CRUISE REPORT
CRUISE No. 1997005
R/V «G.O. Sars»

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1. Introduction

The purpose of this cruise was primarily to study the relationship between the physical and biological environment and the migration behaviour of herring schools in the Norwegian Sea. Secondly, the cruise was designed to map parts of the distribution of the Norwegian spring spawning herring in the Norwegian Sea, and possibly to provide an estimate of abundance of the herring in the area surveyed. The cruise is the second of five norwegian cruises aimed at mapping and abundance of the Norwegian spring spawning herring in the Norwegian Sea and adjacent waters in 1997. The cruise is also part of the ICES coordinated research activity on Norwegian spring spawning herring and the environment in the Norwegian Sea that is established between EU, Faroes Islands, Iceland, Norway and Russia.

The cruise is also part of the *Mare Cognitum* research program at Institute of Marine Research, Bergen. The purpose of this programe is to explore the physical environment and biological ecosystem in the Norwegian Sea. This research programe requires specific sampling procedure with frequent CTD and MOCNESS stations, and trawl sampling trougout the whole water column from surface to 600 m depth.

To fullfill these purposes, the cruise was attempted to be run as a combination between an acoustic exploration survey of fish resources, an acoustic abundance estimation survey, and an environment exploration and monitoring surveys. The survey has therefore been conducted with predetermined transects, continous acoustic recording, tracking of selected schools for about one hour, aimed trawling on recordings and regular environmental stations.

2. Methods for recording, sampling and abundance estimation of fish

Continuous acoustic recordings of fish and plankton were made by a calibrated echo integration unit consisting of a 38 kHz Simrad EK500 working at a range of 0 - 500 m. The integration unit was connected to a Bergen Echo Integrator (BEI) for postprocessing of the recordings and allocation of area backscattering strengths (s_A) to species. The s_A - recordings per nautical mile were averaged over five nautical miles. The echo sounder was operated with the following settings: max. power: 4000 W, time varied gain: 20 log R, pulse length: 1 ms, bandwidth: wide, angle sensitivity: 21.9, 2-way beam angle: -21.0 dB, Sv transducer gain: 25.0 dB, TS transducer gain: 24.9 dB, 3 dB beamwidth: 7.0 dB.

A 95 kHz Simrad SA950 sonar was used to record schools near surface at a range of 50 - 300 m to the side of the vessel, and to track selected schools in the survey area. The sonar was operated with the following settings; TX power: max, range: 300 m, pulse: FM auto, gain: 9, display gain: 9, TVG: 30 log R, AGC: weak, Normalization: weak, Ping-to-ping filter: weak. The sonar is connected to a HP 9000 work station with software for detection and measurements of schools. This school detection system was operated with the following settings; minimum range: 50 m, maximum range: 300 m, colour detection threshold: 15, detection radius: 30 m, minimum gap 5 m, minimum width 5 m, minimum interval 5 m, minimum detection pings: 4.

To record migration behaviour and school dynamics, selected schools were tracked for up to 60 minutes. The schools were then continously recorded by the sonar system, and the position of the vessel was obtained from global positioning system (GPS). The migration speed and direction of the schools was calculated by procedures written in SAS software. The dynamics of the schools were noted continously by a rapporteur in cooperation with a sonar operator, both watching the sonar display.

Acoustic recordings of fish were identified by use of the Åkra-trawl, which has a vertical opening of about 30 m. By ordinary rigging the trawl can be used to catch deep recordings, but the trawl can also be rerigged to catch recordings near the surface by removing the weigths, extending the upper bridles by 12 m, and attaching two large buoys to each upper wing. In two occasions the Harstad pelagic trawl, which has a vertical opening of about 17 m and an innernet in the bag of just 11 mm stretched mesh width, was used to catch recordings of krill.

Subsamples of up to 100 specimens of herring and blue withing were taken from the trawl catches. The length down to nearest 0.5 cm, weight, sex, maturation stage, and stomach content were recorded. Scales from 50 herring and otholits from 50 blue withing were taken for age reading. The stomachs from 30 herring and 20 blue withing from each subsample were frozen for later analysis. Other fish species were length measured, weighted or frozen for later analysis.

The echo recordings were post-processed by the BEI-system, and s_A-values of defined recordings allocated to herring according to the trawl catches and the appearance of the recordings. To estimate the abundance of herring , the allocated s_A-values were averaged for statistical squares of 1° latitude and 2° longitude. For each statistical square, the area density of herring (ρ_A) of herring in number per square nautical mile (N n.mile^{-2}) was calculated by the equation;

$$\rho_A = s_A/\sigma \qquad \text{(N n.mile}^{-2}\text{)} \qquad (1.1)$$

where:

$$\sigma = 4\pi \cdot 10^{1/10 \cdot TS} \qquad (1.2)$$

$$TS = 20 \log L - 71.9 \qquad (1.3)$$

Insertion of equation 1.3 to 1.2, and 1.2 to 1.1 give:

$$\rho_A = s_A \cdot 1.23 \cdot 10^6 \cdot L^{-2} \qquad (N\ n.mile^{-2}) \qquad (1.4)$$

The length (L) applied in eqn. 1.3 and 1.4 was calculated as the average length in the herring samples for the area surveyed. To estimate the total abundance of herring, the area abundance for each statistical square was multiplied by the number of square nautical miles in each square, and then summed for all the statistical squares in defined sub-areas and the total area. The biomass was calculated by multiplying the total abundance by the average weight of the herring for the area surveyed.

The abundance of blue whiting was estimated by the same method, but for this species the area density was clculated by the equation:

$$\rho_A = s_A \cdot 1.488 \cdot 10^6 \cdot L^{-2.18} \qquad (1.5)$$

3. Survey area

The survey started with hydrograpic, nutrients, plankton and sediment sampling and monitoring at the regular stations of the Svinøy transect (Fig. 1). For mapping distribution, recording abundance and tracking selected herring schools, an area between 66 - 67 30 N and 2 E - 4 W was surveyed by a regular grid with 30 nautical mile spacing north - south.

The weather conditions were rather bad during the survey, and we had wind stronger than 25 m/s (Beaufort force 6) for 12 of the 15 days at sea. In 3 occasions when the wind was about 45 m/s (storm) we had to turn the vessel up againts the waves and reduce the speed. On the last three stations of the Svinøy transect we faced our fourth storm!

The CTD (62 cases) and pelagic trawl station (21 cases) taken during the cruise are shown in Fig. 1 and 2.

4. Temperature distribution

The temperature in the area surveyed was characterized by a distinct front from east to west which had its direction north - south at about 0° (Fig. 3). At 50 m depth the temperature was about 4° C at about 0° , decreasing westwards and increasing eastwards. At 300 m depth the tempearture was about 2° C at about 0°, and similarly decreasing westwards and increasing eastwards (Fig. 4).

5. Herring distribution and abundance

The herring were recorded mainly between 65° 30' - 67° 30' N, 003° 30' W - 002° E (Fig. 5). In 9 cases a proper herring sample was caught by the pelagic trawl. The herring in the area averaged 31.3 cm and 0.203 kg, but there was a certain tendency to larger herring in the catches taken in the south-western area (Fig. 6). The herring catches contained more than 50 % females (Fig. 7). The total abundance of herring in the area investigated was estimated to $11.9 * 10^9$ individuals or $2.4 * 10^6$ tonns. However, these numbers are most likely underestimates because the herring schools were often recorded at a depth which probably is beyond the validity of the target strength relationship applied. In addition there were probably substantial attenuation due to surface airbubbles during recordings in bad weather.

6. Herring school migration

32 schools were tracked for up to 60 min during the cruise. The schools were distributed all over the survey area, and occured at depths from about 20 m to about 350 m. Generally, the schools were swimming at depths from 150 m to 350 during daytime (08:00 - 18:00), ascended to the surface during the evening, and descended during the night (Fig. 8). Schools recorded west of 0 occured at greatest depth (Fig. 9).

Similarly, the swimming behaviour of the schools varied considerably. Average horizontal swimming speed varied between 0.5 - 2.2 m/s, with a tendency for schools recorded during the night to swim fastest (Fig. 10). The average migration speed in the migration direction varied between 0.05 - 1.8 m/s, and most schools headed in a western direction (Fig. 11). The average migration speed tended to be faster for schools heading westwards, and faster for schools recorded in the evening and at night (Fig. 12). The heading of the schools was independent of time of day (Fig. 13).

7. Herring school dynamics

The aim of school tracking is to obtain information about the dynamic behaviour of herring during their feeding migration in the Norwegian sea.

Methods

Sonar and echosounder are used to track school for a period of up to 1 hour. In addition to depth, direction and speed of migration and the search path of schools in different areas, the school dynamics was studied by recording intra- and interschool events observed on the the sonar screen on sheets and video-tapes for later analyses. Ther school detection program calculated number, area and density of schools.

Trawl stations are taken to identify the species. At each trawl station CTD and MOCNESS stations are also taken to enable us to relate herring behaviour to the local physical and biological environment. This is the same procedure as conducted during the April 1995 and 1996 survey.

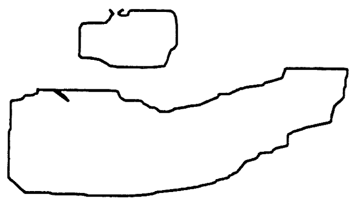
An addition was made to this years survey. By way of collecting information on the clustering nature of schools, experimental mesoscale surveys were carried out. This consisted of concentric cruise track of increasing size which started from the position from the end of school tracking. Three such experiments were conducted.

Results

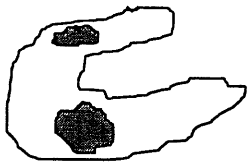
A total of 30 herring schools were tracked. The schools were relatively stable and the event rate was low compared to what has been observed in other situations. However, both joining and splitting of schools were repeatedly observed (Table 1), indicating adaptive adjustments of school size to the prevailing conditions. Intraschool events such as clumping and reorganization were also observed, as well as ring formation. There were some indications of antipredaror behaviour patterns. However, no mammal predators were observed visually in the distribution area of the herring schools, nor were any fish predators caught during the rather intensive trawling.

Herring schools were observed to migrate vertically during the tracking period. When passing over the school after tracking to estimate school size and vertical extent, some but not all schools dived rapidely downwards up to 100 m. The diving reaction reflecs antipredator behaviour, and the response variation may be caused by differences in the state of the schools. The examples of continous recordings are provided below followed by a tabulated summary of behavioural events (Table 1).

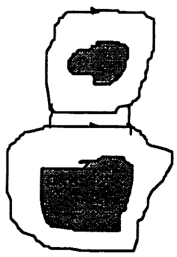
School 18
13:4:97 Gameboy: Leif Nøttestad, Reporter: Steven Mackinson
Video 2: 3.23.31-4.24.14
66 29.83 N 002 49.20 W
13:15 Start. Depth 170m, Range 224m. Tilt 35 deg, Area 2000m2. Large school. Depth range 120-185m.
13:19 School quite stationary. Shallower than most observed today (others up to 400m)
13:20



13:21 Change shape into two lobes - still connected. Tilt 60 deg. 2 density centres

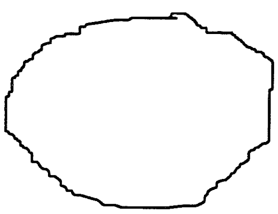


13:22



13:23 Coalescing to one distinct school again. More compact now. Appears more dense at top of school - BUT far side looks less dense because it is being shadowed.

13:27 Still consistent and circular



13:22 Depth 138m

13:36 Still consistent and round. Range 93m, Depth 144. Tilt at 65 deg giving area reading of 500m2
13:46 Target at bottom of screen is air bubbles from turning vessel
13:59 Circular
14:08 Very slightly more elongated
14:15 End observation. School heading at 340 deg. Travelled 0.6nm in 1 hour = 0.30 m/s

School 32: MESOMAP 2
17:4:97 Video 4
Anders Fernö
66 38.93 N 001 16.35 W
20:46 Start. Ring found, 165m deep
20:48 Loose structure
20:54 Elongated form
20:59 Now three units
21:00 Split
21:01 Ring structure
21:03 Loose school with the spliced structure also visible
21:05 Ring structure
21:06 Elongated. Depth 160m
21:16 Depth 150m. Relatively elongated and loose
21:17 The school is on the echosounder
21:24 Loose with two centres
21:32 Another school approaching
21:35 60m distance between schools
21:37 30m distance between schools
21:38 Definite connection
21:40 Join. One school 4200m2
21:41 Very loose structure after the join. Interesting difference
21:45 140 m deep
21.46 end of obs
Passes over 160m depth. School is 50m thick
Direction: 177 deg
Distance 0.78 nm=0.35 m/s

Table 1. Summary of schools and behavioural events. Speed is average migration speed, and Head is average migration direction, Eph is events per hour, NB is number of neighbouring schools.

Date	#	Latitude	Longitude	Track time (hr)	Split	Join	Eph	NB	Depth	Area	Speed (m/s)	Head (°)	Temp	Salinity
08.apr	1	64 45,00 N	00 05.54 W	0,20			0,00	3	168	66	1,03	355		
09.apr	2	65 41,05 N	002 16,04 W	1,10			0,00		327	562	0,34	237	1,944	34,945
09.apr	3	65 45,00 N	002 24.7 W	1,00			0,00	1	259	956	0,36	248	1,995	34,937
09.apr	4	65 49,00 N	002 34.80 E	1,00	1		1,00		250	###	0,21	134	1,9	34,937
10.apr	5	65 51,09 N	002 44,80 W	0,60			0,00		159	269	1,09	271		
								10+						
10.apr	6	65 54,01 N	002 45,40 W	1,08		2	1,85	6	164	390	0,07	54	3,414	34,966
10.apr	7	66 00,61 N	003 24,40 W	1,02	1	1	1,97		359	100	0,32	297	1,429	34,936
11.apr	8	65 59,6 N	000 31,4 E	0,95	1	1	2,11	1	226	173	0,22	60	3,475	34,956
11.apr	9	65 59.9 N	000 38,8 E	0,17	1		6,00		128	785	0,82	253		
12.apr	10	66 29,23 N	002 00.99 E	0,17			0,00		111	168	1,15	278	6,249	35,129
12.apr	11	66 30,00 N	02 00,00 E	0,08			0,00						6,395	35,14
12.apr	12	66 30,3 N	001, 53.16 E	0,62	1	2	4,86	2	208	293	0,18	51	5,407	35,077
12.apr	13	66 29,70 N	000 34,98 E	0,33			0,00	5	219	79	0,34	203		
12.apr	14	66 29,93 N	000 31,80 E	0,42			0,00	1	206	77	0,358	58		
12.apr	15	66 29,78 N	000 25,34 E	0,35			0,00		216	118			3,111	34,934
								10+						
13.apr	16	66 29,88 N	002 07,84 W	0,45			0,00		257	113	0,48	297		
13.apr	17	66 03,09 N	002 09,00 W	1,00			0,00	1	253	638	0,13	347	2,274	34,953
13.apr	18	66 29,83 N	002 49,28 W	1,00			0,00		137	752	0,31	84	2,304	34,962
14.apr	19	66 59,9 N	001 59 W	1,00	1		1,00	2	289	560	0,45	264	2,176	34,979
14.apr	20	66 59,6 N	001 51,4 W	1,00	1	1	2,00	1	163	445	0,1	220	2,443	34,938
14.apr	21	67 00,61 N	001 21,11 W	0,52			0,00	10	11	59	0,8	298		
14.apr	22	67 00,50 N	000 53,79 W	0,32	1	4	15,79		12	58	1,22	263		
								10+						
15.apr	23	66 59,62 N	000 33,05 W	0,25	1		4,00	4	27	43	1,75	271		
15.apr	24	66 59,85 N	000 21,03 W	1,05	3	2	4,76	4	137	###	0,45	267	4,117	35,084
16.apr	25	66 59,86 N	000 49,20 E	0,52	1		1,94		178	770	0,17	240		
16.apr	26	67 30,03 N	000 35,24 W	0,52			0,00	3	353	56	0,4	215		
16.apr	27	67 30,08 N	000 32,60 W	0,58	3		5,14	2	310	139	0,58	150	2,324	34,96
16.apr	28	67 29,9 N	001 01,3 W	0,52			0,00	1	336	79	0,98	228	2,103	34,945
16.apr	29	67 29,8 N	001 08,3 W	1,00	2	1	3,00	2	311	112	0,25	30	2,288	34,941
16.apr	30	67 29,3 N	001 19,4 W	0,98	1	1	2,03		148	452	0,35	166		
17.apr	31	66 42,2 N	001 27,1 W	1,00	1		1,00	1						
17.apr	32	66 38,93 N	001 16,35 W	1,00	1	1	2,00	2					2,415	35,001
18.apr	33	66 13.52 N	000 07.52 W	0,98			0,00						1,646	34,937

8. Blue whiting

Blue whiting were recorded in most of the area surveyed west to 0° W. There were 8 pelagic trawl catches with proper samples of blue whiting (Fig. 14), and the blue whiting averaged 20.3 cm and 0.052 kg. The total abundance in the area surveyed amounted to $27 * 10^9$ individuals or $1.4 * 10^6$ tonns. The highest abundance of blue whiting was found east of the herring concentrations and especially along the Svinøy transect (Fig. 15)

9. Pelagic trawl sampling

Pelagic trawl sampling of schooling herring or blue whiting requires precise navigation and positioning of the trawl horizontally and vertically. The sampling is often made even more difficult by avoidance behaviour of the fish towards vessel and trawl gear. In many cases herring schools descended more than 50 m between the vessel and the trawl. To obtain catches in such occations, the vessel was backed up for about 30 s and the trawl lowered as fast as possible.

To avoid large catches, there was a 1.5 m long split in the bag about 3.5 m in front of the cod end. This modification of the gear ensured that the maximum catch size was about 750 kg. Most catches of schools were 200 - 400 kg (Fig. 16).

10. Plankton, nutrients and chlorophyll

The Svinøy standard transect was sampled in the beginning of the cruise and during our return from our main investigation area. A total of 15 stations with CTD and nutrient samples to 1000 m, chlorophyll samples to 100 m, WP-2 net hauls from 200 m to the surface and 3 MOCNESS stations were sampled along the transect (Tab. 2). The samples are part of the sampling program of the TASC-project at IMR. The rest of the sampling stations was located within the main investigation area covering both the cold and warm side of the front (Tab. 2).

In Coastal water on the shelf the spring plankton production had started and the alga biomass was high (preliminary inspection of chlorophyll filters) and young copepodites of *Calanus finmarchicus* were present. Off the shelf in the core of the Atlantic current biomasses of *C. finmarchicus,* Chaetognaths, Amphipods and *C. hyperboreus* were low as usual, and both primary production and the *C. finmarchicus* population seemed to be in a late winter or early spring state of development. The biomass of Euphausiids was high in the Atlantic water mass.

Within the main investigation area biomasses of all species listed above were high. *C. finmarchicus* was mainly distributed from 500 to 100 m or to the surface, a typical late winter/early spring vertical distribution. Towards the colder water of the East Icelandic current biomasses of *C. finmarchicus* and *Euphausiids* decreased while *C. hyperboreus*, *Chaetognaths* and *Amphipods* increased. From the eastern and warmer part of the area towards the cold water in the west, chlorophyll concentrations were generally increasing indicating a bloom start in the east.

The herring made diurnal vertical migrations from between 300 and 400 m depth during the day to above 100 m during the night. Preliminary inspections of stomach content showed *C. finmarchicus*, *Euphausiids* and *Chaetognaths* to be important food items. At one station apparent feeding on larger food items, *Chaetognaths* and *C. hyperboreus* at almost 400 m depth during day time was observed.

APPENDIX
Daily record of activity

6/4

15:00: Departing Ålesund harbour, steaming out Breisundet in between numerous coastal vessel fishing cod, lifeboat-manouvre, safety-instructions. Cold, clear weather. Starting at Station 1 on Svinøy-transect ca. 17:30.
Sailing north west on Svinøy-transect, station work according to specified plans.

7/4

South eastern gale, Svinøy transect, station work, PT104, catch 1 bucket of blue whiting.

8/4

Southern strong breeze, little gale. Ending Svinøy transect at 64° 40' N 0° at 19:00, PT105, catch 10 buckets of blue whiting and herring, increasing wind during the evening.

9/4

Southern strong gale, a few recordings of herring schools during the night, PT106 at surface in the morning, no catch. PT 107; catch 750 kg herring, PT 108; catch 360 kg herring.

10/4

PT109; catch 300 kg herring, north to 66, west to 4°, turning east, north western storm, force 10n from about 15:00. Backing up against the wind the rest of the day. Wind decreasing gradually during the evening.

11/4

Northern breeze. East along 66°. Tracking school 8 and 9. PT 110: catch 2 buckets of blue whiting and herring. PT 111 at surface: catch 8 herring and 8 blue whiting.

12/4

East along 66 to 2 east, then north to 66 30', and west along 66 30'. PT112, catch 2 lumpsuckers, PT113 catch 10 kg blue whiting. Western gale from about lunch.

13/4

Western gale. PT114, catch 240 kg herring, west along 66° 30' N to 4 W. Little north east storm in the evening, station at 4° W, turning north to 67° 00' N.

14/4

Northern gale force 8, station at 67° 00' N, 4° W at 08:00, crossing east along 67° 00', N. Conversation with Håkon Mosby at 09:00. They will start at 67° 00' N, 2E and make transects to 4 W, then to 66° 30' N, 4° W, then east to 2° E, then to 66° N, 2° E and then to 66° N, 4° W.

15/4

East along 67° 00 N, Passing Håkon Mosby at 01:00 at about 01° 00 West.
Blue whiting east of 0°, conversations with Haakon Mosby at 09:00 and 21:00. At 09:00 Haakon Mosby at N 67° W02, had stopped for about eight hours at about 1° W to repair the SOFAR, the vessel was then observed by us. At 21:00 Håkon Mosby had reached 66° 30' N 3° W.

16/4

Little western storm, force 9 in the morning, decreasing to strong gale around lunch, tracking school 25 - 30 at 67° 30' N, 00° 30' - 01° 10' W, PT119 catch herring. Conversations with Hakon Mosby in at 09:00 and 21:00. At 09:00 Håkon Mosby at 66° 30' N, 1° 10' E. The SOFAR recordings showed a rather sudden cold front between 3° - 4° W, and intermediate water (3° - 4° C) east of the front. The herring seemed located in this intermediate water. Håkon Mosby finish along the 66° 30'N transect in the evening, and recorded much herring on this transect.

17/4

Northern breeze, finishing transect at 67° 30' N by a CTD at 4° W, heading south to 66° 15' N, 0°. Telefax to I. Røttingen about recordings so far. PT120 on recordings of krill shoals, catch, 4 kg krill, PT121 on krill shoals, catch 20 kg krill.Tracking school 31 and 32 with spiral search for neighbours. PT122, catch 20 herring.

18/4

Northern gale, force 7. Heading south to start the Svinøy transect, waves from behind and heavy rolling. PT123, PT124 catch blue whiting, PT125, deep tow at 1100 m, speed 2.0 knots, end of net sonde cable off the winch after 1 hour towing, catch; 5 *Gonatus*, 3 *Cirrotheutis*, 6 blue whiting, *Phasiphea*, *Sergestes* and *Hymenodora glacialis*, *Sagitta maxima*, laksesild.

19/4

Northern breeze, start Svinøy transect at 64 40' N, 0 at about 01:30. Working on the Svinøy transect the whole day.

20/4

South western gale force 8, increasing to south western storm in the afternoon. Finishing the Svinøy transect, the last station at about 18:00.

Appendixtable 1. Nutrient salts (Nut.), clorophyll (Chlor.), phytoplankton (Phyt. Pl.) and zooplankton samples by WP2-net and MOCNESS (MOC) - net (Ø: east, V: west).

					Nut.		Chlor.		Phyt.	WP2	MOC	MOC	MOC	MOC	MOC	MOC	MOC	MOC
St.	Svinøy	Latit.	Long.	Ø/V	Depth	No.	Depth	No	Depth	200-0	700-500	500-400	400-300	300-200	200-100	100-50	50-25	25-0
156	S	6 322	512	Ø	5-150	9	0-100	8	10	150-0								
157	S	6 229	457	Ø	5-190	10	0-100	8	10	190-0								
158	S	6 236	441	Ø	5-180	10	0-100	8	10	180-0								
159	S	6 243	426	Ø	5-170	10	0-100	8	10	180-0					149-98	x	x	x
160	S	6 250	411	Ø	10-580	12	0-100	6	10	x								
161	S	6 257	354	Ø	10-815	12	0-100	5	10, 50	x	x	x	x	x	x	x	x	x
162	S	6 304	339	Ø	10-940	12	0-100	5	10	x								
163	S	6 312	324	Ø	10-1000	12	0-100	5	10	x								
164	S	6 319	308	Ø	10-1000	12	0-100	5	10	x								
165	S	6 326	252	Ø	10-1000	12	0-100	5	10	x								
166	S	6 340	220	Ø	10-1000	12	0-100	5	10	x	754-500	x	x	x	x	x	x	x
167	S	6 354	148	Ø	10-1000	12	0-100	5	10	x								
168	S	6 408	116	Ø	10-1000	12	0-100	5	10	x								
169	S	6 422	04 4	Ø	10-1000	12	0-100	5	10	x								
170	S	6 440	000	Ø	10-1000	12	0-100	5	10	x								
171		6 535	200	V	5-500	12	0-100	7		x								
172		6 538	211	V	5-500	12	0-100	7				x	x	x	x	x	x	x
173		6 545	225	V	5-500	12	0-100	7										
174		6 549	235	V	10-500	12	0-75	6				x	x	x	x	x	x	x
175		6 554	245	V	10-500	11	0-100	7				x	x	x	x	x	x	x
176		6 600	300	V														
177		6 601	324	V	10-500	10	10-100	5										
178		6 600	400	V	5-500	12	0-100	7										
179		6 559	01 2	Ø	5-500	12	0-100	6										
180		6 600	200	Ø	10-500	12	0-100	7										
181		6 630	200	Ø	10-500	11	0-100	7		20-0		x	x	x	x	x	x	
182		6 628	01 5	Ø	10-500	12	0-100	7										
183		6 630	102	V	10-500	12	0-100	7		x								
184		6 630	200	V	10-500	12	0-100	7		x								
185		6 630	210	V	10-500	12	0-100	7				x	x	x	x	x	x	x
186		6 630	249	V	10-500	12	0-100	7		x								
187		6 630	400	V	10-500	12	0-100	7		x								
188		6 700	400	V	10-500	12	0-100	7		x								
189		6 700	300	V	10-500	12	0-100	7		x								
190		6 700	200	V	10-500	11	0-100	6				x	x	x	x	x	x	x

St.	Svinøy	Latit.	Long.	Ø/V	Nut. Depth	No.	Chlor. Depth	No	Phyt. Depth	WP2 200-0	MOC 700-500	MOC 500-400	MOC 400-300	MOC 300-200	MOC 200-100	MOC 100-50	MOC 50-25	MOC 25-0
191		6 660	02 0	V	10-500	12	0-100	7				x	x	x	x	x	x	x
192		6 701	05 3	Ø	10-500	12	0-100	7										
193		6 700	200	Ø	10-500	12	0-100	7				x	x	x	x	x	x	x
194		6 730	200	Ø	10-500	12	0-100	7										
195		6 730	100	Ø	10-500	12	0-100	7		x								
196		6 730	000	Ø	10-500	12	0-100	7										
197		6 728	02 3	V	10-500	12	0-100	7		x								
198		6 730	100	V	10-500	12	0-100	7		x								
199		6 729	120	V	10-500	11	0-100	7		x								
200		6 730	200	V	10-500	12	0-100	7		x								
201		6 730	300	V	10-500	12	0-100	7				x	x	x	x	x	x	x
202		6 730	400	V	10-500	11	0-100	7		x								
203		6 632	05 9	V	10-500	12	0-100	7		x								
204		6 610	0 04	V	10-500	12	0-100	7										
205	S	6 440	000	Ø	10-1000	12	0-100	5	10	x								
206	S	6 422	04 4	Ø	10-1000	12	0-100	5	10	x								
207	S	6 408	116	Ø	10-1000	12	0-100	5	10	x								
208	S	6 354	148	Ø	10-1000	12	0-100	5	10	x								
209	S	6 340	220	Ø	10-1000	12	0-100	5	10	x			500-300	x	x	x	x	x
210	S	6 326	252	Ø	10-1000	12	0-100	5	10	x								
211	S	6 319	308	Ø	10-1000	12	0-100	5	10	x								
212	S	6 312	324	Ø	10-1000	12	0-100	5	10	x								
213	S	6 304	339	Ø	10-1000	12	0-100	5	10	x								
214	S	6 257	355	Ø	10-1000	11	0-100	5	10, 20, 50	x		x	x	x	x	x	x	x
215	S	6 250	411	Ø	10-570	12	0-100	6	10	x								
216	S	6 243	426	Ø	5-175	10	0-100	8	10, 50	x					173-100	x	x	x
217	S	6 236	441	Ø	5-180	10	0-100	8	10	x								
218	S	6 229	457	Ø	5-180	10	0-100	6	10	x								

FIGURES

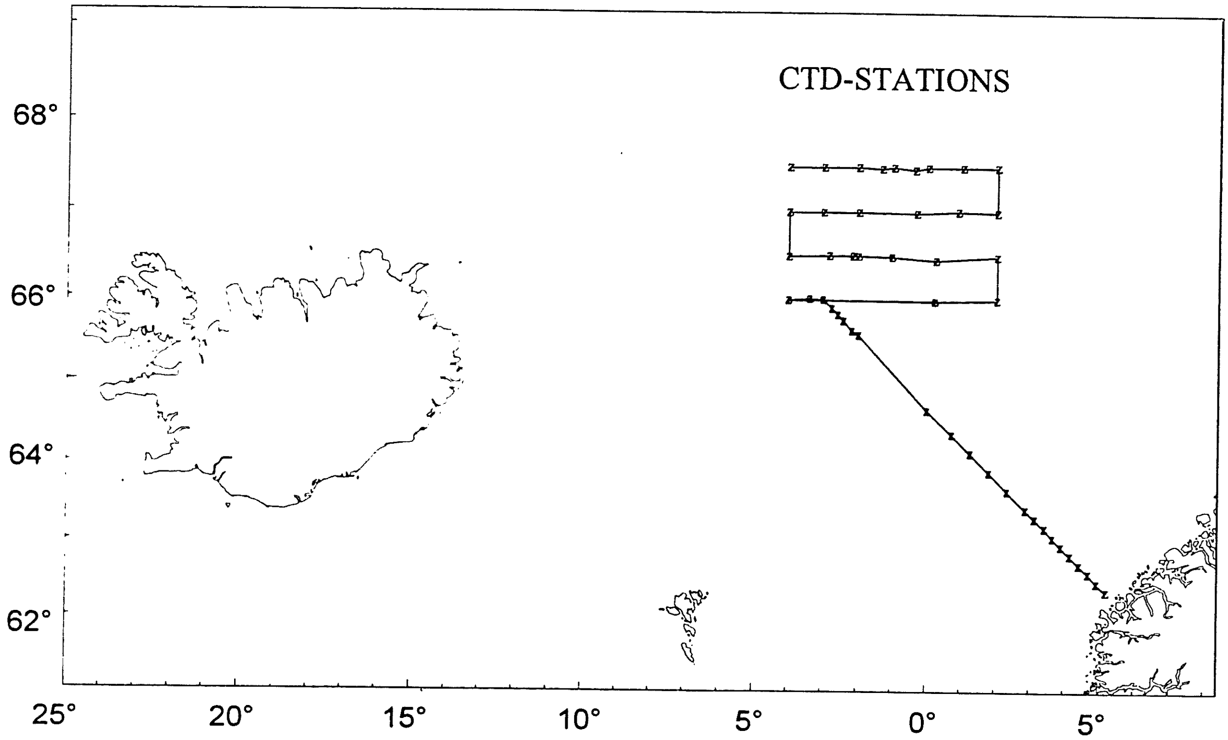


Fig. 1. CTD-stations.

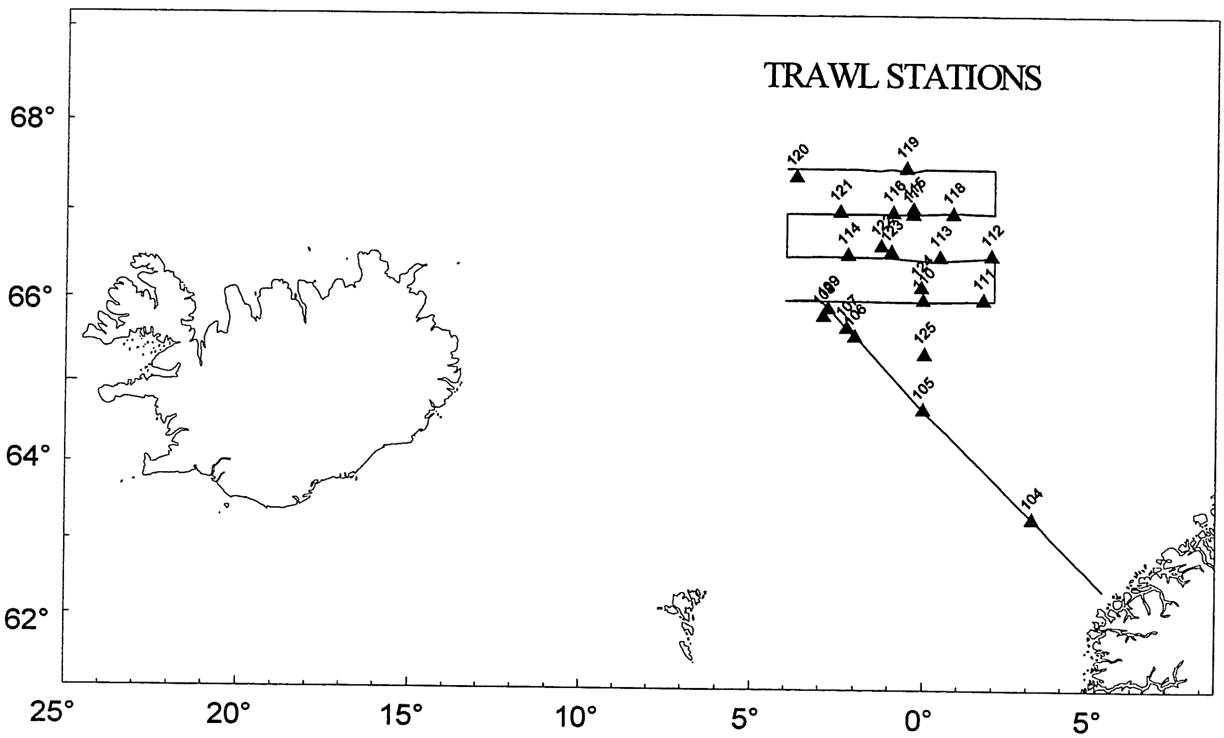


Fig. 2. Pelagic trawl-stations.

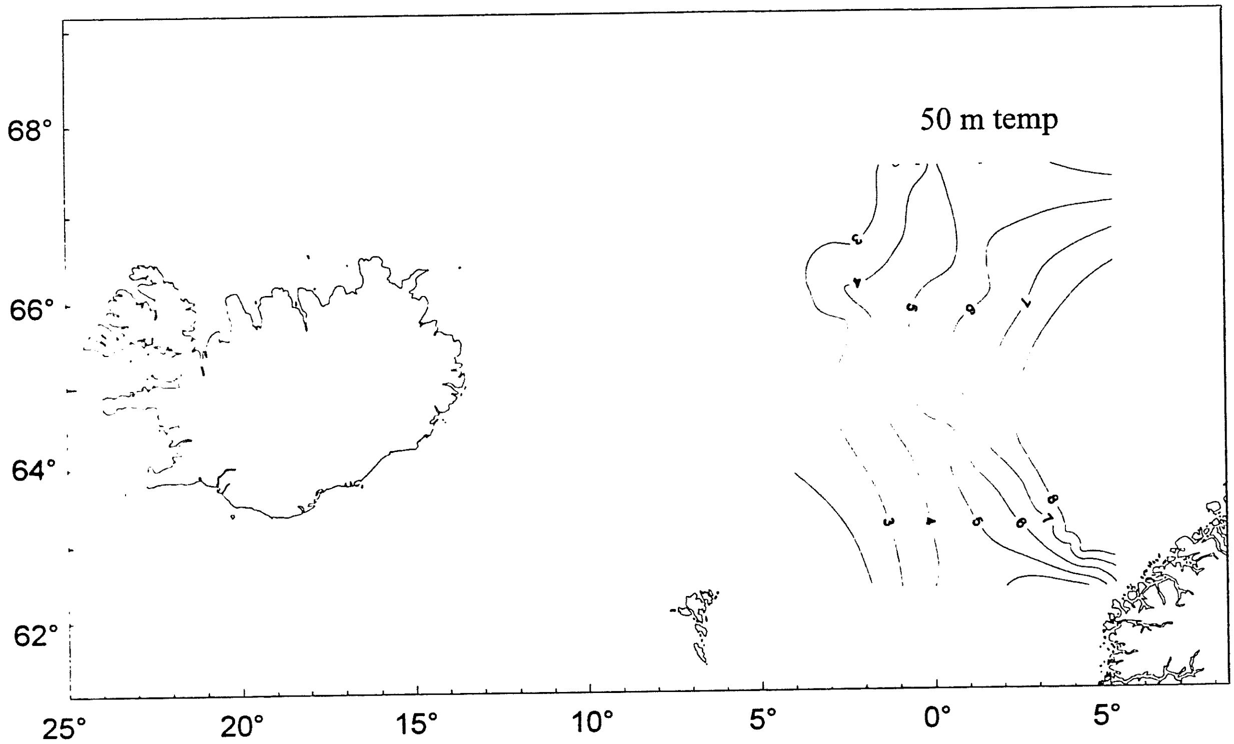


Fig. 3. Temperatures at 50 m depth.

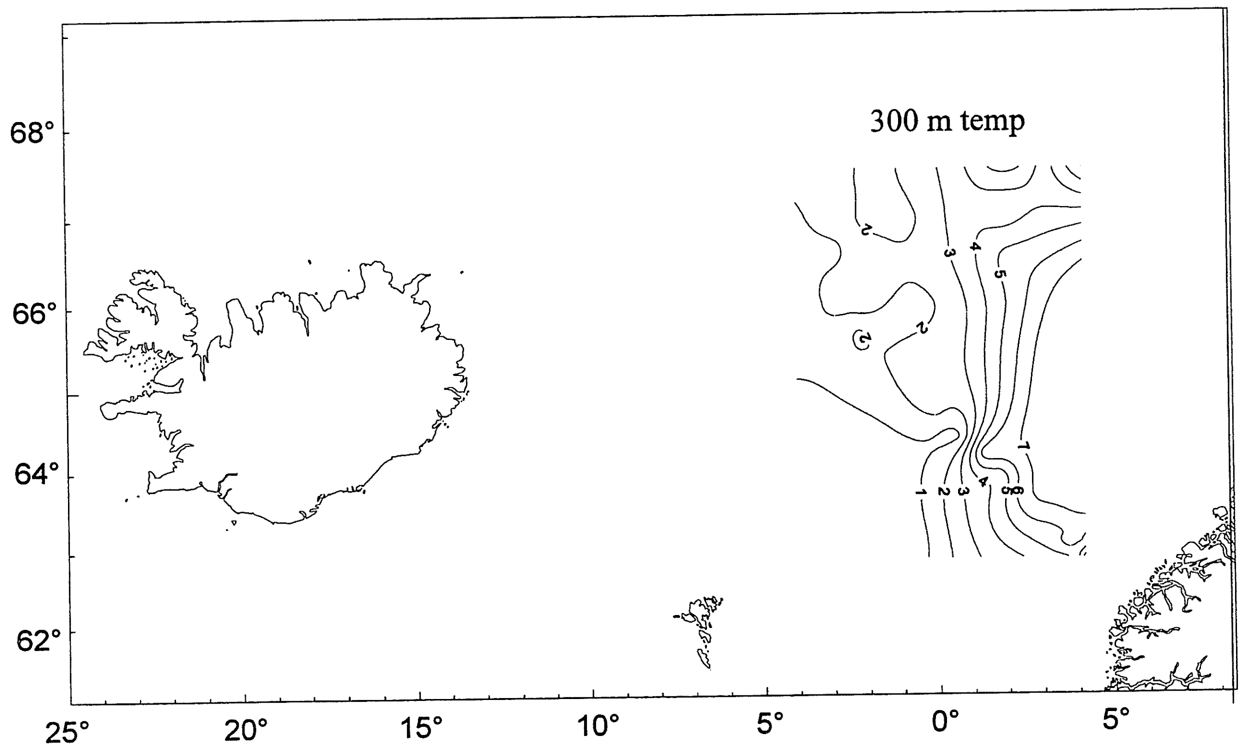


Fig. 4. Temperatures at 300 m depth.

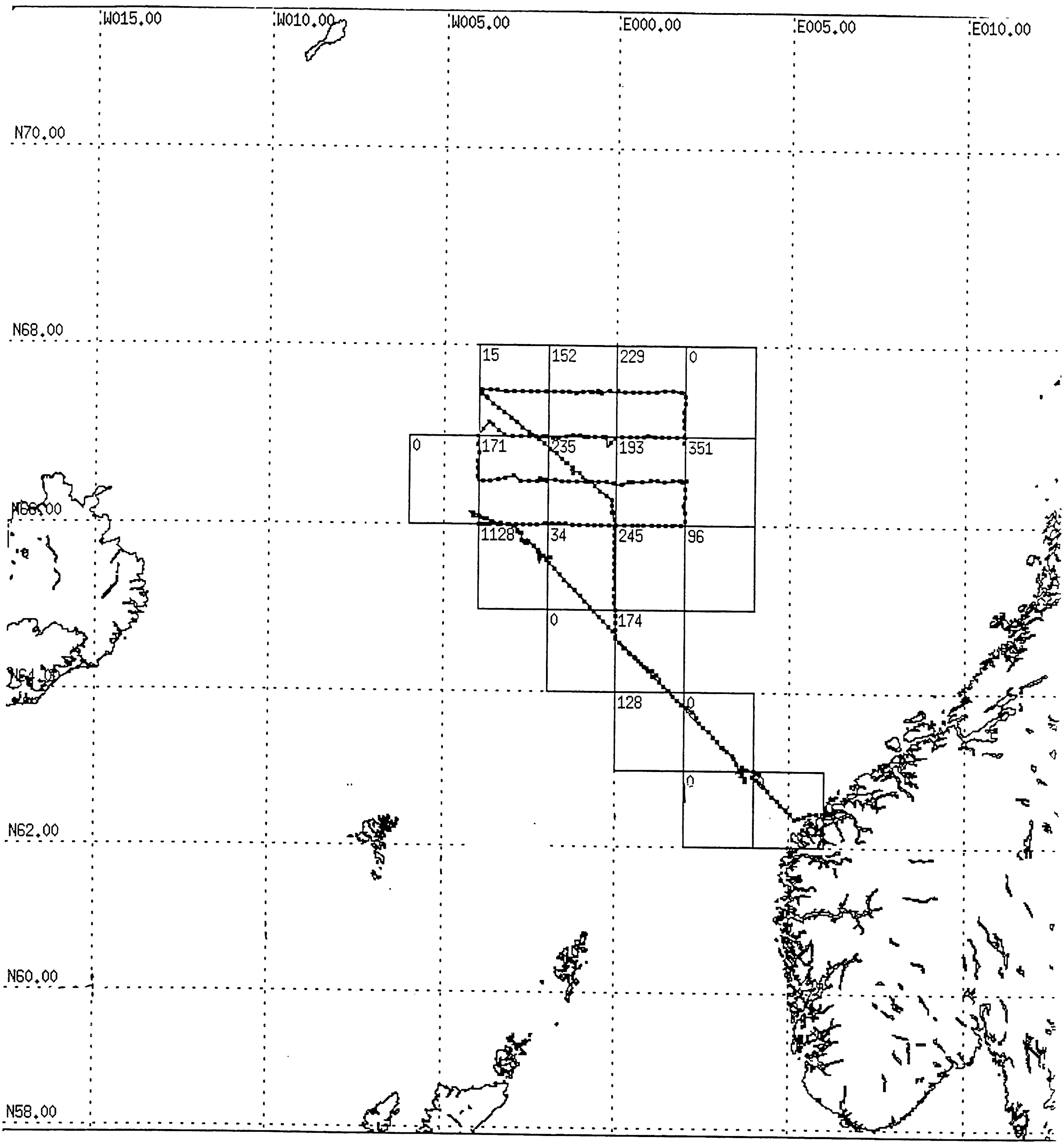


Fig. 5. Herring distribution. Mean sA-values by statistical squares.

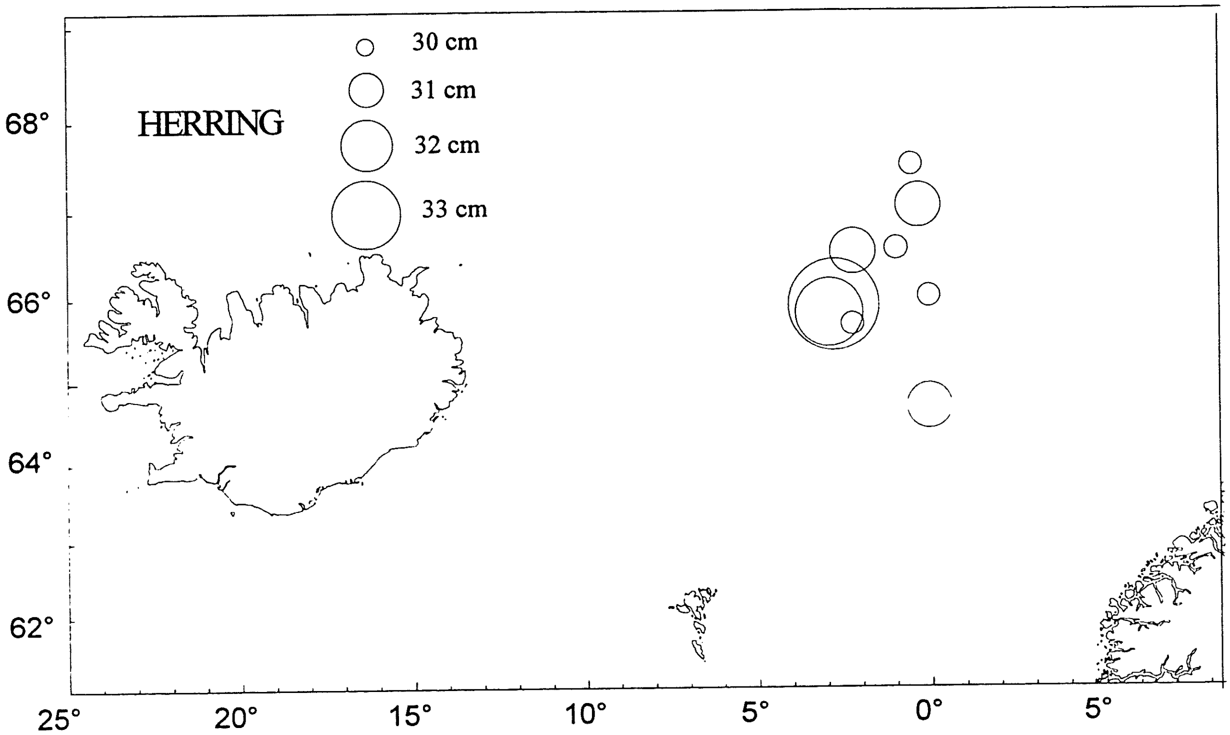


Fig. 6. Positions of herring catches with mean length groups.

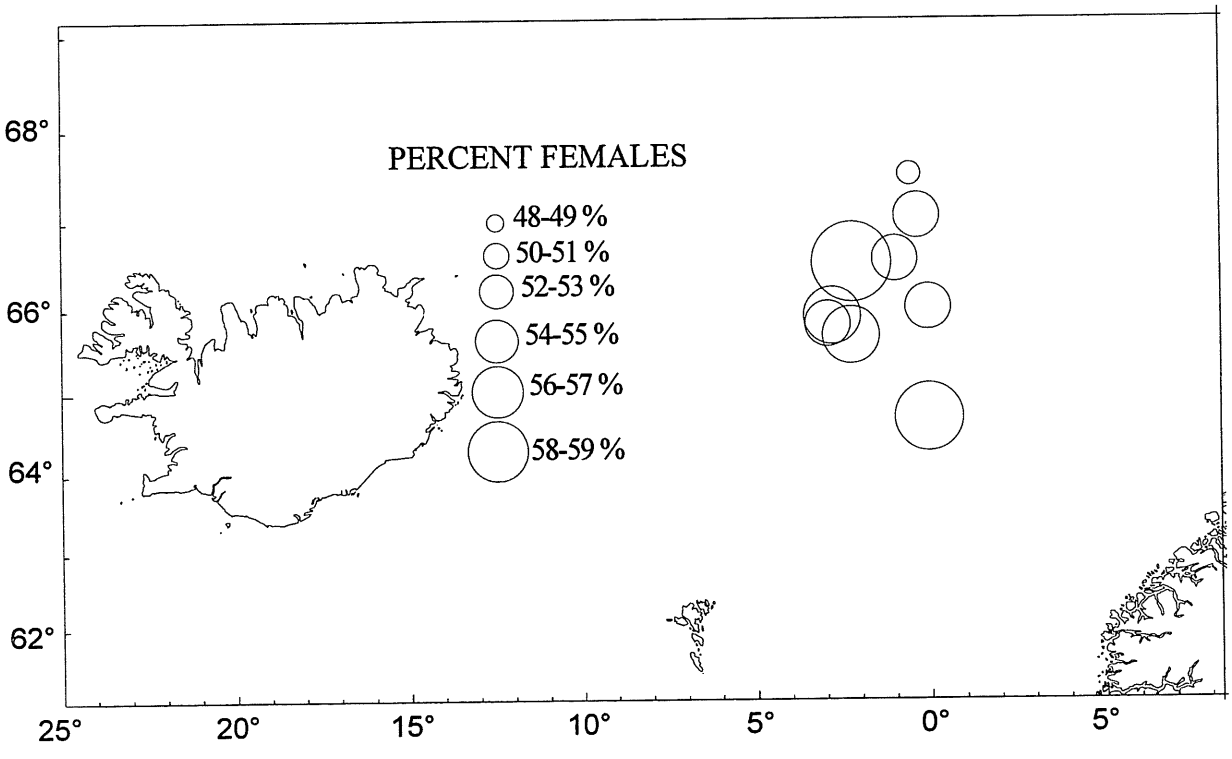


Fig. 7. Positions of herring catches with the percentage of females.

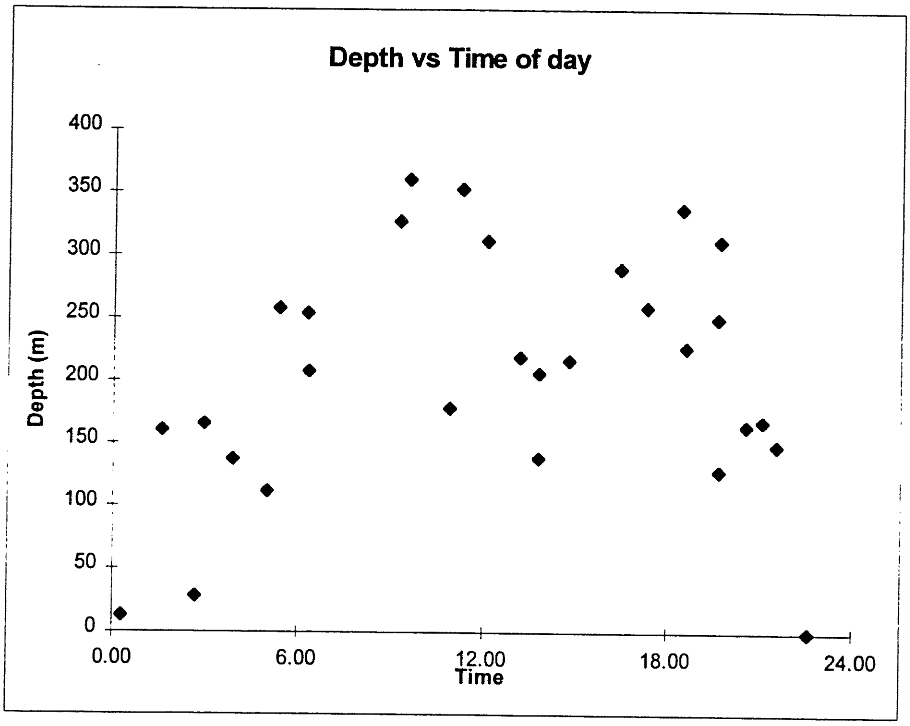


Fig. 8. The relation between depth and time of day in herring schools recorded with sonar.

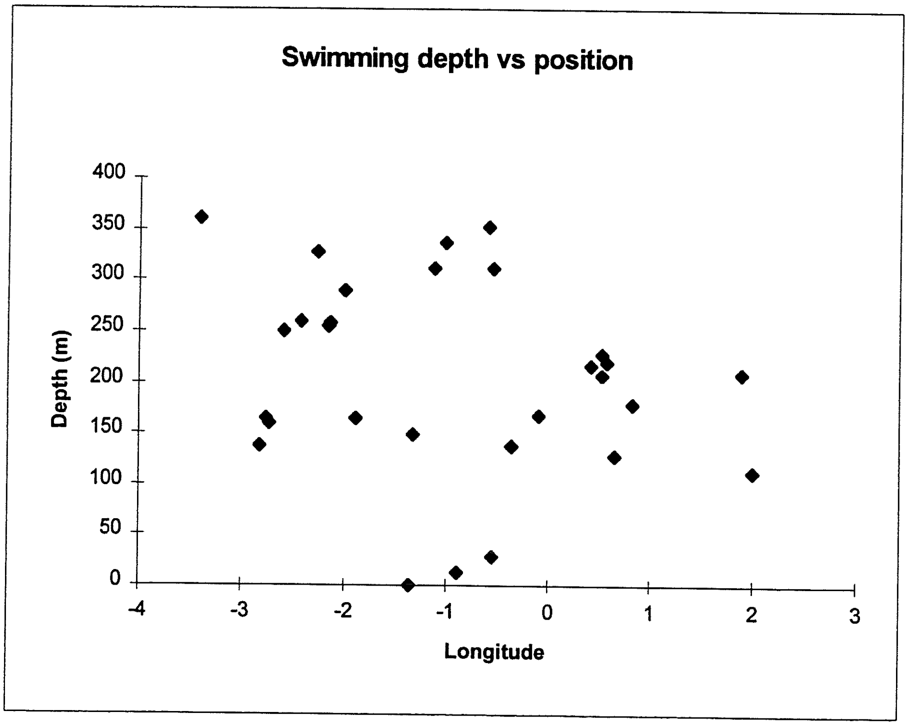


Fig. 9. The relation between depth and position in herring schools recorded with sonar.

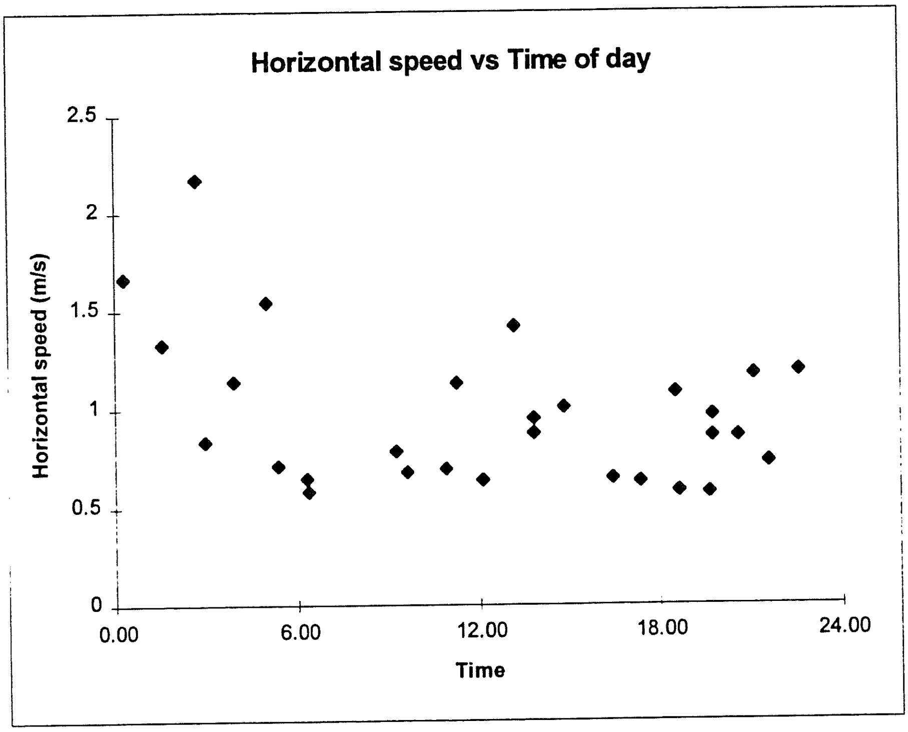


Fig. 10. The relation between depth and position in herring schools recorded with sonar.

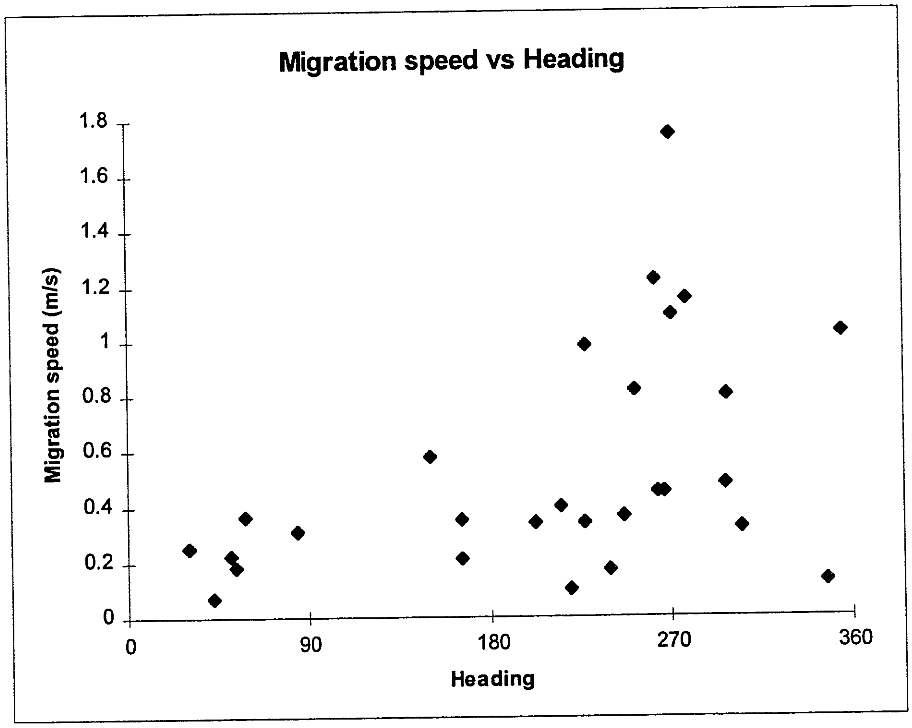


Fig. 11. The relation between migration speed and heading in herring schools recorded with sonar.

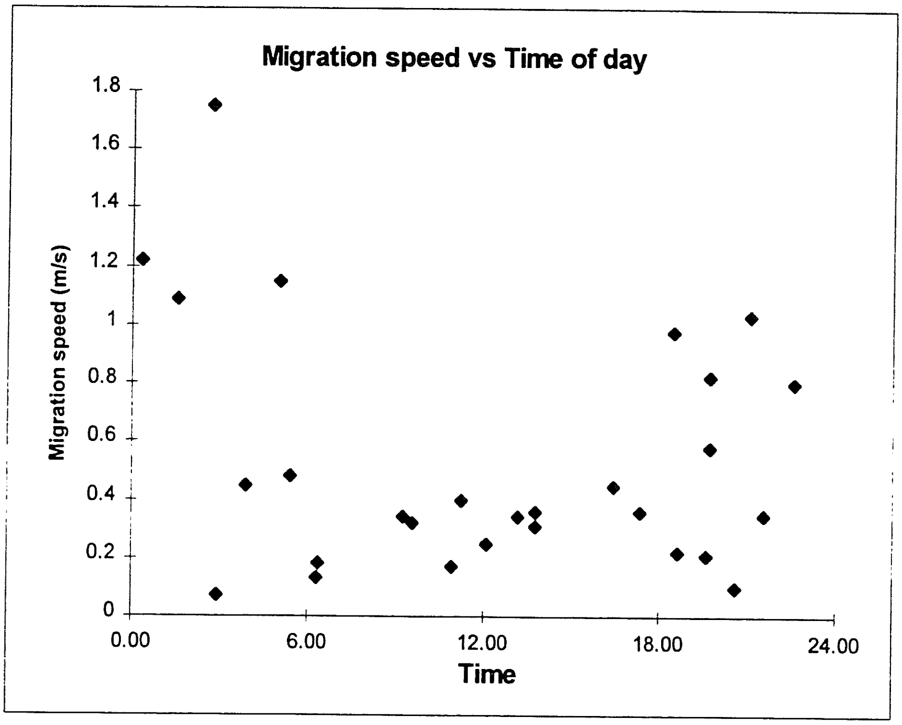


Fig. 12. The relation between migration speed and time of day in herring schools recorded with sonar.

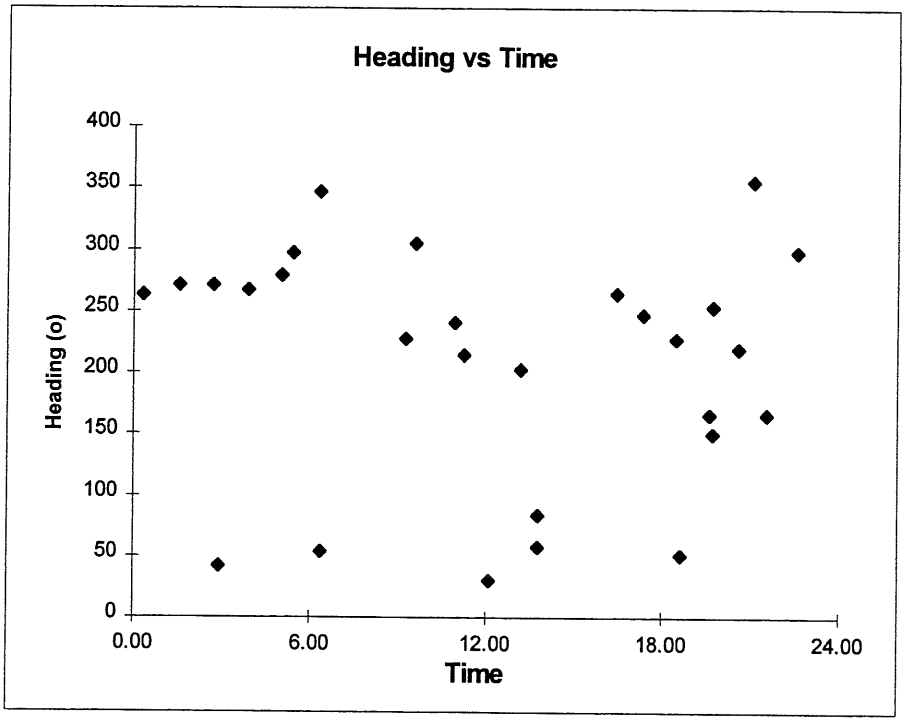


Fig. 13. The relation between heading and time of day in herring schools recorded with sonar.

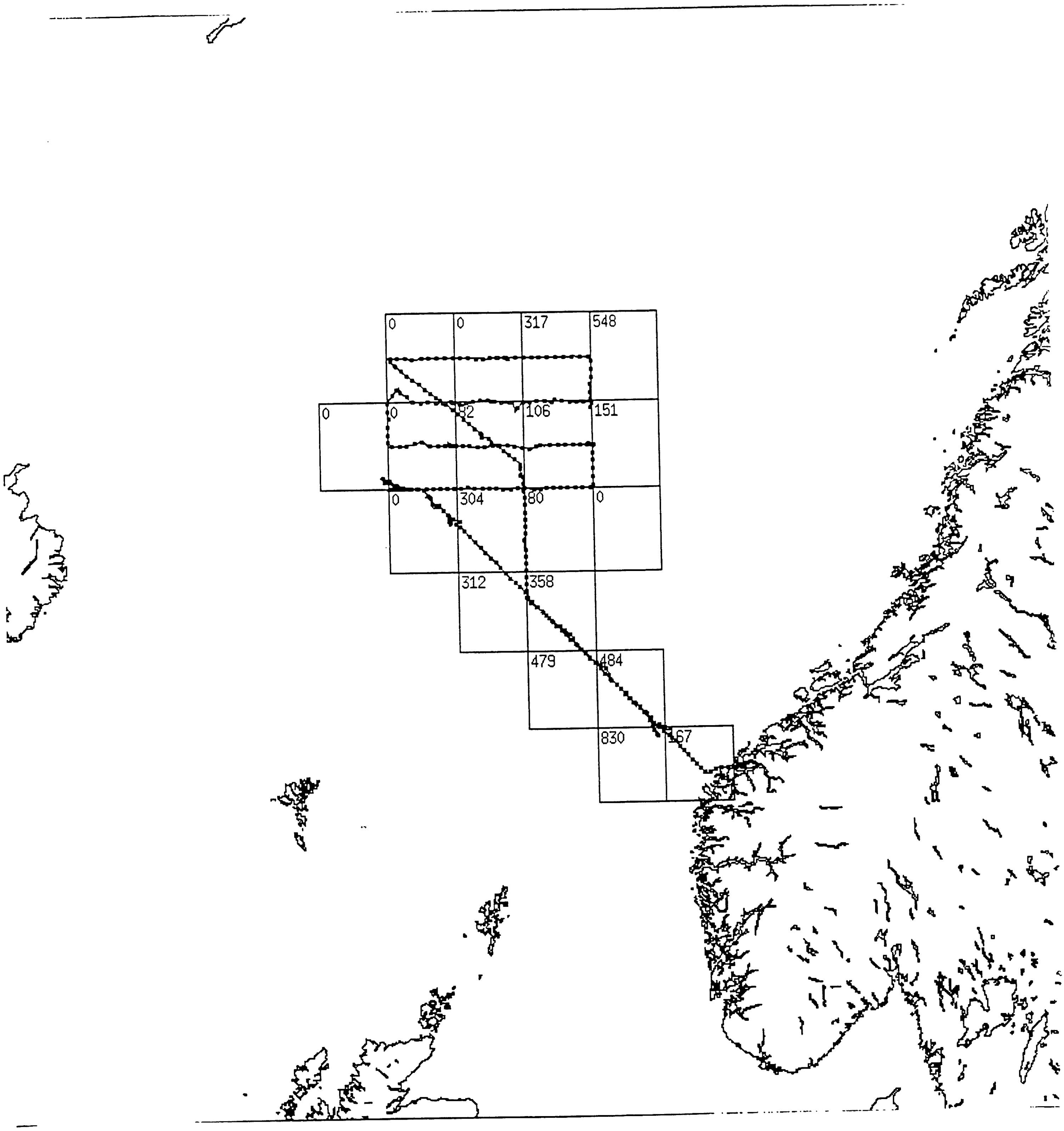


Fig. 14. Blue whiting distribution. Mean sA-values by statistical squares.

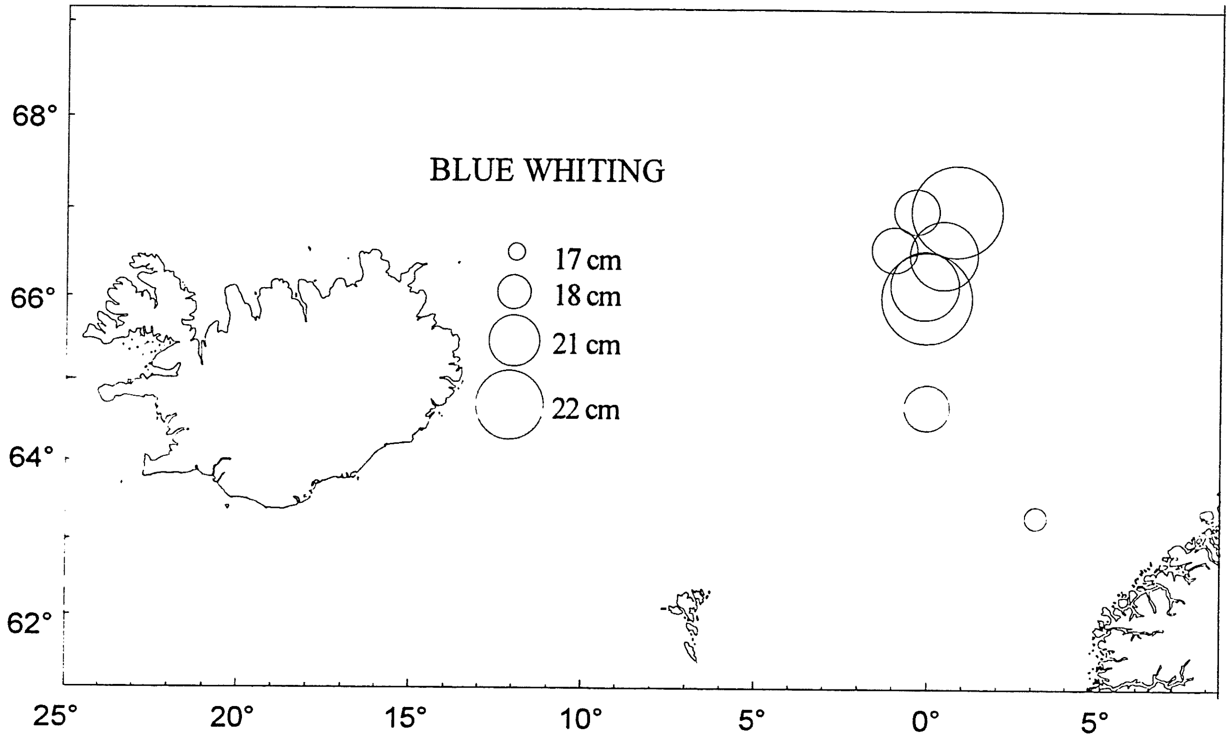


Fig. 15. Positions of Blue whiting catches with mean length groups.

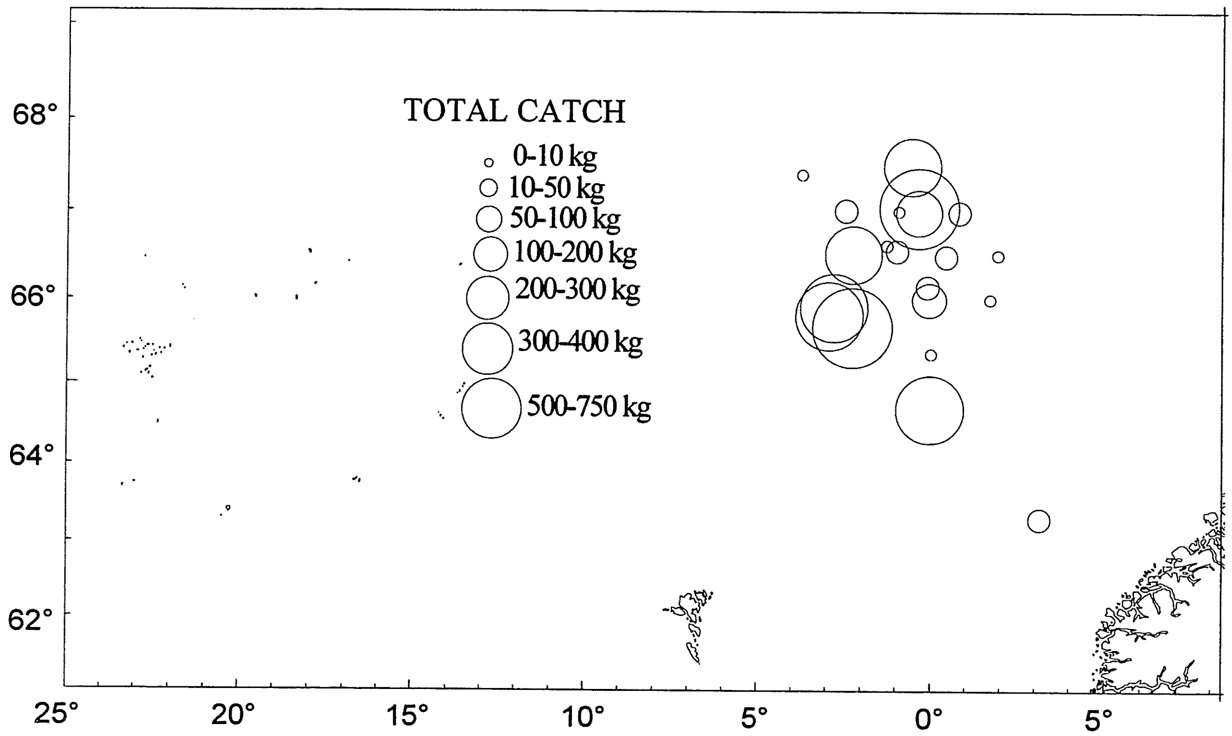


Fig. 16. Distribution of trawl catches. Total catch in kg.