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«Cruise report»

RV Håkon Mosby 14.02-06.03.2005

Distribution and abundance of Norwegian spring spawning herring during the spawning season in 2005

by

Aril Slotte and Øyvind Tangen

Institute of Marine Research, P. O. Box 1870 Nordnes, N-5817 Bergen, Norway

Participants:

Aril Slotte	FG 2, cruise leader	14.02-06.03
Øyvind Tangen	FG 2	14.02-06.03
Leif Nøttestad	FG2	26.02-06.03
Annlaug Haugsdal	FTG 4	14.02-26.02
Anne-Liv Johnsen	FTG 4	14.02-06.03
Geir Landa	Instrument	14.02-06.03
Jan Tore Øvredal	FTG 11	26.02-06.03
Arne Johannessen	BIO, UiB	26.02-06.03
Anders Fernø	BIO, UiB	26.02-06.03
Kari Toft	”Ut i naturen” NRK	26.02-28.02
Jørn Nordli	”Ut i naturen” NRK	26.02-28.02

Objectives

This cruise was split into two different parts with different objectives:

1. From 14-26.02 the main objective was to study the distribution, abundance and age- and size distrubution of NSS herring at spawning grounds from Vesterålen in the north to Møre in the south.

2: From 26.02-06.03 the main objective was to study small-scale migration and spawning dynamics of NSS herring off Møre, with special emphasis on interactions with saithe. The analysis of the data from this study is not finalized and will be published in another report. This was a co-operation with scientists from Institute of Biology, University of Bergen (BIO, UiB).

Material and methods

Surveys and stations

Due to bad weather the vessels was prevented from doing acoustic investigations from 14-17 February. During the period 18-26 February the spawning grounds from Vesterålen to Møre were covered acoustically and with trawling (Figure 1). From 28 February to 6 March the vessel only surveyed areas off Ålesund (Møre) with main emphasis on observing the behaviour of herring and saith with an underwater camera rig placed at the bottom. Survey tracks for this period is not given, but the stations (trawl, gillnet and camera) taken are marked in Figure 2.

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.

All other fish were counted and weighted by species, and length measured. At the last part off Møre, length and weight was merasured on cod and saithe at some of the stations. Their stomach fullness on the subjective scale was noted, and in addition it was noted whether they had consumed eggs of herring or the herring itself (by numbers).

Acoustic data and abundance estimation

Acoustical data were registered with a 38 kHz SIMRAD EK 500 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, relationships for herring (Eq. 1) and blue whiting (Eq. 2), as used in the standard assessment surveys (Foote, 1987).

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

$$\langle TS \rangle = 21.8\log L - 72.8 \quad (2)$$

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

$$N = \langle s_A \rangle \, A \, (4\pi \langle \sigma_{bs} \rangle)^{-1} \quad (3),$$

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. L was set based on biological samples from trawl hauls in these rectangles or from nearby rectangles. Similarly these samples were used for biomass estimates using the appropriate mean weights of the herring.

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. Herring were distributed all over the study area from Vesterålen in the north to Møre in the south (Figure 3). The total spawning stock within this area was estimated to 6.5 million tonnes and 26.6 billion individuals, of which the 1998-, 1999- and 2000-year classes (7-, 6- and 5-year olds) predominated with 12.4, 28.3 and 39.2 % respectively (Table 1). More than 70 % of the SSB was distributed to the north of the historical important spawning grounds off Møre. The Haltenbanken area was by far most important contributing with 26 % of the SSB. However, also Vesterålen contributed with 20 % of the SSB.

Table 1. The overall areas estimates 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 (years)															
Lenght (cm)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	$N*10^6$
15																0
16																0
17																0
18																0
19		17														17
20																0
21																0
22		52														52
23		17														17
24		17														17
25																0
26			40													40
27			69	17												86
28			127	197	81											405
29			44	277	1060	179	104									1664
30				177	1131	1517	555									3380
31				89	719	2793	2341	29	57							6028
32				55	252	2122	4127	113	22							6691
33					68	794	2017	374	173	18		23	39			3506
34						140	1075	269	153	26	65	114	187	75		2104
35							207	102	118	109	31	289	265	262		1383
36							26		32	7	26	165	490	227		973
37									8			19	63	109		199
38													55	12	17	84
39																0
40																0
$N*10^6$	0	103	280	812	3311	7545	10452	887	563	160	122	610	1099	685	17	26646
N%	0	0.3865	1.0508	3.0474	12.426	28.316	39.225	3.3288	2.1129	0.6005	0.4579	2.2893	4.1244	2.5707	0.0638	100
$Biomass*10^3$ t		6.8	42.3	153.5	681.9	1742.7	2578.6	239.6	163.2	45.5	36.3	192.8	377.1	233.6	7.1	6501
Mean length (cm)		22.5	28.1	29.9	30.6	31.8	32.6	33.8	34.2	35.2	35.2	35.6	36	36.1	38.5	32.4
Mean weight (g)		65.7	150.5	189.3	206	231	246.7	269.9	290.1	286	297.2	316.1	343	340.3	413	244

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 it may be related to the new wintering area in the open seas north off Vesterålen. There was a tendency towards decreased age (Figure 5), length (Figure 6) and stage of maturity (Figure 7) with latitude. Also within the two most common age groups, the 6 and 7 year olds (1999 and 1998 year classes), the length (Figure 8) and stage of maturity (Figure 9) as well as the condition factor (Figure 10) 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). 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).

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 fiewer 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.

Acknowledgement

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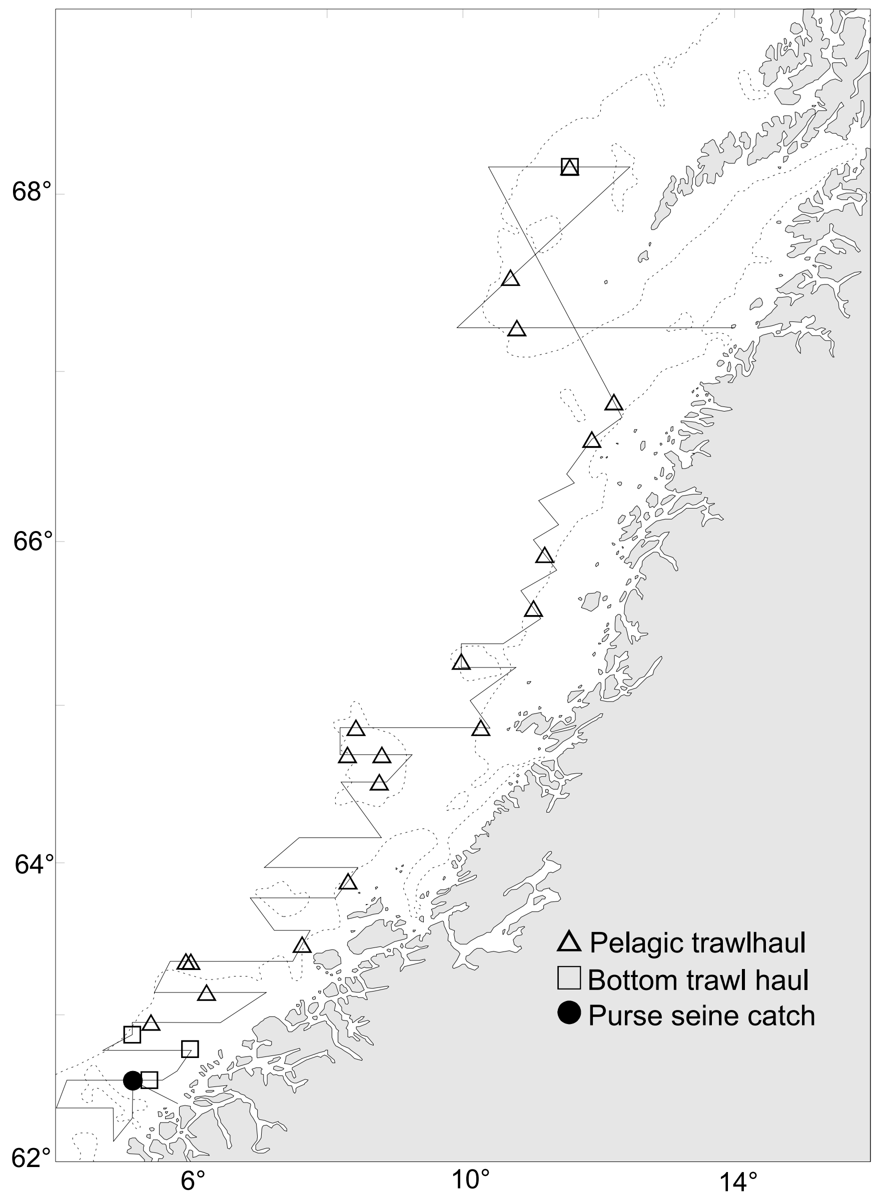


Fig. 1. Cruise track and stations covered by RV "Håkon Mosby" during 17-26 February 2005.

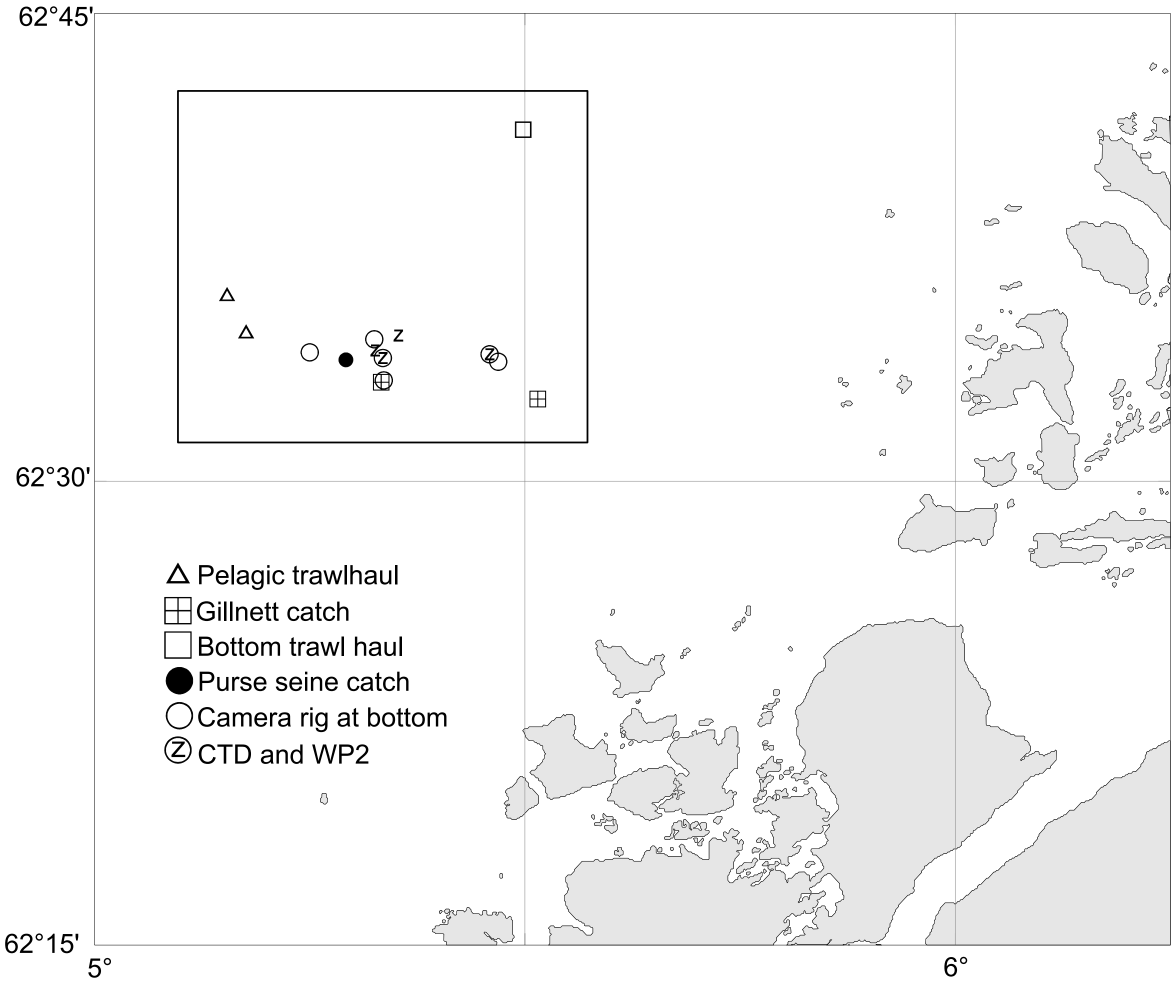
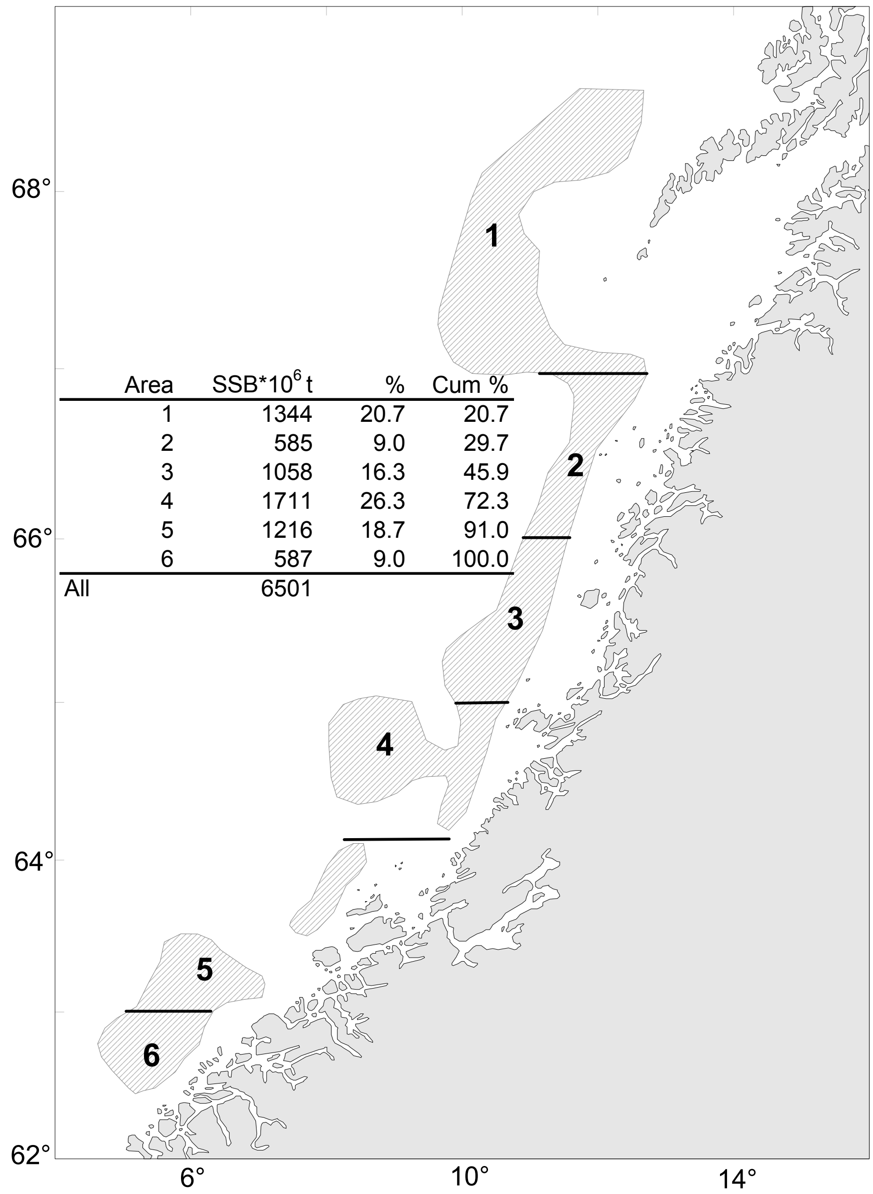


Fig. 2. Stations covered by RV "Håkon Mosby" during 26 February to 6 March 2005. Survey tracks were not consistent and are not included.



Area	SSB*10^6 t	%	Cum %
1	1344	20.7	20.7
2	585	9.0	29.7
3	1058	16.3	45.9
4	1711	26.3	72.3
5	1216	18.7	91.0
6	587	9.0	100.0
All	6501		

Fig. 3. Spawning distribution spawning stock biomass (SSB) of Norwegian spring spawning herring estimated by areas and totally with RV "Håkon Mosby" 17-26 February 2005. The SSB is also given in percentage and cumulative percentage from Area 1 to 6.

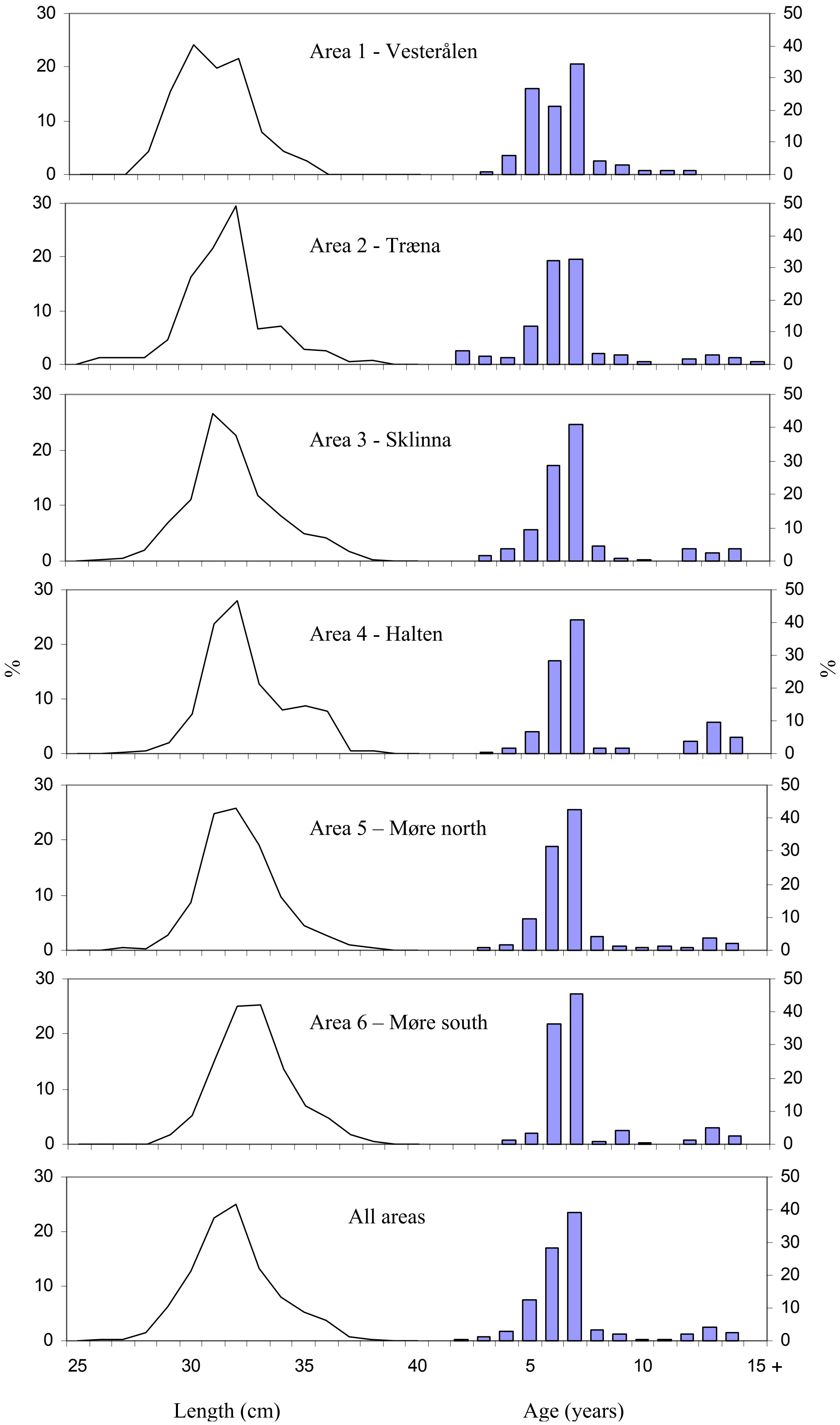


Fig. 4. Length and age distribution (weighted by acoustic abundance) by area and totally.

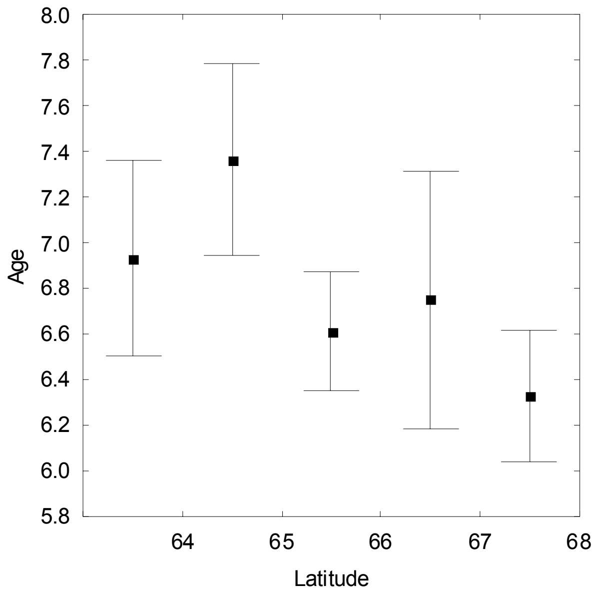


Fig. 5. Herring age related to latitude (mean±95% conf.int).

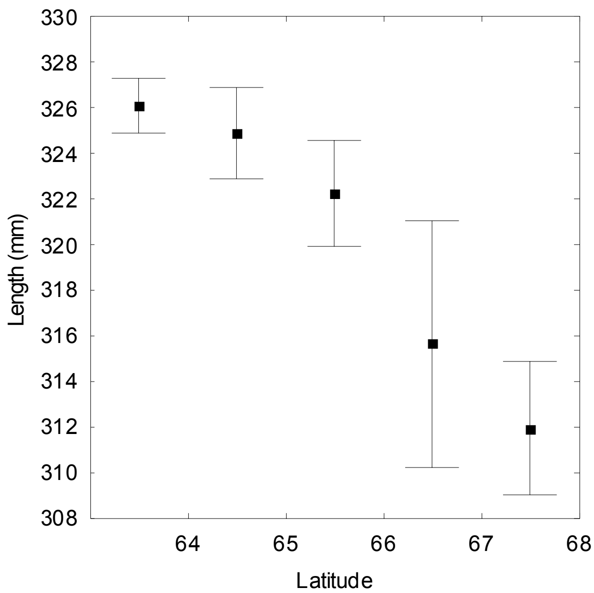


Fig. 6. Herring length related to latitude (mean±95% conf.int).

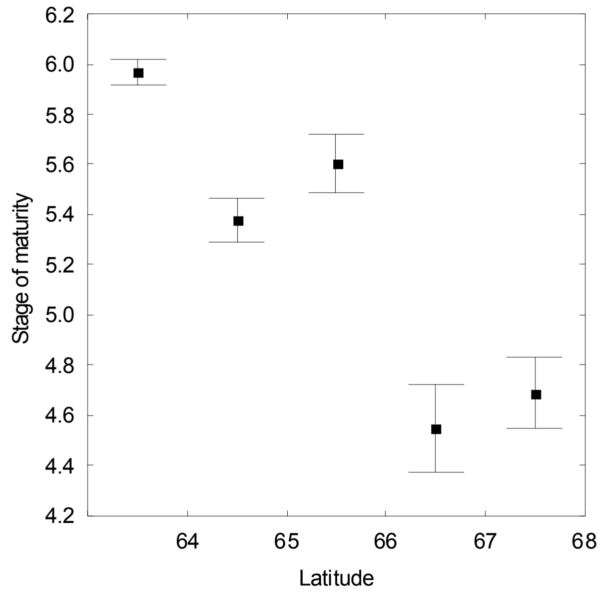


Fig. 7. Stage of maturity related to latitude (mean±95% conf.int).

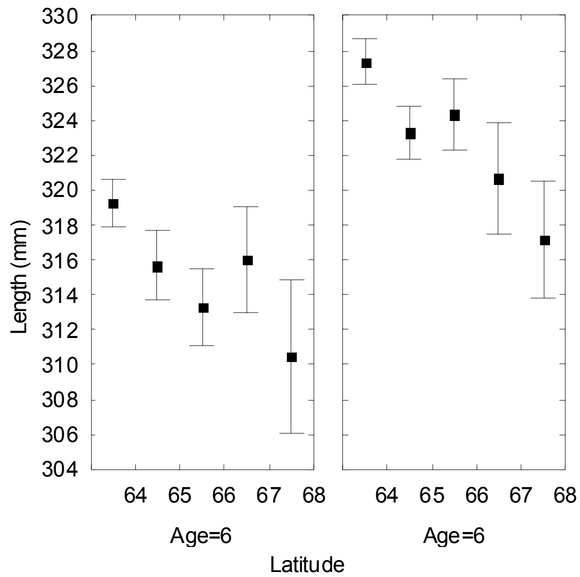


Fig. 8. Length related to latitude for 6 and 7 year olds (mean±95% conf.int).

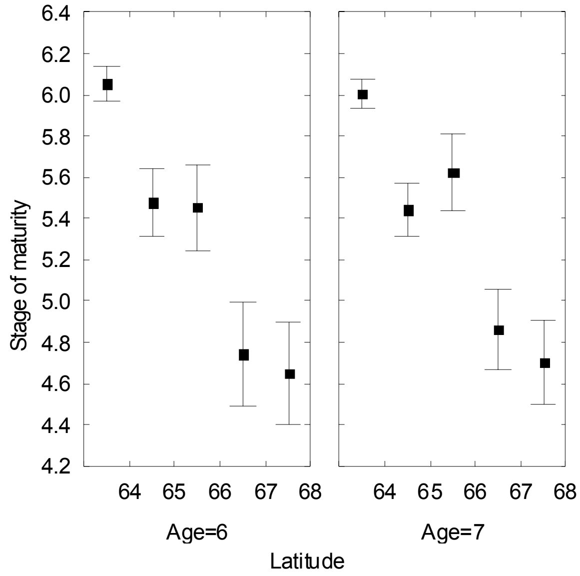


Fig. 9. Stage of maturity related to latitude for 6 and 7 year olds (mean±95% conf.int).

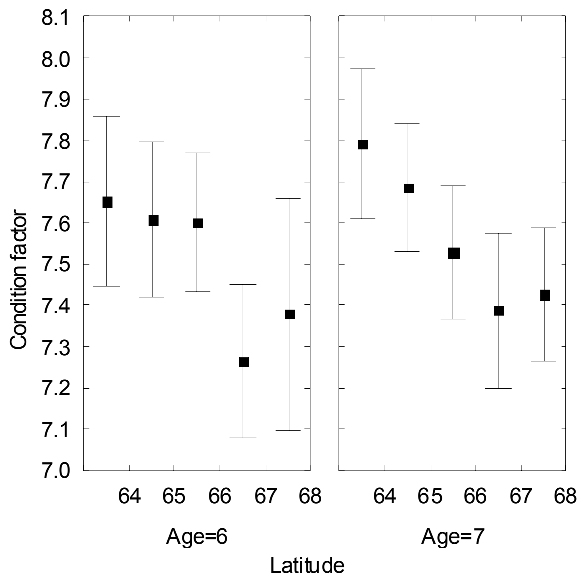


Fig. 10. Pre-spawning condition factor related to latitude for 6 and 7 year olds (mean±95% conf.int).