Jane Stromsland

1987
nr. 8

HELP

Havforskningsinstituttets egg- og larveprogram

Petter Fossum
Herman Bjørke
Roald Sætre

Studies on herring larvae off western Norway in 1986.

HAVFORSKNINGSINSTITUTTETS EGG- OG LARVEPROGRAM (HELP)

UNDERSØKELSE AV SILDELARVER PÅ MØRE I 1986

av

P. Fossum, H. Bjørke og R. Sætre
Fiskeridirektoratets Havforskningsinstitutt
Postboks 1870, 5024 Bergen

SAMMENDRAG

Denne rapporten gir noen foreløpige resultater fra sildelarveundersøkelsene på Møre i april 1986. Den behandler horisontal- og vertikalfordeling av larvene i relasjon til det fysiske miljøet samt deres vekst og næringsopptak.

Gytefeltene kommer klart frem i fordelingen av de minste larvene. Feltene var de samme som ble funnet i 1985. I tillegg fant det sted en mindre gyting ute på eggakanten. Hovedtrekkene i sirkulasjonsmønsteret synes å være det samme som i 1985. Ved å kombinere hydrografiske data, larvefordeling og drivbøyer ser det ut for at man kan få frem både larvenes viktigste driftsruter samt områder hvor larvene holdes tilbake i 10-15 dager.

Larvepopulasjonen i 1986 var totalt dominert av plommesekklarver. Antall larver større enn 12 mm var omkring 10% av det som ble funnet i samme periode i 1985. I 1986 ble det også observert lavere vekst og næringsopptak hos larvene enn i 1985. Alt dette tyder på at rekrutteringen til sildebestanden i 1986 var dårligere enn i 1985.

Størstedelen av larvene ble funnet dypere enn 60 m. Innslaget av nyklekkede larver økt med dypet mens eldre larver ble hovedsaklig funnet i de øvre 40 m. Første næringsopptak ble funnet i 3-6 dagers gamle larver. Dietten var dominert av rauåte larver.

HAVFORSKNINGSINSTITUTTETS EGG- OG LARVEPROGRAM (HELP)

STUDIES ON HERRING LARVAE OFF WESTERN NORWAY IN 1986

by

P. Fossum, H. Bjørke and R. Sætre

Institute of Marine Research

P.O.Box 1870, N-5024 Bergen

Norway

ABSTRACT

This report gives some preliminary results from a study on the spawning grounds of the Norwegian spring-spawning herring in April 1986. It deals with the horizontal and vertical distribution of herring larvae in relation to the physical environment as well as growth and diet.

The spawning area can clearly be seen in the distribution of larvae < 9 mm and these were the same as in 1985. In addition, a smaller spawning area offshore at the continental slope was identified.

The main features of the circulation pattern of the area seems to be the same as in 1985. The combined use of hydrography, larvae distribution and Argos drifters seem able to reveal both the larval drift as well as retention areas with a residence time of 10-15 days.

The larval population in 1986 was totally dominated by yolksac larvae. The number of larvae > 12 mm was about 10% of that found during the same period in 1985. In 1986 a slower growth and a lower feeding ratio in all larval stages was observed compared to 1985. This indicate poorer recruitment in 1986 than in 1985.

The majority of the larvae were found deeper than 60 m opposed to 1985. The percentage of newly hatched larvae increased with depth. Older larvae were found mainly in the upper 40 m. Patchy distribution made a comparison between larvae caught at day and at night difficult. First feeding was observed in 3-6 days old larvae. The diet of the larvae was dominated by copepods nauplii. A shrinkage of 40-50% in dryweight and 3-7% in length due to preservation was observed.

INTRODUCTION

Sampling of larvae of the Norwegian spring-spawning herring has been carried out for a long period (e.g. WIBORG 1960, DRAGESUND 1970, SELIVERSTOV 1974 and BJØRKE 1981). The main objective of these investigations has been to locate spawning areas and to obtain the first indication of the recruitment. The increase of the herring stock in more recent years and development of new gears and methods, actualize the formulation of a project to study the recruitment mechanisms.

In 1985 a pilot study was carried out (BJØRKE, FOSSUM and SÆTRE, 1986). The project was later included in a national program to study the possible consequences on fish eggs and larvae of oil exploration on the Norwegian continental shelf north of 62^{0}N (FØYN and BJØRKE, 1986). This program is given the acronym HELP (Havforskningsinstituttets Egg- og Larveprogram) and is supposed to last for the periode 1986-90.

The objectives of HELP is to:

- obtain detailed knowlegde of the distribution in space and time of the important commercial fish species during their early life stage along the Norwegian coast.

- study the reproductive biology of the same species.

- study the recruitment mechanisms of the Norwegian spring-spawning herring and the Arcto-Norwegian cod.

- study the physical factors affecting both the transport-dispersion and the living condition of the early life stages of fish.

The present report gives some preliminary results from the investigation on the larvae of the Norwegian spring-spawning herring in 1986.

MATERIALS AND METHODS

The study was carried out during the periods 29 March - 7 April and 9 - 18 April. The southern part of the area was covered during both these periods (Fig. 1). Herring larvae were sampled with a modified conical net of 0.5 m^2 opening and 375 µ m mesh size (ELLERTSEN et al. 1984) from 150 m (or 5 m above the bottom) to the surface. The vertical distributions of temperature, salinity, nutrients and chlorophyll contents were observed by Nansen hauls. Five Argos satellitte-tracked, drifting buoys were deployd. These were equipped with a 10 m^2 window blind drogue attached to the buoys via a 30 m tetherline.

The material for the vertical studies was derived from two experiments on Buagrunnen; one from 5-7 April with a Mocness 1 m^2 sampler(mesh 375µ)(WIEBE et al.),and one from April 5 and 6 with a opening/closing Juday net(mesh 375µ and opening 0.5m^2). Difficulties in changing of nets at precise depths arosed during the Mocness experiment and this caused a slight overlapping of depth intervals (Table 1.) About 50 m^3 was filtered with the Mocness sampler within each depth interval and about 10 m^3 with the vertical net. To confirm abundance of larvae a vertical plankton haul was made between each Mocness haul. Bottom depth varied between 120 and 90 m during the Mocness experiment. During the sampling with the Juday net the ship was anchored at a depth of 120 m.

The herring larvae used to morphometric measurements and gut content analysis were preserved in 4% formalin in 10 %. sea water . Only the food organisms that could be recognized through the epithelium of the gut were examined, because of gut content voidance in herring larvae during catching and fixation (HAY 1981). No quantitative analyses of the diet of the herring larvae was performed due to the same reason. The same procedure was followed in 1986 as with the 1985 material (BJØRKE, FOSSUM & SÆTRE 1986) and a comparative analysis between these two sets of data could thus be made.

The herring larvae used to describe the horizontal distribution were measured on board. Standard length (SL) measurements of 50 herring larvae per haul (if present) were taken to nearest mm below. For morphometric measurements in the laboratory a material of 647 herring

larvae were analysed . From each station 20 larvae (if present) were classified according to DOYLE (1977) and ØIESTAD (1983), and measured to nearest 0.1 mm below. Visible prey organisms were dissected out of the gut and classified into one of the following two groups; copepod eggs or copepod nauplii. The larvae were then rinsed in fresh water, dried to constant weight and weighed on a Cahn electrobalance to the nearest µg.

Because of shrinkage due to preservation (THEILACKER & DORSEY 1980), a representativ sample of herring larvae (N= 47) from the whole area of distribution were seperated into different stages when fresh onboard. They were measured to nearest 0.1mm below, rinsed in fresh water and brought to the laboratory where they were dried to constant weight and weighed on a Cahn electrobalance to the nearest µg. This sample represent an estimate of the true standard length and dry weight in the larval population, and a comparison between these larvae and the preserved ones gives information of the shrinkage during fixation.

RESULTS AND DISCUSSION

Hydrography

Surface temperatures (Fig. 2) and salinities (Fig. 3) were 4.5^0 -6.5^0C and 33-35‰. respectively. The northern part of the area was clearly influenced by Atlantic Water masses while in the southern part Coastal Water was dominant. The same pattern could be seen in the surface distribution of nitrate and silicate (Figs. 4-5) with high values in the northern and low values in the southern part. The surface distribution of chlorophyll a (Fig. 6) showed very low values in the northern area. The highest concentrations were found along the shelf break in the central area.

Fig. 7 shows the typical vertical hydrographic structure from the southern (SECTION A), the central (SECTION B) and the northern (SECTION C) part of the investigated area. The location of the sections appear in Fig. 1. Coastal Water (S < 35‰.) covers the upper 100 m in the southern and central shelf area. In the northernmost section (SECTION C) water of coastal origin is seen at the outermost stations. This is probably a result of the splitting of the Norwegian Coastal

Current further south also indicated in the distribution of surface salinity (Fig. 3). According to LJØEN and NAKKEN (1969) the Norwegian Coastal Current splits into two branches between 63^0 and 64^0N. The main branch run parallel and close to the coast on the coastal side of Haltenbanken (Area F, Fig. 17). The other branch follows the edge of the continental slope on top of the Atlantic water.

SECTION A was carried out twice; 31 March and 16 April (Fig. 7). The angle of the sloping interface between the Coastal and the Atlantic Water have decreased during the first part of April resulting in a more seaward extention of the Coastal Water. There is a pronounced reduction of the nitrate content in the upper layers from the end of March to mid-April indicating that a phytoplankton bloom has occurred between the observations. During the same periode the contents of chlorophyll a in the upper 30 m of the section increased from 0.1 - 0.3 to 1.5 - 4.5 mg/m^3 (Fig. 8). Though the surface chlorophyll values 9-18 April in the northern area is low (Fig. 6), reminiscences of a precedent phytoplankton bloom are seen in SECTION C (Fig. 8).

Fig. 9 shows the drifting tracks from the Argos buoys. The bottom topography of the area is rather complicated and this influences the circulation pattern. There are four major shallow banks in the area: Buagrunnen (C), Frøyabanken (D), Haltenbanken (F) and Sklinnabanken (E). The location of these are seen in Fig. 17. Around these banks the topographic steering of the current favour an anti-cyclonic circulation. North of Buagrunnen and of Frøyabanken the water mainly flows eastwards and merge into the channel between Haltenbanken and the coast. This seems to be the main route for the northward drifting larvae. The current speed of the upper layer of this area is between 30 and 60 cm/s which means 7-15 nautical miles/day. Of the two Argos buoys which were drifting further northward, one ended up at 66^0N 26 May and the other one close to $69^0 30'$N at 18 June (Fig. 10).

Horizontal larvae distribution

The hatching of herring larvae started in the southernmost area around 15 March and at Buagrunnen (Area C, Fig. 17) around 1 April. At both locations the maximum hatching occurred in mid-April (BJØRKE, HANSEN and MELLE, 1987).

The horizontal distribution of herring larvae of three different length groups from the first coverage 29 March - 7 April is shown in Figs. 11-13. The distribution of the youngest larvae (Fig. 11) indicate three separated spawning areas; Buagrunnen, close to the shore in the southernmost area and at the shelf break around 63^0N. As can be seen there are very few larvae $\geq$ 12 mm (Fig. 13).

During the second coverage (9-18 April) the total number of larvae < 9 mm is higher (Fig. 14). Two of the apparent spawning areas are the same as on the previous coverage. Additionally, there seems to be a minor spawning near Frøyabanken (Area D, Fig. 17). The number of larvae $\geq$ 12 mm (Fig. 16) is only about 10% of that found during the same period in 1985 (BJØRKE, FOSSUM and SÆTRE, 1986). This may indicate that the recruitment success in 1986 was considerably lower than in 1985.

Off the southernmost coastal spawning area (Area A, Fig. 17) as well as at Buagrunnen the Argos drifters indicate retention areas of the larvae with a recidence time of the water of 10-15 days. Fig. 17 is an attempt to summarize the information on the larval drift. It is based on larvae distribution, the tracks of the Argos drifters and on hydrography. The drifting time from the spawning areas to the passing of the 65^0N lattitude seems to be 40-50 days from the southernmost spawning area and 20-30 days from Buagrunnen. As a significant proportion of the larvae population is below the drogue depth of the Argos buoys and as dispersion mechanisms is not considered, the calculated drifting times is probably underestimates.

Vertical larvae distribution.

Table 1 shows the number of larvae per m^2 surface sampled during the Mocness experiment. Larvae without yolk sac and without the characteristics of stage 2a described by DOYLE (1977) are omitted from the table. Although the Mocness sampling within the area was located by abundance of larvae in vertical net-hauls, some of the Mocnes tows were without any larvae. This indicate patchy distribution of the larvae.

Table 1. Number of larvae per m^2 surface sampled during the Mocness experiment.

Date	5 April					6 April						
Hour	18	20	21	23	24	02	04	06	07	09	12	14	15
Depth													
20-0	31	5	6	5	3	4	4	1	1	0	13	34	31
40-16	17	3	3	8	9	5	4	16	19	1	39	67	34
60-36	5	0	5	13	8	17	20	35	69	1	85	84	57
80-56	17	0	37	131	84	58	36	126	251	2	196	124	81
100-76	49	15					114		399	1			

table continued:

Date	6 April							7 April					
Hour	16	17	19	20	21	22	23	00	02	03	04	05	07
Depth													
20-0	37	56	37	3	36	0	4	1	0	0	0	6	1
40-16	29	50	57	6	24	4	4	1	1	0	0	21	16
60-36	33	81	149	36	81	25	64	19	22	0	0	0	122
80-56	55	130	211	204	125	198	82	54	108	0	0	0	688
100-76													

table continued:

Date	7 April											
Hour	08	09	10	11	12	13	14	15	16	17	20	Total
Depth												
20-0	2	1	1	7	3	2	5	9	4	3	4	360
40-16	7	10	100	132	49	38	32	52	34	15	21	928
60-36	47	24	581	1353	65	656	105	249	153	225	326	4815
80-56	827	1154	3873	2934	1824	728	59	25	36	66	444	14968
100-76			1442	797	1205				23		15	4060

Fig. 18 shows the vertical distribution of larvae when all depth intervals above 80 m were sampled. Nearly 60 % of the larvae were found in the 80-56 m depth interval. Most of these larvae were newly hatched, i.e.stage 1a. The percentage of these larvae increased with depth and only few were found in the upper 20 m. The percentage of the older stages, however, increased in the upper layers and stage 2a were found only in the surface layer.

Fig. 19 shows the distribution during broad daylight i.e. between 09 and 15 hrs. GMT. More than 55% of the larvae were found in the 80-65 m interval. Fig. 20 shows the vertical distribution of the larvae during darkness i.e. between 21 and 02 hrs. GMT. Still most of the larvae were found in the 80-85 m interval and stage 1b was dominating. The number of larvae caught at night were much lesser than that caught at daylight. This is probably caused by a patchy distribution of larvae (Table 1). This is most probably also the reason for the absence of larvae in the deepest haul at night. Because of the patchy distribution of the larvae it is difficult to make any comparison between stage distribution of larvae caught at daylight and in darkness.

Table 2. Number of larvae per m^2 surface sampled during the closing net experiment.

Date	5 April								6 April				
Hour	09	11	13	14	17	19	21	23	01	03	05	07	Total
Depth													
20-0	2	2	8	4	2	2	6	10	2	2	0	8	48
40-21	0	0	2	3	4	0	0	0	0	0	4	2	15
60-41	0	0	0	8	0	0	0	0	6	4	8	12	38
80-61	24	11	4	42	2	0	0	4	30	10	46	38	211
100-81	0	0	2	36	4	0	0	44	40	212	125	218	681
115-101	0	0	26	12	2	0	0	0	2	18	18	428	506

Table 2 shows the number of larvar per m^2 surface during the closing net experiment. Larvae without yolk sac and without the characteristics of stage 2a described by DOYLE (1977) are omitted from

the table. Fig. 21 shows the vertical distribution of the larvae in Table 2. Most of the larvae were found in the 100-81 m interval and the majority of these were in stage 1b. During this experiment newly hatched were recorded in all depth intervals without any clear pattern. Older larvae, however, were mainly found in the upper layers.

During a similar experiment in 1985 in the same area (BJØRKE, FOSSUM and SÆTRE 1986) more than 65% of the larvae were caught in the upper 60 m. Including the larvae omitted from Table 1 and Table 2 the percentage of larvae in the upper 60 m were 12% during the Mocness experiment and 14% during the closing net experiment in 1986. In 1985 the highest abundance of larvae were found in the middle of the pycnocline. In 1986 the pycnocline was less pronounced than in 1985 (Fig. 7 Section A). In 1985 few newly hatched larvae(larvae < 9mm)were found. These two facts might explain the higher abundance of larvae in the deeper intervals observed in 1986.

Length/stage distribution of fixed larvae.

Table 3 shows the length distribution of fixed herring larvae caught in 1986 classified according to DOYLE (1977) and ØIESTAD (1983). Fig. 24 shows the frequency distribution of these larvae. 93% of the larvae were measured to the mearest mm below, while the rest were measured to the nearest 1/10 mm (Table 4). 36 % of the larvae < 9 mm in Table 3 were in stage 1a i.e. three days old or younger, and of larvae < 8 mm, 46 % were in stage 1a. The spawning grounds for herring can thus be more precisely located by mapping distribution of fixed larvae smaller than 8 mm. On the other hand only 16 % of the larvae in Table 3 were smaller than 8 mm while 43 % of the larvae were smaller than 9 mm. By mapping distribution of fixed larvae smaller than 8 mm one might thus loose information of spawning grounds because of low abundance of such larvae. In addition, 64 % of the larvae in stage 1a are omitted from the mapping because they are equal to or larger than 8 mm. Fig. 11 and Fig. 14 which shows the distribution of fresh larvae < 9 mm gives thus a reasonable good location of the spawning grounds of herring when only length data of the larvae are availiable. Mapping of larvae in stage 1a will, however, give a better location of the spawning grounds of Norwegian spring-spawning herring.

Table 3. Length/stage distribution of fixed herring larvae caught in 1986.

Length (mm)	1a	1b	1c	1d	2a	TOT
005		1				1
006	167	38	8	70		283
007	515	353	71	271		1210
008	749	1049	158	515		2471
009	400	1547	474	617		3038
010	57	761	712	397	2	1929
011		24	61	87	25	197
012		1	7	31	9	48
013				4	3	7
014				2		2
015				1		1
TOT	1888	3774	1491	1995	39	9187

Shrinkage of herring larvae

In Table 4 the data of shrinkage due to formalin fixation is given.

Table 4. Per cent shrinkage during formalin fixation

Stage	Nos of larvae Fixed	Unfixed	Shrinkage in length (%)	Shrinkage in dry weight%)
1b	193	7	6.2	40.0
1c	186	18	6.5	45.5
1d	121	12	5.4	44.7
2a	87	10	3.3	38.6

The table shows that the shrinkage both in length and weight is relatively constant between the different stages. The shrinkage in length is relatively moderate, while the shrinkage in weight is very large and the weight is almost halved during the fixation period. The differences in mean length of the same stages between the larvae in Table 4 and the ones represented in Fig. 24 might be due to more accurate measurements of the larvae in Table 4.

Condition of herring larvae

The material in this examination was sampled during the second coverage and consists of 647 herring larvae of standard length 6.2-14.5 mm. The bulk of the larvae belonged to the yolk sac stages 1a-1d. Few larvae had started to develope the dorsal fin, stage 2a, and the development of the larval population was delayed compared to the 1985 season, when most of the larvae sampled in the same area and at the same time were in the 2a stage (BJØRKE , FOSSUM & SÆTRE 1986).

The mean standard length, dry weight and number of larvae in each stage are shown in Table 5.

Table 5. The larval material sampled in 1986.

Substage	Nos. of larvae	Mean standard length (mm)	SD	Mean dry weight (µg)	SD
1a	60	8.1	0.8	144	30
1b	193	9.1	0.9	127	25
1c	186	10.0	0.8	133	26
1d	121	10.6	0.8	151	28
2a	87	11.8	0.8	199	36

The mean hatching weight and the mean weight of the larvae in the different yolksacstages was unchanged compared to the 1985 material (BJØRKE, FOSSUM & SÆTRE 1986).

The delayed development of the larval population in 1986 compared to 1985, seemes to be due to the late hatching this year. Maximum hatching was observed in mid April , (BJØRKE, HANSEN and MELLE 1987) and larvae hatched earlier in the season are probably vanished.

A standard length/ dry weight plot of the present material is shown in Fig. 22. There is no strict relationship between the standard length and the dry weight, indicated by a exponential correlation coeffescient $r^2 = 0.40$, in contrast to the 1985 material with a corresponding correlation coeffiscient $r^2 = 0.81$.

There seemes to be significant less growth of the herring larvae in 1986 than in 1985, with a decrease of the growth parameter (slope) from 0.18 to 0.11. The same preservation procedure was followed both in 1985 and 1986, and this indicate that the larval population in 1986 was exposed to more marginale food conditions than in the previous year.

Some of the variation in the data may be introduced through the preservation, as there is a stronger length/ weight relationship in the plot of the larvae not exposed to formalin (Fig. 23). Therefore the necessity of a comparable preservation procedure and to study the length / weight relationship of unpreserved and preserved larvae must be stressed.

Fig. 24 shows the length frequency distribution of the larvae in the different stages. The jump in standard length from stage 1a to 1b is probably due to the sensitiveness of the newly hatched larvae to handling. They are easily exposed to shrinkage during catching. Except for this the length frequency distribution of the yolksaclarvae seemes to be comparable to the one from the previous year.

The diet of the larvae during Stages 1a-2a, representing a time span estimated to be 23 days (BJØRKE, FOSSUM & SÆTRE 1986) is shown in Fig. 25. The dominating food organism through this period was copepod

nauplii which contributed 80 % to the gut content. The only other food organism found was copepod eggs (20%). The youngest larvae found with gut content were 3-6 days old. In this period copepod eggs and copepod nauplii were of equal importance , later on the diet was dominated of copepod nauplii. No copepod eggs were found in larvae older than 11 days. There is a pronounced reduction in the feeding ratio (number of food organisms per larval gut) in all stages from 1985 to 1986.

The reduced feeding ratio and growth parameter together with the total dominance of yolksac larvae as late as mid April, indicate 1986 as a year with poor recruitment of the Norwegian spring- spawning herring. Investigations carried out in May gave additional information of this (Nedreaas pers. comm.), and the 0-group index established late in the autumn confirmed that this yearclass was a poor one (Røttingen pers. comm.).

CONCLUSIONS

The spawning area can clearly be seen in the distribution of larvae < 9 mm and these were the same as in 1985. In addition a smaller spawning area offshore at the continental slope was identified.

The main features of the circulation pattern of the area seems to be the same as in 1985. The combined use of hydrography, larvae distribution and Argos drifters seem able to reveal both the larval drift as well as retention areas with a residence time of 10-15 days.

The larval population in 1986 was totally dominated by yolksac larvae. The number of larvae > 12 mm was about 10% of that found during the same period in 1985. In 1986 a slower growth and a lower feeding ratio in all larval stages was observed compared to 1985. This indicate poorer recruitment in 1986 than in 1985.

The majority of the larvae were found deeper than 60 m as opposed to 1985. The percentage of newly hatched larvae increased with depth. Older larvae were found mainly in the upper 40 m. Patchy distribution made a comparison between larvae caught at day and at night difficult.

Mapping of the earliest stage of larval development instead of the smallest larvae groups gives a better location of the spawning

grounds.

First feeding was observed in 3-6 days old larvae. The diet of the larvae was dominated by copepod nauplii. A shrinkage of 40-45% in dry-weight and 3-7% in length due to preservation was observed.

REFERENCES

BJØRKE, H. 1981. Distribution of fish eggs and larvae from Stad to Lofoten during April 1976-80. Pp 583-603 in Roald Sætre and Martin Mork (Eds.) The Norwegian Coastal Current. University of Bergen 1981: 895 p.

BJØRKE, H., P. FOSSUM and R. SÆTRE, 1986. Distribution, drift and condition of herring larvae off western Norway in 1985. Coun. Meet. int. Coun. Explor. Sea, (H:39): 1-15.

BJØRKE, H., K. HANSEN and W. MELLE, 1987. Sildeklekking og seigyting på Møre i 1986. Institute of Marine Research's Egg- and Larvae Program (HELP), Report 1987, No. 4.

DOYLE, M.J. 1977. A morphological staging system for the larval development of the herring, (Clupea harengus L.). J. mar. biol. Ass., 57: 859-867.

DRAGESUND, O. 1970. Factors influencing year-class strength of Norwegian spring spawning herring. FiskDir. Skr. Ser. HavUnders.,15 : 381-450.

ELLERTSEN, B., P. FOSSUM, P. SOLEMDAL, S. SUNDBY and S. TILSETH, 1984. A case study on the distribution of cod larvae and availability of prey organisms in relation to physical processes in Lofoten. In: E. DAHL, D.S. DANIELSEN, E. MOKSNESS and P. SOLEMDAL (Eds.), The Propagation of Cod Gadus morhua L. Flødevigen rapportser., 1: 453 - 477.

FØYN, L. and H. BJØRKE, 1986. Strategies in assessment of potential oil pollution effects on the fish resources. Coun. Meet. int. Coun. Explor. Sea, (E:34).

HAY, D.E. 1981. Effects of capture and fixation on gut contents and body size of Pasicic herring larvae. Rapp. P.-v. Rèun. Cons. perm. int. Explor. Mer, 178: 395-400.

LJØEN, R. and O. NAKKEN, 1969. On the hydrography of the shelf water off Møre and Helgeland. Fisk Dir. Skr. Ser. HavUnders., 15: 285 - 294.

SELIVERSTOV, A.S. 1974. Vertical migrations of larvae of the Atlanto-Scandian Herring (Clupea harengus L.) P. 253-262 in BLAXTER, J. H. S. ed. The early life history of fish. Springer-Verlag. Berlin.

THEILACKER, G. and DORSEY, K. 1980. Larval fish diversity, a summer of laboratory and field research. IOC Workshop Report no. 28: 105-142.

WIBORG, K.F. 1960. Investigations on eggs and larvae of commercial fishes in Norwegian coastal and offshore waters in 1957-58. Fisk.-Dir. Skr. Ser. HavUnders., 12 (7): 1-27.

WIEBE, P.H., BURT, K.H., BOYD, S.H. and MORTON, A.W., 1976. A multiple opening/closing net and environmental sensing system for sampling zooplankton. J. Mar. Res., 34: 313-326.

ØIESTAD, V. 1983. Growth and survival of herring larvae and fry (Clupea harengus L.) exposed to different feeding regimes in experimental ecosystems; outdoor basins and plastic bags. Ph. d. thesis:1-299. University of Bergen.

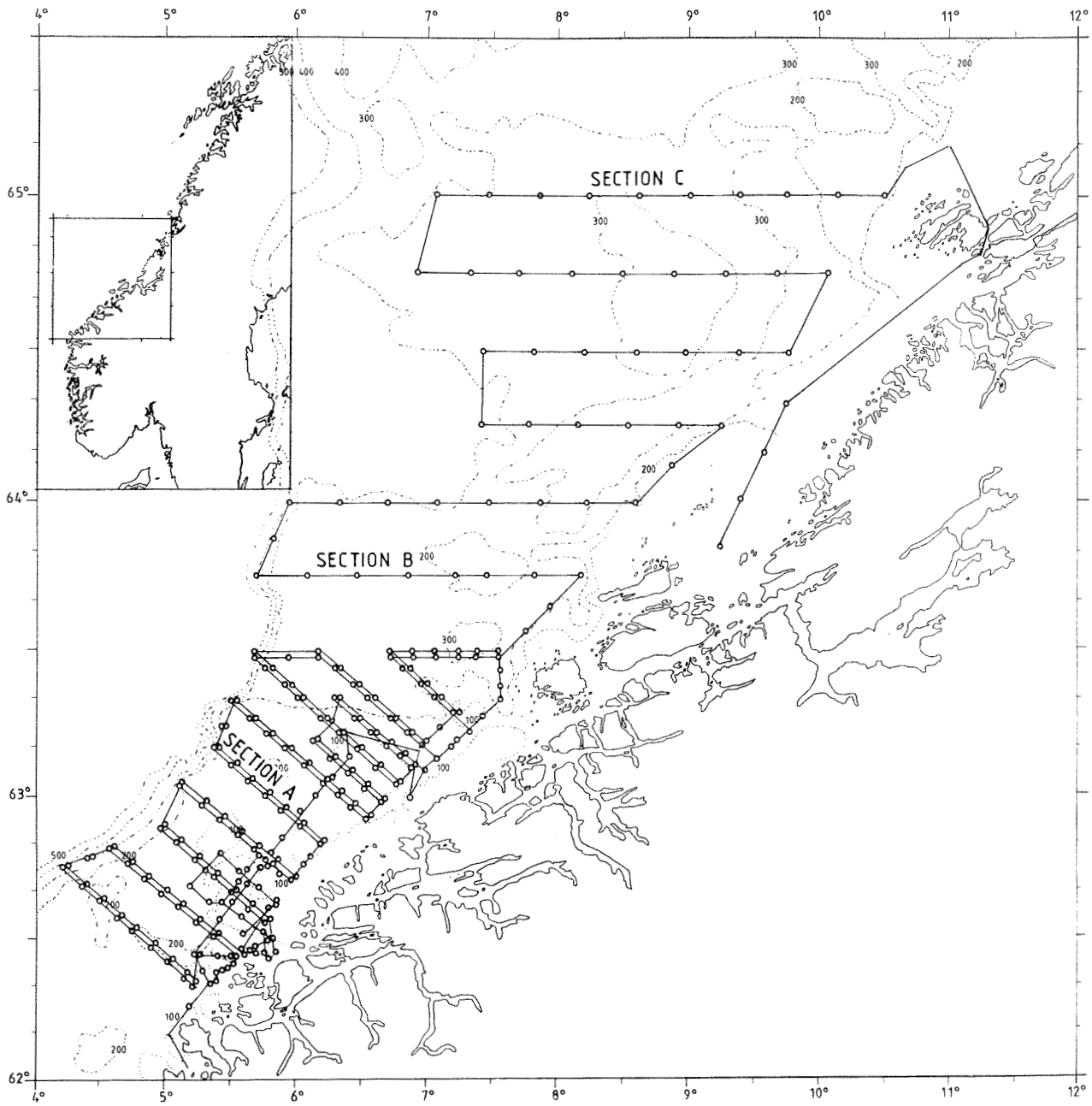

Fig. 1. Grid of stations, 29 March - 18 April 1986. Bathymetric contours for each 100 m are included. Inserted map shows the location of the studied area.

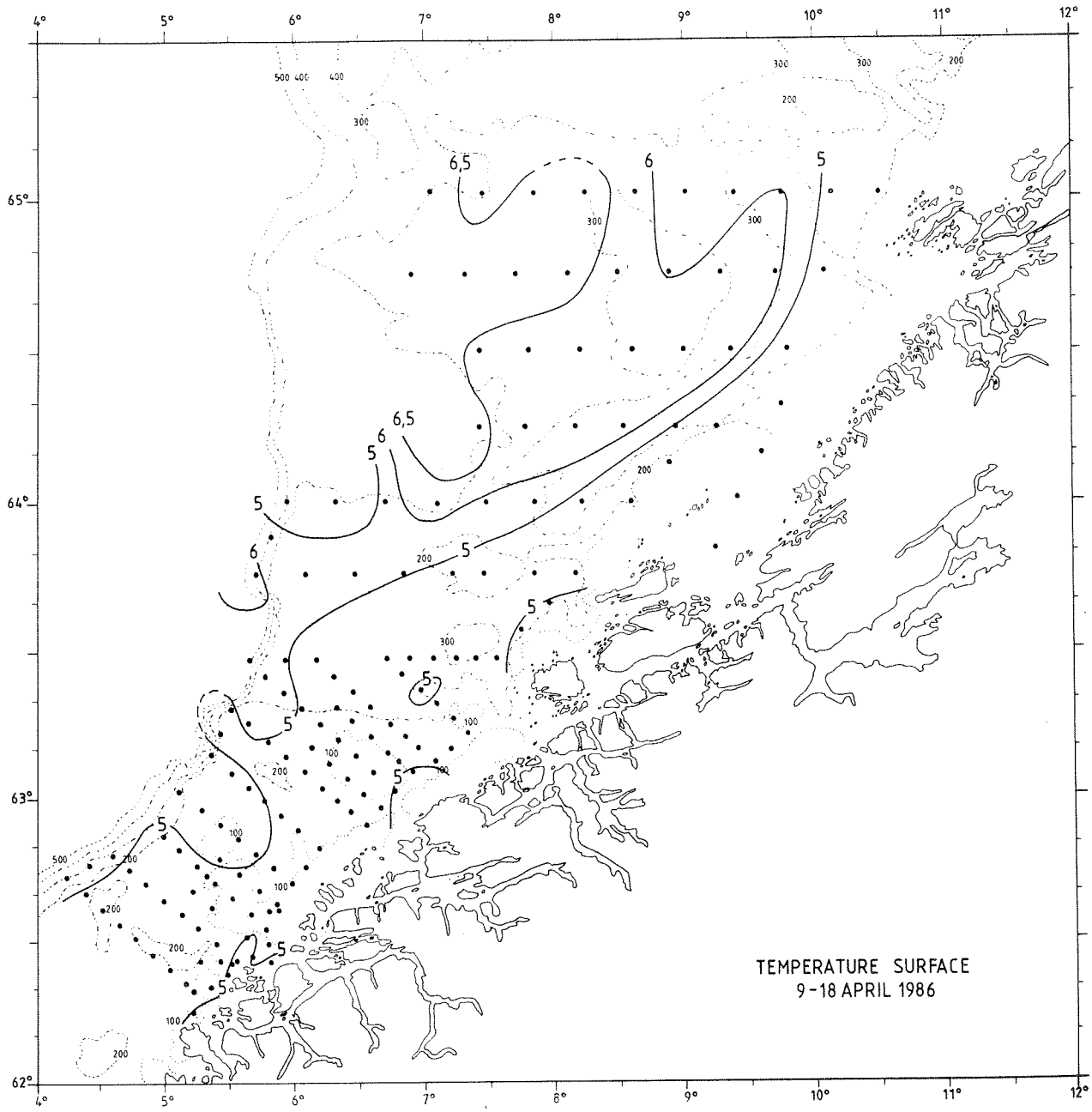

Fig. 2. Surface temperature, 9-18 April 1986.

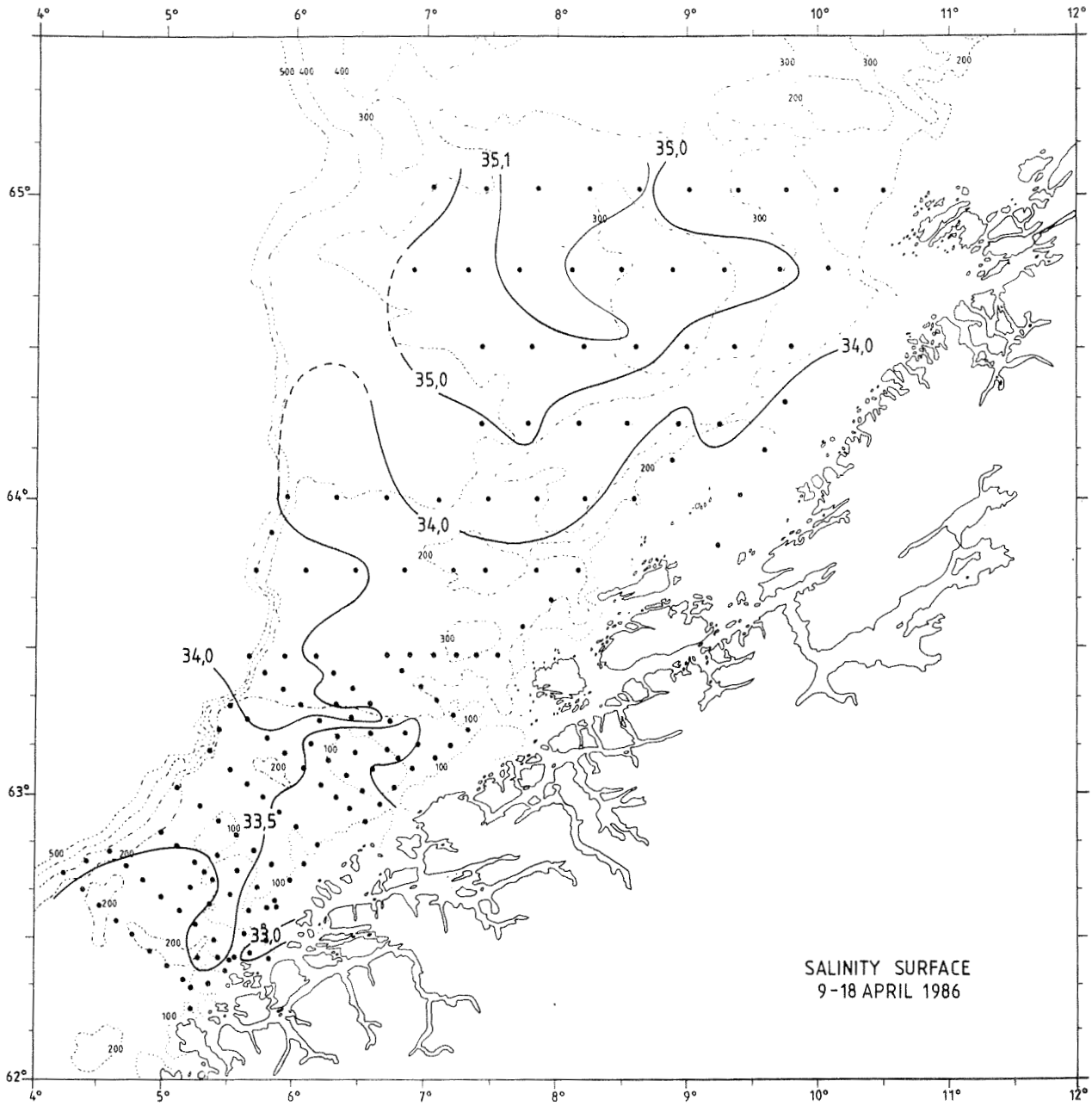

Fig. 3. Surface salinity 9-18 April 1986.

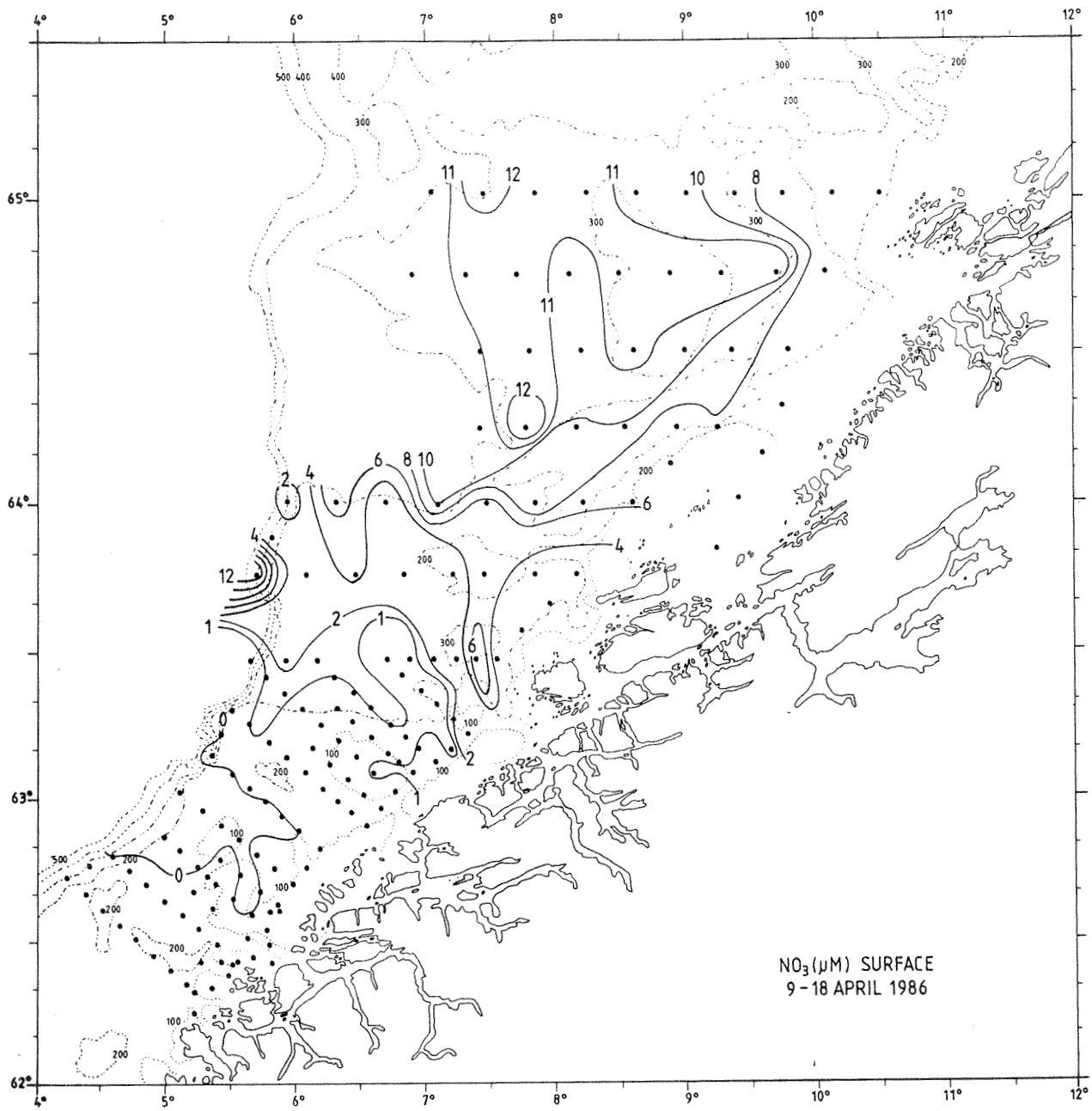

Fig. 4. Surface values of nitrate 9-18 April 1986.

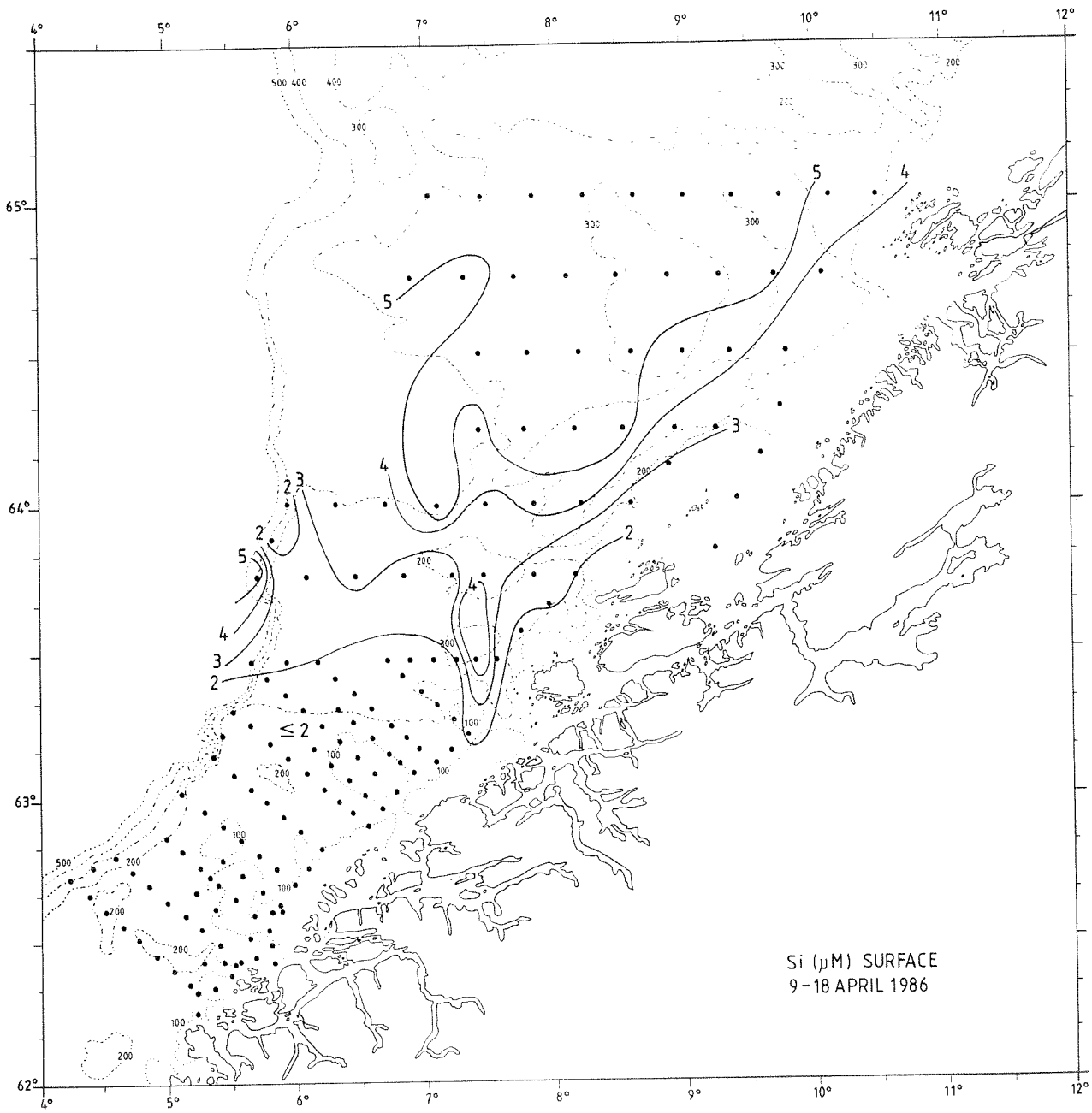

Fig. 5. Surface values of silicate 9-18 April 1986.

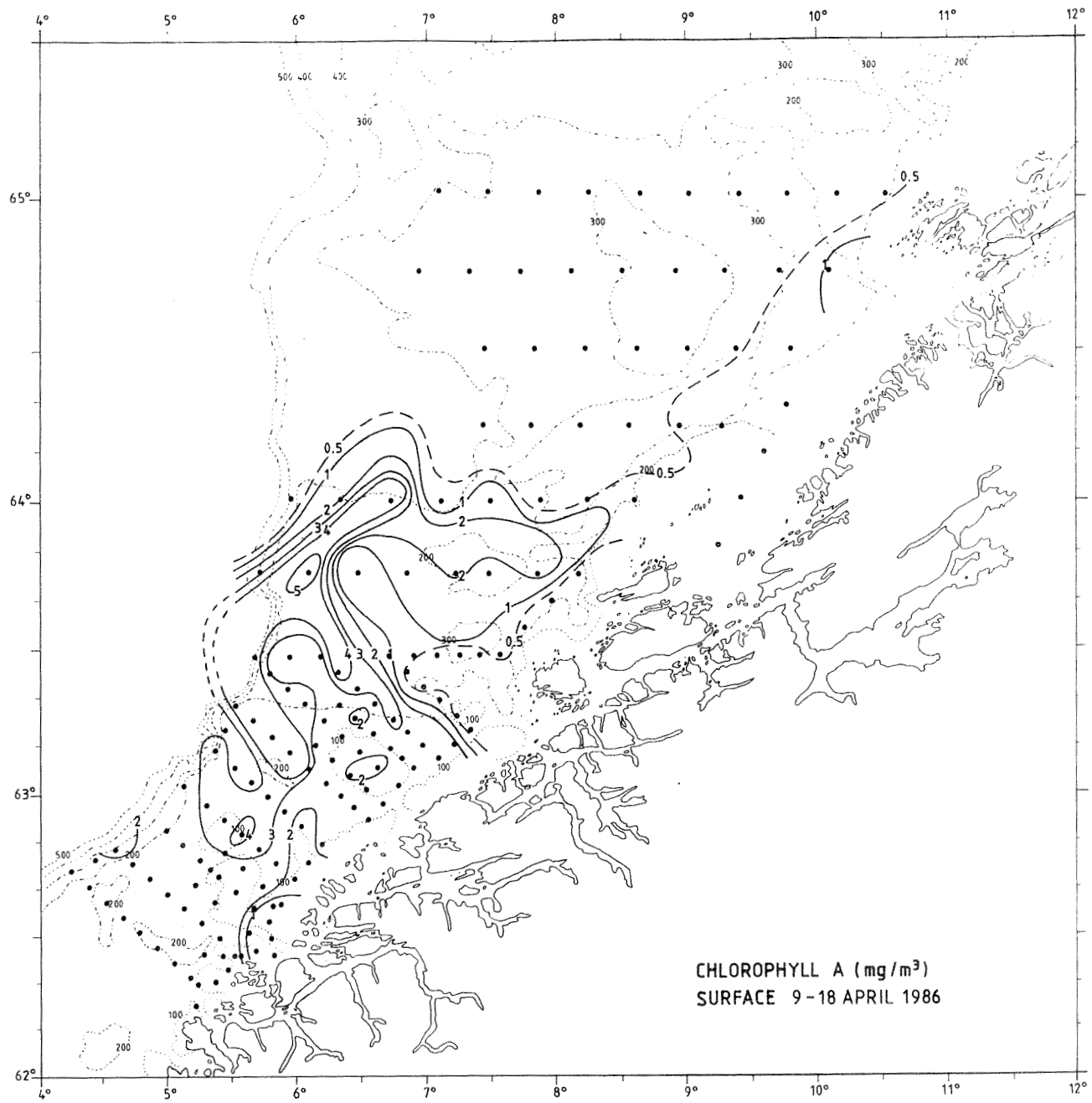

Fig. 6. Surface values of chlorophyll a 9-18 April 1986.

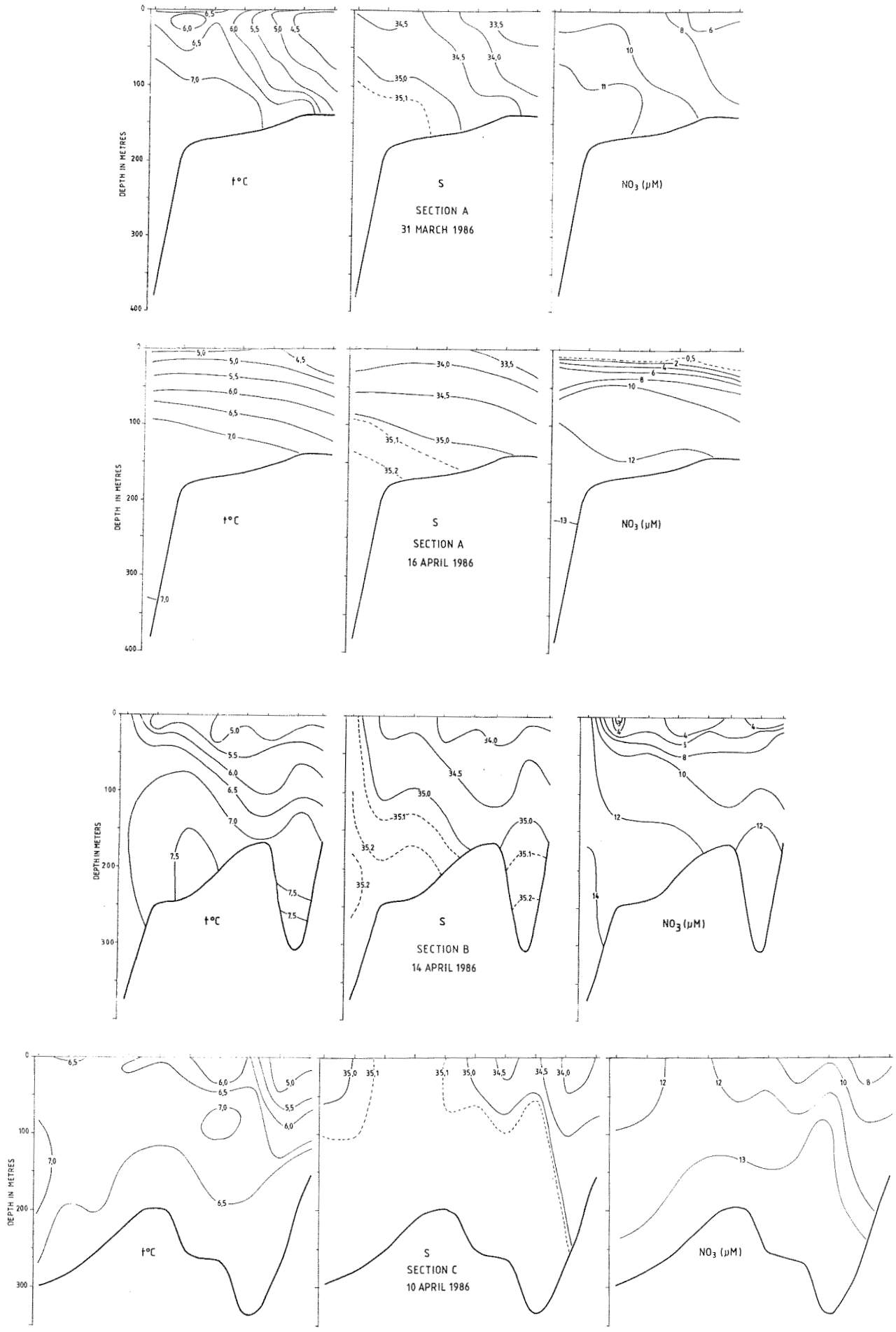

Fig. 7. Hydrographic section A, B and C. Location of these is indicated in Fig. 1.

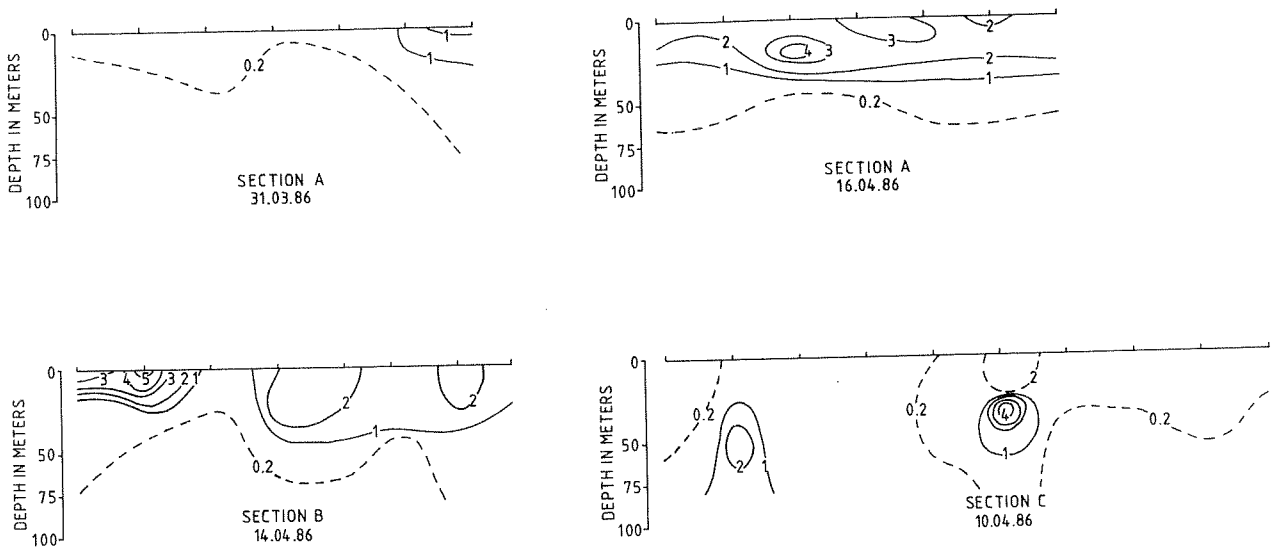

Fig. 8. Chlorophyll a in hydrographic sections A, B and C (Fig. 7).

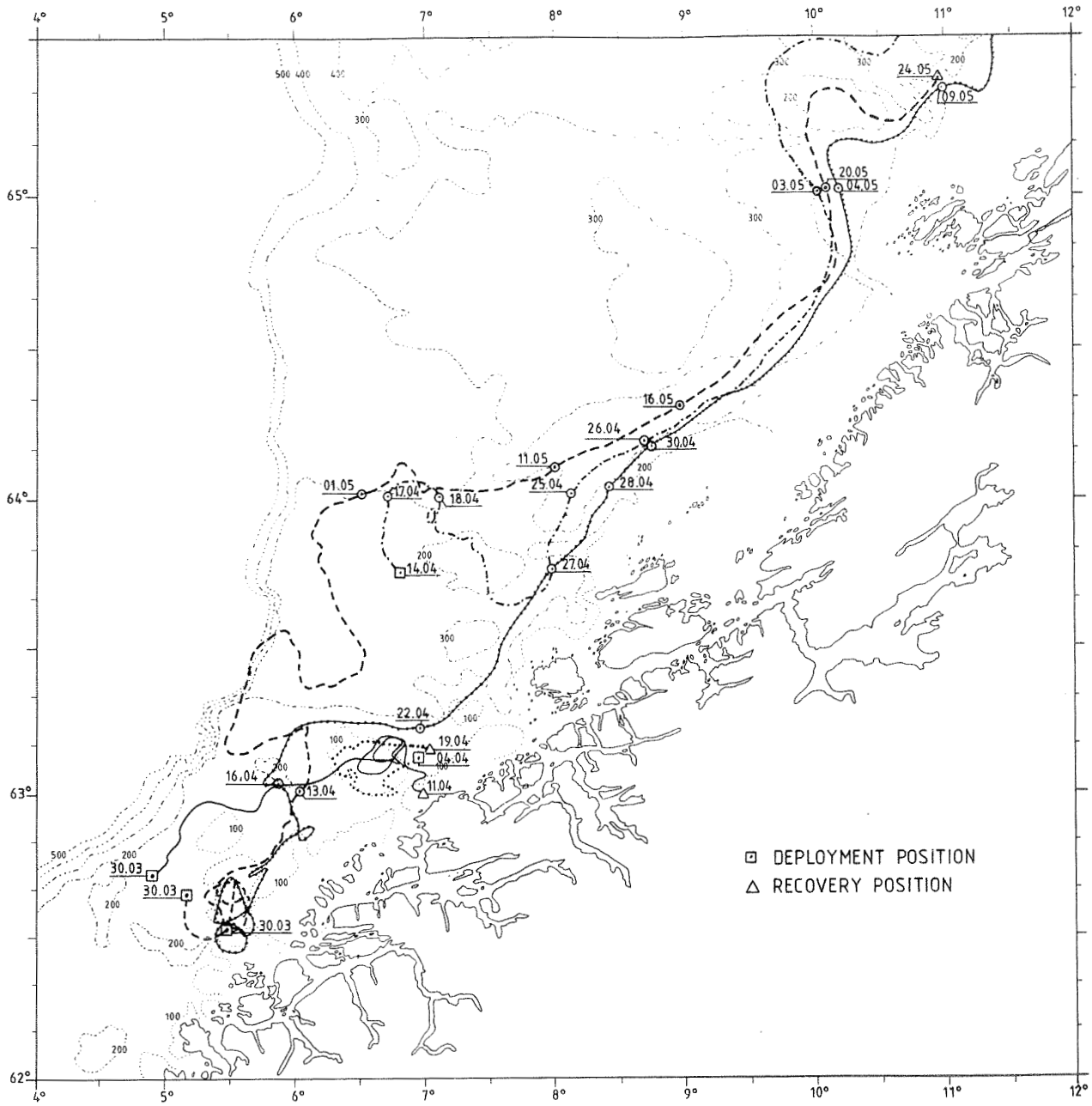

Fig. 9. Tracks of the drifting Argos buoys drogued at 30 m depth.

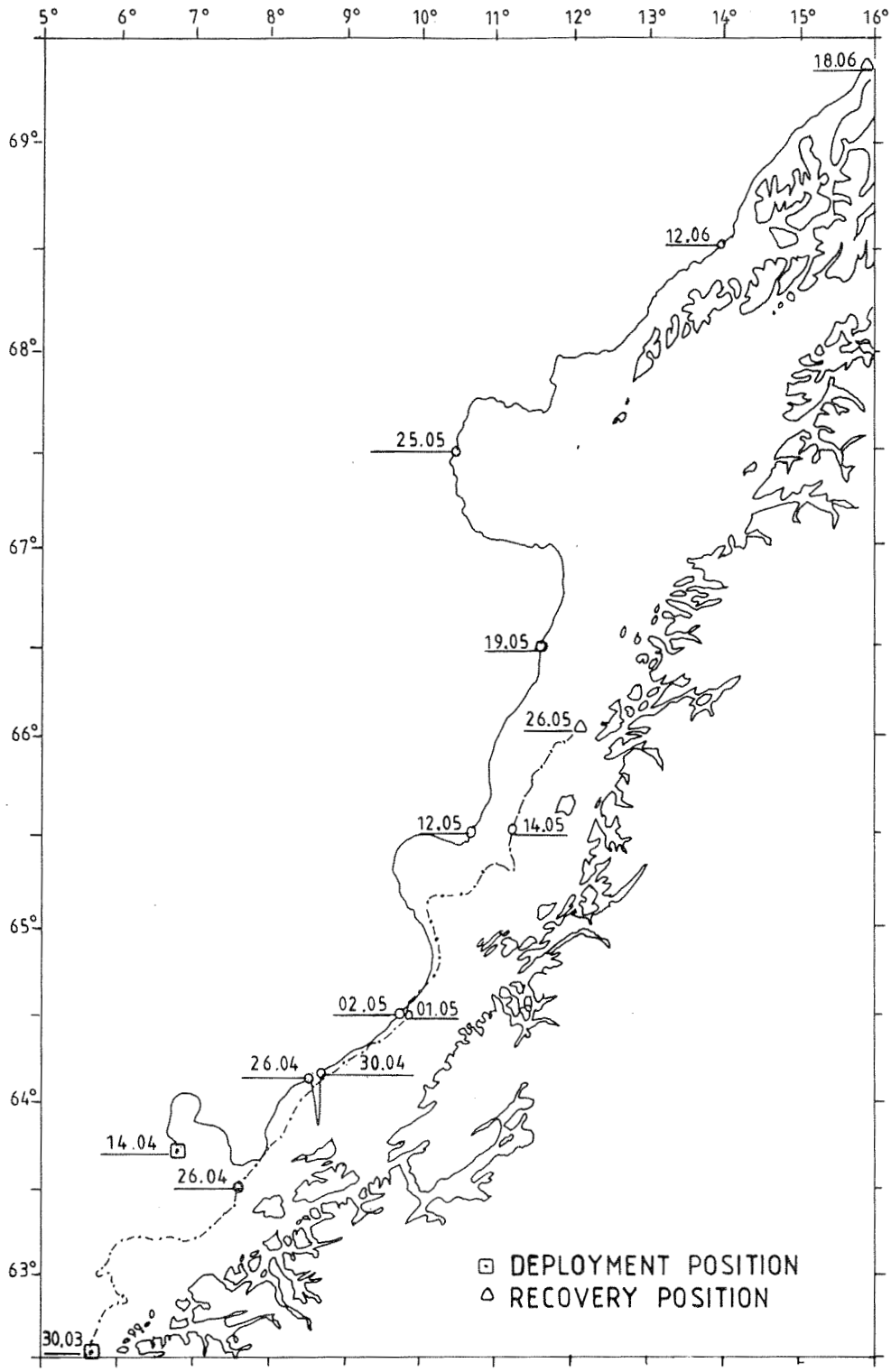

Fig. 10. Tracks of two of the Argos buoys further north.

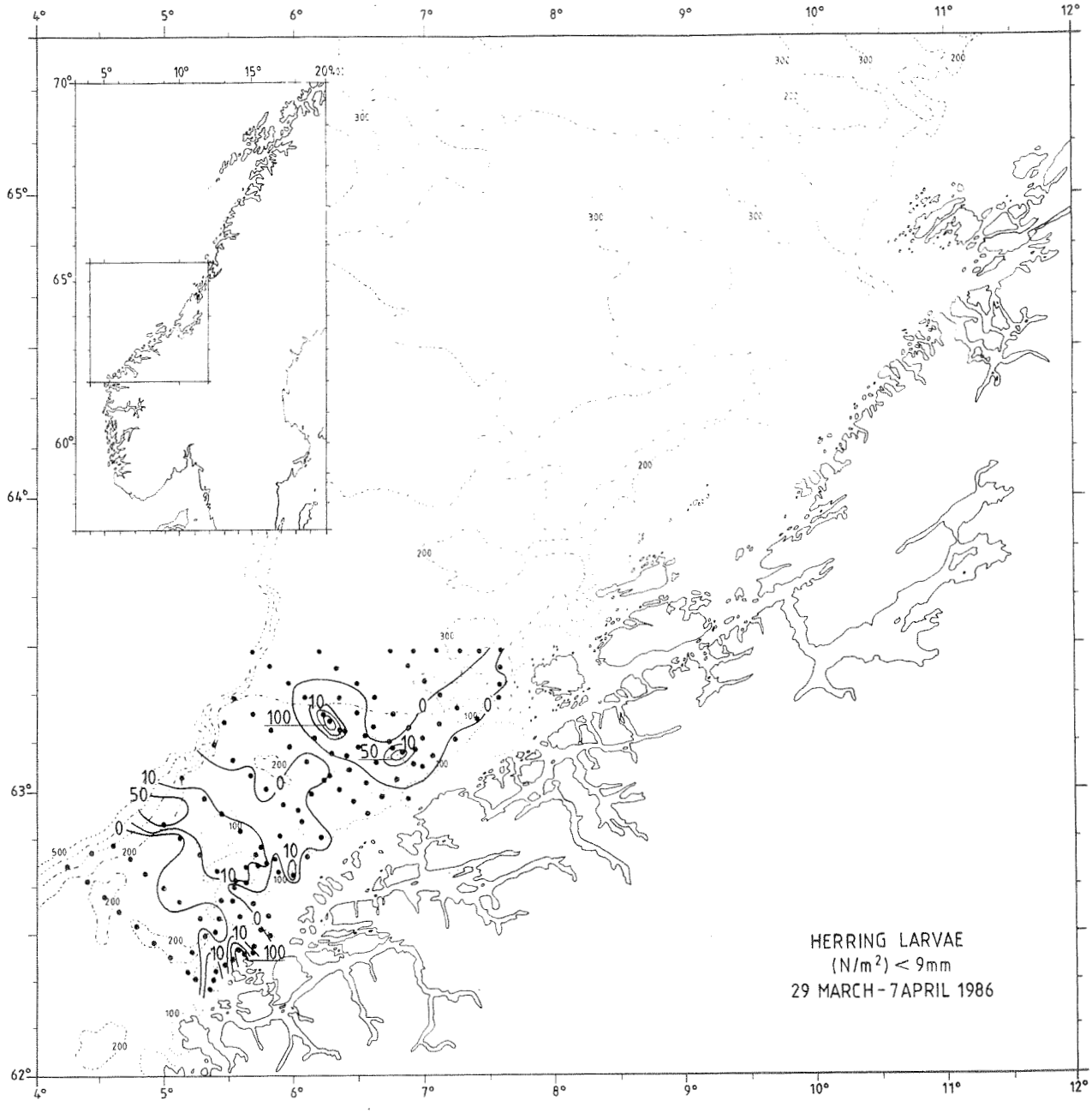

Fig. 11. Distribution of herring larvae < 9 mm (N/m^2), 29 March-7 April 1986.

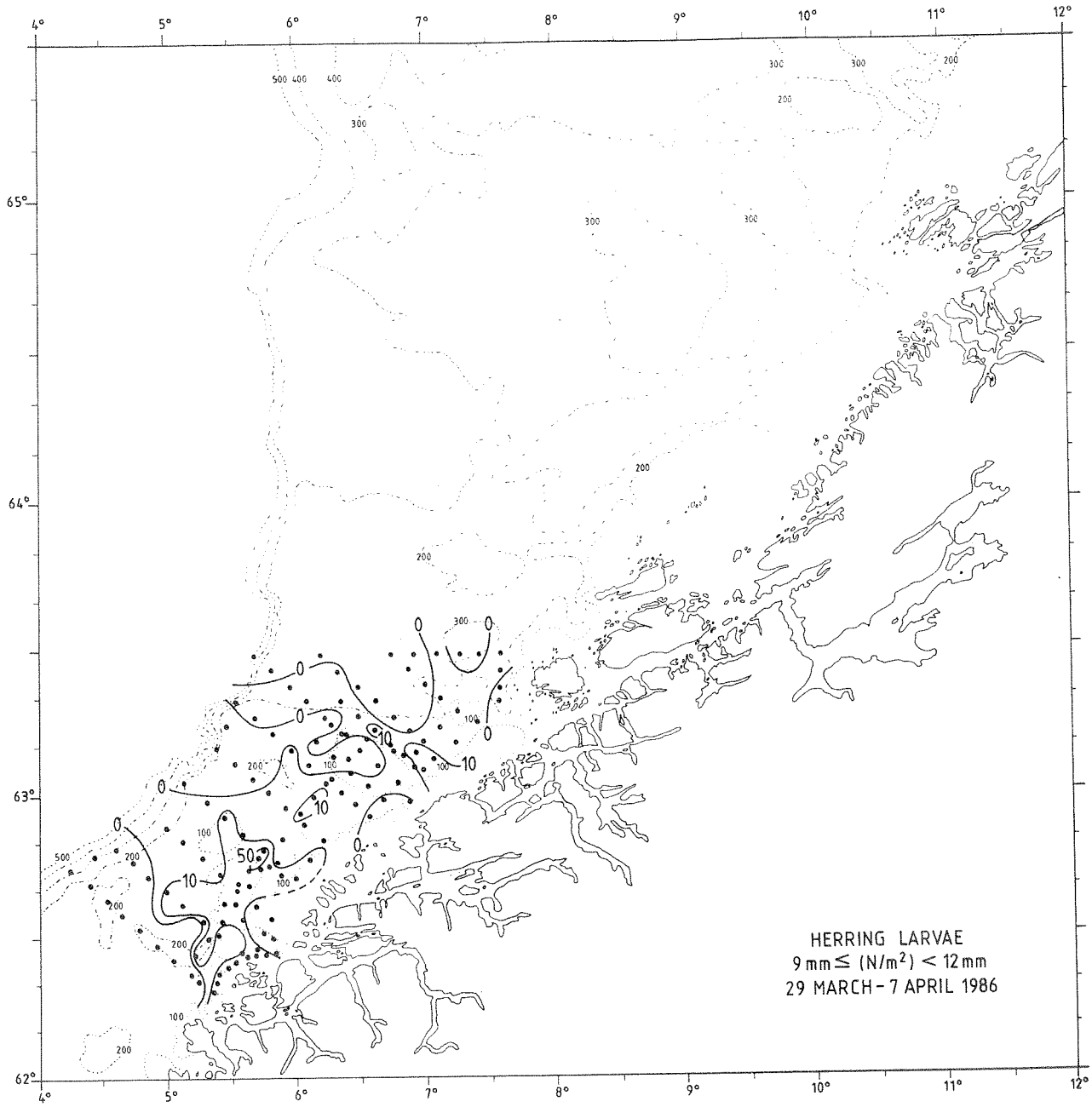

Fig. 12. Distribution of herring larvae between 9 and 11 mm (N/m^2), 29 March - 7 April 1986.

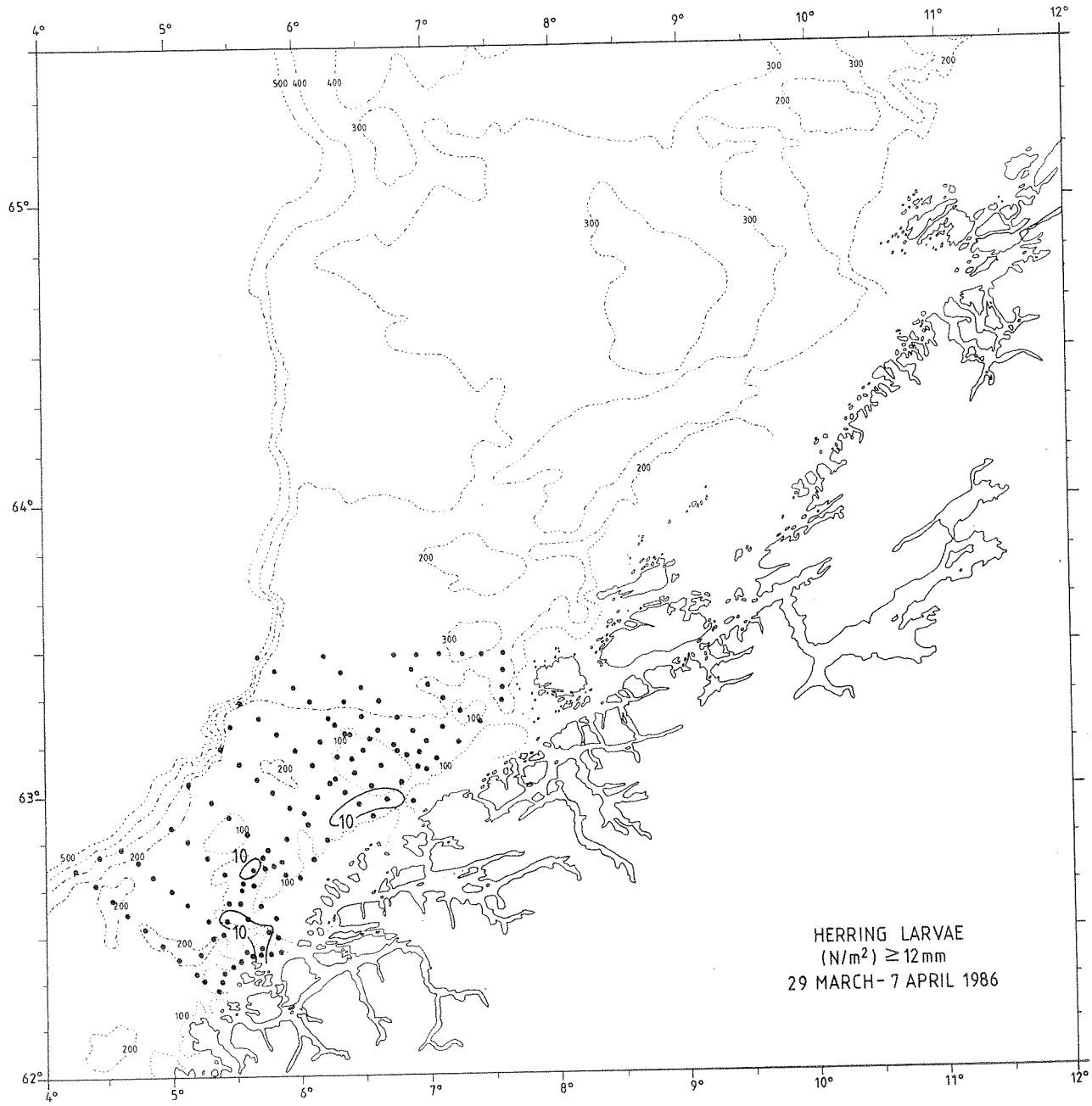

Fig. 13. Distribution of herring larvae > 11 mm (N/m^2) 29 March-7 April 1986.

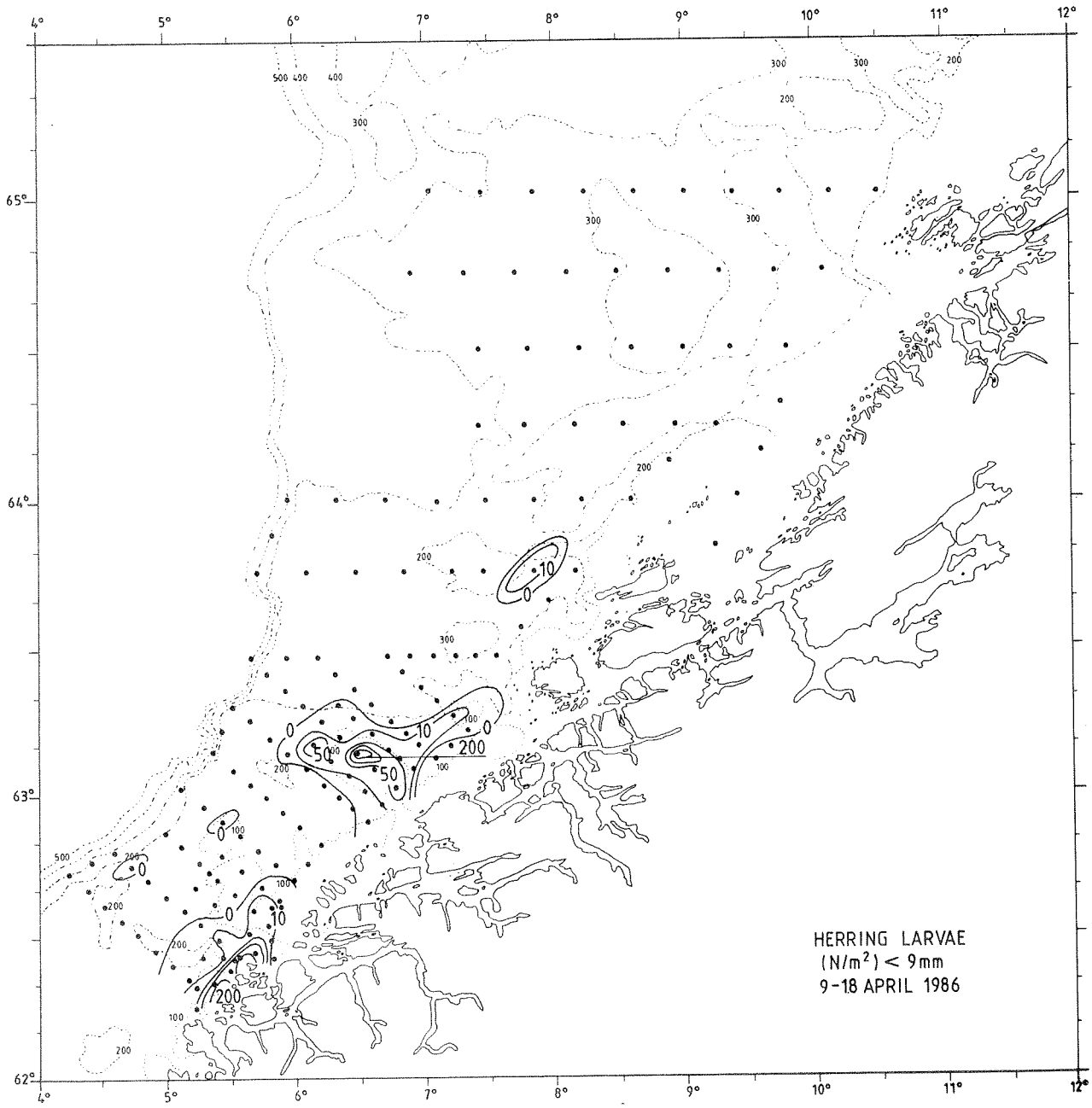

Fig. 14. Distribution of herring larvae < 9 mm (N/m^2) 9-18 April 1986.

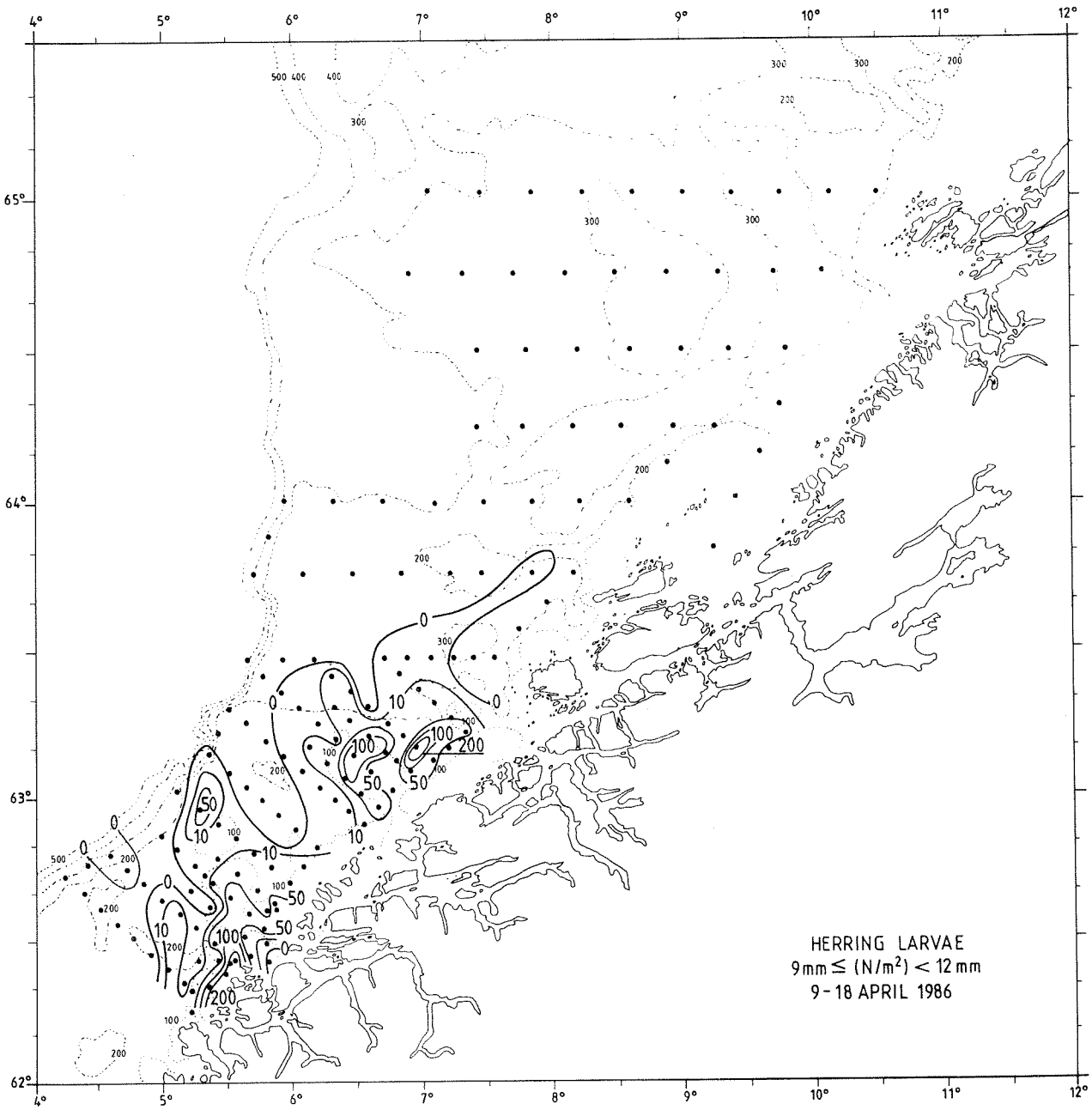

Fig. 15. Distribution of herring larvae between 9 and 11 mm (N/m^2), 9-18 April 1986.

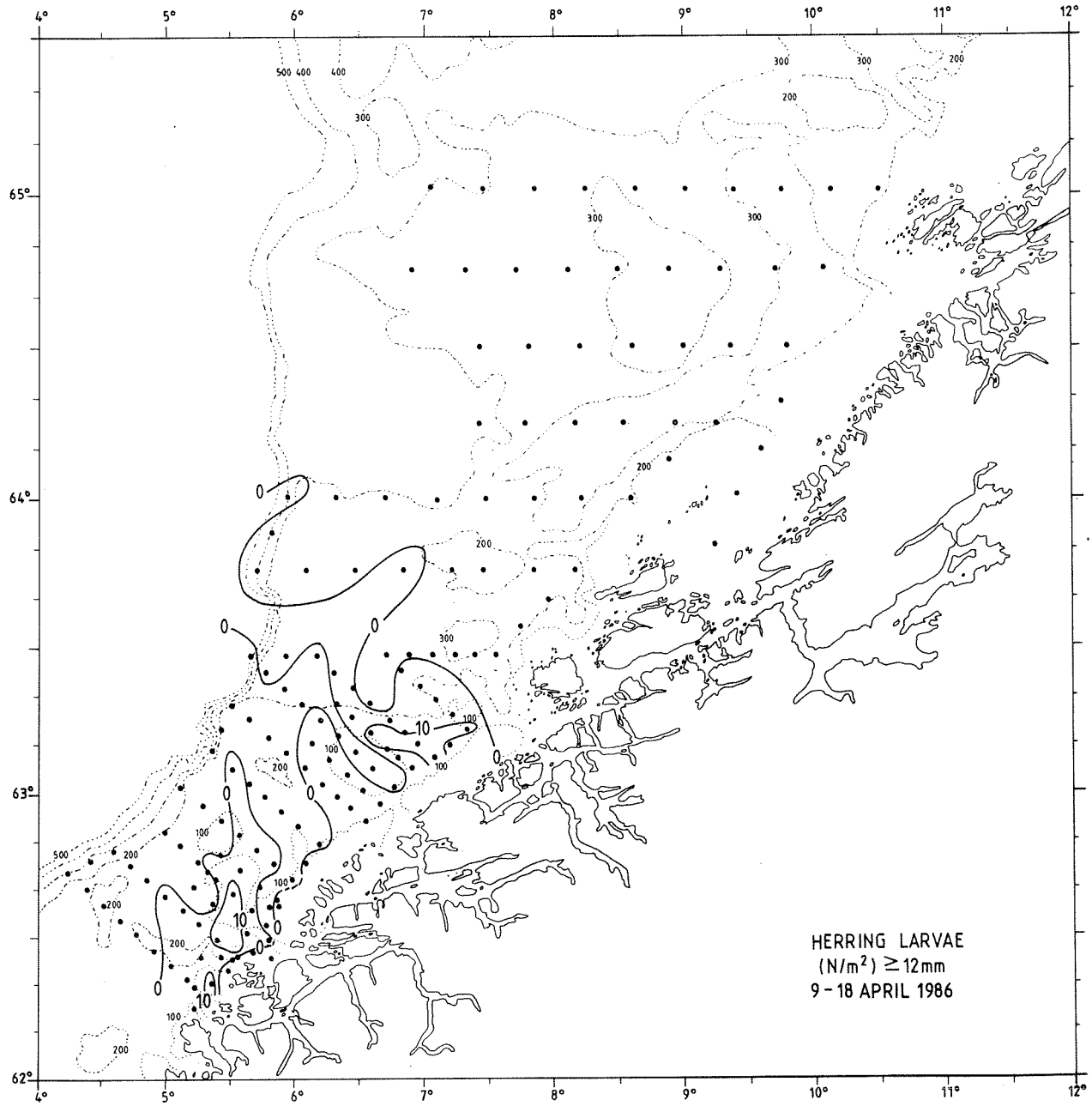

Fig. 16. Distribution of herring larvae > 11 mm (N/m^2), 9-18 April 1986.

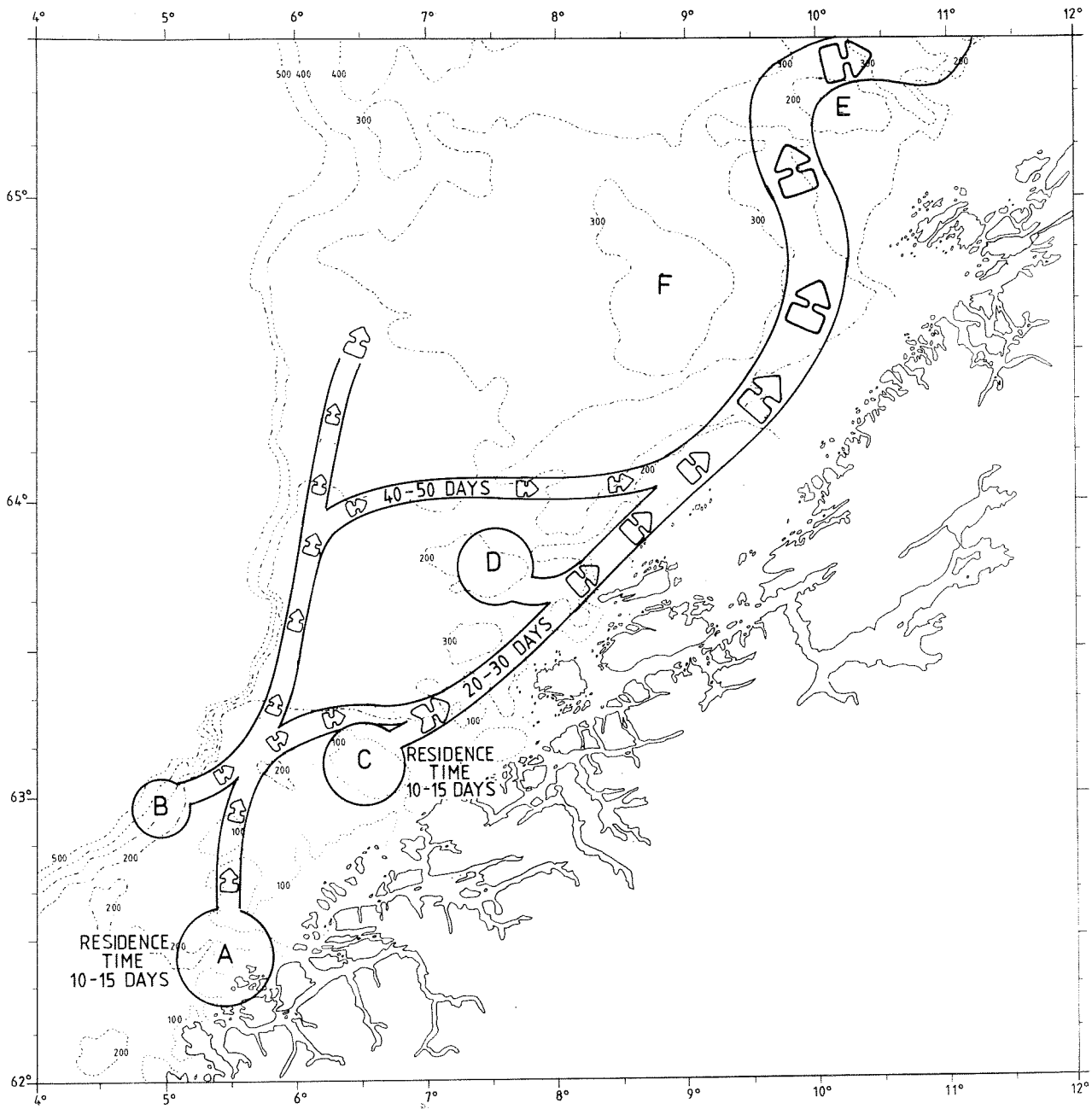

Fig. 17. Observed spawning areas, (circles) and tentative larval drift routes. The indicated drifting time is until passing the 65°N latitude.

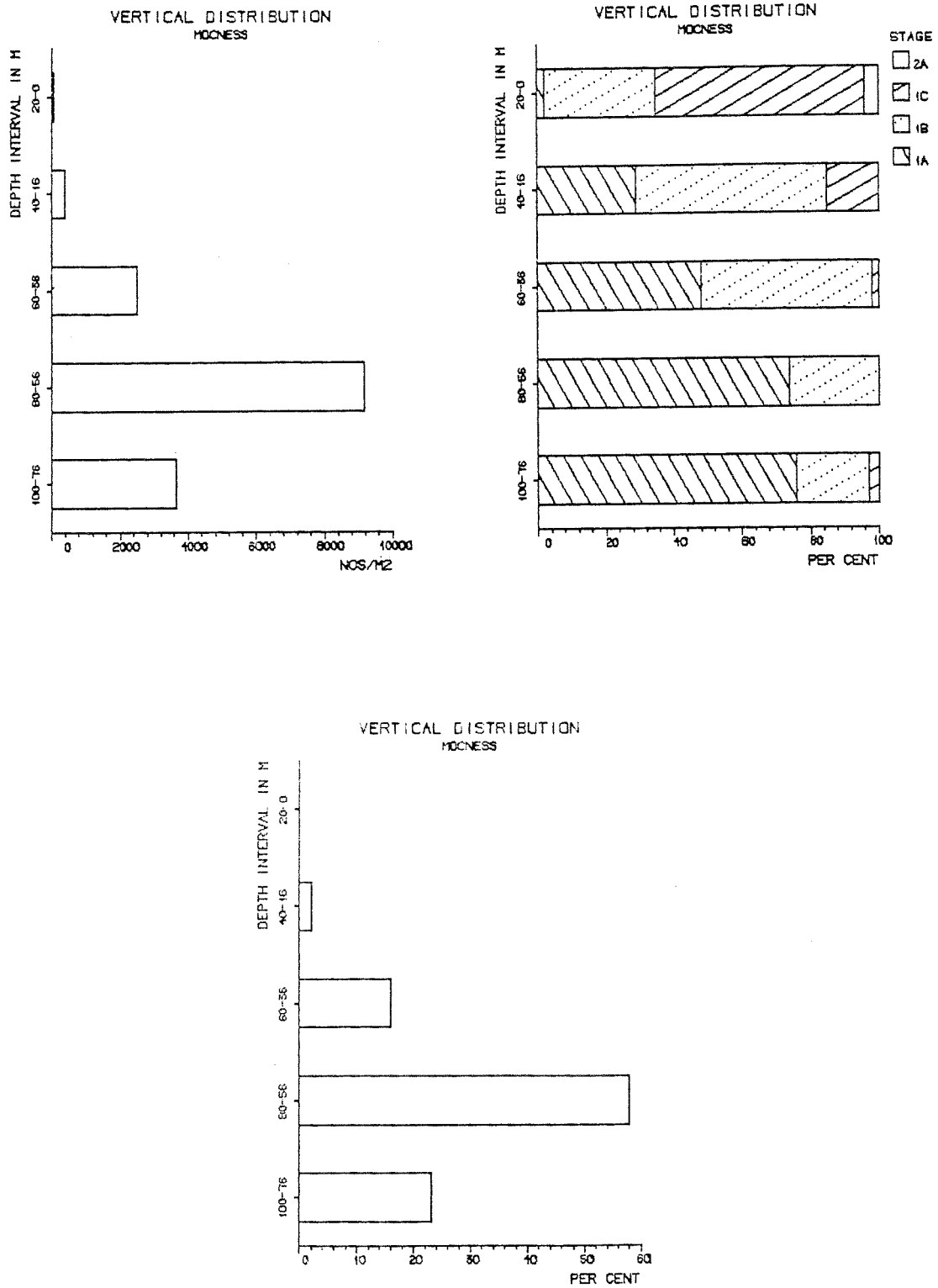

Fig. 18. Vertical distribution of larvae; number, stage and percentage for the Mocness material.

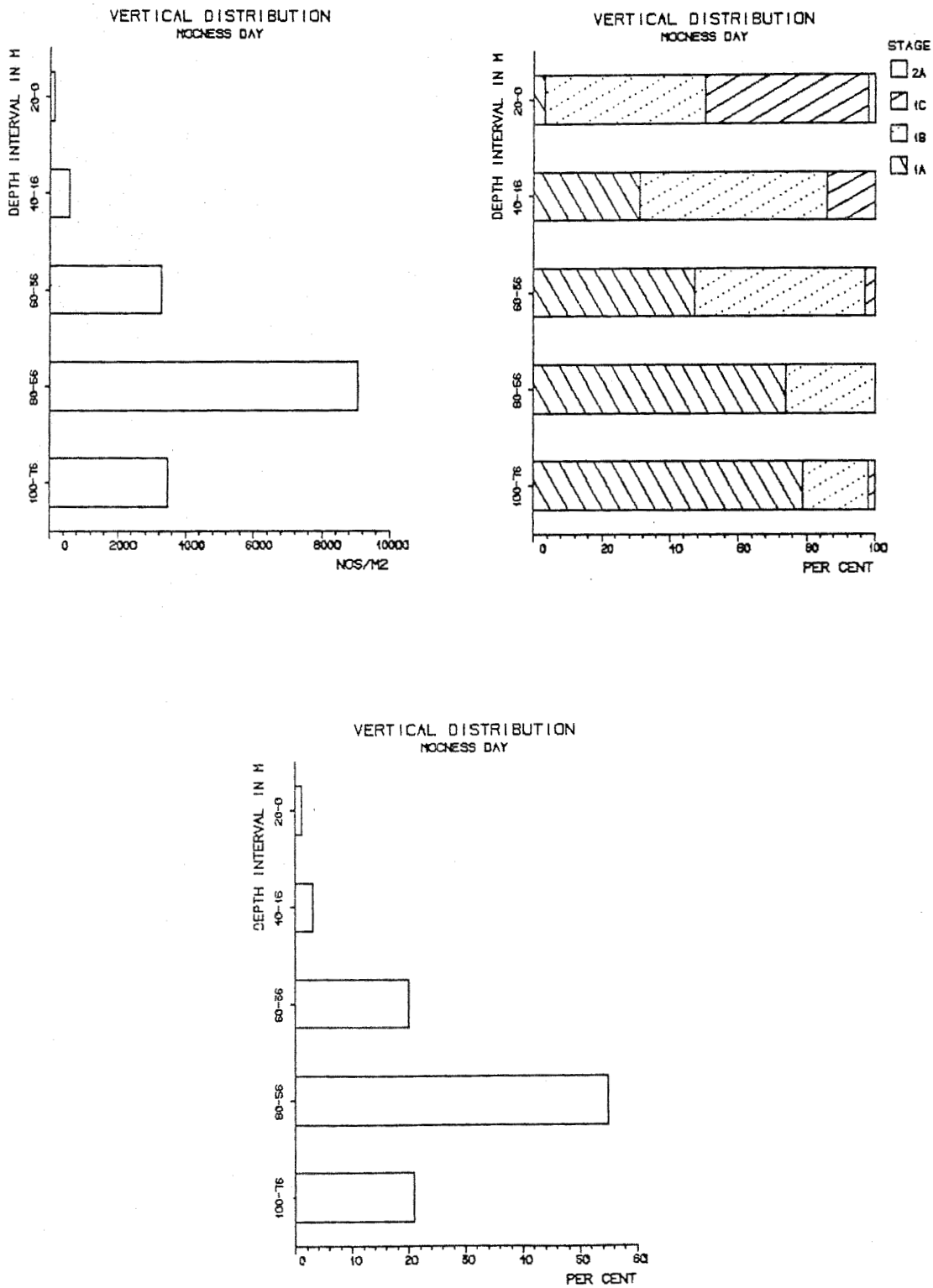

Fig. 19. Vertical distribution of larvae; number, stage and percentage for the Mocness material during day time.

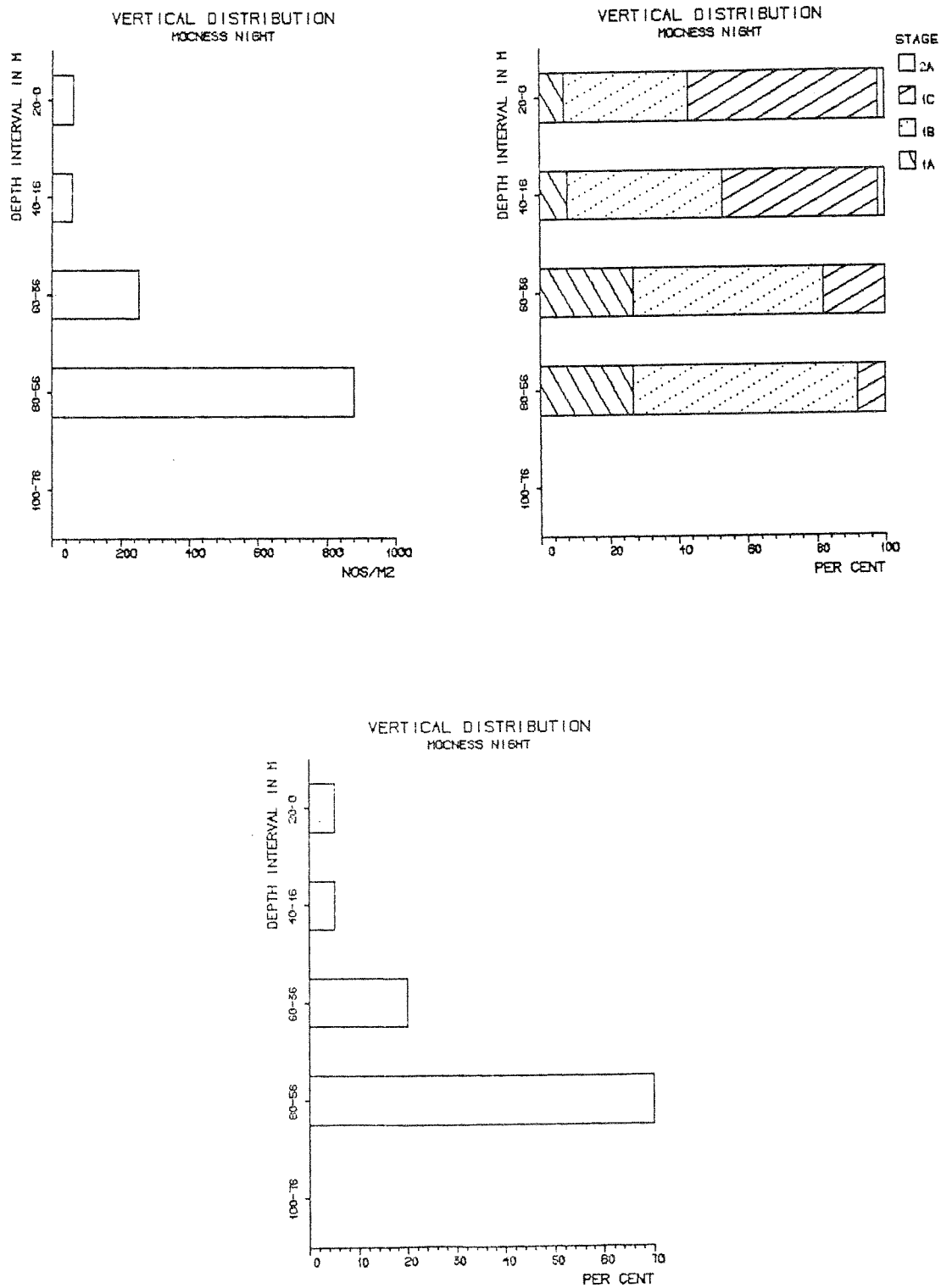

Fig. 20. Vertical distribution of larvae; number, stage and percentage for the Mocness material during night.

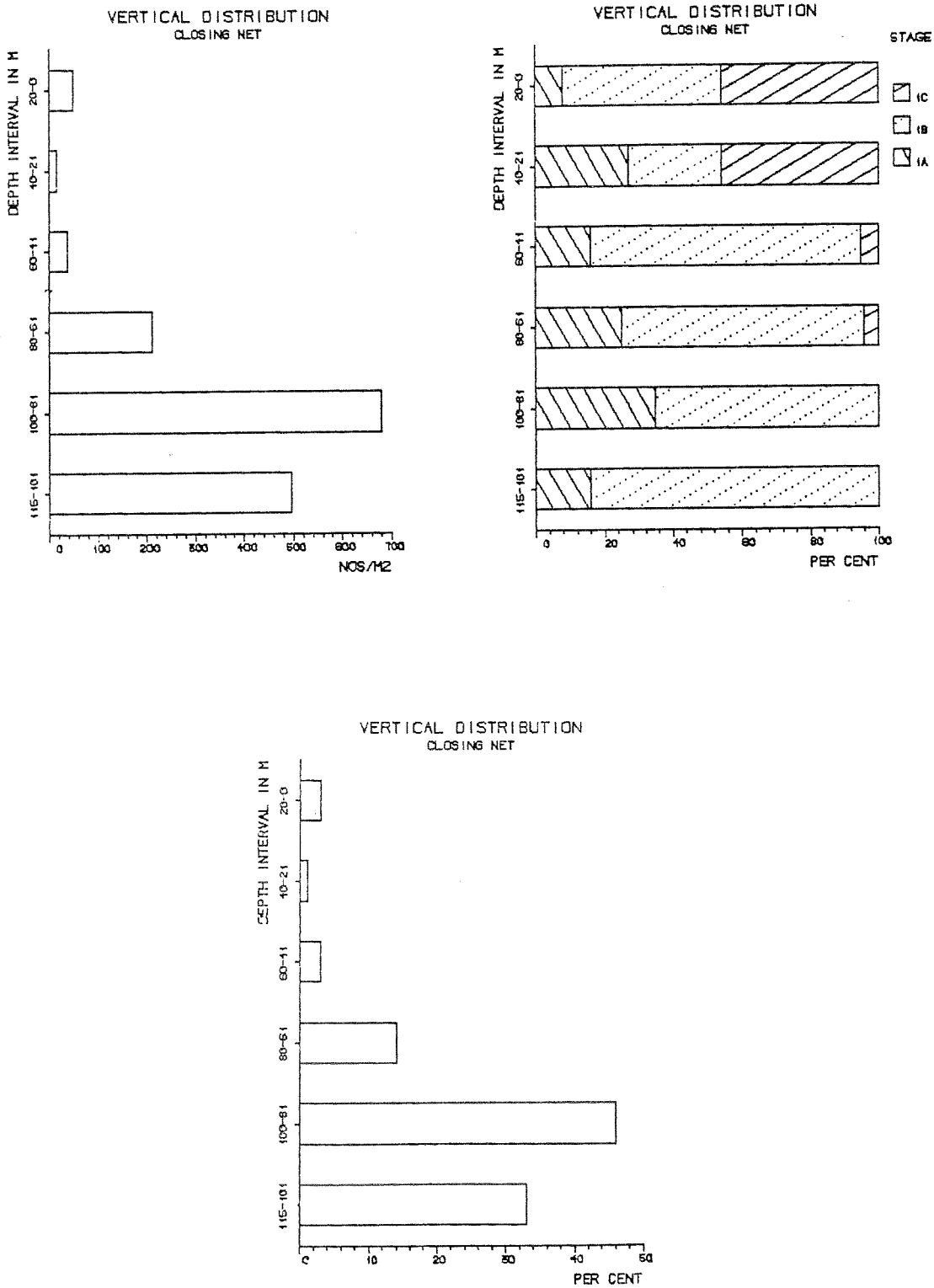

Fig. 21. Vertical distribution of larvae; number, stage and percentage for the closing net.

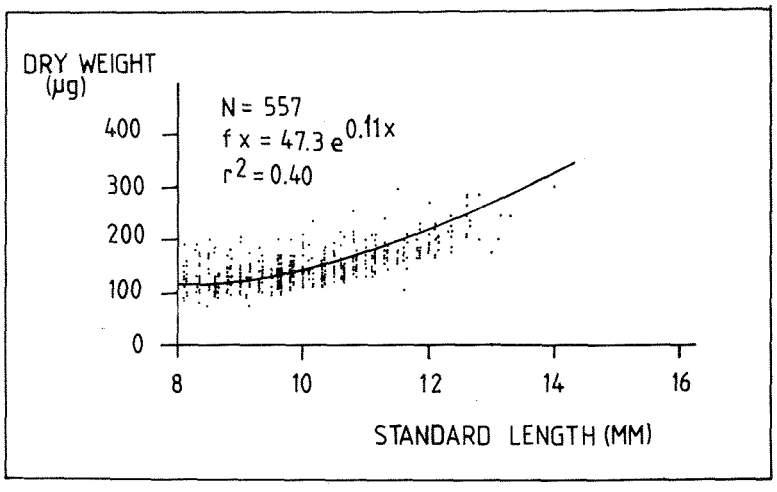

Fig. 22. The length/dry weight plot of the present herring larvae material.

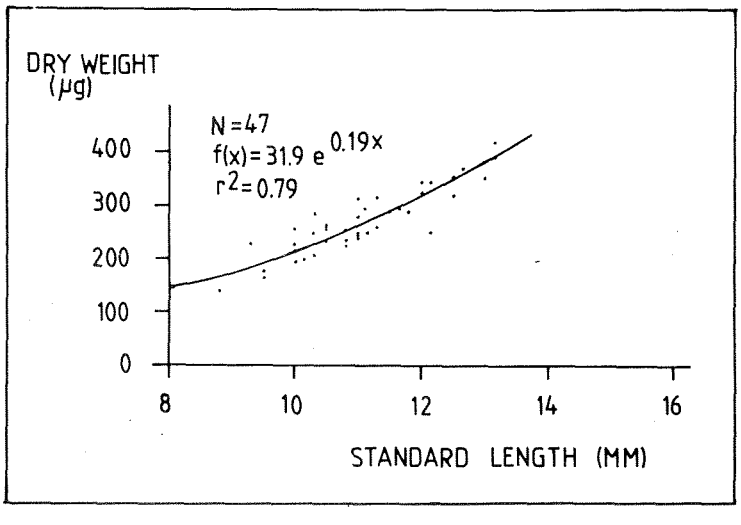

Fig. 23. The length/dry weight plot of the larvae not exposed to formalin fixation.

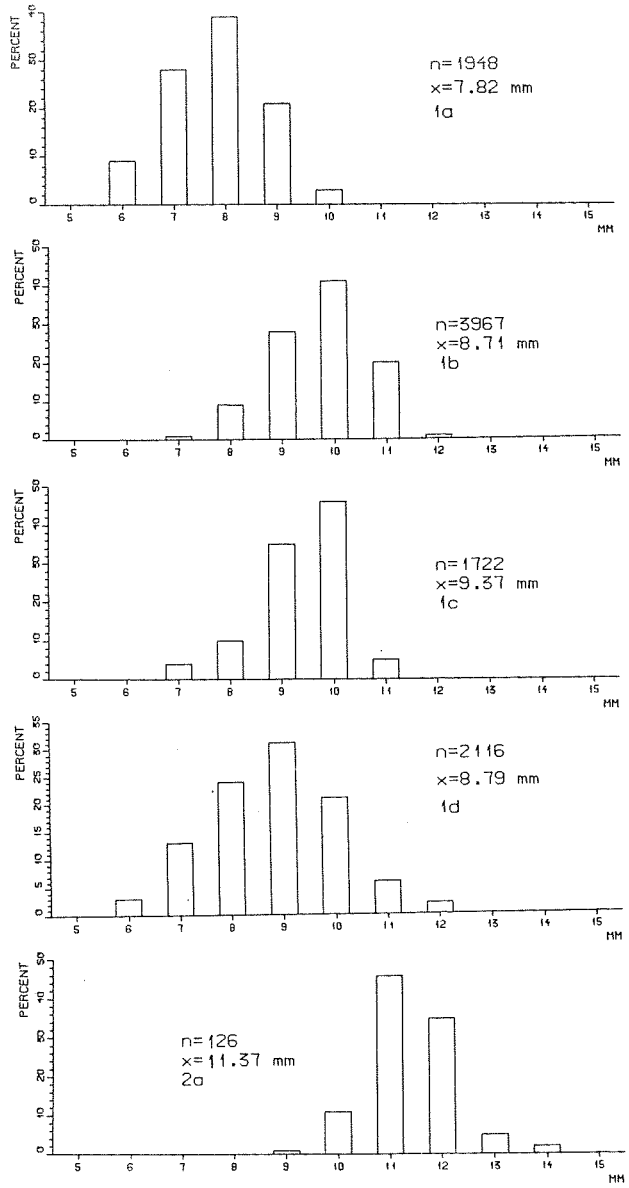

Fig. 24. The per cent length distribution of the different stages.

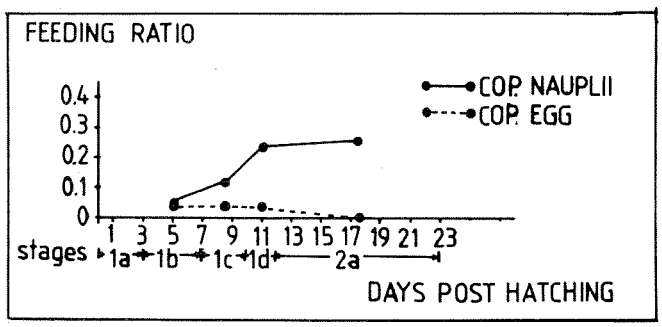

Fig. 25. The diet of the larvae in the period 3-23 days post hatching.

Denne rapportserien har begrenset distribusjon. Opplysninger om programmet og rapportene kan rettes til

Programledelsen for HELP
Fiskeridirektoratets Havforskningsinstitutt
Postboks 1870
5024 Bergen

Oversikt over tidligere utkomne rapporter.

1987	Nr. 1.	P.Solemdal og P.Bratland: Klekkeforløp for lodde i Varangerfjorden 1986.
	Nr. 2.	T.Haug og S.Sundby: Kveitelarver og miljø. Undersøkelser på gytefeltene ved Sørøya.
	Nr. 3.	H.Bjørke, K.Hansen og S.Sundby: Postlarveundersøkelser i 1986.
	Nr. 4.	H.Bjørke, K.Hansen og W.Melle: Sildeklekking og seigyting på Møre 1986.
	Nr. 5.	H.Bjørke and S.Sundby: Abundance indices for the Arcto-Norwegian cod in 1979-1986 based on larvae investigations.
	Nr. 6.	P.Fossum: Sult under larvestadiet - en viktig rekrutteringsmekanisme ?
	Nr. 7.	P.Fossum og S.Tuene: Loddelarveundersøkelsene 1987.