Living Resources Committee **ICES CM 2000/G:02**

REPORT OF THE

PLANNING GROUP FOR HERRING SURVEYS

Bergen, Norway
1–4 February 2000

International Council for the Exploration of the Sea

Conseil International pour l'Exploration de la Mer

Palægade 2–4 DK–1261 Copenhagen K Denmark

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1 TERMS OF REFERENCE

According to C.Res. 1999/2G02 The **Planning Group for Herring Surveys** [PGHERS] (Co-Chairs: E. Torstensen, Norway and K.-J. Stæhr, Denmark) met in Bergen, Norway from 1–4 February 2000 to:

a) coordinate the timing, area allocation and methodologies for acoustic and larval surveys for herring in the North Sea, Divisions VIa and IIIa and the Western Baltic;

b) combine the survey data to provide estimates of abundance for the population within the area;

c) complete the revision of the existing manual of the North Sea Acoustic Survey (Doc. ICES C.M.1994/H:3);

d) conduct a workshop on echogram scrutiny.

PGHERS will report to HAWG and to the Resource Management and Living Resources Committees at the 2000 Annual Science Conference.

To improve communication, the Chair (or a representative) of PGHERS should participate in the meeting of HAWG.

2 PARTICIPANTS

Kees Bakker	The Netherlands
Eckhard Bethke	Germany
Bram Couperus	The Netherlands
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Paul Fernandes	UK (Scotland)
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3 HERRING LARVAL SURVEY

3.1 Review of Larvae Surveys

3.1.1 North Sea

Seven units and time periods were covered in the North Sea during the 1999 larvae surveys.

Area / Period	1–15 September	16–30 September	1–15 October
Orkney / Shetland	--	Germany	--
Buchan	--	Netherlands	--
Central North Sea	--	Netherlands	Germany
	16–31 December	**1–15 January**	**16–31 January**
Southern North Sea	Netherlands	Germany	Netherlands

The measurements of larvae caught and length-frequency distributions are in progress and thus the information necessary for the calculation of larvae abundance is not yet complete. It will be ready for the Herring Assessment Working Group (HAWG) meeting in March 2000.

3.1.2 Western Baltic

German monitoring of the Western Baltic spring-spawning (WBSS) herring larvae started in 1977 and has been conducted every year from March/April to June in the main spawning grounds of WBSS herring: these are the Greifswalder Bodden, Rügen area (area: 510.2 km^2, volume: 2,960 x 106 m^2, mean depth: 5.8 m, maximum depth: 13.5 m) and adjacent waters. Since 1977 the same sampling method, sampling strategy and station grid have been used. Usually 35 standard stations are sampled by R/V CLUPEA in daylight during 10 consecutive cruises. At each station herring larvae samples are taken by means of a MARMAP-Bongo (diameter: 600 mm, mesh size of both nets: 0.315 mm) taking parallel double oblique tows at a speed of 3 knots. Since 1996 a HYDROBIOS-Bongo (mesh size: 0.335 mm) has been used.

For the calculation of the number of larvae per station and area unit, the methods of Smith and Richardson (1977) and Klenz (1993) are used and projected to length-classes. To get the index for the estimation of the year-class strength, the number of larvae with a total length of TL >= 30 mm (larvae after metamorphosis) were calculated, taking growth and mortality into consideration. This index shows a good correlation with recruitment (0-group).

Further details concerning the survey design and the treatment of the samples are given in Brielmann (1979, 1989) and Müller & Klenz (1994). The estimated numbers of larvae for the period 1977 to 1998 are summarised in ICES 1999/ACFM:12/Table 3.5.10. The 1998 estimate of the larval index was the highest recorded value for the 0-group in the whole time period. The 1999 survey data is currently being evaluated and final results will be presented to the ICES HAWG 2000.

3.2 Coordination of Larvae Surveys for 2000/2001

3.2.1 North Sea

In the 2000/2001 period additional effort by Norway will contribute to the larvae surveys. It would be highly preferable to allocate some ship time for sampling in the first half of September in the Orkney/Shetland area, either by Norway or The Netherlands. If this is not possible, some effort should be made to carry out duplicated sampling. The results would give more reliable estimates of larvae abundance than just one survey and could be used for comparison of sampling efficiency and catchability between the involved nations as well as spatial and temporal changes in larvae distribution within one sampling period and unit.

A preliminary survey schedule for the 2000/2001 period is presented in the following table:

Area / Period	1–15 September	16–30 September	1–15 October
Orkney / Shetland	???	Germany + Norway	--
Buchan	Germany	Netherlands + Norway	--
Central North Sea	--	Netherlands	--
	16–31 December	**1–15 January**	**16–31 January**
Southern North Sea	Netherlands	Germany	Netherlands

Survey results, including hydrographic data, should be sent, in the standard format, to IfM Kiel for inclusion into the IHLS database. IfM Kiel will report the summarised results and the updated series of MLAI-values to the HAWG.

3.2.2 Western Baltic

The 2000 German larvae survey on the Western Baltic spring spawning herring will be conducted from 17 April to 30 June 2000 during 10 x 5-days cruises.

4 ACOUSTIC SURVEY

4.1 Review of acoustic surveys in 1999

4.1.1 North Sea and West of Scotland

Five acoustic surveys were carried out during late June and July 1999 covering most of the continental shelf north of 54°30 N in the North Sea and the west of Scotland to a northern limit of 62° N. The eastern limits of the survey area were bounded of the Norwegian and Danish coast, and in Division IIIa the Swedish coast. Western limits by the shelf-edge between 200 and 400 m depth. The areas covered by each of the surveys are given in Figure 4.1.1.

The surveys are reported individually, Appendix 1- 5. A preliminary combined survey result is given in Table 4.1.1.1. A final combined survey result providing spatial distributions for both herring and sprat abundance's by number and biomass at age by statistical rectangle will be presented to the Herring Assessment Working Group 2000.

4.1.2 Western Baltic

A joint German-Danish acoustic survey was carried out with R/V "Solea" from September 25th to October 16th 1999. The survey covered all of Sub-divisions 22, 23, 24 and the southern part of the Kattegat. All investigations were performed at night as in previous years.

The acoustic equipment used was an EK500 echosounder and the Bergen-Integrator BI500. A 38 kHz transducer (38-26) was installed in a towed body. The towed body had a lateral distance of about 30 m from the ship to decrease the influence of escape reactions of fish.

The cruise track was 896 n.mi. long and 45 trawl hauls were carried out to identify targets. From each haul samples were taken for the determination of length, weight and age. After each haul hydrographic measurements were made with a CTD-probe.

The s_A values for each stratum were converted into fish numbers using the following TS-length regressions:

Clupeids: TS = 20 log L (cm) - 71.2

Gadoids: TS = 20 log L (cm) - 67.5

Preliminary estimates of abundance and biomass from herring and sprat are presented in Tables 4.1.2.1-4. Cruise track and haul positions are depicted in Figure 4.1.2.

The abundance of herring was nearly twice the herring numbers from 1998. The percentage of young herring was considerably higher than the year before, especially in Sub-divisions 21 and 22. Therefore the biomass of herring reached the same level in both years.

The sprat stock showed a similar behaviour. The high density of young sprat in the south east part of the Arkona basin increased the total sprat abundance by 140%.

4.1.3 Intercalibration between FRV *Scotia* and FRV *Tridens*

The research vessels "Scotia" (Scotland, UK) and "Tridens" (Netherlands) met on 2 July, at ICES rectangle 48F2 for the intership calibration of acoustic equipment. A two legged zig-zag transect was adopted with Scotia ahead on the first leg for 25 n.mi. and Tridens taking the lead in the second leg for 31 n.mi. Fish concentrations were made up of small schools with the occasional larger school. The integration interval was 1 n.mi. and the S_v threshold was –70 dB.

The aligned sequence of s_A values is shown in Figure (4.1.3). Values of s_A detected by Scotia ranged from 31 to 3058; whilst those of Tridens ranged from 49 to 3650. The mean s_A values over the 56 n.mi. were 525 for Scotia and 538 for Tridens. A number of large values were detected at different times by both vessels; these are attributed to small high density schools which were not seen on both ships simultaneously and only affect observations on a short scale. The scatterplot and calculated regressions (Scotia on Tridens and Tridens on Scotia) are plotted in Figure 4.1.4; the functional regression is plotted as a mean of these two lines. The slope of the functional regression is 1.09 indicating that over the course of the two transects there was no major systematic difference between the two vessels recordings.

4.1.4 Sprat

Data on sprat were available from RV "Tridens" and RV "Solea". No catches were reported from RV "G.O.Sars" and RV "Scotia".

Figure 4.1.5 shows the distribution of sprat as obtained during the acoustic survey. Compared to last year's results, the abundance of sprat was low. RV "Tridens" estimates were lower than in previous years. However, due to technical problems experienced during the cruise of FRV "Solea", the southern part of the German Bight was not sampled; this area is usually expected to have the highest abundance of sprat in the North Sea and it is, therefore, not surprising that the abundance was low.

4.2 Coordination of acoustic survey in 2000

4.2.1 North Sea

Acoustic surveys in the North Sea and West of Scotland in 2000 will be carried out in the periods and areas given in the following table and Figure 4.2.1.

Vessel	**Period**	**Area**
Charter	15-20 days in July	56°- 60°N, 4° - 10° W
G.O. Sars	27 June – 18 July	57°- 61°30 N, 2° - 8° E
Scotia	5 July – 26 July	58°- 61°30 N, 4° W - 2° E
Tridens	19 June – 14 July	54°30 - 58° N, west of 3° E
Walther Herwig	23 June – 14 July	54° - 57° N, east of 3° E
Dana	26 June – 7 July	North of 57° N, east of 6° E

The following intercalibrations have been planned for the acoustic survey in 2000:

Vessels	**Period**
Walther Herwig - G.O. Sars – Dana	Approximately 28 June
Scotia – G.O. Sars	6 – 8 July
Tridens – Walther Herwig	12 – 14 July

Detailed appointments as regards timing and position will be made during the survey by radio communication.

The results from the national acoustic surveys in June-July 2000 will be collected and the result of the entire survey will be presented to the Herring Assessment Working Group. Survey results for sprat should be sent to Else Torstensen, Norway. Survey results for herring should be sent to John Simmonds, Scotland, in the format specified in the manual for the International Acoustic Survey in the North Sea and West of Scotland. Data for both sprat and herring should be at the coordinators by 1 December 2000.

4.2.2 Western Baltic

In the western Baltic and southern part of Kattegat, the following survey will be carried out:

Vessel	Period	Area
Solea	29 September- 20 October	Sub-division 22 south, 22 to 24

Table 4.1.1.1. Preliminary combined result for the international acoustic survey in the North Sea and West of Scotland in 1999

North Sea	Numbers	Biomass	Maturity	x weight(g)	**Baltic**	Numbers	Biomass	Maturity	x weight(g)	**West Scot**	Numbers	Biomass	Maturity	x weight(g)
0	2023.76	8.45	0.00	4.18	0	0.00	0.00	0.00		0	0.00	0.00	0.00	
1	6677.32	254.87	0.00	38.17	1	856.01	46.88	0.00	54.77	1	487.00	26.14	0.00	53.68
2	4769.25	404.17	0.82	84.74	2	902.55	80.09	0.29	88.74	2	293.82	40.32	0.57	137.23
3	4431.41	763.42	0.91	172.27	3	446.51	50.85	0.58	113.88	3	1265.81	210.40	0.98	166.22
4	1069.68	224.70	1.00	210.06	4	120.88	13.17	1.00	108.99	4	393.87	74.09	1.00	188.11
5	485.69	114.93	1.00	236.64	5	22.81	2.73	1.00	119.86	5	280.80	56.91	1.00	202.69
6	289.30	77.90	1.00	269.26	6	2.19	0.39	1.00	179.86	6	126.43	27.69	1.00	218.99
7	126.62	34.94	1.00	275.95	7	1.45	0.26	1.00	179.90	7	78.86	17.75	1.00	225.12
8	48.01	11.46	1.00	238.65	8	0.00	0.00	1.00		8	25.17	5.91	1.00	234.71
9+	77.41	20.82	1.00	268.99	9+	0.73	0.13	1.00	181.74	9+	32.27	7.91	1.00	245.24
Immature	9945.52	392.25			Immature	1679.77	114.23			Immature	642.62	47.60		
Mature	10052.93	1514.96			Mature	673.37	80.29			Mature	2341.40	419.53		
Total	19998.44	1915.65			Total	2353.14	194.52			Total	2984.02	467.13		

Table 4.1.2.1 Preliminary estimates of herring numbers (million) in the Western Baltic, Sept./Oct. 1999

Sub-div.	**Stratum**	**Age groups** 0	1	2	3	4	5	6	7	8+	3+	Sum
21	**41G1**	155.36	10.51	1.00								166.87
21	**41G2**	135.75	22.41	0.64								158.80
21	**42G1**	433.55	3.50	0.44								437.49
21	**42G2**	277.62	72.83	7.93		2.16					2.16	360.55
21	**43G1**	2321.49										2321.49
21	**43G2**	55.29	0.17	0.17	0.17						0.17	55.79
21	**Total**	3379.06	109.42	10.17	0.17	2.16	0.00	0.00	0.00	0.00	2.33	3500.99
22	**37G0**	197.87	53.05	0.25								251.17
22	**37G1**	1015.51	364.62	28.49	8.55	1.42	1.42	2.85			14.24	1422.86
22	**38G0**	651.75	99.92	3.78	0.76			0.76			1.51	756.97
22	**38G1**	449.39	19.25	0.47								469.12
22	**39F9**	90.60	0.92									91.52
22	**39G0**	105.87	5.46									111.33
22	**39G1**	313.78	22.89									336.68
22	**40G0**	58.69	26.82	1.39	0.09		0.17				0.26	87.16
22	**Total**	2883.47	592.92	34.38	9.39	1.42	1.60	3.61	0.00	0.00	16.02	3526.79
23	**40G2**	355.32	208.29	65.35	107.82	53.91	22.05	2.45	0.82	0.82	187.87	816.83
23	**41G2**	4.60	0.76	0.02							0.00	5.38
23	**Total**	359.92	209.05	65.37	107.82	53.91	22.05	2.45	0.82	0.82	187.87	822.21
24	**37G2**	191.46	8.83	3.57	3.36	2.10	0.63				6.09	209.96
24	**38G2**	695.89	32.08	12.99	12.22	7.64	2.29				22.15	763.11
24	**38G3**	400.40	16.86	5.62	4.32	3.46	0.86	0.43			9.08	431.97
24	**38G4**	11.42										11.42
24	**39G2**	260.19	44.97	42.22	63.79	34.42	11.47	0.92	0.46	0.46	111.51	458.89
24	**39G3**	137.77	240.59	66.86	20.26	29.88	9.12	1.01		0.51	60.78	505.99
24	**39G4**	258.97	211.67	69.77	15.96	28.38	5.91	0.59			50.85	591.24
24	**Total**	1956.10	555.00	201.02	119.92	105.88	30.29	2.95	0.46	0.97	260.46	2972.58
22-24	**Total**	5199.48	1356.97	300.77	237.13	161.21	53.94	9.01	1.28	1.78	464.35	7321.58
21-24	**Total**	8578.54	1466.39	310.95	237.30	163.38	53.94	9.01	1.28	1.78	466.68	10822.57

Table 4.1.2.2 Preliminary estimates of herring biomass (t) in the Western Baltic, Sept./Oct. 1999

Sub-div.	Stratum	Age groups 0	1	2	3	4	5	6	7	8+	3+	Sum
21	**41G1**	2501.3	448.9	64.4								3014.6
21	**41G2**	2131.3	1046.7	30.3								3208.3
21	**42G1**	6676.7	150.8	27.5								6855.0
21	**42G2**	4192.1	3437.6	563.2		303.9					303.9	8496.8
21	**43G1**	25304.2										25304.2
21	**43G2**	834.9	7.2	17.8	22.6						22.6	882.5
21	**Total**	41640.4	5091.3	703.1	22.6	303.9					326.6	47761.4
22	**37G0**	2374.4	1745.3	13.7								4133.4
22	**37G1**	11779.9	12907.4	1925.6	634.1	95.4	84.7	207.4			1021.6	27634.6
22	**38G0**	7625.4	3557.1	254.3	52.2			53.6			105.7	11542.7
22	**38G1**	4763.6	614.2	25.2								5403.0
22	**39F9**	1087.2	30.7									1117.9
22	**39G0**	1535.2	165.8									1701.0
22	**39G1**	3702.6	762.4									4465.0
22	**40G0**	839.2	1126.4	76.5	5.9		10.4				16.2	2058.3
22	**Total**	33707.6	20909.3	2295.4	692.1	95.4	95.1	261.0			1143.6	58055.9
23	**40G2**	4477.1	8206.7	6979.0	14189.4	8005.8	4031.6	498.2	174.0	171.4	27070.3	46733.1
23	**41G2**	70.8	32.7	1.4								104.8
23	**Total**	4547.8	8239.4	6980.4	14189.4	8005.8	4031.6	498.2	174.0	171.4	27070.3	46838.0
24	**37G2**	1972.1	323.1	284.8	384.7	197.1	81.8				663.6	3243.5
24	**38G2**	7167.7	1174.2	1035.0	1398.2	716.5	297.2				2411.9	11788.8
24	**38G3**	3403.4	613.8	417.7	472.2	289.2	97.5	41.5			900.4	5335.3
24	**38G4**	134.8										134.8
24	**39G2**	2653.9	1978.7	3546.3	7775.4	4408.8	1601.5	112.3	114.7	93.6	14106.4	22285.3
24	**39G3**	1694.5	9094.1	4365.8	1940.9	1658.5	647.3	72.4		122.1	4441.2	19595.6
24	**39G4**	3521.9	8064.5	4513.9	1457.5	1526.8	375.4	50.4			3410.2	19510.5
24	**Total**	20548.3	21248.4	14163.4	13428.9	8797.0	3100.8	276.7	114.7	215.7	25933.7	81893.9
22-24	**Total**	58803.8	50397.1	23439.1	28310.4	16898.2	7227.5	1035.9	288.7	387.1	54147.7	186787.7
21-24	**Total**	100444.2	55488.4	24142.2	28333.0	17202.1	7227.5	1035.9	288.7	387.1	54474.2	234549.1

Table 4.1.2.3 Preliminary estimates of sprat numbers (million) in the Western Baltic, Sept./Oct. 1999

Sub-div.	Stratum	Age groups 0	1	2	3	4	5	6	7	8+	3+	Sum
21	**41G1**		45.98	9.21	0.28						0.28	55.46
21	**41G2**		31.92	5.45	0.28	1.90					2.17	39.54
21	**42G1**		142.07	11.29	1.08	0.15					1.24	154.59
21	**43G1**		2.71	0.27	0.10						0.10	3.08
21	**Total**		222.67	26.21	1.74	2.05					3.79	252.68
22	**37G0**	10.28	6.14	9.02	8.98	3.64	0.19	0.12			12.93	38.37
22	**37G1**	54.74	60.86	84.69	85.98	33.81	1.610	0.64			122.04	322.33
22	**38G0**	22.28	19.62	14.48	16.89	6.59	0.40	0.16			24.05	80.42
22	**38G1**	65.36	5.79	0.72	0.36	0.14					0.51	72.38
22	**39F9**	15.12	0.22	0.76	0.68	0.19					0.86	16.97
22	**39G0**	0.13	2.83	0.98	1.04	0.66	0.13	0.05			1.89	5.83
22	**39G1**	9.23	1.44	0.25	0.04	0.02					0.07	10.99
22	**40G0**	0.06	0.04	0.04	0.04	0.01					0.05	0.19
22	**Total**	152.66	92.41	108.90	112.20	44.20	2.20	0.92			159.52	513.50
23	**40G2**	2.91	2.64	1.52	1.25	6.46	0.48	1.25			9.44	16.51
23	**41G2**		1.08	0.18	0.01	0.06					0.07	1.34
23	**Total**	2.91	3.72	1.70	1.26	6.52	0.48	1.25			9.52	17.85
24	**37G2**	107.18	9.54	16.22	16.22	6.68	1.91	1.43			26.24	159.18
24	**38G2**	389.57	34.68	58.96	58.96	24.28	6.94	5.20			95.37	578.57
24	**38G3**	1187.57	122.68	212.98	132.90	39.19	5.11	1.70			178.90	1702.13
24	**38G4**	9087.96	323.21	66.54	28.52						28.52	9506.23
24	**39G2**	717.66	20.39	37.51	28.54	8.97	1.63	0.82			39.96	815.53
24	**39G3**	97.88	37.19	77.74	48.94	14.82	2.24	1.12			67.12	279.93
24	**39G4**	7.11	99.56	223.74	154.27	49.23	7.66	5.47			216.63	547.05
24	**Total**	11594.93	647.25	693.70	468.34	143.17	25.48	15.74	0.00	0.00	652.74	13588.63
22-24	**Total**	11756.3	750.8	807.7	584.3	206.9	29.1	20.4			840.8	14119.98
21-24	**Total**	11756.3	973.5	833.9	586.1	209.0	29.1	20.4			844.6	14372.65

Table 4.1.2.4 Preliminary estimates of sprat biomass (t) in the Western Baltic, Sept./Oct. 1999

Sub-div.	Stratum	Age groups 0	1	2	3	4	5	6	7	8+	3+	Sum
21	**41G1**		533.4	109.6	3.8						3.8	646.7
21	**41G2**		507.5	82.3	3.8	29.8					33.6	623.4
21	**42G1**		2685.1	143.3	14.9	2.4					17.4	2845.8
21	**43G1**		39.5	3.9	1.4						1.4	44.9
21	**Total**		3765.5	339.1	24.0	32.2					56.2	4160.8
22	**37G0**	46.3	92.1	166.8	183.2	79.5	5.0	3.0			270.6	575.8
22	**37G1**	323.0	906.8	1710.7	1831.3	919.7	42.0				2793.0	5733.5
22	**38G0**	102.5	288.4	264.9	341.1	139.1	10.3	4.1			494.7	1150.5
22	**38G1**	372.6	54.4	11.9	6.5	2.6					9.1	448.1
22	**39F9**	54.4	3.7	13.6	12.4	3.4					15.9	87.5
22	**39G0**	1.6	39.9	17.8	21.6	15.0	3.4	1.2			41.2	100.4
22	**39G1**	46.2	18.3	3.9	0.7	0.4					1.1	69.4
22	**40G0**	0.2	0.7	0.6	0.7	0.3					1.0	2.5
22	**Total**	946.7	1404.3	2190.3	2397.5	1159.9	60.7	8.3			3626.4	8167.6
23	**40G2**	15.1	29.1	22.8	20.2	134.9	8.5	22.5			186.1	253.0
23	**41G2**		17.2	2.8	0.1	1.0					1.1	21.1
23	**Total**	15.1	46.2	25.6	20.3	135.9	8.5	22.5			187.2	274.1
24	**37G2**	739.6	117.4	241.7	277.4	119.6	36.8	28.2			462.0	1560.6
24	**38G2**	2688.0	426.6	878.4	1008.1	434.5	133.9	102.5			1679.0	5672.0
24	**38G3**	7600.5	1484.4	3066.9	2073.2	623.1	99.2	33.6			2829.1	14980.8
24	**38G4**	49075.0	1713.0	971.5	453.4						453.4	52213.0
24	**39G2**	5095.4	254.9	547.7	462.4	148.0	30.0	16.1			656.5	6554.5
24	**39G3**	606.9	505.8	1119.5	773.2	237.1	41.2	22.0			1073.6	3305.8
24	**39G4**	43.4	1423.7	3289.0	2483.7	802.5	143.2	107.8			3537.2	8293.3
24	**Total**	65848.7	5925.8	10114.8	7531.5	2364.9	484.2	310.1			10690.8	92580.0
22-24	**Total**	66810.4	7376.3	12330.7	9949.3	3660.7	553.4	340.9			14504.3	101021.7
21-24	**Total**	66810.4	11141.8	12669.8	9973.3	3692.9	553.4	340.9			14560.5	105182.5

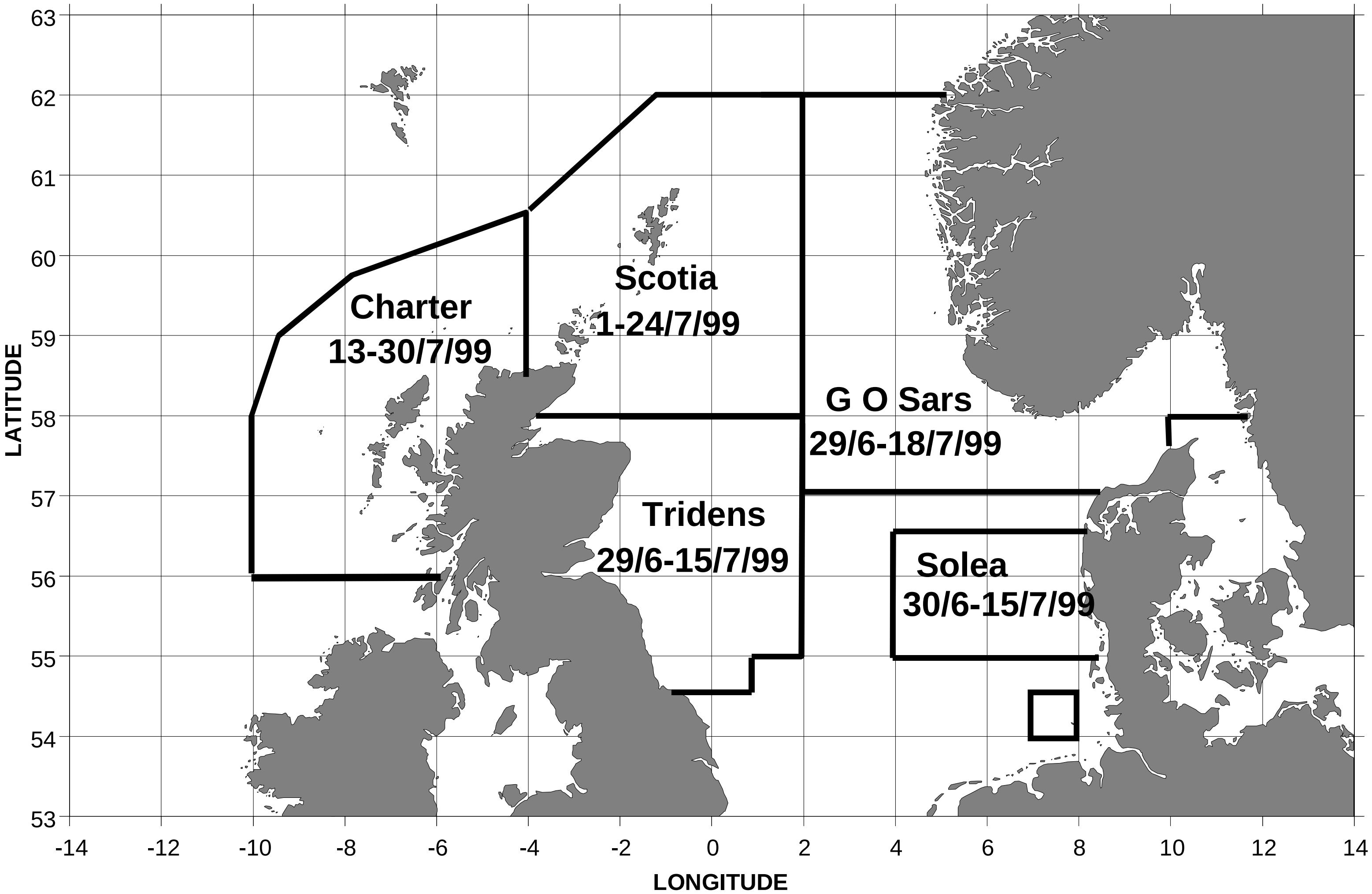

Figure 4.1.1 Layout and dates of survey areas for all participating vessels 1999.

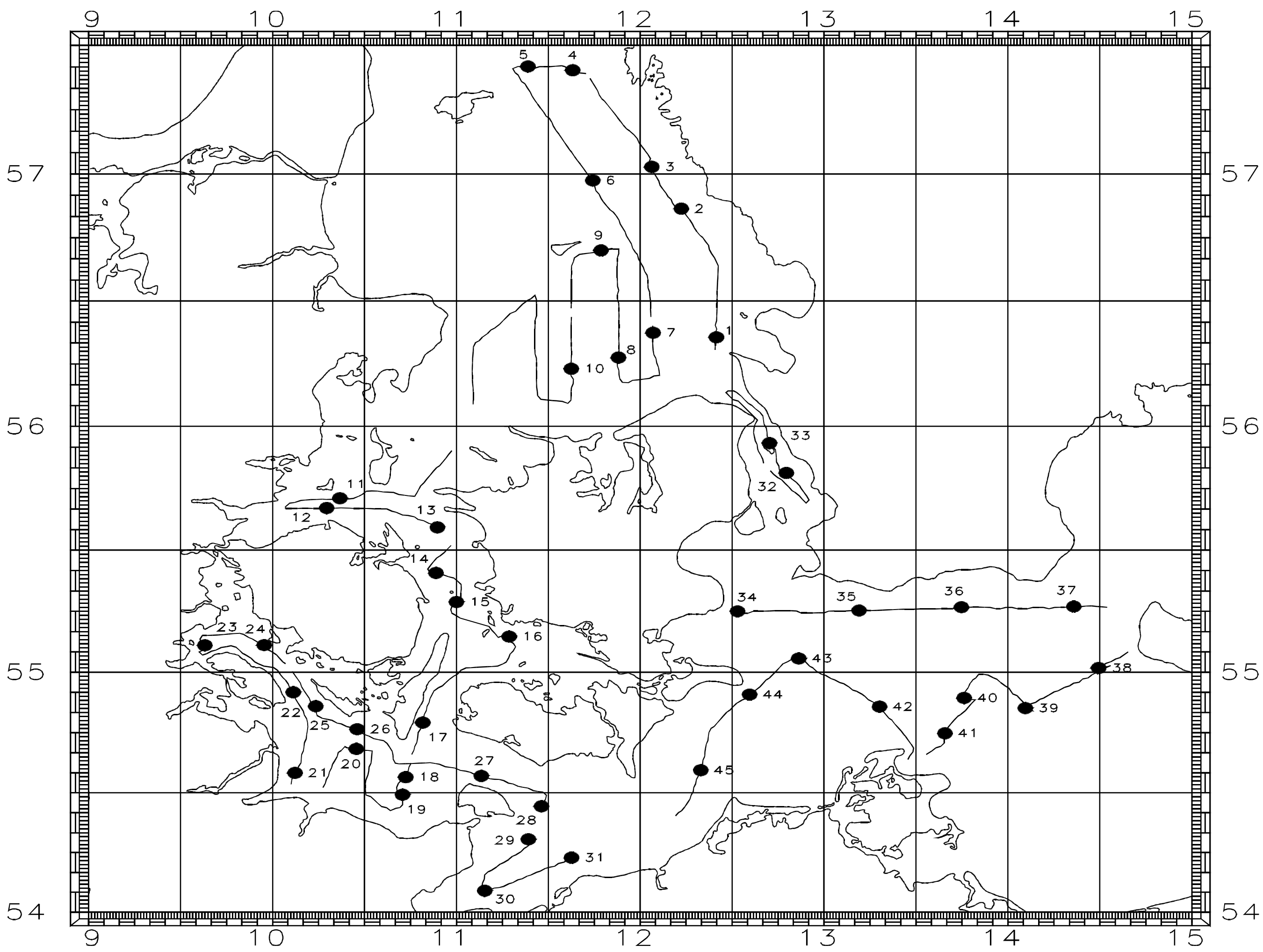

Figure 4.1.2 Cruise track and trawl positions, R/V "Solea" Sept./Oct. 1999

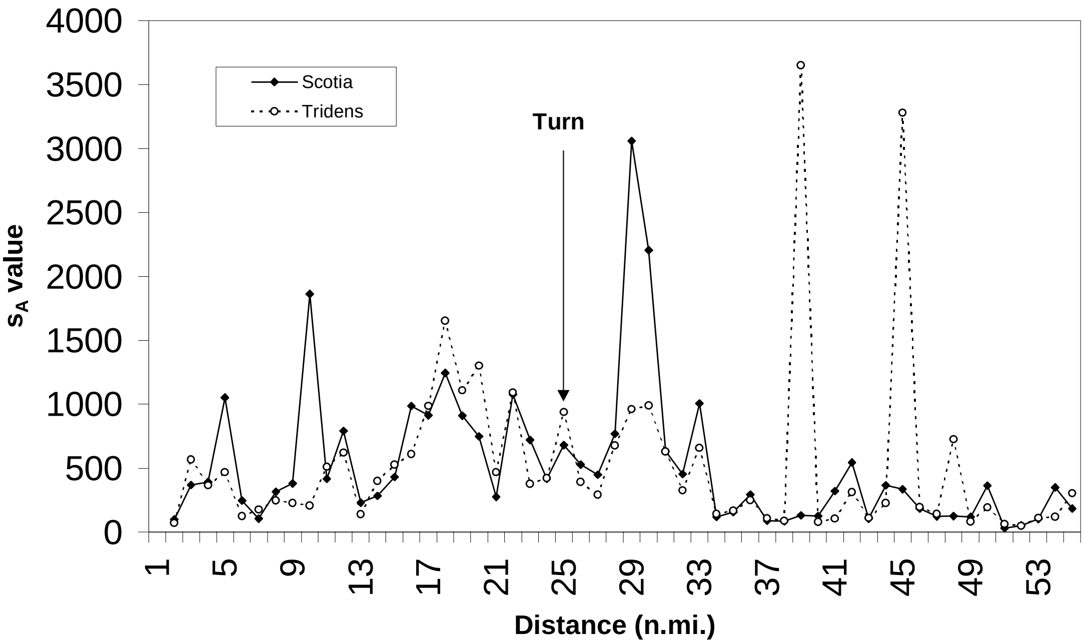

Figure 4.1.3 Sequence of integrator values during the intercalibration between FRV *Scotia* and FRV *Tridens* (July 1999).

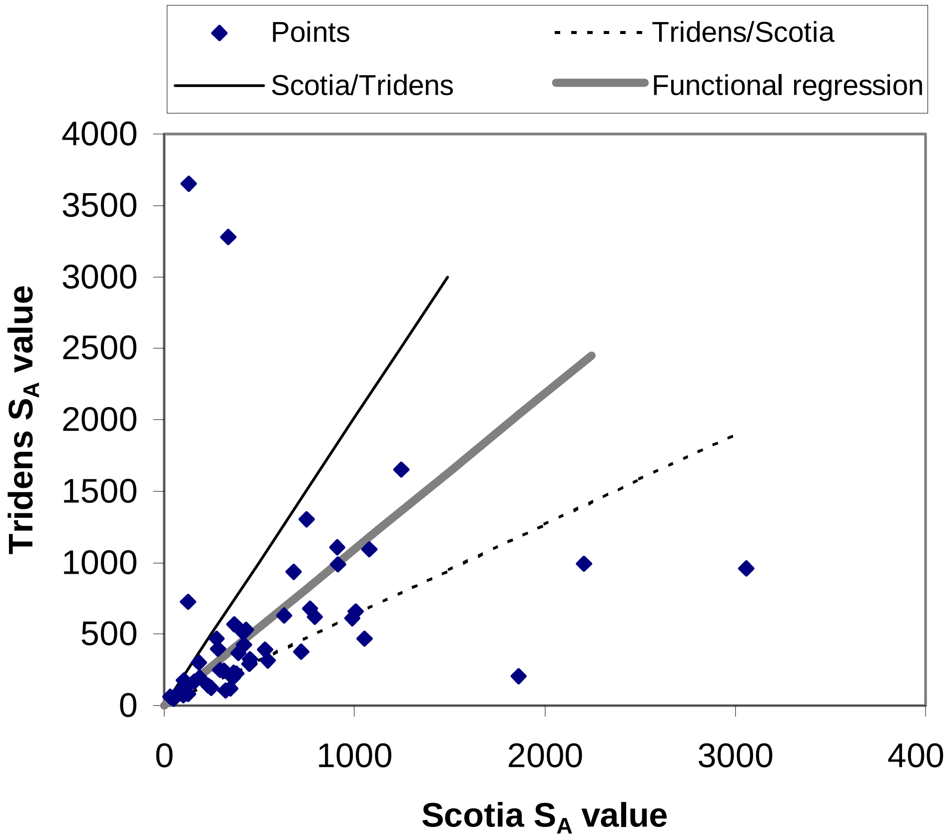

Figure 4.1.4 Scatterplot of integrator values from the intercalibration between FRV Scotia and FRV Tridens (1999) with regressions and mean (functional) regression.

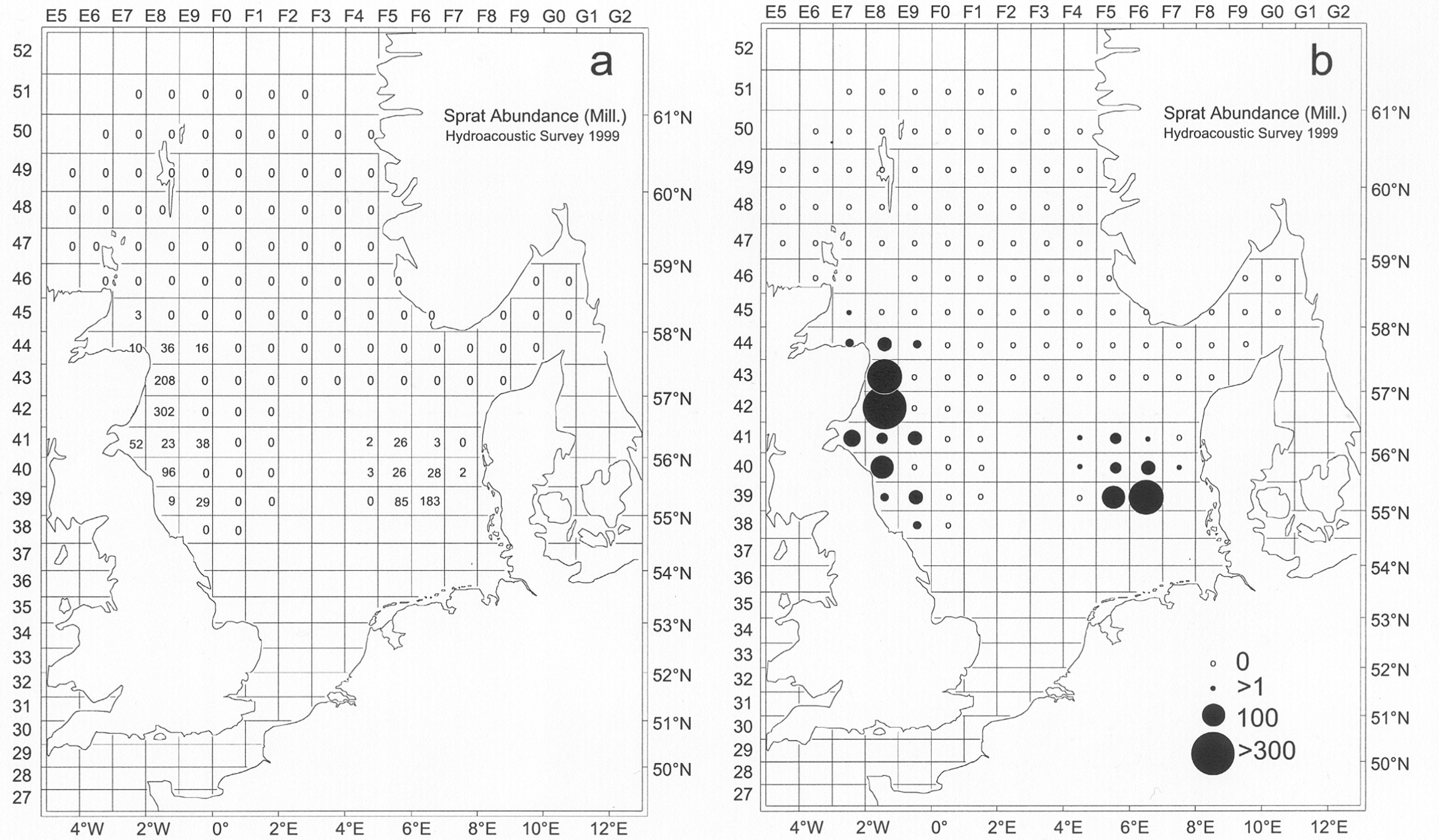

Fig. 4.1.5: Abundance of sprat in the North Sea as obtained from the 1999 herring hydroacoustic surveys. a: mean number in millions. b: dot area is proportional to the sprat abundance.

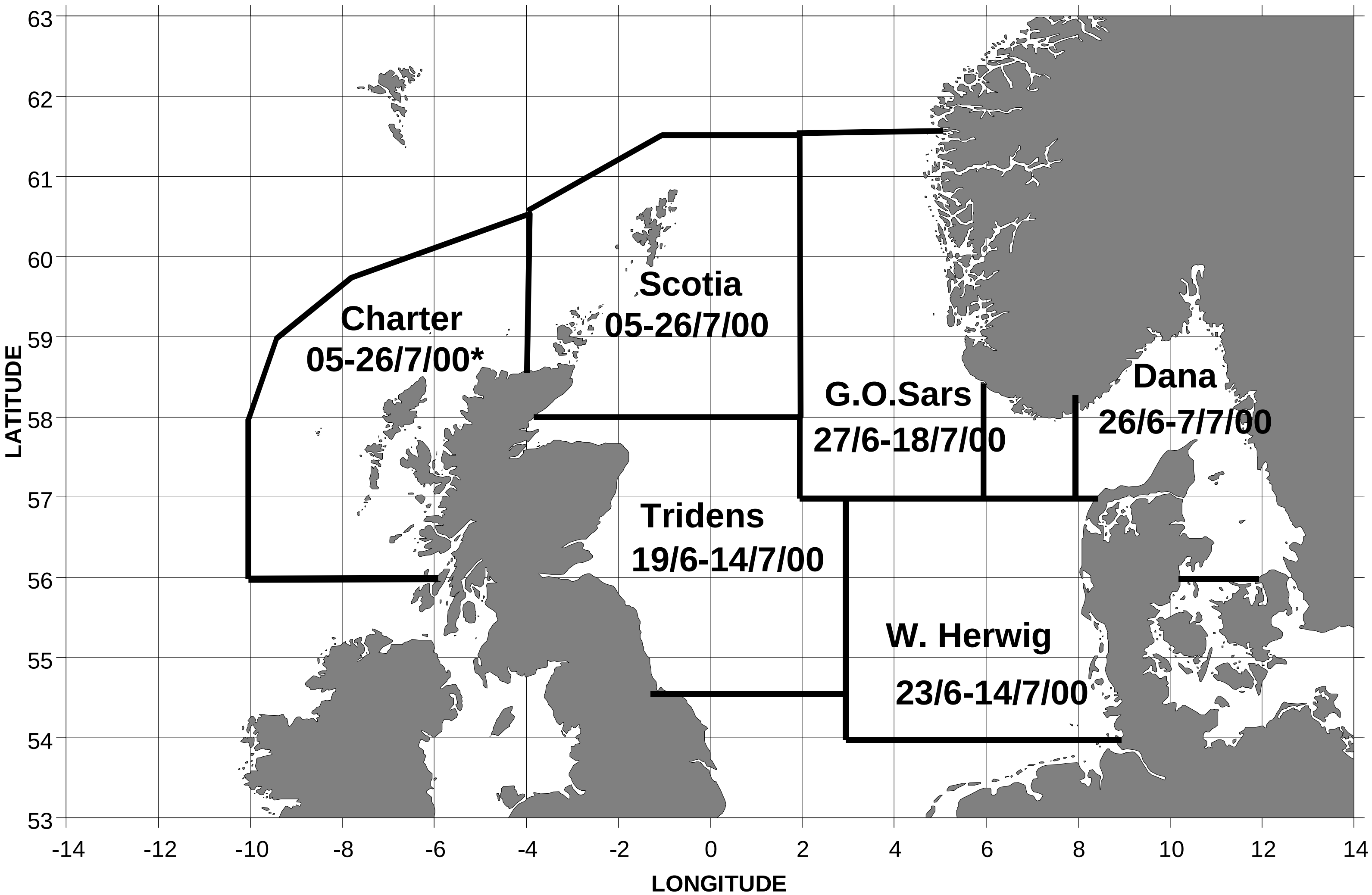

Figure 4.2.1 Layout and dates (*provisional) of survey areas for all participating vessels 2000.

5 PLAN FOR AN INTERNATIONAL SURVEY FOR WESTERN BALTIC SPRING-SPAWNING HERRING

In the terms of reference for the 1999 meeting, the Planning Group for Herring Surveys was asked to investigate the possibilities for an international coordinated acoustic survey covering the whole area where Western Baltic spring-spawning herring (WBSS) are distributed. The planning group then recommended:

- that the present acoustic international surveys for Western Baltic spring-spawning herring in October should be intensified in the Sound (Sub-division 23) and extended to the whole Division IIIa to achieve complete coverage of the total spawning stock in one survey;
- that both the annual acoustic survey in July, targeting North Sea Autumn Spawners, and the new survey in October, should continue until the new survey can provide reliable data for the assessment of Baltic Spring spawners. Participation of Denmark will be necessary to conduct these tasks.

For the year 2000, Sub-division IIIa will be covered in July in the same way as that prior to 1999. For the acoustic survey in October the coverage in Sub-division 23 will be intensified with "Solea", but no additional ships will be available for a total coverage of Sub-division IIIa in October 2000. The planning group concluded that additional effort should be made to gain ship time, preferably by a Danish or Swedish vessel.

6 REVISION OF THE MANUAL

The existing manual of the North Sea Acoustic Survey (ICES C.M. 1994/H:3) has been revised and is attached (Appendix 6). The planning group noted that results from some studies on the development of survey design are in the process of being published (Rivoirard *et al.* in press). The group also awaits the results of an EU-funded market sampling project before revising the section on sampling methods. It was agreed that in future, the small updates and revisions to the manual should be an ongoing function within the group with publication into an appendix to the report at longer intervals.

7 ECHOGRAM SCRUTINY WORKSHOP

A second international scrutiny workshop was held as part of this PGHERS meeting. Participants were asked to bring one day of survey data from the 1999 ICES coordinated North Sea herring acoustic survey. Each days survey data was to be made available in BI500 digital format, along with relevant trawl and other information. Four data sets were supplied from Norway, Scotland, Germany and the Netherlands, from their respective national survey areas. Members of the group were then split into national teams, which scrutinised all four data sets, including their own.

The output from the workshop constituted four sets of echo integrals in five nautical mile EDSU (Elementary Distance Sampling Units) for each of the four surveys. Initial analysis at the workshop indicated that in most cases where trawl data were available there was remarkable consistency between groups analysing a particular survey.

The text table below shows the initial CV values calculated for the four survey data sets.

Vessel	Area	CV
Tridens (Netherlands)	West Central North Sea	16.7
Scotia (Scotland)	Shetland	3.4
Solea (Germany)	German Bight	11.0
G.O.Sars (Norway)	Skagerrak	47.5

No detailed analysis has been carried out thus far. However, the high CV for the GO Sars data set merits further discussion. The variability appears to be due to the herring in this area being found as very small schools associated with very dense plankton layers near the surface. Given a limited data set, the different groups took a variety of routes to analyse these data. These generally involved applying a threshold to the echogram, which eliminated the plankton, and then taking the residual acoustic return as being herring. Relatively minor differences in threshold chosen could result, over many EDSU, in substantial differences in total echo integral. It should be emphasised that herring in this situation represent around 10% of the North Sea herring seen on this survey and this survey covers about 10% of the total biomass. So these differences would occur for only 1% of the total stock biomass.

Conversely, the results from the Scotia survey are particularly encouraging. In this area, the bulk of the herring occurred as clearly differentiable schools, which when trawled on give almost clean catches of herring. The four groups experienced little difficulty in achieving consistent results. In recent years the bulk of the herring biomass in the North Sea in July has been found within the Scotia survey area, and the data set used for this area in the workshop can be considered as fairly typical.

The immediate conclusions from the workshop were that:

- Good scrutiny is only possible with good trawl data and;
- The most difficult scrutiny problems are found where there are fewest herring.

All participants agreed that the workshop was an invaluable exercise in a number of ways, most importantly:

- They could see the problems seen by other colleagues in their surveys;
- They were required to explain their scrutiny methodologies to a critical audience;
- The experience of all participants was broadened by exposure to new problems in new situations. This can be expected to be of mutual benefit and lead to a more consistent approach to scrutiny.

It was also agreed that while the workshop was a useful and fruitful exercise, analysis of novel survey data in this kind of situation is difficult and artificial. In normal practice, the scrutiny would be carried out by scientists who were on the survey, and who had seen the data (acoustic and trawl) being collected. This would normally be done during the survey itself. Given this observation, and that the herring biomass estimate for the North Sea is derived by combining the results from a number of national surveys, the PG recommends that participating nations should try, where possible, to exchange staff between surveys, ideally at the cruise leader level. This should greatly contribute to a consistency of approach and enhance the quality of the coordinated survey.

A full analysis of the workshop results will be carried out in the near future and presented as a working document at the appropriate ICES WGs and at an appropriate theme session at the ICES ASC.

8 RECOMMENDATIONS

The Planning Group for Herring Surveys recommends that:

- The Planning Group for Herring Surveys should meet in IJmuiden, The Netherlands, from 22 to 26 January 2001 under the chairmanship of P.G. Fernandes (UK, Scotland) to:

    a) coordinate the timing, area allocation and methodologies for acoustic and larval survey for herring in the North Sea, Division VIa and IIIa and Western Baltic;
    b) combine the survey data to provide estimates of abundance for the population within the area;
    c) examine aspects of the depth dependence of target strength for herring, specifically:
    d) review the available literature on the depth dependence of target strength in herring;
    e) report on investigations on the depth distribution of herring schools around Shetland for the years 1991-1997;
    f) determine methods to evaluate the depth distribution of herring in past surveys for the whole of the North Sea.

- The Planning Group recommends that efforts should be made to cover the whole Sub-Division IIIa during the October survey on Baltic Spring Spawning Herring. Ideally, Swedish and/or Danish vessels should join FRV “Solea” in these efforts.

- The Planning Group recommends that nations participating in the acoustic surveys should try, where possible, to exchange staff between surveys, to ensure a consistent scrutinizing and evaluation approach, and consistent quality.

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APPENDIX 1

Survey report FRV “Solea” cruise 444
28 June – 15 July 1999

Eberhard Götze, Inst. Fischereitechnik Hamburg, and
Christopher Zimmermann, Inst. Seefischerei Hamburg

Narrative

FRV „Solea“ left the port of Büsum on 30th June 1999 with delay and the survey started in the southwest corner of the working area near Helgoland. Because of a serious damage in the ship’s electric generator the survey had to be interrupted after only 1 day, and the ship returned for repair to the home port.

The survey was continued on 9th July. To cope with the significantly reduced survey time, the remaining survey effort was concentrated on an area where the main part of herring was found during the last years. The limits of this area were 56° 30´N to 55° N, and 4° E to the 20 m depth line off the Danish coast as western boundary. During the last 4 years, a mean of more than 75% of the total estimated herring population numbers were found in this small part of the survey area originally planned to be covered.

The parallel transects were directed in west-east direction with a spacing of 15 nautical miles. The cruise track and the haul positions are shown in figure 1.

The survey finished on 14th July and next morning FRV „Solea“ arrived at Büsum.

Method

The acoustic measurements were performed with the Simrad EK500 echosounder using a frequency of 38 kHz. The echosounder was connected to the Bergen-Integrator BI500. A single beam transducer 38-26 was installed in a towed body running 100 m behind the ship to reduce fish reactions to vessel’s noise. The lateral distance of 30 – 40m from the ship kept the transducer free from the bubbled keel water. The acoustic system was calibrated in Büsum harbour prior to the cruise. The difference of Sv gain to the last calibration was better than –0.1dB. This small deviation indicates a stable operation of the acoustic measuring system.

For the verification of echogram traces 10 trawl hauls were carried out to identify the targets. Trawling was conducted with the pelagic gear PSN388 in the midwater and the bottom trawl “Aalhopser” near the bottom. The trawls were deployed to catch the „typical“ shaped indications of clupeid shoals. Catch compositions are given in table 1. From each haul samples were taken for the determination of length, weight, age and maturity.

The allocation of echo records was carried out by segmentation of ‘typical’ shoals using the BI500. The calibration of this allocation process was supported by the targeted fishery on these shoals. In the most cases a mixture of sprat and young herring was caught. It was not possible to discriminate shoals of the different species only by the inspection of the echogram. Therefore these shoals were classified as ‘clupeoids’ and the proportion of herring and sprat were estimated by means of the trawl results in this stratum. For each stratum the species composition and length distribution were determined as the weighted mean of all trawl results in the respective stratum. In the case of missing hauls in a stratum the results of the adjacent statistical rectangles were used. For these distributions the mean scattering cross section was calculated according to the following TS-length relation (Anon., 1982):

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

The total number of fish was estimated as the product of the mean Sa values and the stratum area divided by the corresponding mean scattering cross section. The total numbers were split into herring and sprat age classes according to the catch compositions and age readings.

Results

The spatial distribution of the herring shoals was similar to the general patterns observed during the last years. It can therefore be assumed that the main part of the herring concentration in the planned observation area was covered. At least, the herring abundance estimates can be used as the lower limit of the true abundance. A total of 4,600 million herring was almost equally divided into age groups 1 and 2. Last year's results yielded only the half of the total number but with the same age proportions.

The general abundance of sprat was low, but the evaluation of the short track conducted south of Helgoland indicates high concentrations of sprat in the southern survey area. This is in accordance with the findings from previous years. The shape of the sprat dominated shoals was different from the typical herring indications in the northern part of the survey area. The spacial extension was small and the echo level of a single shoal was considerably lower than the typical level of the shoals known to be herring. A general estimation of the sprat abundance was not conducted because the coverage of the main distribution area of this species was too poor.

Tables 2 and 3 shows herring and sprat abundance and biomass estimates separated by age class.

Table 1 Catch composition of hauls (in kg per 30 min hauling time) conducted during cruise 444 of FRV Solea in 1999.
Net type (benthic or pelagic) is indicated.

Station	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**Sum**
Net type	pel.	benth.	pel.	pel.	pel.	benth.	benth.	pel.	benth.	pel.	
Sum	**238.01**	**132.97**	**90.25**	**4.41**	**466.55**	**130.26**	**32.54**	**37.66**	**207.49**	**247.34**	**1587.48**
Sum Clupeids	**233.09**	**132.90**	**88.73**	**0.00**	**465.71**	**120.93**	**31.76**	**37.18**	**154.17**	**247.34**	**1511.81**
Clupea harengus	**4.68**	**123.34**	**88.06**		**465.71**	**115.26**	**3.00**	**36.19**	**154.17**	**181.27**	**1171.68**
Sprattus sprattus	**228.41**	**9.56**	**0.67**			**5.67**	**28.76**	**0.99**		**66.07**	**340.13**
Eutrigla gurnardus		0.04	1.36	2.22	0.84	1.81	0.04	0.48	22.10		**28.89**
Gadus morhua									3.42		**3.42**
Hippoglossoides platessoides						1.31			8.31		**9.62**
Hyperoplus lancoelatus							0.03				**0.03**
Limanda limanda						2.71			16.10		**18.81**
Merlangius merlangus	1.28	0.03	0.16	0.02		2.75	0.71		1.02		**5.97**
Microstomus kitt						0.14			0.62		**0.76**
Nephrops norvegicus						0.17					**0.17**
Pleuronectes platessa						0.44			1.07		**1.51**
Scomber scombrus	1.87			0.40							**2.27**
Trachurus trachurus	1.77			1.78					0.68		**4.23**

Table 2 Total estimates of herring abundance (numbers at age in millions) as obtained during the hydro-acoustic survey of FRV Solea in summer 1999. Values for rectangle 37F7 are not shown as only one hydro-acoustic cruise track was completed and the abundance is very likely to be overestimated. Numbers in italics: from interpolated species- and length relations.

ICES Rect		F4		F5		F6		F7	
	Age	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**
41	**numbers per rct.**		**32.8**		**256.9**		**112.1**		**11.9**
	1	*41%*	*13.6*	32%	82.7	*61%*	*68.4*	*67%*	*8.0*
	2i	*0%*	*0.1*	0%	0.0	*0%*	*0.1*	*0%*	*0.0*
	2m	*58%*	*19.1*	68%	174.2	*39%*	*43.6*	*33%*	*3.9*
	3m	*0%*	*0.0*	0%	0.0	*0%*	*0.0*	*0%*	*0.0*
	4	*0%*	*0.0*	0%	0.0	*0%*	*0.0*	*0%*	*0.0*
40	**numbers per rct.**		**43.7**		**623.2**		**1596**		**59.5**
	1	*45%*	*19.7*	49%	303.1	68%	1086.1	*65%*	*38.9*
	2i	*0%*	*0.2*	1%	4.2	0%	0.0	*0%*	*0.0*
	2m	*54%*	*23.5*	51%	315.8	32%	509.5	*35%*	*20.6*
	3m	*1%*	*0.3*	0%	0.0	0%	0.0	*0%*	*0.0*
	4	*0%*	*0.0*	0%	0.0	0%	0.0	*0%*	*0.0*
39	**numbers per rct.**		**149.5**		**1037.1**		**636.9**		
	1	9%	14.1	*54.2%*	*561.9*	53%	335.8		
	2i	0%	0.0	*0%*	*2.0*	0%	0.0		
	2m	85%	127.3	*45.3%*	*469.3*	47%	301.1		
	3m	5%	8.1	*0.4%*	*3.8*	0%	0.0		
	4	0%	0.0	*0%*	*0.0*	0%	0.0		

age 1	2532.3
age 2 I	6.6
age 2 m	2007.9
age 3 m	12.2
age 4	0.0
total	**4559.0**

Table 3 Total estimates of herring biomass (weight at age in kg) as obtained during the hydro-acoustic survey of FRV Solea in summer 1999. Values for rectangle 37F7 are not shown as only one hydro-acoustic cruise track was completed and the abundance is very likely to be overestimated. Numbers in italics: from interpolated species- and length relations.

ICES Rect		**F4**		**F5**		**F6**		**F7**	
	Age	**w /age**	**n**	**w /age**	**n**	**w /age**	**n**	**w /age**	**n**
41	**total**	***826***	***32.8***	**7276**	**256.9**	***2092***	***112.1***	***198***	***11.9***
	1	*77*	*13.6*	465	82.7	*385*	*68.4*	*45*	*8.0*
	2i	*3*	*0.1*	0	0.0	*3*	*0.1*	*0*	*0.0*
	2m	*745*	*19.1*	6811	174.2	*1704*	*43.6*	*153*	*3.9*
	3m	*1*	*0.0*	0	0.0	*0*	*0.0*	*0*	*0.0*
	4	*0*	*0.0*	0	0.0	*0*	*0.0*	*0*	*0.0*
40	**total**	***1061***	***43.7***	**14150**	**623.2**	**26030**	**1596**	***1024***	***59.5***
	1	*111*	*19.7*	1706	303.1	6115	1086.1	*219*	*38.9*
	2i	*4*	*0.2*	98	4.2	0	0.0	*0*	*0.0*
	2m	*920*	*23.5*	12346	315.8	19915	509.5	*805*	*20.6*
	3m	*26*	*0.3*	0	0.0	0	0.0	*0*	*0.0*
	4	*0*	*0.0*	0	0.0	0	0.0	*0*	*0.0*
39	**total**	**5729**	**149.5**	***21872***	***1037.1***	**13659**	**636.9**		
	1	80	14.1	*3164*	*561.9*	1890	335.8		
	2i	0	0.0	*46*	*2.0*	0	0.0		
	2m	4976	127.3	*18346*	*469.3*	11769	301.1		
	3m	674	8.1	*317*	*3.8*	0	0.0		
	4	0	0.0	*0*	*0.0*	0	0.0		

age 1	14256.7
age 2 I	153.3
age 2 m	78489.4
age 3 m	1017.8
age 4	0.0
total	**93917.2**

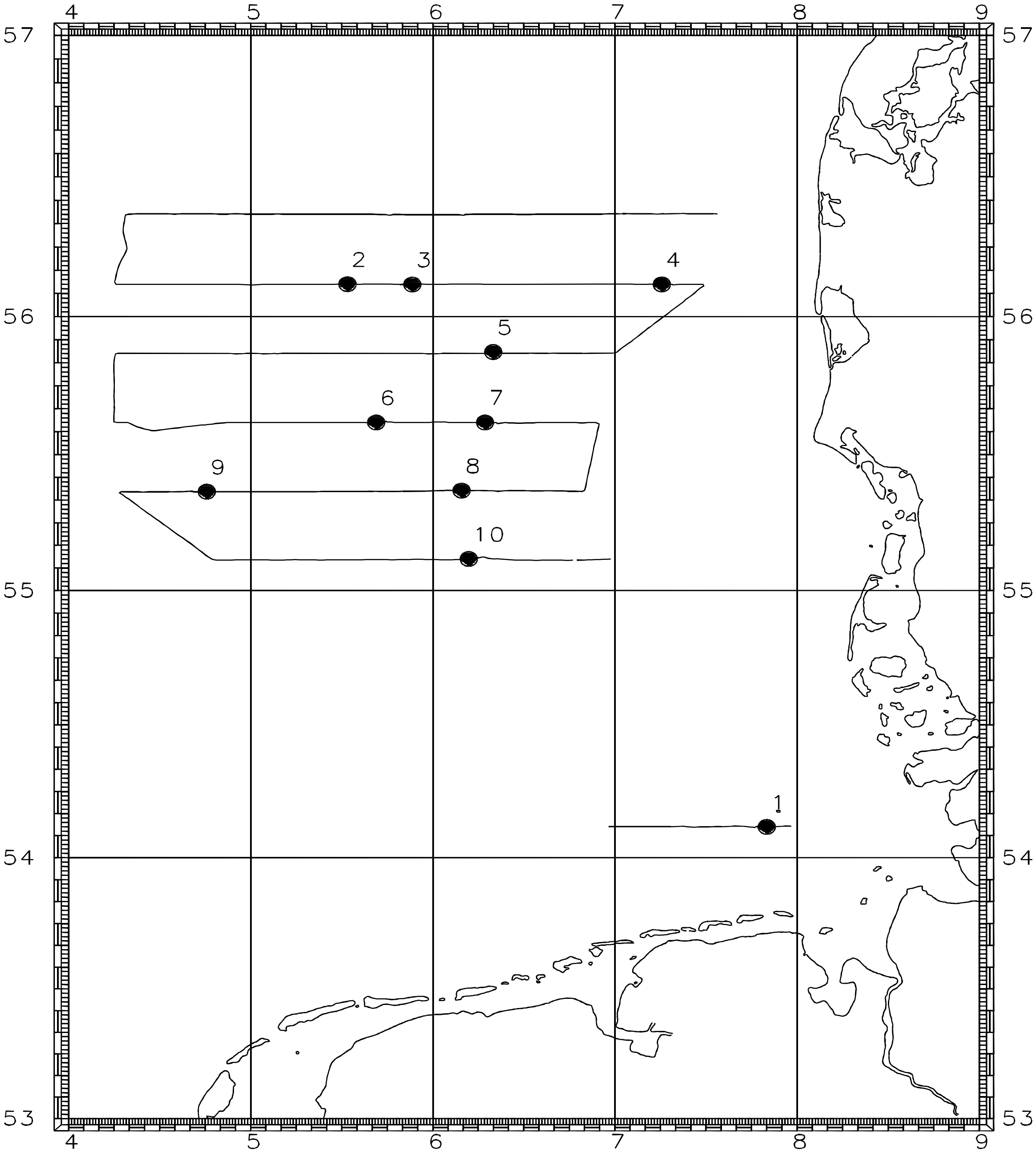


Figure 1: Cruise 444 of FRV Solea in 1999: Cruise track (tracks which were used for echo integration only) and position of the verification hauls (dots).

APPENDIX 2

Survey report RV “G.o.SARS” cruise 444
29 June – 18 July 1999

E.Torstensen and R.Toresen
Institute of Marine Research, Bergen, Norway

Objectives: Abundance estimation of herring and sprat in the area between latitudes, 57°00'N and 62°00'N and east of 02°00'E. Map the general hydrographical regime and monitor the standard profiles Utsira - Start Point and Feie - Shetland.

Participation: V. Anthonypillai, E. Hermansen, R. Johannesen, H. Myran, B.V. Svendsen, R. Toresen (cr.l.), E. Torstensen, J.A. Vågenes,

Guest: Wang Yong, China

Narrative

In this report the results from the Norwegian coverage of the International Herring Acoustic Survey for 1999 is presented. The time series of this survey extends back to 1984. Five countries cooperate to survey the North Sea and the Skagerrak for an acoustic abundance estimation of herring and sprat. The surveys are planned in the Planning Group for Herring Surveys (ICES 1999b) which is a sub group under the ICES Herring Assessment Working Group for the Area South of 62^{o}N. In the recent years, the total survey area has been divided between the participating countries, represented by the vessels, as shown in Figure 1.

RV “G.O. Sars”, started in Bergen, 29 June 1999. A call was made in Arendal on 30 June Egersund on 7 July, Haugesund on 10 July and in Lerwick, Shetland on 16 July. The survey was finished in Bergen on 18 July.

This year the Norwegian survey included Skagerrak. The survey started in the inner Skagerrak and was continued in the North Sea from south to north. Systematic parallel transects in the east-west direction were carried out and the distance between the transects was 15-20 NM.

Survey effort

Fig. 2a-b shows the cruise track with fishing stations and the hydrographic profiles. Nearly 3300 NM was surveyed and the total number of trawl hauls were 77, 68 pelagic and 9 bottom trawls. The number of CTD stations for temperature, salinity and density measures were 125.

Methods

The catches were sampled for species composition, by weight and numbers. Biological samples, i.e. length and weight compositions were taken of the most important species. Otoliths were taken of herring, sprat and mackerel for age determination. Herring were also examined for fat content and maturity stage in the whole area. Vertebral counts for the separation of autumn spawning herring and Baltic spring spawners were taken of herring samples east of 2°00’E.

The acoustic instruments applied for abundance estimation were a SIMRAD EK500 echo sounder and the Bergen Echo Integrator system (BEI). The setting of the instruments were as follows:

Absorption coeff.	10 dB/km
Pulse Length	Medium
Bandwidth	Wide
Max Power	2,000 W
Angle Sensitiv.	21.9
2-Way Beam Angle	-21.0 dB

Sv Transd. Gain	26.86 dB
TS Transd. Gain	27,07 dB
3 dB Beamwidth	7.0/6.8 deg
Alongship Offset	-0.07 deg
Athw. ship Offset	0.04 deg

Sounder: ES 38 B.

The weather conditions during the survey were excellent for acoustic registrations.

The S_A-values were divided between the following categories on the basis of trawl catches and characteristics on the echo recording paper:

herring, sprat, other pelagic fish, demersal fish, plankton

The following target strength (TS) function was applied to convert S_A-values of herring and sprat to number of fish:

$$TS = 20 \log L - 71{,}2 \text{ dB} \qquad (1)$$

or on the form:

$$C_F = 1.05 \cdot 10^6 \cdot L^{-2} \qquad (2)$$

where L is total length.

The acoustic method as used for the abundance estimation of small pelagic fish is described by Toresen *et al* (1998).

In the Skagerrak and off the south west coast of Norway, North Sea autumn spawners and Western Baltic spring spawners mix during summer. No system for routine stock discrimination on individual herring during the survey, is available. The proportion of Baltic spring spawners and North Sea autumn spawners by age were calculated by applying the formula, WBaltic= ((56,5-VS(sample))/(56.5-55.8)) (ICES 1999a).To calculate the maturing part of the two stocks in each age group, the observed maturity stages were applied for both stocks

Results

Hydrography

The horizontal distributions of temperature at 5m, 50m and at bottom in the surveyed area are shown in Fig. 3a-c. The surface water had temperatures ranging from 13°C east of Shetland to 16-17°C off the west coast of Norway. In Skagerrak the surface temperature was about

14-15 °C. The temperatures measured at 5 m were 2-3°C higher than last year, in which it was a rather cold summer. However, the temperature regime in 50m depth seems much the same as that of last year.

Distribution and abundance of herring and sprat

Herring

The horizontal distribution of herring is shown in Fig. 4. In Skagerrak herring was found in the whole surveyed area with the highest densities along the Swedish west coast. Here immature autumn spawners (0- and 1-ringers) dominated in a mixture with maturing and adult Western Baltic spring spawners. Herring in the North Sea was mostly found in the south eastern part and close to the east coast of Shetland.

The registrations were very scattered in the whole surveyed area and the recorded herring were mainly found close to the surface. No ‘real’ herring schools were detected and most of the trawling positions were regularly chosen, by trawling every 20-30 NM, and not based on echo registration. Due to this behaviour herring may have been underestimated during the survey. East of Shetland, herring were found in medium dense concentrations close to the bottom.

The abundance by ICES statistical squares, divided in Western Baltic spring spawners and North Sea autumn spawners, are given in Table 1 (Skagerrak) and Table 2 (North Sea).The numbers are given age disaggregated. The numbers in age groups 2 and 3 are split in mature/immature parts. Surveyed squares with no herring recordings are not presented in the tables. Table 3 and 4 present the mean weights at age applied for biomass estimations in Skagerrak and the North Sea, respectively. Total estimated numbers of herring by age and length are given for Skagerrak in Table 5 and for the North Sea in Table 6. The total estimated biomass per age group and stock is also shown in these tables.

The biomass estimates of North Sea herring and Baltic spring spawners, in Skagerrak and in the North Sea, are shown in the text table below. The total biomass estimate of herring in the area covered by the norwegian vessel is about 485 000 t. The estimated spawning stock biomass of North Sea herring was about 260 000 t which is significantly more than was estimated last year, 73 000 t. The estimated biomass of Baltic spring spawners in the North Sea this year of 75 000 tonnes is somewhat lower than last years estimate of 90 000 tonnes.

Area	Herring Biomass	(10^3 tonnes)
	North Sea herring	Baltic Spring
Skagerrak	3	115
North Sea	260	75
Total	263	190

Sprat

Few specimens of sprat were caught near the border between Skagerrak and Kattegat. From a low number in only one trawl haul, no Sa-values were allocated to sprat.

References

ICES 1999a. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 1999/ACFM: 12

ICES 1999b. Report of the Planning Group for Herring Surveys, Hirtshals, Denmark, 2-4 February 1999. ICES CM 1999/G: 7, Ref.D.

Anon. 1999c. 1998 ICES Co-ordinated acoustic survey of ICES Divisions IIIa, IVa, IVb and VIa (north). ICES CM 1999/J:16 (poster).

Toresen, R., Gjøsæter, H. and de Barros, P. 1998. The acoustic method as used in the abundance estimation of capelin (*Mallotus villosus* Müller) and herring (*Clupea harengus* Linné) in the Barents Sea. Fisheries Research, 34: 27-37.

Table 1. HERRING-SKAGERRAK Estimated number of herring in ICES stat squares in Skagerrak by stocks and agegroups.
R/V 'G.O. Sars', 29 June - 18 July 1999

46F9	**0**	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
North Sea Autumn spawners	0.00	1.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.13
Baltic Spring Spawners	0.00	0.22	1.86	0.56	4.41	0.00	2.64	0.00	0.00	0.00	0.00	0.00	9.69

46G0	**0**	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
North Sea Autumn spawners	466.16	357.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	823.29
Baltic Spring Spawners	0.00	165.69	96.81	2.57	24.18	10.07	10.07	1.28	1.28	0.00	0.00	0.00	311.94

45F8	**0**	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
North Sea Autumn spawners	0.00	6.04	1.21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.25
Baltic Spring Spawners	0.00	1.24	2.97	0.00	1.82	0.73	1.27	0.55	0.91	0.36	0.00	0.36	10.21

45F9	**0**	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
North Sea Autumn spawners	0.00	3.08	3.23	0.79	0.00	0.00	0.00	4.66	0.72	2.15	0.36	0.00	14.99
Baltic Spring Spawners	0.00	0.50	15.77	3.87	21.86	6.09	7.17	0.00	0.00	0.00	0.00	0.00	55.26

45G0	**0**	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
North Sea Autumn spawners	577.31	440.09	0.00	0.00	0.64	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1018.05
Baltic Spring Spawners	0.00	159.49	88.08	0.00	9.27	7.70	7.70	0.00	0.00	0.00	0.00	0.00	272.23

45G1	**0**	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
North Sea Autumn spawners	338.96	244.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	583.09
Baltic Spring Spawners	0.00	90.30	40.67	4.52	6.33	2.71	4.52	0.00	0.00	0.00	0.00	0.00	149.05

44F8	**0**	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
North Sea Autumn spawners	0.00	23.18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23.18
Baltic Spring Spawners	0.00	7.32	71.16	20.33	40.67	10.17	50.83	0.00	0.00	0.00	0.00	0.00	200.48

Table 1. Continue

44F9			North Sea Autumn spawners									
0	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
0.00	281.56	18.85	5.28	0.00	0.00	1.82	0.00	0.00	0.00	0.00	0.00	307.52
			Baltic Spring Spawners									
0	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
0.00	70.39	59.71	16.72	9.43	0.00	4.46	3.14	0.00	0.00	0.00	0.00	163.84

44G0			North Sea Autumn spawners									
0	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
388.98	315.09	0.00	0.00	0.00	0.21	0.00	0.00	0.00	0.00	0.00	0.00	704.27
			Baltic Spring Spawners									
0	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
0.00	113.95	57.34	0.00	4.95	5.46	4.95	0.00	0.00	0.00	0.00	0.00	186.65

44G1			North Sea Autumn spawners									
0	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
474.14	341.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	815.65
			Baltic Spring Spawners									
0	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
0.00	126.31	63.22	0.00	6.32	6.32	6.32	0.00	0.00	0.00	0.00	0.00	208.50

43F8			North Sea Autumn spawners									
0	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
0.00	103.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	103.24
			Baltic Spring Spawners									
0	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
0.00	12.76	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.76

43F9			North Sea Autumn spawners									
0	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
0.00	235.15	15.75	4.41	0.00	0.00	1.52	0.00	0.00	0.00	0.00	0.00	256.83
			Baltic Spring Spawners									
0	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
0.00	58.79	49.86	13.96	7.87	0.00	3.73	2.62	0.00	0.00	0.00	0.00	136.84

Table 2. HERRING-NORTH SEA. Estimated number by ICES stat squares divided in stocks and agegroups.
R/V 'G.O. Sars', 29 June - 18 July 1999

43F4	North Sea Autumn spawners											
0	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
161.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	161.54
	Baltic Spring Spawners											
0	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

43F5	North Sea Autumn spawners											
0	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
8.48	20.67	2.42	1.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.48
	Baltic Spring Spawners											
0	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
0.00	3.09	2.33	1.83	0.00	1.02	0.00	0.00	0.00	0.00	0.00	0.00	8.26

43F6	North Sea Autumn spawners											
0	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
0.00	262.17	8.82	6.47	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	277.46
	Baltic Spring Spawners											
0	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
0.00	0.00	6.93	5.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	12.01

43F7	North Sea Autumn spawners											
1	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
0.00	378.98	12.74	9.35	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	401.07
	Baltic Spring Spawners											
1	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
0.00	0.00	10.01	7.34	0.00	4.23	0.00	0.00	0.00	0.00	0.00	0.00	21.58

44F3	North Sea Autumn spawners											
0	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
0.00	13.29	1.78	8.92	0.36	1.86	0.81	0.19	0.00	0.00	0.00	0.00	27.21
	Baltic Spring Spawners											
0	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
0.00	1.00	0.92	4.60	0.61	3.16	0.35	0.00	0.00	0.00	0.00	0.00	10.63

44F4	North Sea Autumn spawners											
0	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
0.00	6.33	0.85	4.25	0.17	0.88	0.39	0.09	0.00	0.00	0.00	0.00	12.96
	Baltic Spring Spawners											
0	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
0.00	0.48	0.44	2.19	0.29	1.51	0.17	0.00	0.00	0.00	0.00	0.00	5.06

44F5	North Sea Autumn spawners											
0	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
0.00	157.57	21.16	105.78	4.24	22.03	9.62	2.29	0.00	0.00	0.00	0.00	322.67
	Baltic Spring Spawners											
0	**1**	**2I**	**2M**	**3I**	**3M**	**4**	**5**	**6**	**7**	**8**	**9+**	**Total**
0.00	11.86	10.90	54.49	7.21	37.50	4.12	0.00	0.00	0.00	0.00	0.00	126.09

44F6 **North Sea Autumn spawners**

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	7.08	20.11	9.31	5.03	9.68	0.00	0.00	0.00	0.00	0.00	0.00	51.21

Baltic Spring Spawners

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	0.54	9.31	4.31	9.68	18.65	8.17	4.90	0.00	1.09	0.00	0.00	56.65

44F7 **North Sea Autumn spawners**

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	2.97	8.43	3.90	2.11	4.06	0.00	2.06	0.00	0.46	0.00	0.00	23.99

Baltic Spring Spawners

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	0.23	3.90	1.81	4.06	7.82	3.43	0.00	0.00	0.00	0.00	0.00	21.24

45F3 **North Sea Autumn spawners**

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	25.57	3.43	17.16	0.69	3.57	1.56	0.37	0.00	0.00	0.00	0.00	52.36

Baltic Spring Spawners

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	1.92	1.77	8.84	1.17	6.09	0.67	0.00	0.00	0.00	0.00	0.00	20.46

45F4 **North Sea Autumn spawners**

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	261.90	35.16	175.82	5.90	30.71	15.98	3.81	0.00	0.00	0.00	0.00	529.29

Baltic Spring Spawners

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	19.71	18.11	90.57	10.05	52.28	6.85	0.00	0.00	0.00	0.00	0.00	197.59

45F5 **North Sea North Sea Autumn spawners**

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	17.12	13.52	2.43	0.00	0.00	0.00	1.35	0.45	0.00	0.00	0.00	34.87

Baltic Spring Spawners

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	0.00	9.01	1.62	13.72	17.37	8.11	0.00	0.00	0.00	0.00	0.00	49.83

45F6 **North Sea Autumn spawners**

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	1.53	1.66	0.36	0.93	1.77	0.00	0.00	0.00	0.00	0.00	0.00	6.26

Baltic Spring Spawners

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	0.00	4.05	0.89	0.46	0.87	0.70	0.00	0.00	0.00	0.00	0.00	6.97

46F2 **North Sea Autumn spawners**

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	1.65	1.57	1.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.09	4.37

Baltic Spring Spawners

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	0.25	0.58	0.39	0.43	1.64	0.69	0.17	0.00	0.00	0.00	0.00	4.15

46F3 **North Sea Autumn spawners**

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	16.80	16.02	10.89	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.88	44.59

Baltic Spring Spawners

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	2.51	5.92	4.03	4.39	16.68	7.02	1.76	0.00	0.00	0.00	0.00	42.31

46F4 **North Sea Autumn spawners**

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	43.77	26.36	0.23	0.22	1.12	0.00	0.00	0.00	0.00	0.00	0.00	71.70

Baltic Spring Spawners

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	0.00	6.18	0.05	3.43	17.49	6.20	2.55	0.00	0.00	0.00	0.36	36.27

46F5 **North Sea Autumn spawners**

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	4.12	2.63	0.47	0.00	0.00	0.00	0.26	0.09	0.00	0.00	0.00	7.57

Baltic Spring Spawners

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	0.00	1.75	0.32	2.67	3.38	1.58	0.00	0.00	0.00	0.00	0.00	9.69

47F3 **North Sea Autumn spawners**

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	34.00	13.76	10.52	3.24	11.33	3.64	3.24	0.40	0.00	0.00	0.00	80.14

Baltic Spring Spawners

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

47F4 **North Sea Autumn spawners**

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	40.95	16.58	12.68	3.90	13.65	4.39	3.90	0.49	0.00	0.00	0.00	96.54

Baltic Spring Spawners

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

48F3 **North Sea Autumn spawners**

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	34.77	8.02	26.21	7.49	18.72	6.42	3.21	0.53	1.07	0.53	0.00	106.99

Baltic Spring Spawners

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

48F4 **North Sea Autumn spawners**

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	1.05	0.24	0.79	0.23	0.57	0.19	0.10	0.02	0.03	0.02	0.00	3.24

Baltic Spring Spawners

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

49F2 **North Sea Autumn spawners**

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	0.15	0.35	0.27	1.31	1.96	0.81	0.50	0.42	0.12	0.00	0.12	6.00

Baltic Spring Spawners

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

49F3 **North Sea Autumn spawners**

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	0.55	1.25	0.97	4.71	7.06	2.91	1.80	1.52	0.42	0.00	0.42	21.60

Baltic Spring Spawners

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

49F4 **North Sea Autumn spawners**

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	1.37	1.42	0.74	0.19	4.65	1.42	0.68	0.40	0.17	0.00	0.06	11.11

Baltic Spring Spawners

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

49E9 **North Sea Autumn spawners**

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	7.15	7.15	171.50	7.15	450.18	221.52	78.60	0.00	0.00	0.00	0.00	943.24

50F1 **North Sea Autumn Spawners**

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	1.09	2.46	1.91	9.28	13.92	5.73	3.55	3.00	0.82	0.00	0.82	42.57

50F2 **North Sea Autumn Spawners**

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	0.27	0.61	0.48	2.32	3.48	1.43	0.89	0.75	0.20	0.00	0.20	10.64

50F3 **North Sea Autumn Spawners**

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	0.49	1.09	0.85	4.12	6.19	2.55	1.58	1.33	0.36	0.00	0.36	18.92

50F4 **North Sea Autumn Spawners**

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	0.64	1.43	1.11	5.41	8.12	3.34	2.07	1.75	0.48	0.00	0.48	24.83

51E9 **North Sea Autumn spawners**

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	0.53	0.53	0.53	0.53	33.66	16.56	5.88	0.00	0.00	0.00	0.00	58.24

51F4 **North Sea Autumn spawners**

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	0.61	1.36	1.06	5.15	7.73	3.18	1.97	1.67	0.45	0.00	0.45	23.65

Table 3. HERRING-SKAGERRAK. Weight at age (g) for age groups and mature/immature fish in sub areas.
R/V 'G.O. Sars', 29 June - 18July 1999.

46F9

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0	69.03	77.70	86.50	94.30	117.00	98.30	135.20	137.00			116.00	83.80

46G0-W

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
	57.00	80.20	84.00	97.80	113.70	102.70	138.00	167.00				74.50

46G0-E

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
4.4	46.20	62.20		111.00	98.00	68.00						28.67

45F8

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
	59.10	78.10		96.00	126.80	118.10	170.30	198.00	223.00	120.00	190.50	93.70

45F9

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
0.00	66.10	88.40	112.80	112.40	123.50	142.60	158.50	218.00	180.50	142.00		113.18

45G0-W

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
	62.20	64.60		60.00								62.70

45G0-E

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
4.4	46.20	62.20		111.00	98.00	68.00						28.67

45G1

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
4.4	46.20	62.20		111.00	98.00	68.00						28.67

44F8

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
	74.00	80.00	128.50	108.50	124.00	119.20						99.70

44F9

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
	62.40	82.10	94.60	91.70		101.00	95.00					69.63

44G0-W

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
5.4	51.60	64.10			98.00							43.88

44G0-E

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
4.4	46.20	62.20		111.00	98.00	68.00						28.67

44G1

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
4.4	46.20	62.20		111.00	98.00	68.00						28.67

43F8

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
	37.80											37.80

43F9

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
	62.40	82.10	94.60	91.70		101.00	95.00					69.63

Table 4. HERRING-NORTH SEA. Weight at age (g) for age groups and mature/immature fish in sub areas.
R/V 'G.O. Sars', 29 June - 18 July 1999

	0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
51F4		99.50	130.80	179.70	146.20	211.50	209.60	218.20	248.30	245.70		247.70	192.50
50F4		99.50	130.80	179.70	146.20	211.50	209.60	218.20	248.30	245.70		247.70	192.50
50F3		99.50	130.80	179.70	146.20	211.50	209.60	218.20	248.30	245.70		247.70	192.50
50F2		99.50	130.80	179.70	146.20	211.50	209.60	218.20	248.30	245.70		247.70	192.50
50F1		99.50	130.80	179.70	146.20	211.50	209.60	218.20	248.30	245.70		247.70	192.50
49F4		93.90	115.50	133.70	139.40	158.10	169.90	188.10	227.30	245.70		193.00	146.70
49F3		99.50	130.80	179.70	146.20	211.50	209.60	218.20	248.30	245.70		247.70	192.50
49F2		99.50	130.80	179.70	146.20	211.50	209.60	218.20	248.30	245.70		247.70	192.50
49E9		81.00	110.00		89.00	181.10	248.80	235.30	261.00	230.00	0.00	0.00	109.30
48F4		77.70	97.50	128.30	112.90	153.70	161.30	173.80	142.00	264.50	199.00		118.00
48F3		77.70	97.50	128.30	112.90	153.70	161.30	173.80	142.00	264.50	199.00		118.00
47F4		73.90	88.60	111.60	103.40	120.80	119.40	145.40	142.00				94.50
47F3		73.90	88.60	111.60	103.40	120.80	119.40	145.40	142.00				94.50

46F5

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
	65.40	88.90	116.90	96.30	114.50	116.90	112.30	105.00				93.80

46F4

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
	70.30	90.20	112.60	107.40	123.50	130.20	145.10				173.00	94.90

46F3

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
	76.50	92.80	119.10	109.40	120.70	136.00	160.00				173.00	105.50

46F2

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
	76.50	92.80	119.10	109.40	120.70	136.00	160.00				173.00	105.50

45F6

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
	69.90	84.30	105.20	90.30	109.30	109.20	143.50		131.00			93.00

45F5

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
	65.40	88.90	116.90	96.30	114.50	116.90	112.30	105.00				93.80

45F4

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
	69.00	97.30	133.80	105.40	138.20	126.50	163.00					106.50

45F3

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
	69.00	97.30	133.80	105.40	138.20	126.50	163.00					106.50

44F7

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
	70.90	84.40	114.80	104.10	112.30	119.10	140.80		165.50			103.30

44F6

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
	70.90	84.40	114.80	104.10	112.30	119.10	140.80		165.50			103.30

44F5

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
	69.00	97.30	133.80	105.40	138.20	126.50	163.00					106.50

44F4

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
	69.00	97.30	133.80	105.40	138.20	126.50	163.00					106.50

44F3

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
	69.00	97.30	133.80	105.40	138.20	126.50	163.00					106.50

43F7

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
	49.60	81.20	119.50		95.70							56.70

43F6

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
	49.60	81.20	119.50		95.70							56.70

43F5

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
1.70	61.70	81.50	119.50		95.70							57.80

43F4

0	1	2I	2M	3I	3M	4	5	6	7	8	9+	Total
1.70												1.70

Table 5 : HERRING- SKAGERRAK. Estimated number and biomass of herring by age and length groups.Totals also divided in stocks. RV GO Sars, 29 June-18 July 1999.

					Age groups							
Length (cm)	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9+**	**N (mill)**	**Ton (10^3)**
7.0-7.9	119	0	0	0	0	0	0	0	0	0	119	0
8.0-8.9	477	0	0	0	0	0	0	0	0	0	477	2
9.0-9.9	1197	0	0	0	0	0	0	0	0	0	1197	5
10.0-10.9	423	0	0	0	0	0	0	0	0	0	423	3
11.0-11.9	30	0	0	0	0	0	0	0	0	0	30	0
12.0-12.9	0	0	0	0	0	0	0	0	0	0	0	0
13.0-13.9	0	0	0	0	0	0	0	0	0	0	0	0
14.0-14.9	0	0	0	0	0	0	0	0	0	0	0	0
15.0-15.9	0	78	0	0	0	0	0	0	0	0	78	2
16.0-16.9	0	233	0	0	0	0	0	0	0	0	233	8
17.0-17.9	0	727	0	0	0	0	0	0	0	0	727	29
18.0-18.9	0	890	0	1	0	0	0	0	0	0	891	42
19.0-19.9	0	532	41	0	0	0	0	0	0	0	572	31
20.0-20.9	0	352	181	1	10	0	0	0	0	0	544	33
21.0-21.9	0	236	157	1	30	0	0	0	0	0	424	30
22.0-22.9	0	99	142	11	1	0	0	0	0	0	253	21
23.0-23.9	0	11	101	59	19	6	0	0	0	0	196	18
24.0-24.9	0	1	18	65	19	1	0	0	0	0	104	11
25.0-25.9	0	0	8	31	12	1	0	0	0	0	51	6
26.0-26.9	0	0	11	17	4	2	0	0	1	0	36	5
27.0-27.9	0	0	0	1	1	2	1	0	0	0	5	1
28.0-28.9	0	0	0	0	11	1	0	0	0	0	13	2
29.0-29.9	0	0	0	0	0	0	1	1	0	0	2	0
30.0-30.9	0	0	0	0	0	0	0	1	0	0	2	0
31.0-31.9	0	0	0	0	0	0	0	0	0	0	0	0
32.0-32.9	0	0	0	0	0	0	0	0	0	0	1	0
N (mill)	2246	3158	660	187	107	13	3	3	1	0	6377	250
NS herring	2246	2351	50	1	3	5	1	2	0	0		
Baltic spr	0	807	610	186	104	8	2	0	0	0		
								NS herring (millions)				4658.50
								SSB, NS herring (ton 10^3)				2.70
								Baltic spr (ton 10^3)				115.09

Table 6. HERRING-NORTH SEA. Estimated number and biomass by age and length groups. Totals also divided in stocks. RV GO Sars, 29 June-18 July 1999.

Length (cm)	0	1	2	3	4	Age groups 5	6	7	8	9+	N (mill)	Ton (10^3)
6.0-6.9	33.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33	0.03
7.0-7.9	107.20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	107	0.19
8.0-8.9	22.70	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	23	0.06
9.0-9.9	5.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	5	0.02
10.0-10.9	1.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2	0.01
11.0-11.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0.00
12.0-12.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0.00
13.0-13.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0.00
14.0-14.9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0	0.00
15.0-15.9	0.00	30.99	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	31	0.92
16.0-16.9	0.00	126.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	127	4.38
17.0-17.9	0.00	222.05	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	222	9.01
18.0-18.9	0.00	193.92	7.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	202	9.74
19.0-19.9	0.00	198.08	0.91	0.00	0.00	0.00	0.00	0.00	0.00	0.00	199	11.27
20.0-20.9	0.00	218.73	3.83	0.00	0.00	0.00	0.00	0.00	0.00	0.00	223	15.06
21.0-21.9	0.00	184.99	39.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	224	16.90
22.0-22.9	0.00	139.81	140.46	15.72	3.34	1.45	0.00	0.00	0.00	0.00	301	25.90
23.0-23.9	0.00	71.30	259.33	54.62	6.07	0.00	0.00	0.00	0.00	0.00	391	38.89
24.0-24.9	0.00	0.00	244.03	132.25	14.50	1.26	0.00	0.00	0.00	0.00	392	49.40
25.0-25.9	0.00	0.00	249.83	163.89	35.93	4.79	0.54	0.00	0.00	0.00	455	61.38
26.0-26.9	0.00	0.00	121.11	183.41	69.32	7.57	0.00	0.91	0.00	0.00	382	57.26
27.0-27.9	0.00	0.00	46.26	179.71	20.88	5.69	0.00	0.00	0.00	0.00	253	42.33
28.0-28.9	0.00	0.00	0.00	190.39	75.98	21.67	1.44	1.01	0.55	0.00	291	58.79
29.0-29.9	0.00	0.00	1.01	59.50	65.85	11.63	10.70	0.77	0.00	0.00	149	32.81
30.0-30.9	0.00	0.00	0.00	1.90	58.62	25.00	24.05	0.00	7.68	2.34	120	28.21
31.0-31.9	0.00	0.00	0.00	0.95	0.00	41.31	27.96	2.11	0.00	0.00	72	17.81
32.0-32.9	0.00	0.00	0.00	0.00	0.00	7.68	0.95	8.69	0.00	0.00	17	4.97
N (mill)	170	1387	1114	982	351	128	66	13	8	2	4221	485
NS herring	170	1345	831	719	299	116	65	12	8	3		
Baltic spr	0	42	280	251	48	10	0	1	0	0		

NS herring (millions)	3568.18
SSB, NS herring (ton 10^3)	259.35
Baltic spr (ton 10^3)	73.97

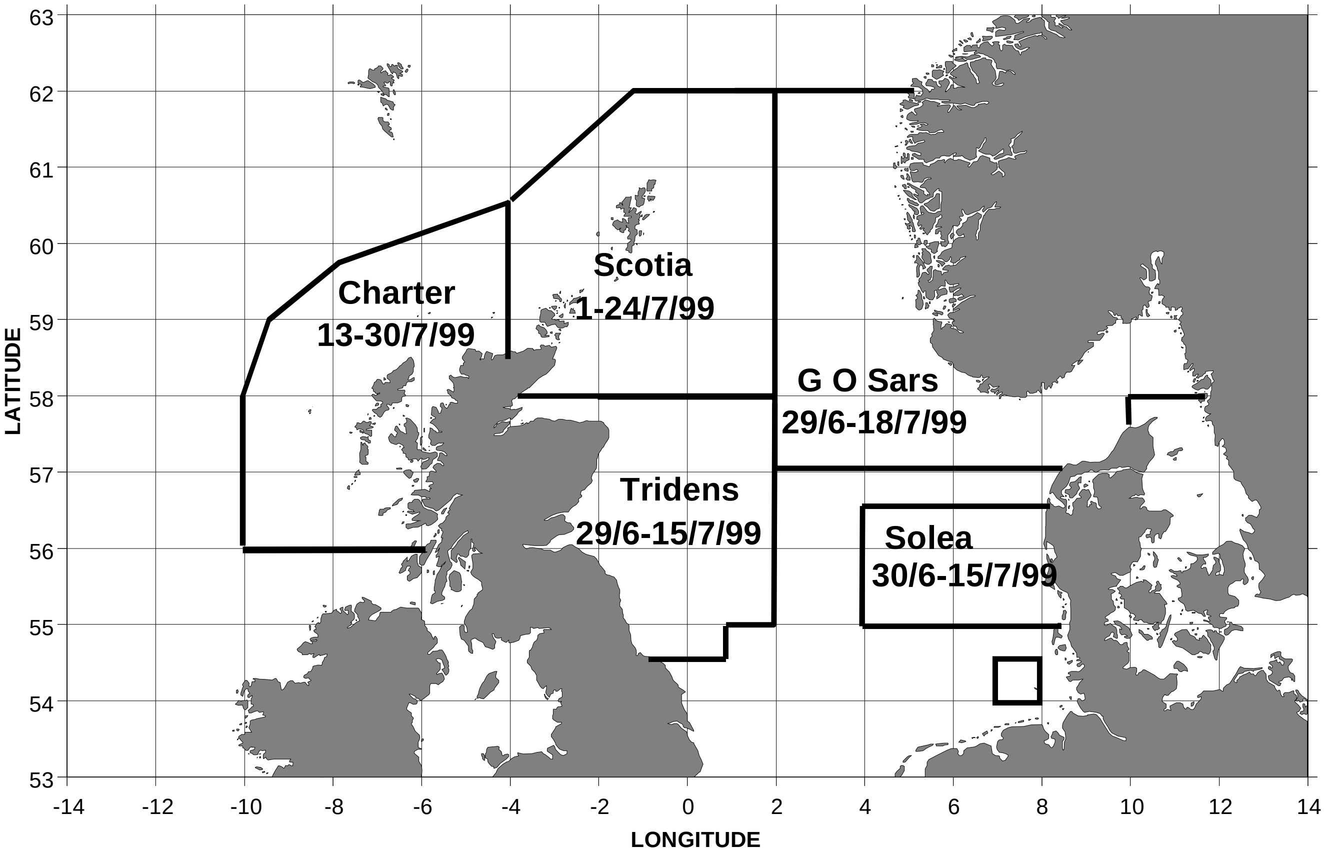


Figure 1. Layout and dates of survey areas for all participating vessels 1999.

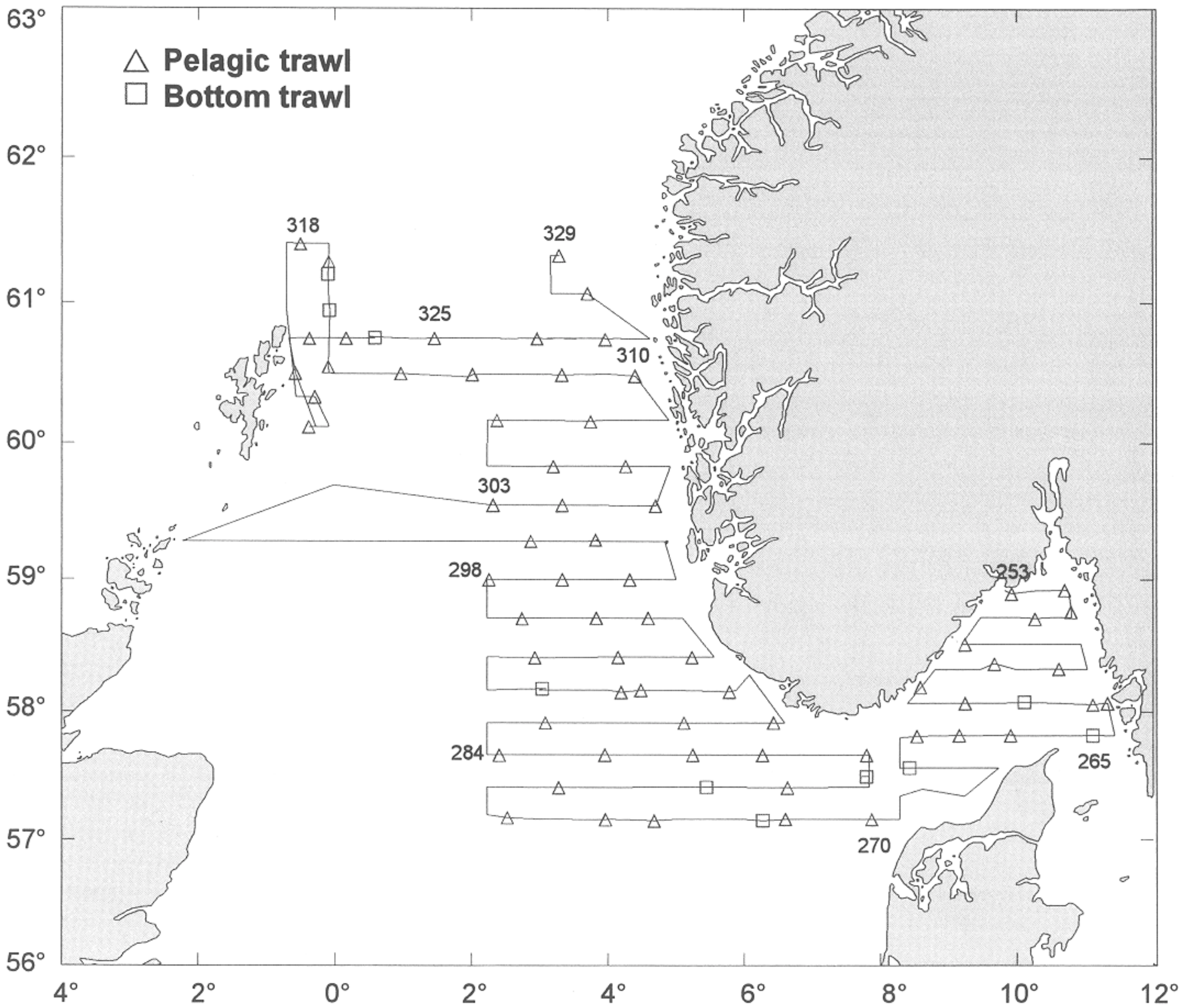


Figure 2a .Course lines with trawl stations, R/V G. O. Sars, 29 June - 18 July 1999

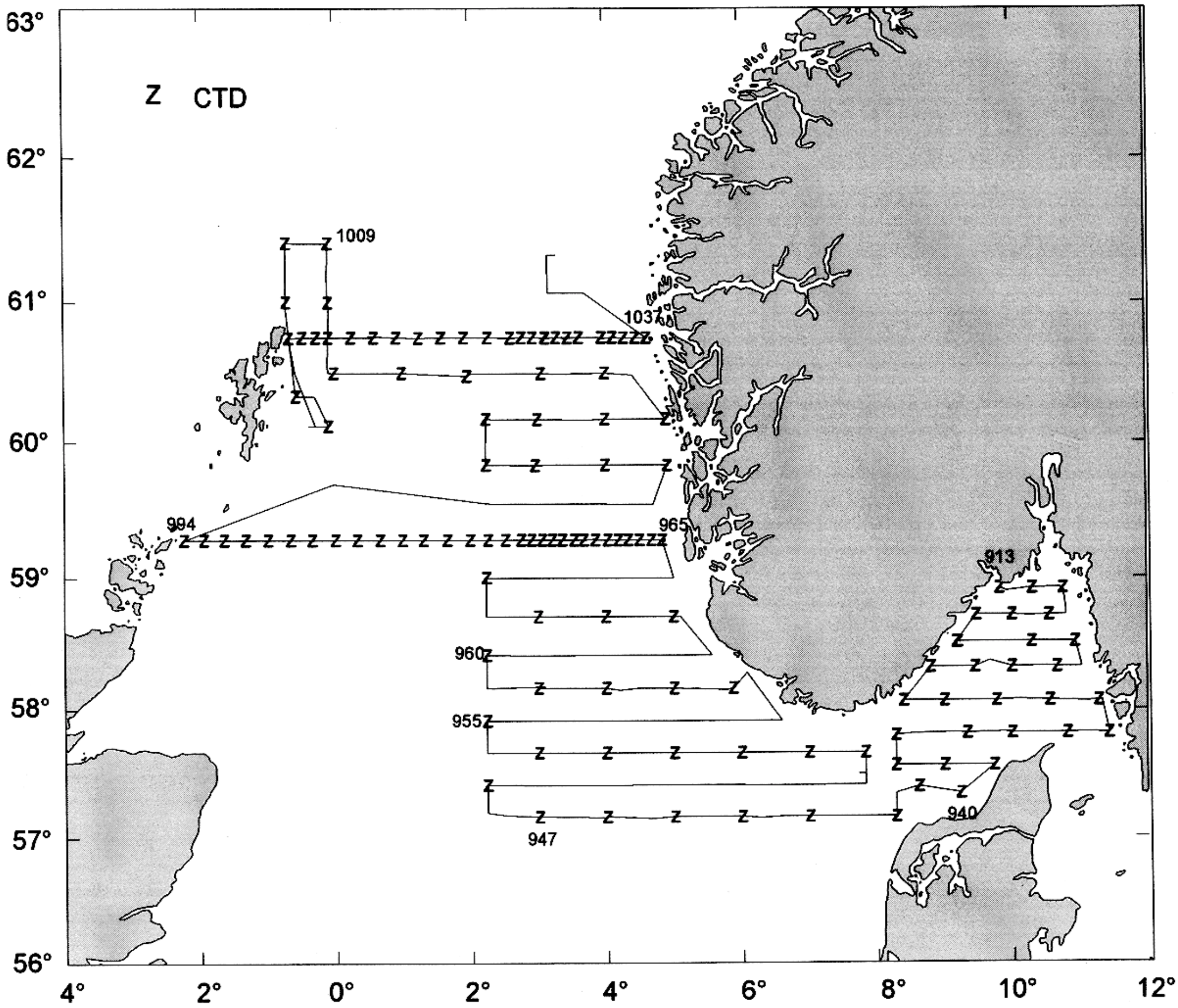


Figure 2b .Course lines with CTD (Z) stations, R/V G. O. Sars, 29 June - 18 July 1999

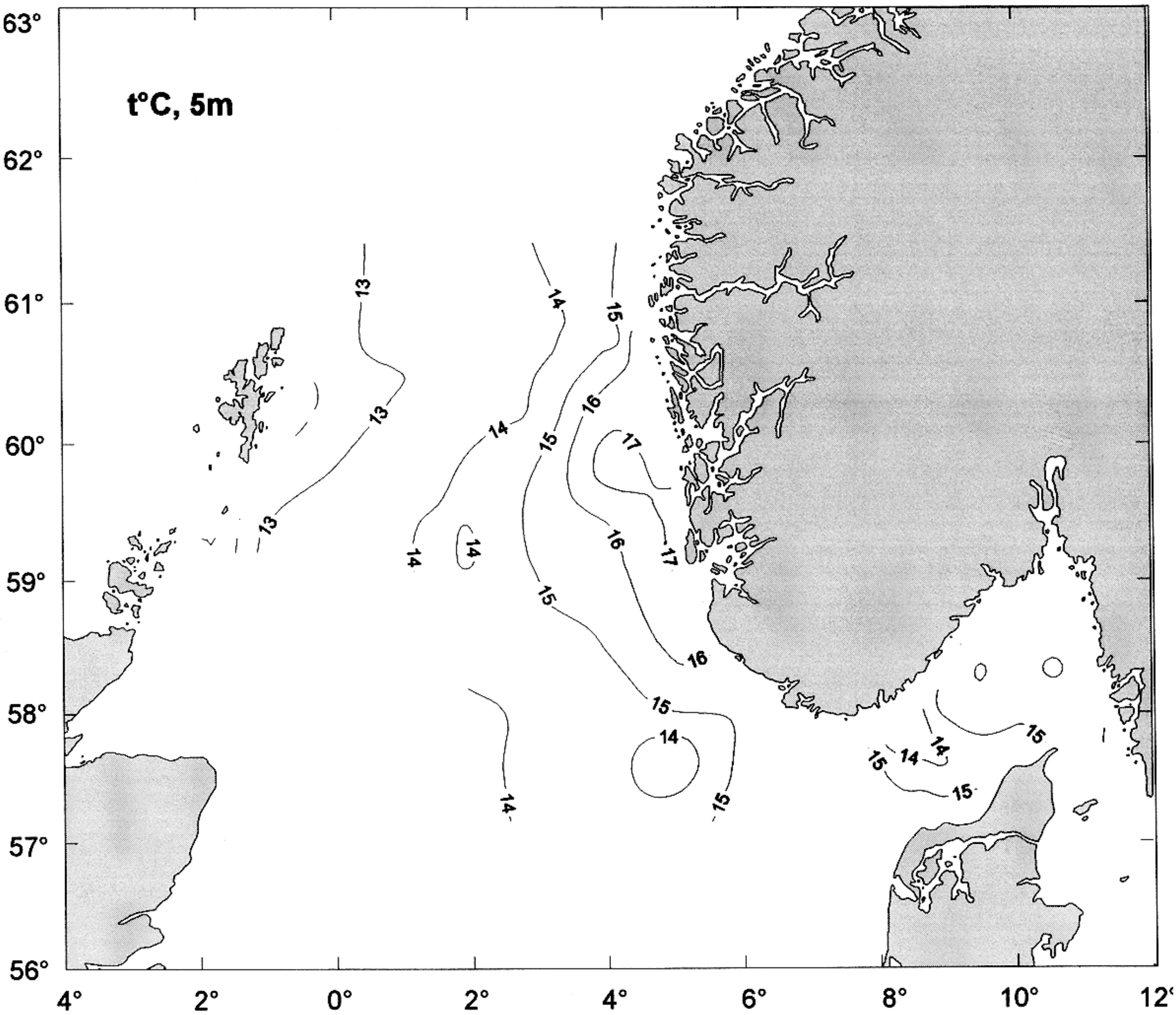


Figure 3a .Distribution of temperature in 5m, R/V G. O. Sars, 29 June - 18 July 1999

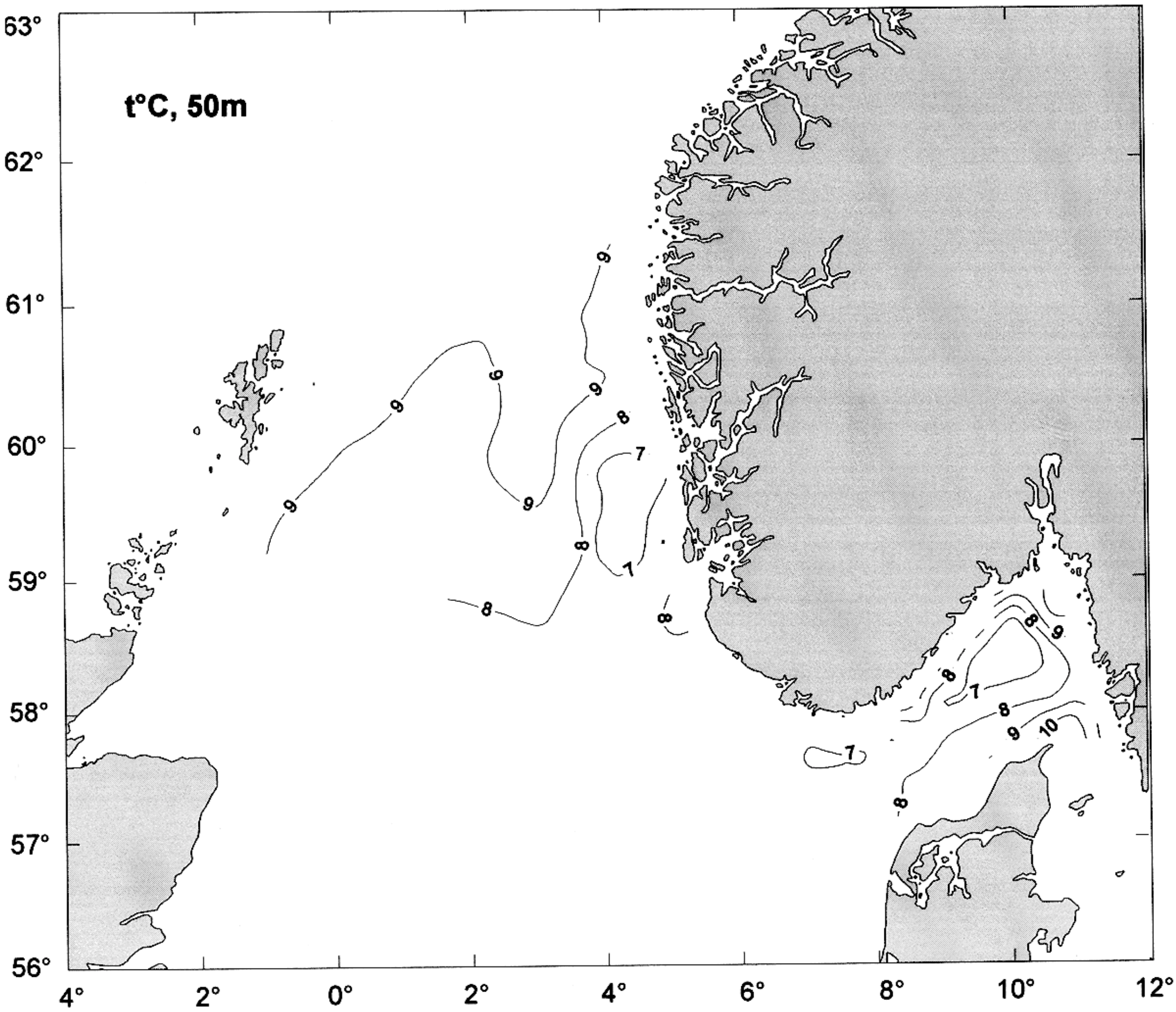


Figure 3b .Distribution of temperature in 50m, R/V G. O. Sars, 29 June - 18 July 1999

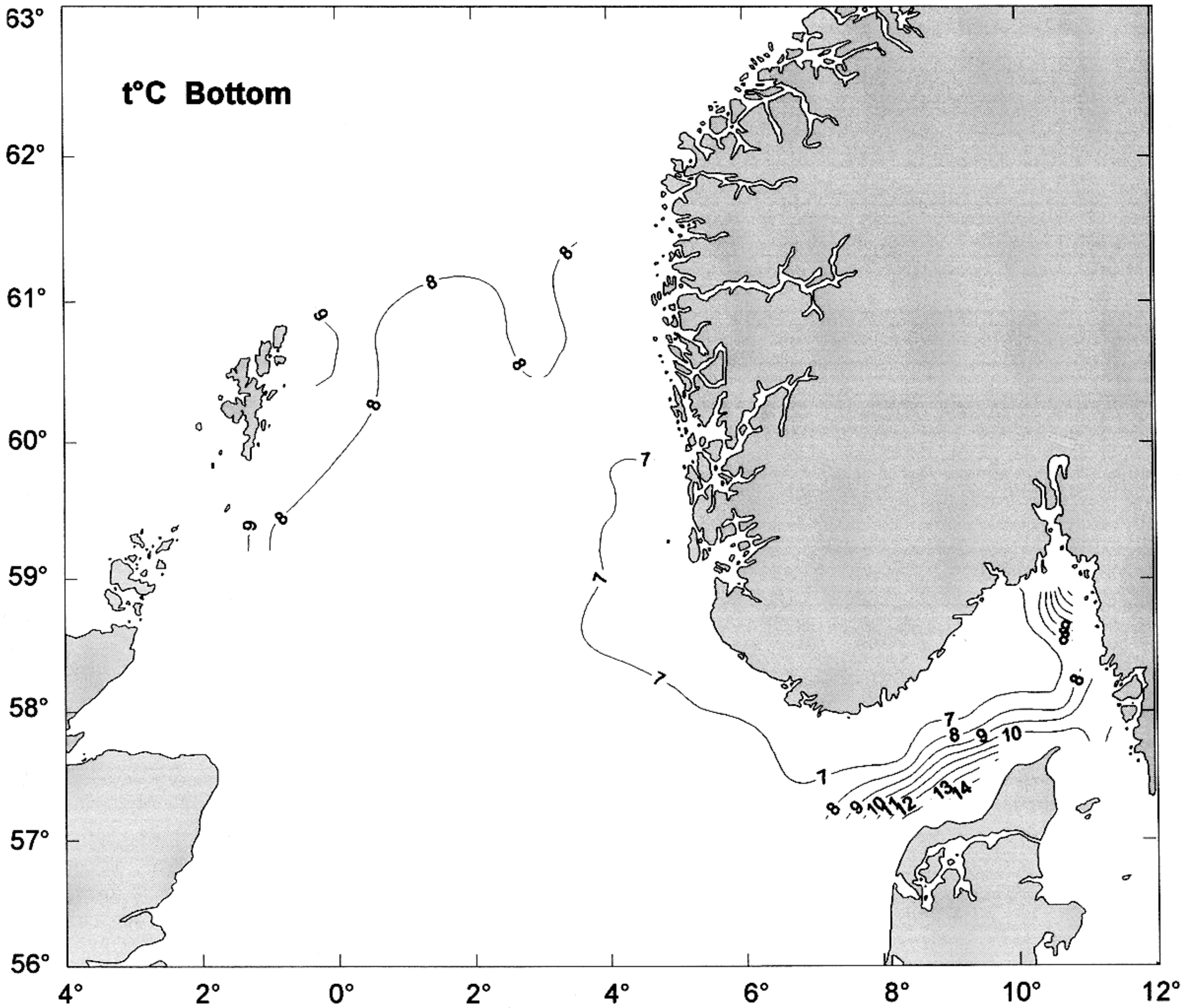


Figure 3c .Distribution of temperature at bottom, R/V G. O. Sars, 29 June - 18 July 1999

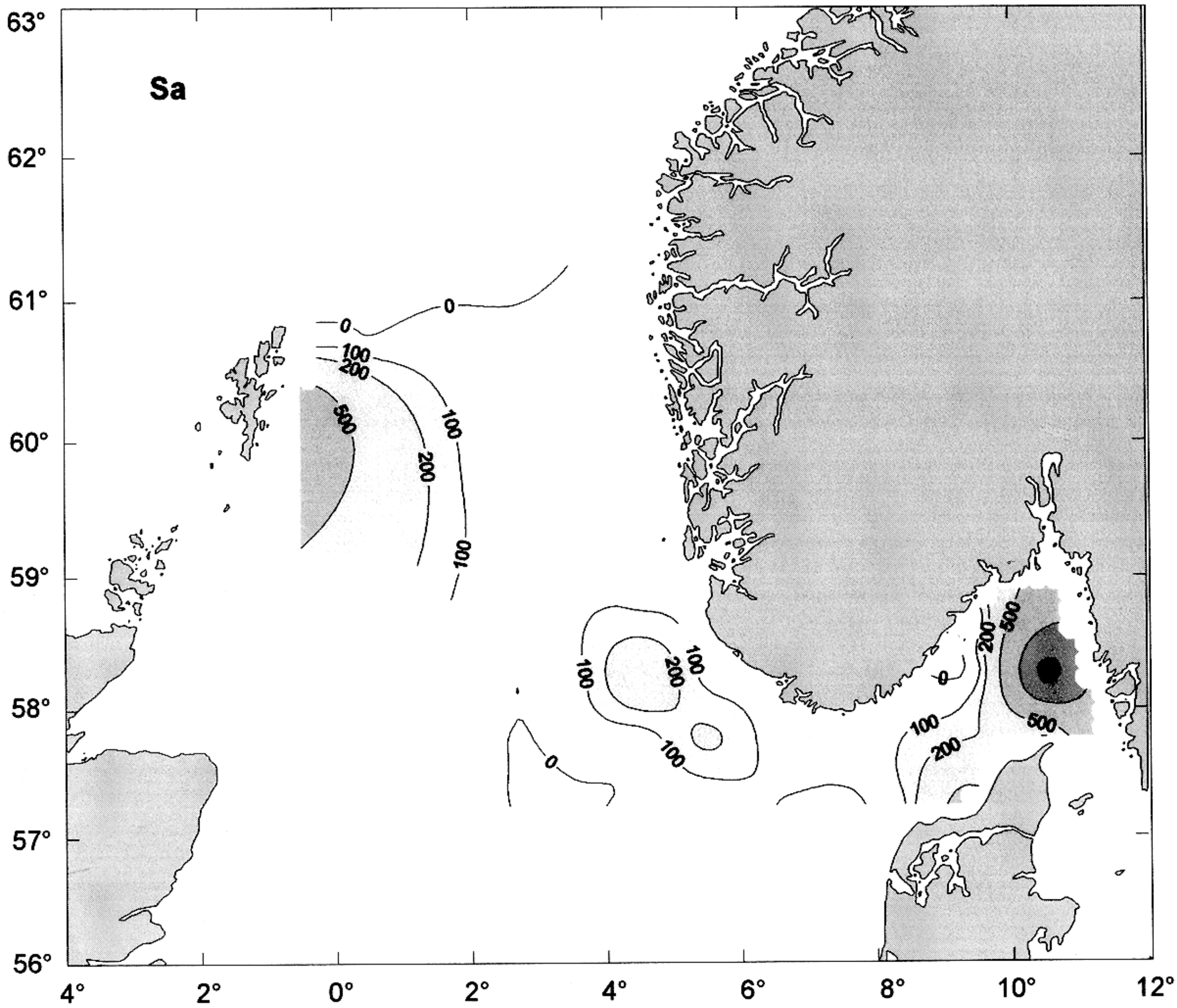


Figure 4 .The horizontal distribution of herring, R/V G. O. Sars, 29 June - 18 July 1999

APPENDIX 3

Survey report RV "Tridens"
21 June – 16 July 1999

Calibration - 22 June

On the 22th of June, an attempt to calibrate the echosounder and the transducers took place in the bay of Kristiansand. During the calibration procedure it turned out to be impossible to adjust the TS- and SV-gain in the transducer-menu of the EK500 echosounder. The Sa-values found during the calibration were 50% of the theoretical values. In addition, later on the way back to IJmuiden some other parameters in the EK500 menu were not adjustable. It was therefore concluded that the echosounder was damaged and that the calibration was a failure.

In the remaining part of the week the sounder was repaired. It was decided to calibrate sometime during the actual survey.

North Sea echo-survey 28 June - 16 July 1999

On 28/6 the Tridens headed for the position 58°10 N - 1°50 E. Here the survey was started in western direction on the next day. On the 1st of July Tridens cruised in the direction of Scapa flow where the calibration took place in the evening (58°56.71 N - 003°00.57 W). The weather conditions were bad due to a breeze from the northwest. Nevertheless there were no problems with the calibration of the 38kHz hull-mounted transducer. During the calibration of the towed body transducer, the copper sphere moved severely. As a result it was not possible to conduct a sv-calibration. Therefore the sv-correction factor has been derived from the ts-gain:

$$\text{sv-correction factor} = 10^{\frac{(TS_c - TS_m)}{10}}$$

Where TS_c is the targetstrength of the copper calibration sphere and TS_m value measured.

The sa-values were multiplied by this correction factor. The calculated correction factor was 0.98.

The R.V. Scotia arrived at night at Scapa Flow. It was appointed to conduct an intercalibration the next day southwest of the Orkney's. Both vessels sailed next to each other for 55 miles. Taking into account the amount of fish-schools seen, the length of this traject was considered long enough. It was concluded, after a preliminary analysis that the sa-values of both vessels were similar.

After the intercalibration, Tridens resumed the survey, sailing east-west transects and moving stepwise southwards. In the weekend of 4/7 and 5/7 it stayed in Aberdeen. During the next week, in which hardly any herring was encountered, large pieces of transect were sailed during night to save time. On 9/7 the cable-set of the towed body appeared to be damaged. The survey was temporarily conducted with the hull-mounted transducer. The weekend was spent in Edinburgh. At the start of the third survey week, a new cable set was mounted. During a check of the electrical cable to the towed body, it was found that two quadrants made connection. It was therefore decided to switch over to the hull-mounted transducer. During the same week Tridens received a Mayday of a small cutter which was about to sink and was obliged to set course to its position (small dent in the 56°55 transect). Tridens had to stay standby for two hours and witnessed a rescue operation on high sea. On 15/7 in the afternoon, the survey ended and Tridens set course to IJmuiden.

Methods

A SIMRAD EK500 system was used. The 38 kHz splitbeam transducer was mounted in a towed body. A hull-mounted transducer of the same type was used as a back-up in case of problems with the towed body transducer. Integration of the echo recordings was done by the BI500 post processing system. This system was also used to allocate sa-values to species.

Ship's speed was 12.5 knots (weather allowing) and the survey was going on from 4.00 to 21.00 UTC. During the hours of darkness, the survey was interrupted because results from previous surveys had shown that herring at this time of the day may rise close to the surface and may not be detected by the transducer. Due to lack of time however, in low density areas the survey was continued during dark until some kind of traces showed up. Trial fishing was done with a 2000 meshes pelagic trawl with a 20 mm cod end lining.

Figure 1 shows the survey track and the trawl stations.

During the survey 17 hauls were conducted, 10 samples of herring (484 specimens), 4 sprat samples (100 specimens) has been collected and 25 CTD-profiles were taken.

Results

Herring

The only herring observations of any importance were observed at the northern boundary of the survey-area in the 45xx ICES squares, consisting of adult herring as well as 1- and 2-ringers. As in previous years adult herring was found at the eastern part of the area in stratified water. The remaining part of the area was as good as empty, apart from some relatively old herring in *The Pit of Blyth* and *The Farne Deeps* (stratum D).

The hauls have been grouped in 4 strata (A-D, figure 2). Results on herring are presented in tables 3 and 4 and in figure 3. Distribution by length and age is presented in appendix 1.

Sprat

Some minor concentrations of sprat were found along the British coast. The hauls have been grouped in two strata (A and B, figure 2). Results on sprat are presented in table 5 and 6 and in figure 4.

Remarks

Norway pout and scrutinizing-problems

From the north down to 55°55 N (haul 11), a lot of hauls contained Norway pout. This species was generally not the most abundant species in the catch, but it was assumed that the catch did not reflect the real abundance of this small species because it may have escaped through the large meshes in the front part of the pelagic trawl. In the following hauls Norway pout was found mixed with herring: 1,5,6,8,9,10 and 11. The allocation of echo-traces to sa-values in the area covered by these hauls was extremely problematic since traces of Norway pout and herring are very similar, while the percentage of the two species in the catch is assumed to be not representative.

In the - as far as herring is concerned - empty area between 57°30 and 56° N, the estimations of the amount of herring per ICES square are very inaccurate. The estimations for squares 41xx, 42xx and 43xx in figure 3 could be over- or underestimated a number of times their own value. Fortunately, for the final results of the combined international survey the bias will be limited, because the absolute numbers a relatively low.

Bram Couperus IJmuiden, 12-2-2000

date and time: 1 July 1999,	position: off Kristiansand harbour 58°56.71N - 003°.00.57W
bottom depth: 30 m	wind: 6 BF (but in the shelter)
salinity: $34.7^{o}/_{oo}$	wave height: 0.5 m
water temperature: 12.1 °C (surface), 10.2 (20 m)	transducer: 38 kHz

Transceiver menu before calibration

pulse length: medium	bandwidth: wide
max. power: 2000 W	angle sensitivity: 21.9
2-way beam angle: -20.6	Sv transducer gain: 26.5
TS transducer gain: -26.5	3 dB beam width: 7.1
alongship offset: ?	athw. ship offset: ?
ping interval: 1.0	transmitter power: normal

standard target:	copper sphere, -33.6 dB
distance transducer - target:	20.4
TS values measured:	-33.8
new transducer gain:	26.4
new TS values measured:	-33.7
SA values measured:	5320
SA value calculated:	5347
default transducer gain:	26.5
correction factor:	1.01

Table 1b. Calibration report EK-500, 38 kHz transducer

- Hull mounted

Tridens 29 June - 15 July, 1999

date and time: 1 July 1999,	position: off Kristiansand harbour 58°56.71N - 003°.00.57W
bottom depth: 30 m	wind: 6 BF (but in the shelter)
salinity: $34.7^{o}/_{oo}$	wave height: 0.5 m
water temperature: 12.1 °C (surface)	transducer: 38 kHz

Transceiver menu before calibration

pulse length: medium	bandwidth: wide
max. power: 2000 W	angle sensitivity: 21.9
2-way beam angle: -20.6	Sv transducer gain: 26.5
TS transducer gain: -26.5	3 dB beam width: 7.1
alongship offset: ?	athw. ship offset: ?
ping interval: 1.0	transmitter power: normal

standard target: copper sphere, -33.6 dB

distance transducer - target: 9.6

TS values measured: -32.5

new transducer gain: 27.05

new TS values measured: -33.6

SA values measured: -

SA value calculated: 24976

default transducer gain: 26.5

correction factor: 0.79

Table 1a. **Calibration report EK-500, 38 kHz transducer**

- Towed body

Tridens 29 June - 15 July, 1999

table 2. **Trawl Station List**

Tridens 29-Jun - 15-Jul 1999 trawl catches in kg

haul no	date	time UTC	latitude(N)	longitude	E/W	depth meters	duration min.	herring	N. pout	other gadoids	mackerel	sprat	others	comments
1	29-Jun-99	13.40	58.10	001.33	E	100	70	210	450		2.5			
2	30-Jun-99	07.20	58.10	001.23	W	105	21	4800	1	7		0.1	0.2	
3	30-Jun-99	17.03	57.55	001.55	W	74	22	90				7.5		
4	02-Jul-99	14.45	58.01	002.18	W	51	15							sandeel in the meshes
5	05-Jul-99	08.45	57.55	001.18	E	90	20	18.1	3.3	0.3	17.4			jellyfish
6	05-Jul-99	13.15	57.40	001.41	E	85	28	15.3	105	0.6	5.1		1	
7	06-Jul-99	06.30	57.25	001.06	W	63	15		80	0.5		0.15	1.5	
8	06-Jul-99	16.55	57.11	001.45	E	92	65	220	136	3	35			
9	07-Jul-99	07.10	56.55	001.38	E	70	15	15	26.4	3		4.5		jellyfish
10	07-Jul-99	14.01	56.55	000.14	W	80	104	19	16	9.6	19.5		0.7	jellyfish
11	09-Jul-99	12.29	56.10	000.29	W	78	23	1.4	7	41	1	0.3	1.2	sandeel in the meshes/jellyfish
12	12-Jul-99	06.30	55.55	001.23	W	70	24	8			7.8	22		jellyfish (herring = 0 group!)
13	13-Jul-99	06.35	55.25	000.59	W	92	54	93	0.1	3.4		2.9		jellyfish
14	13-Jul-99	18.50	55.10	001.19	E	53	50	0.1		4.8			16.6	
15	14-Jul-99	13.33	55.10	000.43	E	70	47	0.1		320	5.7		16.2	
16	14-Jul-99	16.50	55.10	001.09	W	86	30	66	2.5	39		11.4	1	jellyfish
17	15-Jul-99	10.10	54.40	000.18	W	62	65	0.2		403			5.4	

table 3. Length distribution herring Tridens 29-Jun - 15-Jul 1999

length	haul 1	haul 2	haul 3	haul 4	haul 5	haul 6	haul 7	haul 8	haul 9	haul 10	haul 11	haul 12	haul 13	haul 14	haul 15	haul 16	haul 17
13.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.0	0.00	0.00	0.50	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.5	0.00	0.00	1.51	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16.0	0.00	0.00	1.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.45	0.00	0.00	0.00	0.00	0.00	0.00
16.5	0.00	0.00	4.02	0.00	0.00	0.00	0.00	0.00	0.00	0.73	6.45	0.00	0.00	0.00	0.00	0.00	0.00
17.0	0.00	0.00	4.52	0.00	0.00	0.00	0.00	0.00	0.00	2.19	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17.5	0.00	0.00	4.52	0.00	0.00	0.78	0.00	0.76	0.00	3.65	3.23	0.00	0.00	33.33	0.00	1.40	0.00
18.0	0.00	0.00	2.01	0.00	0.00	2.33	0.00	0.00	0.00	6.57	19.35	0.00	0.65	0.00	0.00	5.59	0.00
18.5	0.90	0.00	2.01	0.00	0.00	7.75	0.00	0.00	0.00	10.22	9.68	0.00	0.65	33.33	0.00	3.50	0.00
19.0	0.00	0.00	1.51	0.00	0.00	8.53	0.00	0.00	0.00	6.57	19.35	0.00	3.23	0.00	0.00	5.59	0.00
19.5	0.00	0.00	2.01	0.00	0.77	1.55	0.00	0.76	0.00	15.33	9.68	0.00	4.52	0.00	0.00	12.59	0.00
20.0	1.80	0.00	1.51	0.00	0.77	3.10	0.00	0.00	0.00	15.33	9.68	0.00	3.87	33.33	0.00	8.39	0.00
20.5	0.00	0.58	4.52	0.00	0.00	6.20	0.00	0.76	0.00	7.30	3.23	0.00	12.26	0.00	0.00	9.09	0.00
21.0	0.00	0.58	10.05	0.00	3.08	11.63	0.00	5.34	0.00	7.30	3.23	0.00	5.16	0.00	0.00	3.50	0.00
21.5	1.80	12.79	13.07	0.00	10.00	5.43	0.00	4.58	0.00	3.65	0.00	0.00	7.10	0.00	0.00	4.20	0.00
22.0	4.50	10.47	12.56	0.00	9.23	6.98	0.00	7.63	0.00	7.30	6.45	0.00	4.52	0.00	0.00	0.00	0.00
22.5	4.50	20.35	12.56	0.00	5.38	7.75	0.00	7.63	0.00	5.11	0.00	0.00	4.52	0.00	0.00	4.20	0.00
23.0	9.91	12.79	7.54	0.00	3.85	5.43	0.00	4.58	0.00	2.19	0.00	50.00	0.65	0.00	0.00	2.80	0.00
23.5	0.00	8.14	7.04	0.00	10.00	7.75	0.00	14.50	0.00	2.92	0.00	0.00	3.23	0.00	0.00	1.40	0.00
24.0	15.32	16.28	3.02	0.00	13.08	16.28	0.00	13.74	0.00	0.73	0.00	0.00	2.58	0.00	0.00	3.50	0.00
24.5	9.91	3.49	1.51	0.00	8.46	8.53	0.00	13.74	0.00	2.92	3.23	0.00	0.65	0.00	0.00	3.50	50.00
25.0	17.12	8.14	0.50	0.00	10.00	0.00	0.00	13.74	0.00	0.00	0.00	0.00	7.10	0.00	33.33	1.40	50.00
25.5	13.51	3.49	1.01	0.00	8.46	0.00	0.00	5.34	0.00	0.00	0.00	0.00	7.74	0.00	66.67	4.90	0.00
26.0	5.41	2.33	0.00	0.00	10.00	0.00	0.00	3.82	0.00	0.00	0.00	0.00	7.10	0.00	0.00	4.20	0.00
26.5	5.41	0.58	1.01	0.00	2.31	0.00	0.00	3.05	0.00	0.00	0.00	0.00	9.68	0.00	0.00	7.69	0.00
27.0	2.70	0.00	0.00	0.00	3.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.87	0.00	0.00	6.29	0.00
27.5	0.00	0.00	0.50	0.00	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	7.10	0.00	0.00	2.10	0.00
28.0	3.60	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.23	0.00	0.00	3.50	0.00
28.5	1.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.65	0.00	0.00	0.70	0.00
29.0	0.00	0.00	0.00	0.00	0.77	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
29.5	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	50.00	0.00	0.00	0.00	0.00	0.00
30.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
31.5	0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
32.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
mean length	24.67	23.17	21.11		23.92	21.76		23.67		20.16	18.98	26.50	23.56	18.67	25.33	22.39	24.75
TS mean length	-43.27	-43.81	-44.61		-43.53	-44.35		-43.63		-45.00	-45.52	-42.65	-43.66	-45.66	-43.04	-44.10	-43.24
mean weight	128.19	99.36	78.11		112.20	89.98		115.58		63.62	51.44		105.04			90.70	

table 4. Summarized results all sampling areas Herring - best estimate

Tridens 29-Jun - 15-Jul 1999

im = immature
ad = adult

summary all sampling areas	**numbers in millions**													
	autumn spawners													
	97im	96im	96ad	95im	95ad	94	93	92	91	90	89	88	<88	totals
A	368.8	195.7	402.7	0.0	154.2	9.7	0.8	3.6	0.0	0.0	0.4	0.0	0.0	1135.9
B	100.5	81.4	202.8	0.0	154.6	48.1	8.4	0.0	2.3	0.0	0.9	0.9	0.0	599.8
C	129.4	9.5	11.5	0.0	1.1	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	156.2
D	103.5	34.4	17.7	0.0	15.7	15.0	13.6	38.0	13.0	16.0	13.9	7.6	0.0	288.3
totals	702.2	321.0	634.6	0.0	325.6	77.6	22.7	41.6	15.2	16.0	15.2	8.5	0.0	2180.3

summary all sampling areas	**weight in '000 tons**													
	autumn spawners													
	97im	96im	96ad	95im	95ad	94	93	92	91	90	89	88	<88	totals
A	21.3	16.5	42.8	0.0	19.1	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	101.0
B	6.9	6.6	23.1	0.0	20.3	7.0	1.6	0.0	0.6	0.0	0.0	0.0	0.0	66.1
C	6.8	0.7	1.0	0.0	0.1	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.1
D	6.1	2.3	1.6	0.0	1.6	1.7	1.9	5.3	1.9	2.3	2.1	1.2	0.0	27.9
totals	41.1	26.0	68.5	0.0	41.1	10.6	3.5	5.3	2.5	2.3	2.1	1.2	0.0	204.1

table 5. Length distribution Sprat Tridens 29-Jun - 15-Jul 1999

length	haul 1	haul 2	haul 3	haul 4	haul 5	haul 6	haul 7	haul 8	haul 9	haul 10	haul 11	haul 12	haul 13	haul 14	haul 15	haul 16	haul 17
5.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8.0	0.00	0.00	0.00	0.00	0.00	0.00	8.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.23	0.00
8.5	0.00	0.00	0.00	0.00	0.00	0.00	20.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.61	0.00
9.0	0.00	0.00	9.39	0.00	0.00	0.00	12.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	11.29	0.00
9.5	0.00	0.00	28.18	0.00	0.00	0.00	12.00	0.00	0.00	0.00	0.00	0.00	6.90	0.00	0.00	8.06	0.00
10.0	0.00	0.00	39.23	0.00	0.00	0.00	28.00	0.00	0.00	0.00	0.00	0.00	16.09	0.00	0.00	16.13	0.00
10.5	0.00	0.00	17.13	0.00	0.00	0.00	8.00	0.00	0.00	0.00	0.00	0.00	21.84	0.00	0.00	11.29	0.00
11.0	0.00	0.00	2.76	0.00	0.00	0.00	8.00	0.00	0.00	0.00	0.00	0.00	14.94	0.00	0.00	17.74	0.00
11.5	0.00	0.00	0.55	0.00	0.00	0.00	4.00	0.00	0.00	0.00	0.00	0.00	17.24	0.00	0.00	6.45	0.00
12.0	0.00	0.00	1.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.05	0.00	0.00	9.68	0.00
12.5	0.00	0.00	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	8.05	0.00	0.00	6.45	0.00
13.0	0.00	0.00	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.30	0.00	0.00	8.06	0.00
13.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.45	0.00	0.00	0.00	0.00
14.0	0.00	0.00	0.55	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.15	0.00	0.00	0.00	0.00
14.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17.5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
mean length			9.96				9.54						11.08			10.69	
TS mean length			-51.02				-51.38						-50.12			-50.42	
mean weight			7.80				5.76						9.12			9.60	

table 6. Summarized results all sampling areas Sprat - best estimate

Tridens 29-Jun - 15-Jul 1999

im = immature
ad = adult

summary all sampling areas **numbers in millions**

	98im	98ad	97im	97ad	96	95	94	93						totals
A	83.7	224.7	0.0	29.7	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	339.1
B	55.4	294.6	0.0	321.2	15.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	687.0
totals	139.1	519.3	0.0	350.9	16.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1026.0

summary all sampling areas **weight in '000 tons**

	98im	98ad	97im	97ad	96	95	94	93						totals
A	0.4	1.5	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1
B	0.0	2.0	0.0	3.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5
totals	0.4	3.5	0.0	3.6	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	7.6

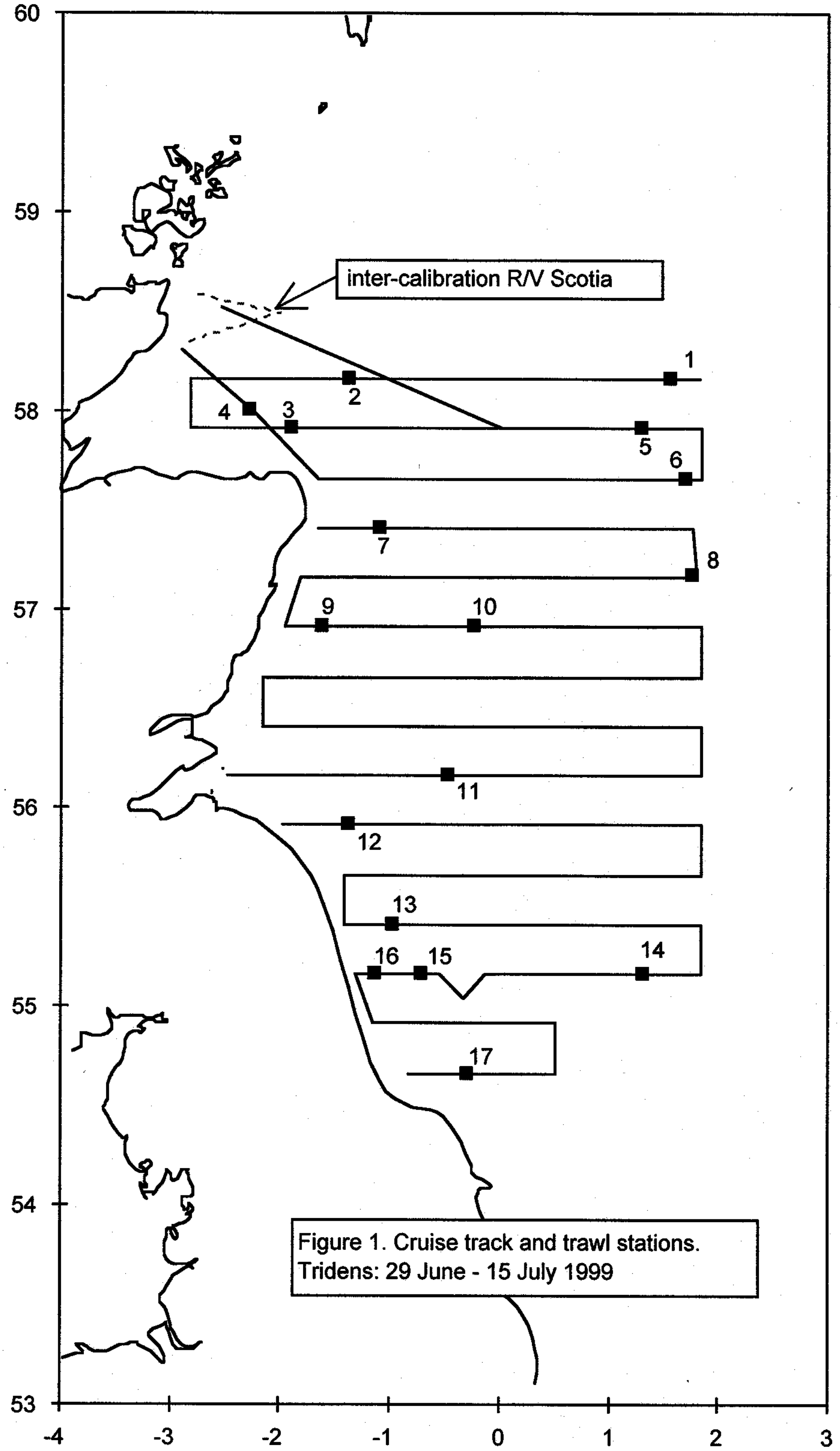


Figure 1. Cruise track and trawl stations.
Tridens: 29 June - 15 July 1999

North Sea echo survey
Tridens 1999

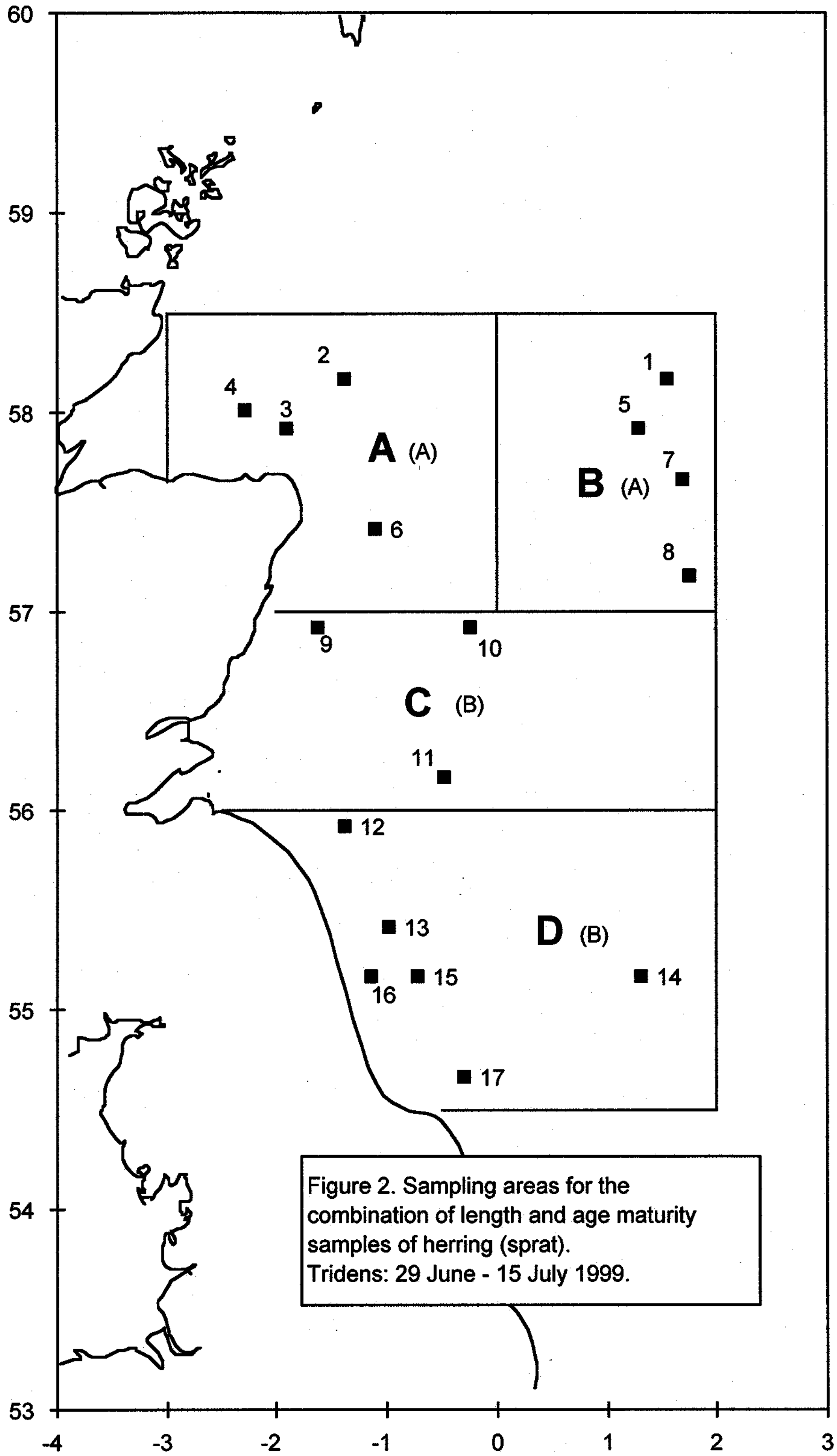
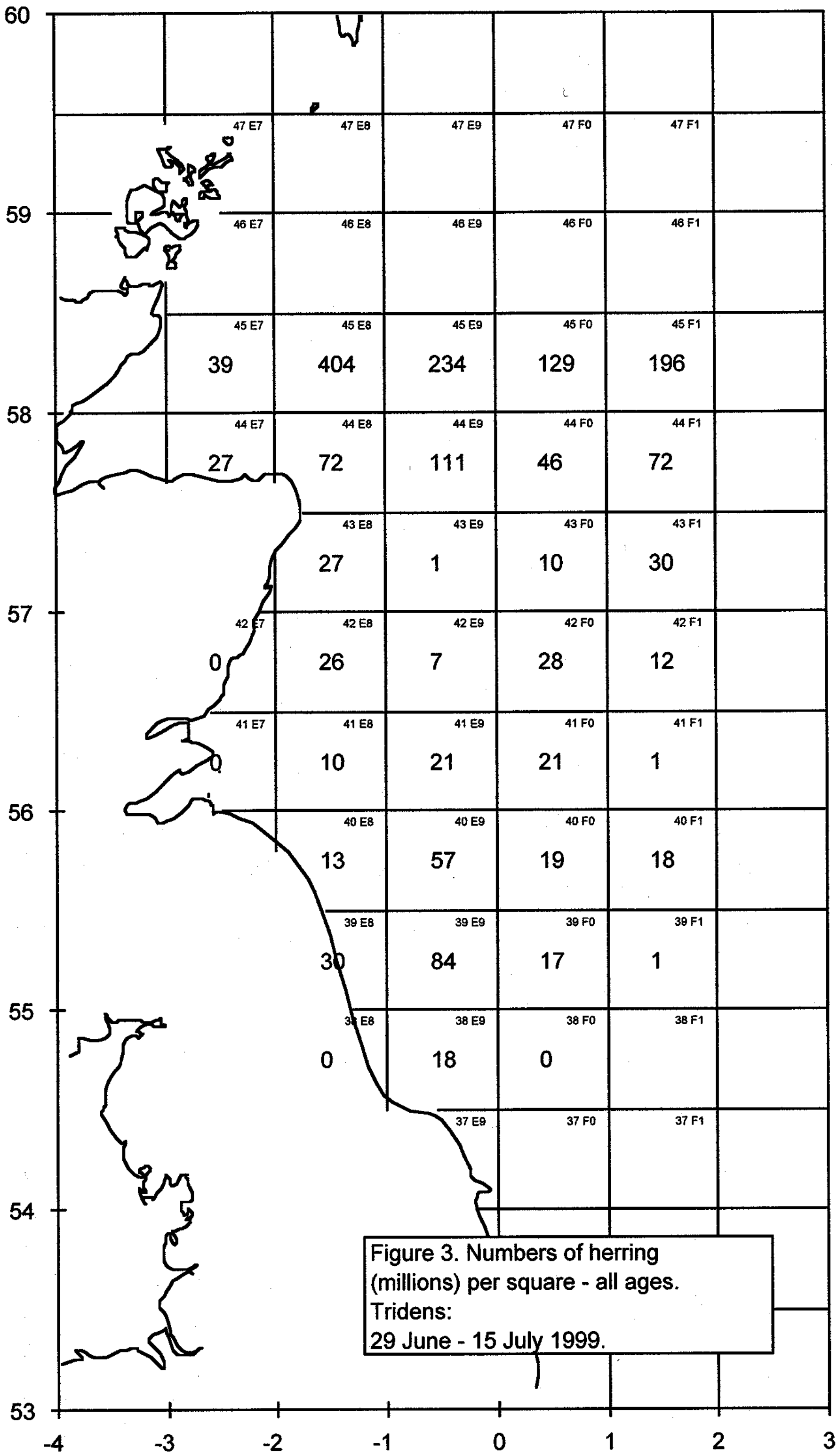


Figure 2. Sampling areas for the combination of length and age maturity samples of herring (sprat).
Tridens: 29 June - 15 July 1999.

North Sea echo survey
Tridens 1999



North Sea echo survey
Tridens 1999

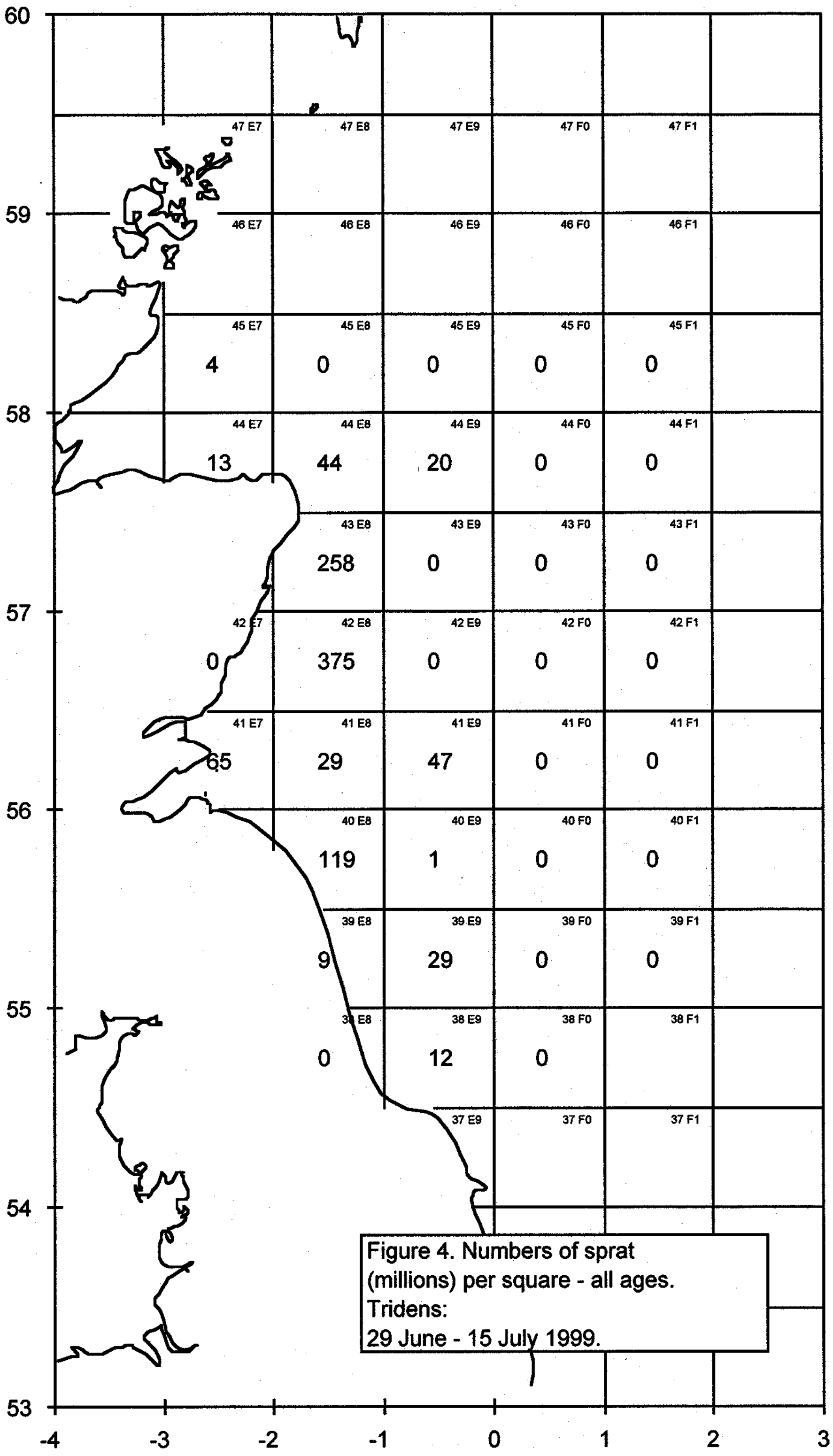


Figure 4. Numbers of sprat (millions) per square - all ages. Tridens: 29 June - 15 July 1999.

North Sea echo survey
Tridens 1999

Tridens 29-Jun - 15-Jul 1999 **sampling area A** im = immature

ad = adult

Age/length composition by sampling area — Herring - best estimate

	autumn spawners													
length	97im	96im	96ad	95im	95ad	94	93	92	91	90	89	88	<88	totals
13.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
15.5	2	0	0	0	0	0	0	0	0	0	0	0	0	2
16.0	2	0	0	0	0	0	0	0	0	0	0	0	0	2
16.5	3	0	0	0	0	0	0	0	0	0	0	0	0	3
17.0	2	0	0	0	0	0	0	0	0	0	0	0	0	2
17.5	2	0	0	0	0	0	0	0	0	0	0	0	0	2
18.0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
18.5	1	0	0	0	0	0	0	0	0	0	0	0	0	1
19.0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
19.5	1	0	0	0	0	0	0	0	0	0	0	0	0	1
20.0	2	0	0	0	0	0	0	0	0	0	0	0	0	2
20.5	3	0	0	0	0	0	0	0	0	0	0	0	0	3
21.0	7	1	0	0	0	0	0	0	0	0	0	0	0	8
21.5	6	2	3	0	0	0	0	0	0	0	0	0	0	11
22.0	3	7	3	0	0	0	0	0	0	0	0	0	0	13
22.5	2	4	5	0	0	0	0	0	0	0	0	0	0	11
23.0	0	2	8	0	0	0	0	0	0	0	0	0	0	10
23.5	0	0	8	0	1	0	0	0	0	0	0	0	0	9
24.0	0	0	2	0	7	0	0	0	0	0	0	0	0	9
24.5	0	0	3	0	2	0	0	0	0	0	0	0	0	5
25.0	0	0	2	0	3	0	0	0	0	0	0	0	0	5
25.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26.0	0	0	1	0	1	0	0	0	0	0	0	0	0	2
26.5	0	0	1	0	0	1	0	0	0	0	0	0	0	2
27.0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
27.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
millions	368.8	195.7	402.7	0.0	154.2	9.7	0.8	3.6	0.0	0.0	0.4	0.0	0.0	1135.9
mean w	57.8	84.3	106.3		123.7	137.0								
000 tons	21.3	16.5	42.8	0.0	19.1	1.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	101.0

Tridens 29-Jun - 15-Jul 1999 **sampling area B** im = immature
ad = adult

Age/length composition by sampling area Herring - best estimate

	autumn spawners													
length	97im	96im	96ad	95im	95ad	94	93	92	91	90	89	88	<88	totals
13.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.0	2	0	0	0	0	0	0	0	0	0	0	0	0	2
18.5	3	0	0	0	0	0	0	0	0	0	0	0	0	3
19.0	3	1	0	0	0	0	0	0	0	0	0	0	0	4
19.5	2	0	0	0	0	0	0	0	0	0	0	0	0	2
20.0	3	1	0	0	0	0	0	0	0	0	0	0	0	4
20.5	3	0	0	0	0	0	0	0	0	0	0	0	0	3
21.0	5	4	0	0	0	0	0	0	0	0	0	0	0	9
21.5	3	7	2	0	0	0	0	0	0	0	0	0	0	12
22.0	2	6	3	0	0	0	0	0	0	0	0	0	0	11
22.5	5	7	3	0	0	0	0	0	0	0	0	0	0	15
23.0	2	1	10	0	0	0	0	0	0	0	0	0	0	13
23.5	0	0	13	0	5	0	0	0	0	0	0	0	0	18
24.0	0	0	14	0	9	0	0	0	0	0	0	0	0	23
24.5	0	0	8	0	9	4	0	0	0	0	0	0	0	21
25.0	0	0	7	0	12	4	0	0	0	0	0	0	0	23
25.5	0	0	4	0	7	2	0	0	0	0	0	0	0	13
26.0	0	0	2	0	6	4	0	0	0	0	0	0	0	12
26.5	0	0	1	0	1	3	0	0	0	0	0	0	0	5
27.0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
27.5	0	0	0	0	2	1	2	0	0	0	0	0	0	5
28.0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
28.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29.0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
29.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31.5	0	0	0	0	0	0	0	0	1	0	0	0	0	1
32.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
millions	100.5	81.4	202.8	0.0	154.6	48.1	8.4	0.0	2.3	0.0	0.9	0.9	0.0	599.8
mean w	68.5	80.6	114.0		131.1	145.9	187.8		287.0					
000 tons	6.9	6.6	23.1	0.0	20.3	7.0	1.6	0.0	0.6	0.0	0.0	0.0	0.0	66.1

Tridens 29-Jun - 15-Jul 1999 **sampling area C** im = immature

ad = adult

Age/length composition by sampling area — Herring - best estimate

length	autumn spawners 97im	96im	96ad	95im	95ad	94	93	92	91	90	89	88	<88	totals
13.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16.0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
16.5	3	0	0	0	0	0	0	0	0	0	0	0	0	3
17.0	2	0	0	0	0	0	0	0	0	0	0	0	0	2
17.5	2	0	0	0	0	0	0	0	0	0	0	0	0	2
18.0	7	0	0	0	0	0	0	0	0	0	0	0	0	7
18.5	5	0	0	0	0	0	0	0	0	0	0	0	0	5
19.0	6	0	0	0	0	0	0	0	0	0	0	0	0	6
19.5	7	0	0	0	0	0	0	0	0	0	0	0	0	7
20.0	14	1	0	0	0	0	0	0	0	0	0	0	0	15
20.5	7	0	0	0	0	0	0	0	0	0	0	0	0	7
21.0	1	2	0	0	0	0	0	0	0	0	0	0	0	3
21.5	1	0	3	0	0	0	0	0	0	0	0	0	0	4
22.0	2	1	1	0	0	0	0	0	0	0	0	0	0	4
22.5	1	0	3	0	1	0	0	0	0	0	0	0	0	5
23.0	0	0	2	0	0	0	0	0	0	0	0	0	0	2
23.5	0	0	1	0	0	0	0	0	0	0	0	0	0	1
24.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24.5	0	0	0	0	0	1	0	0	0	0	0	0	0	1
25.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
26.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
28.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
29.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
millions	129.4	9.5	11.5	0.0	1.1	4.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	156.2
mean w	52.6	69.3	88.3		95.0	110.0								
000 tons	6.8	0.7	1.0	0.0	0.1	0.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	9.1

Tridens 29-Jun - 15-Jul 1999 **sampling area D** im = immature
ad = adult

Age/length composition by sampling area Herring - best estimate

	autumn spawners													
length	97im	96im	96ad	95im	95ad	94	93	92	91	90	89	88	<88	totals
13.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17.5	1	0	0	0	0	0	0	0	0	0	0	0	0	1
18.0	3	0	0	0	0	0	0	0	0	0	0	0	0	3
18.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19.0	3	1	0	0	0	0	0	0	0	0	0	0	0	4
19.5	5	1	0	0	0	0	0	0	0	0	0	0	0	6
20.0	8	1	0	0	0	0	0	0	0	0	0	0	0	9
20.5	7	4	0	0	0	0	0	0	0	0	0	0	0	11
21.0	4	2	0	0	0	0	0	0	0	0	0	0	0	6
21.5	2	2	0	0	0	0	0	0	0	0	0	0	0	4
22.0	1	0	2	0	0	0	0	0	0	0	0	0	0	3
22.5	1	0	4	0	0	0	0	0	0	0	0	0	0	5
23.0	0	1	0	0	2	0	0	0	0	0	0	0	0	3
23.5	0	0	1	0	1	0	0	0	0	0	0	0	0	2
24.0	0	0	0	0	2	1	0	0	0	0	0	0	0	3
24.5	0	0	0	0	0	2	0	0	0	0	0	0	0	2
25.0	0	0	0	0	0	0	1	1	0	0	0	0	0	2
25.5	0	0	0	0	0	1	0	2	0	0	0	0	0	3
26.0	0	0	0	0	1	0	1	2	1	0	0	0	0	5
26.5	0	0	0	0	0	0	2	2	2	3	2	1	0	12
27.0	0	0	0	0	0	0	0	0	2	3	1	0	0	6
27.5	0	0	0	0	0	0	0	1	0	0	1	0	0	2
28.0	0	0	0	0	0	0	0	1	0	1	0	2	0	4
28.5	0	0	0	0	0	0	0	0	1	0	1	1	0	3
29.0	0	0	0	0	0	0	0	0	0	0	0	0	1	1
29.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
31.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
32.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
millions	103.5	34.4	17.7	0.0	15.7	15.0	13.6	38.0	13.0	16.0	13.9	7.6	0.0	288.3
mean w	58.9	67.1	89.4		103.0	116.0	140.3	138.3	143.5	142.9	151.6	154.5	169.0	
000 tons	6.1	2.3	1.6	0.0	1.6	1.7	1.9	5.3	1.9	2.3	2.1	1.2	0.0	27.9

Tridens 29-Jun - 15-Jul 1999 **sampling area A** im = immature
ad = adult

Age/length composition by sampling area Sprat - best estimate

length	98im	98ad	97im	97ad	96	95	94	93						totals
5.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9.0	2	0	0	0	0	0	0	0	0	0	0	0	0	2
9.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10.0	0	4	0	0	0	0	0	0	0	0	0	0	0	4
10.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11.0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
11.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13.0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
13.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
millions	83.7	224.7	0.0	29.7	0.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	339.1
mean w	4.3	6.5		8.7	17.0									
000 tons	0.4	1.5	0.0	0.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1

Tridens 29-Jun - 15-Jul 1999 **sampling area B** im = immature
ad = adult

Age/length composition by sampling area Sprat - best estimate

length	98im	98ad	97im	97ad	96	95	94	93						totals
5.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9.5	0	1	0	0	0	0	0	0	0	0	0	0	0	1
10.0	0	2	0	0	0	0	0	0	0	0	0	0	0	2
10.5	0	2	0	0	0	0	0	0	0	0	0	0	0	2
11.0	0	1	0	5	0	0	0	0	0	0	0	0	0	6
11.5	0	0	0	3	0	0	0	0	0	0	0	0	0	3
12.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12.5	0	0	0	1	0	0	0	0	0	0	0	0	0	1
13.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14.0	0	0	0	0	1	0	0	0	0	0	0	0	0	1
14.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
millions	55.4	294.6	0.0	321.2	15.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	687.0
mean w		6.8		10.3	13.3									
000 tons	0.0	2.0	0.0	3.3	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.5

APPENDIX 4

Survey report FRV "SCOTIA"
1 – 24 July 1999

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Methods

The acoustic survey on FRV *Scotia* was carried out using a Simrad EK500 38 kHz sounder echo-integrator with transducer mounted on the drop keel. Further data analysis was carried out using Echoview software and Marine Lab Analysis systems. The survey track (Fig.2) was selected to cover the area in one levels of sampling intensity based on the limits of herring densities found in previous years, a transect spacing of 15 nautical miles was used in most parts of the area with the exception of a section over the 80 miles holes east of Orkney and areas both east and west of Shetland where short additional transects were carried out at 7.5 nm spacing. On the administrative boundaries of 1 E and 4 W the ends of the tracks were positioned at 2 the actual track spacing from the area boundary, giving equal track length in any rectangle within the area. The between-track data could then be included in the data analysis. Additional work with Autosub 1 and autonomous submarine were carried out during the survey. The results are reported in Fernandes et al (1999). Transects at the coast and shelf break were continued to the limits of the stock and the transect ends omitted from the analysis. The origin of the survey grid was selected randomly with a 15 nm interval the track was then laid out with systematic spacing from the random origin. Where 7.5 nm spacing was used the same random origin was used.

Trawl hauls (positions shown in Fig. 2) were carried out during the survey on the denser echo traces. Each haul was sampled for length, age, maturity and weight of individual herring. Between 250 and 700 fish were measured at 0.5 cm intervals from each haul. Otoliths were collected with five per 0.5 cm class below 27 cm, and ten per 0.5 cm class for 27.5 cm and above. The same fish were sampled for weight including and excluding gonads, sex, maturity, stomach contents and macroscopic evidence of Ichthyophonus infection.

Data from the echo integrator were summed over quarter hour periods (2.5 n.mi. at 10 knots). Echo integrator data was collected from 11 m below the surface (transducer at 8 m depth) to 1 m above the seabed. The data were divided into four categories, by visual inspection of the echo-sounder paper record and the integrator cumulative output; "herring traces", "probably herring traces" and "probably not herring traces" all below 50 m and shallow herring schools above 50 m. For the 1999 survey 77% of the stock by number was attributable to the "herring traces" and 19% to the "probably herring traces" and 4% to the shallow herring schools. The third category which gave 14% of total herring was attributable to particularly to Norway pout in the south and east of the area and some mixtures of haddock and whiting. In most cases the fish species in the area were either easily recognisable from the echo-sounder record or did not appear to occupy the same area as the herring. Some damage to fishing gear occurred in the second part of the cruise and trawling was reduced, giving some uncertainty in the area to the North of Orkney Herring were found almost exclusively in waters where the seabed was deeper than 100 m, except for the area east of Orkney.

One calibration was carried out the transducer and cable systems used during the survey. Agreement between calibration this year and last year on the same systems was better than 0.01 dB. The second calibration on the last day of the survey had to be abandoned due to bad weather. To calculate integrator conversion factors the target strength of herring was estimated using the TS/length relationship recommended by the acoustic survey planning group (Anon, 1982):

$$TS = 20\log_{10}L - 71.2 \text{ dB per individual}$$

The weight of fish at length was determined by weighing fish from each trawl haul which contained more than 200 herring. Lengths were recorded by 0.5 cm intervals to the nearest 0.5 cm below. The resulting weight-length relationship for herring was:

$$W = 2.257\ 10^{-3}\ L^{3.400} \text{ g L measured in cm}$$

Survey Results

A total of 38 trawl hauls were carried out (Fig. 2), the results of these are shown in Table 1. 27 hauls with significant numbers of herring were used to define four survey sub areas (Fig. 3). The mean length keys, mean lengths, weights and target strengths for each haul and for each sub area are shown in Table 2. A total of 2,694 otoliths were taken to establish 4 age length keys, one per area (Figure 3). The numbers and biomass of fish by quarter ICES statistical rectangle are shown in Figure 2. A total estimate of 7,635 million herring or 1,379 thousand tonnes was calculated for the survey area. 1,263 thousand tonnes of these were mature. Herring were found mostly in water with the seabed deeper than 100 m, with traces being found in waters with depths of up to 200 m. The survey was continued to 250 m depth for most of the western and northern edge between 0 and 4 W. Herring were generally found in similar water depths and location to 1998 however, the distributions were more northerly with less herring found west of Shetland and Orkney. The fish traces were continuous in character similar to 1998 more mixed in size but in most case quite separate from other species. Table 3 shows the estimated herring numbers mean lengths weights and biomass and percentage mature by sub area and by age class.

In addition to the 1,379 thousand tonnes of herring, approximately 191 thousand tonnes of other fish species were observed in mid water in similar depths and conditions. Examination of the catch by species (Table 1) shows the difficulty of allocating this between species so this has not been attempted. The dominant part must be considered to be Norway pout with some haddock, mackerel and whiting. The proportions of mature 2 ring and 3 ring herring were estimated at 71% and 91% respectively. This is a lower proportion for 2 ring mature than those found in 1998. Proportion of 3 ring mature was lower than the long term mean by about 4 %. There is again evidence of icthyophonus in the population. The general lower than last to last year however, some 2 ring fish were found to be infected. Twenty five out of 2,694 fish examined were found to be infected compared with thirty of the 3,600 herring examined in 1998. The age structured infection rates are shown below.

Age/Maturity	1	2	3	4	5	6	7	8	9
% Infected	0.0%	1.1%	0.9%	0.7%	0.6%	1.5%	1.8%	0.0%	0.0%

Sprat

Only one haul gave any sprats and effectively no sprat were found on the survey

Table 1 Species composition by haul FRV Scotia 1-24 July 1999

Trawl shooting position						Estimated Raised Numbers Caught by species												Sample	
No	Date	Time	Latitude	Longitude	depth	Herring	Mackerel	Sprat	NPout	Bl	Haddoc	Whiting	Argentin	L sole	G gurnard	C	T minutus	(kg)	
275	2/7/99	21:20	58 04.20N	001 29.20W	50														O grp Pout meshed
276	3/7/99	06:00	58 04.03N	000 42.36W	104	14160	30												
277	3/7/99	17:55	58 11.00N	361 29.84E	105	460			12		42	1							
278	4/7/99	09:55	58 19.70N	001 39.90W	114	1800			25		20	35							Omm 5
279	5/7/99	04:29	58 33.86N	000 43.52W	131	2190	180		415		10								
280	5/7/99	08:05	58 33.80N	000 02.90W	100														O grp Pout meshed
281	6/7/99	06:05	58 49.00N	360 01.08E	130	2030	5		245			5							
282	6/7/99	12:28	58 49.13N	001 18.83W	112	3698	8		1238			15							
283	7/7/99	05:07	59 03.93N	000 54.53W	133	12175			4900		275	75	25					70	
284	7/7/99	21:20	59 19.00N	360 26.03E	132	4392	17		125		8	8							
285	8/7/99	05:55	59 11.85N	000 31.52W	140	27540			1620			180							
286	8/7/99	14:20	59 25.53N	360 00.13E	136	13354			1716			22						106	
287	8/7/99	21:10	59 19.00N	001 15.60W	111	1725	21		141		156	117	27	12	9	3		98	
288	9/7/99	04:12	59 19.01N	001 53.21W	104														O grp Pout meshed
289	9/7/99	11:21	59 34.46N	001 34.20W	80														O grp Pout meshed
290	9/7/99	13:30	59 39.94N	001 11.13W	113	1440	69		307		75	83	5	3	3	3	3		
291	10/7/99	09:35	59 48.80N	360 17.00E	124	15880			1400										
292	11/7/99	04:10	59 58.31N	001 08.24W	94														O grp Pout meshed
293	11/7/99	07:00	60 03.96N	000 53.42W	105	85	8		93		42	13	1					32	3 Sebasties,1 Scad
294	13/7/99	13:08	60 11.97N	000 21.78W	127	21			250		4		1						1 Hake
295	13/7/99	15:44	60 11.77N	000 12.48W	137	5	15		262	1	8	1							1 Scad 1 Cod ! Saithe
296	13/7/99	21:00	60 26.90N	000 37.30W	130	1647			213		10								
297	14/7/99	04:00	60 34.11N	000 30.76W	144	1587			200				7						
298	14/7/99	08:55	60 33.90N	360 09.60E	135				3450		5		15						
299	14/7/99	11:53	60 33.93N	360 34.15E	143	23500	50		####		50							96	
300	15/7/99	04:06	60 49.01N	360 01.33E	155	12525	75												
301	15/7/99	09:10	60 41.90N	000 31.70W	128	701	2		174		15	2	6						
302	16/7/99	08:49	61 03.19N	361 15.15E	148	285	4		1691	787								200	
303	17/7/99	06:03	61 19.04N	000 00.34W	170	1005	2		492		1	16							
304	17/7/99	21:00	60 56.32N	001 00.19W	104	332	26												1 Scad 7 Cod
305	18/7/99	15:46	60 39.96N	001 35.68W	106	5													
306	18/7/99	20:45	60 40.06N	002 14.02W	137	555	76											102	
307	19/7/99	08:26	60 31.94N	002 08.43W	140	2905	5												
308	19/7/99	14:00	60 18.98N	002 18.91W	122	767	42												
309	20/7/99	07:49	60 04.16N	002 10.36W	95		4					2							O grp Pout meshed
310	21/7/99	15:21	59 26.55N	003 37.45W	165	890													
311	22/7/99	05:10	59 18.95N	003 25.39W	115	591	1				1								8 Spurdog
312	22/7/99	13:55	59 07.00N	003 53.34W	107	3393	53	7											
313	23/7/99	06:46	58 59.39N	003 59.34W	60														O grp Pout meshed

Table 2 Length Frequency distribution, mean length, mean weight, and target strength by trawl and by area (figure 2) FRV Scotia 1-24 July 1999

length/trawl	278	mean	281	285	mean	276	277	279	282	283	287	290	mean	284	286	291	296	297	299	300	301	302	303	304	306	307	308	310	311	312	mean
17.5							0.2						0.0																		
18.0							0.2						0.0																		
18.5																															
19.0	0.3	0.3					0.2						0.0																		
19.5	0.3	0.3					0.4						0.1																		
20.0	1.1	1.1																											0.2		0.0
20.5	1.9	1.9					0.4		0.2				0.1																		
21.0	10.8	10.8					0.2		0.2				0.1																		
21.5	15.6	15.6				0.2	0.9		0.6	0.2	1.2	0.7	0.6																		
22.0	24.4	24.4	0.7		0.4	3.6	2.2	2.7	4.1		4.7	1.7	2.7				0.2												0.2		0.0
22.5	15.0	15.0				5.1	4.8	5.9	6.1	1.0	5.4	2.4	4.4								0.2										0.0
23.0	14.7	14.7	0.2	0.4	0.3	10.2	7.0	6.6	10.8	4.9	7.7	4.4	7.4				0.4				0.4						0.2		0.2	0.2	0.1
23.5	7.8	7.8	0.5	0.7	0.6	10.8	8.3	10.7	11.2	8.4	11.1	6.3	9.5				1.6				1.3			0.6				0.2	0.9		0.3
24.0	3.3	3.3	3.0	4.6	3.8	19.1	10.9	17.6	17.6	15.2	13.9	13.0	15.3	0.2	0.8	1.0	2.2	0.2		0.2	2.8			0.6				0.4	1.8	0.2	0.6
24.5	1.7	1.7	8.1	10.9	9.5	16.9	11.7	16.9	16.6	18.5	17.4	14.4	16.1	2.8	5.3	3.3	3.0	0.8		0.2	4.5			3.3		0.3	2.6	0.9	1.1	0.6	1.7
25.0	1.9	1.9	14.0	22.2	18.1	13.8	13.5	16.4	16.4	23.4	15.0	22.0	17.2	8.2	9.2	6.8	5.3	2.5	0.4	0.8	5.6			4.5	0.2	0.2	5.0	0.9	2.5	3.1	3.3
25.5	0.3	0.3	15.5	16.8	16.1	8.5	8.5	10.7	6.9	12.3	10.1	11.7	9.8	11.8	11.9	13.4	5.7	3.6	1.7	6.0	6.9			5.1	0.2	0.7	8.9	3.7	6.5	8.8	5.6
26.0	0.3	0.3	20.7	18.3	19.5	5.7	10.7	7.8	5.1	10.5	8.7	12.4	8.7	15.7	19.4	17.6	9.7	7.8	9.8	9.6	9.6	4.9		6.3	3.6	3.4	15.2	6.4	11.1	14.9	9.7
26.5	0.6	0.6	13.1	10.9	12.0	3.0	6.5	2.5	3.4	3.9	2.3	5.9	3.9	14.4	14.7	17.4	10.7	9.5	13.6	12.2	12.4	9.5	1.9	6.9	7.0	8.3	16.3	7.7	13.5	11.8	11.0
27.0			9.9	9.2	9.5	2.1	4.8	0.5	0.4	1.0	0.7	2.6	1.7	14.0	12.4	17.6	12.3	16.6	21.9	20.6	14.1	11.6	7.2	9.6	13.5	12.7	18.5	11.6	15.3	16.7	14.5
27.5			3.7	2.6	3.2	0.6	3.7	1.1	0.2	0.6	1.0	1.5	1.3	8.9	9.1	10.1	10.3	11.6	14.5	15.8	11.6	8.8	10.9	8.4	14.7	12.2	10.7	12.0	12.6	11.0	11.4
28.0			4.4	2.0	3.2		2.2	0.2	0.2		0.5		0.4	6.3	7.4	6.8	8.3	13.4	14.5	12.8	10.7	12.6	16.4	9.6	13.5	13.8	7.4	12.2	10.8	11.8	11.1
28.5			1.2	0.4	0.8	0.2	1.1	0.2			0.3	0.4	0.3	5.1	1.5	2.3	6.9	10.7	8.3	7.2	4.9	8.1	14.1	8.1	10.8	8.8	2.2	8.4	6.1	7.7	7.1
29.0			2.0	0.2	1.1	0.2	0.4					0.2	0.1	1.5	2.0	0.8	5.1	3.2	4.7	1.6	1.9	10.2	11.7	6.6	9.6	8.1	1.7	9.7	4.5	4.9	5.2
29.5			1.0	0.2	0.6		0.4						0.1	1.7	1.8	2.0	2.4	4.2	2.6	2.6	2.1	7.7	10.1	6.0	6.0	6.4	1.5	6.7	3.4	2.9	4.1
30.0			0.5	0.2	0.4		0.4					0.2	0.1	2.3	1.3	0.3	3.0	4.0	1.5	3.2	2.1	5.6	8.2	5.1	3.8	6.9	2.2	5.8	2.9	1.4	3.5
30.5			0.5	0.2	0.4		0.2						0.0	2.3	0.8	0.5	2.6	2.1	1.1	2.0	2.1	3.2	4.2	5.4	3.8	4.8	2.4	4.7	2.0	1.8	2.7
31.0			0.5		0.2		0.2					0.2	0.1	1.7	1.0		3.6	2.9	1.3	2.4	1.7	3.9	3.4	3.9	4.3	4.5	1.1	3.2	2.0	1.0	2.5
31.5														1.3	0.3		2.4	2.9	1.9	1.0	1.5	3.5	4.5	2.7	1.9	3.6	1.3	2.6	0.9	0.6	1.9
32.0			0.2		0.1									0.9	1.0	0.3	1.2	1.9	1.5	0.4	1.3	3.2	4.0	1.8	2.9	3.1	1.3	0.9	0.7	0.2	1.6
32.5				0.2	0.1									0.2	0.2		1.4	1.3	0.2	0.8	1.1	1.8	1.3	2.7	1.9	1.5	0.7	0.6	0.2	0.2	0.9
33.0			0.2		0.1									0.4			0.6	0.2	0.2	0.4	0.6	1.8		0.9	1.7	0.2	0.7	0.9		0.2	0.5
33.5																	0.2	0.4	0.2			1.1	0.8	0.9	0.5	0.3	0.2	0.2	0.2		0.3
34.0																	0.6	0.2	0.2	0.2	0.4	0.7	0.5	0.3				0.2			0.2
34.5														0.2						0.2		1.4	0.3	0.3							0.1
35.0																						0.7	0.5								0.1
35.5																															
36.0																															
36.5																										0.2					0.0
Number	360		406	459		472	460	438	493	487	575	540		527	607	397	494	476	470	501	467	285	377	332	416	581	460	534	443	509	
mean length	22.8	22.8	26.6	26.2	26.4	24.8	25.4	24.9	24.7	25.3	24.9	25.4	25.1	27.5	27.1	27.0	28.0	28.4	28.1	28.1	27.7	29.3	29.6	28.7	29.0	29.1	27.6	28.7	27.8	27.7	28.2
mean weight	94	94	159	151	155	126	137	128	124	133	127	136	130	179	171	168	192	201	193	192	184	224	229	209	215	216	182	207	186	184	196
TS/individual	-44.0	-44.0	-42.7	-42.8	-42.8	-43.3	-43.1	-43.3	-43.3	-43.1	-43.3	-43.1	-43.2	-42.4	-42.5	-42.6	-42.2	-42.1	-42.2	-42.2	-42.3	-41.8	-41.8	-42.0	-41.9	-41.9	-42.4	-42.0	-42.3	-42.3	-42.2
TS/kilogram	-33.8	-33.8	-34.7	-34.6	-34.7	-34.3	-34.5	-34.3	-34.3	-34.4	-34.3	-34.4	-34.4	-34.9	-34.8	-34.8	-35.1	-35.1	-35.1	-35.1	-35.0	-35.3	-35.4	-35.2	-35.3	-35.3	-35.0	-35.2	-35.0	-35.0	-35.1

Table 3 Numbers, mean length, mean weight, biomass and percentage mature by area (figure 2) FRV Scotia 1-24 July 1999.

	Number	Mean Length	Mean Weight	Biomass	Maturity
Area I	(millions)	(cm)	(g)	tonnes *103	(%)
1A	15.76	21.87	88.08	1.39	0.0
2I	33.35	22.14	91.71	3.06	
2M	8.49	23.32	109.13	0.93	20.3
3I	2.41	22.20	93.54	0.23	
3M	1.86	24.37	125.89	0.23	43.5
4A	0.00			0.00	100.0
5A	0.00			0.00	100.0
6A	0.00			0.00	100.0
7A	0.00			0.00	100.0
8A	0.00			0.00	100.0
9+	0.00			0.00	100.0
Total	61.86	22.30	94.27	5.83	
Area II					
1A	0.49	22.00	89.32	0.04	0.0
2I	12.65	24.60	129.94	1.64	
2M	50.58	25.47	145.88	7.38	80.0
3I	28.32	25.27	142.02	4.02	
3M	79.52	25.98	156.17	12.42	73.7
4A	19.05	26.91	175.77	3.35	100.0
5A	5.00	28.45	211.01	1.05	100.0
6A	2.54	29.82	247.59	0.63	100.0
7A	0.48	29.77	246.62	0.12	100.0
8A	0.24	30.50	265.56	0.06	100.0
9+	0.73	31.69	303.61	0.22	100.0
Total	199.60	25.89	155.02	30.94	
Area III					
1A	75.32	22.75	100.91	7.60	0.0
2I	331.14	23.46	111.21	36.82	
2M	644.36	24.61	130.59	84.15	66.1
3I	186.38	24.61	130.14	24.26	
3M	284.01	25.64	149.58	42.48	60.4
4A	40.72	26.34	163.17	6.64	100.0
5A	17.47	27.42	187.37	3.27	100.0
6A	0.95	30.22	258.15	0.24	100.0
7A	1.42	30.16	256.65	0.36	100.0
8A	0.00			0.00	100.0
9+	0.00			0.00	100.0
Total	1581.76	24.55	130.13	205.83	
Area IV					
1A	2.93	22.09	91.65	0.27	0.0
2I	69.11	24.88	135.19	9.34	
2M	569.31	25.75	151.84	86.45	89.2
3I	161.86	25.71	150.92	24.43	
3M	3339.07	27.20	182.17	608.26	95.4
4A	834.09	28.63	216.72	180.76	100.0
5A	371.22	30.02	253.69	94.17	100.0
6A	261.17	31.12	285.71	74.62	100.0
7A	103.94	31.75	305.01	31.70	100.0
8A	29.52	31.65	302.74	8.94	100.0
9+	49.46	32.62	335.25	16.58	100.0
Total	5791.68	27.70	196.06	1135.53	
Total Area					
1A	94.50	26.11	112.65	9.30	0.0
2I	446.25	24.57	117.17	50.87	
2M	1272.74	24.29	135.49	178.90	74.0
3I	378.96	23.37	129.65	52.93	
3M	3704.46	26.51	175.79	663.40	90.7
4A	893.85	27.92	209.66	190.76	100.0
5A	393.68	29.52	247.53	98.50	100.0
6A	264.66	30.82	282.87	75.49	100.0
7A	105.84	31.58	302.97	32.18	100.0
8A	29.76	31.40	302.44	9.00	100.0
9+	50.18	32.14	334.79	16.80	100.0
Total	7634.90	26.46	180.50	1378.13	

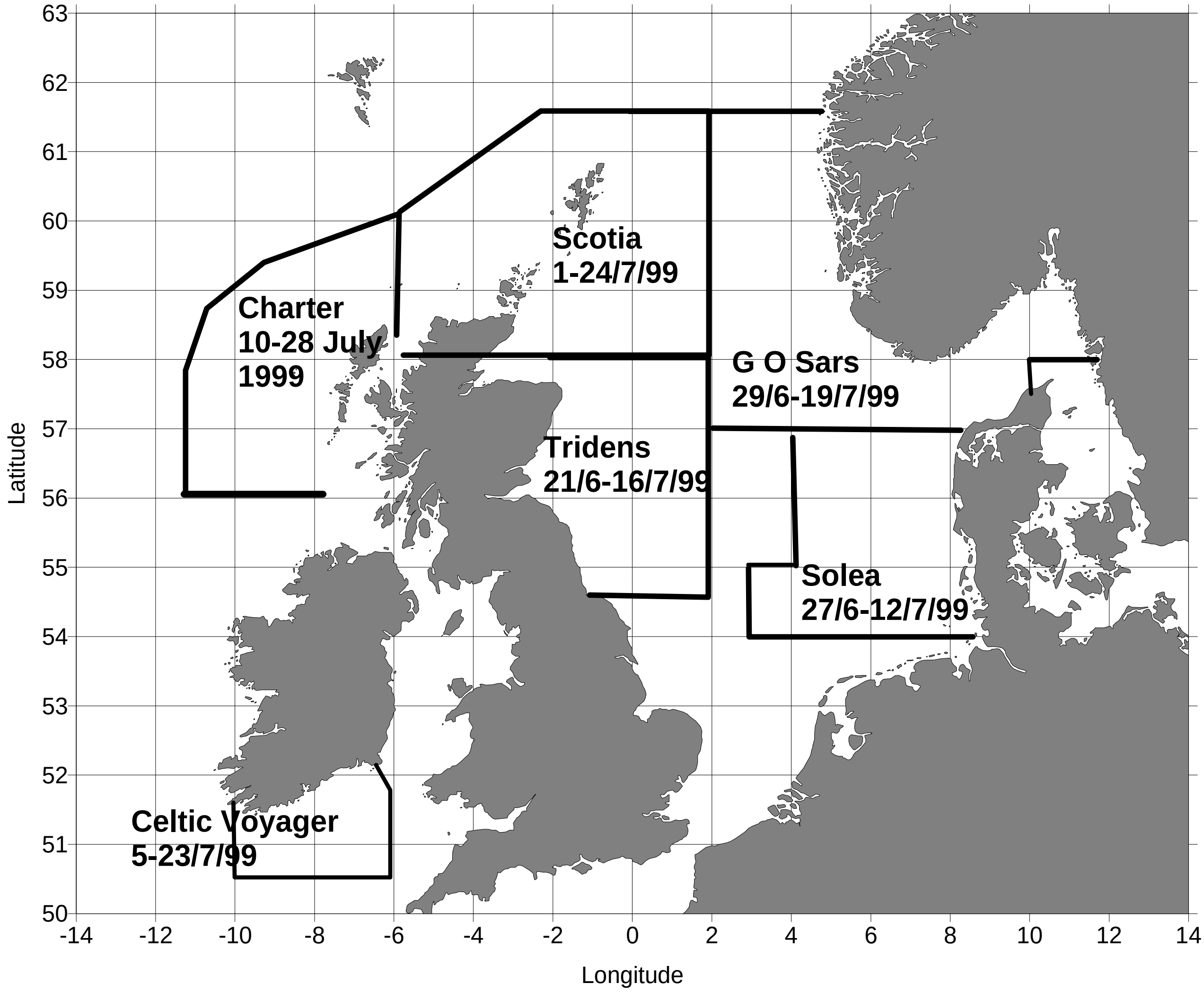

Figure 1 layout and dates of survey areas for all participating vessels 1999

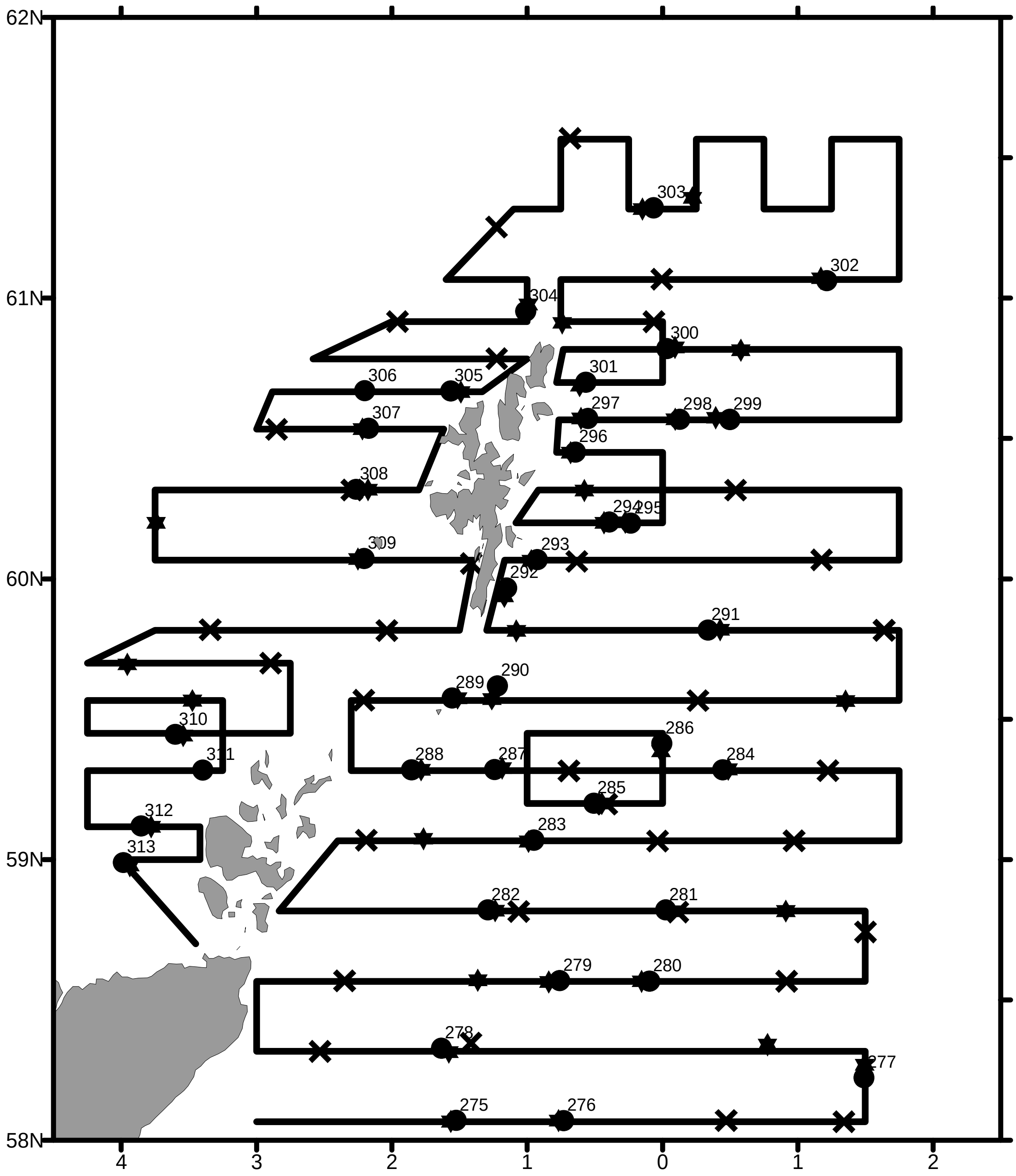

Figure 2. Cruise track, trawl stations (●), CTD stations (✶), XBT Stations (✖)
FRV Scotia 1-24 July 1999

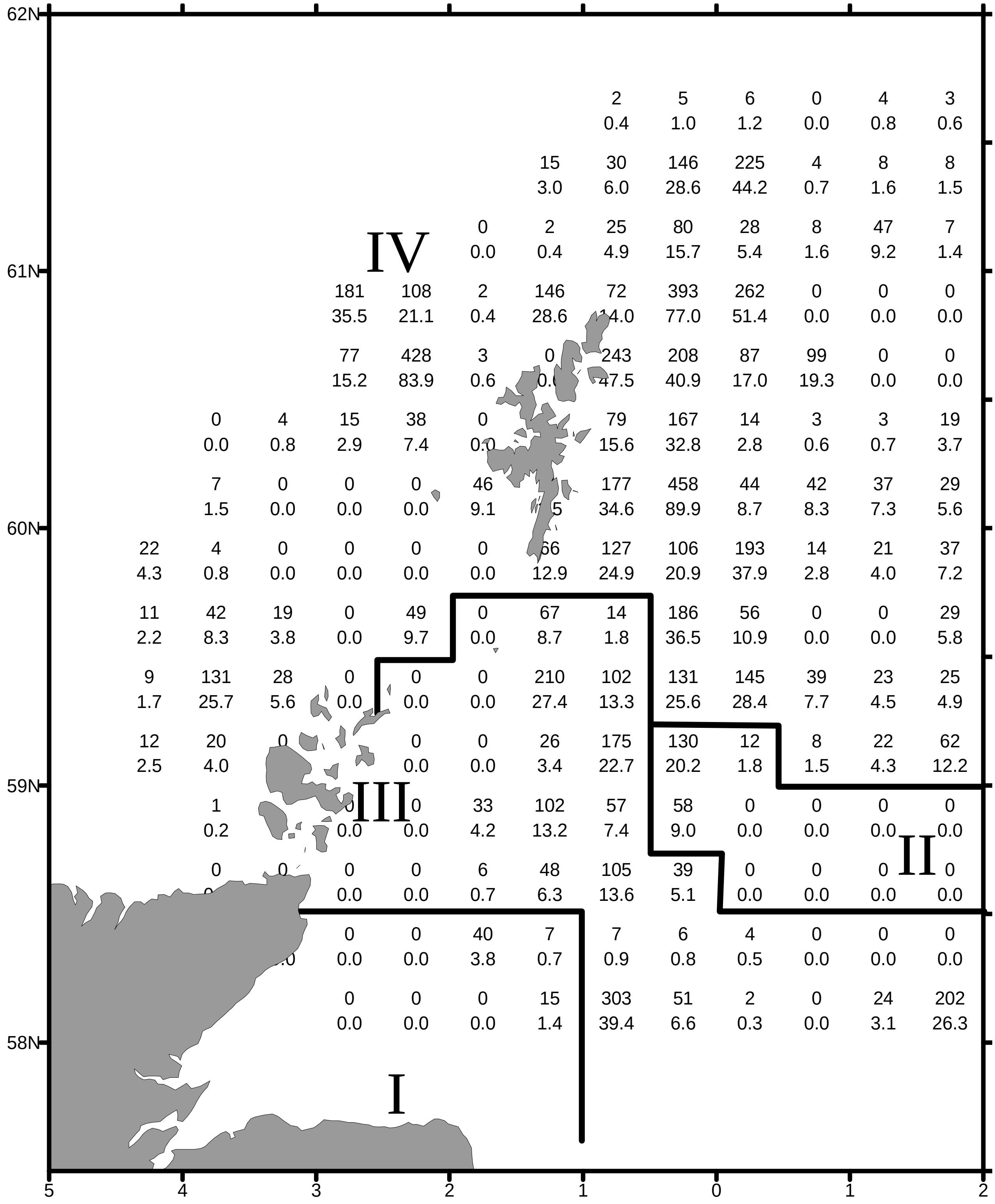

Figure 3 Numbers (millions and Biomass (thousands of tonnes and analysis area FRV Scotia 1-24 July 1999

APPENDIX 5

Survey report for MFV *Christina S* in ICES area VIa(N)
13 July - 30 July 1999

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DRAFT REPORT: NOT TO BE CITED OR DISSEMINATED WITHOUT PRIOR REFERENCE TO THE AUTHOR

Methods

The acoustic survey on the Marine Laboratory Aberdeen vessel MFV *Christina S* (13 July to 30 July 1999) was carried out using a Simrad EK500 38 kHz sounder echo-integrator. Further data analysis was carried out using Simrad BI500 and Marine Laboratory Analysis systems. The survey track (Fig. 1) was selected to cover the area in three levels of sampling intensity based on herring densities found in 1991-99. Areas with highest intensity sampling had a transect spacing of 4.0 nautical miles, areas with medium intensity sampling had a transect spacing of 7.5 nautical miles and lower intensity areas a transect spacing of 15 nautical miles. The track layout was systematic, with a random start point. The ends of the tracks were positioned at ½ the actual track spacing from the area boundary, giving equal track length in any rectangle within each intensity area. Where appropriate the between-track data could then be included in the data analysis. Between track data were abandoned at the westward end of all transects, and on the eastward ends between 56^o 45' and 58^o 00'N, along the coast of the Outer Hebrides.

38 trawl hauls (Figure 2 & Table 1) were carried out during the survey on the denser echo traces. Each haul was sampled for length, age, maturity and weight of individual herring. Up to 350 fish were measured at 0.5 cm intervals from each haul. Otoliths were collected with 2 per 0.5 cm class below 22 cm, 5 per 0.5 cm class from 20 to 27 cm and 10 per 0.5 cm class for 27.5 cm and above. Fish weights were collected at sea from a random sample of 50 fish per haul.

Data from the echo integrator were summed over quarter hour periods (2.5Nm at 10 knots). Echo integrator data was collected from 9 metres below the surface (transducer at 5m depth) to 1m above the seabed. The data were divided into five categories, by visual inspection of the echo-sounder paper record and the integrator cumulative output; "herring traces", "probably herring traces", "sprat traces", “gadoid traces” and a species mixture category. No “probably not herring” category was included in this survey as all non herring traces were reliably identified as either gadoids, sprat or mackerel.

For the 1999 survey the total estimated stock was 524,000 tonnes. The spawning stock biomass (mature herring only) was estimated at 473,100 tonnes. The survey area extended into ICES Sub-area IVa, The observed tonnage in this area was approximately 58,000 tonnes giving a total of 466,000 tonnes in VIa(N). 75.7% of the stock by number was attributable to the "herring traces" and 22.5% to the "probably herring traces".

As in previous years, in general, herring were generally found in waters where the seabed was deeper than 100m, however, herring were also caught in reasonable quantities in shallower waters on three hauls (hauls 23, 28 & 29). Norway pout and blue whiting which were found commonly throughout the north of the survey area in some previous years were relatively uncommon in 1999. Blue whiting were caught in large quantities on only three hauls (13, 31 & 32), all these hauls were close to the shelf break. Isolated hauls showed good catches of pout, however these were usually isolated from herring schools. Mackerel was again relatively common across the area, but posed no identification problems. It is possible that a significant part of the fish scored in category 3 were in fact herring and this would indicate a small underestimate of the true stock. It was not usually possible to make a definite assignment of these marks to species, and where doubt existed it was assumed that they were NOT herring. Similar difficulties were encountered in 1994 & 95 but on a much larger scale.

Three sets of calibrations were carried out during the survey, at the beginning, middle and end of the survey. One tow cable was found to be faulty on the second calibration and was replaced. Examination of the echograms showed that the fault had developed approximately four days prior to the calibration. The fault resulted in the loss of function on two quadrants of the transducer. The faulty system was calibrated and a theoretical calculation of beam pattern calculated for the system, this was used to correct the scrutinised echo-integrals prior to analysis. A new cable was installed and the system re-calibrated. Two days after calibration this cable also developed a fault, which was detected immediately, and was replaced. The final calibration was carried out on this cable/transducer configuration. The integrator data were corrected for the deviations between the calibrations of the three cable/transducer configuration.

To calculate integrator conversion factors the target strength of herring was estimated using the TS/length relationship recommended by the acoustic survey planning group (Anon 1982) for clupeoids:

$$TS = 20\log_{10}L - 71.2 \text{ dB per individual}$$

The weight of herring at length was determined by weighing fish from each trawl haul which contained more than 50 fish. Lengths were recorded by 0.5 cm intervals to the nearest 0.5 cm below. The resulting weight-length relationship for herring was:

$$W = 0.004833\ L^{3.172} \text{ g} \quad L \text{ measured in cm}$$

Survey Results

A total of 38 trawl hauls were carried out, the results of these are shown in Table 1. 22 hauls contained more than 50 herring and these hauls were used to define 9 survey sub areas (Figure 3). The sub-areas were defined as:

I	North Minch
II	South Minch
III	Barra Head
IV	Barra Head South
V	South West Hebrides
VI	Lewis
VII	Shelf Break
VIII	North VIa(N)
IX	Orkney

The stock estimate for VIa(N) is very similar to 1998 (458.200 to 466,000 tonnes). There was little evidence of change in distribution. The main concentrations were again at Barra Head, off the coast of Lewis and along the shelf edge North and west of Lewis (Figures 4 & 5). No herring were seen south of 56^{o} 30'N in contrast to 1998 and the abundances between 4 and 5^{o}W were lower in 1999.

There are also some indications of changes in the age and maturity structure of the stock (see Table 3). In 1998 87% of the two ringers were mature, in 1999 64% were mature. The proportion of older fish (4+) in the stock increase from 34% in 1998 to 41% in 1999. This can be compared with 55% in 1995, 43% in 1996 and 16.6% in 1997 - it should be noted that the 1997 survey was carried out one month earlier than the other years surveys. The stock estimates in the last two years are consistent with the pattern up to 1996. This suggests that the stock situation is relatively stable, and that the 1997 survey can be considered as an underestimate.

Table 1 Catch composition by trawl haul. *Christina S* (13 July- 30 July 1999)

	Position			Numbers caught								
	Latitude (^oN)	Longitude (^oW)		herring	whiting	haddock	pout	mackerel	horse mackerel	blue whiting	sprat	others
1	58 32.41	5 34.91	140	91	126	50	5			3		10 dogfish
2	58 18.95	6 56.70	115		249	669	507			69	183	
3	58 62.72	5 45.30	110	2	62	15	257			5	48	
4	57 39.25	6 36.80	85	2	197	17	73				316	1 sandeel
5	56 42.30	6 31.07	100	49	36			676			10290	
6	56 23.04	6 45.26	80	12	28			7			15960	
7	56 05.47	9 03.31	170	1		10	4					11 poor cod
8	56 32.24	7 48.34	150	1860	15	10	10					5 hake 35 boarfish
9	56 40.00	8 43.97	125	420				4	5			
10	56 38.94	7 36.66	100	21550								
11	56 46.54	7 37.91	100	33465	460			805				
12	56 47.46	8 29.30	125	44	10	92	4			1		8 Argentine, 1 cod, 1 saithe
13	57 02.53	9 02.90	140	233		48	108		20	348		56 argentine, 16 poor cod
14	57 10.10	8 18.82	125	16695				410				
15	57 32.48	8 25.66	150	4685				60				
16	57 46.71	8 46.72	140	98	2	8	77			20		1 poor cod
17	57 45.00	7 46.10	100				3140					
18	57 54.97	7 40.56	100	5313								
19	58 10.38	7 18.80	100	37151								
20	58 16.02	5 53.78	100	14	322	322	21					
21	58 20.13	5 57.94	125		96	312	12					
22	58 16.70	7 05.46	100	1830				260				
23	58 23.05	5 29.32	90	30856								
24	58 40.07	6 02.84	120	5	2	18					360	
25	58 36.86	6 28.44	100	73				645				
26	58 48.81	7 34.27	160	38214			515		103			
27	58 47.93	4 53.75	85	2	7	24	108	25	15			
28	58 48.18	3 53.64	90	7832				59			14	
29	58 55.25	5 34.10	90	1652								
30	58 55.12	6 23.43	125	1955				10				
31	58 55.19	6 57.38	175	9482						341		
32	59 02.88	6 56.29	195	7	1			36		1080		1 hake 1 argentine
33	59 02.86	4 59.09	60				620	42				
34	59 10.47	5 14.40	115	706	16			6				
35	59 10.21	6 20.30	115	340		7		3				
36	59 19.92	6 30.10	200		36	1						
37	59 35.22	5 44.68	125	760								
38	59 48.53	3 13.31	80	609			62	4				

Table 2. Herring length frequency by trawl haul by sub area. *Christina S* (13 July to 30 July 1999) mean length - cm, mean weight - g, target strength - dB)

Haul No	Area I				Area II	Area III	Area IV			Area V							Area VI			
	1	23	25	Mean	5	11	8	10	Mean	9	12	13	14	15	16	Mean	18	19	22	Mean
13.0																				
13.5																				
14.0																				
14.5					2.0															
15.0																				
15.5					6.1															
16.0					10.2															
16.5					8.2															
17.0					14.3															
17.5					14.3															
18.0					8.2															
18.5	3.3			1.1	18.4															
19.0	1.1		15.1	5.4	8.2															
19.5			21.9	7.3		0.3		0.2	0.1									0.4		0.1
20.0	1.1		19.2	6.8		3.4												0.4		0.1
20.5	1.1		12.3	4.5		4.1														
21.0			8.2	2.7		8.9		0.2	0.1											
21.5			5.5	1.8		8.2														
22.0		0.4		0.1		4.5												0.4	0.3	0.2
22.5	1.1			0.4		1.7														
23.0	9.9		2.7	4.2		1.7													0.5	0.2
23.5	6.6	1.5	1.4	3.2		1.7		0.2	0.1										0.3	0.1
24.0	20.9	2.2	4.1	9.1		4.5		0.9	0.5				0.4			0.1	0.4	1.4	1.1	1.0
24.5	16.5	3.7		6.7		5.2	0.3	3.5	1.9					1.1		0.2	0.4	4.6	3.0	2.7
25.0	12.1	13.5		8.5		13.4	4.0	6.0	5.0	2.1			7.3	4.0		2.2	12.1	16.3	13.9	14.1
25.5	13.2	20.2		11.1	2.0	13.4	5.9	7.9	6.9	4.3	9.1		10.7	8.4		5.4	18.6	17.4	16.4	17.5
26.0	4.4	29.2	2.7	12.1	6.1	11.3	8.3	13.9	11.1	11.4	15.9	6.0	26.1	18.3	6.1	14.0	29.0	32.2	28.7	30.0
26.5	3.3	15.0	2.7	7.0		7.9	7.8	15.3	11.6	15.2	15.9	9.9	19.5	19.4	6.1	14.3	17.7	15.2	15.8	16.3
27.0	3.3	9.4	1.4	4.7	2.0	7.2	10.8	16.0	13.4	18.6	15.9	16.3	18.4	21.6	19.4	18.4	12.6	7.1	10.9	10.2
27.5	1.1	2.8	2.7	2.2		1.4	10.8	12.1	11.4	16.2	15.9	17.2	9.2	11.3	24.5	15.7	6.5	3.5	4.1	4.7
28.0	1.1	1.5		0.9		1.0	13.7	7.7	10.7	11.9	13.6	23.6	5.0	7.3	22.4	14.0	2.6	1.0	4.4	2.7
28.5		0.2		0.1			12.4	4.9	8.6	8.6	6.8	13.3	1.5	5.1	9.2	7.4		0.2		0.1
29.0		0.2		0.1			12.6	5.8	9.2	9.0	4.5	7.3	1.9	2.0	9.2	5.7			0.3	0.1
29.5		0.2		0.1	0.1		8.3	2.1	5.2	1.9	2.3	4.3		0.5	3.1	2.0			0.3	0.1
30.0							2.7	2.1	2.4			1.3		1.0		0.4				
30.5							2.2	0.7	1.4	0.7		0.4				0.2				
31.0							0.3	0.2	0.3			0.4				0.1				
31.5								0.2	0.1											
32.0																				
32.5																				
33.0																				
33.5																				
34.0																				
34.5																				
Number	91	30586	73		49	33465	1860	21550		420	44	233	16695	4685	98		5313	7151	1830	
mean lgt	24.8	26.4	21.4	24.2	18.7	24.7	28.2	27.4	27.8	27.8	27.6	28.2	27.0	27.3	28.2	27.7	26.6	26.3	26.5	26.5
mean wt	130	156	84	123	57	130	194	177	186	185	180	194	168	174	192	182	161	155	159	159
TS/ind	-43.3	-42.8	-44.5	-43.5	-45.6	-43.3	-42.2	-42.4	-42.3	-42.3	-42.4	-42.2	-42.6	-42.5	-42.2	-42.4	-42.7	-42.8	-42.7	-42.7
TS/kg	-34.4	-34.7	-33.8	-34.4	-33.2	-34.4	-35.1	-34.9	-35.0	-35.0	-34.9	-35.1	-34.8	-34.9	-35.0	-35.0	-34.8	-34.7	-34.7	-34.7

Table 2. Herring length frequency by trawl haul by sub area. *Christina S* (13 July to 30 July 1999) mean length - cm, mean weight - g, target strength - dB) – continued.

Haul No	Area VII					Area VIII					Area IX
	26	31	37	38	Mean	29	30	34	35	Mean	28
15.5											
16.0											
16.5											
17.0											
17.5											
18.0											
18.5											
19.0											1.1
19.5											0.5
20.0											0.8
20.5											0.8
21.0											0.8
21.5											0.3
22.0				0.3	0.1						2.2
22.5											3.6
23.0				0.3	0.1						6.3
23.5				0.3	0.1						6.3
24.0				0.3	0.1						11.6
24.5		0.6		0.3	0.2	0.3		0.3		0.1	9.7
25.0		0.3		6.2	1.6	4.2	4.2	2.0		2.6	10.5
25.5		0.3		6.2	1.9	9.5	5.4	4.0	0.3	4.8	9.9
26.0	1.1	1.2	0.3	14.4	5.5	21.4	27.0	17.8	5.3	17.9	16.0
26.5	6.2	2.7	1.3	14.4	6.7	20.3	21.6	17.8	10.6	17.6	7.2
27.0	8.4	8.7	6.8	12.5	11.1	17.9	20.5	15.9	16.8	17.7	6.1
27.5	16.4	9.6	8.9	8.5	11.2	9.3	8.1	12.2	15.0	11.1	3.6
28.0	17.8	10.8	15.1	7.6	12.8	6.5	6.2	11.3	17.6	10.4	1.9
28.5	17.8	12.6	16.1	6.2	11.4	5.9	3.1	4.2	12.4	6.4	
29.0	10.5	15.6	16.8	5.6	11.9	2.3	2.8	3.4	8.5	4.3	0.9
29.5	9.7	9.6	12.9	3.3	8.0	0.7	0.5	2.8	3.8	2.0	
30.0	6.2	7.2	6.8	3.6	5.1	0.5	0.3	1.8	2.4	1.2	
30.5	2.7	6.9	5.9	4.6	4.6	0.5		1.4	2.4	1.1	0.2
31.0	0.9	5.7	4.2	1.8	3.2	0.2	0.3	1.6	3.2	1.3	
31.5	1.2	3.3	1.8	1.8	1.9	0.1		1.4	0.9	0.6	
32.0	0.5	1.9	1.1	1.5	1.2	0.2		1.1	0.9	0.6	
32.5	0.3	1.1	0.7		0.5			0.4		0.1	
33.0	0.1	0.8	0.5		0.3			0.3		0.1	
33.5		0.4	0.3		0.2						
34.0	0.1		0.4		0.1	0.1				0.1	
34.5		0.1			0.1			0.1		0.1	
35.0											
35.5		0.2			0.1						
36.0		0.1			0.1						
36.5											
37.0		0.1			0.1						
Number	38214	9482	760	609		1652	1955	706	340		7832
mean lgt	28.4	29.5	29.4	27.9	28.8	27.3	27.2	27.8	28.5	27.7	25.4
mean wt	197	223	222	189	208	174	172	187	200	183	140
TS/ind	-42.1	-41.8	-41.8	-42.3	-42.0	-42.5	-42.5	-42.3	-42.1	-42.3	-43.1
TS/kg	-35.1	-35.3	-35.3	-35.0	-35.2	-34.9	-34.9	-35.0	-35.1	-35.0	-34.5

Table 3 Herring numbers and biomass by age, maturity and area. *Christina S* (13 July to 30 July 1999)

Category	Number x 10^{-6}	Mean Length (cm)	Mean weight (g)	Biomass (tonnes x10^{-3})
Area I (North Minch)				
1 ring	143.11	19.87	68.97	9.87
2 ring immature	67.46	23.98	123.38	8.32
2 ring mature	72.82	24.28	128.46	9.35
3 ring immature	5.75	24.76	135.79	0.78
3 ring mature	190.55	25.96	157.76	30.06
4	6.96	27.46	188.02	1.31
5	3.66	27.26	183.21	0.67
6	0.00			0.00
7	0.83	27.50	188.19	0.16
8	0.00			0.00
9+	0.00			0.00
Total	491.15	23.69	123.24	60.53
Area II (South Minch)				
1 ring	328.76	17.34	45.67	15.01
2 ring immature	0.00			0.00
2 ring mature	0.00			0.00
3 ring immature	0.00			0.00
3 ring mature	29.89	25.88	155.72	4.65
4	7.47	27.00	177.74	1.33
5	0.00			0.00
6	0.00			0.00
7	0.00			0.00
8	0.00			0.00
9+	0.00			0.00
Total	366.12	18.23	57.34	20.99
Area III (Barra Head)				
1 ring	13.29	21.22	84.48	1.12
2 ring immature	10.68	25.00	140.34	1.50
2 ring mature	5.76	25.34	146.37	0.84
3 ring immature	0.00			0.00
3 ring mature	8.30	25.91	156.62	1.30
4	2.26	27.13	180.35	0.41
5	0.71	27.40	186.27	0.13
6	0.14	28.00	199.06	0.03
7	0.00			0.00
8	0.00			0.00
9+	0.00			0.00
Total	41.14	24.1	129.61	5.33

Table 3 (continued)

Category	Number x 10^{-6}	Mean Length (cm)	Mean weight (g)	Biomass (tonnes $x10^{-3}$)
Area IV (Barra Head South)				
1 ring	0.33	20.25	73.07	0.02
2 ring immature	10.80	25.23	144.16	1.56
2 ring mature	14.84	25.62	151.20	2.24
3 ring immature	3.20	26.75	172.62	0.55
3 ring mature	32.59	26.52	168.47	5.49
4	23.43	27.37	185.56	4.35
5	23.46	28.12	202.38	4.75
6	11.74	28.50	210.60	2.47
7	6.91	29.18	227.21	1.57
8	3.93	29.64	238.01	0.94
9+	9.53	29.25	228.31	2.18
Total	140.75	27.29	185.54	26.12
Area V (South West Hebrides)				
1 ring	0.00			0.00
2 ring immature	11.83	25.43	147.63	1.75
2 ring mature	24.82	25.77	153.83	3.82
3 ring immature	8.38	26.60	169.89	1.42
3 ring mature	360.19	26.50	168.18	60.58
4	186.87	27.27	183.70	34.33
5	143.22	27.76	194.29	27.83
6	67.59	28.22	204.32	13.81
7	52.02	28.64	213.92	11.13
8	14.62	28.86	219.41	3.21
9+	13.83	28.98	221.77	3.07
Total	883.39	27.17	182.18	160.93
Area VI (Lewis)				
1 ring	1.42	20.44	75.55	0.11
2 ring immature	20.17	24.76	135.84	2.74
2 ring mature	21.91	25.29	145.72	3.19
3 ring immature	5.89	25.77	153.80	0.91
3 ring mature	303.31	25.97	157.76	47.85
4	41.94	26.74	173.03	7.26
5	19.39	27.13	180.90	3.51
6	1.32	27.80	194.85	0.26
7	0.53	28.00	199.06	0.10
8	0.00			0.00
9+	0.00			0.00
Total	415.87	25.97	158.87	65.86

Table 3 (continued)

Category	Number x 10^{-6}	Mean Length (cm)	Mean weight (g)	Biomass (tonnes x10^{-3})
Area VII (Shelf Break)				
1 ring	0.00			0.00
2 ring immature	3.18	24.13	126.32	0.40
2 ring mature	20.31	25.85	155.84	3.17
3 ring immature	6.78	28.12	202.56	1.37
3 ring mature	199.18	27.32	185.24	36.90
4	110.64	28.23	205.15	22.70
5	103.31	29.04	224.24	23.17
6	52.36	29.80	242.62	12.70
7	20.83	30.44	259.62	5.41
8	8.12	30.61	263.58	2.14
9+	12.09	31.79	298.28	3.61
Total	536.80	28.29	207.82	111.56
Area VIII (North VIIa)				
1 ring	0.00			0.00
2 ring immature	1.99	25.16	142.72	0.28
2 ring mature	13.55	25.87	155.92	2.11
3 ring immature	2.23	26.52	168.47	0.38
3 ring mature	171.96	26.74	173.04	29.76
4	49.86	27.73	193.93	9.67
5	20.82	28.48	211.28	4.40
6	10.18	29.84	244.00	2.48
7	4.48	30.06	249.96	1.12
8	1.14	31.12	278.30	0.32
9+	0.71	32.23	309.95	0.22
Total	276.91	27.19	183.23	50.74
Area IX (Orkney)				
1 ring	5.63	19.89	69.10	0.39
2 ring immature	20.38	23.18	111.34	2.27
2 ring mature	62.00	24.49	132.08	8.19
3 ring immature	1.99	23.00	107.96	0.22
3 ring mature	60.27	26.09	160.34	9.66
4	6.24	26.75	173.87	1.09
5	0.29	28.00	199.06	0.06
6	0.30	30.50	259.91	0.08
7	0.00			0.00
8	0.00			0.00
9+	0.00			0.00
Total	157.11	24.86	139.70	21.95

Table 3 (continued)

Category	Number x 10^{-6}	Mean Length (cm)	Mean weight (g)	Biomass (tonnes x10^{-3})
Total Area				
1 ring	492.54	18.22	53.86	26.53
2 ring immature	146.49	24.28	128.48	18.82
2 ring mature	236.01	24.92	139.48	32.92
3 ring immature	34.23	26.25	164.42	5.63
3 ring mature	1356.24	26.42	166.82	226.25
4	435.67	27.51	189.20	82.43
5	314.86	28.21	204.88	64.51
6	143.62	28.93	221.63	31.83
7	85.59	29.18	227.66	19.49
8	27.81	29.58	237.35	6.60
9+	36.16	30.05	250.80	9.07
Total	3309.23	25.55	158.35	524.01

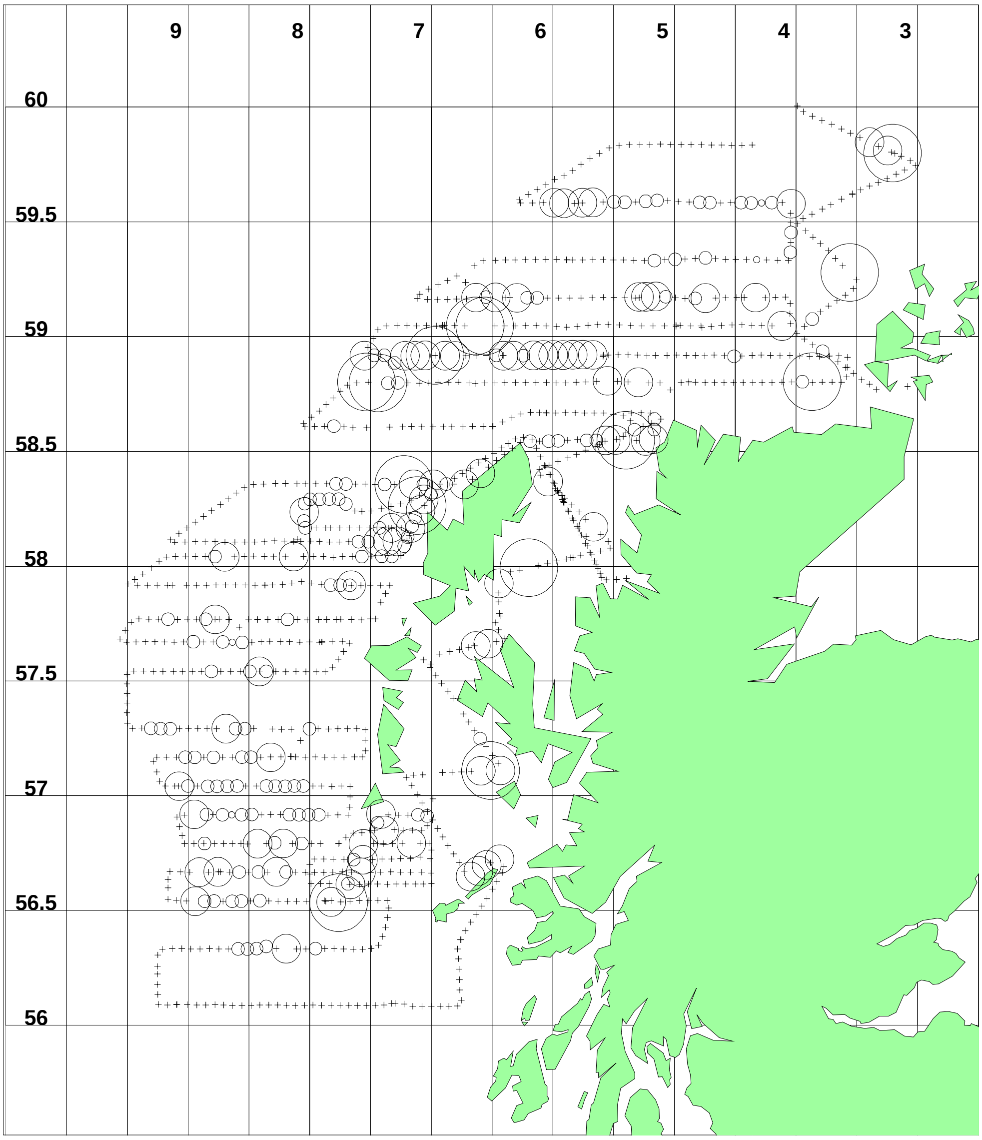

Figure 1. Map of the survey area showing the cruise track for Christina S (13 July to 30 July 1999). Circles are proportional to herring integral on a log scale. Crosses represent EDSU where no herring were observed.

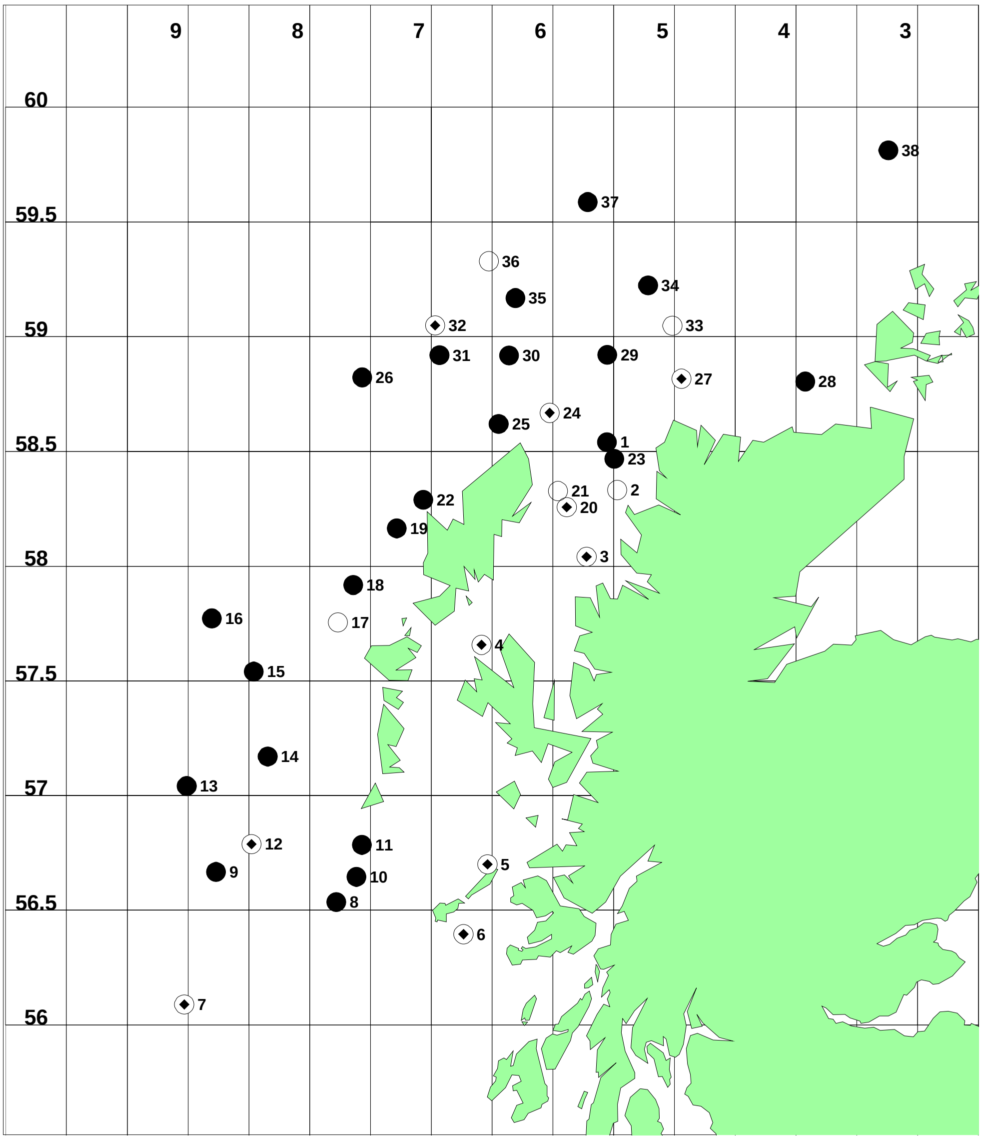

Figure 2. Map of the survey area showing the haul locations for Christina S (13 July to 30 July 1999). Closed circles represent hauls with more than 50 herring, marked open circles represent hauls with less than 50 herring, and plain open circles represent hauls with no herring.

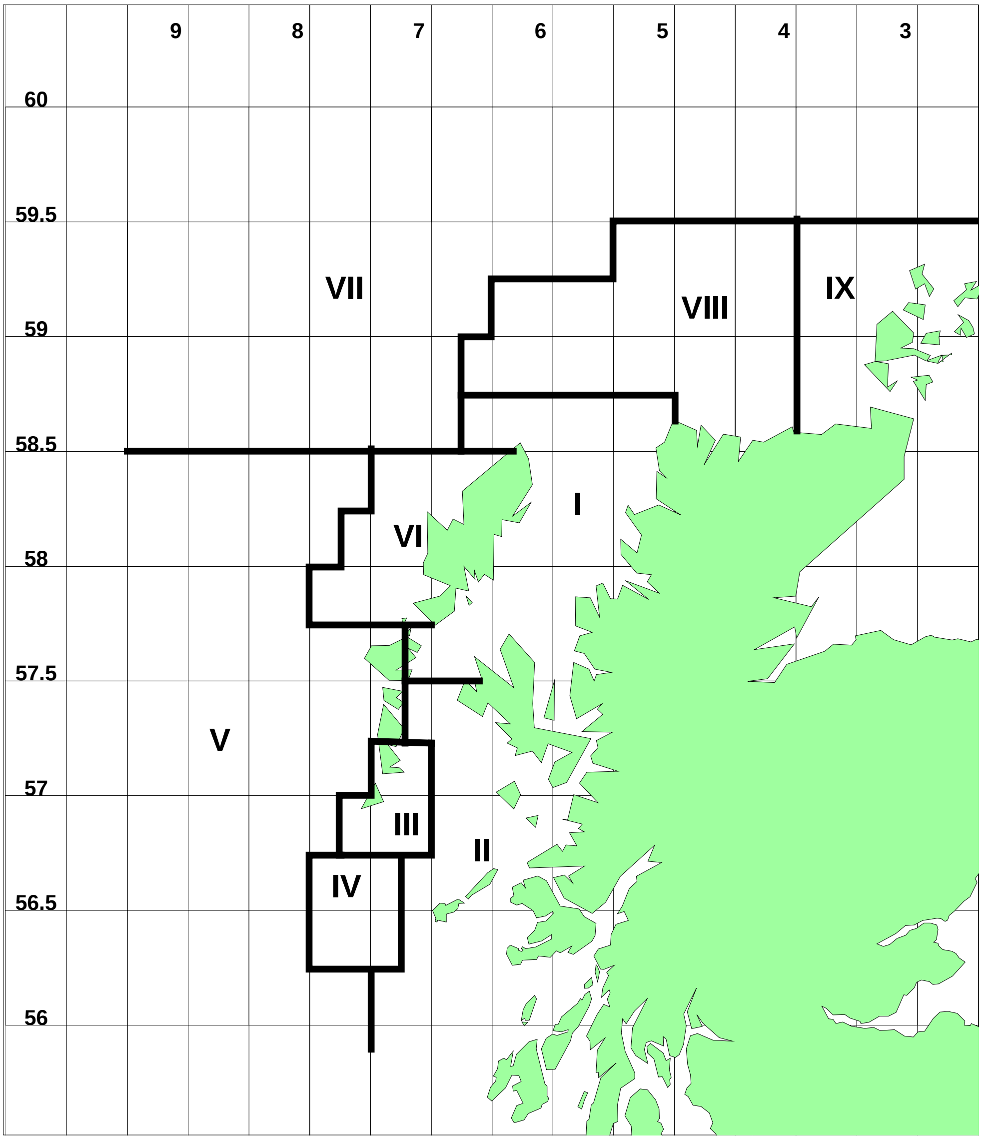

Figure 3. Map of the survey area showing herring strata subdivisions based on analysis of length frequency patterns from trawl hauls.

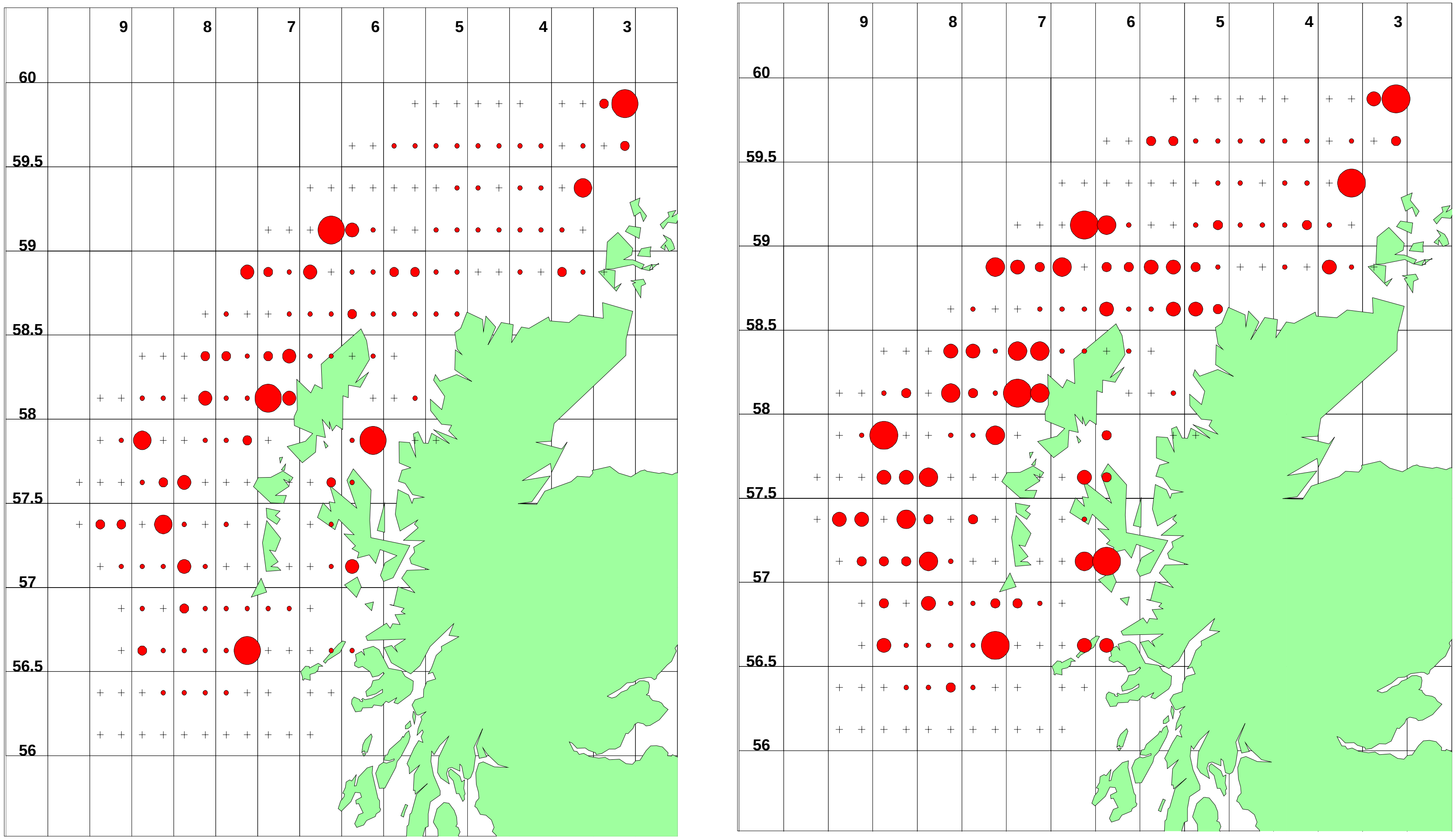

Figure 4. Distribution of herring by biomass (left) and numbers (right) from Christina S survey (13 July to 30 July 1999). Circles are proportional to abundance.

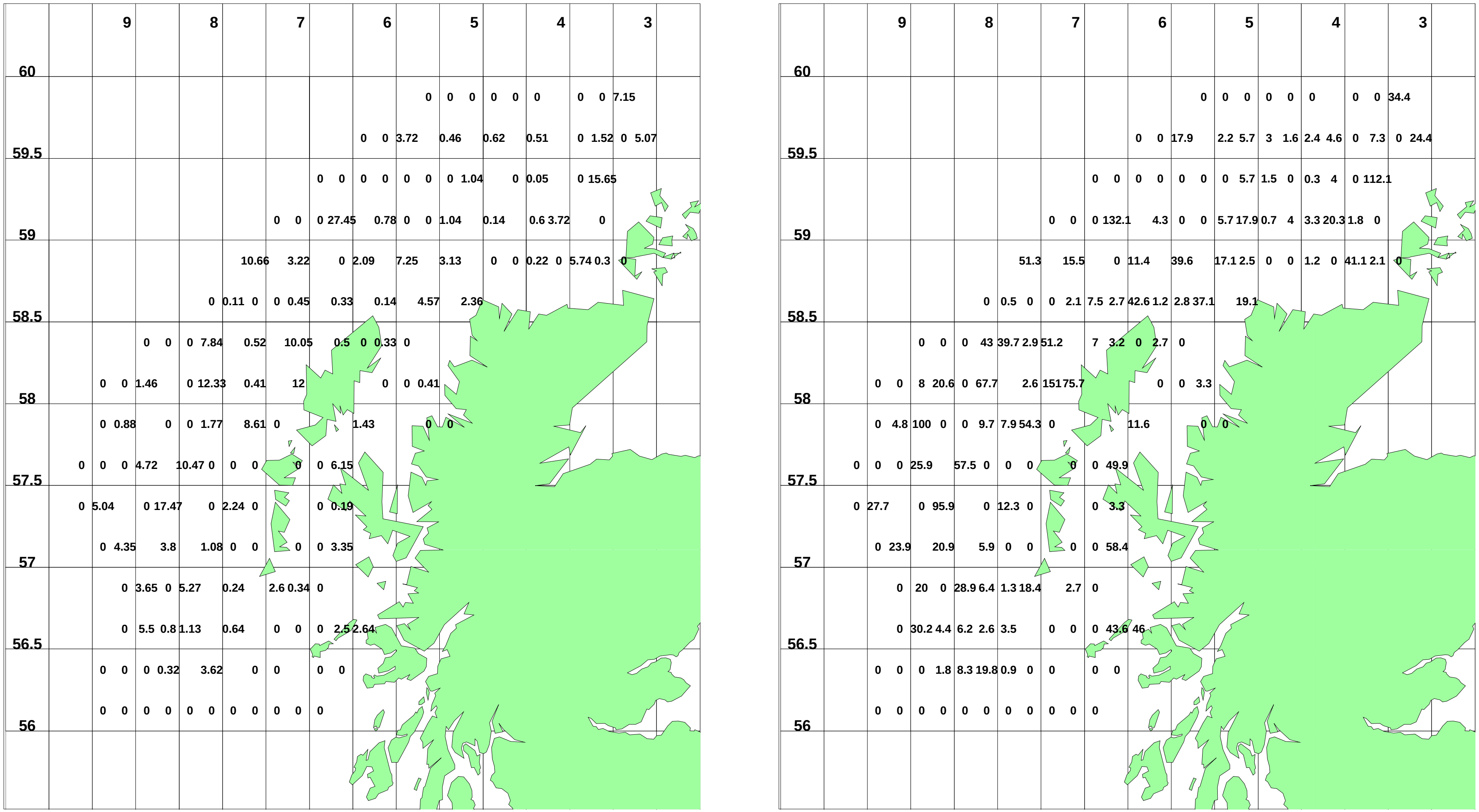

Figure 5. Distribution of herring by biomass (left) and numbers (right) from Christina S survey (13 July to 30 July 1999). Biomass is in thousands of tonnes and numbers in millions of herring.

APPENDIX 6.

Manual For Herring Acoustic Surveys In ICES Divisions III, IV And VIa

Version 2

February 2000

Contents

Transducer and calibration

The standard frequency used for the survey is 38 kHz. In order of preference, it is advisable to mount the transducer in a dropped keel, a towed body or on the hull of the vessel. Steps should be taken to ensure that the flight of the towed body is stable and level, this should ideally be achieved with the aid of a motion sensor.

Calibration of the transducer should be conducted at least once during the survey. Calibration procedures are described in the Simrad EK500 manual and Foote *et al.* (1987). Ideally, the procedure as described in the Simrad manual should be followed with certain exceptions (see below). Minimum target range for the calibration of a split beam 38 kHz echosounder is 10 metres, although greater distances are recommended (about 20 m), particularly with hull mounted transducers, where centering of the target below the transducer is facilitated if the target is suspended at a greater depth. An average integrated value for the sphere, taken when it is centrally located, should be taken as the measured s_A. The calculations should be then performed a number of times (two or three) in an iterative procedure such that the values of measured s_A and theoretical s_A should converge, as described in the Simrad manual. A choice is then made as to whether the S_v Transducer gain should be changed, rendering absolute s_A values, or alternatively, the S_v Transducer gain can be unaltered and a correction factor applied to the s_A values. Only one strategy should be applied during a cruise, such that for example, the latter option is to be employed when calibration is only possible after the cruise has started. If possible, the transducer should be calibrated both at the beginning and the end of the survey; with a mean correction factor applied to the data. If a new calibration differs by more than 0.4 dB, the system should be thoroughly inspected.

There are a number of parameters which require knowledge of the speed of sound in water. It is therefore recommended that appropriate apparatus be used to determine the temperature and salinity of the water so that sound speed can be calculated (see MacLennan & Simmonds 1992 for equations) and entered into the EK500.

It is evident that all versions of the EK500 up to and including version 5.* do not take account of the receiver delay in the calculation of target range (see Fernandes & Simmonds 1996). This is particularly important when calibrating at short range (10 m) as it can lead to a systematic underestimate of biomass of 3%. The correct range to the target should therefore be applied in calibration (see below). The equivalent two way beam angle (ψ) should also be corrected for sound speed according to Bodholt (1999).

A number of calibration parameters and results should be included as a minimum in the survey report. These are tabulated in Table 1. Some of these parameters are not included in the Simrad operator manual and are defined as follows.

Table 1. Calibration report sheet

Calibration report			
Frequency (kHz)			
Transducer serial no.			
Vessel			
Date			
Place			
Latitude			
Longitude			
Bottom depth (m)			
Temperature (°C)			
Salinity (ppt)			
Speed of sound (m.s-1)			
TS of sphere (dB)			
Pulse duration (s)			
Equivalent 2-way beam angle (dB)			
Receiver delay (s)			
Default S_v transducer gain			
Iteration no.	1	2	3
Time			
Range to half peak amplitude (m)			
Range to sphere (m)			
Theoretical s_A (m2.nmile-2)			
Measured s_A (m2.nmile-2)			
Calibated S_v transducer gain			
DeltaG = New gain - Old gain			
Correction factor for pre-calibration s_A's on EK			
Correction factor for pre-calibration S_v's			
Default TS transducer gain			
Iteration no.	1	2	3
Time			
Measured TS			
Calibrated TS gain			

Receiver delay = $\mathbf{t_{del}}$ This is very specific to the echosounder bandwidth (due to the band pass filters), to the transducer bandwidth, and to a lesser extent to the standard target and the pulse duration which may affect the peak value. Target, bandwidth and pulse duration specific values for the Simrad EK400 are given in Foote *et al.* (1987, their Table 1). Values for the EK500 are not available, but Simrad recommend using

3 sample distances (10 cm) in wide bandwidth (3 kHz). This equates to a value of $\mathbf{t_{del}}$ of 0.00039 s at 38 kHz.

Range to half peak amplitude = $\mathbf{r_m}$ This is the measured range between the start of the transmit pulse and the point on the leading edge of the echo at which the amplitude has risen to half the peak value (m). This is usually determined from experience with the readings from an oscilloscope display. For example, for a 38.1 mm tungsten carbide standard target insonified at 38 kHz at a colour threshold setting of -70 dB (S_v colour min.), it is measured as from the top of the transmit pulse to the leading edge of the pink colour on the target sphere echo.

Range to sphere = $\mathbf{r_{sph}}$ may then be calculated from:

$$\mathbf{r_{sph} = r_m - ((c \times t_{del})/2)}$$

Correction factor for pre-calibration s_A's on EK500 = K = 1/(10^(DeltaG/5))

Where:

DeltaG = Calibrated S_v Transducer Gain – Default S_v Transducer gain

Correction factor for pre-calibration S_v's on EK = 10($\log_{10}$(s_A correction factor))

Instrument settings during the survey (for the Simrad EK500).

For most settings the default values from the manufacturer may be used, or alternatively the operator can choose his own settings depending on the circumstances. It is recommended that each year the same settings be used for the printer in order to facilitate comparison of echograms.

There are a number of settings that are set during calibration that have a direct influence on the fundamental operation for echo-integration and target strength measurement and therefore affect logged data. Once set according to the particular transducer, these should **NOT** be changed during the survey. These important settings are listed in Table 2.

The minimum detection level on the bottom detection menu depends on the water depth and bottom type. At depths less than 100 m and hard bottoms, the threshold level may be set at –30 dB: this will enable the instrument to detect dense schools close to the bottom. At depths greater than 100 m or soft bottoms, the threshold has to be lowered (-60 dB), otherwise the upper layer of the bottom will be counted as fish as well.

In the operation menu it is recommended to use as short a regular ping interval as possible. It is not advisable to use a ping rate of 0.0 seconds (variable interval according to depth) as this brings about irregular sample (ping) numbers per equivalent distance sampling unit which may bias the analysis.

A bottom margin of the order of 0.5 m is recommended for the layer menus. In shallow areas (<100 m) this can be somewhat reduced.

The S_v minimum for echo integration and presentation of the echogram should be set at –70 dB. Increasing the S_v minimum will reduce the integration values if the herring occur in scattering layers or in loose aggregations. This setting is less important when the data is collected by a post processing package such as Simrad's BI500 or Sonardata's echoview software as the threshold can be determined in post processing.

Table 3 lists those settings which are important for target strength measurements. It should be noted however, that the transducer depth setting may affect the calibration if the range to target is read form the echo sounder.

Survey design

Transects are spaced at a maximum distance of 15 nautical miles. Two aspects should be considered in choosing the direction of the transects. Transects should preferably run perpendicular to the greatest gradients in fish density, which are often related to gradients in bottom topography and hydrography. This means that transects will normally run perpendicular to the coast. The second aspect considers the direction in which the fish are migrating. If there is evidence of rapid displacement of the fish throughout the area, it is advisable to run the transects parallel to the direction of the migration. This survey design will minimise the bias caused by migration. A detailed simulation study of the effects of motion on the survey design of North Sea herring is available in Rivoirard *et al*. (in press).

Ship's speed during the survey is typically 10-12 knots. At higher speeds, problems are encountered with engine noise or propellor cavitation. These problems, however, depend on the vessel. In rough weather, the ship's speed may be reduced in order to avoid problems with air bubbles under the ship, although this problem is alleviated by the use of a dropped keel.

If species identification depends on recognition of schools on the echogram (see section 4.3), the survey will have to be interrupted during periods in the 24 hour cycle when the schools disperse. This occurs during the hours of darkness, depending on the area. When schools disperse during darkness, some of the herring may rise to the surface and get above the transducer. During this time (23:00 – 03:00 around Shetland / Orkney for example) it is advisable to cease surveying. It is recommended – if time permits during the survey – to study the diurnal behaviour of fish schools, in order to determine at what time during the 24hr period the fish may not be available to the echosounder.

Table 2. Important calibration and survey settings, which should not be changed during the survey. Those marked * indicate settings that are specific to the transducer / transceiver.

/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/BANDWIDTH
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/PULSE LENGTH
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/MAX. POWER*
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/2-WAY BEAM ANGLE*
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/SV TRANSD. GAIN*
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/TS TRANSD. GAIN*
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/ABSORPTION COEF.*
/OPERATION MENU/TRANSMIT POWER
/BOTTOM DETECTION MENU/BOTTOM DETECTION-1 MENU/MINIMUM DEPTH
/BOTTOM DETECTION MENU/BOTTOM DETECTION-1 MENU/MAXIMUM DEPTH
/BOTTOM DETECTION MENU/BOTTOM DETECTION-1 MENU/MINIMUM LEVEL
/SOUND-VELOCITY MENU/PROFILE TYPE
/SOUND-VELOCITY MENU/VELOCITY MIN
/SOUND-VELOCITY MENU/ VELOCITY MAX

Table 3. Settings affecting tracking or locating objects within the beam. Those marked * indicate settings that are specific to the transducer / transceiver.

/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/TRANSDUCER DEPTH
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/ANGLE SENS.ALONG*
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/ANGLE SENS.ATHW.*
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/ALONGSHIP OFFSET*
/TRANSCEIVER MENU/TRANSCEIVER-1 MENU/ATHW.SHIP OFFSET*
/TS DETECTION MENU/TS DETECTION-1 MENU/MIN. VALUE
/TS DETECTION MENU/TS DETECTION-1 MENU/MIN. ECHO LENGTH
/TS DETECTION MENU/TS DETECTION-1 MENU/MAX. ECHO LENGTH
/TS DETECTION MENU/TS DETECTION-1 MENU/MAX. GAIN COMP.
/TS DETECTION MENU/TS DETECTION-1 MENU/MAX. PHASE DEV.
/MOTION SENSOR MENU/HEAVE
/MOTION SENSOR MENU/ROLL
/MOTION SENSOR MENU/PITCH
/MOTION SENSOR MENU/TD-1 ATH. OFFSET
/MOTION SENSOR MENU/TD-1 ALO. OFFSET
/MOTION SENSOR MENU/TD-2 ATH. OFFSET
/MOTION SENSOR MENU/TD-2 ALO. OFFSET
/MOTION SENSOR MENU/TD-3 ATH. OFFSET
/MOTION SENSOR MENU/TD-3 ALO. OFFSET

Species allocation of acoustic records

Different methods of species allocation are being used in the various areas. The method used depends largely upon the schooling behaviour of the herring and sprat, and the mixing with other species. In the North Sea and Division VIa the species allocation is based mainly on the identification of individual schools on the echogram. In the Skagerrak-Kattegat and Baltic the identification is based on composition of trawl catches. Both methods are described in more detail below.

Only persons who are familiar with the area and the way fish aggregations of different species occur in the area should scrutinise the echo records. The way species aggregate either in schools or in layers, mixed or not mixed with other species is very different per (sub) area. Allocation of s_A values to species always needs support of trawl-information. However, one has to be aware that the catch composition is influenced by the fish behaviour in response to the net. It is therefore necessary to judge whether the catch-composition is a reflection of the real species composition and whether the allocated percentage of sprat/herring needs correction.

It is obvious that during the scrutinising process subjective decisions have to be made. However, joint sessions of scientists from participating countries who scrutinised each others data has shown that the deviation between the estimated quantities of herring are within the range of 10%, provided that trawl information of the recordings is available (Reid *et al.* 1998).

Using the EK500 printer output and/or post processing systems

Scrutiny of the echo recordings may be done by measuring the increment of the integrator line on the printed paper output of the echogram. This is a simple and efficient way of scrutinising if one deals with single species schools and if there are no problems with bottom integration. Post processing systems may then be used as backup. More generally, computer based post-processing systems such as the Simrad BI500 or Sonardata Echoview systems are currently being used for scrutinising. The printer output is mostly used as a visual backup.

It is recommended that one depth-range is used for the whole area in the printer output and on post-processing systems. This will ensure that similar echo traces from all parts of the survey area will have the same appearance and hence are visually more comparable.

Allocation to classified schools

In the western and northern part of the area covered by the survey, most of the herring occur in well-defined schools, often of a characteristic shape as pillar-shaped large dense schools or as layers of very small and dense school at the surface. In the northern and central part, schools of Norway pout and herring are difficult to distinguish from each other. In low density area's of the western area mixed layers and aggregation of small schools consisting of gadoids and herring may occur.

Sprat marks in the North Sea and VIa appear mostly as quite large, typical, pillar-shaped marks, usually slightly more diffuse than herring and usually in shallow water.

Use of trawl Information

The allocation of echo-traces to species is governed by the results of trawl hauls. In many cases these are considered together with observations from the netsonde and the echogram during the haul. In some cases it is not possible to assign schools (echo traces) to species directly e.g. where the haul contains a mixture of species and no clear differentiation can be made between the observed schools. In such situations the integral is assigned to a species mixture category according to the trawl results. This is defined as percentage by number or weight taking into account the correct conversion to scattering length (see section 6.2); post processing software is then used to apply weights and lengths. There are two main problems with using trawl data to define "acoustic" mixtures:

- Different species are known to have different catchabilities, so the exact proportions in the trawl are unlikely to be an exact sample of the true mixture. For instance herring are likely to be faster swimmers than Norway pout.

- Herring are often found in a mixture with "0" group pout, which are mostly lost through the meshes. This may also occur with other small gadoids. In this case the exact proportions are unavailable and the operator must make an informed guess.

Thresholding to filter out plankton

An advantage of using a post-processing system like the BI500 and EchoView, is the ability to change the threshold-value of the received echo's. By changing the threshold the non-target-species (plankton in particular) can be filtered out. The threshold used may differ, depending on a variety of conditions, including the water depth (more care should be taken at greater depth) and the particular size of fish. Examples of conditions where certain thresholds have been applied are described below; they should not be used without verification. At the beginning of the survey it is advisable to find the right thresholds by isolating schools and changing the threshold.

In stratified waters (mainly in the northern - and northeastern part of the survey area) there is often a layer of plankton in the upper 50 m. In this layer, very small, dense schools of herring may be found. Normally all the plankton is filtered out at –42 dB. The remaining s_A values may be assigned to herring if clear schools are still visible and, of course, trawl information indicates that herring are present. In the range of 30-60 m the same procedure may be used. Here, s_A values are normally assigned to schools of fish after filtering out plankton by putting the threshold in the range of –48 to –51 dB. In the layer below 60 m a threshold of –54 to –60 dB may be applied. In the deeper parts of the area (>150m) a lower threshold than –60 dB may be applied. At these depths, often close to the bottom, herring schools are normally, larger and easier to recognise.

Use of other frequencies

The echosounder frequency routinely used in the North Sea echo survey is 38 kHz. However, data may be collected at 120 and 200 kHz. In some cases these can be used as an aid to identify marks to species. For instance, herring and mackerel may have different target strengths at different frequencies. Mackerel is believed to backscatter more strongly at 200 kHz than at 38 kHz, whilst for herring the reverse is the case. In the absence of good observations of such relationships, this approach should be used with caution.

Use of single target TS distribution data

The SIMRAD EK500 used with a split-beam transducer allows the collection of TS values for all single targets detected in the beam. A TS distribution can then be produced for each EDSU. In some situations there may be two species present in an area with substantially different TS values, and this could be used to determine the species allocation. Again, this data must be used with caution. There are doubts about the precision of the TS detection algorithm, particularly in older firmware releases. By definition, single targets are unlikely to be detected from fish in schools. As schools are often the main subject for herring acoustic surveys, such data may be unrepresentative. However, where the survey encounters diffuse mixtures, there may be value in such data.

Use of image analysis techniques

The Marine Laboratory Aberdeen has developed an image processing system for post processing of echograms. This can extract a range school descriptors; energetic, morphometric and positional, which can be used to define the characteristics of schools of a particular species. Such systems have also been developed elsewhere and one example is available with Sonardata's Echoview post processing software. In general such systems can differentiate most observed schools to species, however, these are usually the schools which an experienced survey operator can also discriminate by more traditional methods. These systems are likely to become more invaluable in the future when they can be combined with multi-frequency data.

Allocation to mixed layers or mixed schools

Sometimes herring occur mixed with other species in aggregations of smaller schools. In this case, species allocation is based on the composition of trawl catches.

In the southern North Sea, Skagerrak, Kattegat and the Baltic, herring and sprat may occur in mixed schools. Those schools are separated from other fish using the standard scrutinising procedures (see above) and the allocation of the proportion of herring (spring and/or autumn spawners) and sprat is done afterwards on the basis of catch composition. Trawl catches within each stratum (or statistical rectangle) are combined to give an average species, stock, age and length composition of the clupeid fraction of the catch.

BIOLOGICAL SAMPLING

Trawling

Species allocation of the acoustic records is impossible if no trawl information is available. The general rule is to make as many trawl hauls as possible, especially if echo traces are visible on the echosounder after a blank period. If surface schools are known to occur in the area it is often advisable to take occasional surface trawls even in the absence of any significant marks.

The principal objective is to obtain a sample from the school or the layer that appears as an echo trace on the sounder. The trawling gear used is of no importance as long as it is suitable to catch a sample of the target-school or layer. Some dimensions of the trawls used by the participants are given in Table 4.

Table 4. Characteristics of trawl gear used in the North Sea herring survey. "Mesh sizes in all panels" are listed for panels from the mouth of the net to the cod end; the number of entries is not an indication of the number of panels as adjacent panels may have the same mesh size.

Country	Vessel	Power	Code	Name	Type	Panels	Headl	Groundr	Sweeps	Length	Circum	Mesh sizes in all panels						Height	Spread
		kW			B/P	2/4	m	m	m	m	m	mm	mm	mm	mm	mm	mm	m	m
DEN	DAN2																		
GFR	WAH3	2900	GOV	GOV	B	2	36.0	52.8	110.0	51.7	76.0	200	160	120	80	50		4	23
GFR	WAH3	2900	PS205	PSN205	P	4	50.4	55.4	99.5	84.3	205.0	400	200	160	80	50		15	28
GFR	SOL	588	AAL	Aalhopser	B	2	31.0	29.7	63.5	57.5	119.0	160	120	80	40			6	19
GFR	SOL	588	PS388	Krake	P	4	42.0	42.0	63.5	59.8	142.4	400	200	80				10	21
NED	TRI2	2940		2000 M Pel. Trawl	P	4	64.0	72.0	100.0	140.0	400	800	400	200	120	80		16	45
NOR	GOS	1700	3532	Akratral	P	4	72.0	72.0	160.0	130.0	486.4	3200	1620	400	200	100	38	33	
SCO	SCO2	3000	PT160	Pel. Sampl. Trawl	P	4	36.0	36.0	70.0	87.0	256.0	800	600	400	200	100	38	14	20

During trawling it is important to take note of the traces on the echosounder and the netsonde in order to judge if the target-school entered the net or if some other traces "spoil" the sample. It is recommended that notes be made on the appearance and behaviour of fish in the net during every haul. If a target is missed during a haul, the catch composition should not be used for species allocation.

- Representative or length stratified samples

Currently, samples for age and weight are taken in different manners, either as representative or as length-stratified samples, depending on the research vessel. An international standard is currently under discussion.

DATA ANALYSIS

This section describes the calculation of numbers and biomass by species from the echo-integrator data and trawl data. Most of this section is taken from Simmonds *et al.* 1992.

The symbols used in this section are defined in the text but for completeness they have been collated and are given below:

F_i	estimated area density of species i
K	equipment physical calibration factor
$<\sigma_i>$	mean acoustic cross-section of species i
E_i	partitioned echo-integral for species i
E_m	echo-integral of a species mixture
c_i	echo-integrator conversion factor for species i
TS	target strength
TS_n	target strength of one fish
TS_w	target strength of unit weight of fish
a_i, b_i	constants in the target strength to fish length formula
a_n, b_n	constants in formula relating TS_n to fish length
a_w, b_w	constants in formula relating TS_w to fish length
a_f, b_f	constants in the fish weight-length formula
L	fish length
W	weight
L_j	fish length at midpoint of size class j
f_{ij}	relative length frequency for size class j of species i
w_i	proportion of species i in trawl catches
A_k	area of the elementary statistical sampling rectangle k
Q	total biomass

Q_i total biomass for species i

The objective is to estimate the density of targets from the observed echo-integrals. This may be done using the following equation from Foote *et al.* (1987):

$$F_i = \left(\frac{K}{<\sigma_i>}\right)E_i \qquad \textbf{(1)}$$

The subscript i refers to one species or category or target. K is a calibration factor, $<\sigma_i>$ is the mean acoustic cross-section of species i, E_i is the mean echo-integral after partitioning and F_i is the estimated area density of species i. The quantity is the number or weight of species i, depending on whether σ_i is the mean cross-section per fish or unit weight. $c_i= (K/<\sigma_i>)$ is the integrator conversion factor, which may be different for each species. Furthermore, c_i depends upon the size-distribution of the insonified target, and if this differs over the whole surveyed area, the calculated conversion factors must take the regional variation into account.

K is determined from the physical calibration of the equipment, which is described in section 1 above. K does not depend upon the species or biological parameters. Several calibrations may be performed during a survey. The measured values of K or the settings of the EK500 may be different but they should be within 10% of one another. If two successive measurements are very different the cause should be investigated since the equipment may be malfunctioning. Otherwise, K should be taken as the average of two measurements before and after the relevant part of the survey.

Conversion factors for a single species

The mean cross-section $<\sigma_i>$ should be derived from a function which describes the length-dependence of the target-strength, normally expressed in the form:

$$TS = a_i + b_i Log_{10}(L) \qquad \textbf{(2)}$$

Where a_i and b_i are constants for the i'th species, which by agreement with the other participants in the survey are given in Table 5.

Table 5. The recommended target strength relationships for herring surveys in the North Sea and adjacent waters.

	Target Strength Equation Coefficients	
Species	$\mathbf{b_i}$	$\mathbf{a_i}$
Herring	20	-71.2
Sprat	20	-71.2
Gadoids	20	-67.5
Mackerel	20	-84.9
horse mackerel	20	-71.2

The equivalent formula for the cross-section is:

$$\sigma_i = 4\pi 10^{\left(\left(a_i + b_i Log(L)\right)/10\right)} \qquad \textbf{(3)}$$

The mean cross-section is calculated as the σ average over the size distribution of the insonified fish. Thus L_j is the mid-point of the j'th size class and f_{ij} is the corresponding frequency as deduced from the fishing samples by the method described earlier. The echo-integrator conversion factor is $c_i = K/<\sigma_i>$. The calculation may be repeated for any species with a target strength function.

$$< \sigma_i >= 4\pi \sum_j f_{ij} 10^{\left(\left(a_i + b_i Log(L_j)\right)/10\right)} \qquad \textbf{(4)}$$

Note that it is the cross-section that is averaged, not the target-strength. The arithmetic average of the target-strengths gives a geometric mean, which is incorrect. The term "mean target-strength" may be encountered in the literature, but this is normally the target-strength equivalent to $<\sigma_i>$, calculated as $10\log_{10}(<\sigma_i>/4\pi)$. Some authors refer to TS as 10 $\log(\sigma_{bs})$ the definition of σ is different from σ_{bs} and should not be confused.

Conversion factors for mixed species layers or categories

Sometimes several species are found in mixed concentrations such that the marks on the echogram due to each species cannot be distinguished. From inspection of the echogram, the echo-integrals can be partitioned to provide data for the mixture as one category, but not for the individual species. However, further partitioning to species level is possible by reference to the composition of the trawl catches (Nakken and Dommasnes, 1975).

Suppose E_m is the echo-integral of the mixture, and w_i is the proportion of the i'th species, calculated from fishing data. It is necessary to know the target-strength or the acoustic cross-section, which may be determined in the same manner as for single species above. The fish density contributed by each species is proportional to w_i. Thus the partitioned fish densities are:

$$F_i = \frac{w_i K}{\left(\sum_i w_i < \sigma_i >\right)} E_m \qquad \textbf{(5)}$$

The w_i may be expressed as the proportional number or weight of each species, according to the units used for $<\sigma_i>$ and c_i. Consistent units must be used throughout the analysis, but the principles are the same whether it is the number of individuals or the total weight that is to be estimated.

Using weight-length relationships

The abundance is expressed either as the total weight or the number of fish in the stock. When considering the structure of the stock, it is convenient to work with the numbers at each age. However, an assessment of the commercial fishing opportunities would normally be expressed as the weight of stock yield. Consistent units must be used throughout the analysis. Thus if the abundance is required as a weight while the target-strength function is given for individual fish, the latter must be converted to compatible units. This may be done by reference to the weight-length relationship for the species in question.

For a fish of length L, the weight W is variable but the mean relationship is given by an equation of the form:

$$W = a_f L^{b_f} \qquad \textbf{(6)}$$

Where a_f and b_f are taken as constants for one species. However, a_f and b_f could be considered as variables varying differently with stock and time of year as well as species. Suppose the target-strength of one fish is given as:

$$TS_n = a_n + b_n \log_{10}(L) \qquad \textbf{(7)}$$

The corresponding function TS_w, the target-strength of unit weight of fish has the same form with different constants:

$$TS_w = a_w + b_w \log_{10}(L) \qquad \textbf{(8)}$$

The number of individuals in a unit weight of fish is (1/W), so the constant coefficients are related to the formulae:

$$b_w = b_n - 10 b_f \qquad \textbf{(9)}$$

$$a_w = a_n - 10 \log_{10}(a_f) \qquad \textbf{(10)}$$

Abundance estimation

So far the analysis has produced an estimate of the mean density of the insonified fish, for each part of the area surveyed, and for each species considered. The next step is to determine the total abundance in the surveyed area. The abundance is calculated independently for each species or category of target for which data have been obtained by partitioning the echo-integrals. The calculations are the same for each category:

$$Q_i = \sum_{k=1}^{n} A_k F_i \qquad \textbf{(11)}$$

The total biomass for all species is:

$$Q = \sum_{i} Q_i \qquad \textbf{(12)}$$

The F_i are the mean densities and A_k are the elements of the area that have been selected for spatial averaging. They may be calculated from the shape of an area or measured, depending upon the complexity of the area. The presence of land should be taken into account, possibly by measuring the proportions of land and sea.

DATA EXCHANGE

Each individual country is responsible for working up its own survey data. However, the results need to be submitted to the chair of the PGHERS in a standard format for the coordinated survey results. In addition, the s_A values per sampling unit allocated to target species together with all trawl information should be entered in the international database for acoustic herring surveys in the North Sea (HERSUR-database).

Exchange of data for the combined survey result.

The standard spreadsheet template should be used to enter the results of the survey by ICES statistical rectangles on two data sheets: the cruise sheet by ICES statistical rectangle; and the proportions by age class sheet.

The cruise sheet consists of six columns of data with as many rows as there are statistical rectangles sampled in the survey. The six columns are: the central (decimalised) latitude of the ICES rectangle; central (decimalised) longitude of the ICES rectangle; the biological sub-area to which the ICES rectangle belongs; the ICES statistical rectangle code (calculated according to the first two columns); herring abundance in millions of fish; and the survey weight (in nautical miles of survey track per rectangle). Part of an example data sheet is given in Table 6.

The proportions data contains the proportion of North Sea autumn spawners and Baltic spring spawners broken down according to biological sub-areas (in rows) and age/maturity (in columns). These proportions can be submitted as actual proportions or as total abundances. It also contains the mean weights at age/maturity by biological sub-area for North Sea autumn spawners and Baltic spring spawners. An example of this data sheet is given in Table 7.

For coordinated surveys a joint report is produced that contains charts with the following results:

- number of 1-ringed herring per rectangle
- number of 2-ringed herring per rectangle
- number of 3+ringed herring per rectangle
- total number and total biomass of herring per rectangle (excluding 0-ringers)

In order for the coordinator to prepare this report, the following data should be supplied by each participant:

- a chart giving the total number of herring per rectangle (excluding 0-ringers)
- a chart showing the stratification for age keys and mean weights per age
- for each stratum an age/length key and the mean weight by age group. The age groups (in winter rings) to be used are:

1,2 immature (maturity stage 1 or 2), 2 mature (maturity stage 3+), 3 immature, 3 mature, 4, 5, 6, 7, 8, 9+.

Data exchange for the international acoustic database (HERSUR).

All acoustic data from the national surveys is to be entered in the international database for acoustic surveys in the North Sea (HERSUR) together with the biological data from trawling.

Acoustic data, consisting of the s_A value per sampling unit allocated to species, together with additional information on time, position and instrumentation shall be exchanged according to the format described in the HERSUR Exchange Format Specification (to be submitted March 2000). This specification also described how trawl information is to be submitted.

Data exchange will be performed through the Internet (www.dfu.min.dk/hersur) through XLM files described in the HERSUR Exchange Format Specification. A users guide to the Internet site and upload procedure will be submitted in March 2000.

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Table 6. An example of the excel worksheet used to submit survey data by ICES statistical rectangle - the 'cruise sheet' with data from four ICES statistical rectangles.

1999 Cruise sheet on ICES stat square scale.
Ship name and country (in here): Scotia

Origin:	**00A0**
lat	**35.5**
long	**-50**

Latitude	Longitude	Sub-area	Stat Rect	Abundance (millions)	Survey weight (n.mi.)
59.75	2.5	**A**	**48F2**	15.00	40
59.75	3.5	**A**	**48F3**	9.35	45
59.25	2.5	**B**	**47F2**	2.65	27
59.25	3.5	**B**	**47F3**	12.33	60
			-71F0		
			-71F0		
			-71F0		
			-71F0		
			-71F0		
			-71F0		
			-71F0		
			-71F0		
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			-71F0		
			-71F0		

Table 7. An example of the excel worksheet used to submit survey data broken down by age/sub area - the 'proportions sheet'.

	North Sea Autumn spawners.								Weights in over here >>>>>>				
				Abundance (proportion of)......									
Sum	**Stratum**	**0**	**1**	**2i**	**2m**	**3i**	**3m**	**4**	**5**	**6**	**7**	**8**	**9+**
0.000	**A**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	**B**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	**C**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	**D**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	**E**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	**F**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	**G**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	**H**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	**I**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	**J**	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

North Sea Autumn spawners....											
Mean weight (grams).....											
0	**1**	**2i**	**2m**	**3i**	**3m**	**4**	**5**	**6**	**7**	**8**	**9+**
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

APPENDIX 7

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