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«Cruise report»

RV Håkon Mosby 16-28.02.2006

Distribution and abundance of Norwegian spring spawning herring during the spawning season in 2006

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 16-24th of February the spawning grounds from Møre to Vesterålen were covered acoustically and with trawling and CTDs (Figures 1-2). At the 24th of February a storm centre hit Vesterålen and we were prevented from covering the entire assumed distribution area before having to return to Bergen. During the return to Bergen the area from 63°-61°N was roughly surveyed without observing herring.

Biological sampling

The following variables of individual herring were analysed. Total weight (W) in g, total length (L_T) in cm (measured to nearest 0.5 cm below), maturity stage, gonad weight (W_G) in g. 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. Gonad weight was also noted on each specimen. Stomach fullness was also noted on a subjective scale from 1 to 5, where 1 is empty and 5 is full and stretched. With few exceptions gonad samples of 30 females were collected and stored for measurements of eggdiameter, fecundity and atresia on a later stage (responsible scientist, Olav Kjesbu, IMR). All other fish were counted and weighted by species, and length measured.

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).

$$\langle TS \rangle = 20 \log L - 71.9 \text{ dB} \qquad (1)$$

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

$$N = \langle s_A \rangle A (4\pi \langle \sigma_{bs} \rangle)^{-1} \qquad (2),$$

where $\langle s_A \rangle$ is the mean nautical area backscattering coefficient within the area, A is the size of the area in nmi^2, and $\langle \sigma_{bs} \rangle$ 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 all of the survey and schools were tracked and data logged in some areas. The sonar revealed very few shallow schools, and insignificant amounts of herring avoided the research vessel.

Results

Abundance and distribution

As in previous years (Slotte, 1998*a*) the herring were mostly distributed in layers; close to the surface at night time and closer to bottom at daytime. In the deeper off shore areas, the daytime layer was as deep as 300 m. Herring was also observed at the bottom during night time spawning. The geographical distribution extended all over the study area from Møre in the south to Vesterålen in the north (Figure 3). The total spawning stock within this area was estimated to 4.9 million tonnes and 21.8 billion individuals, of which the 2002-, 1999- and 1998-year classes (4-, 7 and 8-year olds) predominated with 46.5, 20.8 and 20.2 % respectively (Table 1, Figure 4). As in 2005 (Slotte & Tangen 2005), more than 70 % of the SSB was distributed to the north of the historical important spawning grounds off Møre, emphasising the tendency of Møre being less important then in the1990s.

Due to the storm at the end of the survey, and limited survey time. The northern limits of distribution and also the western limits have not been found. Probably the spawning distribution extends further northwards. It is also likely that fish migrating southwards from the northern wintering grounds (north of Vesterålen) have distributed over a large area south of Vesterålen before reaching the coastline for spawning. Given the northern oceanic wintering, it is clear that more time is needed in future years to cover larger areas and all possible migration routes properly.

Latitudinal variations in age, length, length at age and condition

The spawning distribution of this stock was very far to the north in comparison with historic spawning distributions, and more equal to 2005 (Slotte & Tangen 2005). This distribution may be related to the new wintering area in the open ocean north off Vesterålen. There was a tendency towards decreased age (Figure 5) and length (Figure 6) with latitude. Also within the dominating age group, the 4 year olds, the length (Figure 7) as well as condition factor (Figure 8) decreased with latitude.

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). 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. The increase in temperature north to south is also evident during the spawning period it self at the main spawning depths 100-150 m (Figure 9).

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.

Another factor that may have influence on the spawning distribution is the increase in temperature that has occurred over the last years. This may also have influenced the spawning time, which has been relatively early and short the last 2-3 year in comparison with previous years. These are, however, observations that one needs to study more before conclusions may be drawn.

Spatial differences in temperature

CTD stations covering the migration route and spawning grounds of the herring revealed that the area is strongly influenced by the cold coastal current at shallow depths and the warmer Atlantic current at deeper depths (Figure 9). The general picture is an increase in temperature westwards as the influence of the Atlantic current increases. The spawning depth of the herring is mainly at the depth interval 100-150 m, and at this depth interval the influence of the Atlantic current decreases northwards, suggesting lower spawning temperatures northwards.

Acknowledgement

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Tables

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 during the spawning season in 2005.

	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																0		
19		9														9	0	40
20		4														4	0	49
21																0	0 .	
22																0	0 .	
23			21													21	2	77
24			7													7	1	98
25			0	48												48	5	101
26			47	214												261	30	115
27				2829												2829	373	132
28				1554	44											1598	246	154
29				2489	99	30										2618	448	171
30				2047	84	40	36									2207	409	185
31				815	206	276	831	215								2343	526	224
32				127	144	460	1248	764								2743	684	250
33				44	64	237	1441	1364								3150	859	273
34					43	60	895	1414	63	2	11	1	48	12	0	2549	757	297
35							89	565	29	16	0	16	7	165	0	887	298	335
36								85	41	29	0	96	65	32	50	398	142	357
37														114	23	137	52	380
38															45	45	18	410
39															17	17	8	435
40																0		
N*10^6	0	13	75	10167	684	1103	4540	4407	133	47	11	113	120	323	135	**21871**	**4858**	
B (1000 t)		0.5	7.7	1670.6	153.8	272.7	1194.3	1251.6	41.6	16.9	3.3	40.4	38.6	114.1	51.8			
Mean L		19.8	25.5	29.1	31.5	32.4	33.1	33.9	35.3	36.1	34.5	36.3	35.6	36.3	37.7			
Mean W		43	102	164	225	247	263	284	313	363	307	357	322	353	385			

Figures

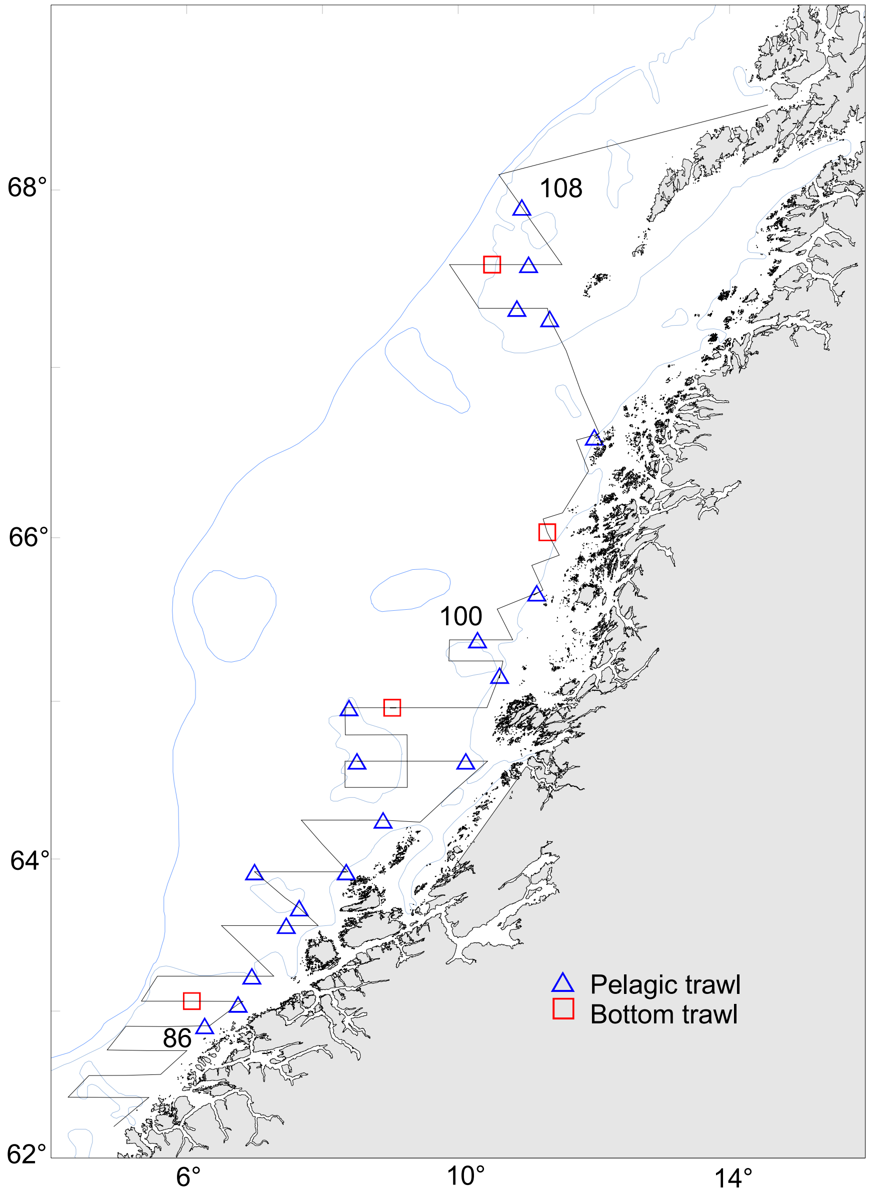

Fig. 1. Cruise track and trawl stations covered by RV "Håkon Mosby" during 16-24th of February 2006.

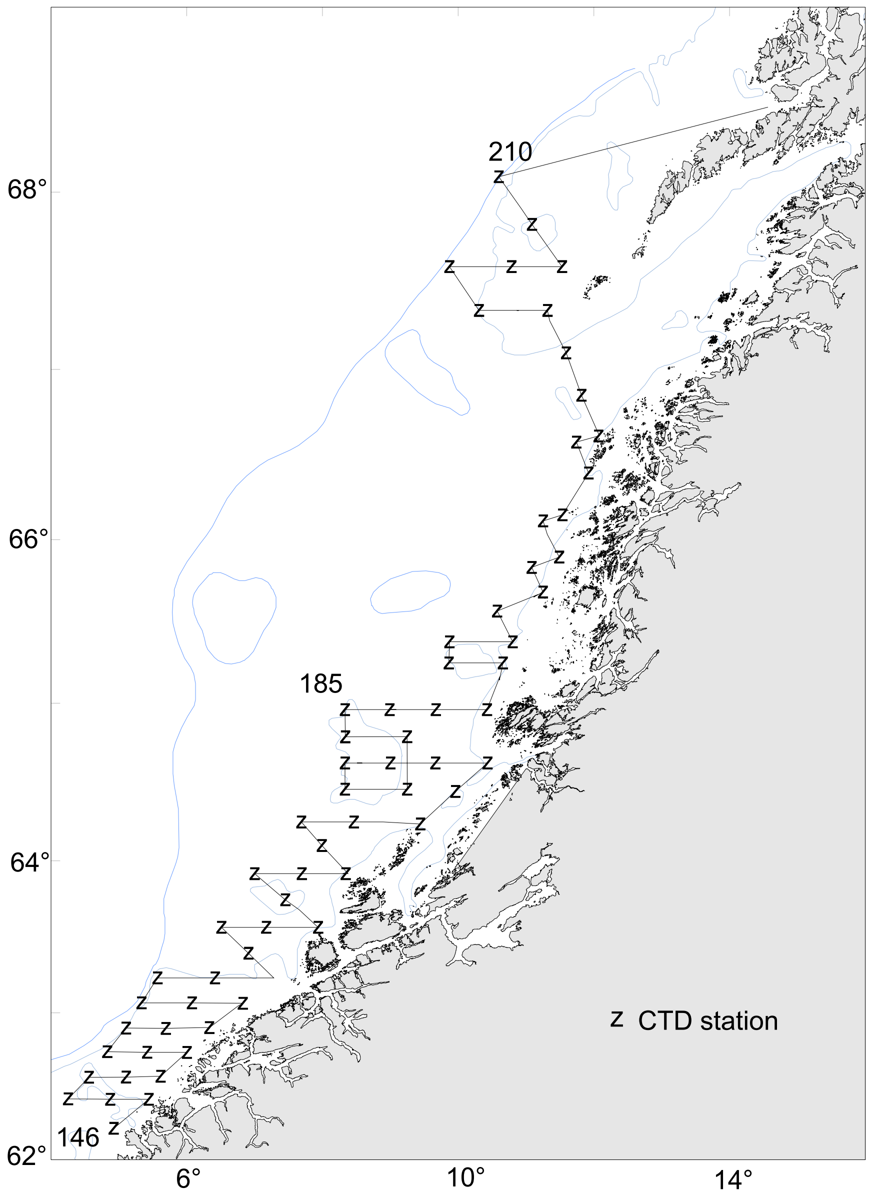

Fig. 2. Cruise track and CTD-stations covered by RV "Håkon Mosby" during 16-24th of February 2006.

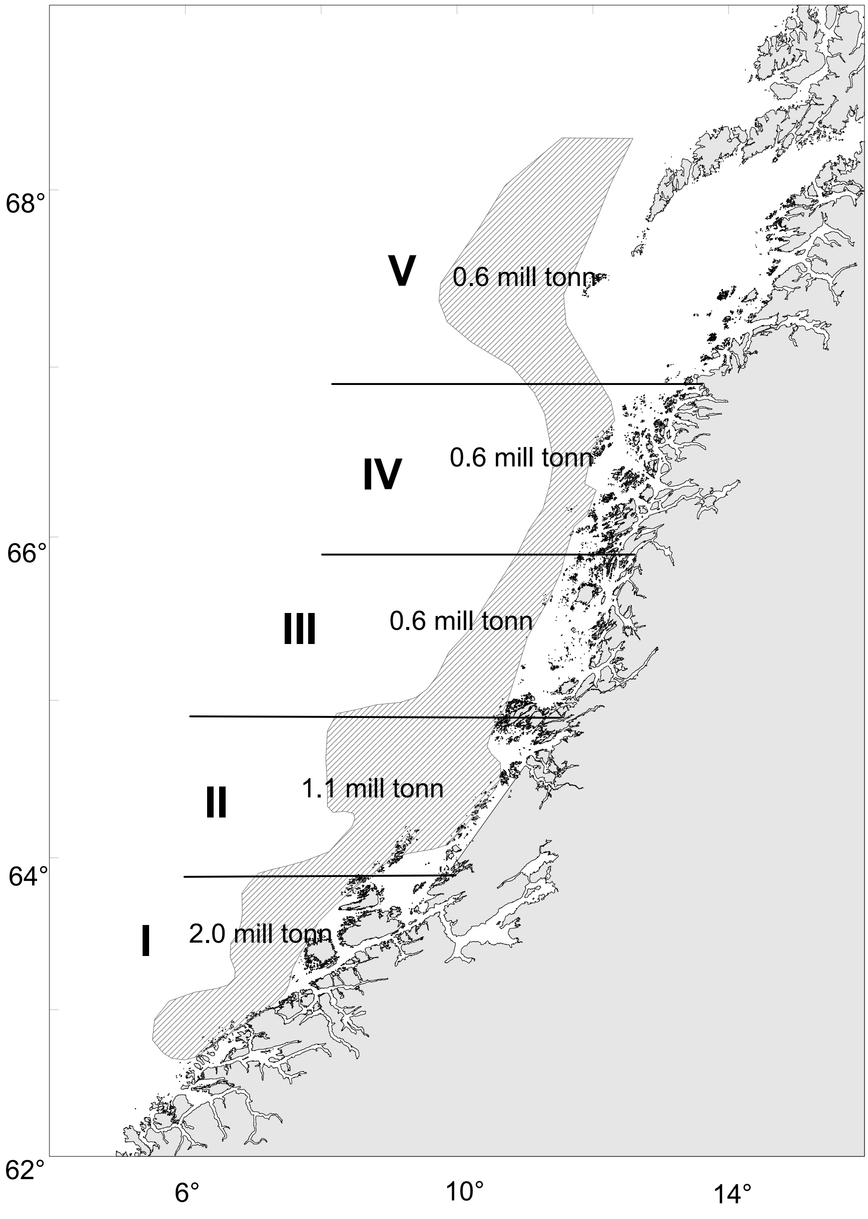

Fig. 3. Spawning distribution and spawning stock biomass (SSB) of Norwegian spring spawning herring estimated by areas with RV "Håkon Mosby" 16-24th of February 2006.

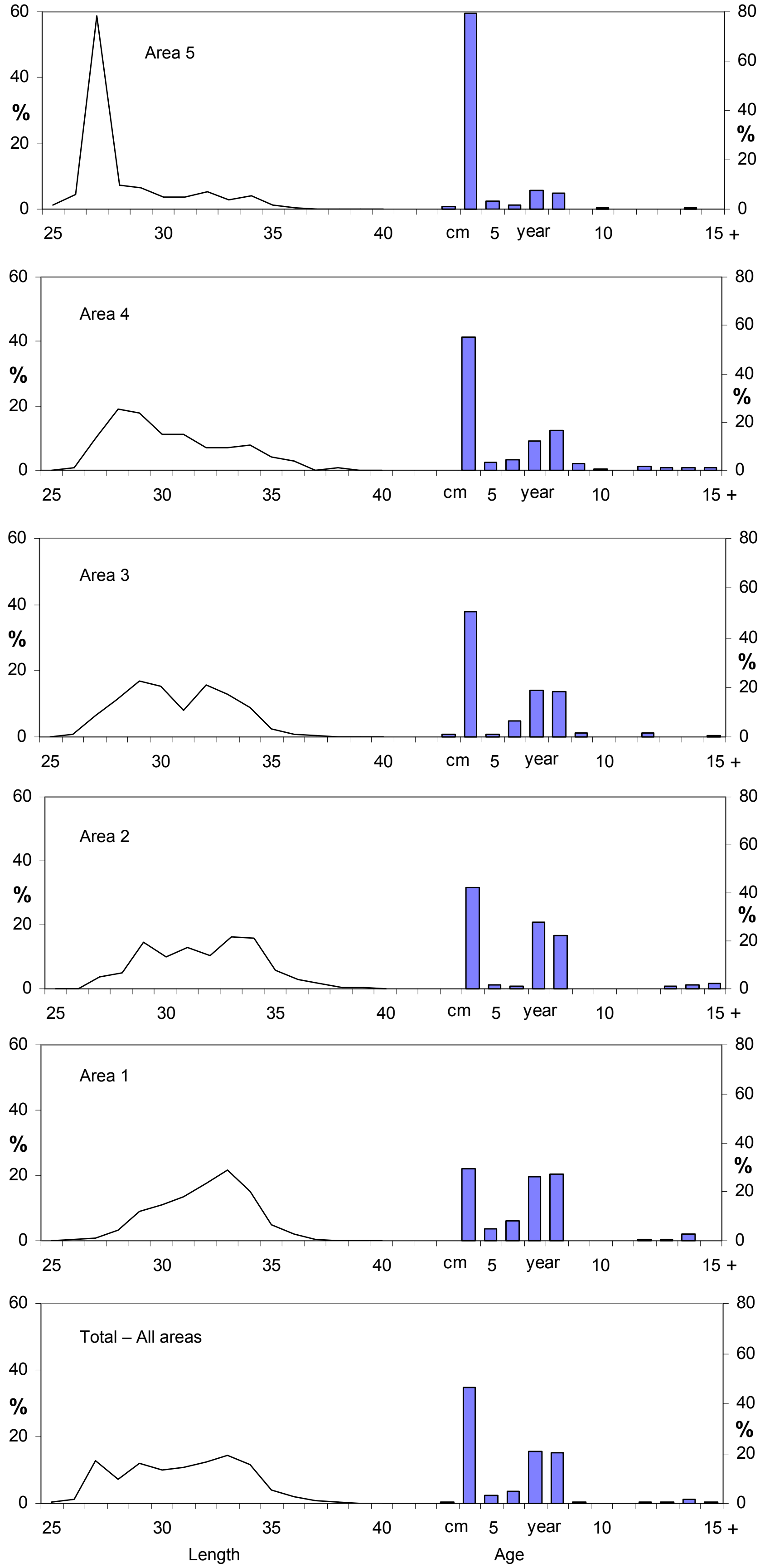

Fig. 4. Length and age composition (weighted by acoustic abundance) by area and totally.

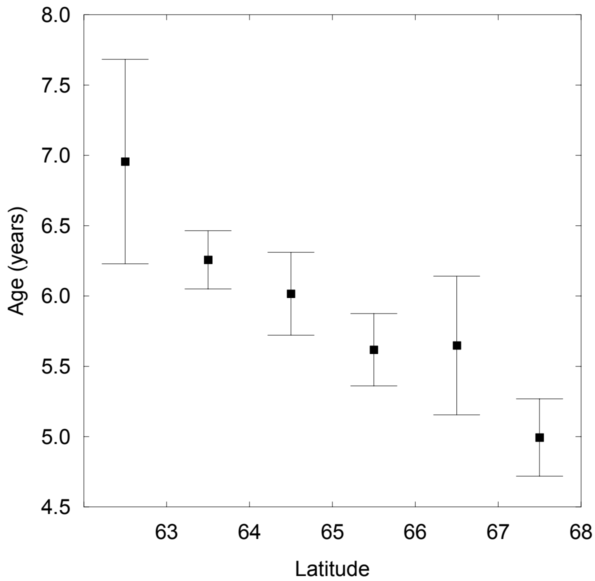

Fig. 5. Herring age related to latitude of collection (mean±95% conf.int).

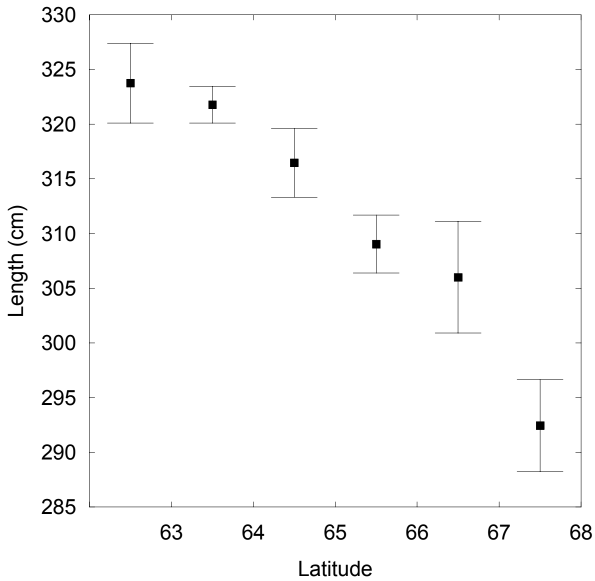

Fig. 6. Herring length related to latitude of collection (mean±95% conf.int).

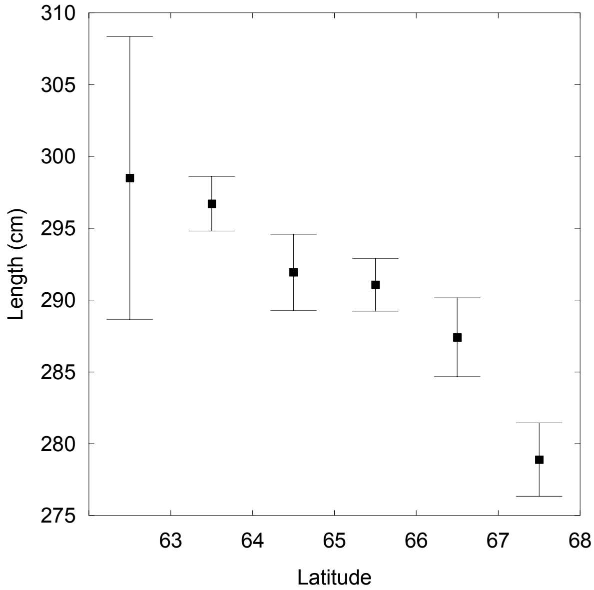

Fig. 7. Length of 4-year olds related to latitude of collection (mean±95% conf.int).

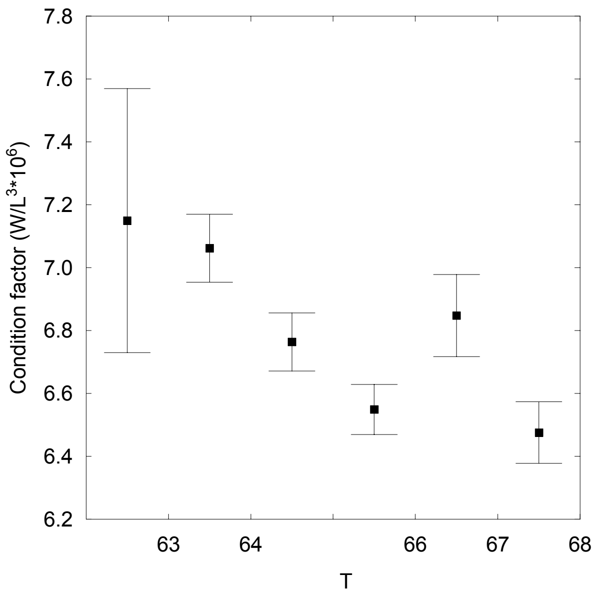

Fig. 8. Condition factor of 4-year olds related to latitude of collection (mean±95% conf.int).

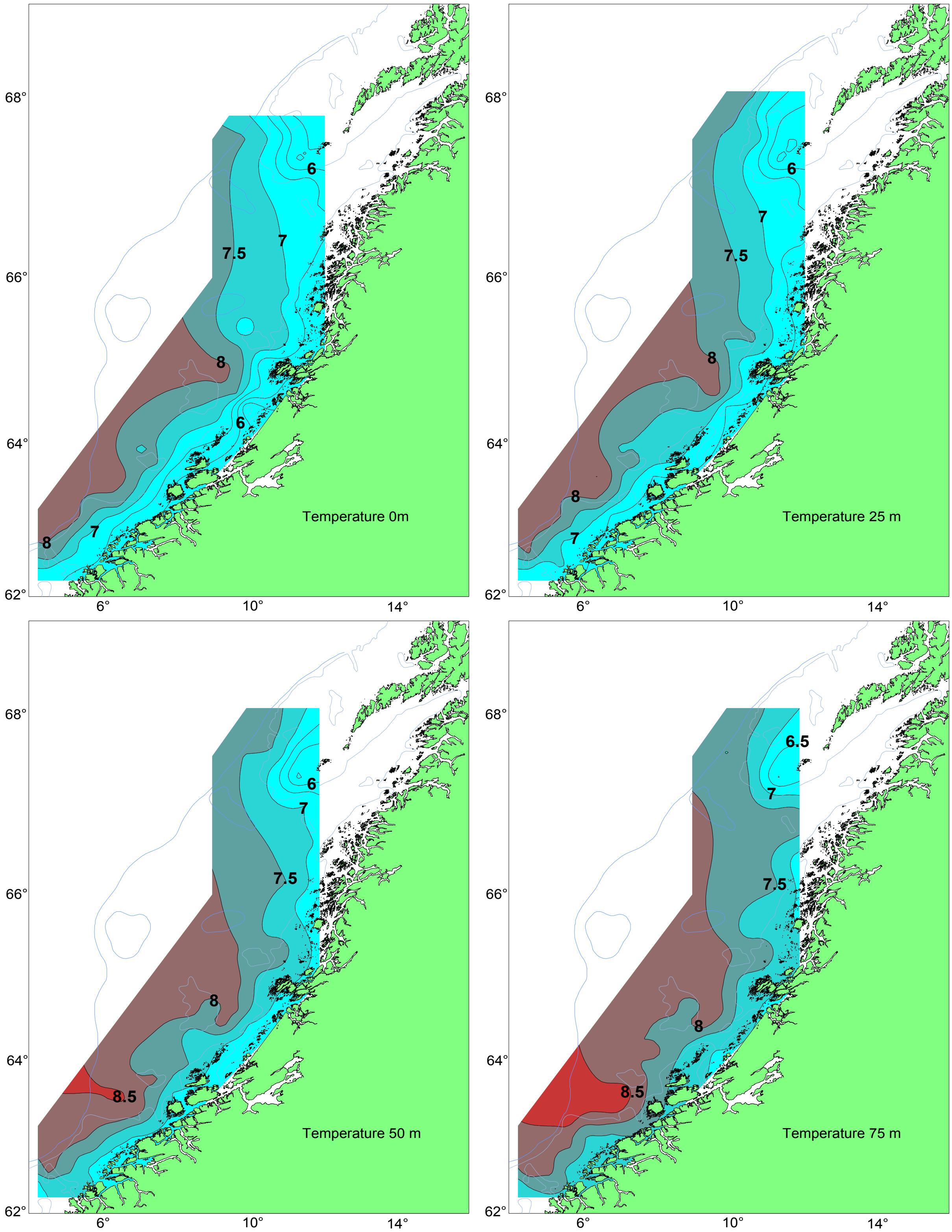

Fig. 9. Temperature isoclines at various depths.

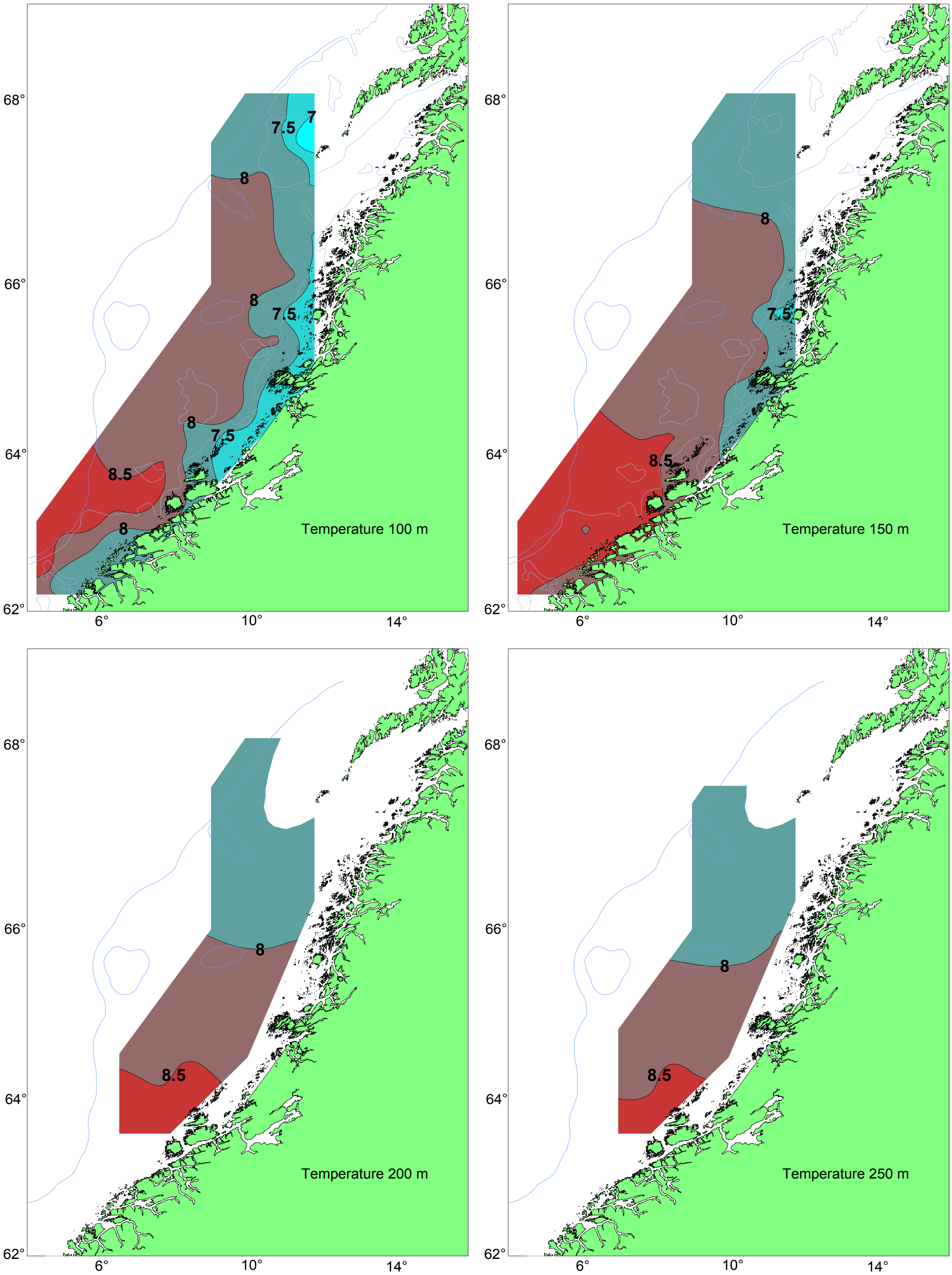

Fig. 9 continues.