	herring 17 000
2	59.26N 01.35W	9/7	19.25	100	herring 1 000, whiting 2 000
3	60.00N 00.25W	10/7	07.30	25	herring 12 000
4	59.50N 00.48W	10/7	14.50	45	herring 500
5	60.01N 01.55W	10/7	21.50	55	whiting 3 000, mackerel 100
6	59.40N 02.00W	11/7	08.20	25	herring 10, whiting 1 500, mackerel 80
7	59.36N 00.00W	11/7	16.30	35	N. pout 300
8	59.30N 01.26W	11/7	22.20	20	whiting 1 250, loligo 1 250
9	59.00N 00.20W	14/7	13.15	20	sheppy argentine 60
10	59.00N 00.52W	14/7	16.20	30	herring 9 000
11	59.00N 02.06W	14/7	21.50	30	whiting 900, herring 100
12	59.20N 00.30W	15/7	11.15	6	herring 3 500
13	59.20N 01.55W	15/7	17.00	15	whiting 250
14	61.00N 01.29W	16/7	07.50	55	mackerel 1 500, haddock 90
15	61.00N 00.42W	16/7	11.45	85	N. pout 200, mackerel 70
16	60.50N 00.00W	16/7	17.10	45	N. pout 350
17	60.35N 00.00W	17/7	09.40	40	N. pout 1 500

Table II Catches in trawl hauls made by THALASSA:

Haul n°	Gear	Date Hour GMT	Position	Depth m	Duration (mins)	Herring kg $\bar{l}$ cm	Whiting	Norway pout	Mackerel	Haddock	Cod	Others
1	P	16-7 16h00	59°26 N 2°17 W	69	24	0 /	0,4	0	0	0	0	241 Squids
2	P	17-7 10h00	59°45 N 3°02 W	76	36	0,9 31,0	0	0	16,5	0,5	0	0,1
3	P	17-7 13h00	59°36 N 2°53 W	73	44	13,5 27,2	0	0	40,5	0	0	0,1
4	P	17-7 20h00	59°38 N 2°58 W	80	30	5,5 29,1	0,4	0	6,5	0	0	[illegible],0
5	P	18-7 8h00	59°52 N 3°44 W	114	55	0 /	0,69	0	7,2	0	0	3,0
6	P	19-7 7h00	59°06 N 3°52 W	112	53	0,6 27,6	0	0	0	0,2	0	0,1
7	P	19-7 15h00	59°05 N 4°05 W	83	44	0 /	0	0	0	0	0	0
8	P	20-7 17h00	59°12 N 3°49 W	122	61	0,2 /	0	0	0	7	0	0,5
9	SP	23-7 7h00	59°46 N 3°49 W	136	43	0 /	99	156	0	121	63	163
10	SP	23-7 11h00	59°53 N 3°35 W	140	40	0 /	10	27	0	64	17	187
11	SP	23-7 14h00	59°47 N 2°55 W	77	32	0,5 31,5	1,6	5	0	16	31	24
12	SP	24-7 9h00	59°43 N 2°05 W	111	28	0 /	113	70	0	41	58	56
13	B	24-7 16h00	59°29 N 1°02 W	123	43	3,5 30,6	99	4	0	279	7	45
14	B	25-7 8h00	59°28 N 1°19 W	102	21	0 /	155	0	0	75	9	160 Saithe

P : pelagic trawl
SP : semi pelagic trawl
B : bottom trawl

Table IV Catches in trawl hauls made by G O SARS (kg/hour) (P = pelagic, B = bottom), with details of trawl hauls used for allocation of biomass:

	Trawl st. no.	Date	Hour (GMT)	Trawl depth	HERRING	MACKEREL	WHITING	HADDOCK	NORWAY POUT	COD	SAITHE	GURNARD	FLATFISH	OTHER FISH	JELLYFISH	REMARKS (n.r.=not representative)
B	185	23	07	87	-	-	12	128	0,3	29	-	18	3	35	-	n.r.,outside herring area
P	186	24	05	25	17	-	0,2	0,9	-	-	-	-	-	-	30	applied for area B&C
B	187	24	08	118	-	-	27	140	-	37	124	-	6	27	-	n.r.,outside herring area
B	188	24	14	110	-	-	64	104	10	51	-	1	22	138	-	n.r.,below main recordings
P	189	24	21	25	-	0,2	0,4	2	-	1	-	-	-	-	200	n.r.,outside herring area
P	190	25	03	100	38	-	28	-	+	-	-	-	-	0,1	-	applied for area B&D
P	191	25	07	105	32	-	17	0,6	0,2	-	-	-	-	-	20	applied for area B&D
B	192	25	16	90	-	-	62	141	-	32	-	14	7	27	-	n.r.,outside herring area
P	193	27	05	70	-	1	4	0,6	+	0,1	-	0,8	-	-	-	applied for area A
P	194	27	09	60	-	-	160	19	-	-	-	-	-	-	-	applied for area A
P	195	27	13	75	-	-	-	-	-	5	-	-	5	54	-	n.r. outside herring area
P	196	27	21	80	506	-	-	-	-	-	-	-	-	-	-	applied for area A&B
P	197	28	04	20	0,2	22	6	0,5	-	0,1	-	-	-	-	100	n.r.,towed in plankton layer
P	198	23	14	76	15	1	-	3	-	-	6	-	-	1	-	applied for area A,B&D
P	199	28	19	85	0,2	-	-	-	-	-	-	-	-	-	-	applied for area A
P	200	29	03	45	-	-	0,9	-	40	-	-	-	-	0,2	23	n.r.,outside herring area
P	201	29	06	10	-	-	-	-	-	-	-	-	-	-	150	n.r.,outside herring area
P	202	29	08	60	0,6	7	0,8	-	-	-	-	-	-	-	-	applied for area A
B	203	29	14	128	1	-	63	115	343	6	-	-	1	2	-	n.r., outside herring area
P	204	29	19	130	-	-	-	-	180	-	-	-	-	-	-	n.r.,outside herring area
P	205	30	05	70	0,3	-	37	3	-	-	-	-	-	-	-	applied for area D
B	206	30	19	80	-	-	32	408	10	4	-	3	9	46	-	n.r.,outside herring area
P	207	30	11	70	-	-	294	-	17	-	-	-	-	2	-	n.r.,outside herring area
P	208	30	15	50	-	-	1	-	-	-	-	-	-	-	16	n.r.,trawl not operating properly
P	209	31	00	93	9	-	30	-	-	-	-	1	0,1	-	-	applied for area D
P	210	31	03	75	0,2	-	1244	-	-	-	-	-	-	-	-	applied for area B&D

Table V Catches in bottom trawl hauls made by EXPLORER (hauls with severe gear damage excluded):

Haul No.	Date	Position		Catch (kg) HERRING	OTHERS
170	12 July	59°48'N	00°27'W	1	330
171	12 July	60°43'N	00°37'W	0	60
172	13 July	60°37'N	01°41'W	0	180
174	14 July	60°13'N	00°33'W	23	120
175	14 July	60°10'N	00°34'W	10	330
176	15 July	59°01'N	01°01'W	225	735
177	15 July	59°00'N	01°02'W	0	240
178	17 July	59°19'N	01°01'W	1	390
179	17 July	59°33'N	01°05'W	3	660
180	19 July	59°20'N	03°33'W	1	240
181	20 July	59°04'N	03°53'W	3	660
182	20 July	58°52'N	03°38'W	22	1620
183	21 July	59°40'N	02°42'W	3	120
186	22 July	59°55'N	01°35'W	0	450
187	23 July	59°42'N	01°45'W	1	475
188	23 July	59°49'N	01°41'W	7	185
189	23 July	59°29'N	01°16'W	200	380
190	24 July	59°58'N	02°25'W	0	50
191	24 July	60°16'N	02°27'W	0	600
192	25 July	60°09'N	01°42'W	0	350

Note: other species were predominantly gadoids including Norway pout.

Table VI Catches in pelagic trawl hauls, made by SCOTIA:

Haul No.	Date	Position		Catch (kg) HERRING	OTHERS	Predominant species
24	26 June	60°36'N	00°40'W	0.5	60	Norway pout, haddock, whiting
25	27 June	60°33'N	00°40'W	10	20	Norway pout
26	27 June	60°32'N	00°43'W	2.5	120	Norway pout
27	27 June	60°38'N	00°36'W	0.5	0.5	-
28	27 June	60°40'N	00°43'W	1.7	20	Norway pout
29	28 June	60°40'N	00°43'W	3.0	12	Norway pout
30	30 June	59°49'N	03°48'W	0.2	15	Grey gurnard
32	1 July	59°30'N	01°36'W	0	2	-
33	3 July	59°40'N	01°03'W	75	0	-
34	3 July	59°42'N	00°58'W	270	4	-
35	4 July	59°56'N	01°09'W	1.2	0	-
36	4 July	59°54'N	01°08'W	150	30	Norway pout
37	4 July	59°52'N	01°02'W	0	2	-
38	5 July	60°36'N	00°38'W	1	60	Norway pout
39	5 July	60°35'N	00°25'W	0	4	-
40	5 July	60°36'N	00°42'W	0	0.2	-
41	6 July	60°14'N	00°18'W	0	30	Norway pout, Sebastes
42	9 July	59°38'N	01°46'W	0	30	whiting
43	10 July	59°44'N	01°02'W	0	2	-
44	12 July	60°33'N	01°40'W	0	5	-
45	12 July	60°33'N	01°42'W	0	3	-
46	13 July	59°42'N	01°51'W	3	540	whiting
47	13 July	59°41'N	01°50'W	5	510	mackerel

Table VII Percentage length compositions of herring in each statistical rectangle, weighted by estimated numbers of fish in each haul sampled:

Length to ½cm below	60°30'–61°N 0°–1°W	60°–60°30'N 0°–1°W	59°30'–60°N 0°–1°W	59°30'–60°N 1°–2°W	59°30'–60°N 2°–3°W	59–59°30'N 0°–1°W	59°–59°30'N 1°–2°W	59–59°30'N 2°–3°W	59–59°30'N 3°–4°W	58°30'–59°N 3°–4°W
23	0.2									
.5	0.2		0.1							
24	0.2		0.1	0.008						2.0
.5	0.7		0.04	0.01		1.0	0.1		5.3	1.0
25	0.5	0.002	0.9	0.05		0.3	0.6		10.5	3.1
.5	0.3	0.002	2.7	0.07		1.8	0.9		5.3	1.0
26	3.9	0.004	2.3	1.4		3.4	3.3	3.8		3.1
.5	1.7	0.8	3.4	0.8		5.5	4.8		5.3	4.1
27	2.5	0.004	4.2	2.1		5.2	6.1	5.8	5.3	4.1
.5	2.9	4.7	6.6	2.1		8.8	4.7	13.5	5.3	4.1
28	6.1	3.9	2.9	3.5		12.0	10.2	5.8	5.3	4.1
.5	8.3	8.6	5.2	3.6	7.7	11.5	12.2	13.5	10.5	9.2
29	8.1	12.6	8.6	9.9		19.0	8.5	7.7	5.3	1.0
.5	9.8	9.4	11.9	10.6	7.7	10.4	8.2	19.2	15.8	12.2
30	7.8	11.8	6.1	11.9	15.4	5.7	5.0	7.7	5.3	10.2
.5	7.4	7.1	7.4	5.5	15.4	5.7	8.0	3.8	5.3	10.2
31	8.4	5.5	4.9	10.5	38.5	5.4	2.1	5.8	5.3	17.3
.5	9.5	9.4	5.4	13.6		1.9	8.2	5.8	5.3	5.1
32	9.5	4.7	8.4	11.1	15.4	1.9	6.4	1.9		3.1
.5	4.9	9.5	10.9	5.9		1.5	4.5	3.8	5.3	3.1
33	4.1	3.2	5.4	4.0		0.2	1.8	1.9		2.0
.5	1.5	3.2	1.2	1.3		0.5	3.6			
34	0.7	1.6	1.2	0.7			0.9			
.5	0.5	1.0		1.3						
35	0.2	2.4								
.5	0.2	0.004		0.01						
36	0.2	0.004		0.01						
.5										
37		0.002								
Number Measured	449	275	513	1327	13	320	284	52	19	98
Mean length (cm)	30.2	30.8	30.1	30.7	30.9	29.0	29.7	29.4	28.6	29.6

Table VIII Percentage maturity composition of herring:

Maturity stage	SCOTIA 27 June–4 July	G O SARS 23–31 July
1	–	–
2	7.4	1.2
3	52.5	4.7
4	38.6	10.6
5	0.2	43.0
6	–	31.8
7	–	2.2
8	1.4	6.5

Table II. Abundance of herring and herring + bottom fish (1000 tonnes) estimated by different methods. G O SARS survey $\overline{TS}$ = Average target strength (dB/kg).

	Abundance of herring 1000 tonnes				Abundance of herring + bottom fish, 1000 tonnes	
	Estimates based on evaluation of integrator values of pure herring		Estimates based on integrator values for herring + bottom fish and trawl catch data.			
	Length dependent $\overline{TS}$	Length independent $\overline{TS}$	Length dependent $\overline{TS}$	Length independent $\overline{TS}$	Length dependent $\overline{TS}$	Length independent $\overline{TS}$
Sub-area A	12.1	10.0	6.7	5.9	15.2	13.4
Sub-area B	4.5	3.6	3.6	3.3	5.8	5.2
Sub-area C	0.7	0.6	0.4	0.7	0.4	0.8
Sub-area D	6.5	5.2	3.3	2.8	9.8	8.2
TOTAL	23.8	19.4	14.0	12.7	32.4	27.6

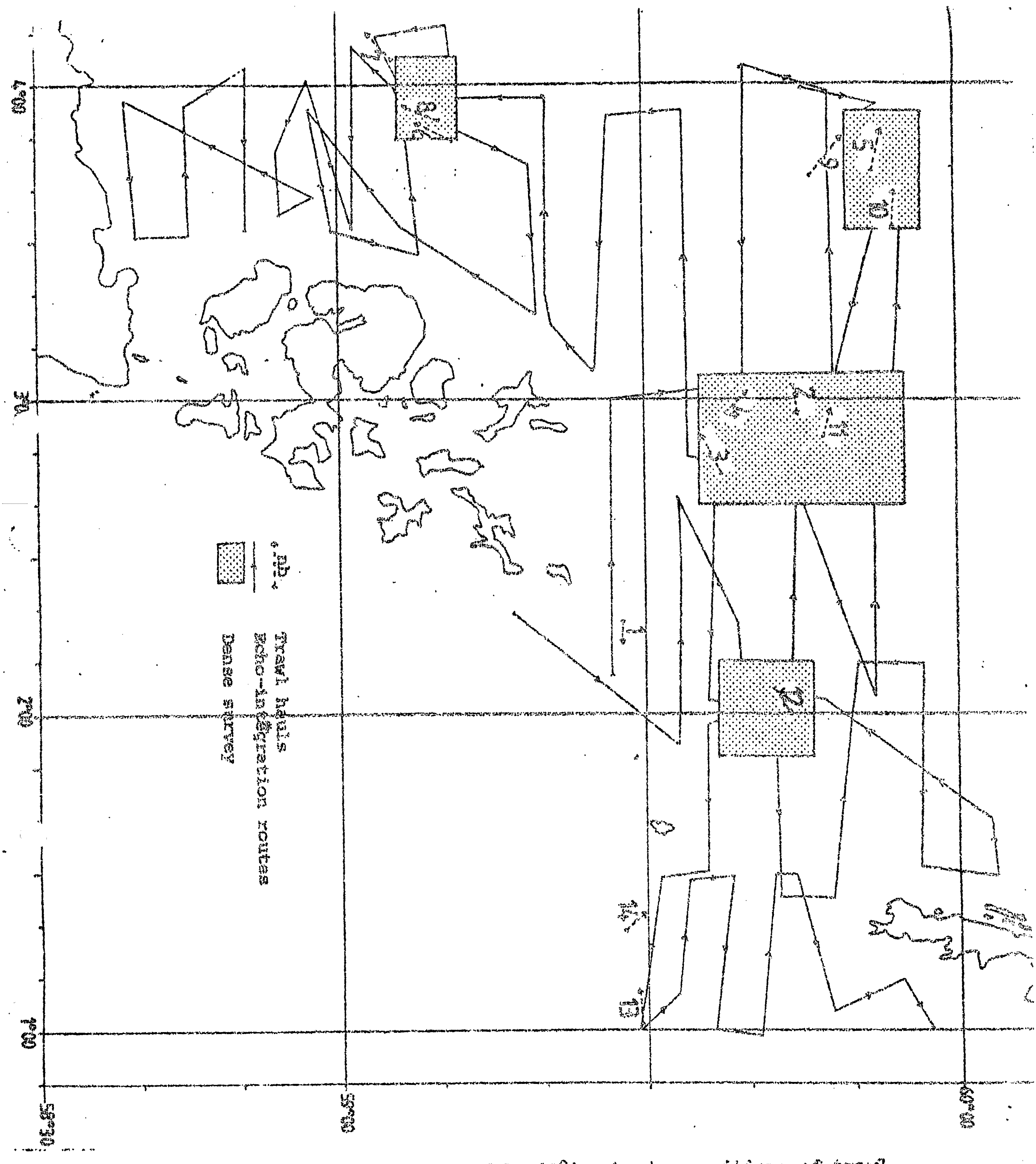

Fig 1: Survey track of THALASSA, 15-25 July 1980, showing positions of trawl hauls and areas of intensive echointegration surveys.

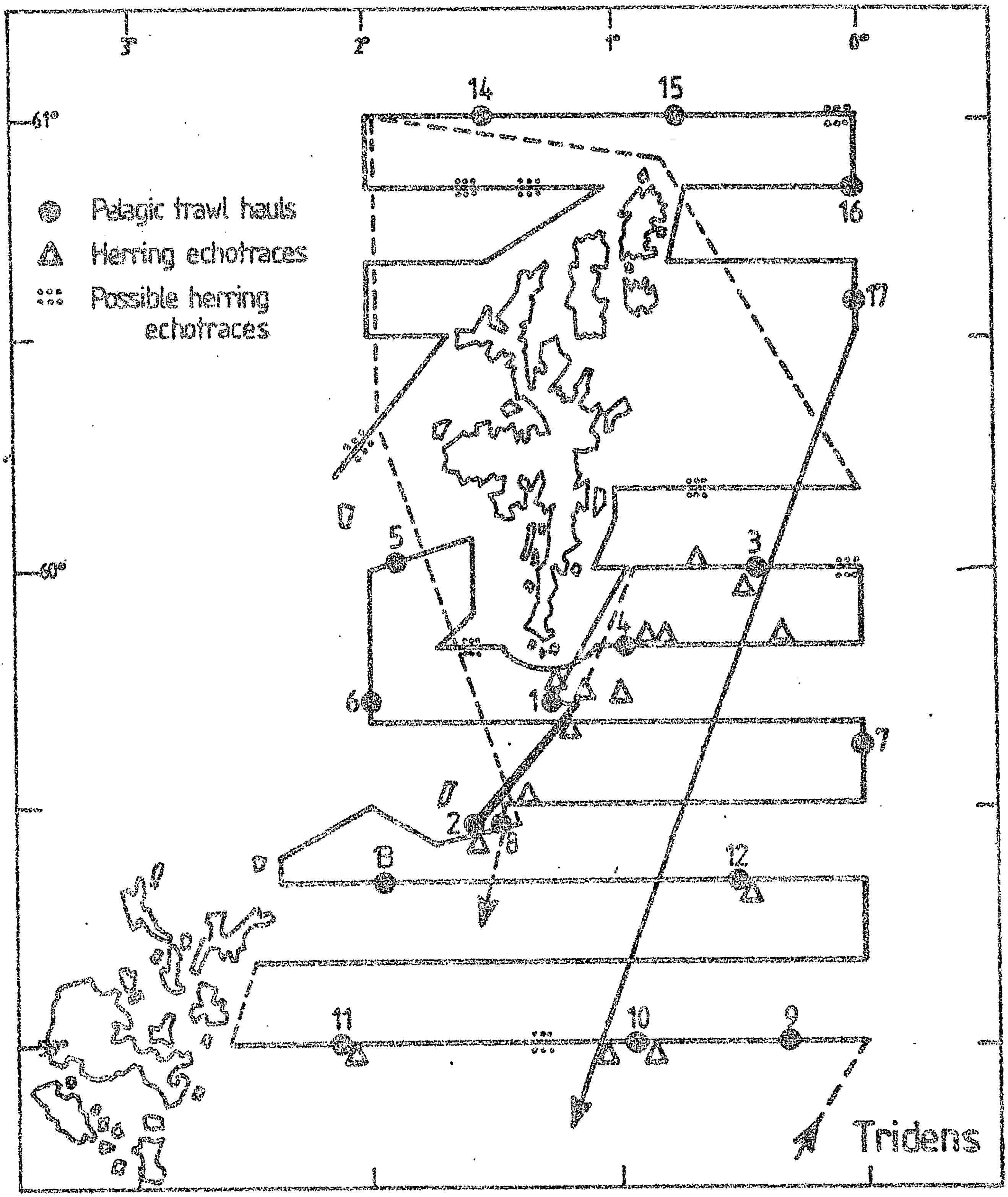

Fig 2: Survey track of TRIDENS, 8-17 July 1980, showing positions of trawl hauls and areas of herring echotraces.

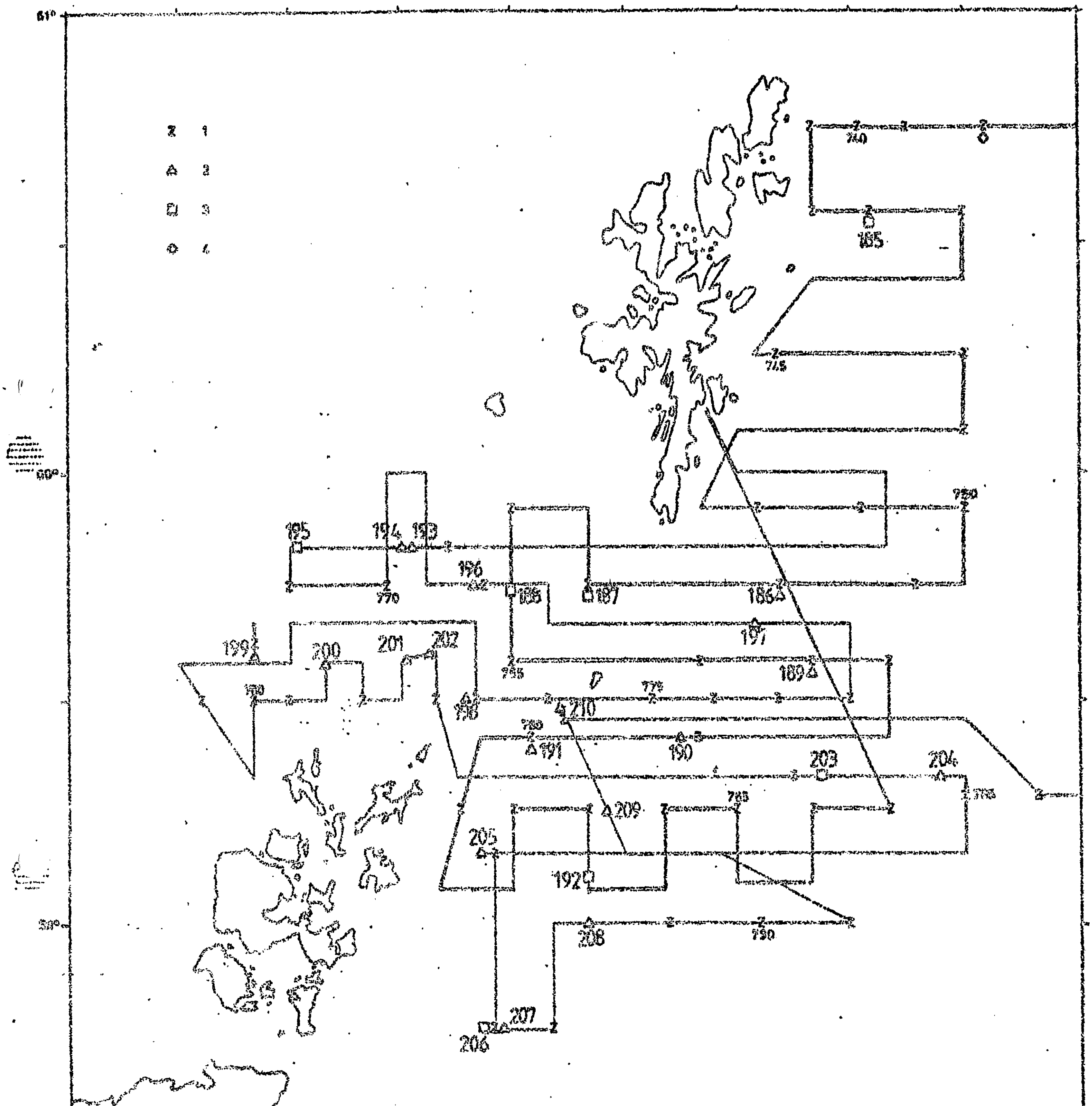

Fig 3: Survey track and stations of G O SARS, 23-31 July 1980. —— 23-26 July, —— 27-31 July. 1: Hydrographic station; 2: Pelagic trawl; 3: Bottom trawl; 4: Zooplankton station (Juday net).

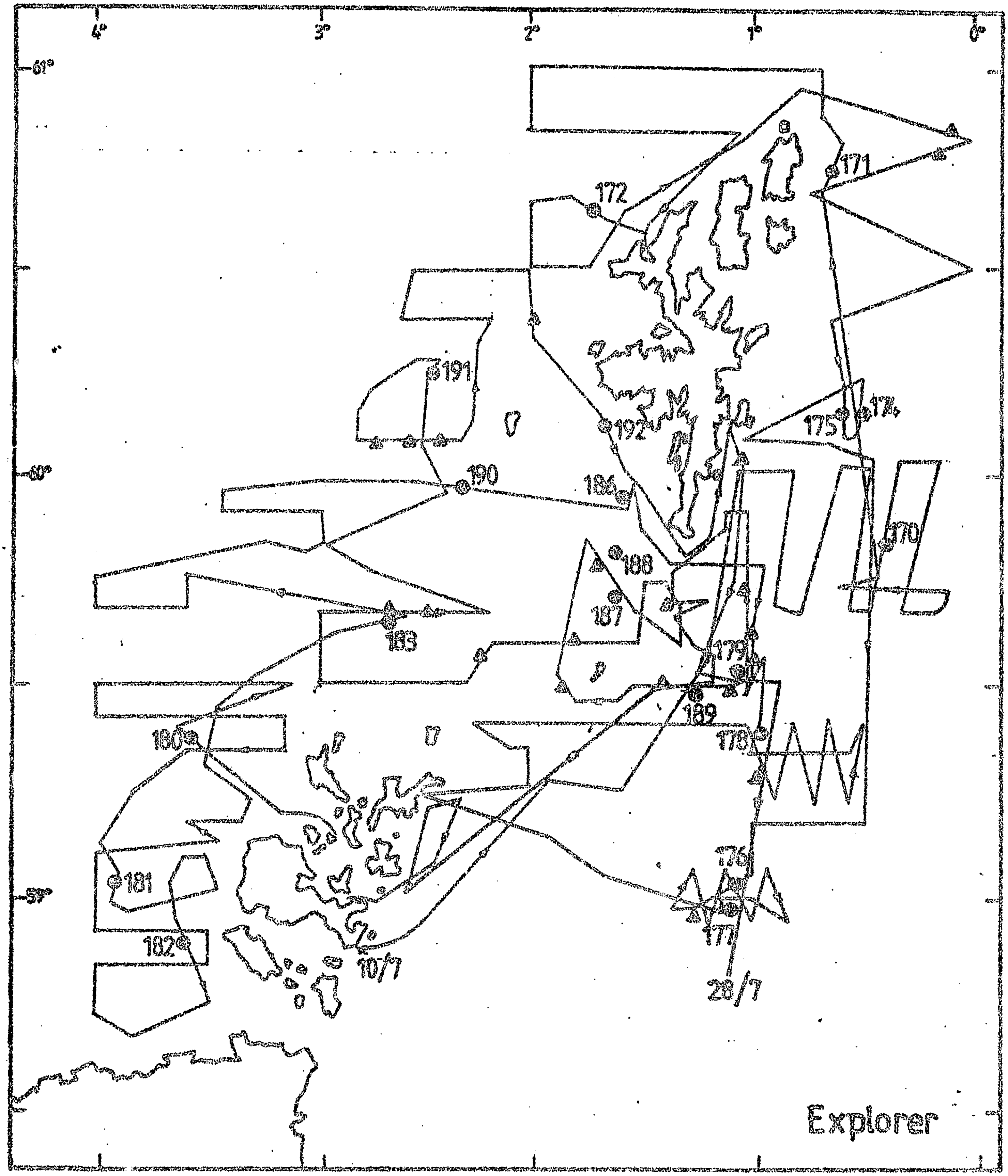

Fig 4: Survey track of EXPLORER, 10-28 July 1980, showing positions of trawl hauls (numbered black circles) and area of "plume" echotraces (triangles).

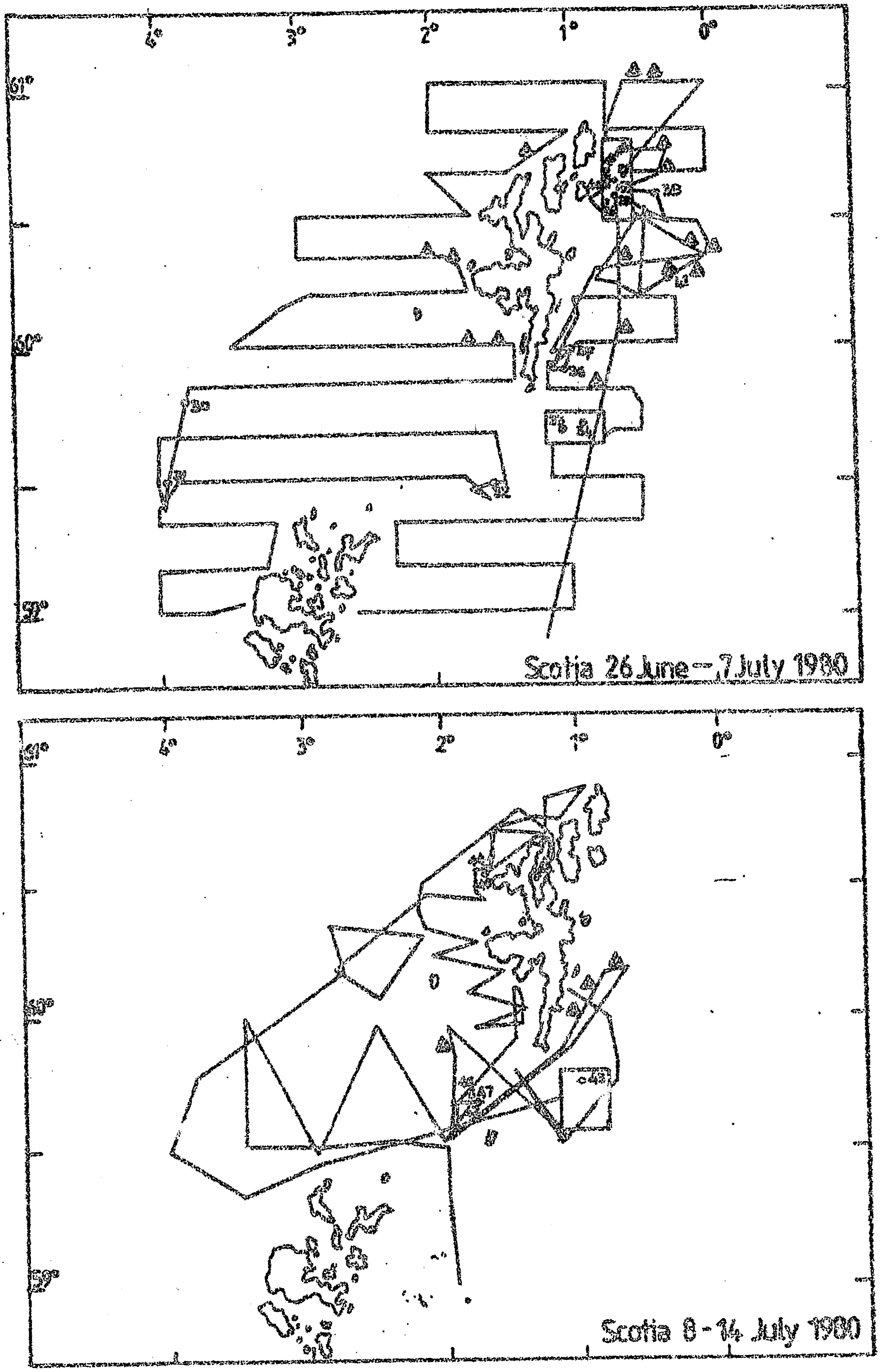

Fig 5: Survey track of SCOTIA, 26 June–14 July 1980, showing position of trawl hauls and areas of "plume" echotraces. Boxes show areas of intensive surveys in which numerous herring echotraces were recorded. Numbered dots = trawl hauls; triangles = "plume" echotraces.

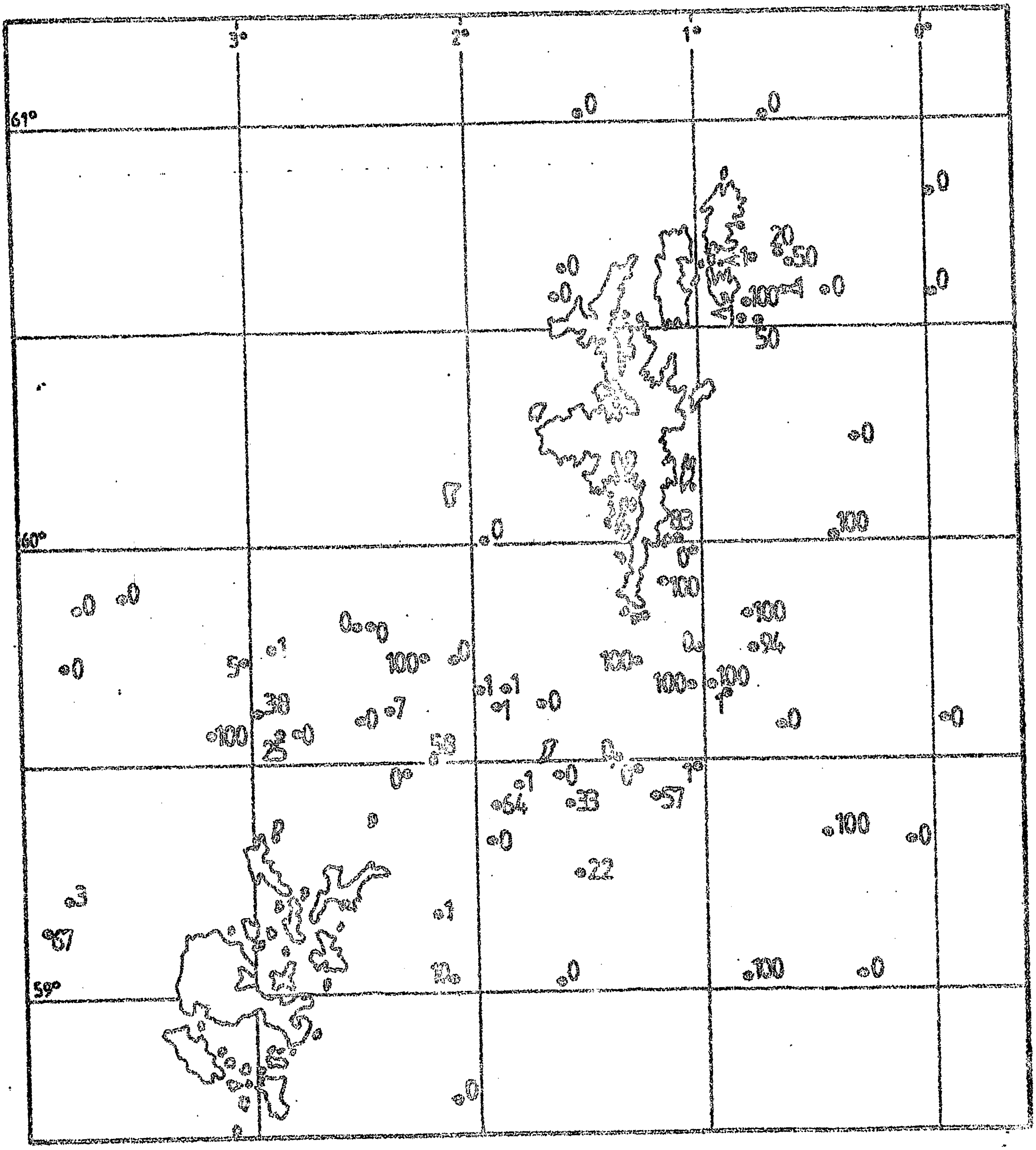

Fig 6: Percentage of herring by weight in pelagic trawl hauls. Trawl hauls with insignificant catches excluded.

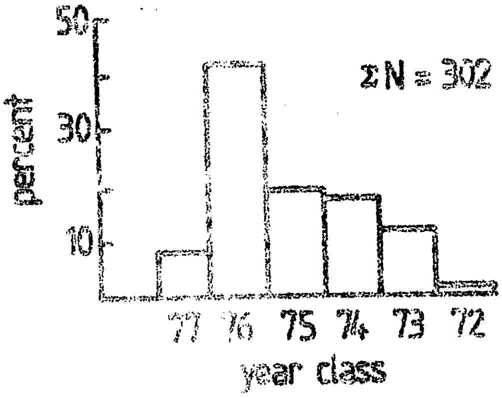

Fig 7: Year-class distribution of herring in G O SARS samples.

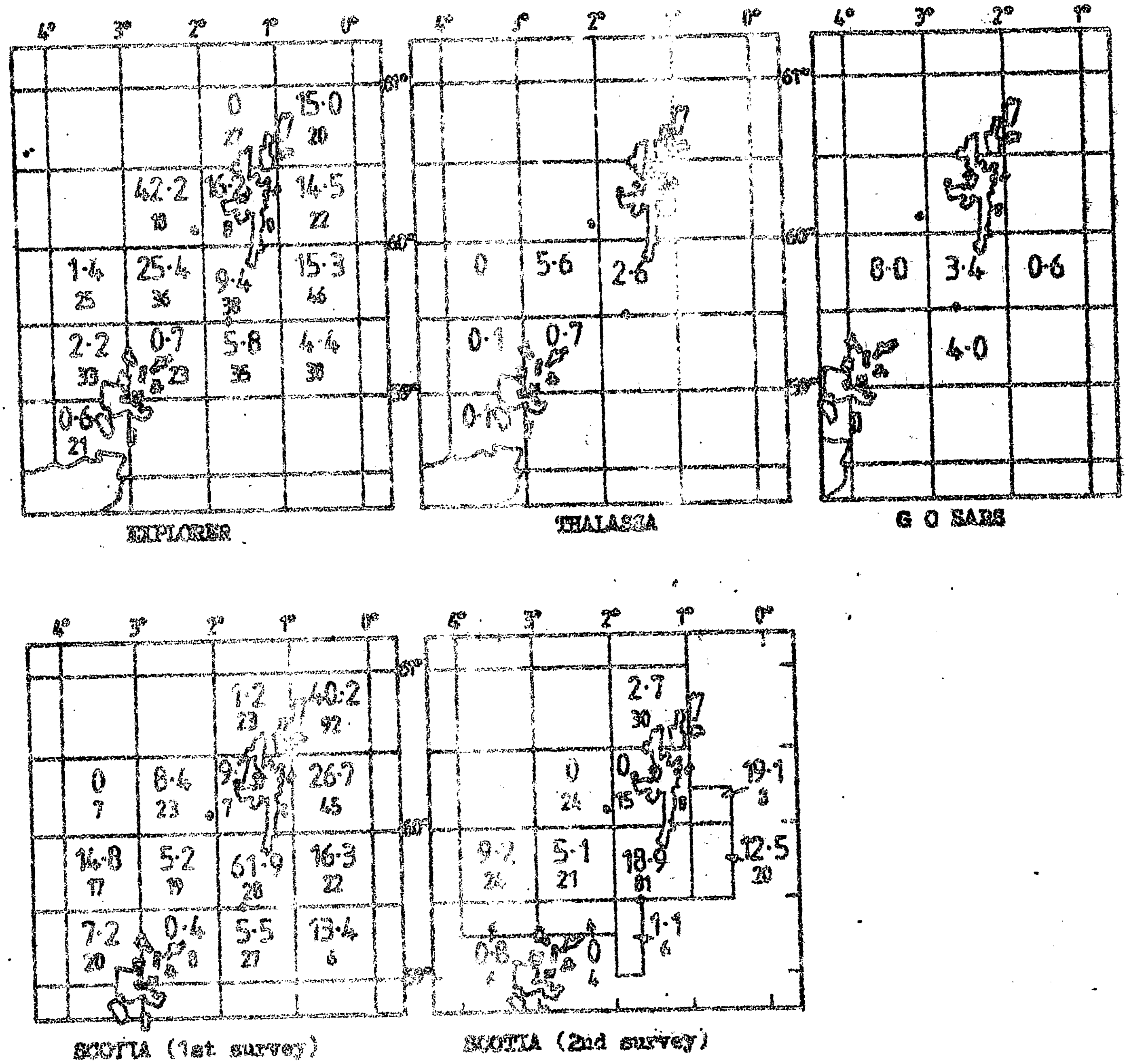

Fig 8: Estimated biomass of herring in thousand tonnes per statistical rectangle on each survey. For the EXPLORER and SCOTIA surveys the number of half hour integrations per rectangle are shown.

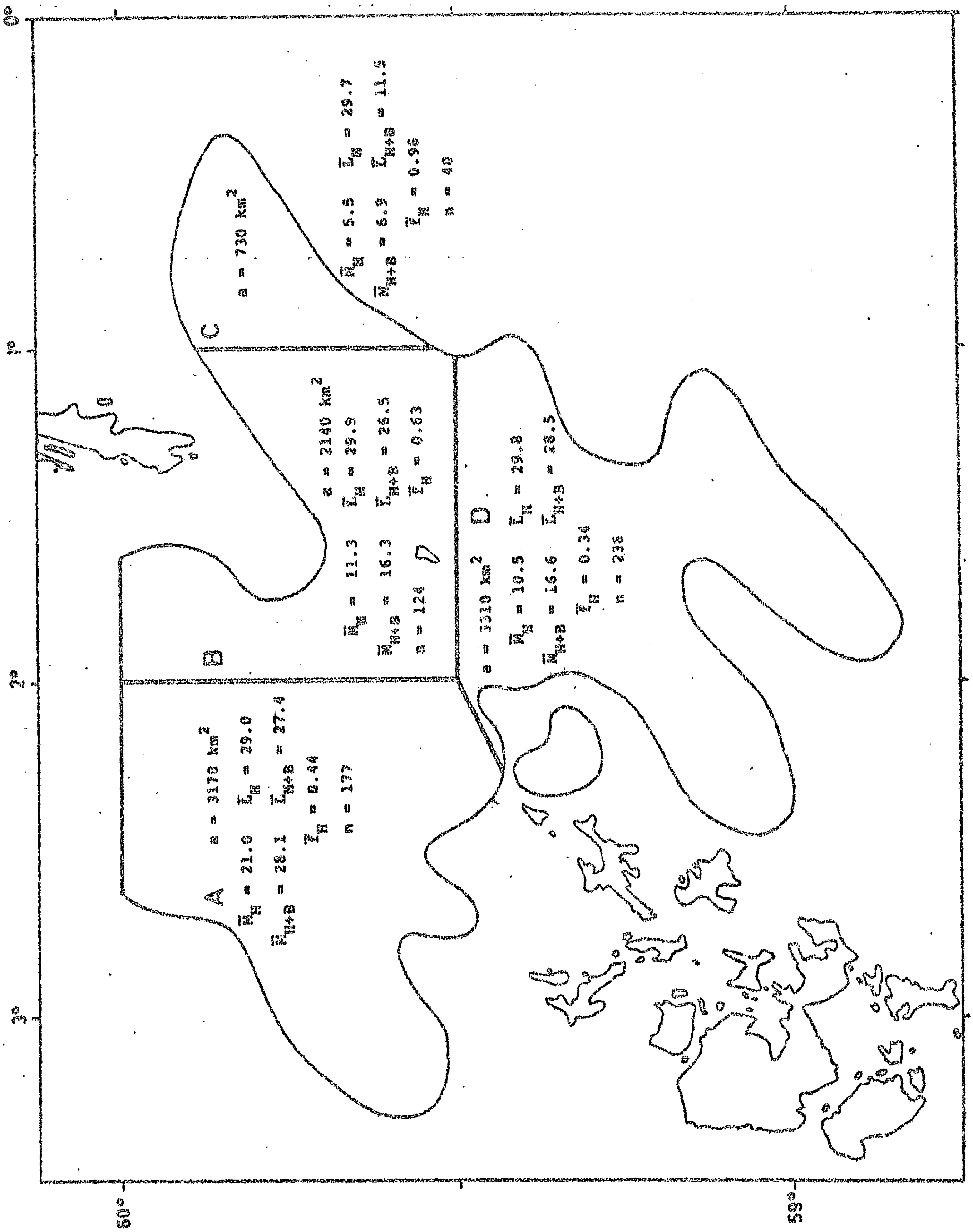

Fig 9: Subareas A, B, C and D surveyed by G O SARS. a = size of the subarea, $\bar{M}_H$ = average integrator value for "pure" herring, $\bar{M}_{H+B}$ = average integrator value for herring + bottom fish, $\bar{L}_H$ = average length for herring, $\bar{L}_{H+B}$ = average length of herring + bottom fish, $\bar{f}_H$ = average weight fraction of herring, n = steamed distance (nautical miles) within the subarea.

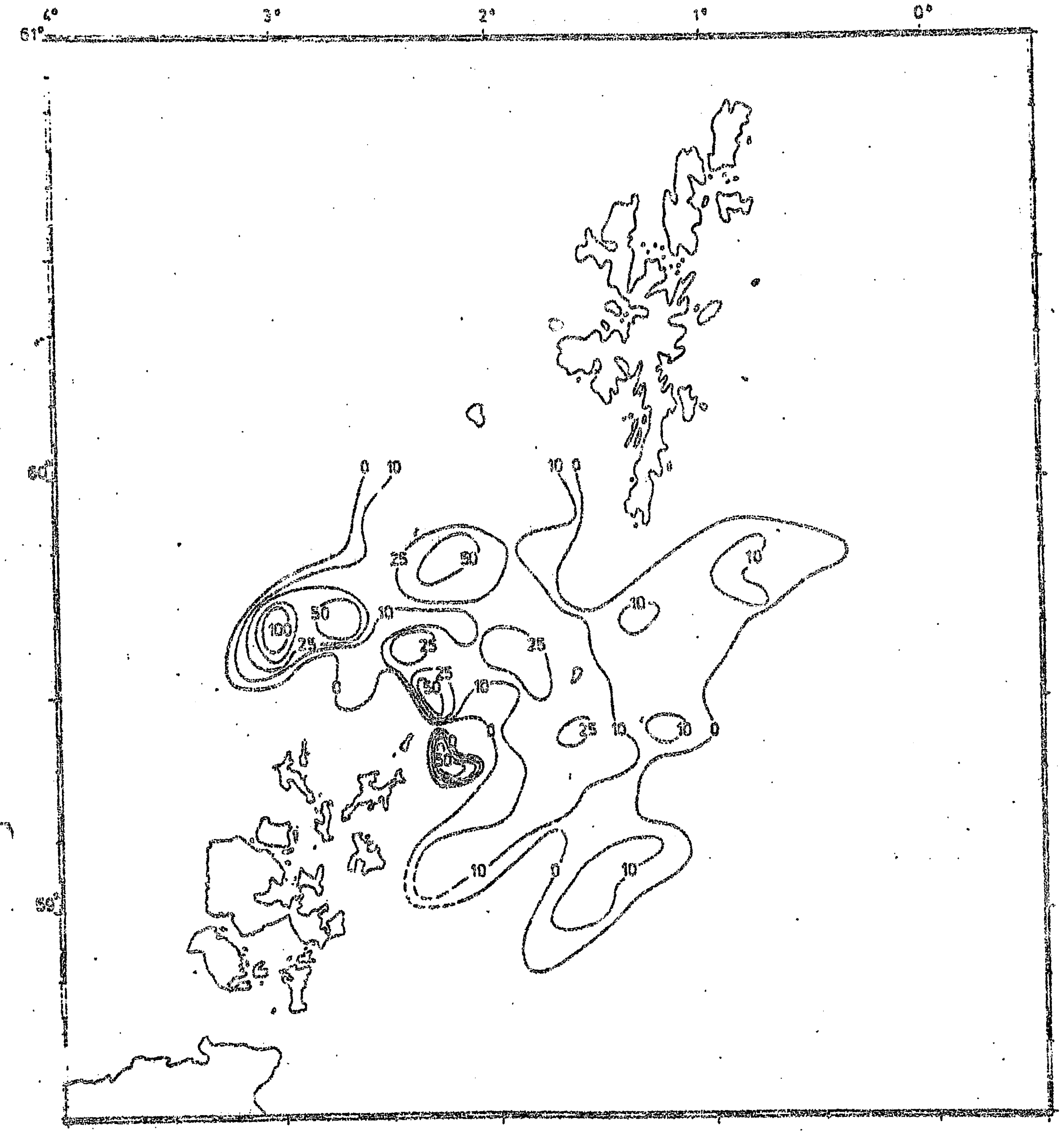

Fig 10: Distribution of integrator values for herring, G.O SARS -s", 23-31 July 1989.