Preliminary report from the acoustic herring survey with R/V "G.O. Sars" in the Shetland area 18 - 30 July 1983

by

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Methods

Distribution and abundance of herring were estimated by echo integration and trawling. Technical data and settings of acoustic equipment are given in Table 1. A 19 kHz sonar was run continuously to give indications of schools during surveying and to guide the vessel toward schools during trawling. A 120 kHz sonar was connected to a tape recorder to record fish echoes for later doppler analysis. A large-meshed pelagic trawl ("Fotö, Modell 80") was used for sampling and identification of traces. The mesh size is 3200 mm (bar) at the trawl opening, gradually decreasing to 11 mm (bar) in the cod end. The upper and lower panel have 21 meshes at trawl opening and the side panels have 10 meshes. Vertical trawl opening is usually 15-20 m at 4 knots speed.

To detect eventually newly hatched herring larvae a "Bongo 20" net was used for double oblique plankton hauls from 0-30 m depth. Following the recommendations from the Planning Group (CM 1983/H:12) the plankton samples were taken southwest of Foula.

Average integrator values per nautical mile were obtained every two nautical mile sailed. Contributions from traces considered to be herring were separated. This seperation was based on the experience from the trawl catches. Average integrator value ($\bar{M}_H$) for herring was calculated within quarter rectangles. The number of herring per quarter rectangle was calculated as $N = \bar{M}_H \cdot C_I \cdot C_F \cdot A$, where A is the area of the rectangle, $C_I = 0.0814$ m^2

back-scattering cross-section needed per square nautical mile to give an integrator reading of 1 mm/n.mile.
$C_F = 10^{-0.1 \cdot TS} = 13.2 \cdot 10^6 \cdot L^{-2}$ which is the number of L cm herring needed to give 1 m^2 back-scattering cross-section, assuming TS = 20 log L -71.2 dB as recommended by the Planning Group (CM 1983/H:12).

Results

Figure 1 shows survey grid and stations. Most of the herring was recorded in four small areas indicated in Figure 2. The surveyed area was divided in four sub-areas, each containing one of these concentrations (Fig. 2). In sub-area East and South all schools identified as herring during daytime had a rather narrow horizontal extension and wide vertical extension compared to other fish schools. Typically the width of the herring schools was 30-100 m and the height 10-40 m (Fig. 3). They also occurred higher up in the water coulumn than most other fish recordings, except for some heavy traces of Norway pout close to the east coast of Shetland (Fig. 4). Those schools were wider and had a more irregular shape than the herring schools. Further from the coast all Norway pout was recorded as smaller schools less than 20 m off bottom, like the deepest recordings in Figure 4.

In the Middle sub-area most of the herring occurred in schools like those described above, but in the deepest basin west of Sumburgh some small schools 10-20 m off bottom gave a few herring mixed with whiting and mackerel. In subarea West the herring schools had a more irregular shape and were closer to the bottom (Fig. 5).

During night some herring kept in schools while others (possibly the smaller herring) scattered. Therefore the allocation of integrator values was more difficult during night.

Table 2 shows the composition of trawl catches and Table 3 shows the length distributions of herring. Distributions of

maturity stages are given in Table 4. Some trawl hauls were without success because the herring tended to avoid both sidewards and downwards. The big herring at the east coast was most difficult to catch. 0-group Norway pout is too small to be caught representatively. The trawl catch compositions are therefore not considered to be representative for the composition of the echo recordings. Due to this it was decided that the catches should only be used for identification of traces.

Within each sub-area the average length distribution were used to calculate average target strength (Table 5) and number of herring per cm - group (Table 6). Numbers were converted to weights using the equation:

$$\text{weight in grams} = 2.457 \cdot 10^{-7} \cdot (\text{length in mm})^{3.645}$$

which is the regression of length and weight data obtained onboard FRV "Scotia" in the whole Orkney - Shetland area from 6 - 26 July 1983.

The maturity samples showed that all herring below 25 cm and about 30% of the 25 cm herring were immature (stage I and II). A few in stage VIII were found in sub-area East, while all the rest were expected to spawn this autumn (stages III - VII). The total estimate of 1279 million herrings (250 000 tonnes) thus consists of 456 million immatures (27 000 tonnes) and 820 million spawners (222 000 tonnes).

The quarter rectangle between North $60^{\circ}00'$ - $60^{\circ}15'$ and West $01^{\circ}00'$ - $00^{\circ}30'$ was covered with north-south legs 2.5 nautical miles apart during daytime the 21 July. This was done to get a comparison with the results obtained with FRV "Scotia", which covered the same area during the same day. The estimate from this coverage was 224.2 million herring, based on 48 integrator-readings (96 nautical miles). When combining all track lines in the same square (92 nautical miles) during the rest of the survey, another estimate of 118.8 million herring was obtained.

This estimate is based on both day and night observations, while the first one is based on only daytime observations. Comparisons of day and night observations in other squares did not, however, indicate systematic differences. The difference observed in this case might be random or caused by movements of the herring schools. The estimates given in Figure 2 and Table 6 are based on all observations in the square.

No herring larvae were caught in the 8 plankton hauls made in sub-area West. The maturity stages observed did not either indicate any early spawning in the area.

Table 1. Technical data and setting of acoustic equipment, R/V "G.O.Sars".

Echo sounder	Simrad EK 400
Frequency	38 kHz
Receiver gain	-10 dB+20 log R+2·0.008·R
Pulse length	1.0 ms
Bandwidth	3.3 kHz
Transducer	45x48 cm
Effective beam angle (10 log Ψ)	-23.2 dB
Basic range	150 m
Source level + Voltage response	134.5 dB at 0 dB receiver gain
Integrator	NORD-100 computer
Threshold	17 millivolts peak
Instrument constant (C_I) for survey settings	0.0814 m^2 backscattering cross section per square nautical mile per integrator unit

Table 2. Trawl catches, R/V "G.O.Sars" 18.-30. July 1983. P = pelagic trawl, B = bottom trawl.

ST NO	DATE	HOUR (GMT)	POSITION NORTH	POSITION WEST	CATCH (number of fish) Herring	Whiting	N. pout	Mackerel	Others	TOTAL (kg)	Remarks
B 824	18	1405	60°45'	00°01'	-	3	1 227	-	180	454	
P 827	18	1825	60°44'	00°27'	-	-	-	-	-	-	Salps meshed
P 832	19	1445	60°36'	00°19'	-	-	-	15	-	7	Krill meshed
B 833	19	1520	60°30'	00°06'	1	27	1 014	-	421	192	
P 835	20	0000	60°27'	00°47'	7	47	3 000	-	-	80	
P 837	20	0710	60°19'	00°47'	10	280	10 000	-	4	151	
P 839	20	0900	60°14'	00°58'	-	57	60 000	-	3	155	
P 841	20	1300	60°09'	00°30'	-	3	-	-	28	26	
P 842	20	1550	60°10'	00°54'	8 333	20	-	-	-	2 512	
P 845	21	0123	59°56'	01°09'	-	29	750	-	2	12	
P 846	21	0320	59°26'	01°10'	-	-	4 500	-	-	15	
P 849	21	1230	60°15'	00°48'	-	-	-	-	6	3	Schools avoided
P 850	21	1740	60°14'	00°37'	1	-	-	-	10	14	Schools avoided
P 851	21	1915	60°12'	00°38'	2	-	-	-	48	36	Schools avoided
P 852	21	2340	60°12'	00°51'	17 000	-	-	-	-	5 000	
P 853	22	1000	60°02'	00°10'	-	1	50	1	59	43	0-gr.haddock meshed
P 855	22	1445	59°50'	00°34'	-	-	-	-	9	8	Schools avoided
P 858	22	2130	59°55'	01°36'	35	1 990	-	60	7	594	
P 859	22	2317	60°00'	02°27'	-	2	810	-	-	3	
P 863	23	0535	59°48'	01°41'	11	22	-	76	16	49	
B 864	23	0800	59°45'	01°40'	-	-	340	-	41	44	
P 865	23	1130	59°56'	01°49'	3	726	-	278	2	566	
P 870	23	2300	59°41'	01°57'	1 900	4	3 600	-	-	202	
P 871	24	0125	59°46'	01°58'	20	700	1 050	-	-	235	
P 873	24	0570	60°05'	02°20'	1	2	100	106	-	28	
P 878	24	1725	59°26'	01°21'	260	1 290	-	44	19	370	
P 881	24	2236	59°40'	01°00'	650	530	-	-	900	300	0-gr.haddock meshed
P 883	25	1730	60°01'	01°01'	-	-	18 000	-	-	60	
P 884	25	1845	59°58'	01°04'	-	-	4 280	-	-	20	
P 887	26	0515	59°23'	00°14'	-	-	-	-	10 000	22	Müllers pearlside
P 889	26	1128	59°20'	01°24'	-	170	-	-	-	45	
P 890	26	1325	59°20'	01°22'	12	3 450	23 400	-	2	1 500	
P 891	26	1700	59°05'	01°37'	63 300	-	-	-	-	10 000	
P 895	27	0255	59°17'	01°48'	4 130	1	-	4	-	351	
P 902	27	2200	59°46'	03°20'	-	-	9 000	2	-	30	
P 906	28	0300	59°43'	02°29'	-	-	1 500	-	-	5	
B 909	28	0650	59°53'	02°55'	-	1	19	-	97	29	Bad bottom
P 911	28	0945	60°01'	02°41'	7 710	-	-	1	-	2 500	
P 913	28	1425	60°06'	02°37'	-	-	-	-	-	0	Schools avoided
P 914	28	1530	60°04'	02°41'	1 456	-	-	1	-	521	
P 915	28	1850	60°11'	02°13'	284	2	-	95	32	142	
P 916	29	0410	60°41'	01°31'	-	-	-	-	-	0	Krill meshed
P 917	29	0635	60°47'	01°07'	1	-	-	9	1	4	Schools avoided
P 919	29	1400	60°41'	00°43'	-	-	1 923	-	-	52	
P 920	29	1645	60°39'	00°41'	1	-	-	-	-	0	Missed the schools

Table 3. Length distribution (%) of herring R/V "G.O.Sars" 18.-30. July 1983

SUB-AREA / LENGTH (cm)	WEST			EAST		MIDDLE				SOUTH		
ST.NO.	911	914	915	842	852	858	870	871	881	878	891	895
14												0.8
16												3.1
18										2.8		22.1
20							2.0			22.6		14.2
22										22.6		7.9
24							20.0			2.8		7.9
26							34.0	10.0		0.9	1.8	17.3
28						2.9	30.0	5.0		4.7	13.2	8.7
30							8.0		1.0	0.9	11.5	3.1
32						2.9	2.0				5.3	5.5
34						11.4	2.0	5.0	7.0		2.6	3.1
36				1.5		22.9		35.0	11.0	1.9	3.1	0.8
				5.4	3.0	34.3		15.0	34.0	9.4	17.2	4.7
	2.9			7.7	5.0	19.8		10.0	20.0	10.4	20.3	0.8
	3.9	1.1	3.0	10.8	9.0			5.0	16.0	13.6	16.3	
	11.7	4.4	3.0	10.8	8.0	2.9		5.0	7.0	3.8	5.3	
	2.9	6.6	8.1	9.2	13.0				1.0	0.9	2.6	
	12.6	12.1	21.2	13.8	22.0	2.9	2.0		2.0			
	28.2	33.0	29.3	22.3	20.0			5.0	1.0	0.9	0.4	
	32.0	27.5	29.3	10.8	19.0			5.0		0.9	0.4	
	5.8	13.2	6.1	6.9	1.0							
		2.2		0.8								
No. meas.	103	91	99	130	100	35	50	20	100	106	227	127

Table 4. Distribution (%) of maturity stages of herring R/V "G.O.Sars" 18.-30. July 1983.

SUB-AREA	ST. NO.	I	II	III	IV	V	VI	VII	VIII	No in sample
WEST	911				1.0	23.3	19.4	56.3		103
"	914			1.1	6.6	62.6	27.5	2.2		91
"	915					40.0	5.0	55.0		100
EAST	842			6.0	60.0	31.0			3.0	100
"	852			4.0	96.0					100
MIDDLE	858		5.7	34.3	60.0					35
SOUTH	891	32.6	2.6	11.0	30.8	22.5	0.4			227

Table 5. Average target strength ($\overline{TS}$) of herring within sub-areas, R/V "G.O. Sars" 18 - 30 July 1983.

Sub-area	WEST	EAST	MIDDLE	SOUTH
$\overline{TS}$ (dB)	-40.9	-41.2	-42.9	-44.1

Table 6. Estimated number (N millions) and weight (W 1000 tonnes) of each cm-group of herring within sub-areas.

	WEST		EAST		MIDDLE		SOUTH		TOTAL	
cm	N	W	N	W	N	W	N	W	N	W
14							1.8	0.03	1.8	0.03
							5.9	0.12	5.9	0.12
16							48.8	1.30	48.8	1.30
					1.4	0.05	72.3	2.40	73.7	2.45
18					-	-	60.0	2.45	60.0	2.45
					-	-	21.2	1.05	21.2	1.05
20					13.8	0.83	39.4	2.36	53.2	3.19
					30.3	2.17	52.4	3.75	82.7	5.92
22					26.2	2.22	30.6	2.59	56.8	4.81
					6.3	0.63	22.9	2.29	29.2	2.92
24					3.3	0.38	11.2	1.30	14.5	1.68
					17.6	2.38	7.6	1.03	25.2	3.41
26			1.9	0.29	47.4	7.39	46.5	7.25	95.8	14.93
			9.9	1.78	57.3	10.25	60.0	10.74	127.2	22.77
28	1.8	0.36	16.3	3.33	34.4	7.03	52.4	10.70	104.9	21.42
	4.8	1.11	23.4	5.43	14.6	3.39	37.1	8.60	79.9	18.53
30	11.4	2.99	21.0	5.52	10.2	2.68	12.4	3.25	55.0	14.44
	10.5	3.10	26.2	7.76	0.8	0.24	1.8	0.52	39.3	11.62
32	27.2	9.03	42.3	14.05	4.7	1.56	0.6	0.20	74.8	24.84
	53.6	19.95	50.1	18.62	4.1	1.54	2.4	0.87	110.2	40.98
34	52.6	21.80	35.2	14.59	3.6	1.48	1.8	0.73	93.2	38.60
	14.9	6.87	9.4	4.35					24.3	11.22
36	1.2	0.63	0.9	0.48					2.1	1.11
TOTAL	178.0	65.85	236.6	76.22	276.0	44.22	588.8	63.53	1279	250
IMMATURE	-	-	-	-	87	7	369	20	456	27
SPAWNING STOCK	178	66	233	75	189	37	220	44	820	222

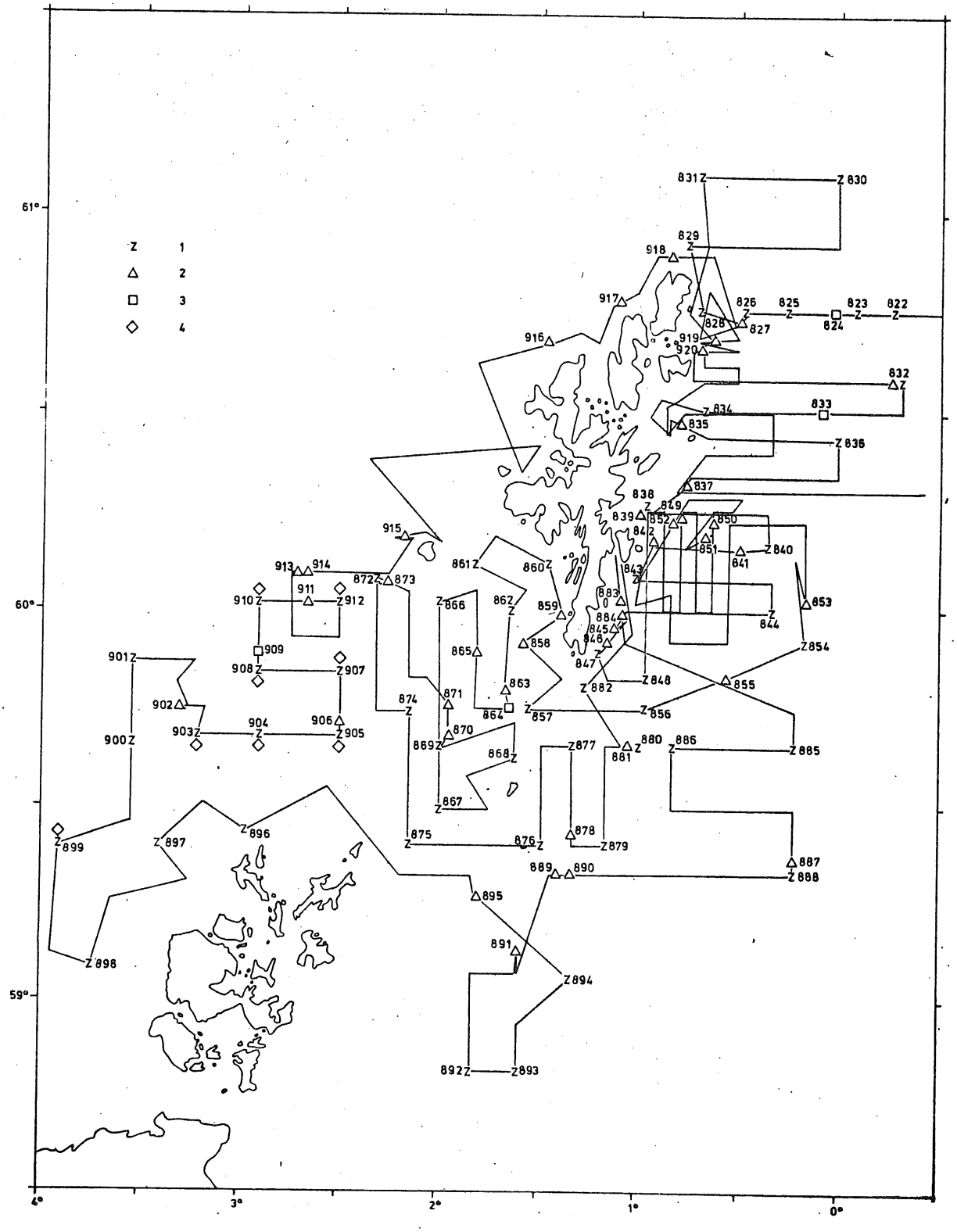

Figure 1. Survey grid and stationes, R/V "G.O.Sars" 18-30 july 1983.

1: Hydrographic station (CTD-zonde)

2: Pelagic trawl

3: Bottom trawl

4: Plankton station (Bongo 20)

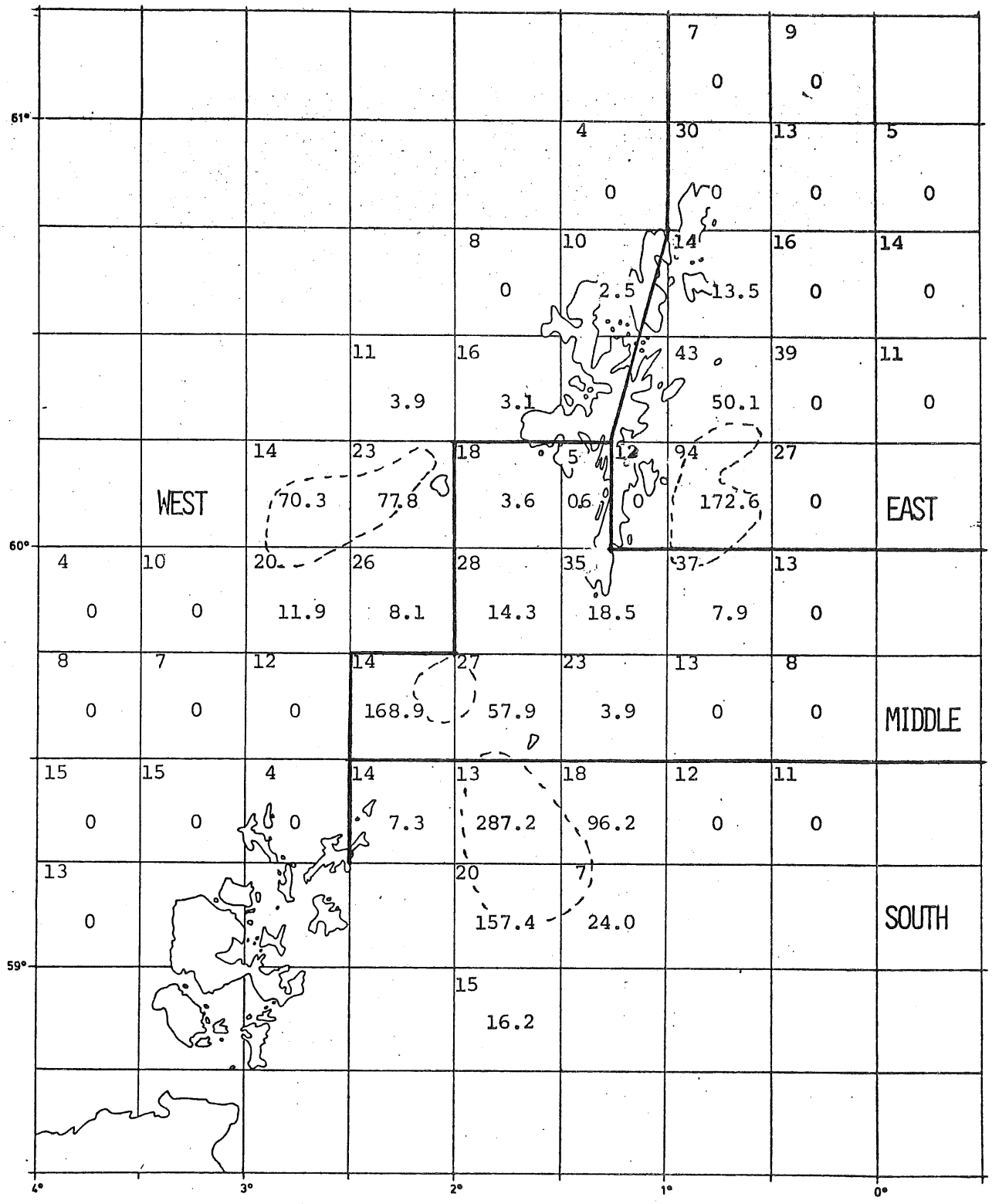

Figure 2. Estimated number (millions) of herring within squares. Number of integrator readings is given in the upper left corner of the squares. Sub-areas are divided by thick lines. The areas with significant herring recordings are indicated by broken lines.

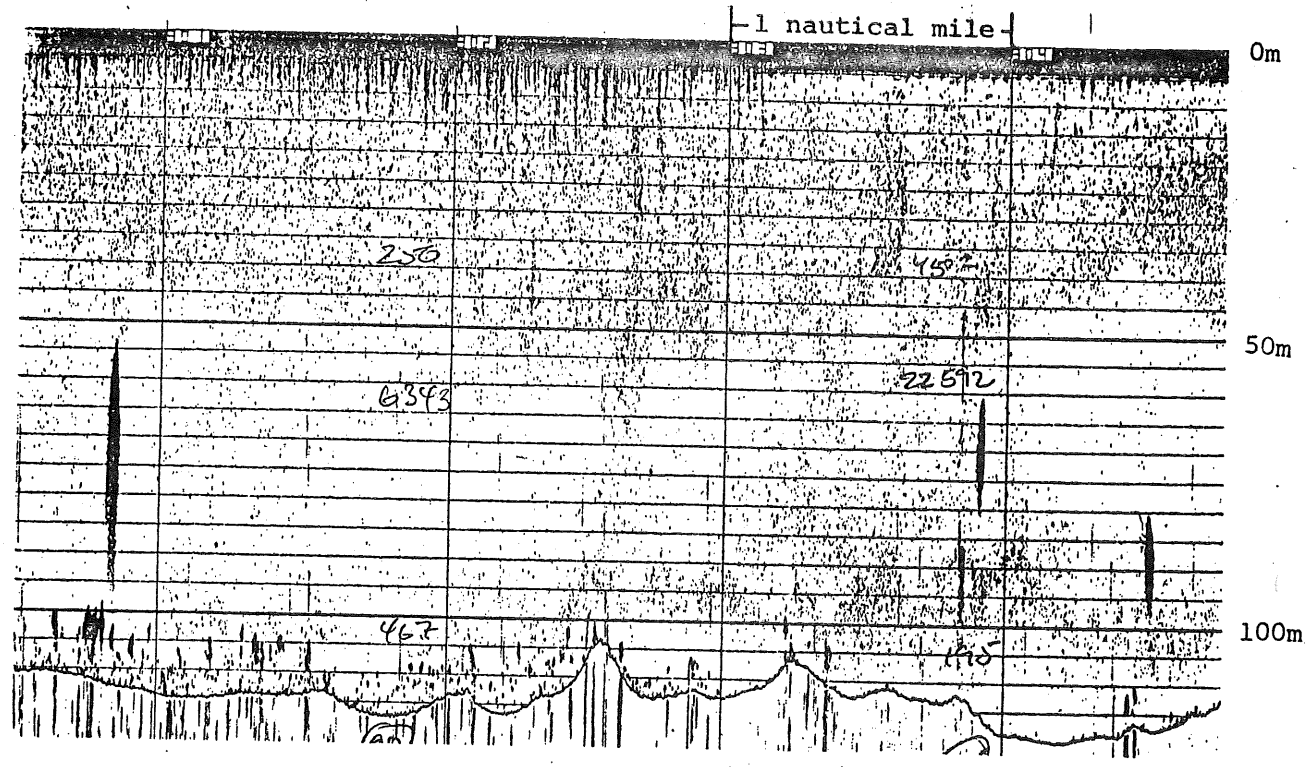

Figure 3. Typical herring schools at 50-100 m depth, identified at trawl station 842. Recordings 5-15 m above bottom are expected to be a mixture of whiting and 0-group Norway pout. The trawl stations 837,839 and 884 represent such mixed recordings.

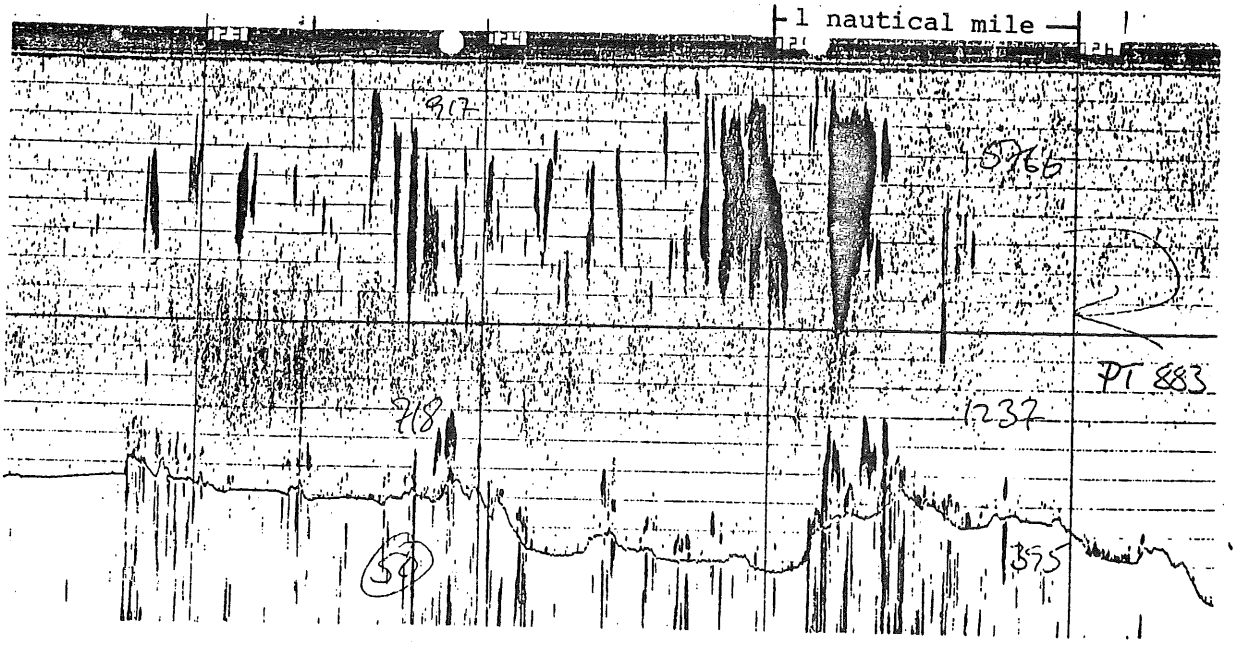

Figure 4. Schools of Norway pout recorded close to the coast sout-east of Lerwick. The shallow schools are identified at trawl station 883 and the deepest ones at trawl station 884.

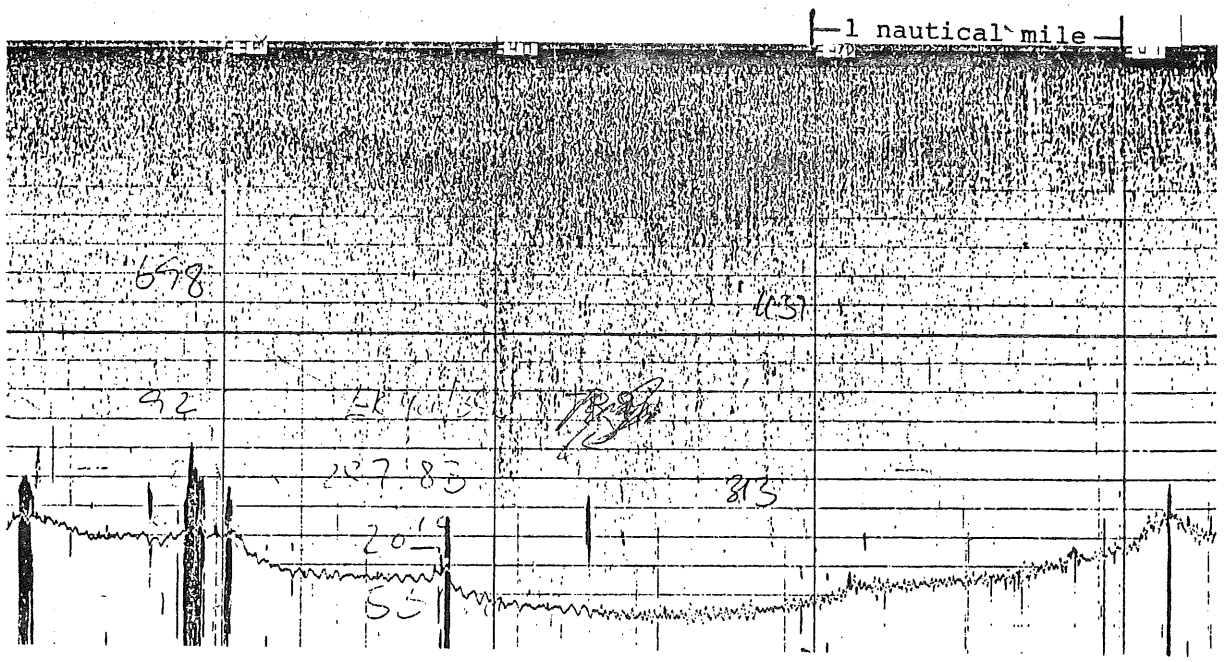

Figure 5. Herring schools identified at trawl station 911, south-west of Foula.