Toktrapport/Havforskningsinstituttet/ISSN 1503-6294/Nr. 2 - 2007

HAVFORSKNINGSINSTITUTTET
INSTITUTE OF MARINE RESEARCH

«Cruise report»

MS "Gardar" 16.02-05.03.2007

Distribution and abundance of Norwegian spring spawning herring during the spawning season in 2007

by

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Participants:

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Objectives

The main objective was to study the distribution, abundance and age- and size composition of Norwegian spring spawning herring at the spawning grounds from Vesterålen in the north to Møre in the south.

Material and methods

Survey design and stations

During the period 16th of February to 5th of March 2007 the spawning grounds from Møre to Vesterålen were covered acoustically and with trawling using the commercial vessel MS "Gardar" (Fig. 1). Trawling was carried out on acoustic observations all over the area, at a total of 42 stations. It was early discovered that the main part of the stock already had finished spawning and were migrating westwards entering the Norwegian Sea. Hence, the coverage was extended to the 1000 m depth line, in order to include most of the spent herring in the acoustic estimates. It is still likely that a significant part of the stock already had entered the Norwegian Sea, not being included in the estimate.

Biological sampling

The following variables of individual herring were analysed. Total weight (W) in g and total length (L_T) in cm (measured to nearest 0.5 cm below) on up to 100 individuals per sample,

and in addition the sex, maturity stage, stomach fullness and gonad weight (W_G) in g (given maturity stage<7) were measured in 30 individuals. The maturity stages were determined by visual inspection of gonads as recommended by ICES (Anon. 1962): immature = 1 and 2, maturing = 3 to 4, ripe = 5, spawning = 6, spent = 7 and recovering = 8. Stomach fullness was also noted on a subjective scale from 1 to 5, where 1 is empty and 5 is full and stretched. Gonad samples of maturing and spawning females were collected and stored for measurements of egg diameter, fecundity and atresia on a later stage (responsible scientist, Olav Kjesbu, IMR).

Acoustic data and abundance estimation

Acoustical data were registered with a 38 kHz SIMRAD EK 60 echo sounder and echo integrator. In addition BEI, Bergen echo integrator system, was also applied in the interpretation the data (Knudsen, 1990). The recorded area echo abundance, i.e. the nautical area backscattering coefficient (NASC), s_A (MacLennan et al., 2002), was interpreted and distributed to herring, groundfish and plankton. The data were stored with a resolution of 1 nmi on the horizontal scale and 10 m intervals on the vertical scale.

Conversion of the area echo abundance to numerical fish quantities and biomass was achieved by using the adopted mean target strength, <TS> to length, L, relationship for herring (Eq. 1) as used in the standard assessment surveys (Foote, 1987).

$$<TS> = 20\log L - 71.9 \text{ dB} \quad (1)$$

The number of fish, N, within a particular area (A) was computed in the standard manner:

$$N = <s_A> A (4\pi<\sigma_{bs}>)^{-1} \quad (2),$$

where $<s_A>$ is the mean nautical area backscattering coefficient within the area, A is the size of the area in nmi^2, and $<\sigma_{bs}>$ is the mean backscattering cross section of the fish species, as estimated from the target strength equation (MacLennan et al., 2002). The IMR SAS program BEAM was utilized in the abundance estimation. Areas (A) were set to rectangles, 30 minutes on the latitudinal scale and 1 degree on the longitudinal scale. The areas within these rectangles were reduced according to coverage or according to topography and landline.

Length (L) was set based on biological samples from trawl hauls in these rectangles or/and from nearby rectangles. Similarly these samples were used for biomass estimates using the appropriate mean weights of the herring. A 120 kHz Simrad SH80 sonar was used during the survey. The sonar revealed very few shallow schools, and insignificant amounts of herring avoided the research vessel.

Results

Abundance and distribution

In previous years the herring has mostly been distributed in layers during the spawning season (Slotte, 1998*a*; Slotte & Tangen 2005, 2006); close to the surface at night time and closer to bottom at daytime. In the deeper off shore areas, the daytime layer has often been observed as deep as 300-400 m. The same pattern was observed during the survey in 2007, but this year most of the herring were already spent fish leaving the spawning grounds, and they appeared as a very dispersed layer in the deep during night, and as small schools close to bottom at day time.

The geographical distribution extended all over the study area from Møre in the south to Vesterålen in the north (Fig. 2). The total spawning stock within this area was estimated to 6 million tonnes and 26.8 billion individuals, of which the 2002-, 1999- and 1998-year classes (5-, 8 and 9-year olds) pre-dominated (Table 1). As in 2005 and 2006 (Slotte & Tangen 2005, 2006), most of the stock in 2007 was distributed to the north of the historical important spawning grounds off Møre (Fig. 3), emphasising the tendency of Møre being less important then in the1990s. In fact, the spawning distribution of this stock was far to the north in comparison with historic spawning distributions, and quite equal to 2005 and 2006 (Slotte & Tangen 2005, 2006). This distribution may be related to the new wintering area in the open ocean north off Vesterålen, being farther to the north west than Vestfjorden.

Geographical variations in length, age and stage and maturity

There was a tendency towards decreasing age and size with increasing latitudes, in addition to a tendency of increasing age and size westwards from the coast (Fig. 4, 5 and 6). This size dependent distribution pattern is in accordance with the observations in recent years, which

has been thoroughly discussed in Slotte and Dommasnes, 1997, 1998, 1999, 2000; Slotte, 1998*b*; Slotte, 1999*a*, Slotte 2000, Slotte et al. 2000, Slotte & Tangen 2005, 2006). The main hypothesis is that this could be due to the high energetic costs of migration, which is relatively higher in small compared to larger fish (Slotte, 1999*b*). Large fish and fish in better condition will have a higher migration potential and more energy to invest in gonad production and thus the optimal spawning grounds will be found farther south (Slotte and Fiksen, 2000), due to the higher temperatures of the hatched larvae drifting northwards.

There is also an element of learning and it seems that the relatively young part of the stock wintering to the north of Vesterålen instead of in Vestfjorden may have fewer old teachers leading the way towards spawning grounds farther to the south, which may explain some of the northern spawning distribution.

Spawning time

In 2007 the spawning seemed to be even earlier then in 2006, and this is probably due to the increase in temperature that has occurred over the last years. In addition, it was apparent that the spent individuals were found far to the west and heading for the feeding area, whereas the maturing and spawning fish were found along the coast related to bank areas (Fig. 7). The spent fish were more pre-dominant among the old individuals of the 1991 and 1992-year classes than in the young 2002-year class (Fig. 8). The fact that young recruit spawners spawn later in the season than the older repeat spawners is a common phenomenon in this stock (Slotte et al., 2000).

Acknowledgement

All the participants and the rest of the crew on board MS “Gardar” are thanked for their valuable work during the cruise. Special thanks goes to Annlaug Haugsdal and Anne-Liv Johnsen for their cheerfulness and hard work in the fish lab, and to the engineers Reidar Johannesen and Martin Dahl for making sure that all needed instruments were working properly at all times. Else it must be emphasised that everybody from “Gardar” did what they possibly could to support the scientific crew; the service was splendid from the beginning to the end. Thanks to all for a very nice survey both scientifically and socially.

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Tables

	Age																	
Length (cm)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	$N*10^6$	B 1000 t	Mean W (g)
15																0		
16																0		
17																0		
18		7	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0.2	33
19		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0 .	
20		87	0	0	0	0	0	0	0	0	0	0	0	0	0	87	4.2	48.7
21		15	15	0	0	0	0	0	0	0	0	0	0	0	0	30	1.6	55.1
22		0	115	0	0	0	0	0	0	0	0	0	0	0	0	115	7.6	66.1
23		0	148	0	0	0	0	0	0	0	0	0	0	0	0	148	11	74.3
24		0	167	25	0	0	0	0	0	0	0	0	0	0	0	192	15.6	81.2
25		0	17	14	4	0	0	0	0	0	0	0	0	0	0	35	3.3	96.7
26		0	51	95	9	0	0	0	0	0	0	0	0	0	0	155	18.8	120.9
27		0	5	574	132	0	0	0	0	0	0	0	0	0	0	711	98.3	138.1
28		0	11	507	547	0	0	0	0	0	0	0	0	0	0	1065	161.9	152
29		0	0	701	2539	132	0	0	0	0	0	0	0	0	0	3372	586.2	173.9
30		0	0	70	5004	3	0	0	0	0	0	0	0	0	0	5077	987.6	194.6
31		0	5	47	4598	237	45	9	20	0	0	0	0	0	0	4961	1043.8	210.4
32		0	0	64	1371	440	82	297	194	0	0	0	0	0	0	2448	583.7	238.5
33		0	0	0	351	101	174	1117	723	31	0	0	0	18	0	2515	654.1	260.1
34		0	0	0	0	0	201	1381	1586	81	70	0	0	37	37	3393	981.4	289.2
35		0	0	0	13	39	90	365	503	77	74	4	152	9	35	1361	427.1	313.9
36		0	0	0	0	0	0	101	66	71	131	1	57	15	361	803	268	333.6
37		0	0	0	7	0	0	0	0	3	1	15	60	60	119	265	93.6	354.1
38		0	0	0	0	0	0	0	0	0	0	0	0	49	67	116	44.5	384.2
39		0	0	0	0	0	0	0	0	0	0	0	16	0	3	19	8.8	454.7
40		0	0	0	0	0	0	0	0	0	0	0	0	1	6	7	2.8	421.8
$N*10^6$	0	109	534	2097	14575	952	592	3270	3092	263	276	20	285	189	628	**26882**	**6004**	
B 1000 t		5.3	44.4	332.3	2910.9	221.3	160.9	913.8	873.5	80.9	82.7	6.6	92.7	61.7	206.4			
Mean L		20.5	24.1	28.7	30.8	32.1	33.9	34.1	34.3	35.2	35.7	37.1	36.3	36.6	36.7			
Mean W		49	83	159	200	233	272	279	283	308	299	352	326	327	346			

Table 1. The overall areas estimate of abundance in millions (N) and biomass in thousand tonnes (B) (spawning stock biomass = SSB) of Norwegian spring spawning herring

Figures

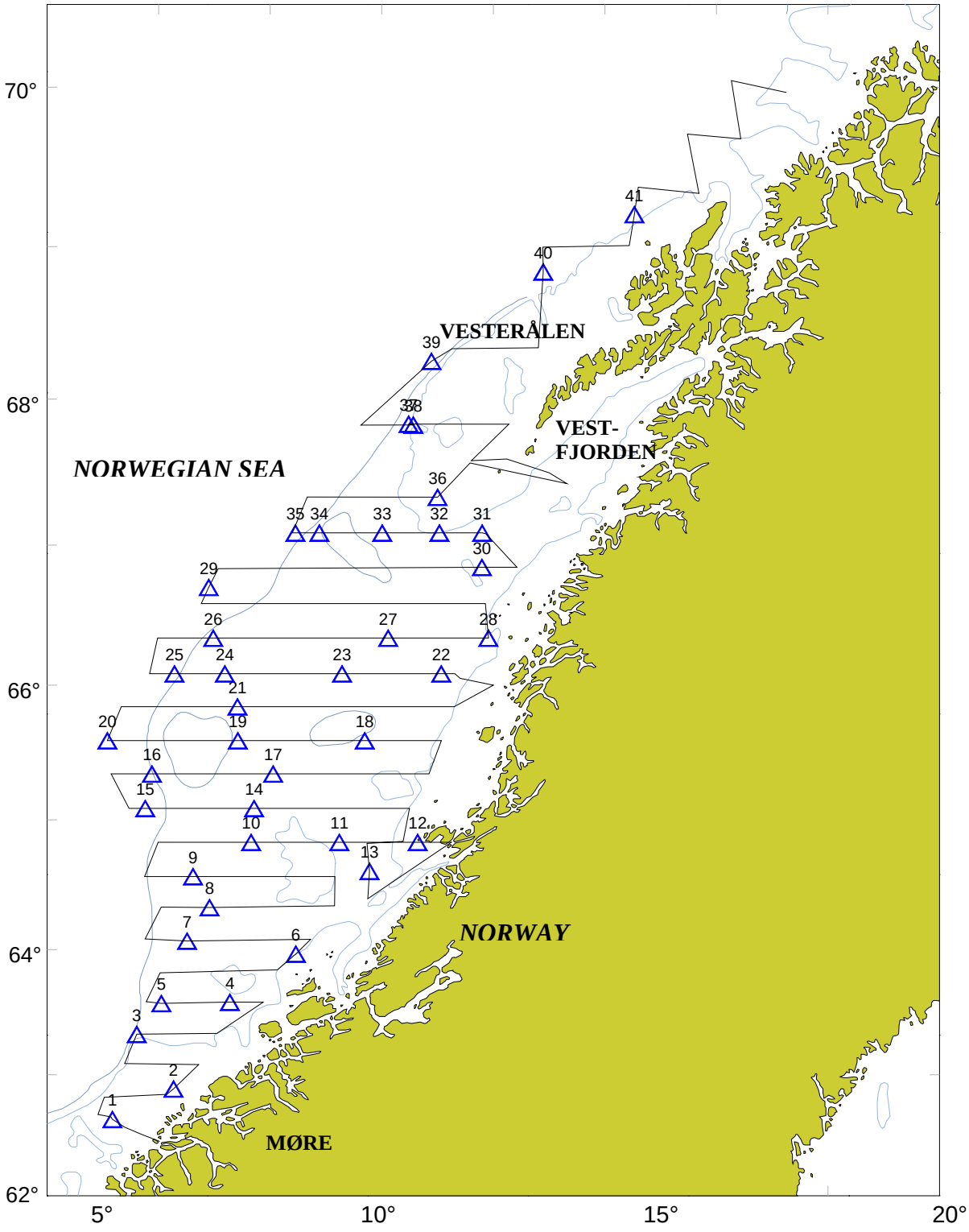

Fig. 1. Cruise track and trawl stations covered by MS “Gardar” during 16 February to 5 March 2007.

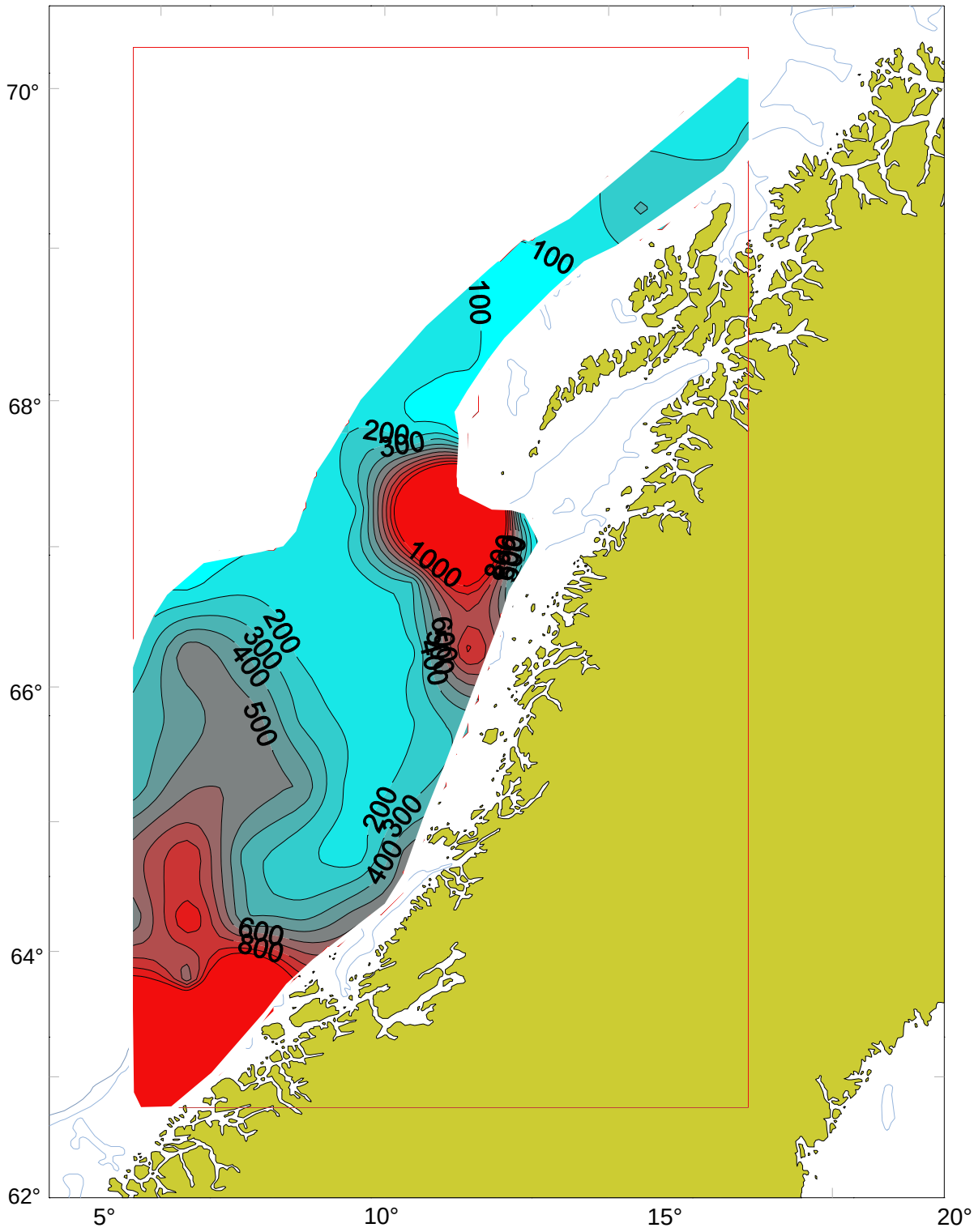

Fig. 2. Distribution and density of Norwegian spring spawning herring in terms of s_A values (NASC) estimated by areas with MS “Gardar” during 16 February to 5 March 2007.

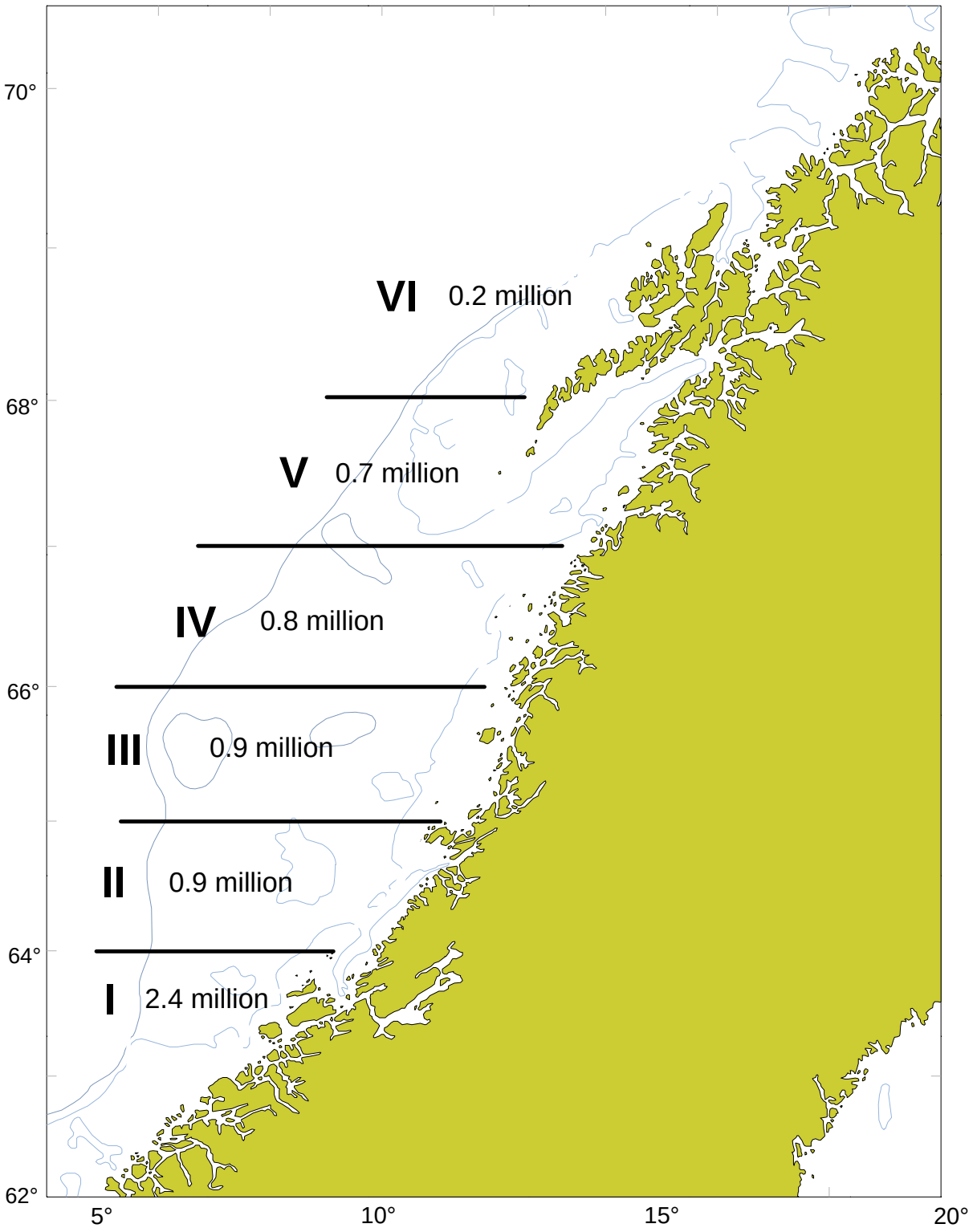

Fig. 3. Biomass estimates of Norwegian spring spawning herring (million tones) by area as estimated with MS "Gardar" during 16 February to 5 March 2007.

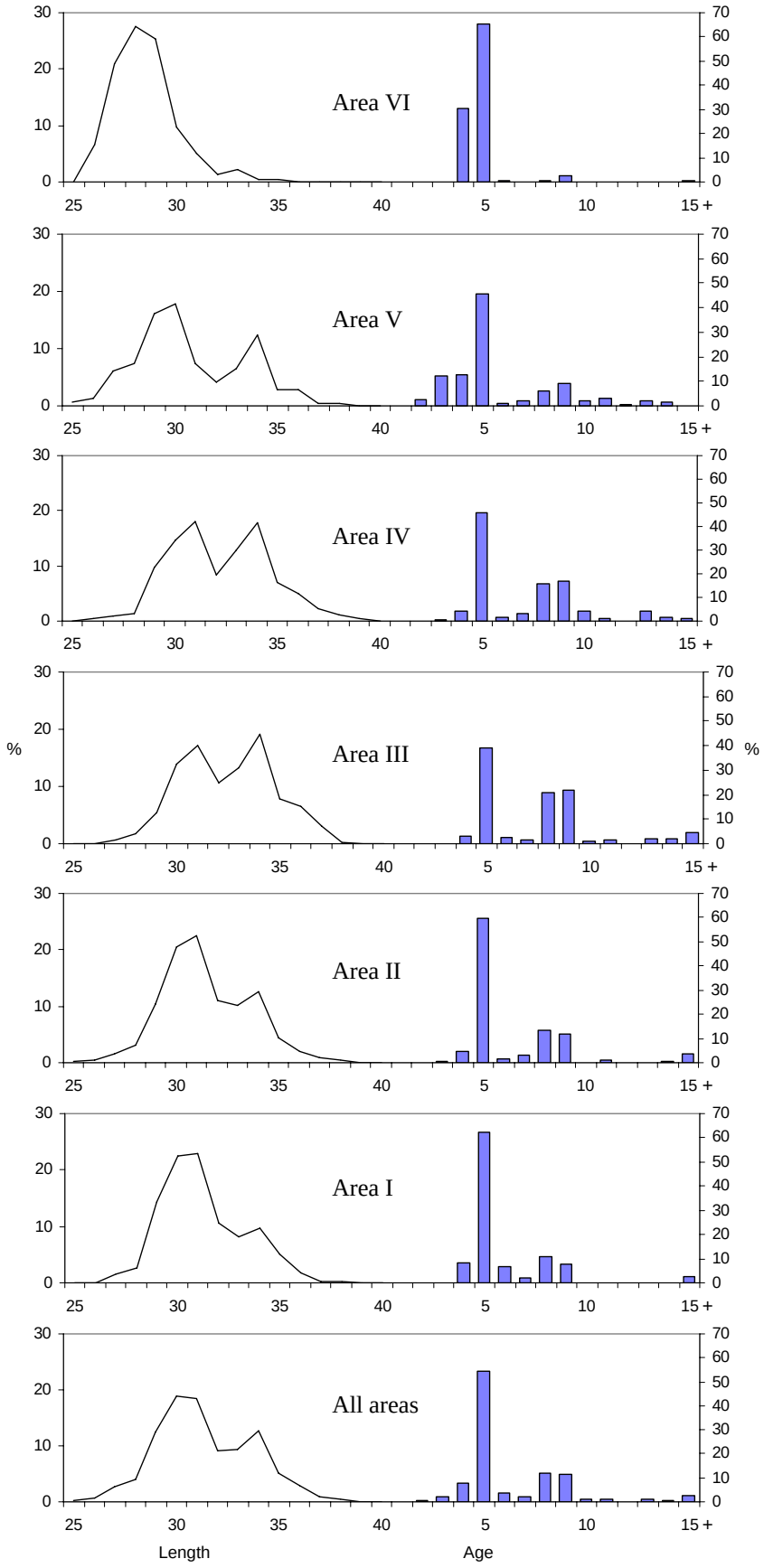

Fig. 4. Length and age composition of Norwegian spring spawning herring (million tones) by area and totally as estimated from trawl samples with MS “Gardar” during 16 February to 5 March 2007.

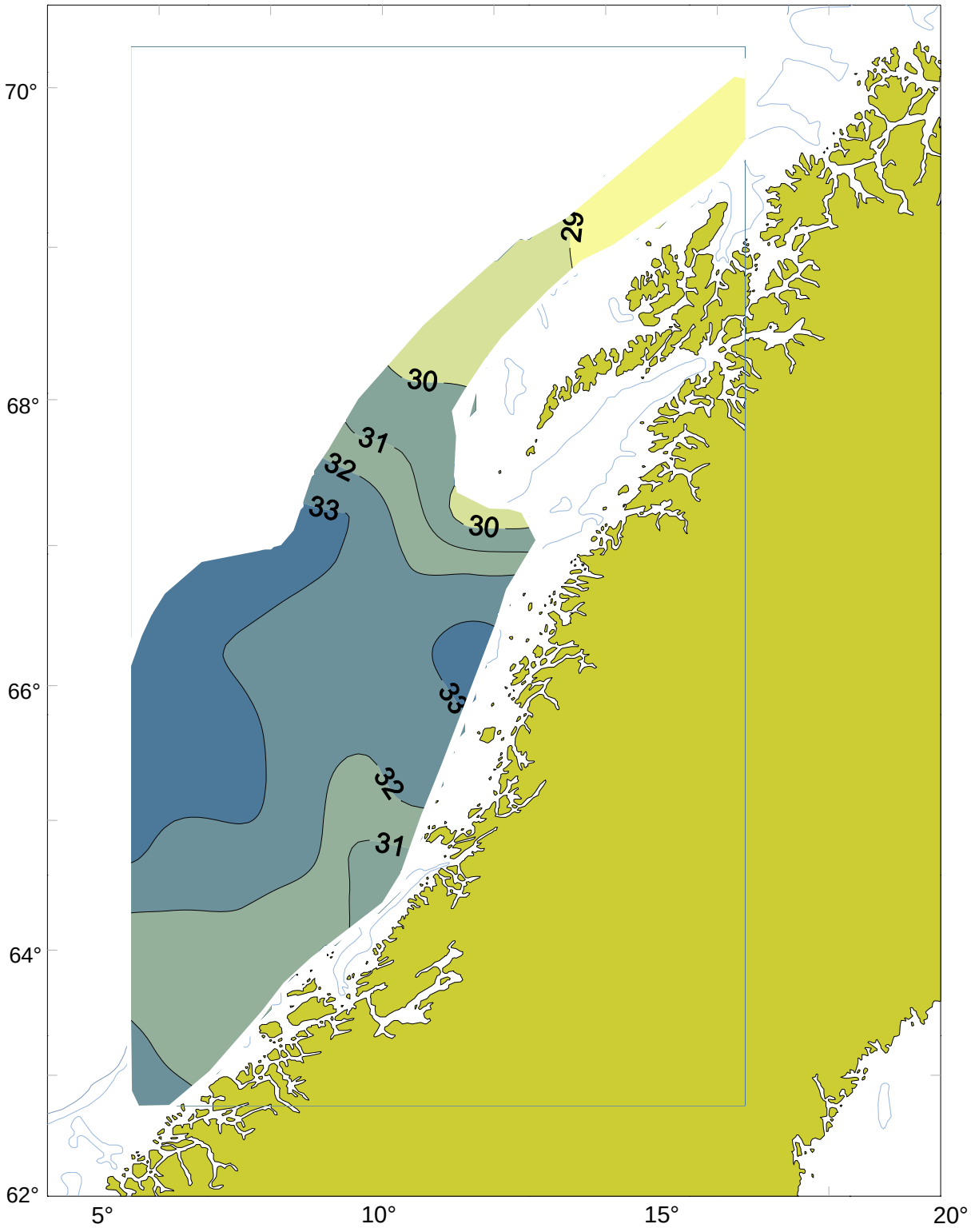

Fig. 5. Distribution of Norwegian spring spawning herring by mean length (cm) in trawl samples from MS "Gardar" during 16 February to 5 March 2007.

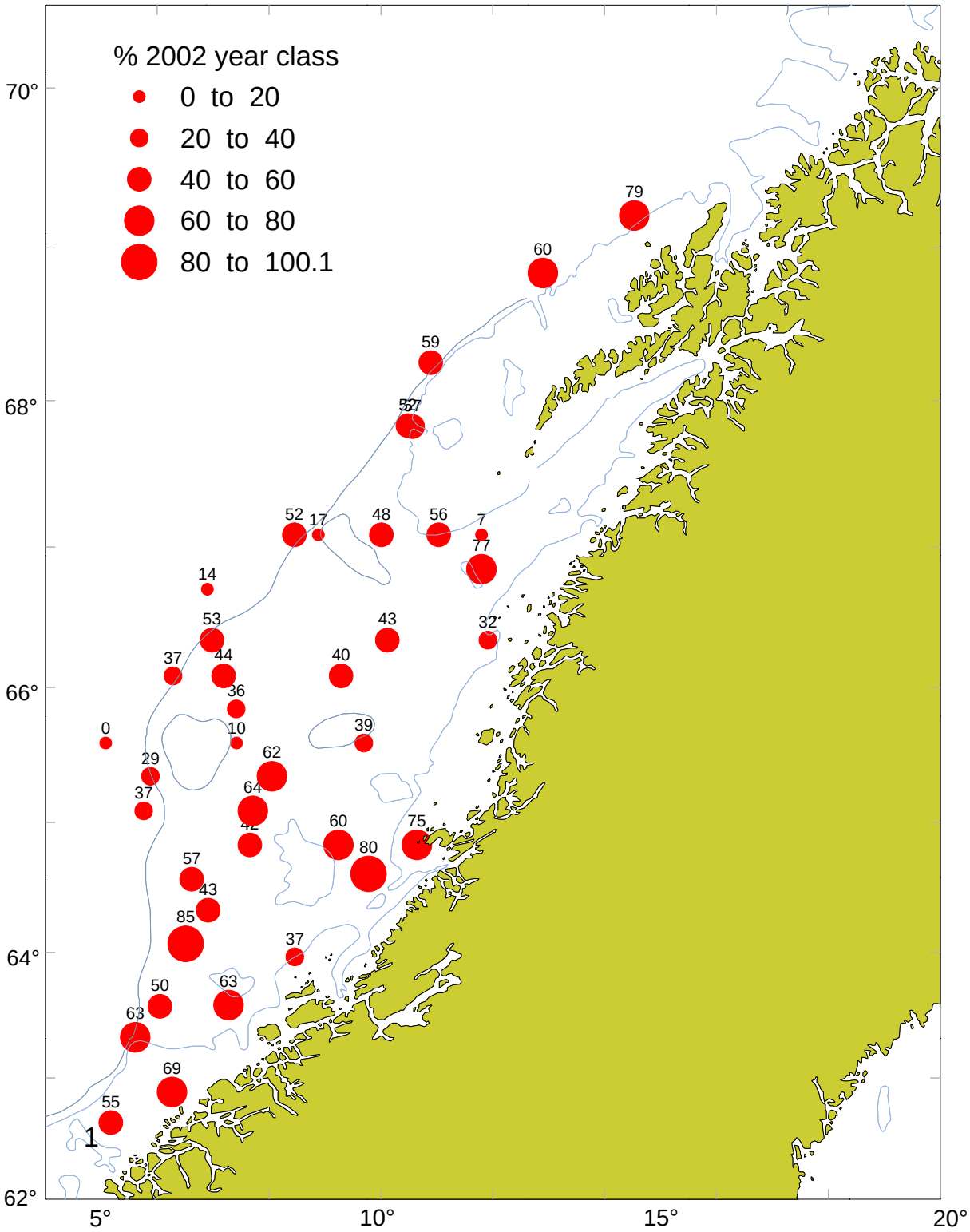

Fig. 6. Geographical differences in the percentage of the pre-dominant 2002-year class of Norwegian spring spawning herring as estimated from trawl stations with MS “Gardar” during 16 February to 5 March 2007.

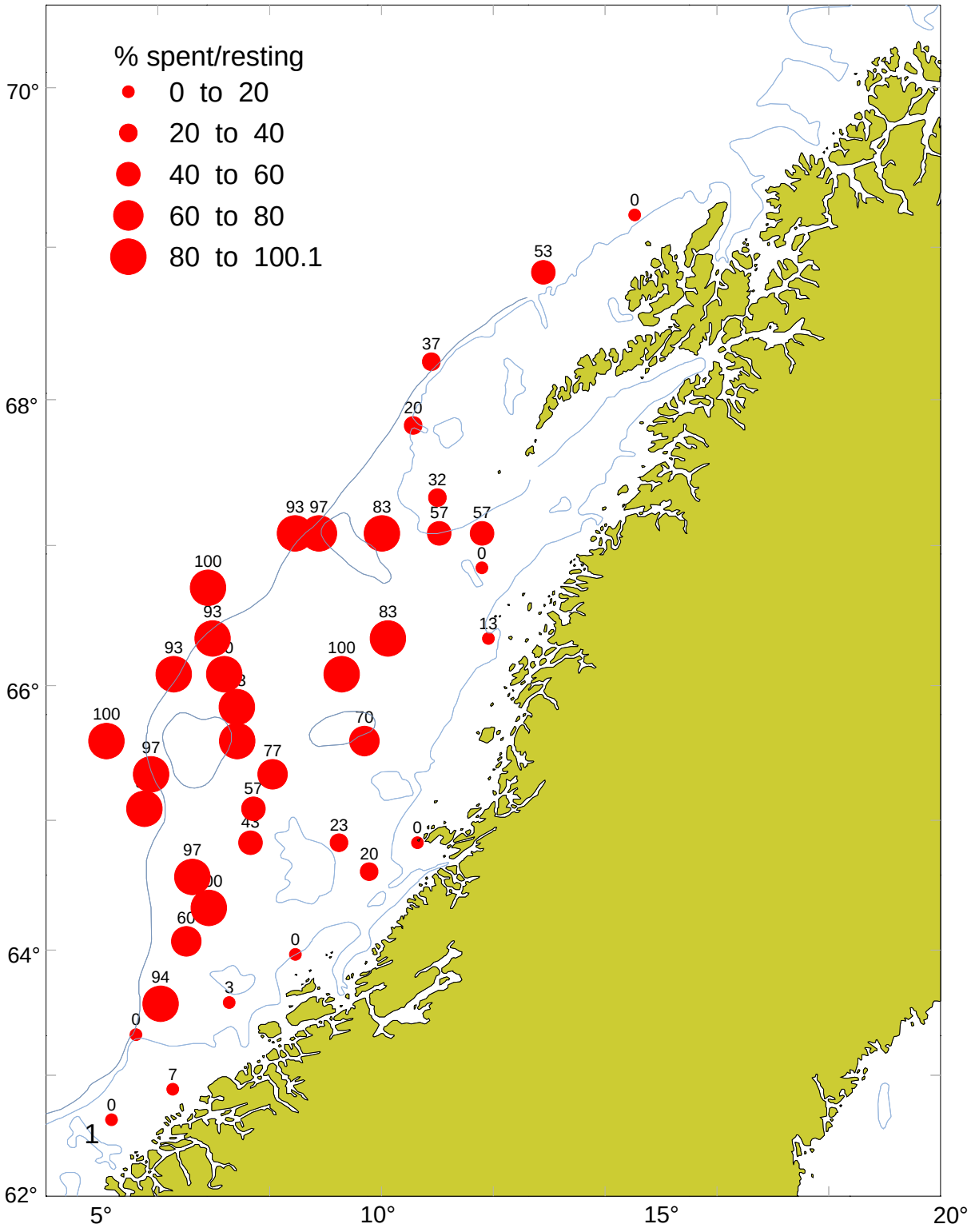

Fig. 7. Geographical differences in the percentage of spent/resting Norwegian spring spawning herring as estimated from trawl stations with MS “Gardar” during 16 February to 5 March 2007.

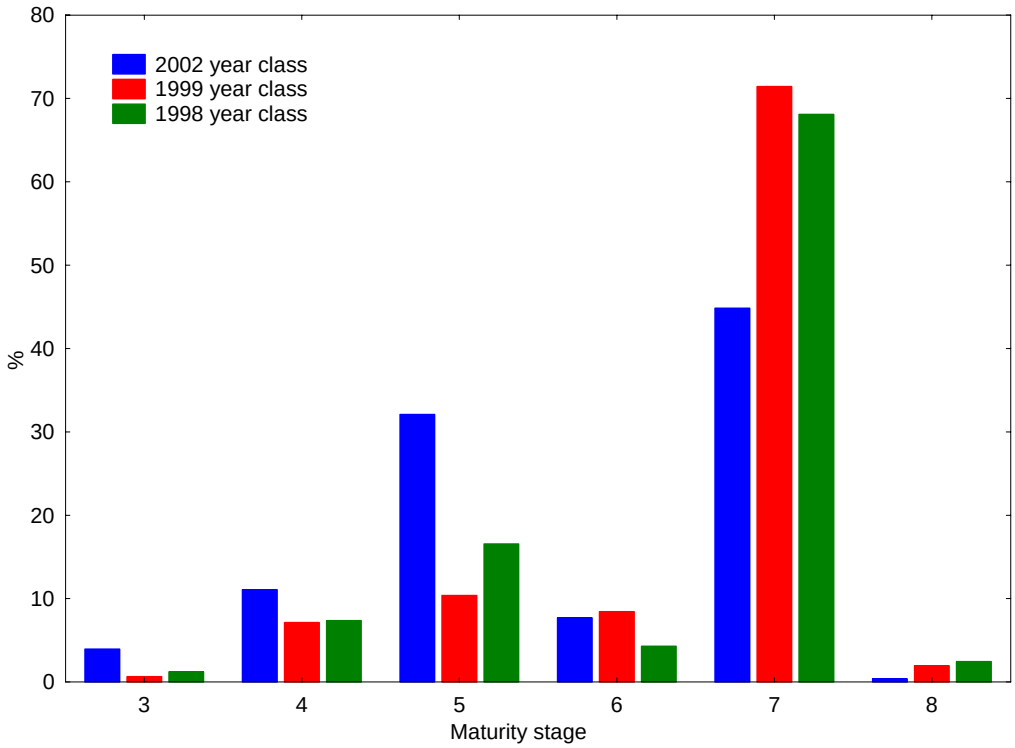

Fig. 8. Maturity stage composition of Norwegian spring spawning herring as estimated from trawl stations with MS “Gardar” during 16 February to 5 March 2007. The year classes 2002, 1998 and 1999 are compared. The maturity stages were classified as: maturing=3 to 4, ripe=5, spawning/running=6, spent=7 and recovering after spawning=8. Individuals in immature stages (immature=1 and 2) were not found.