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MILJØ - RESSURS - HAVBRUK

Nordnesgaten 50 Postboks 1870 5817 Bergen
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Tittel:
DISTRIBUTION AND ABUNDANCE OF NORWEGIAN SPRING SPAWNING HERRING DURING THE SPAWNING SEASON IN 2000

Forfatter(e):
Aril Slotte & Are Dommasnes

Senter:
Senter for Marine Ressurser

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During the period 15.02-26.03.2000 the maturing and spawning herring (*Clupea harengus* L.) were distributed along the Norwegian coast from 57°N to 69°N. Between 61°N and 69°N the biomass and abundance estimates were 4.7 million tonnes and 17.4 billion individuals respectively. The respective biomass estimates at the traditional spawning grounds off Karmøy (59°-59°30N) and at the spawning grounds farther south (57-59°N) were 56.000 tonnes and 84.000 tonnes at the highest. The 1992 and 1991 year classes predominated the spawning stock with 44.4 % and 24.4 % respectively, but the proportion of 1991 year class tended to increase northwards from 62°N. The body length and condition factor of abundant year classes tended to increase southwards. The temperature increased with depth. In addition it tended to decrease northwards and southwards from 62°N at all depths. North of 61°N the herring mainly spawned at depths between 100-200 m with ambient temperatures at 7-9°C. South of 61°N the majority of the herring spawned at depths below 75 m with temperatures at 5-7°C. The spawning temperatures in all areas seemed somewhat higher in 2000 compared with the two previous years.

Emneord:
Abundance, distribution, herring, migration, spawning

Prosjektleder

Seksjonsleder

«Cruise report»

RV *Michael Sars* 15.02.-26.03.2000

Distribution and abundance of Norwegian spring spawning herring during the spawning season in 2000

by

Aril Slotte and Are Dommasnes

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

Participants

Anthonypillai, V.	15.02 - 05.03
Dommasnes, A.	15.02 - 05.03, cruise leader
Gill, H.	05.03 - 26.03
Gullaksen, O.	15.02 - 05.03
Hermansen, E.	15.02 - 05.03
Hestenes, K.	05.03 - 26.03
Johannessen, J.	15.02 - 05.03
Kvinge, B.	15.02 - 05.03
Nilsen, K.	05.03 - 26.03
Nygård, J. E.	05.03 - 26.03
Slotte, A.	05.03 - 26.03, cruise leader
Tangen, Ø.	05.03 - 26.03

Methods

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. Integrator values were divided into herring and «other categories» based on the density and appearance of the registrations, target strength (TS) distribution and data from trawl catches. Based on the acoustic observations and age composition in the trawl catches the distribution area was divided into sub areas. Conversion of integrator readings (S_A) to number of herring was achieved by the following relation between target strength (TS) and total fish length (L):

$$TS(db) = 20.0 \cdot \log L - 71.9$$

The number of individuals (N) within a certain area (A) was given by:

$$N = 1/\sigma \cdot S_A \cdot A \text{ where } 1/\sigma = 10^6 \cdot 1.23 \cdot L^{-2}$$

The area A with positive integrator values was delimited after plotting the 1 n.m. integrator values attributed to herring along the survey lines. The mean integrator value (S_A) was the arithmetic mean of all positive values within the area A.

Results

Abundance and distribution

The spawning grounds from 61°N to 69°N were surveyed during 15 February to 11 March (**Figs. 1 and 2**). 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. The total spawning stock within this area was estimated to 4.703 million tonnes and 17.360 billion individuals, of which about 40 % was distributed at the spawning grounds north of Møre (north of 64°N) (**Fig. 3, Table 1**). The 1992 and 1991 year class (8 and 9 year olds) predominated in the spawning stock with 44.4 % and 24.4 % respectively, but the proportion of 1991 year class tended to increase northwards from Møre (**Fig. 4**). In addition the proportion of recruiting herring dominated by the 1996 year class (4 year olds) increased at the northernmost grounds.

Table 1. The overall areas estimates of abundance in millions (N) (spawning stock abundance = SSN) and biomass in thousand tonnes (B) (spawning stock biomass = SSB) of Norwegian spring spawning herring during the spawning season in 2000.

		Age													
	Sum	2	3	4	5	6	7	8	9	10	11	12	13	14	15+
Tot. N	19903.34	1516.47	690.31	1996.43	163.57	592.13	1997.43	7714.15	4239.59	553.02	71.22	2.70	0.00	5.56	360.74
Tot. B	4912.66	85.10	64.62	327.08	34.04	151.78	531.24	2170.23	1217.98	174.31	23.16	1.06	0.00	2.21	129.86
SSN	17360.02	0.00	80.00	1620.26	123.20	592.13	1997.43	7714.15	4239.59	553.02	71.22	2.70	0.00	5.56	360.74
SSB	4703.57	0.00	8.48	267.13	26.12	151.78	531.24	2170.23	1217.98	174.31	23.16	1.06	0.00	2.21	129.86

During 15-17 March the areas surrounding the island of Karmøy were surveyed (**Fig. 5**). The track was repeated two times during 20-21 March and 22-23. The repeated surveys

demonstrated a decline in herring biomass within the area from 56000 tonnes to 26000 tonnes during one week (**Fig. 6**). The age composition at these southern grounds was very similar to that off southern Møre (Area 1), only with somewhat higher proportion of 4 and 6 years olds.

The spawning grounds to the south of Karmøy were surveyed during 18-20 March and 23-25 March (**Fig. 7**). There was an increase in biomass from 26000 tonnes to 84000 tonnes between the first and second time (**Fig. 8**), suggesting that the spawning was somewhat delayed in this area compared with Karmøy. No samples were collected at these southernmost grounds, but the age composition was probably similar to that observed off Karmøy.

Latitudinal variations in length and condition

The body length (**Fig. 9**) and condition factor (**Fig. 10**) of the abundant year classes tended to increase southwards. 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; Slotte, 1998*b*; Slotte, 1999*a*). 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).

Temperatures in the spawning area

The temperature (**Figs. 11-13**) increased with depth. In addition, it tended to decrease northwards and southwards from 62°N at all depths. The majority of the herring off Møre and northwards, spawned at depths between 100-200 m with ambient temperatures at 7-9°C (**Fig. 11**). At the southernmost grounds (south of 61°N) the majority of the herring spawned at depths below 75 m, i.e. at temperatures of 5-7°C (**Figs. 12-13**). The differences in temperature with depth and latitude were similar in 2000 as in the two previous years (Slotte and Dommasnes 1998, 1999), but the temperatures in 2000 seemed to be somewhat higher.

Acknowledgement

All the participants and the rest of the crew on board RV Michael Sars are thanked for their valuable work during the cruise.

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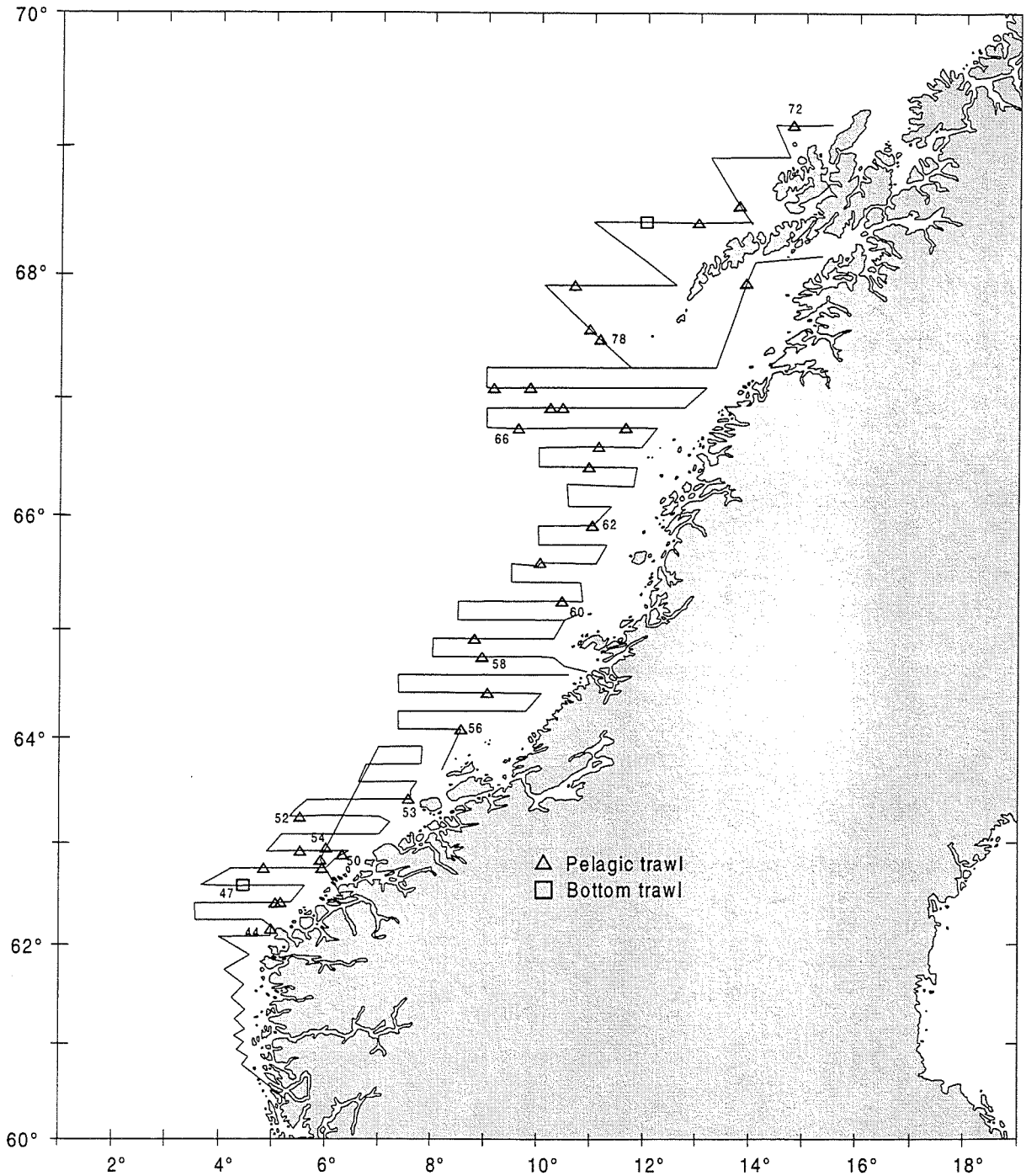


Fig. 1. Cruise tracks and trawl stations during an acoustical survey with RV Michael Sars 15.02-11.03.2000.

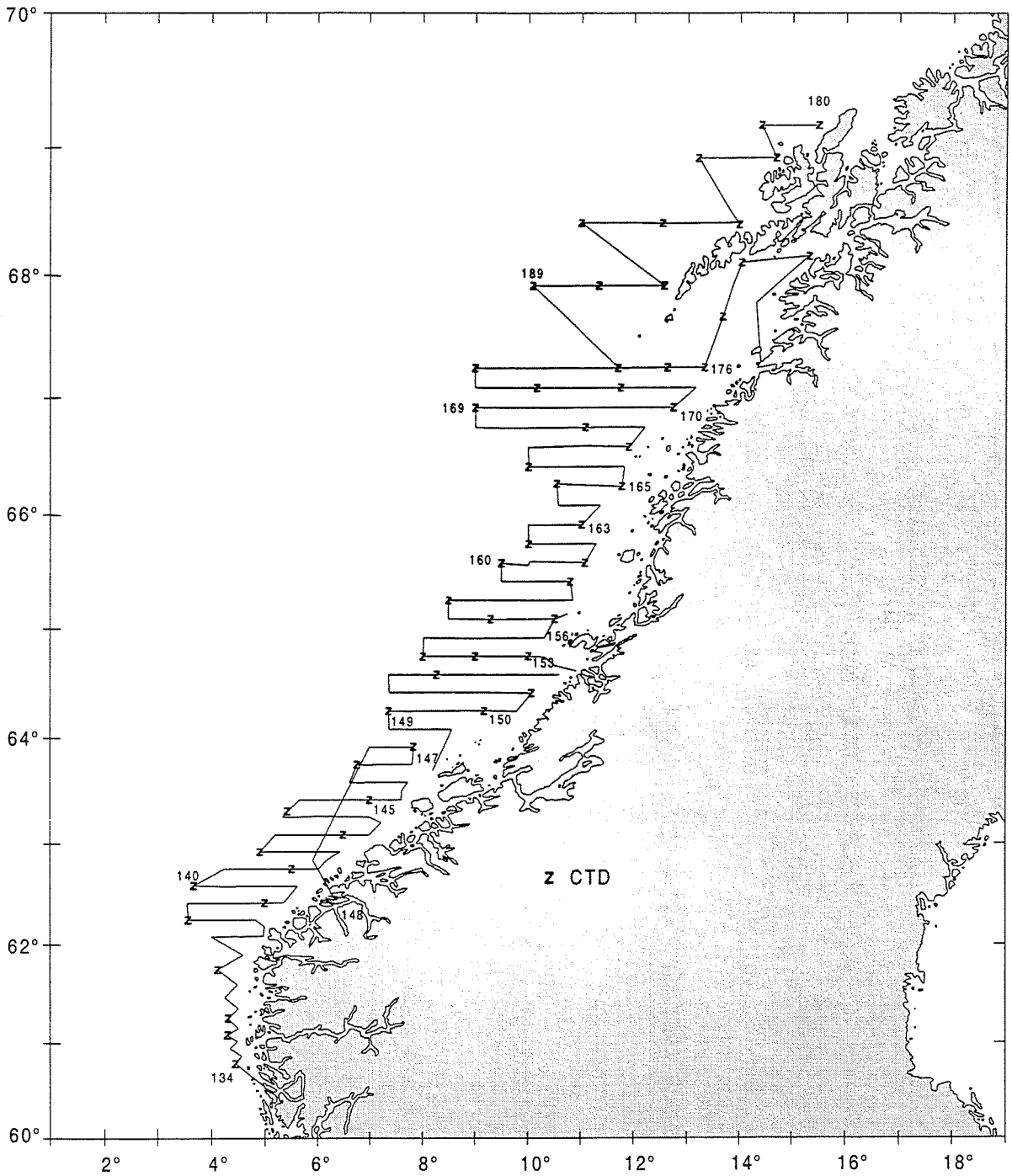
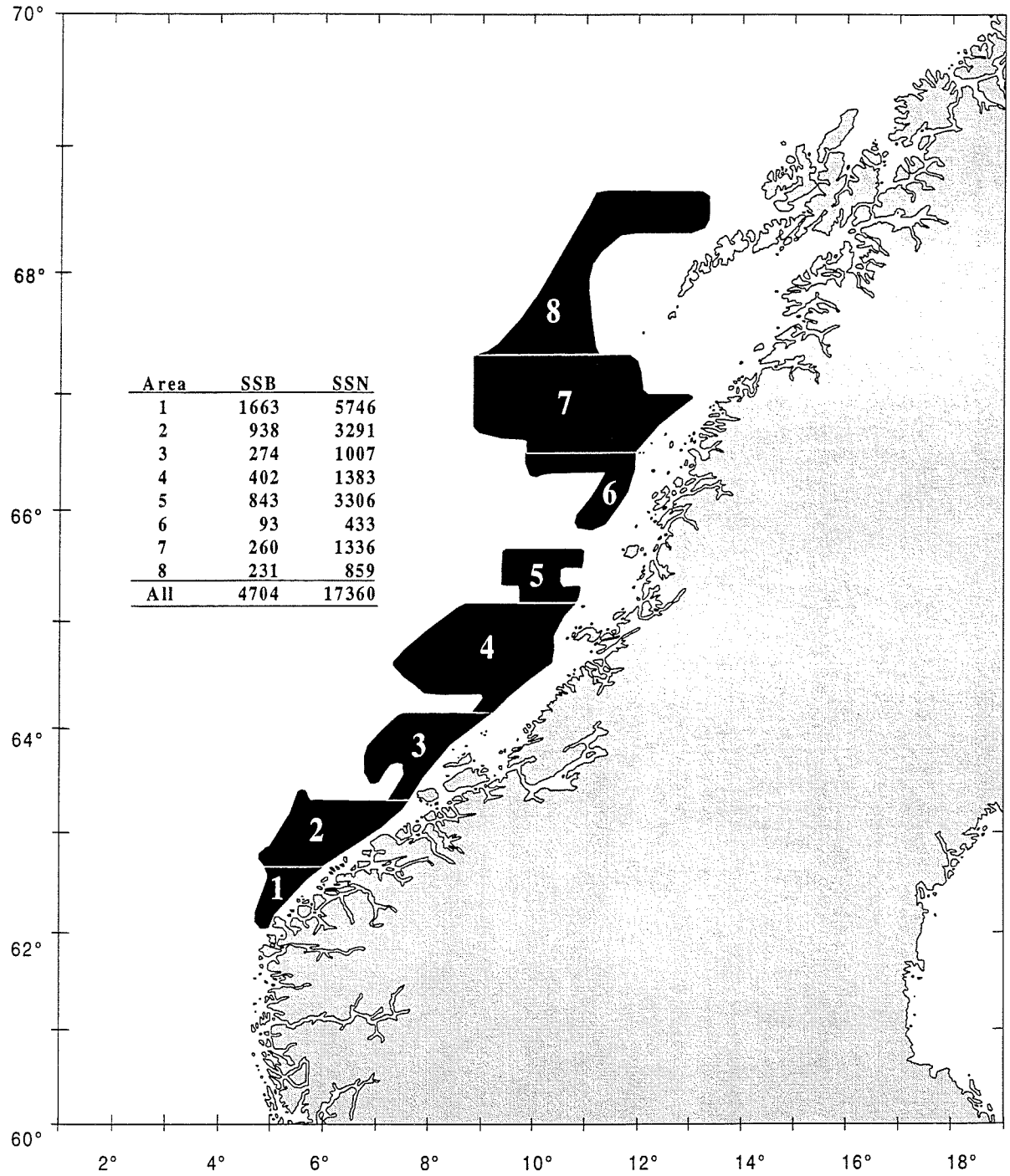


Fig. 2. Cruise tracks and CTD- stations during an acoustical survey with RV Michael Sars 15.02-11.03.2000.



Area	SSB	SSN
1	1663	5746
2	938	3291
3	274	1007
4	402	1383
5	843	3306
6	93	433
7	260	1336
8	231	859
All	4704	17360

Fig 3. Estimates of spawning stock biomass (SSB) in 1000 tonnes and abundance (SSN) in million individuals during an acoustical survey with RV Michael Sars 15.02 - 11.03.2000.

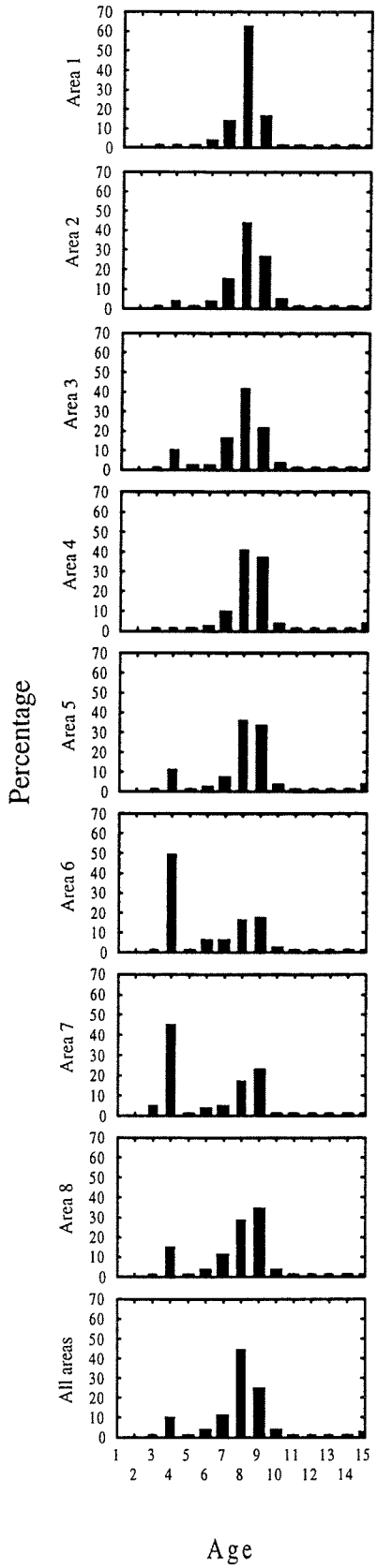


Fig 4. Age composition of herring by area estimated from trawl samples taken during an acoustical survey with RV Michael Sars 15.02 - 11.03.2000.

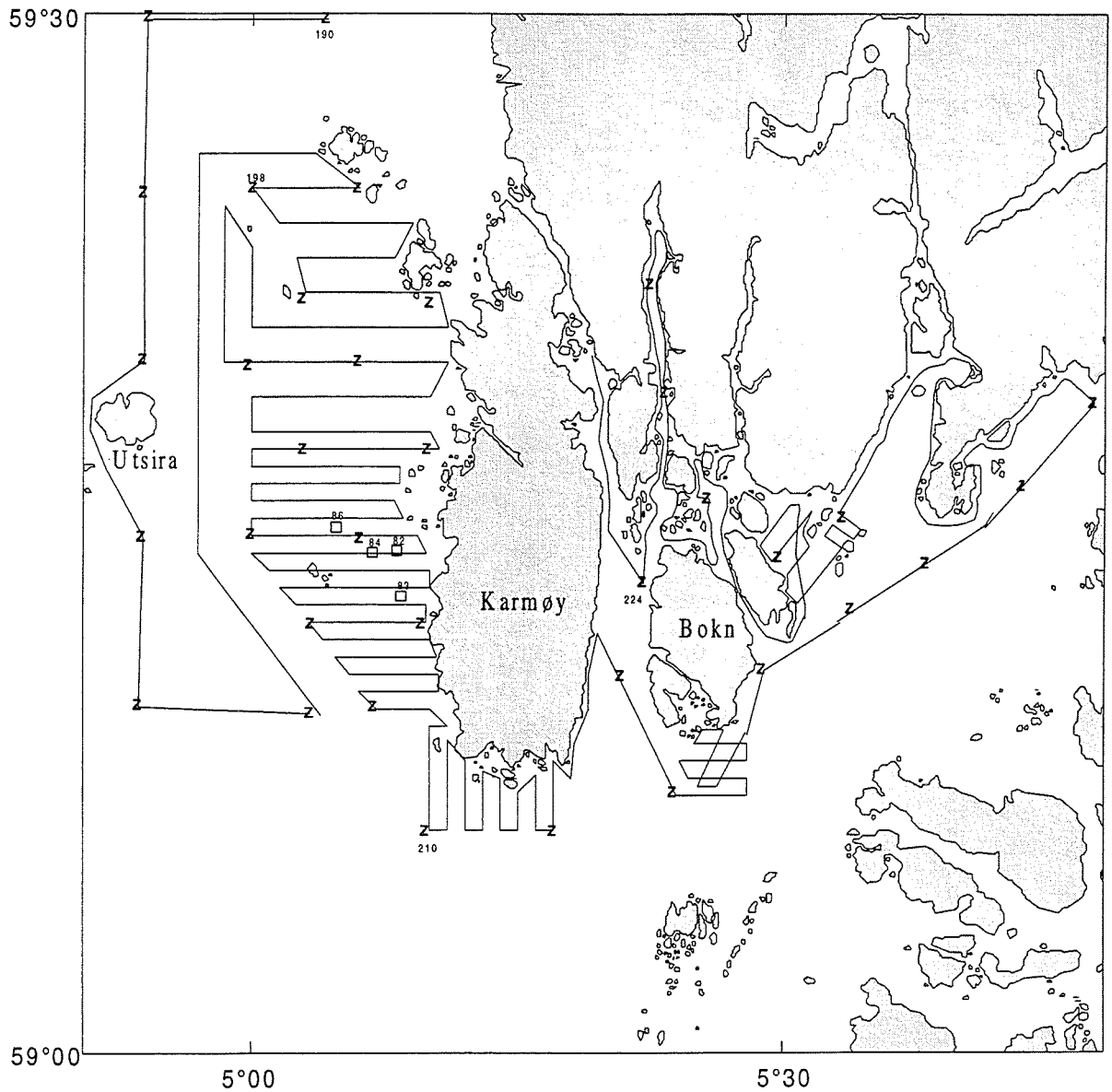


Fig 5. Cruise tracks, CTD-stations (z) and bottom trawl stations (rectangles) during an acoustical survey with RV Michael Sars 15.-17.03.2000. The cruise track was repeated during 20-21.03. and 22.-23.03.

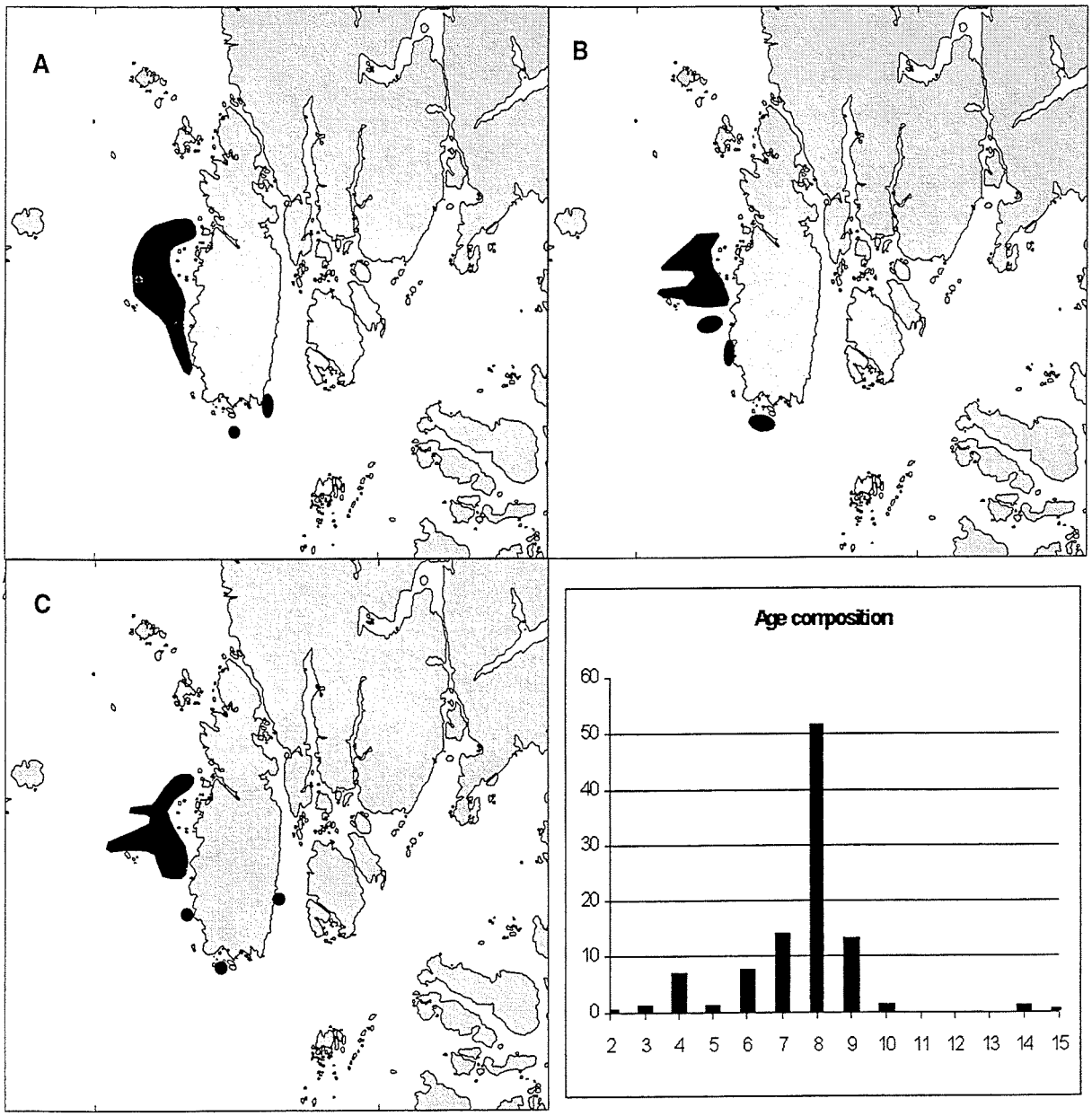


Fig 6. A) Distribution of herring during an acoustical survey with RV Michael Sars 15.-17.03.2000, biomass estimated was 56.000 tonnes. B) Distribution during 20-21.03., the estimate was 36.000 tonnes. C) Distribution during 22.-23.03., the estimate was 26.000 tonnes. Bottom right: herring age composition (%) at southern grounds.

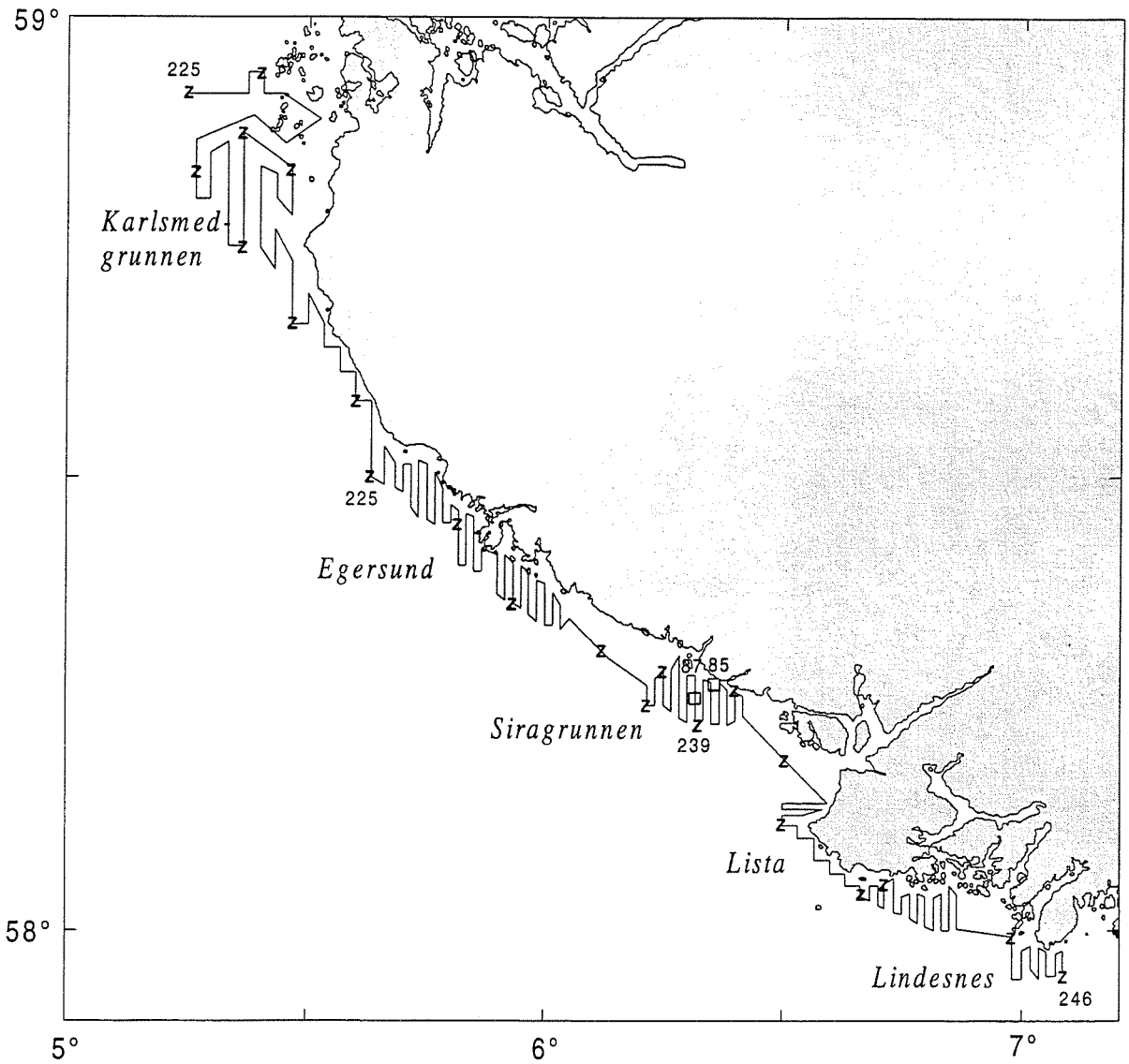


Fig 7. Cruise tracks and CTD-stations (z) during an acoustical survey with RV Michael Sars 18.-20.03.2000. The track was repeated during 23-25.03.

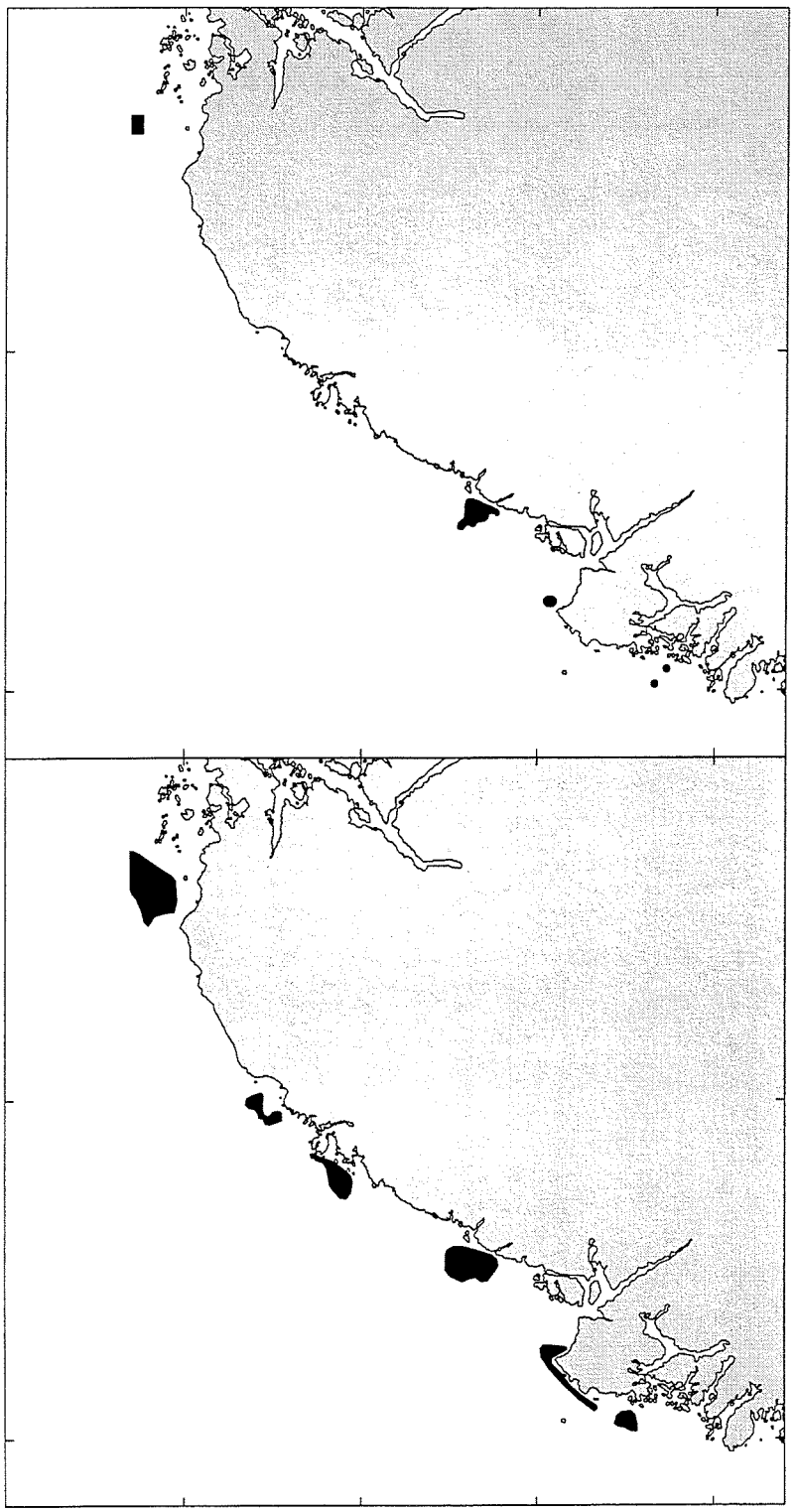


Fig. 8. Upper: Distribution of herring during an acoustical survey with RV Michael Sars 18.-19.03.2000. The biomass estimated was 26.000 tonnes. Bottom: Distribution during 23-25.03., the biomass was 84.000 tonnes.

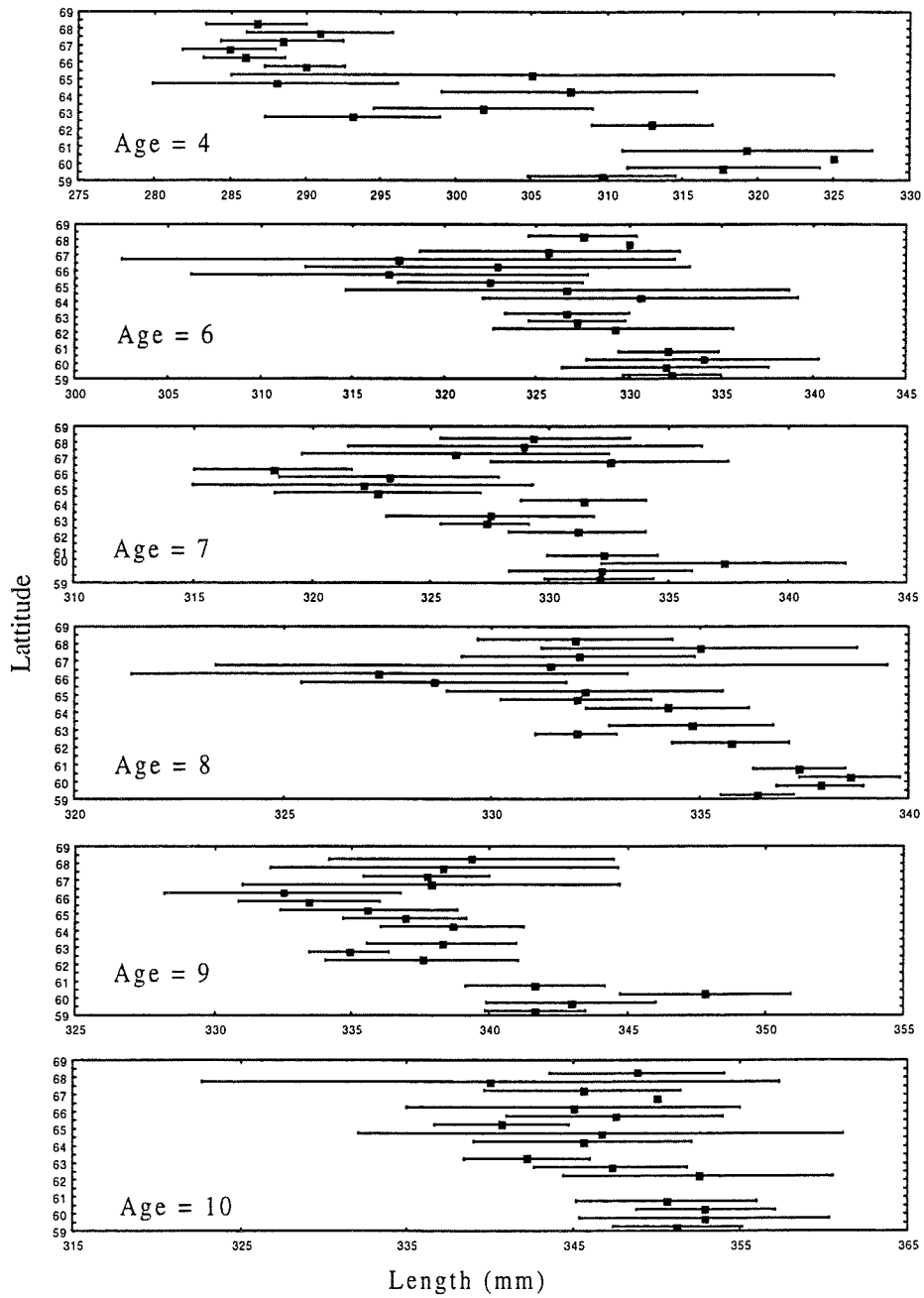


Fig. 9. Body length of abundant herring year classes in relation to latitude off collection. Individuals included in the analysis were collected during the period 15 March to 15 April 2000, i.e. samples from commercial fishery and other cruises were included in addition to the samples collected during the Michael Sars cruise.

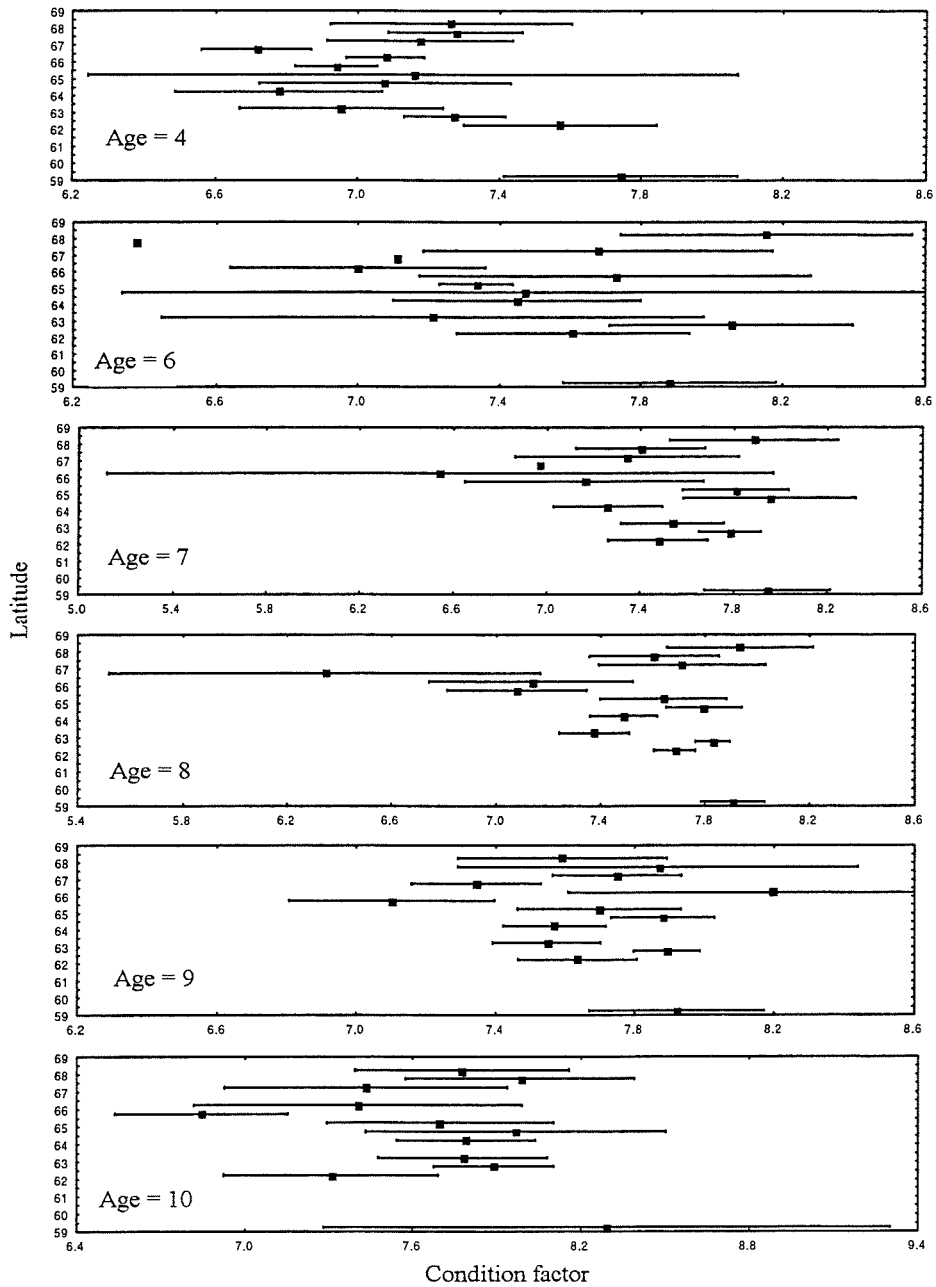


Fig. 10. The condition factor ($W/L^3*1000000$) of abundant herring year classes in relation to latitude off collection. Individuals included in the analysis were in maturity stages 3-6 collected during the cruise with Michael Sars 15.02-26.03.2000.

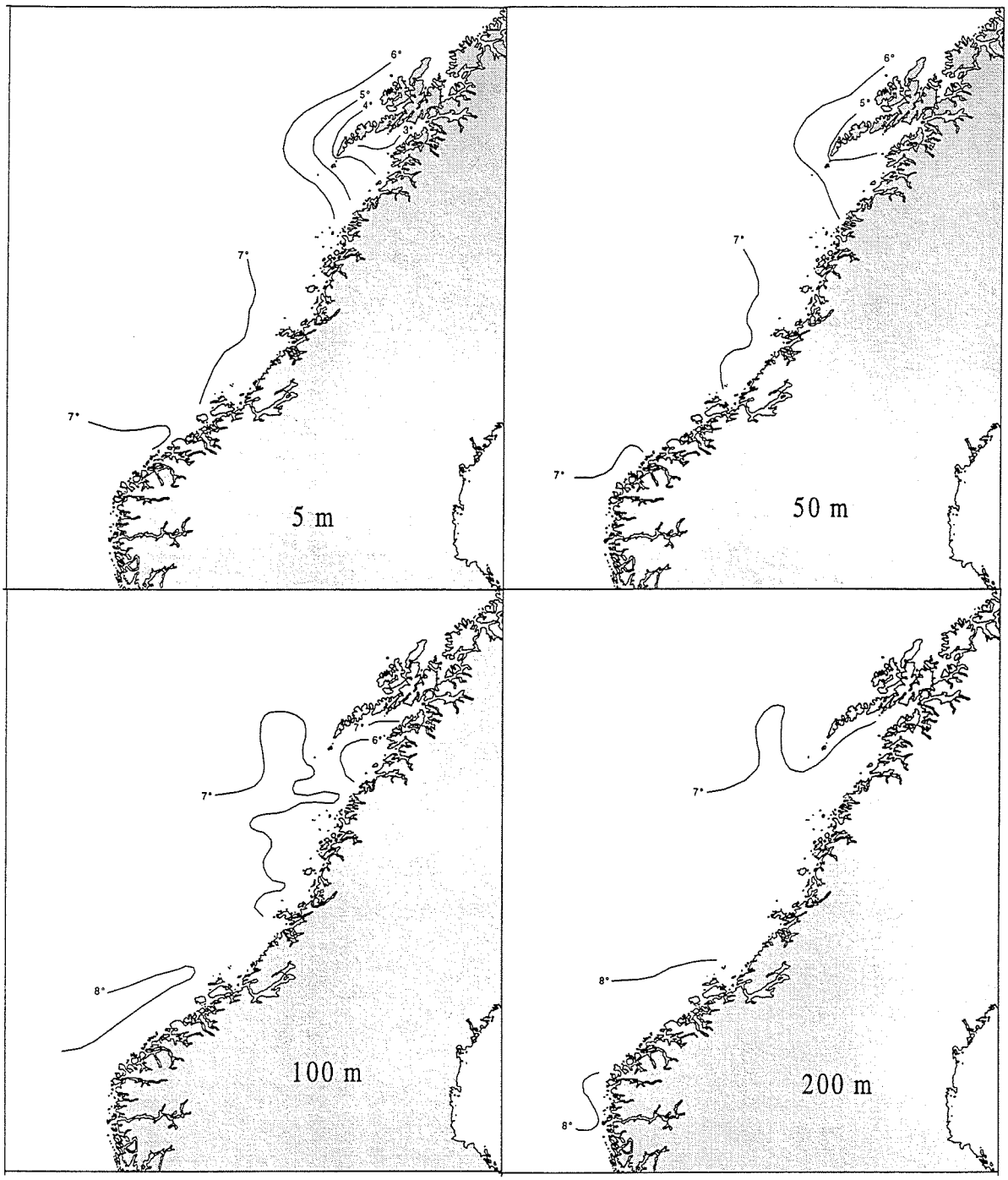


Fig. 11. Temperature at different depths in the main spawning areas of Norwegian spring spawning herring, measured during an acoustical survey with RV Michael Sars 15.02 - 11.03.2000.

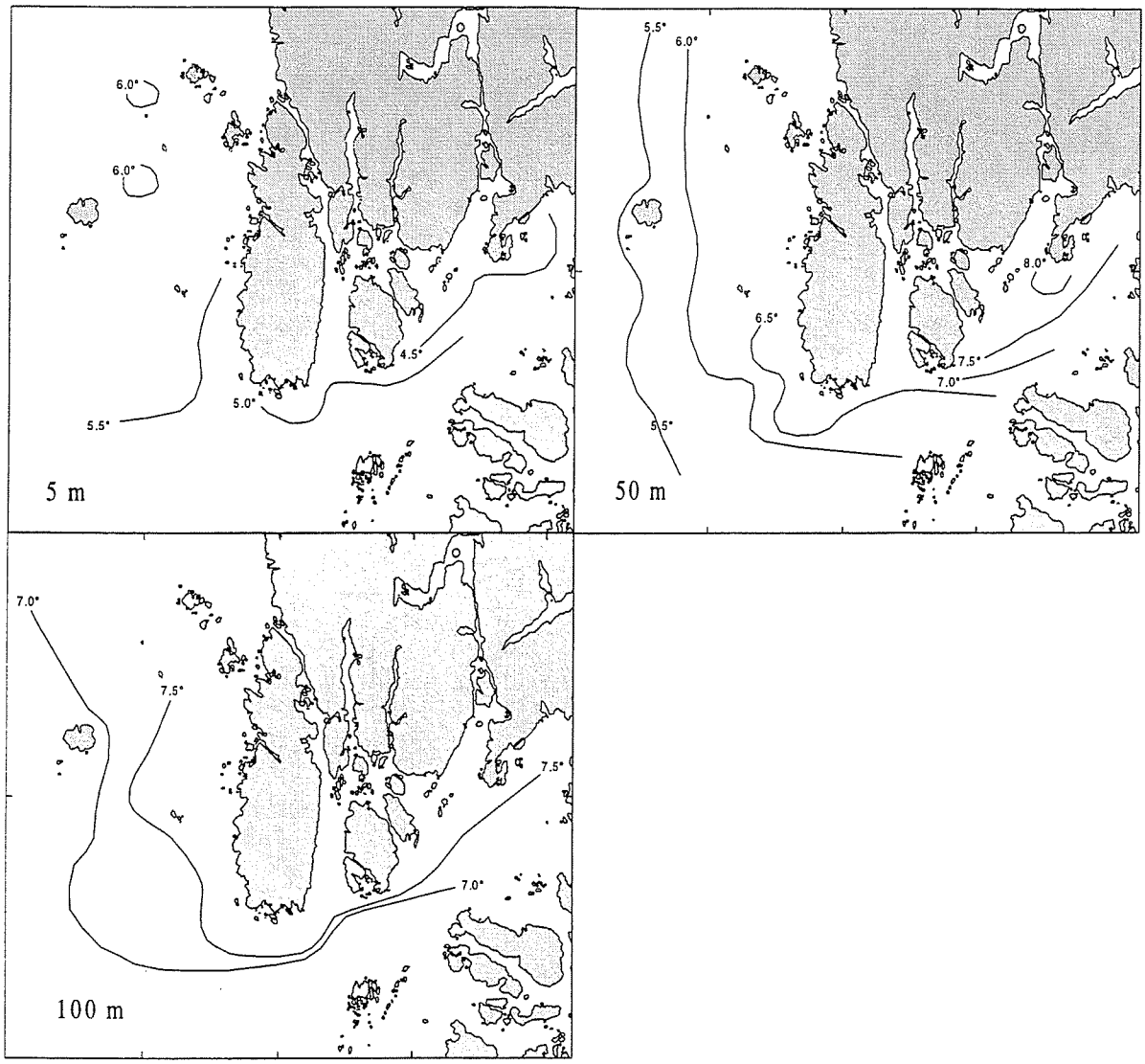


Fig. 12. Temperature at different depths around the island of Karmøy, measured during an acoustical survey with RV Michael Sars 15.-17.03.2000

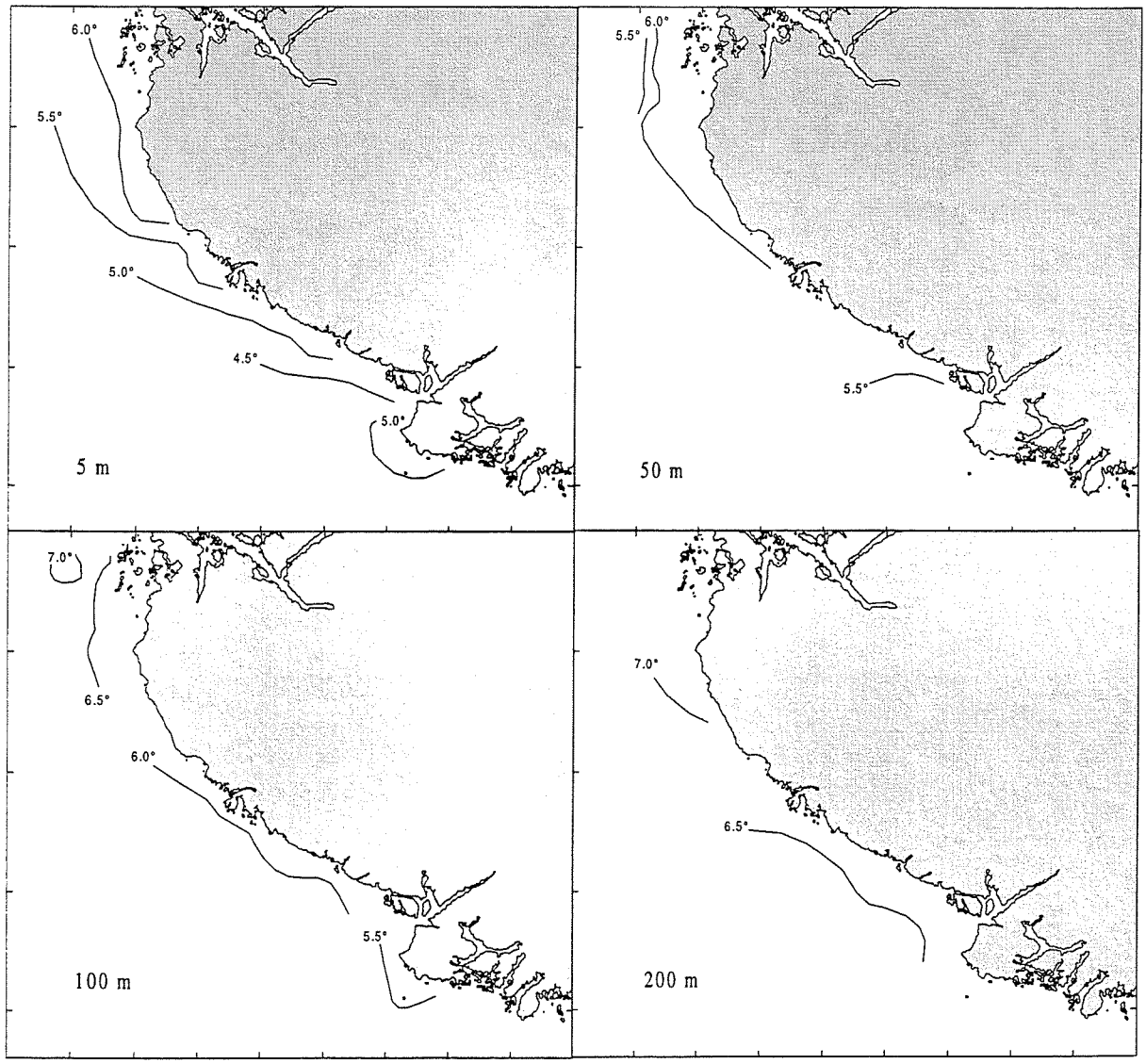


Fig. 13. Temperature at different depths along the southernmost spawning grounds of Norwegian spring spawning herring (Karlsmedgrunnen-Lindesnes), measured during an acoustical survey with RV Michael Sars 18.-19.03.2000