

**2001 ICES COORDINATED ACOUSTIC SURVEY OF  
ICES DIVISIONS IIIa, IVa, IVb AND VIa (NORTH)**

E J Simmonds<sup>1</sup>, D G Reid<sup>1</sup>, E Torstensen<sup>2</sup>,  
K-J Staehr<sup>3</sup>, C. Zimmermann<sup>4</sup> S Jansen<sup>4</sup> E Götze<sup>6</sup>, and A S Couperus<sup>5</sup>

<sup>1</sup>FRS Marine Laboratory, PO Box 101, Victoria Road, Torry,  
Aberdeen, AB11 9DB, Scotland, UK

<sup>2</sup>Institute of Marine Research, Bergen, Norway

<sup>3</sup>Danish Institute for Fisheries Research, The North Sea Centre, Hirtshals, Denmark

<sup>4</sup>Inst Seefischerei, Hamburg

<sup>5</sup>RIVO, IJmuiden, The Netherlands

<sup>6</sup>Inst Fischereitechnik, Hamburg

ABSTRACT

Six surveys were carried out during late June and July covering most of the continental shelf north of 54°N in the North Sea and to the west of Scotland to a northern limit of 62°N. The eastern edge of the survey area was bounded by the Norwegian and Danish coasts, and to the west by the shelf edge between 200 and 400 m depth. The surveys are reported individually in the report of the planning group for herring surveys, and a combined report has been prepared from the data from all surveys. The combined survey results provide spatial distributions of herring abundance by number and biomass at age by statistical rectangle; and distributions of mean weight and fraction mature at age.

INTRODUCTION

Six surveys were carried out during late June and July covering most of the continental shelf north of 54°N in the North Sea and 56°N to the west of Scotland to a northern limit of 62°N. The eastern edge of the survey area is bounded by the Norwegian, Danish and German coasts, and to the west by the shelf edge at approximately 200 m depth. The surveys are reported individually in appendices Ia-f of the report of the planning group for herring surveys (ICES, 2002). The vessels, areas and dates of cruises are given below and in Figure 1:

Vessel	Dates	Area Surveyed	Days
RV Taits	10-30 July	56- 60N, 4 - 10 W	21
M. Sars	29 June – 24 July	57- 6130 N, 2 - 8 E	27
Scotia	3 July – 23 July	58- 6130 N, 4 W - 2 E	21
Tridens	25 June – 20 July	54 30 - 58 N, west of 3 E	26
Solea	29 June – 20 July	54 - 57 N, east of 3 E	22
Dana	30 June – 11 July	North of 57 N, east of 6 E	13

The data has been combined to provide an overall estimate. Estimates of numbers at age, maturity stage and mean weights at age are calculated as weighted means of individual

survey estimates by ICES statistical rectangle. The weighting applied is proportional to the survey track for each vessel that has covered each statistical rectangle. The data has been combined and estimates of North Sea autumn spawning herring, Western Baltic spring spawning herring, and West of Scotland (VIa<sub>north</sub>) herring are shown in Tables 1-3.

## METHODS

The acoustic surveys were carried out using Simrad EK500 or EY500 38 kHz sounder echo-integrator with transducers mounted on the hull, drop keel and towed bodies. Further data analysis was carried out using either BI500, Echoview or Echoann software. The survey track was selected to cover the area giving a basic sampling intensity over the whole area 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 some relatively high density sections east of Orkney, east and west of Shetland, and in the Skaggeerak where short additional transects were carried out at 7.5 nm spacing.

The following target strength values have been used to analyse the data:

herring	TS = 20 log L - 71.2 dB
sprat	TS = 20 log L -71.2 dB
gadoids	TS = 20 log L - 67.5 dB
mackerel	TS = 21.7 log L - 84.9 dB

A part of the area comprising the five ICES rectangles 45E7, 45E8, 45E9, 45F0 & 45F1 from 4°W to 2°E and latitude 58° to 58°30' N was not surveyed in 2001 (Fig. 1). While this is not a critical part of the area, an analysis of historical data (1989-2000) indicated that it could contribute up to 5% to the total biomass of the combined survey. On previous occasions, unsurveyed areas were thought to contribute less than 1% of the total and were, therefore, ignored. This year there is therefore the potential for the unsurveyed area to cause bias and so it was deemed important to fill in the area with an estimate of abundance. However, as there is no established method for filling in missing in data, the following three options were examined:

1. An average proportion of abundance in the missing area relative to that of the whole area. In this area the average biomass over the 12-year period is 4.6% of the total biomass. Applying the same proportion gives an estimate for the missing area of 154,000 t in 2001.
2. A median factor of the mean density in the area to the mean density derived from adjacent connecting rectangles (5 north, 5 south and one to the east) over the 12-year period. The median density factor is 1.18 which gives an estimate for the missing area of 211,000 t in 2001.
3. A linear interpolated value from the adjacent 4 connecting rectangles in 2001. This is similar to a kriging estimate for the missing data when the data is on a regular grid. This method gives an estimate for the missing area of 178,000t in 2001.

Option 3 lies almost exactly half way between the other two options so has been chosen as a good compromise. This result contributes an additional 5.5% to the overall North Sea abundance for the remaining fully surveyed area. The increases in immature and mature proportions are similar in magnitude at 5.5 and 5.6% respectively.

## Combined Acoustic Survey Results

The estimates of North Sea SSB are 2.4 million tonnes and 15,000 millions herring (Table 1). The North Sea survey is consistent with previous years, giving a total adult mortality of about 0.4 over the last 2 years, which is similar to the estimates from the assessment, (0.45). The SSB in the 2001 survey is seen to be rising from 1.7 million tonnes in 2000 (Table 4) to 2.6 million tonnes in 2001. The survey also shows the exceptional numbers of 2 ring herring in the 1998 year class, in the North Sea, which is consistent with the observation of an exceptionally large year class observed in the MIK and IBTS surveys (ICES 2001) and the acoustic survey in 2000. The acoustic survey indicates that the abundance of this year class is still 4 times the preceding (1997) year class (Table 4), which is consistent with the 2000 survey.

The system for combining surveys was developed in 1997 recently the historic survey series was entered into the same system. The original surveys were combined with equal weight, later they were weighted by the survey effort. There are small changes to the series due to these differences in the analysis. In addition a calibration error of 9% was found in the Scottish survey following the change in transducer with the new vessel 3 years ago. The new series has been tested in the assessment and there are small differences in the results, an increase of 3% in SSB and a reduction of 2.5% in terminal  $f$  for ages 2-6wr. These are not significant changes in a management context.

The estimates of Western Baltic spring spawning herring SSB are 100,000 tonnes and 774 millions (Table 2) and show a reduction compared with previous years, with a decrease in SSB from 2000 (Table 5).

The West of Scotland survey gives estimates of SSB are 359,000 tonnes and 2,100 millions (Table 3), and shows the high 1995 year class again this year (Table 6), total adult mortality shows higher mortality (0.5) but the mean mortality over the last 3 years has been 0.3 this is consistent with the 2001 assessment that the stock is lightly exploited (ICES 2001).

The spatial distributions of the abundance (numbers and biomass) of autumn spawning herring are shown in Figures 2. The distribution of numbers by age are shown in figures 3 for 1 ring, 2 ring and 3+ ring autumn spawning herring. The survey provides estimates of maturity and weight at age, the mean weight at age for 1 and 2 ring herring along with the proportion mature for 2 and 3 ring herring are shown in Figure 4. The spatial distribution of mature and immature autumn spawning herring is shown in Figures 5 & 6 respectively. The spatial distributions of the abundance (numbers and biomass) of Western Baltic spring spawning herring are shown in Figures 7. The distribution of numbers by age are shown in Figures 8 for 1 ring, 2 ring and 3+ ring. The mean weight at age for 1 and 2 ring herring along with the proportion mature for 2 and 3 ring herring are shown in Figure 9. The spatial distribution of mature and immature Western Baltic spring spawning herring is shown in Figures 10 & 11 respectively.

## REFERENCES

- ICES. 2001. Report of the Herring Assessment Working Group for the Area South of 62°N. ICES CM 2000/ACFM:10.
- ICES. 2002. Report of the planning group for herring surveys. ICES CM 2002/G:02.

TABLE 1 Total numbers and biomass of North Sea autumn spawning herring in the area surveyed in the acoustic surveys July 2001, with mean weights, mean lengths and fraction mature by winter ring.

Age (wr)	Numbers	Biomass	Maturity	weight(g)	length (cm)
0	14052.7	113.0	0.00	8	10.6
1	6837.1	343.0	0.00	50	18.4
2	12290.5	1561.6	0.77	127	24.1
3	3082.8	499.1	0.92	162	25.9
4	1461.9	298.9	1.00	204	27.8
5	1676.1	381.5	1.00	228	28.7
6	449.6	106.8	1.00	237	29.0
7	169.6	43.2	1.00	255	29.7
8	97.7	27.9	1.00	286	30.6
9+	58.9	17.3	1.00	294	31.6
Immature	23979.0	770.1			
Mature	16197.8	2622.1			
Total	40176.8	3392.2			

TABLE 2 Total numbers and biomass of Western Baltic spring spawning herring in the area surveyed in the acoustic surveys July 2001, with mean weights, mean length and fraction mature by winter ring.

Age (wr)	Numbers	Biomass	Maturity	weight(g)	length (cm)
0	0.0	0.0	0.00		
1	65.5	3.5	0.10	54	19.3
2	641.2	55.6	0.33	87	22.0
3	452.3	51.2	0.52	113.2	23.8
4	153.1	21.5	1.00	140.5	25.2
5	96.4	17.9	1.00	185.2	27.3
6	37.6	6.9	1.00	182.6	27.6
7	23.0	4.8	1.00	206.3	28.4
8	8.5	1.9	1.00	222.2	30.0
9+	3.4	0.8	1.00	238.8	30.5
Immature	707.0	64.4			
Mature	774.0	99.6			
Total	1481.0	164.0			

TABLE 3 Total numbers and biomass of autumn spawning of West of Scotland herring in the area surveyed in the acoustic surveys July 2001, with mean weights, mean lengths and fraction mature by winter ring.

Age (wr)	Numbers	Biomass	Maturity	weight(g)	length (cm)
0	70.3	0.2	0.00	3	7.5
1	313.1	19.6	0.00	62	19.2
2	1062.7	139.8	0.93	132	24.3
3	217.7	37.1	0.99	170	26.4
4	172.8	32.8	1.00	190	27.3
5	437.5	86.7	1.00	198	27.7
6	132.6	28.1	1.00	212	28.2
7	102.8	22.6	1.00	220	28.6
8	52.4	12.3	1.00	236	29.2
9+	34.7	8.8	1.00	254	29.9
Immature	462.2	28.8			
Mature	2134.3	359.2			
Total	2596.5	388.0			

TABLE 4

Estimates of North Sea autumn spawners (millions) at age from acoustic surveys, 1984-2001. For 1984-1986 the estimates are the sum of those from the Division IVa summer survey, the Division IVb autumn survey, and the Divisions IVc, Vild winter survey. The 1987 to 2001 estimates are from the summer survey in Divisions IVa,b and IIIa excluding estimates of Division IIIa/Baltic spring spawners. For 1999 and 2000 the Kattegat was excluded from the results because it was not surveyed. Estimates in 2000 and 1999 modified following checks in historic series.

Year	Numbers (millions)																			
	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001		
Age (ring)																				
1	551	726	1,639	13,736	6,431	6,333	6,249	3,182	6,351	10,399	3,646	4,202	6,198	9,416	4,449	5,087	24,735	6,837		
2	3,194	2,789	3,206	4,303	4,202	3,726	2,971	2,834	4,179	3,710	3,280	3,799	4,557	6,363	5,747	3,078	2,922	12,290		
3	1,005	1,433	1,637	955	1,732	3,751	3,530	1,501	1,633	1,855	957	2,056	2,824	3,287	2,520	4,725	2,156	3,083		
4	394	323	833	657	528	1,612	3,370	2,102	1,397	909	429	656	1,087	1,696	1,625	1,116	3,139	1,462		
5	158	113	135	368	349	488	1,349	1,984	1,510	795	363	272	311.0	692.1	982.4	506.4	1,006	1,676		
6	44	41	36	77	174	281	395	748	1,311	788	321	175	98.7	259.2	445.2	313.6	482.5	449.6		
7	52	17	24	38	43	120	211	262	474	546	238	135	82.8	78.6	170.3	138.6	266.4	169.6		
8	39	23	6	11	23	44	134	112	155	178	220	110	132.9	78.3	45.2	54.3	120.4	97.7		
9+	41	19	8	20	14	22	43	56	163	116	132	84	206.0	158.3	121.4	87.2	97.2	58.9		
Total	5,478	5,484	7,542	20,165	13,496	16,377	18,262	12,781	17,173	19,326	13,003	11,220	18,786	22,028	16,104	15,107	34,928	26,124		
Z(2+/3+)	0.92	0.57	1.02	0.81	0.81	0.11	0.11	0.57	0.37	0.74	1.21	0.53	0.43	0.40	0.76	0.60	0.34	0.37		
Smoothed Z(2+/3+)	0.78	0.70	0.82	0.82	0.46	0.13	0.32	0.44	0.53	0.92	0.91	0.57	0.45	0.50	0.91	0.46	0.22	0.45		
SSB ('000 t)	807	697	942	817	897	1,637	2,174	1,874	1,545	1,216	1,035	1,082	1446.2	1,780	1,792	1,534	1,833	2,622		

TABLE 5

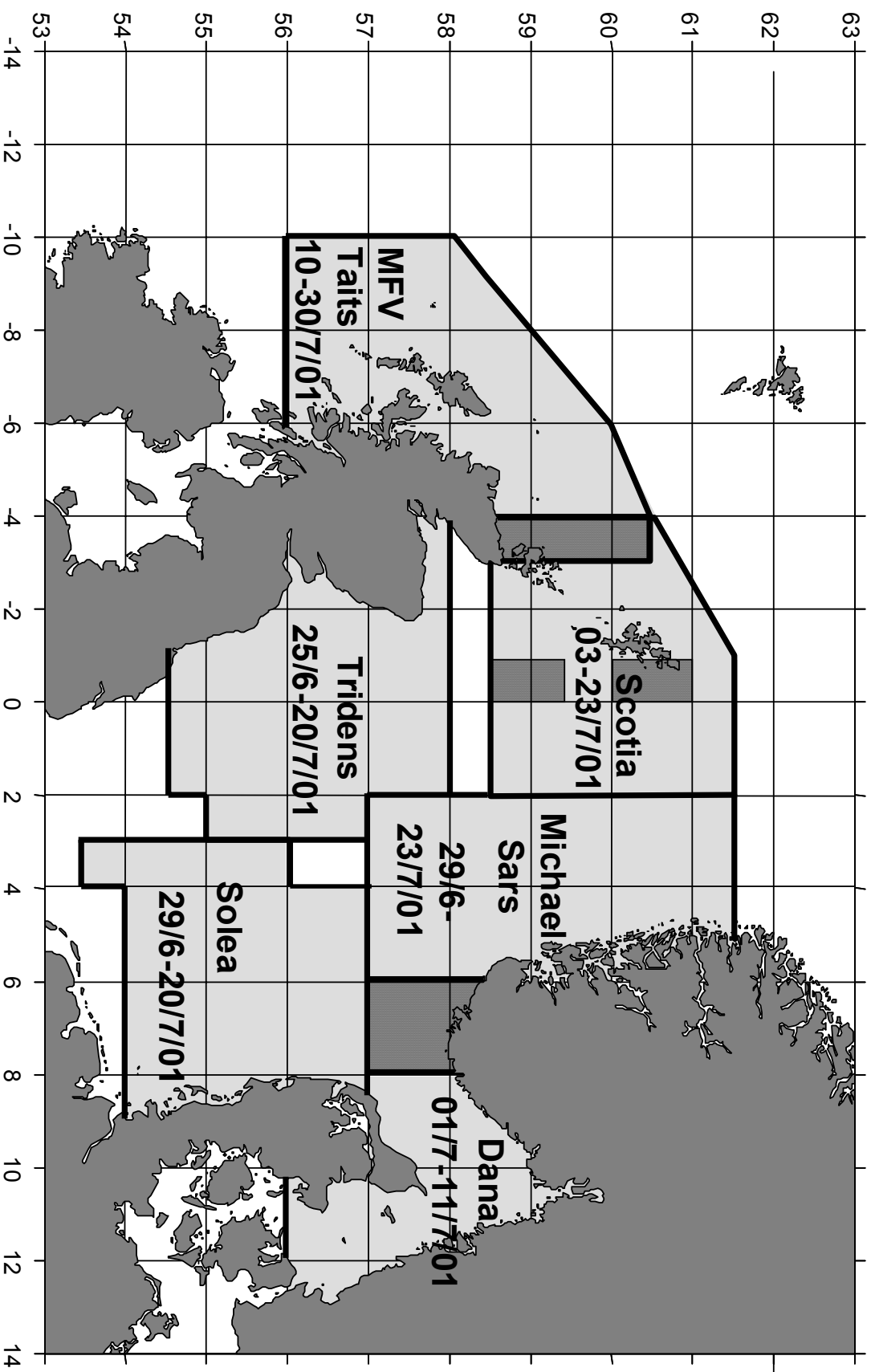
Numbers of Western Baltic Spring Spawning herring at age (winter rings) from acoustic surveys 1991 to 2001.

AGE	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
2	1864	2092	2768	413	1887	1005	715	1682	1143	1891.1	641.2
3	1927	1799	1274	935	1022	247	787	901	522.7	673.6	452.3
4	866	1593	598	501	1270	141	166	282	134.8	363.9	153.1
5	350	556	434	239	255	119	67	111	28.3	185.7	96.4
6	88	197	154	186	174	37	69	51	2.8	55.6	37.6
7	72	122	63	62	39	20	80	31	1.5	6.9	23.0
8	10	20	13	34	21	13	77	53	0.7	9.6	11.9

TABLE 6

Numbers at age and SSB of West of Scotland Autumn Spawning herring at age (winter rings) from acoustic surveys 1987, 1991 to 2001. Values in 1999 modified following checks in historic data.

Age	1987	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
1	249.1	338.3	74.3	2.8	494.2	441.2	41.2	792.3	1221	534.2	447.6	313.1
2	578.4	294.5	503.4	750.3	542.1	1103	576.5	641.9	794.6	322.4	316.2	1062
3	551.1	327.9	211.0	681.2	607.7	473.2	802.5	286.2	666.8	1388	337.1	217.7
4	353.1	367.8	258.1	653.1	285.6	450.3	329.1	167.0	471.1	432.0	899.5	172.8
5	752.6	488.3	414.8	544.0	306.8	153.0	95.4	66.1	179.1	308.0	393.4	437.5
6	111.6	176.3	240.1	865.2	268.1	187.1	60.6	49.5	79.3	138.7	247.6	132.6
7	48.1	98.7	105.7	284.1	406.8	169.1	77.4	16.3	28.1	86.5	199.5	102.8
8	15.9	89.8	56.7	151.7	173.7	236.5	78.2	29.0	13.9	27.6	95.0	52.4
9+	6.5	58.0	63.4	156.2	131.9	201.5	114.8	24.4	36.8	35.4	65.0	34.7
SSB	273.0	452.0	351.5	866.2	533.7	452.1	370.3	140.9	375.9	419.5	460.2	359.2



**Figure 1.** Survey area layouts and dates for all participating vessels in the 2001 acoustic survey of the North Sea and adjacent areas. Shaded areas indicate areas of overlap.

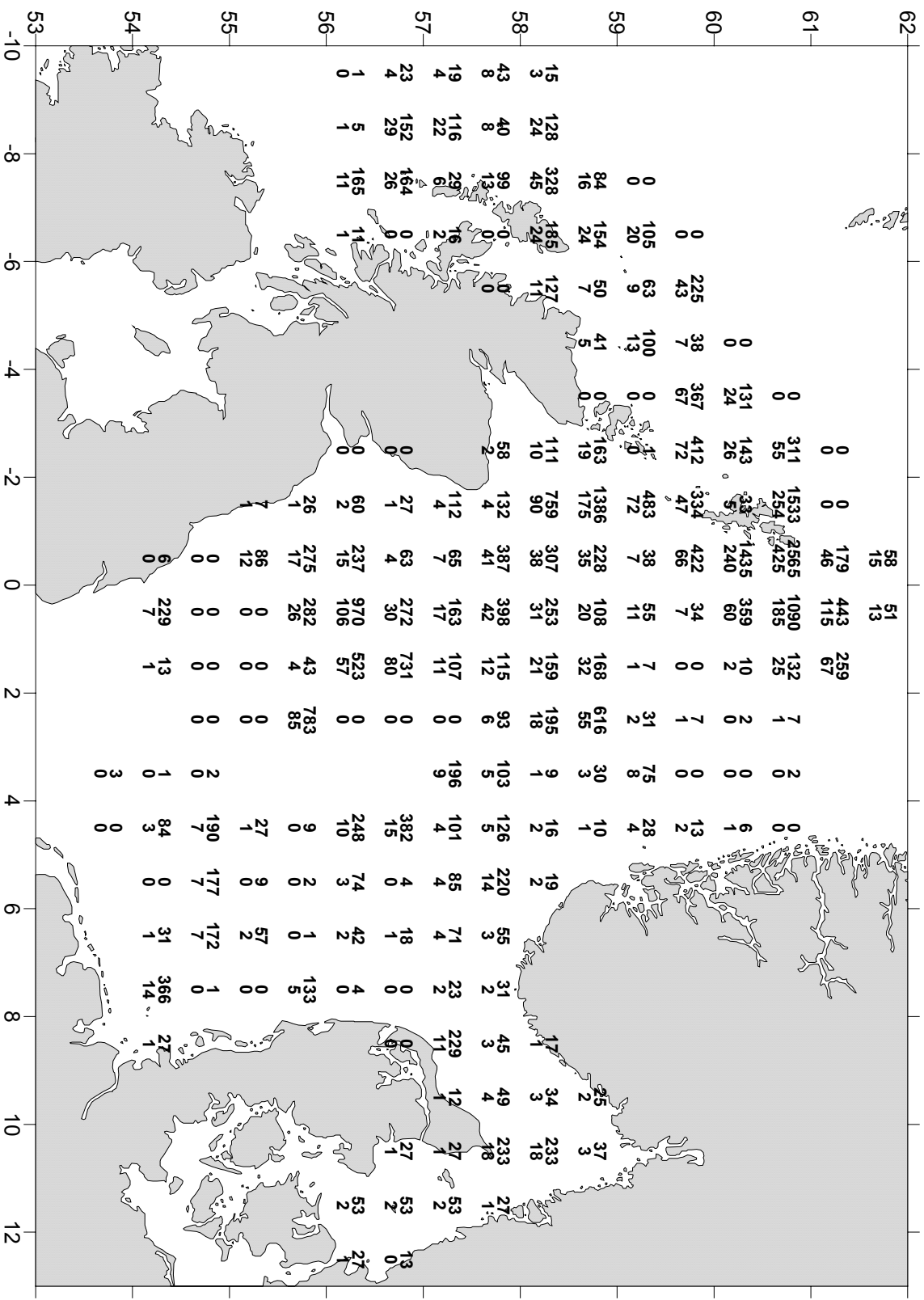


Figure 2 Abundance of Autumn spawning herring from combined acoustic survey July 2001. Numbers (millions) (upper figure), and biomass (thousands of tonnes) (lower figure)



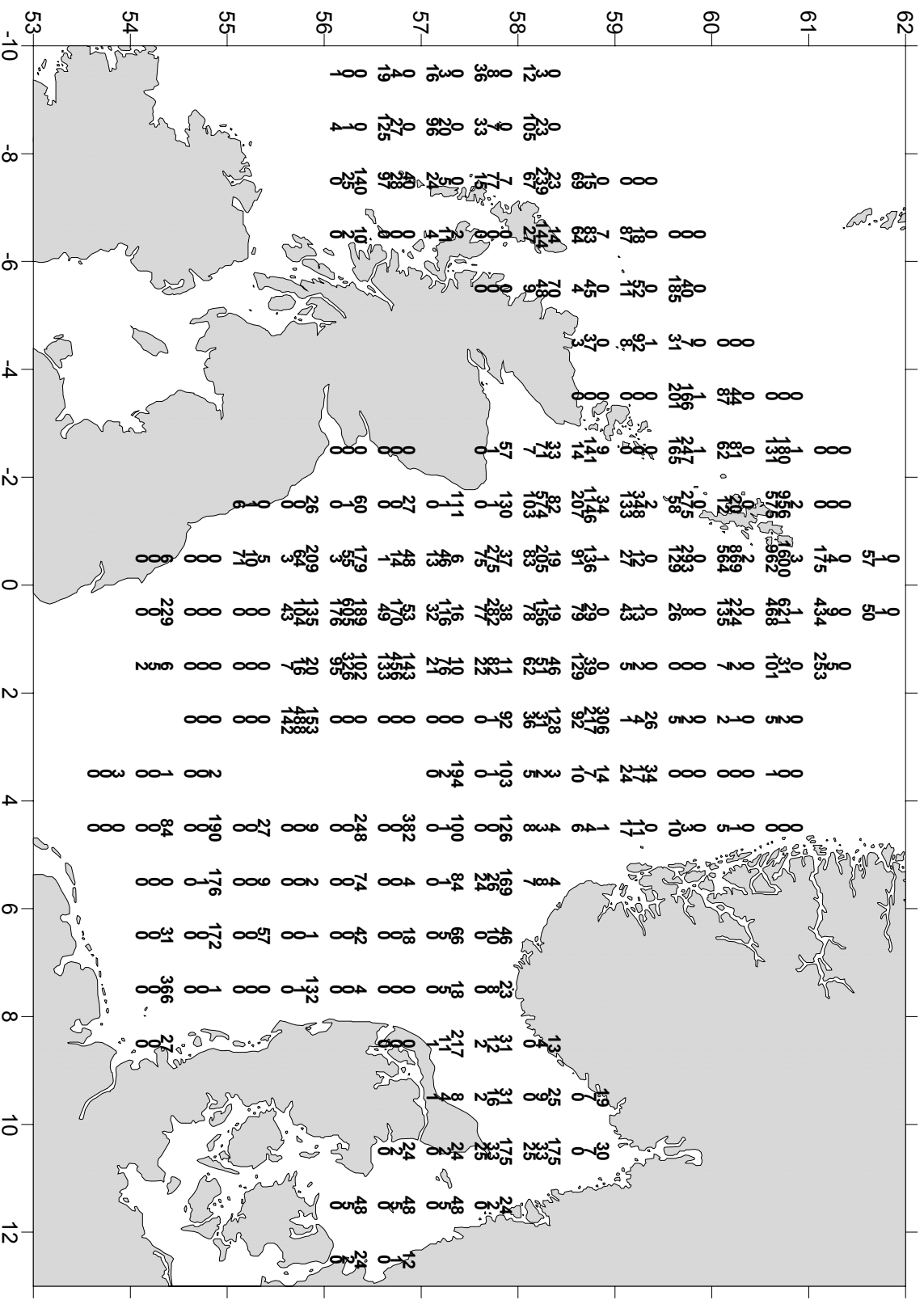


Figure 3 Numbers (millions) of Autumn spawning herring from combined acoustic survey July 2001. 1 ring (upper figure), 2 ring (centre figure), 3+ (lower figure)

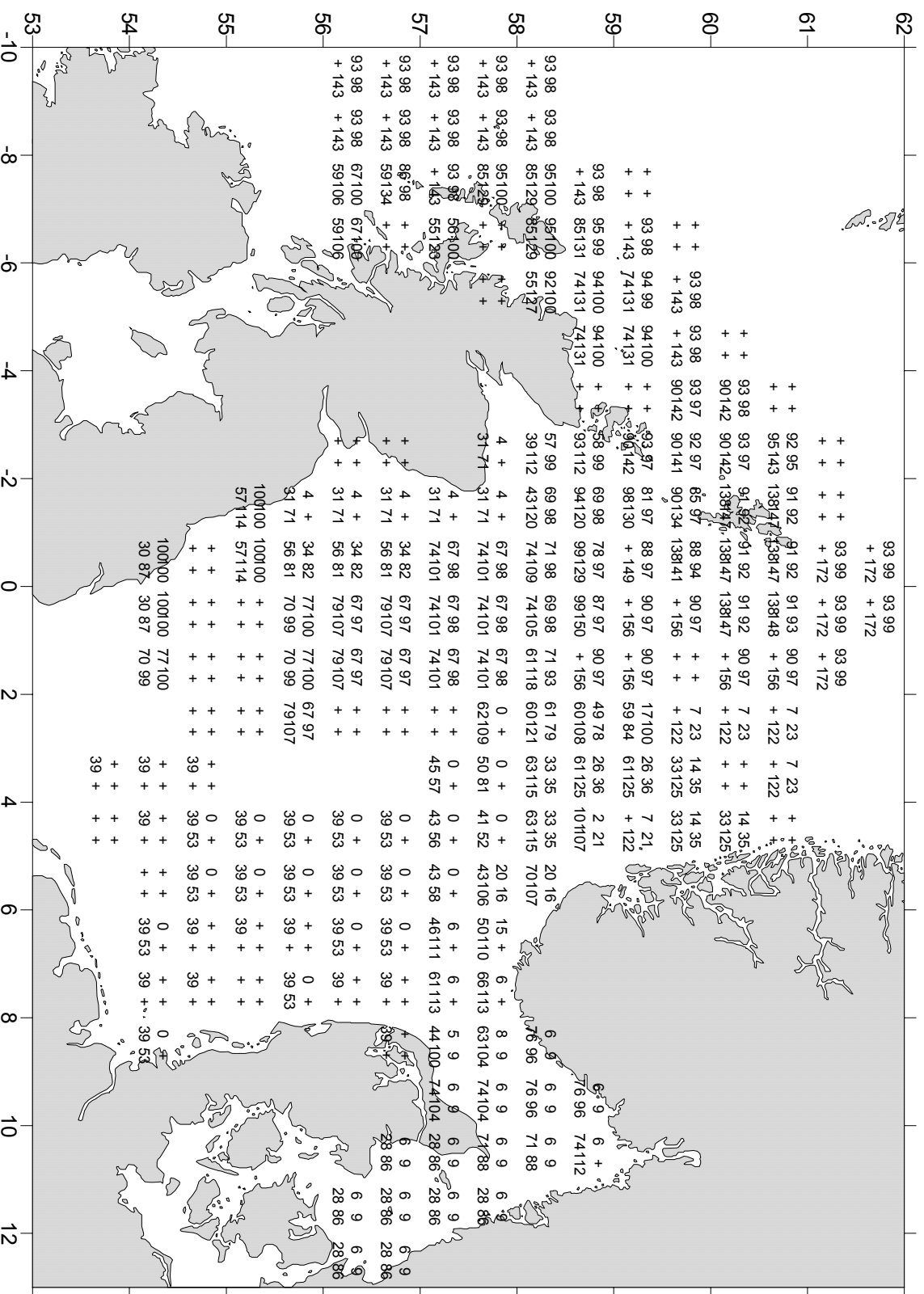


Figure 4 Mean weight & maturity of Autumn spawning herring from combined acoustic survey July 2001. Fraction mature (upper) 2 ring (left), 3 ring (right), mean weights (lower) 1 ring (left), 2 ring (right), 0 indicates measured fraction mature, + indicates surveyed with zero abundance, blank unsurveyed rectangle.

Figure 5 Abundance of mature autumn spawning herring from combined acoustic survey July 2001. Numbers of herring,

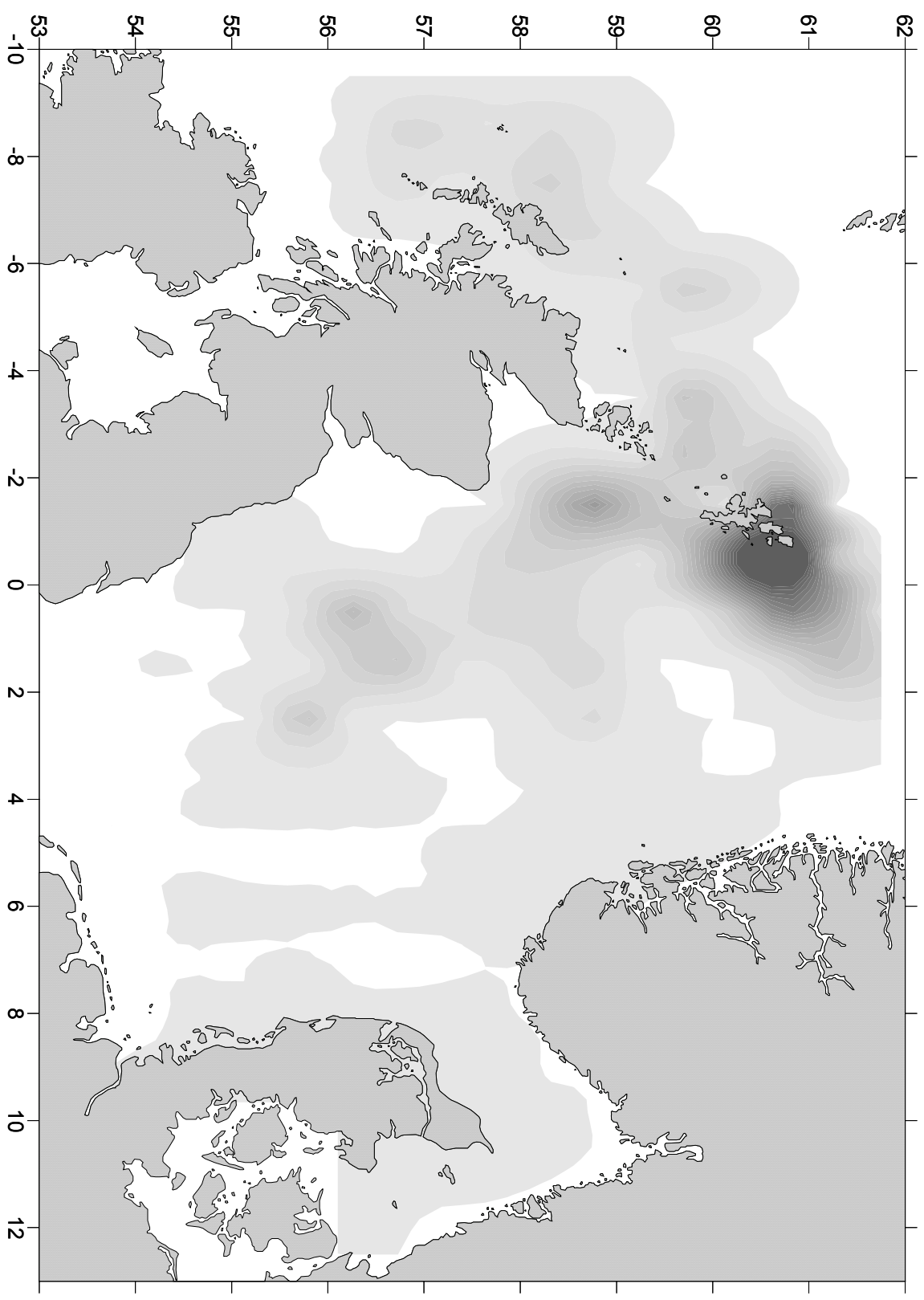
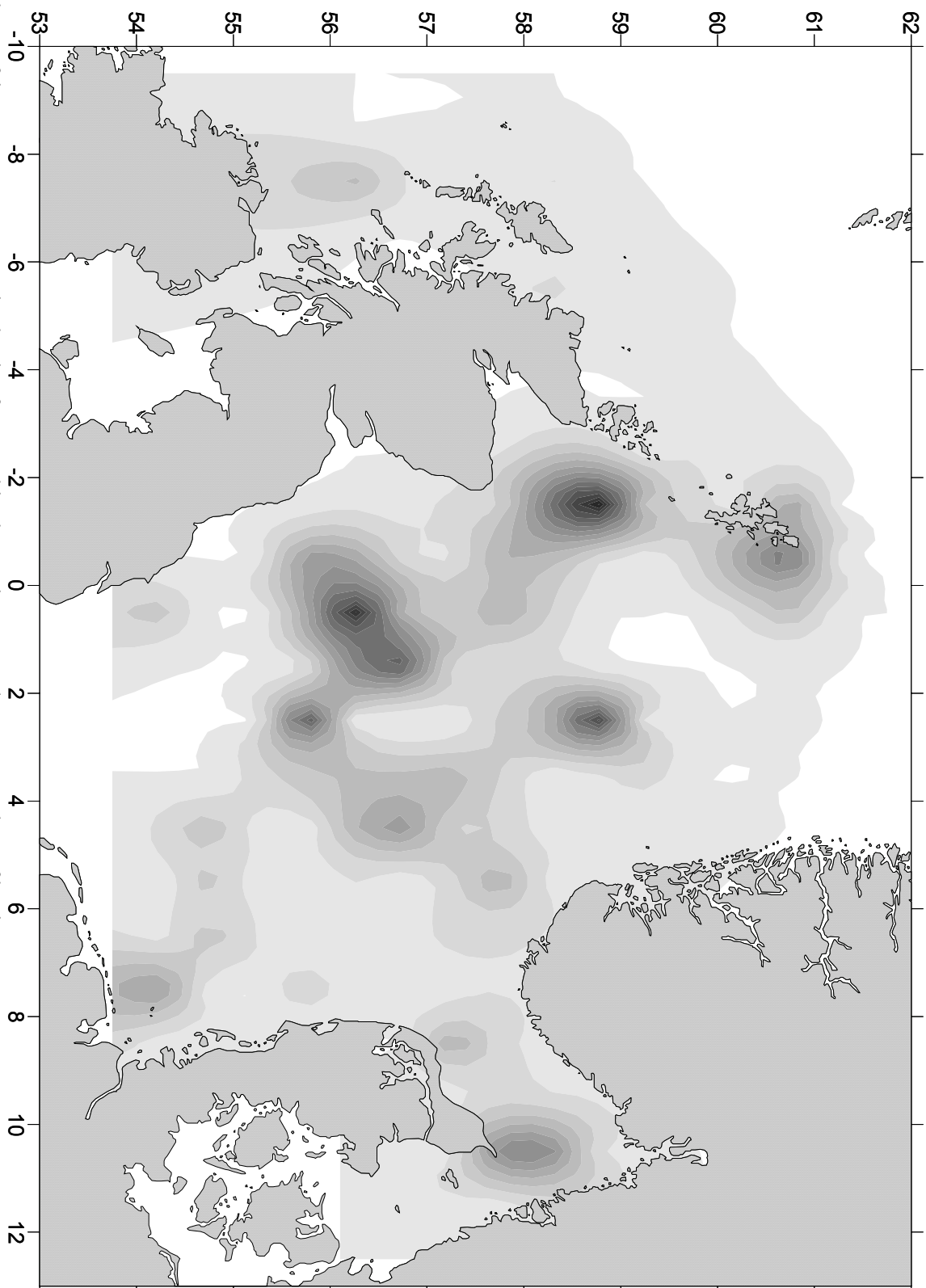


Figure 6 Abundance of immature autumn spawning herring from combined acoustic survey July 2001. Numbers of herring..



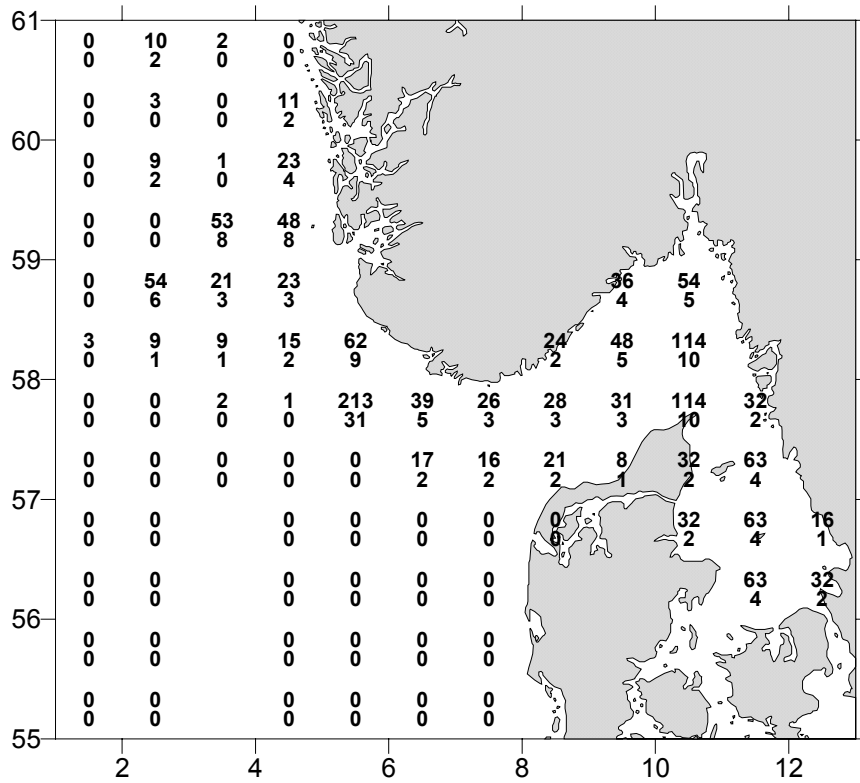


Figure 7 Numbers (millions) (upper =) and biomass (thousands of tonnes) (lower) of Western Baltic spring spawning herring from combined acoustic survey July 2001.

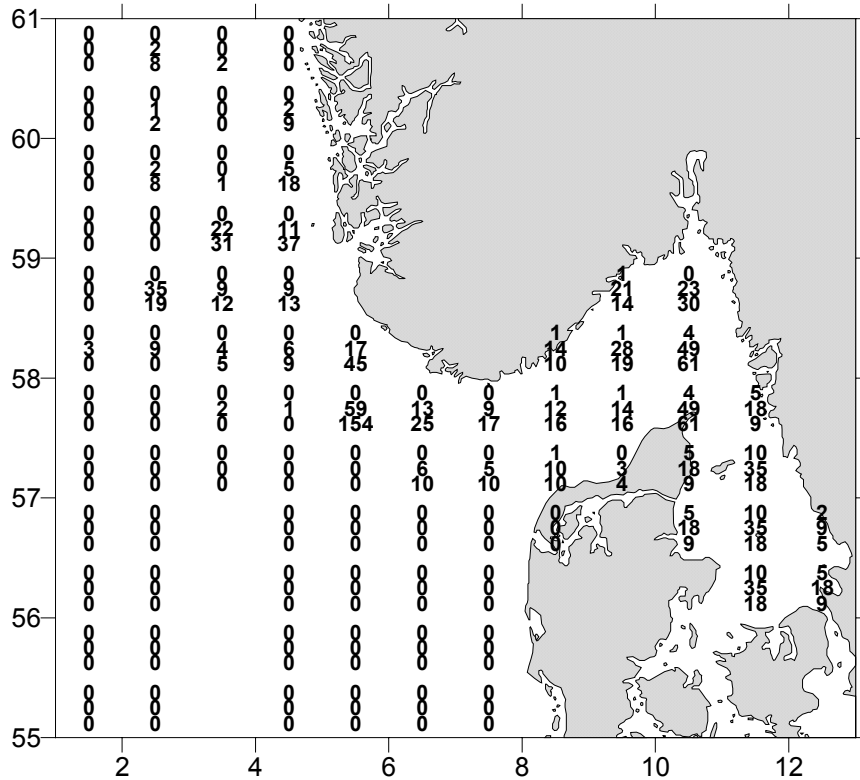


Figure 8 Numbers (millions) of Western Baltic spring spawning herring from combined acoustic survey July 2001. 1 ring (upper figure), 2 ring (centre figure), 3+ (lower figure)

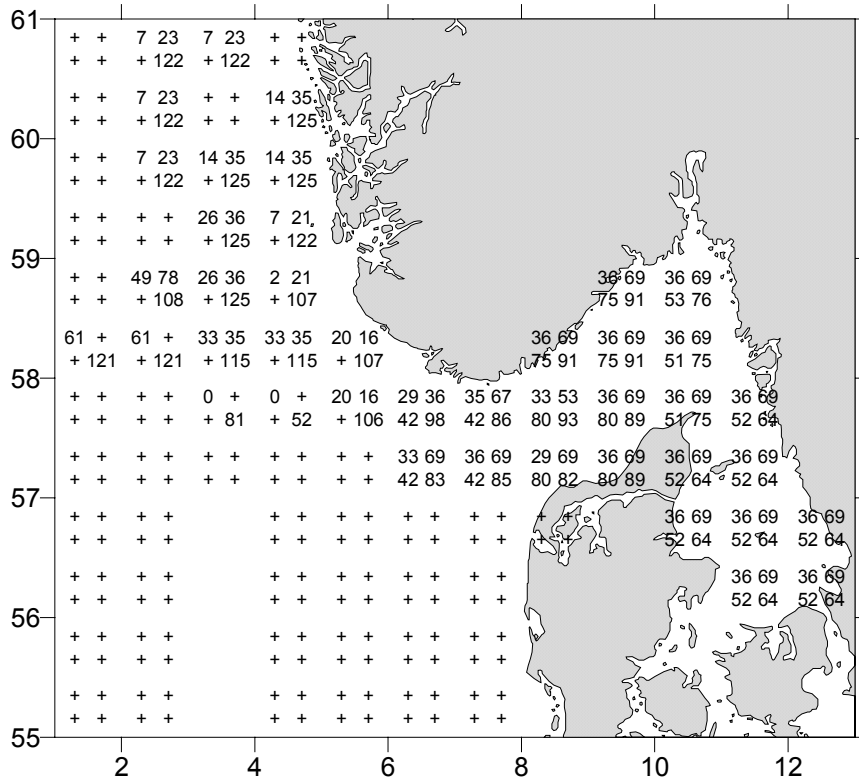


Figure 9 Mean weight & maturity of Western Baltic spring spawning herring from combined acoustic survey July 2001. Fraction mature (upper) 2 ring (left), 3 ring (right), mean weights (lower) 1 ring (left), 2 ring (right), 0 indicates measured fraction mature, + indicates surveyed with zero abundance, blank unsurveyed rectangle.

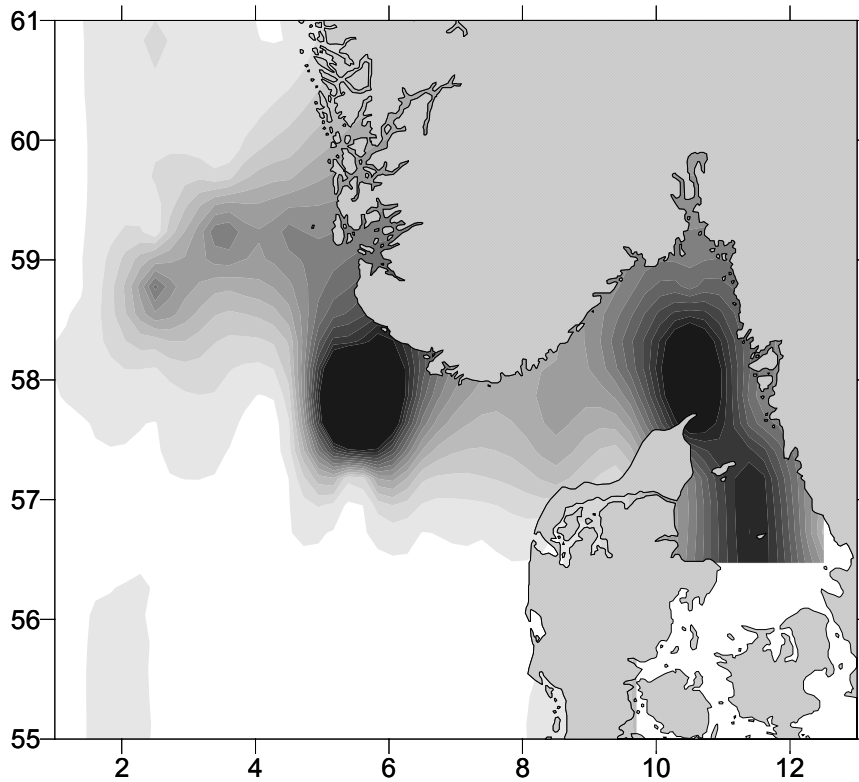


Figure 10 Abundance of mature Western Baltic spring spawning herring from combined acoustic survey July 2001. Numbers of herring.

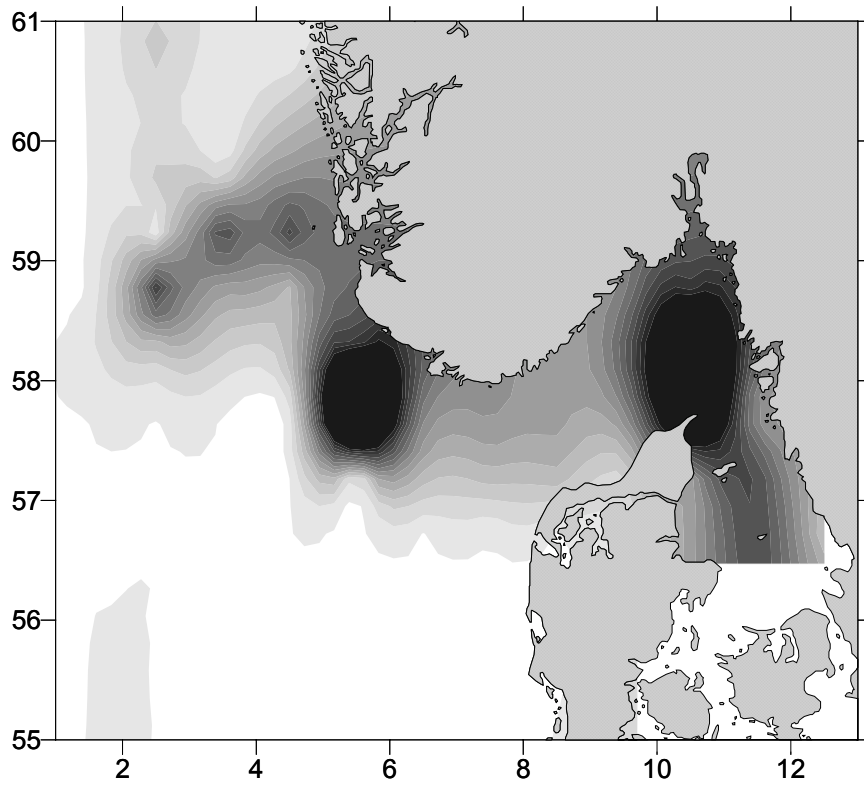


Figure 11 Abundance of immature Western Baltic spring spawning herring from combined acoustic survey July 2001. Numbers of herring.