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REPORT ON THE ICES-COORDINATED ACOUSTIC SURVEY OF HERRING STOCKS IN 1981

INTRODUCTION

In accordance with Council resolution 1980/2:24, a coordinated acoustic survey was carried out in the northwestern North Sea in the period 13 July-31 August 1981. Plans for the survey are described in Anon (1981). Vessels from the Netherlands, Norway and the UK took part.

Owing to the late finish of the survey in 1981, this report consists only of a compilation of reports on the three cruises together with a brief summary of the main results.

PRELIMINARY REPORT ON SURVEY BY R/V "G.O. SARS", 13-29 JULY 1981
by A Aglen and O J Østvedt, Institute of Marine Research, Bergen, Norway

Methods

The distribution and abundance of herring was estimated by aid of sonar mapping, echo integration and trawling. In addition data for "in situ" measurements of target strength were collected. These data are not yet processed and await further analysis. A Simrad EK 400/38 scientific echo sounder, a Simrad QD digital integrator and a NORD-10 computer were applied for echo integration.

Settings and technical data:

Frequency:	38 kHz
Transducer:	30 x 30cm, ceramic
10 log ψ:	-21dB
TVG and Gain:	20 log R + 2αR -10dB (where α = 0.008dB/m)
Deviations from theoretical TVG:	< 0.5dB at the actual depths
Threshold:	50 millivolt
Bandwidth:	3.3kHz; pulse length: 1.07 millisecond
Source level + Voltage response:	134.9dB, measured by aid of a 60mm copper sphere with -33.7dB target strength as described by Foote et al., (1981).

The sonar was run at 1250m basic range, 3° tilt and auto training in 3° steps within 30° on each side.

For sampling and identification of echo recordings three different trawls were used: a pelagic trawl with a maximum opening of 16 x 16m, a pelagic trawl with a maximum opening of 25 x 25m and a bottom trawl with a maximum opening of 20 x 6m. Hydrographic measurements were made with a CTD-zonde and zooplankton samples were taken with a Juday net. For each trawl catch the species and size distribution was established. Stomachs were preserved from cod, haddock, whiting, saithe and mackerel. Length, weight, sex, maturity stage and otoliths were taken from 100 individuals from each significant catch of herring.

Integrator readings were allocated to four categories: herring, bottom fish, 0-group fish and plankton. The allocation was mainly based on the appearance of the recordings, supported by frequent trawling. Average integrator values ($\bar{M}$) were calculated for each 225 (n.mile)^2 square. The herring biomass (B) within each square was estimated as $B = \bar{M} \frac{0.42}{27} \bar{L}225$ (tonnes) where $\bar{L}$ = average fish length (cms). The conversion factor $\frac{0.42}{27} \bar{L}$ is based on an average target strength of -31dB per kg for 27cm herring and a 20 log L length dependence for the target strength of an individual, as suggested by the Planning Group (Anon, 1981). This corresponds to a $\bar{TS} = -10 \log L - 16.7$dB/kg when individual weight is proportional to L^3. The values of target strength corresponding to the mean lengths of herring in trawl samples are approximately -31.8dB/kg east of 4°W and -31.0dB/kg west of 4°W.

Results

Figure 1 shows the survey grid and stations. A 10 mile grid (10 n.mile between parallel track lines) was run through most of the area. This was intensified to a 5 mile grid in areas with good herring recordings.

In the Shetland area (east of 4°W) all the recordings identified as herring were dense schools, typically extending from 20 to 60m depth, clearly separated from other fish recordings. During a couple of hours of darkness the schools slightly "loosened" but kept the school formation. Most of the schools were found south-east of Foula and east of Sumburgh Head. Between the first (15-20 July) and second (26-28 July) coverage of the area the schools had moved slightly south-southwestward.

Smaller schools 5-10m off the bottom were recorded over wide areas, especially between 2° and 4°W. None of these were identified as herring. Both pelagic and bottom trawl hauls gave mainly Norway pout (0-gr), haddock and whiting (Table 1).

South of Sule Skerry and North Rona (west of 4°W) the herring were exclusively found in small schools close to the bottom during daytime, rising about 20m off the bottom and scattering during the somewhat longer period of darkness in this area. The herring tended to be mixed with some haddock, whiting and gurnard (Table 2).

Figure 2 shows the distribution of echo sounder recordings and sonar contacts of herring along the track lines. The sonar was not run during the first 5 days of the cruise. The best sonar conditions were found in the area between Shetland and Orkney Islands where vertical temperature gradients were small. Schools detected in front of the vessel were often observed avoiding to the one or the other side when the vessel approached.

The estimated herring biomass within squares is shown in Figure 3. The total estimate for the area covered west of 4°W is about 19 400 tonnes. In the Shetland area the first coverage gave about 45 000 tonnes and the second about 30 000 tonnes.

The samples from the Shetland area contained larger (and older) herring than the samples west of 4°W. Length distributions are shown in Figure 4 and Table 3 shows the age compositions.

The herring in the Shetland area were more mature than in the western area. The last trawl haul (July 28) south of Shetland contained 9% with running gonads.

Discussion

Because of the observed avoidance, a significant proportion of the schools encountered may have been lost for echo integration. Too few data were collected to quantify this underestimation. More systematic use of sonar during later surveys may give an answer.

In the Shetland area where herring schools were clearly separated from other fish, the allocation of integrator values is believed to be precise. However, in the western area the allocations were more uncertain.

REPORT OF SURVEY BY R/V "TRIDENS", 27 JULY-7 AUGUST 1981

This brief report is based on information supplied by Mr G. van de Kamp and Mr G. Eltink, Netherlands Institute of Fishery Investigations, IJmuiden, the Netherlands, and on an acoustic analysis carried out by E.J. Simmonds (Aberdeen).

Methods

The survey was carried out using a Simrad EK 38 echosounder and a Marine Laboratory, Aberdeen, digital echointegrator. The settings and details of the acoustic equipment used during the cruise are listed below.

Frequency: 38kHz; Transducer: 15 x 30cm magnetostrictive: 10 log ψ: -18.2dB; Time varied gain (TVG): 20 log R + 2αRdB, where α = 0.008; pulse length 0.6ms; Receiver bandwidth: 3kHz; source level and receiver sensitivity referred to 1m point on the TVG function (measured using 60mm copper sphere of -33.6dB target strength) = +35.1dB.

The basic data were in the form of half-hour integrations.

The cruise track showing those parts of the track in which integration was carried out is shown in Figure 5. Integration was carried out only during hours of daylight. Echotraces were identified using a midwater trawl. Integrator readings were subsequently allocated to herring and other species by inspection of the echotraces. For each quarter statistical rectangle (15' latitude x 30' longitude), the mean herring density was estimated as the arithmetic mean of individual half-hour integrations. Target strengths of herring based on the values agreed by the Planning Group were -31.9dB/kg in the Orkney-Shetland area (mean length of herring 31.8cm, mean weight 290g) and -30.9dB/kg in the northern part of the Moray Firth (mean length 23.8cm, mean weight 131g).

Results

The results of trawl hauls are given in Table 4. Herring were caught in the south Shetland-Fair Isle area and in the Moray Firth off Clyth Ness. Echotraces consisting of plumes identified as being caused by herring, were recorded in the area south of Shetland (Figure 5). In addition echotraces thought to be those of herring were recorded in the Moray Firth during the return to Aberdeen at the end of the cruise. The estimated herring biomass in each quarter statistical rectangle is shown in Figure 6. The total for the area surveyed is 28 000 tonnes.

The length composition of herring samples taken by TRIDENS are given in Table 5. In the area south of Shetland (hauls 3 and 4), the herring were large and mostly full at maturity stage 5. South of Foula (haul 9) on 4 August, large spent herring were caught. In the Moray Firth (haul 12), the herring were on average smaller and consisted of full fish, spents and immatures.

REPORT ON SURVEY BY FRV "SCOTIA", 12-31 AUGUST 1981
by R S Bailey and E J Simmonds, Marine Laboratory, Aberdeen, UK

The survey by FRV "Scotia" was extended into the northern part of Division VIa and into the area east of Scotland where herring concentrations had been reported. The cruise track and trawl haul positions are shown in Figure 7. For the acoustic survey a Simrad EK 38 echosounder was used in conjunction with a Marine Laboratory, Aberdeen, digital echointegrator. Details and settings of the equipment used during the survey are given below.

Frequency 38kHz; Transducer 15 x 30cm ceramic; 10 log ψ: -16.4dB; TVG = 20 log R + 2 αR dB, where α = 0.008; pulse length = 0.6ms; Receiver bandwidth = 3kHz; source level and receiver sensitivity referred to 1m point on the TVG function (measured using a 60mm copper sphere of -33.6dB target strength); +33.3dB, The basic data were in the form of half-hour integrations.

On the survey, no plume echotraces characteristic of herring were recorded. Dense echotraces near the seabed were found over large areas, and the results of trawl hauls through them indicated that they were predominantly 0-group Norway pout and in some areas adult whiting and mackerel. Herring were caught in small quantities in some hauls in the south Shetland-Fair Isle region, but they were not associated with a distinctive echotrace. Echotraces which were identified as herring by trawl were found only in the northern Moray Firth close inshore off Wick. These consisted of very small marks distributed throughout the water column.

The biomass of herring was estimated for each quarter statistical rectangle in the following way. The echotraces were screened and integration values attributable to fish were extracted. At dusk, fish close to the bottom rose into midwater and became more diffuse and by night (2030-0400 GMT) the total integration in the whole water column was used. The integrator values from fish were allocated to herring and other species from the results of trawl hauls (Table 6). The small quantities of mackerel in some hauls in areas where herring were caught were excluded on the grounds that their target strength is lower than that of herring by more than 10dB (Edwards & Armstrong, 1981).

Using the target strength/length relationship advocated by the Planning Group, the target strengths used were as follows:

	Mean length of herring (see Table 5)	Mean weight of herring	Target strength
north of 58°45'N Shetland-Fair Isle	31.5cm	285g	-31.9dB/kg
58°-58°45'N (northern Moray Firth)	27cm	177g	-31dB/kg
south of 58°N (Aberdeen Bay)	8.6cm	7.1g	-27.1dB/kg

Sprats of similar size to herring in Aberdeen Bay were assumed to have the same target strength.

Other fish, predominantly 0-group Norway pout and other gadoids were assumed to have a target strength of -31dB/kg, based on cage measurements of the target strength of gadoids of a wide length range.

The estimated biomass of herring in each quarter statistical rectangle based on day and night values is given in Figure 8. The total for the whole area surveyed is 58 000 tonnes in the area north of 57°30'N. Because of the difficulty of distinguishing fish from plankton echotraces during the hours of darkness, a further estimate of herring biomass was made using daytime values only. The total for the same area, including some interpolated values for rectangles not surveyed by day, was 53 000 tonnes, ie not significantly lower than that using both day and night values. It is thus clear that the inclusion of diffuse night traces in the estimates did not bias the result upwards. The total fish biomass in the area surveyed was estimated to be 620 000 tonnes, of which most was probably 0-group Norway pout.

The herring caught in the area south of Shetland were almost entirely large spent herring (Stage VIII) with a small component of maturing and ripe fish (Table 5). In the Moray Firth, the fish were smaller and mostly at Stage IV.

SUMMARY AND CONCLUSIONS

For the 1981 survey the Planning Group advocated using a length dependent target strength for herring, assuming that the target strength of 27cm herring is -31dB/kg and that individual target strength is proportional to 20 $\log_{10}$L, where L is in cm. Based on this formula, the herring biomass estimates for the Orkney-Shetland area east of 4°W and north of 58°00'N) by the three ships taking part are:

Ship	Dates	No of quarter rectangles surveyed	Herring biomass (t x 10^{-3})
G.O. SARS	15-20 July	62	45 000
"	26-28 July	21	30 000
TRIDENS	27 July-7 August	28	28 000
SCOTIA	12-31 August	65	58 000

The target strength values on which the estimates are based varied according to the mean length of fish caught in each area but was approximately -31.8dB/kg in the main area of distribution. Taking into account the area coverage, there is considerable agreement between the estimates. All of them, moreover, indicate a very low population estimate in this area compared with the figure of 75-100 000 tonnes the previous year based on approximately the same target strength value (Anon, 1981).

Herring caught in the south Shetland-Fair Isle area in 1981 were mostly large fish and the only samples aged to date indicate a predominance of the 1973 and 1976 year classes. On the 1980 survey the 1976 year class predominated which indicates a drop in relative abundance of this year-class. Furthermore, there was little evidence of any substantial new recruitment to this area in 1981. In late July and August most herring caught in the south Shetland area were mature, while in mid-late August most were already spent. There was thus little evidence in the area surveyed of any substantial quantities of prespawners expected to spawn in September, the only area being a small area in the northern Moray Firth, where smaller fish were found.

During July and early August, the herring shoals were clearly recognisable as plumes on the echorecordings and identification was confirmed by trawling. In

mid-late August, no characteristic herring echotraces were found, and the integration values were allocated on the proportion of each species in trawl hauls. Allocation by substantiated trace identification has obvious advantages and it therefore appears that, in 1981, August was too late for an acoustic survey of the herring stock in this area despite the fact that the fish should be concentrated on the spawning grounds in that period.

REFERENCES

Anon	1981	Report of the Planning Group on ICES-coordinated herring and sprat acoustic surveys. ICES CM 1981/H:5, pp 9, mimeo.
Edwards, J.I. and Armstrong, F.	1981	Measurement of the target strength of live herring and mackerel. ICES CM 1981/B:26, pp 5, mimeo.
Foote, K.G., Knudsen, H.P., Vestnes, G., Brede, R. and Nielsen, R.L.	1981	Improved calibration of hydroacoustic equipment with copper spheres. ICES CM 1981/B:20.

Table 1. Trawl catches made by G.O.SARS east of 4°W.

Haul No.	Position	Date	Hour (GMT)	Duration (min.)	Catches in kg: Herring	Catches in kg: Others	Predominant species
Pelagic trawl							
240	60°35'N 00°17'W	14/7	2250	20		6.5	Norway pout (0-gr)
242	59°55'N 00°52'W	15/7	1355	35		No catch	
243	59°55'N 00°39'W	15/7	1610	50		6.3	Haddock
244	59°56'N 00°46'W	15/7	2335	55	40.3	3.3	Herring
245	59°45'N 01°15'W	16/7	0250	45	2.0	0.6	Herring
247	59°05'N 00°05'W	17/7	0100	20		16.0	Norway pout (0-gr)
248	58°45'N 02°12'W	17/7	0900	60		101.5	Whiting
250	59°30'N 02°29'W	18/7	0250	60		35.3	Whiting
251	59°29'N 02°29'W	18/7	0400	25		0.3	Whiting
252	59°39'N 04°00'W	18/7	0940	20		3.3	Gurnard
255	59°52'N 04°00'W	18/7	2350	20		No catch	
256	59°43'N 02°33'W	19/7	2310	20	4000.-	+	Herring
257	60°25'N 00°28'W	20/7	1725	30		+	Norway pout (0-gr)
258	60°58'N 00°49'W	20/7	2215	20		57.6	Norway pout (0-gr)
261	60°52'N 01°12'W	21/7	2135	15		50.0	Norway pout (0-gr)
262	61°03'N 01°13'W	22/7	0035	30		202.2	Norway pout (0-gr)
265	60°20'N 01°57'W	23/7	0040	45	1500.-		Herring
266	59°51'N 01°31'W	23/7	0130	20		2.0	Whiting
286	59°47'N 01°52'W	28/7	0140	50	34.1	11.9	Herring
288	59°53'N 00°57'W	28/7	1430	30		+	Haddock (0-gr)
Bottom trawl							
239	60°45'N 00°16'W	14/7	1750	60		195.5	Haddock
241	60°15'N 00°02'W	15/7	0650	60		156.-	Haddock
246	59°25'N 01°17'W	16/7	1330	60		204.6	Haddock
249	59°29'N 01°27'W	17/7	1800	60		62.7	Whiting
253	59°40'N 03°01'W	18/7	1345	45		108.5	Cod
254	59°45'N 02°30'W	18/7	1730	30		26.7	Haddock
259	60°47'N 01°43'W	21/7	0850	40		65.4	Haddock
260	60°44'N 02°13'W	21/7	1315	30		144.5	Norway pout
263	61°08'N 01°18'W	22/7	0345	30		172.1	Norway pout
264	60°21'N 01°59'W	22/7	1435	15		22.2	Lesser-spotted dogfish
284	59°47'N 02°29'W	27/7	1055	60		54.6	Lesser-spotted dogfish
285	60°00'N 02°10'W	27/7	1830	30		51.3	Haddock
287	59°47'N 01°30'W	28/7	0835	30		20.6	Haddock

Table 2. Trawl catches made by G.O.SARS west of 4°W.

Haul No.	Position	Date	Hour (GMT)	Duration (min.)	Catches in kg Herring	Catches in kg Others	Predominant species
Pelagic trawl							
267	59°10'N 04°00'W	23/7	1155	30		0.3	Haddock
269	58°40'N 05°55'W	23/7	2300	40	0.2	12.4	Gurnard
270	58°40'N 06°00'W	24/7	0025	20	450.-	18.5	Herring
272	58°51'N 05°50'W	24/7	1010	60	4.3	2.6	Herring
274	58°46'N 05°48'W	25/7	0320	30	2.0		Herring
275	58°46'N 04°54'W	25/7	0650	50		2.4	Haddock
277	58°45'N 04°55'W	25/7	1105	45		0.4	Haddock
278	59°18'N 04°49'W	25/7	1535	30		No catch	
279	58°58'N 04°20'W	26/7	0445	110	0.1	16.1	Norway pout (0-gr)
280	59°15'N 04°14'W	26/7	1510	30		6.5	Whiting
282	59°30'N 04°43'W	26/7	2155	15		10.9	Norway pout (0-gr)
283	59°35'N 04°35'W	27/7	0100	30		10 -	Norway pout (0-gr)
Bottom trawl							
268	58°42'N 06°05'W	23/7	2200	15	32.0	137.8	Haddock
271	58°51'N 05°40'W	24/7	0825	45		50.1	Haddock
273	59°20'N 06°20'W	24/7	1810	60		441.5	Sheppy argentine
276	58°46'N 04°52'W	25/7	0900	60		133.7	Haddock
281	59°26'N 04°30'W	26/7	1840	60		91.2	Whiting

Table 3. Age composition (%) in samples taken by "G.O. Sars" July 1981.

Year Class	79	78	77	76	75	74	73	<73	No. of oto-liths
Age (winter rings)	1	2	3	4	5	6	7	>7	
East of 4°W	0.4	0.4	3.8	33.6	10.9	7.6	41.2	2.1	238
West of 4°W	0	12.5	47.9	26.7	4.2	0.4	8.3	0	240

Table 4 Trawl catches made by TRIDENS

Haul No (see Fig. 5)	Position	Date	Time GMT	Duration (min)	Catches in kg		Predominant species and comments
					Herring	Others	
1	59°00'N 02°10'W	29 Jul	1710	35	-	1120	Whiting
2	59°10'N 01°15'W	30 Jul	1405	40	-	770	Whiting (380), haddock (380)
3	59°10'N 01°41'W	"	1715	75	10	890	Whiting (720), mackerel (90)
4	59°40'N 01°08'W	31 Jul	0730	60	15000	80	Mackerel
5	59°40'N 01°31'W	"	1145	30	-	1	*
6	59°42'N 01°53'W	"	1445	35	-	-	**
7	60°45'N 00°12'W	3 Aug	0855	35	-	4	**
8	59°50'N 01°00'W	4 Aug	0715	45	5	225	Whiting**
9	59°55'N 02°12'W	"	1425	30	70	51	Whiting**
10	59°26'N 01°38'W	"	2015	50	-	2780	Whiting (1920), haddock (400)
11	59°30'N 00°03'W	5 Aug	1010	85	-	883	Norway pout
12	58°15'N 02°59'W	6 Aug	0650	30	10	210	Whiting

*0-group Norway pout and sandeels in meshes
**0-group Norway pout in meshes

Table 5 Length compositions of herring sampled by TRIDENS and SCOTIA (hauls containing more than 10 herring only).

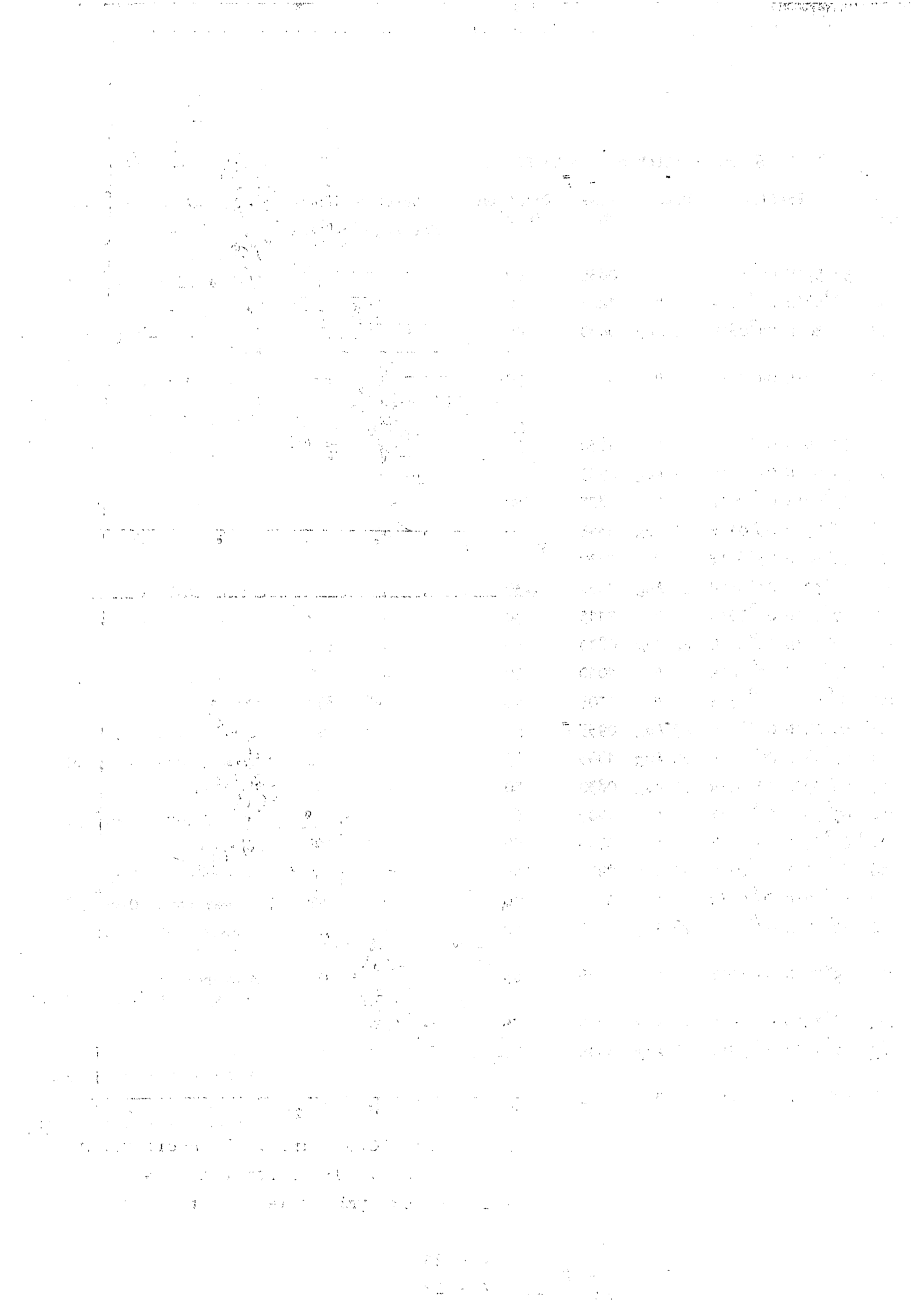
(See Tables 4 and 6 for details of trawl hauls

	TRIDENS					SCOTIA						
	3	4	8	9	12	104	105	112	121	122	123	124*
Length to cm below												
6												326
7											5	2941
8											28	2614
9											7	245
10											4	27
11											2	27
12												
13											2	2
14					3						6	29
15					6						20	114
16					3						31	90
17					1						11	25
18											4	1
19							1				1	
20										1		4
21							3			1		
22					2		5			2	3	1
23					2		3				8	
24					6		17			15	8	
25					7		141		1	40	6	
26			1		11		154	2		119	9	
27		1		1	10	3	96	6	5	100	7	
28			1		3	3	26	8	3	63	2	
29	4	5		3	4	6	7	11	3	37		
30	20	11		3		23	9	58	16	23		
31	21	23	1	16	1	54	8	55	7	12	1	
32	11	20	4	27		85	1	46	4	3		
33	4	15	3	24		33		21		2		
34		6	2	6		4		5				
35		3						1				
Total	60	84	12	80	59	211	471	213	39	418	165	6446

*Numbers raised from sample to total catch

Table 6 Trawl catches made by SCOTIA

Haul No	Position	Date	Time GMT	Duration (min)	Catches in kg Herring	Others	Predominant species and comments
99	58°59'N 06°38'W	14 Aug	0855	60	< 1	8	Norway pout (0-group)
100	58°44'N 06°49'W	"	1225	60	-	-	No fish
101	59°30'N 04°06'W	15 Aug	0840	80	< 1	220	Norway pout (0-group) 150kg Mackerel 60kg
102	59°30'N 04°22'W	"	1130	90	< 1	490	Norway pout (0-group) 390kg Mackerel 45kg Whiting 45kg
103	59°44'N 02°57'W	"	1830	50	1	60	Norway pout (0-group)
104	59°56'N 02°03'W	17 Aug	0755	60	45	4	Mackerel
105	59°47'N 01°20'W	"	1825	70	-	-	No fish
106	58°29'N 03°01'W	19 Aug	1345	40	> 1000	-	Codend burst on hauling
107	58°30'N 03°01'W	"	1530	30	-	-	Net damaged
108	59°32'N 03°55'W	21 Aug	1820	c.30	-	-	Trial haul
109	59°31'N 03°35'W	"	2115	30	-	16	Norway pout (0-group)
110	59°19'N 01°35'W	22 Aug	0830	40	-	c.5	Grey gurnard
111	59°20'N 01°42'W	"	1010	50	-	95	Norway pout (0-group)
112	59°43'N 02°03'W	"	1705	75	48	890	Whiting
113	59°05'N 01°48'W	23 Aug	0955	65	< 1	95	Norway pout (0-group)
114	60°44'N 00°42'W	25 Aug	1845	45	-	6	Norway pout (0-group)
115	60°39'N 01°52'W	26 Aug	0830	50	-	-	No fish
116	60°54'N 00°42'W	"	1705	60	-	< 1	Norway pout (0-group)
117	60°53'N 00°41'W	"	1945	55	-	215	Mackerel 205kg
118	60°15'N 00°27'W	27 Aug	0905	115	-	4	Norway pout (0-group)
119	60°10'N 00°04'W	"	1430	90	-	95	Norway pout (0-group)
120	60°00'N 01°25'W	28 Aug	1040	60	-	470	Norway pout (0-group) 460kg Spurdog 10kg
121	59°39'N 01°42'W	"	1655	65	8	130	Mackerel 65kg Norway pout (0-group) 65kg
122	58°30'N 03°00'W	29 Aug	1035	25	ca 10000	-	
123	57°11'N 01°58'W	30 Aug	1005	55	5	10	Sprat 0-group sandeel in meshes
124	57°10'N 01°57'W	"	1230	45	30	65	Sprat 0-group sandeel in meshes



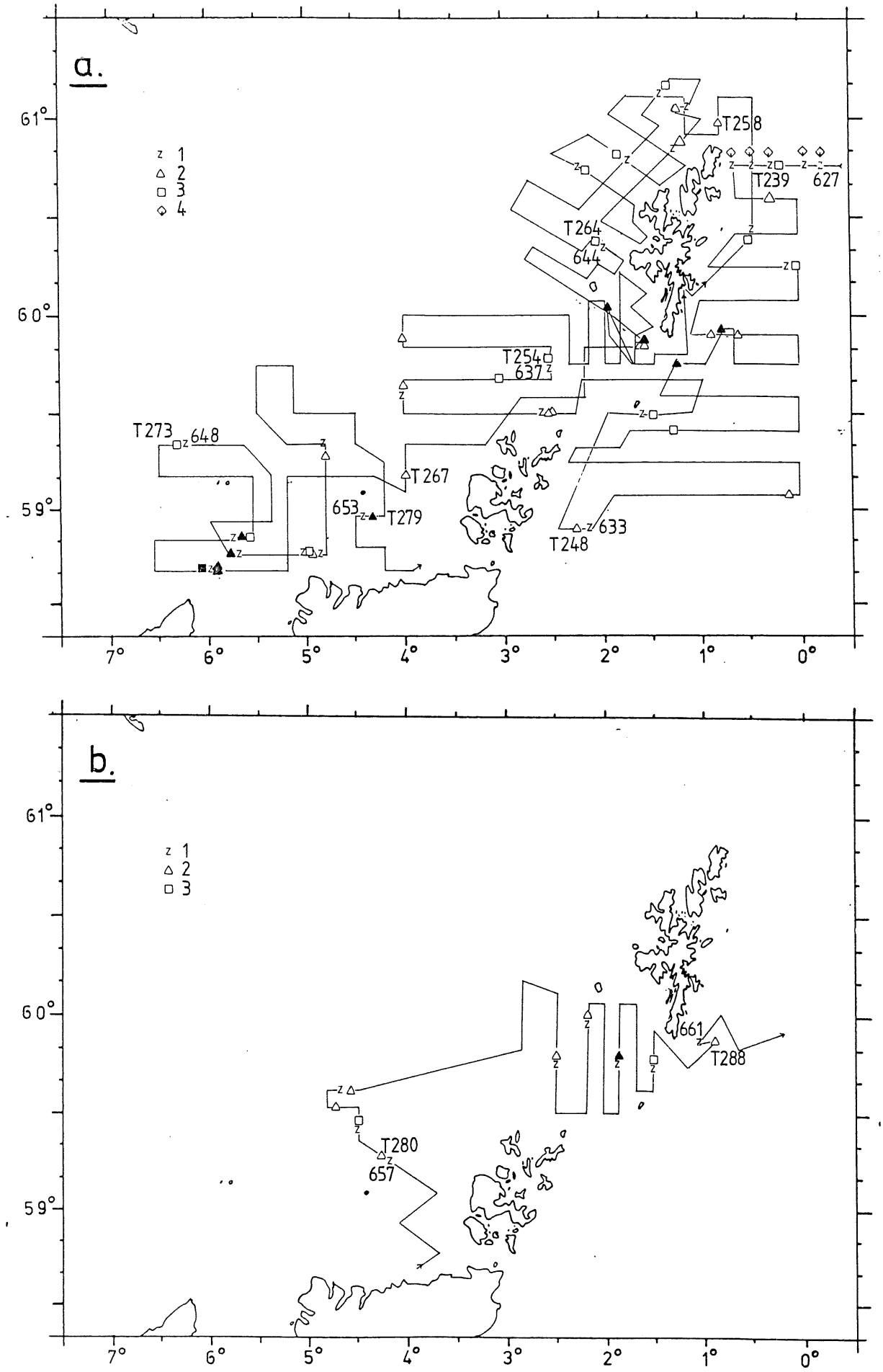


Figure 1. Survey grid and stations "G.O. Sars". 1: Hydrographic station, 2: Pelagic trawl, 3: Bottom trawl 4: Zooplankton sample. Black symbols means catches of herring.

a. July 14 - 26

b. July 26 - 28

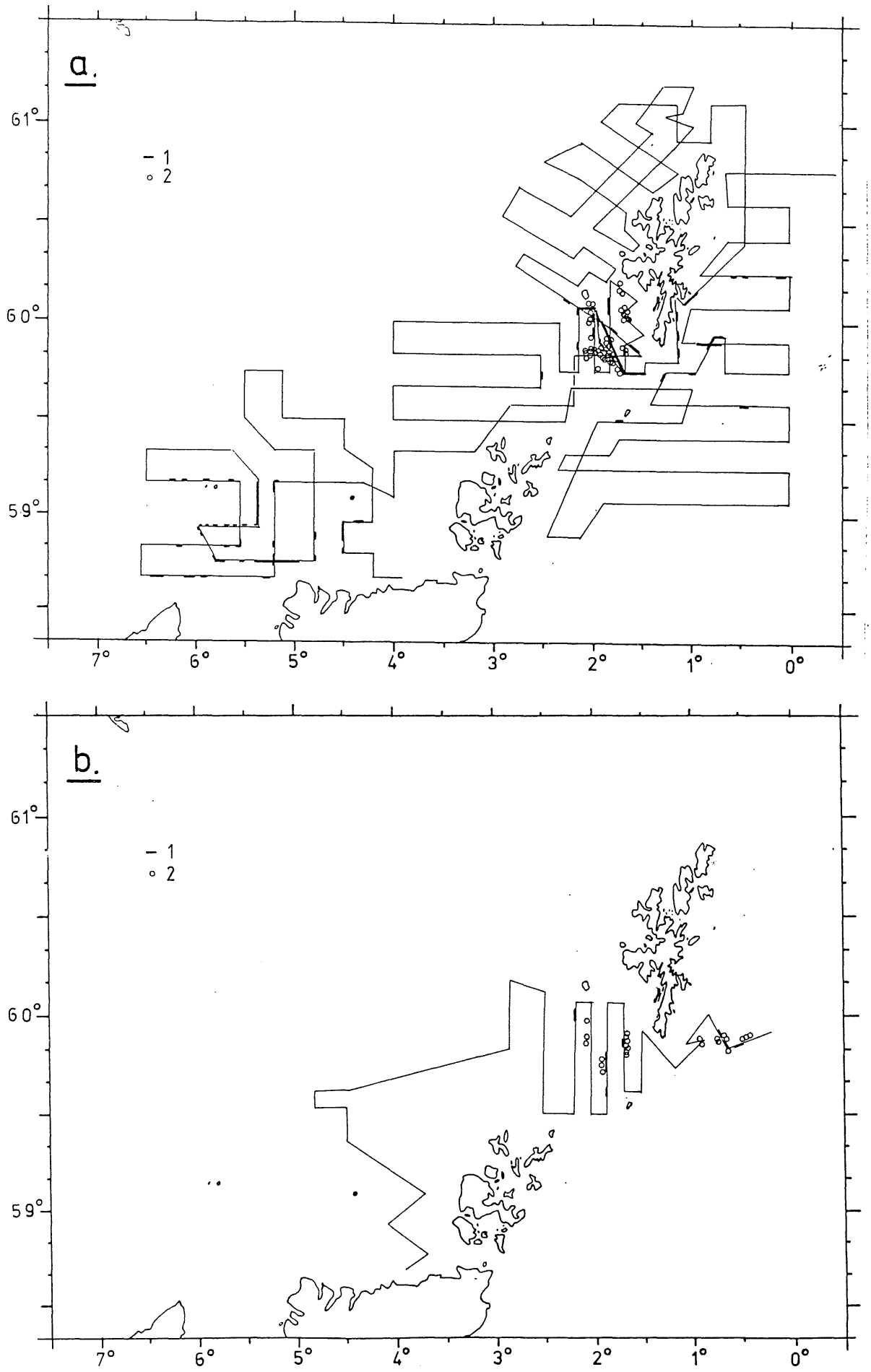


Figure 2. Echo sounder recordings (1) and sonar contacts (2) of herring, "G.O. Sars".

a. July 14 - 26

b. July 26 - 28

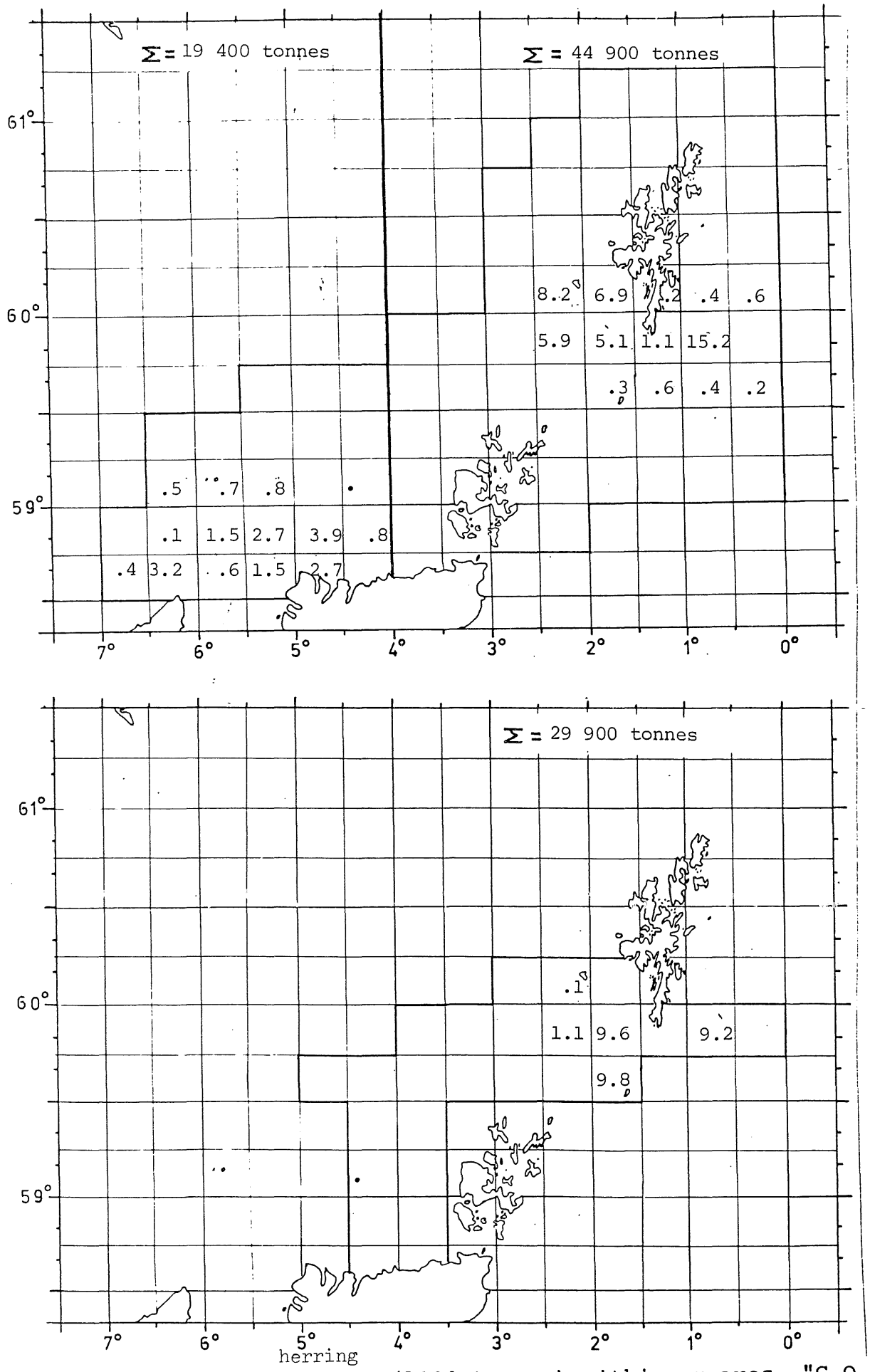
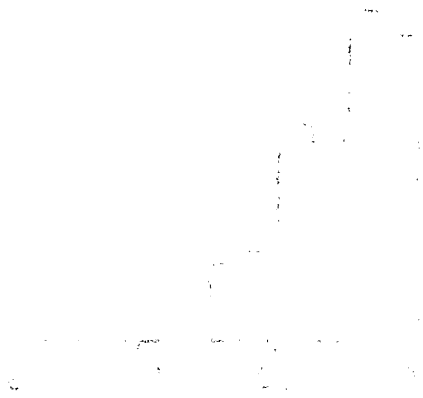
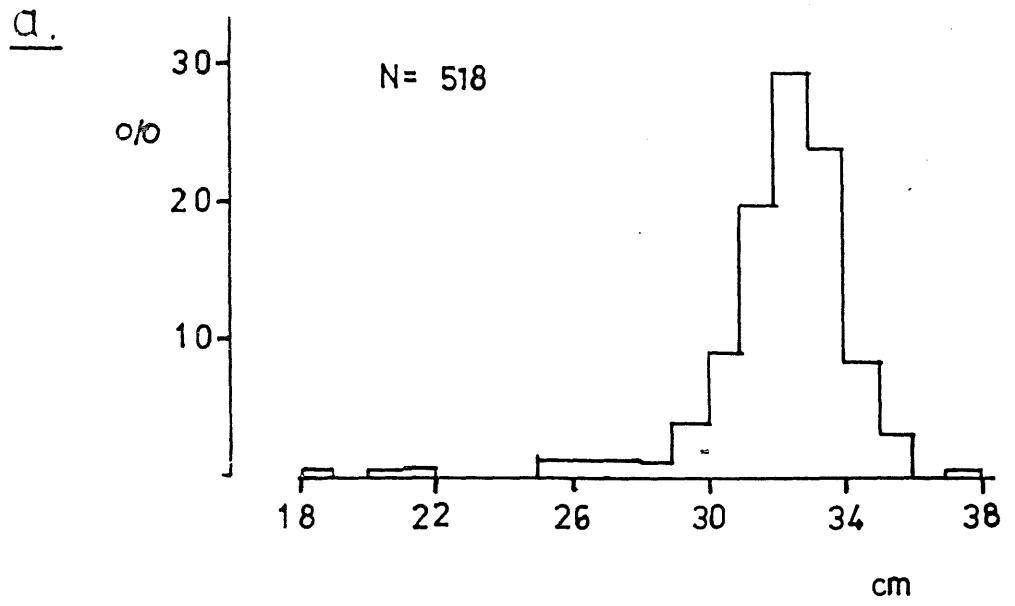


Figure 3. Estimated/biomass (1000 tonnes) within squares, "G.O. Sars".

a. July 14 - 26

b. July 26 - 28





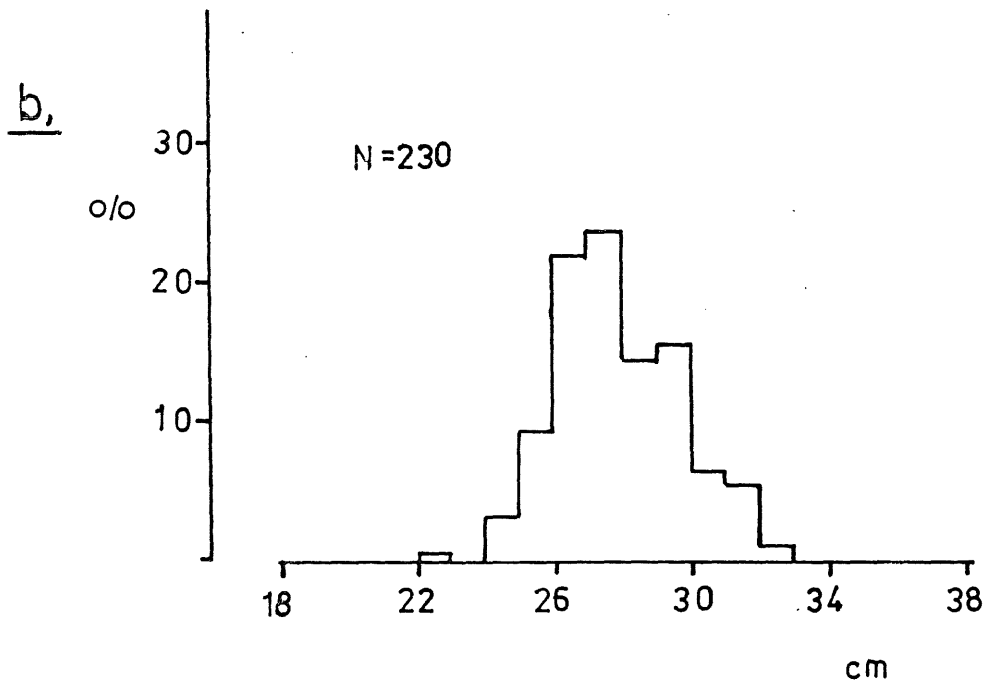


Figure 4. Length distribution of herring, "G.O. Sars".
(N = number measured)

a. East of 4°W

b. West of 4°W

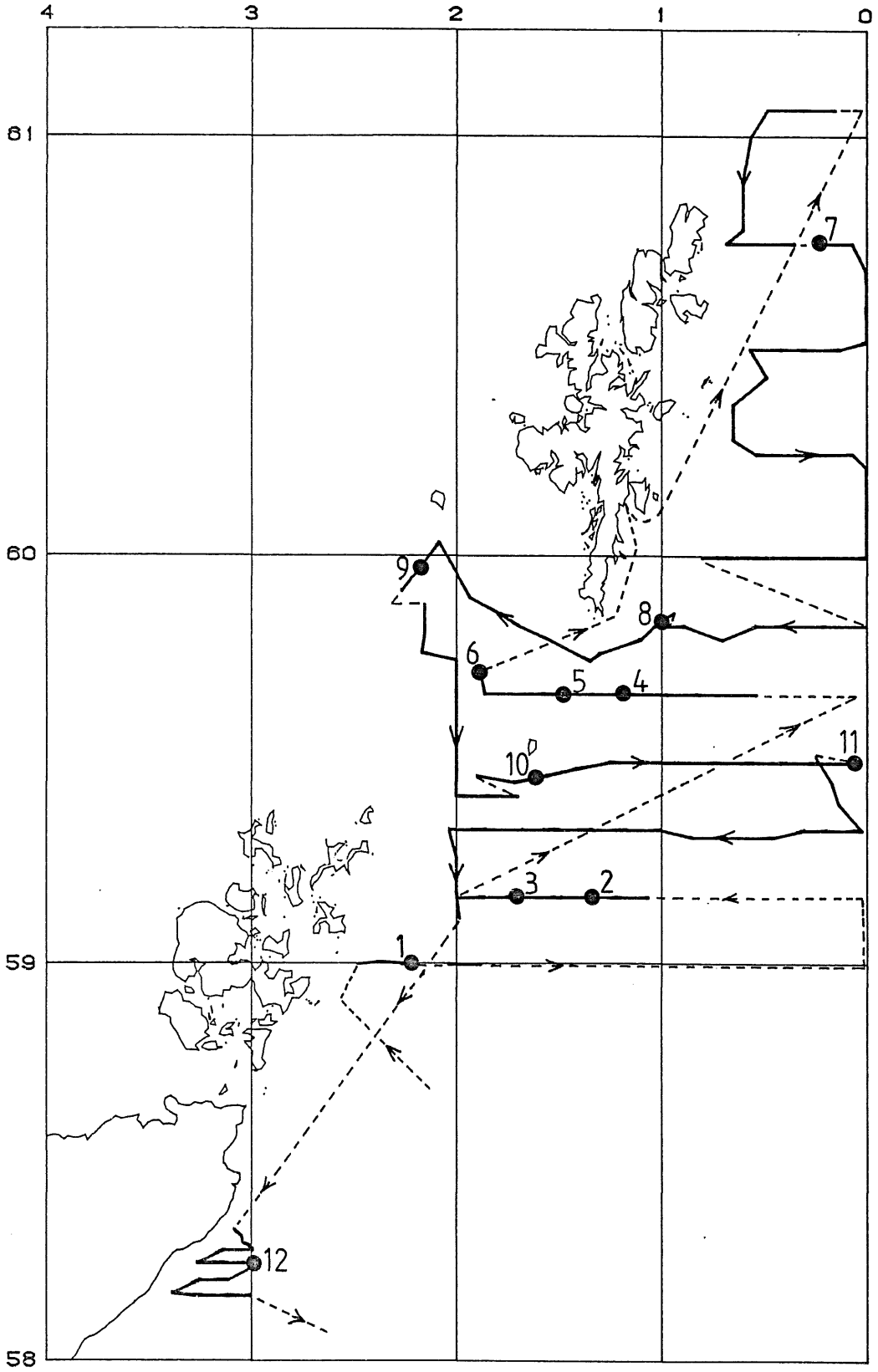
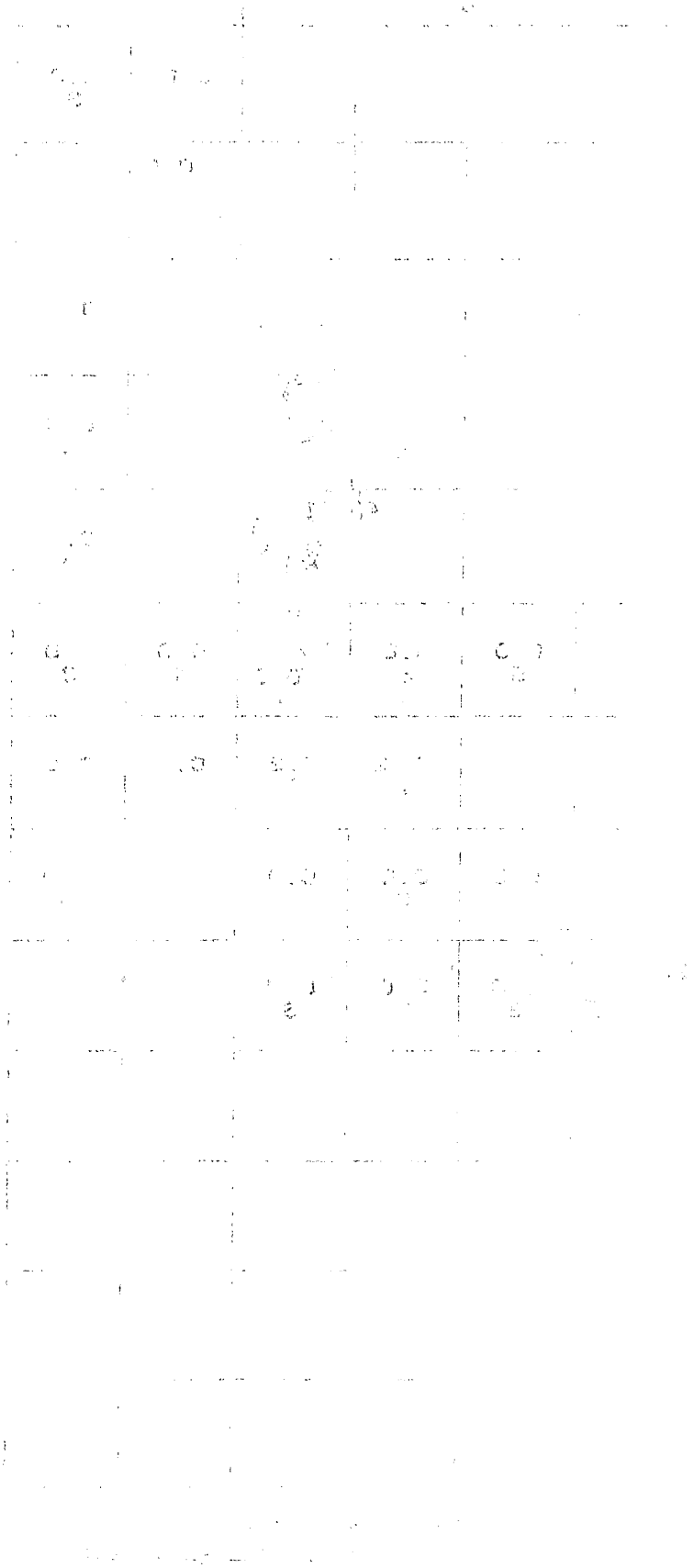


Figure 5 Survey track and trawl hauls, TRIDENS 27 July-7 August 1981
Hatched - steaming; full line - echointegrator survey



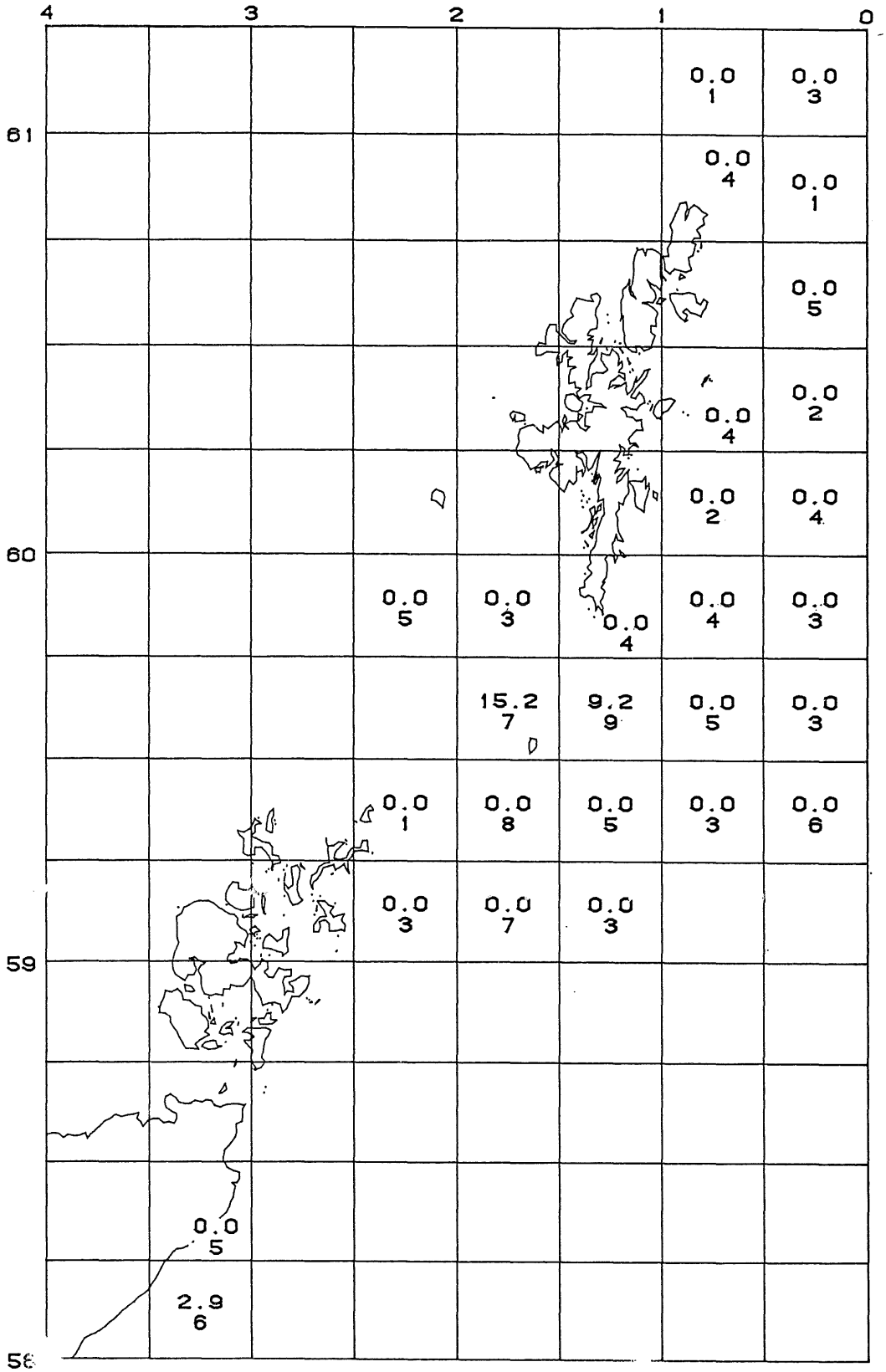


Figure 6 Estimated biomass of herring (thousand tonnes) in each rectangle.
TRIDENS 27 July-7 August 1981 (Lower figure is number of half-hour integrations)

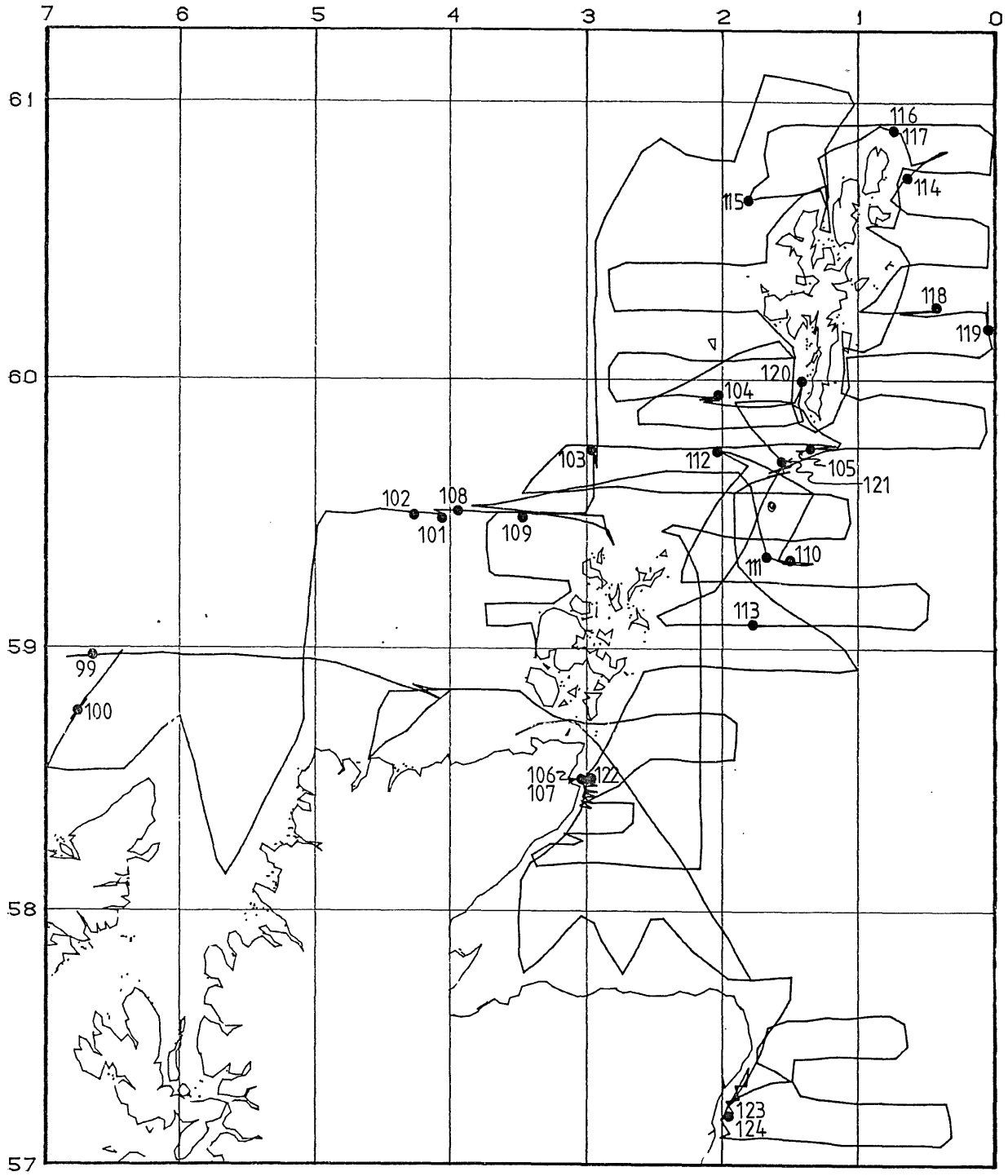
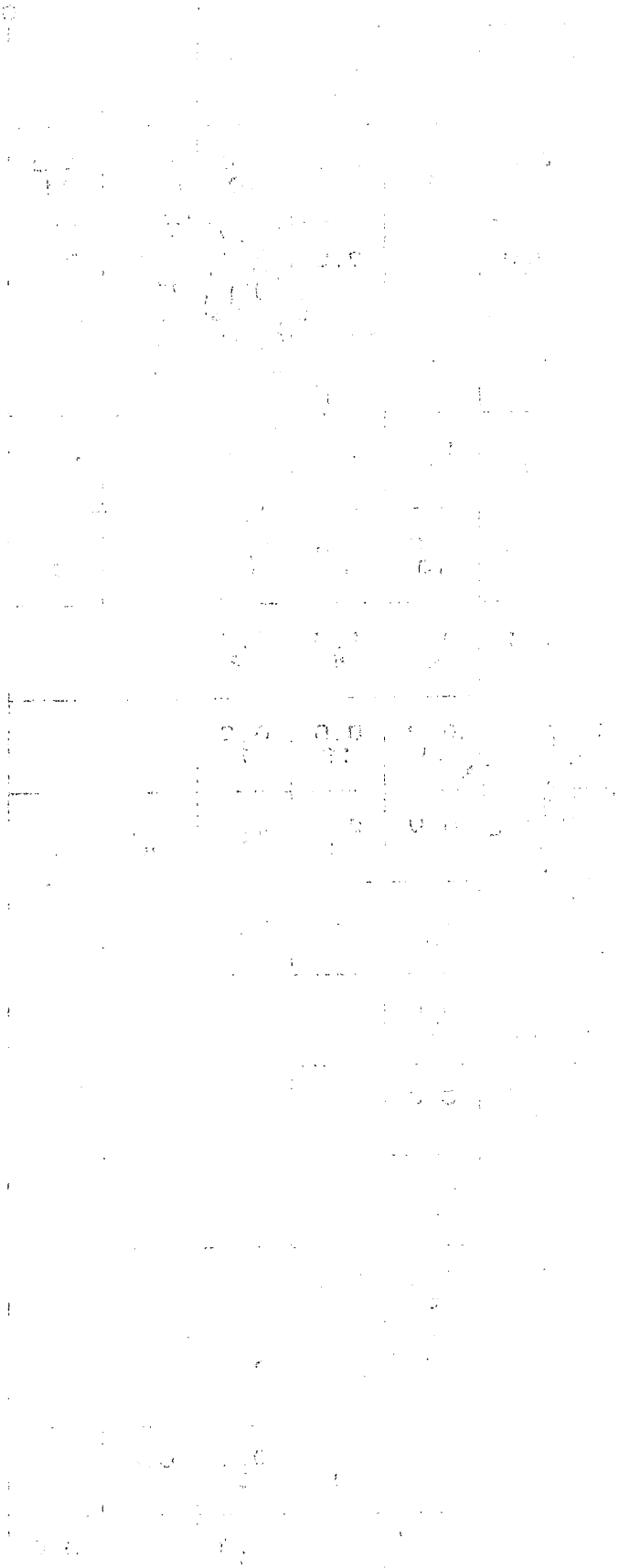


Figure 7 Survey track and trawl hauls, SCOTIA 12-31 August 1981



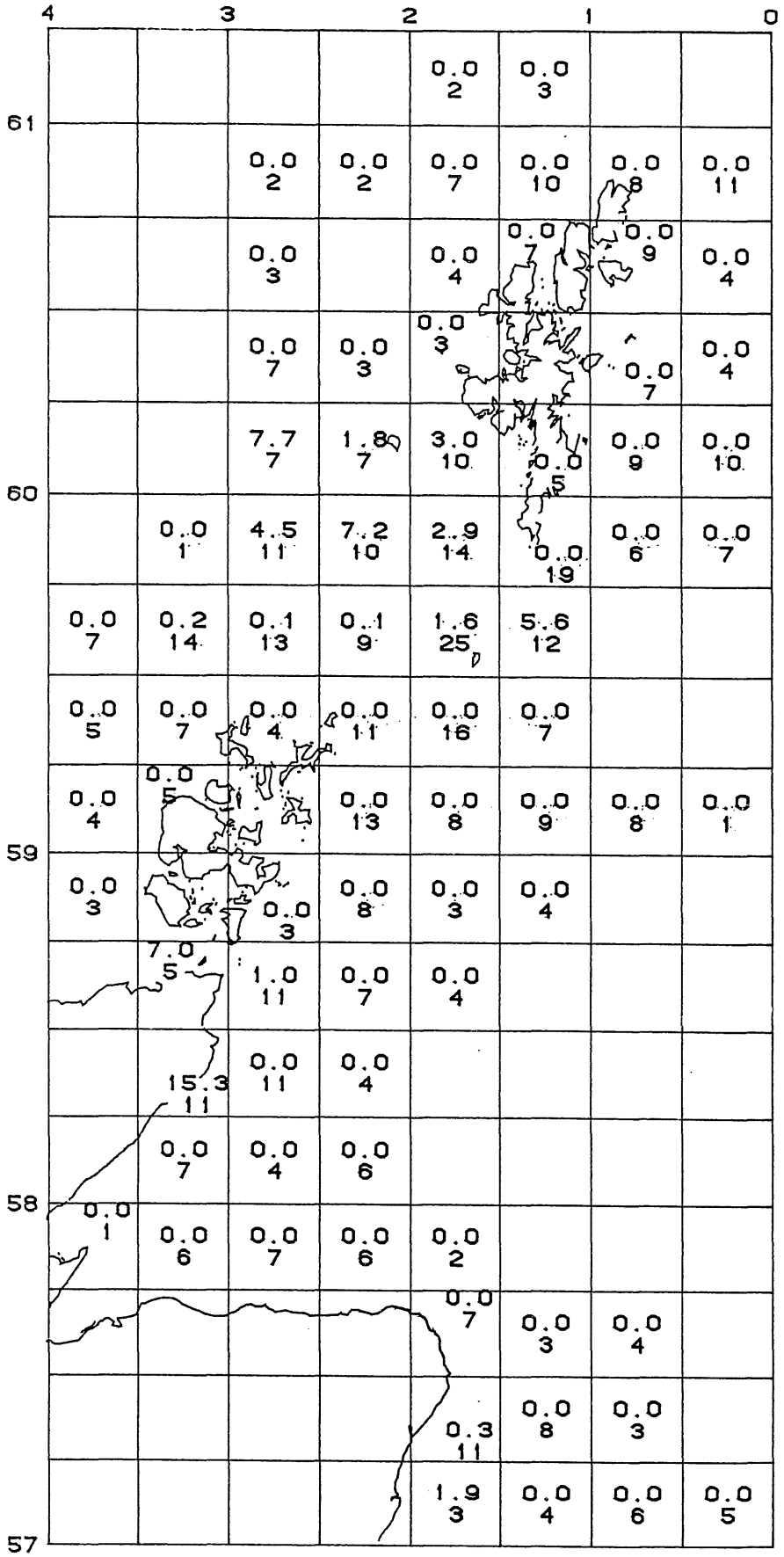


Figure 8 Estimated biomass of herring (thousand tonnes) in each rectangle SCOTIA 12-31 August 1981 (Lower figure is number of half-hour integrations)