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ACOUSTIC SURVEY ON BLUE WHITING IN THE NORWEGIAN SEA, AUGUST/SEPTEMBER 1985

ABSTRACT

Seven research vessels from USSR, Norway, GDR, Iceland and the Faroes participated in the fourth ICES-coordinated acoustic survey on blue whiting in the Norwegian Sea and adjacent waters.

Blue whiting were recorded over the major part of the Norwegian Sea, with the highest concentrations near the slope around Faroe Islands.

The acoustic estimate of blue whiting was 4.9 mill. tonnes. This is an increase of 1.1 mill. tonnes compared to August 1984. The 1982 and 1983 year-classes make up the bulk of the stock.

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INTRODUCTION

Acoustic surveys on blue whiting, which have taken place during spring west of the British Isles, have yielded estimates of the spawning stock. For monitoring the stock, however, there was in addition a need for an estimate of the total stock.

In 1982 the first ICES-coordinated international acoustic survey on blue whiting in the Norwegian Sea took place in accordance with a recommendation from ICES (Anon. 1982). In 1983 and 1984 similar surveys were also carried out (Anon. 1983a, 1984).

The fourth ICES-coordinated acoustic survey on blue whiting in the Norwegian Sea and adjacent waters was then conducted from 27 July to 5 September 1985 (C.Res. 1984/2:9(ii)-10.)

MATERIAL AND METHODS

Five countries with the following research vessels participated in the survey:

Nation	Vessel	Survey period	Instrument constant $C_I \cdot 4\pi$	Vertical opening of pelagic trawl (m)
USSR	"Kokshaysk"	9-10 Aug	0.83	60
Norway	"Eldjarn"	29 Jul-18 Aug	0.29	15, 18
"	"Michael Sars"	15 Aug-5 Sep	1.36	20, 45
GDR	"Walter Barth"	10-18 Aug	* -	38
Iceland	"Arni Fridriksson"	10-27 Aug	2.88	17
"	"Bjarni Sæmundsson"	10 Aug-5 Sep	2.60	15
Faroes	"Magnus Heinason"	27 Jul-14 Aug	1.33	40

*No integrator

Names of the institutes and personnel of the scientific staff participating in the cruises are given in Appendix I.

In May 1985 a Workshop met in Bergen to review the results of the similar surveys in 1982, 1983 and 1984, and in the light of the analysis of the survey results, made plans and suggestions for the coordinated acoustic survey in August 1985 (Anon. 1985).

The cruise tracks of all vessels participating together with the trawl stations and the hydrographical stations are shown on Figs 1 and 2 respectively. Around Iceland and off the Northern Norwegian Coast the blue whiting survey was combined with 0-group fish investigations, and north of Iceland and west of Jan Mayen with capelin investigations.

All the vessels but one were equipped with echo integrator connected to 38 kHz echo sounders. The acoustic systems of each vessel had been calibrated against a standard target copper-spheres (Cu-60 mm). The instrument constants ($C_I \cdot 4\pi$) for standardizing the integrator values into comparable units, are listed in the text-table above.

The echo recordings were integrated and expressed as numbers of square meters reflecting targets per square nautical mile sea surface, averaged for each five nautical mile sailed. The recordings were identified and biological samples collected by use of pelagic trawl. The size of the trawls, expressed by the vertical opening, are also listed in the text-table above.

The composition of the trawlcatches together with analysis of the corresponding echo paper recordings gave basis for dividing the integrator values into different species.

The procedure at sea, and the conveyance of the collected data was in general followed as suggested in the Planning Group Report of 1983 (Anon. 1983b).

The estimation of the blue whiting biomass was by the same method as in the three previous years (Anon. 1984). The total area surveyed was divided into rectangles of 1° latitude and $2^{\circ}30'$ longi-

tude in which the area of blue whiting distribution were measured according to zero-line. The average integrator values for each rectangle were calculated and representative length and weight distribution established. These were based on trawl catches within the rectangle in question, or from neighbouring rectangles.

Conversion of the integrated echo intensity into biomass was done by use of a fish length dependent density coefficient. The number of fish within an area is given by the product of the size of the area (square nautical miles) and the fish density (nos. of fish per square nautical mile). The fish density can be written as

$$\bar{P}_A = \frac{1}{\bar{\sigma}_{b \cdot s}} \cdot \overline{C_I \cdot M}$$

where

$\bar{P}_A$ is the number of fish per square nautical mile,

$\bar{\sigma}_{b \cdot s}$ is the mean backscattering cross section of the fish, [$\bar{T}S = 10 \log \bar{\sigma}_{b \cdot s}$]

C_I is the instrument constant, and

M is the echo integrator values.

The density coeffisient (C_F-value) for blue whiting is the same as used for young cod. The value corresponds to a target strength of -40.5 dB for a 30 cm fish:

$$C_F = \frac{1}{\sigma_{b \cdot s}} = 1.87 \cdot 10^7 \cdot L^{-2.18}$$

where L is the fish length in cm (Anon. 1982, 1984).

The scaling factor of the instrument constant has previously been 10 to get a convenient order of magnitude, with corresponding reduction of the C_F-value. This has been changed in 1985 to a factor of 4π which is more appropriate (see text-table page 2).

The integrator standard of 1985 therefore is $\frac{4\pi}{10}$ times the old standard, and hence lead to a new expression of the density coeffisient:

$$C_F = 1.488 \cdot 10^6 \cdot L^{-2.18}$$

which was then used in the calculation of blue whiting biomass in August 1985.

The length distribution of blue whiting in each rectangle were weighted by the average integrator value, and the number of specimen and corresponding weight in each length group calculated by use of computer programme. The result of each rectangle were then summed for the sub-areas and total.

Age-length keys based on analysis of otoliths sampled by the Norwegian vessels, were established and used for calculation of the age-composition in the stock.

All of the vessels but one operated a great number of hydrographical stations, using either bathythermograph (XBT), CTD-sonde or Nansen water-bottles with reversing thermometer.

RESULTS

Hydrography

The horizontal distributions of the temperature at sea surface, 200 m and 400 m depth, are shown in Figs 3, 4 and 5 respectively.

The water masses had approximately the same temperature conditions as during the similar surveys in 1984 and 1982, but somewhat warmer than in 1983. However, at 400 m depth in the area between Iceland and Jan Mayen the water was not found to be below $0^{\circ}C$ in 1985, as it was in 1984 and 1983.

Blue whiting

The relative values of blue whiting recorded during the survey are shown in Fig. 6. The distribution of blue whiting was very similar to previous years with the highest concentrations in the southern part of the investigated area, especially around the Faroes, west of Iceland and along western Norway.

Neither in the south nor in the north was the zero-line of the blue whiting distribution defined. And significant concentrations of blue whiting might well have been distributed outside the area surveyed.

In the second half of July a Norwegian research vessel with other objectives than blue whiting, surveyed the Norwegian Trench south to 58°N. Blue whiting was observed to be at approximately the same level as found during the same period in 1984, (Bergstad, pers. comm.), i.e. in quite noticable concentrations.

To the north blue whiting was also observed outwith the area surveyed. From mid July to mid August a Norwegian research vessel conducting shrimp investigations worked a fair number of bottom trawl stations in the Bear Island - Spitsbergen area. Blue whiting were caught in various numbers along the slope all the way up to 78°30'N, i.e. off Prins Karls Forland (Fig. 7). (Øynes, pers. comm.)

The total biomass of blue whiting was estimated to 4.9 mill. tonnes representing 47.2×10^9 individuals. (Table 1). Of this the 1983 year-class contributed with 2.4 mill. tonnes, the 1982 year-class with 1.6 mill. tonnes and the 1984 and the 1985 year-classes with 0.5 and 0.03 mill. tonnes respectively. The 1981 year-class and older were found to contribute together with 0.5 mill. tonnes only. The biomass by rectangle is shown in Fig. 8. The sub-areas used in the calculations are also shown in Fig. 8.

The length- and age compositions of the stock is illustrated in Figs 9-12 for the total area and for each of the sub-areas.

The 1983 year-class was the most numerous age group in all sub-areas except in the two northern, sub-area V and VI, which were dominated by the 1982 year-class. Of the total estimate in numbers these year-classes contributed 50% and 26% respectively. The 0- and I-group constituted 5% and 13% respectively while the year-class 1981 and older fish contributed with 5% only.

The observations of blue whiting in the Bear Island - Spitsbergen area, however, were of significant larger fish with peak-lengths at 36 cm. The length distributions from three parts of this area are shown on Fig. 13 which also illustrate increasing size with increasing latitude.

The total weight/length relationship of blue whiting is plotted on Fig. 14.

DISCUSSION

During the survey the main feeding area of the "northern" blue whiting stock was covered. However, due to restrictions in vessel time allocated the area east and south of Jan Mayen was only poorely surveyed and the eastern Norwegian Sea was not surveyed north of 71°N.

As recorded during the three previous years, the main concentrations of blue whiting were found to the south in the area investigated, in Faroese - Icelandic waters and towards the Norwegian west coast.

The estimated biomass, 4.9 mill. tonnes of blue whiting, is 1.1 mill. tonnes higher than the comparable estimate in 1984 and 2.1 mill. tonnes higher than in 1983. The biomass and number of blue whiting by year-class estimated in the three last years, are given in the text-table below.

1983			1984			1985		
Age years	$t \cdot 10^{-6}$	$N \cdot 10^{-9}$	Age years	$t \cdot 10^{-6}$	$N \cdot 10^{-9}$	Age years	$t \cdot 10^{-6}$	$N \cdot 10^{-9}$
0	0.22	8.5	0	0.05	2.1	0	0.03	2.2
1	1.52	22.7	1	1.77	30.6	1	0.47	6.0
2+	1.09	5.3	2	1.56	14.6	2	2.40	24.0
			3+	0.41	1.9	3	1.58	12.5
						4+	0.46	2.4
Total	2.83	36.5		3.79	49.2		4.94	47.1

The two rich 1982 and 1983 year-classes make up the absolute bulk of the blue whiting biomass estimate (80%), and are at present the main objective of the commercial fishery in the Norwegian Sea.

Compared to these year-classes the recruitment in 1984 and 1985 appears to have been at a much lower level.

Compared to spawning stock estimates in spring the 1981 and older year-classes were underestimated during the summer surveys in 1983 and 1984. The reason for this was analysed by the workshop on the blue whiting surveys which met in Bergen in May 1985 where a number of sources of biases were identified (Anon. 1985). The present estimate of the 1981 year-class and older fish (0.5 mill. tonnes) appears also to be an underestimate compared to the estimate of (1.7 mill. tonnes) the same year-classes obtained by a Faroese research vessel at the spawning areas in the spring 1985 (Jákupsstovu and Thomsen, 1985).

During a bottom trawl survey to the Spitsbergen and Bear Island area in July - August 1985, large blue whiting (Fig. 13) was caught along the entire shelfedge from 73° to 78°N (Fig. 7) and at some trawl stations in significant numbers. This area was not covered by the acoustic survey. It seems thus that the larger blue whiting have a wider distribution than the smaller blue whiting and hence only a part of it has been surveyed.

In August 1982, the stock were measured to 4.6 mill. tonnes, and then an unexpected drop to 2.8 mill. tonnes in 1983. For the adult part only, the difference was about 3 mill. tonnes (Anon. 1983a). Though the remaining part of the adults are only partly recorded, the results of the August surveys in the Norwegian Sea give comparable values of the stock size. The rebuilding of the total stock are still mainly due to the two good year-classes of 1982 and 1983.

Considering the observations of blue whiting outside the area surveyed both in north and south, the estimate of 4.9 mill. tonnes is clearly an underestimate.

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APPENDIX I.

Blue whiting acoustic survey, Norwegian Sea, 1985.

Survey period	Vessel	Research Institute	Scientific staff
9.-20.8	"Kokshaysk"	Polar Research Institute of Marine Fisheries and Oceanography - PINRO - Murmansk USSR	Isaev N.A., Zubov B.J., Shapovalov B.J., Kapenizov B.L., Antropov N.V., Melnikov S.D., Ignatjev Ju. G.
29.7-18.8	"Eldjarn"	Havforskningsinstituttet Bergen, Norway	Anthonypillai V., Blindheim J., Dommasnes A., Eklund O., Folkestad E., Romslo, A.
15.8-5.9	"Michael Sars"	Havforskningsinstituttet Bergen, Norway	Kolbeinson S., Kvinge, B, Løvheim L., Monstad T. (coordinator), Nilsen J.H., Tangen Ø.
10.-18.8	"Walter Barth"	Institut für Hochseefischerei und Fischverarbeitung, Rostock, GDR	Schultz N., Ulrich G.
0.-27.8	"Arni Fridriksson"	Hafrannsoknastofnunir, Reykjavik, Iceland	Sveinbjørnsson, S. Vilhjalmsson, H., Helgason, V. Malmberg, S.Å.
10.8-5.9	"Bjarni Sæmundsson"	- " -	Halldórsson O., Reynisson, P., Magnusson J.V. Olafsson, J.
27.7-14.8	"Magnus Heinason"	Fiskirannsoknarstovan Torshavn, Faroe Islands	Jákupsstovu S.H. í, Mouritson, R., Thomsen, B., Thomsen, J.K.

Table 1. Biomass (tonnes x 10^{-3}), abundance (N x 10^{-6}), size of distribution area (square nautical mile) and density [tonnes/(n.mile)^2 and N x 10^{-3}/(n.mile)^2] of blue whiting by year-classes and areas in the Norwegian Sea, August 1985.

Area / Year class	VII		I		II		III		IV		V		VI		Total	
	Biom.	N	Biom.	N	Biom.	N	Biom.	N	Biom.	N	Biom.	N	Biom.	N	Biom.	N
1985	-	-	-	-	12.4	1088	13.1	1104	1.3	54	-	-	-	-	26.8	2246
1984	2.5	34	56.5	946	122.6	1482	184.9	2368	80.2	896	18.8	218	5.1	59	470.6	6003
1983	19.2	195	148.9	1628	743.8	7323	1039.1	10453	302.7	3020	91.1	811	60.1	520	2404.9	23950
1982	11.6	99	175.2	1364	460.7	3723	651.6	5230	60.4	514	115.1	839	108.8	756	1583.4	12525
1981+	1.8	13	92.6	472	129.5	714	127.8	698	0.6	4	77.8	382	32.3	160	462.4	2443
Sum	35.1	341	473.2	4410	1469.0	14330	2016.5	19853	445.2	4488	302.8	2250	206.3	1495	4948.1	47167
Area size	5600		34696		109653		83524		7550		54415		28915		324353	
Density	6.3	61	13.6	127	13.4	131	24.1	238	59.0	594	5.6	41	7.1	52	15.3	145

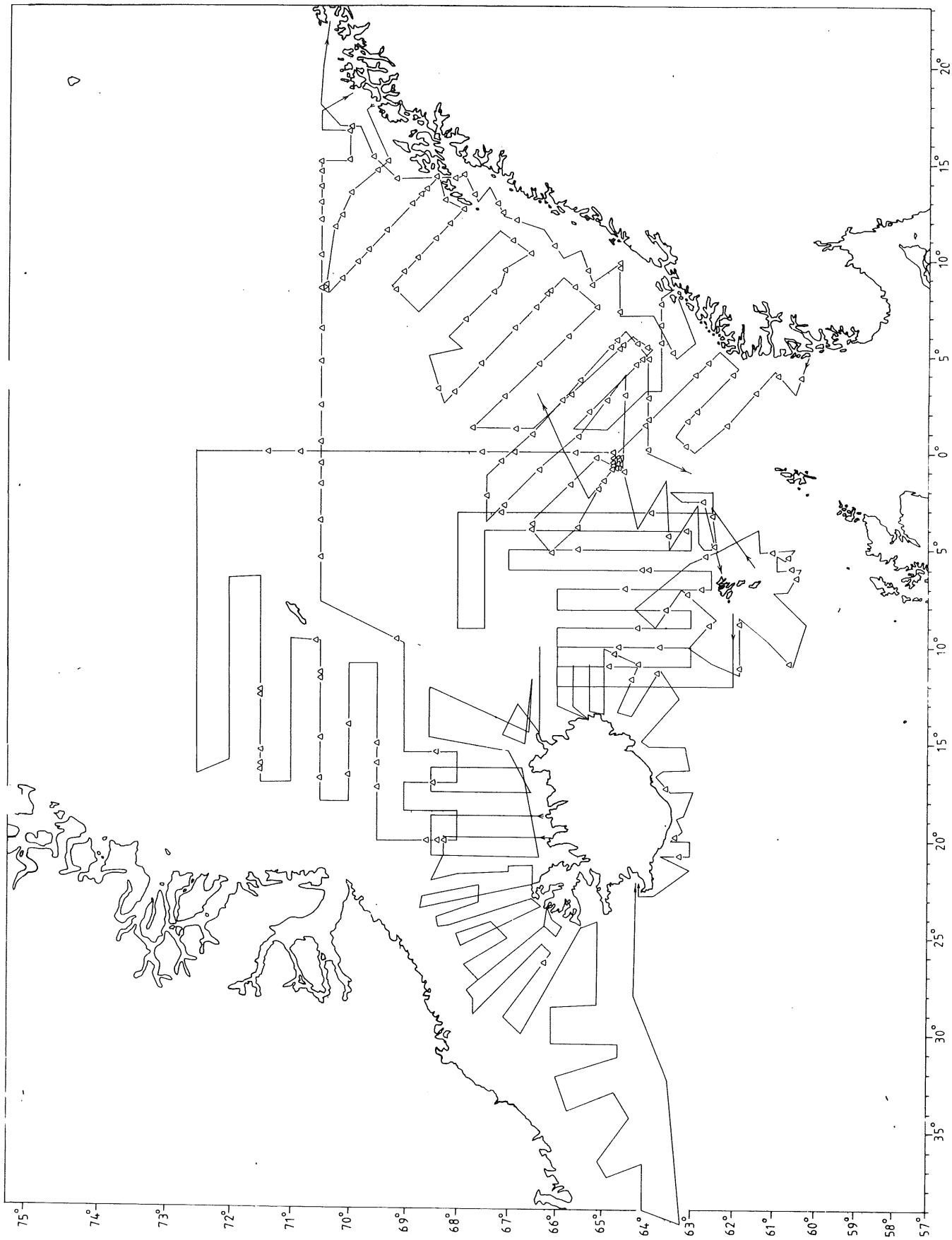

Fig. 1. Cruise tracks and trawl stations of the seven research vessels, August (27 July - 5 September) 1985.
Triangel: Pelagic trawl station.

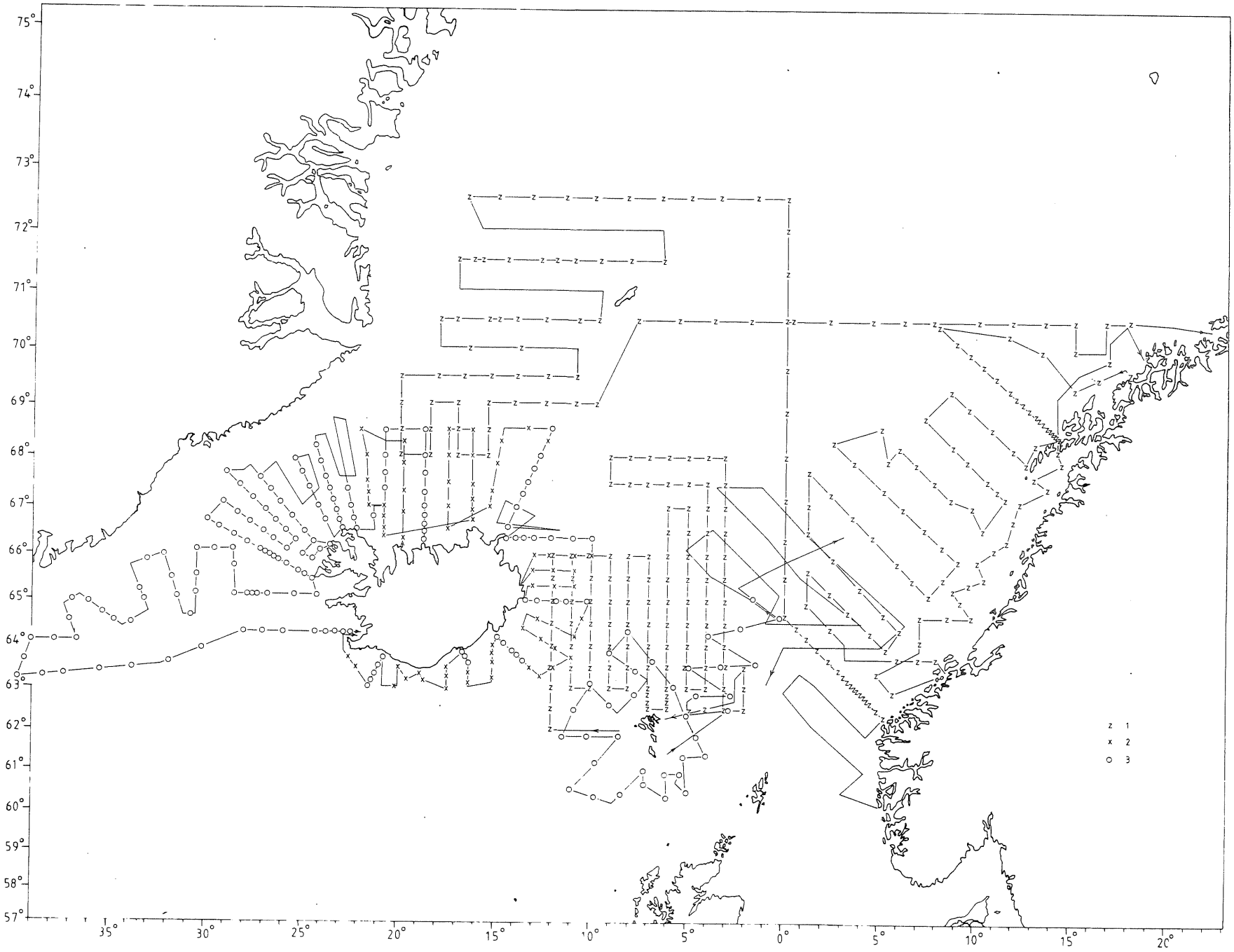

Fig. 2. Cruise tracks and hydrographical stations, August 1985. 1) CTD-sonde, 2) Bathythermograph (XBT), 3) Nansen water-bottles with reversing thermometer.

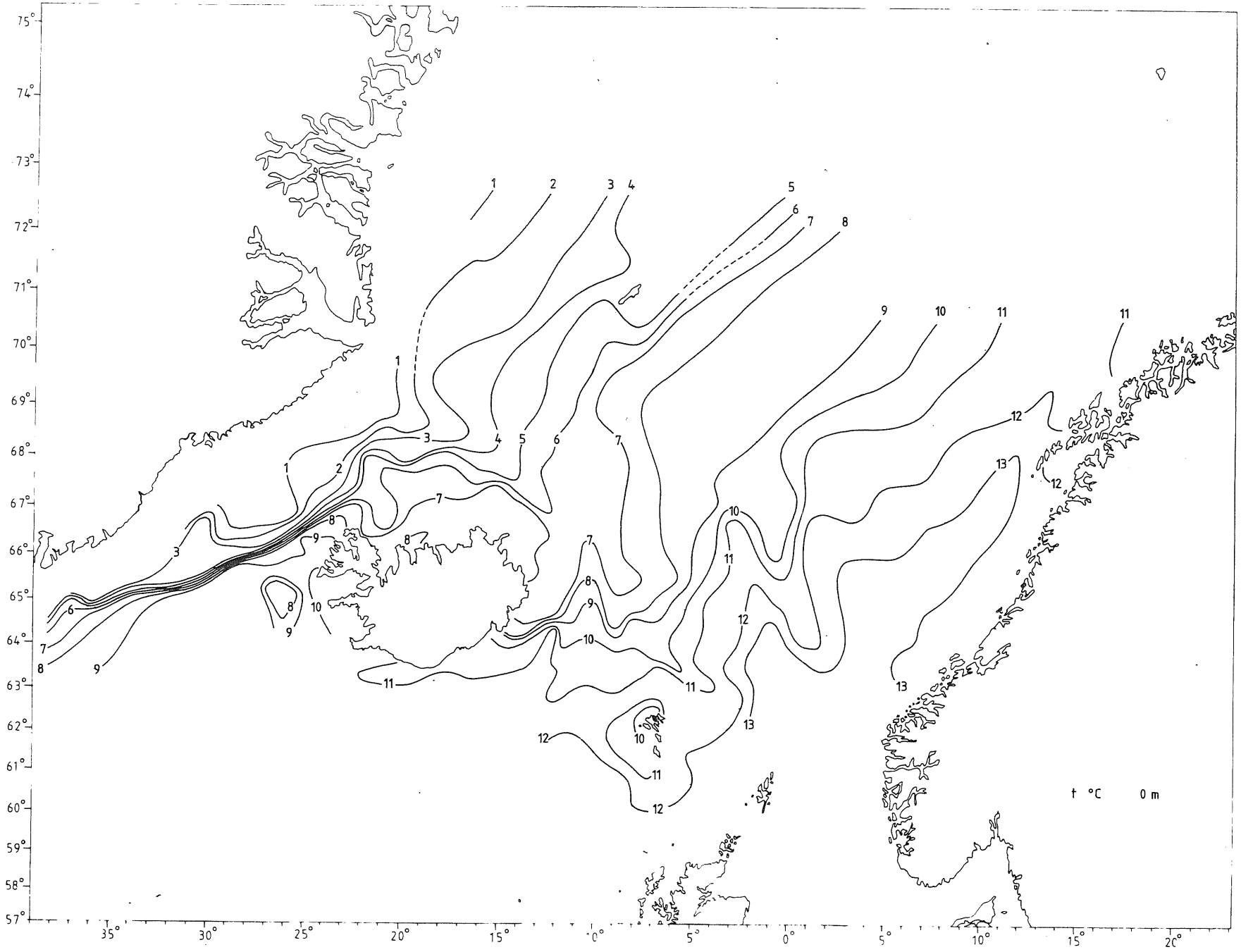

Fig. 3. Temperature (t°C) at sea surface, August 1985.

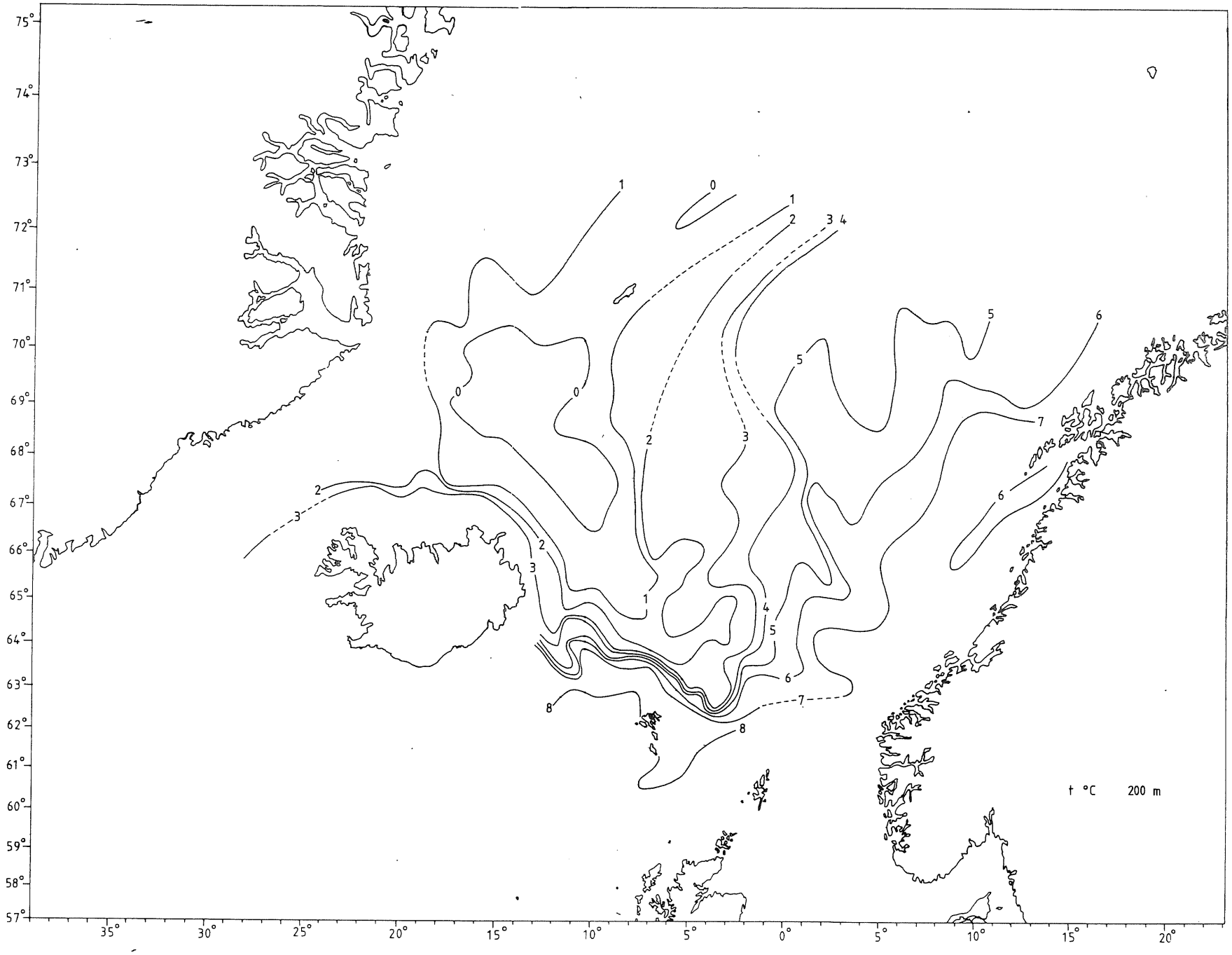

Fig. 4. Temperature (t°C) at 200 m depth, August 1985.

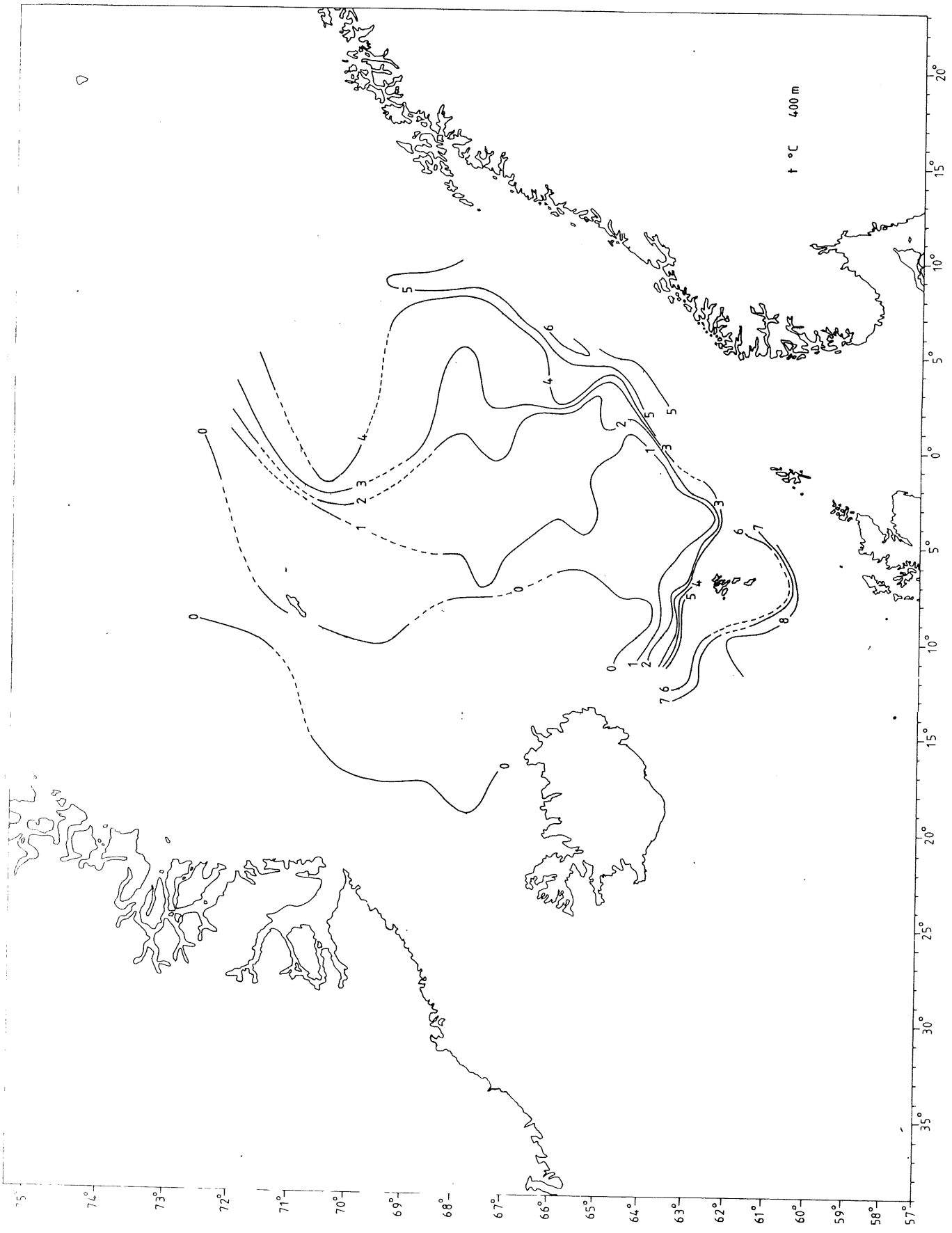

Fig. 5. Temperature (t°C) at 400 m depth, August 1985.

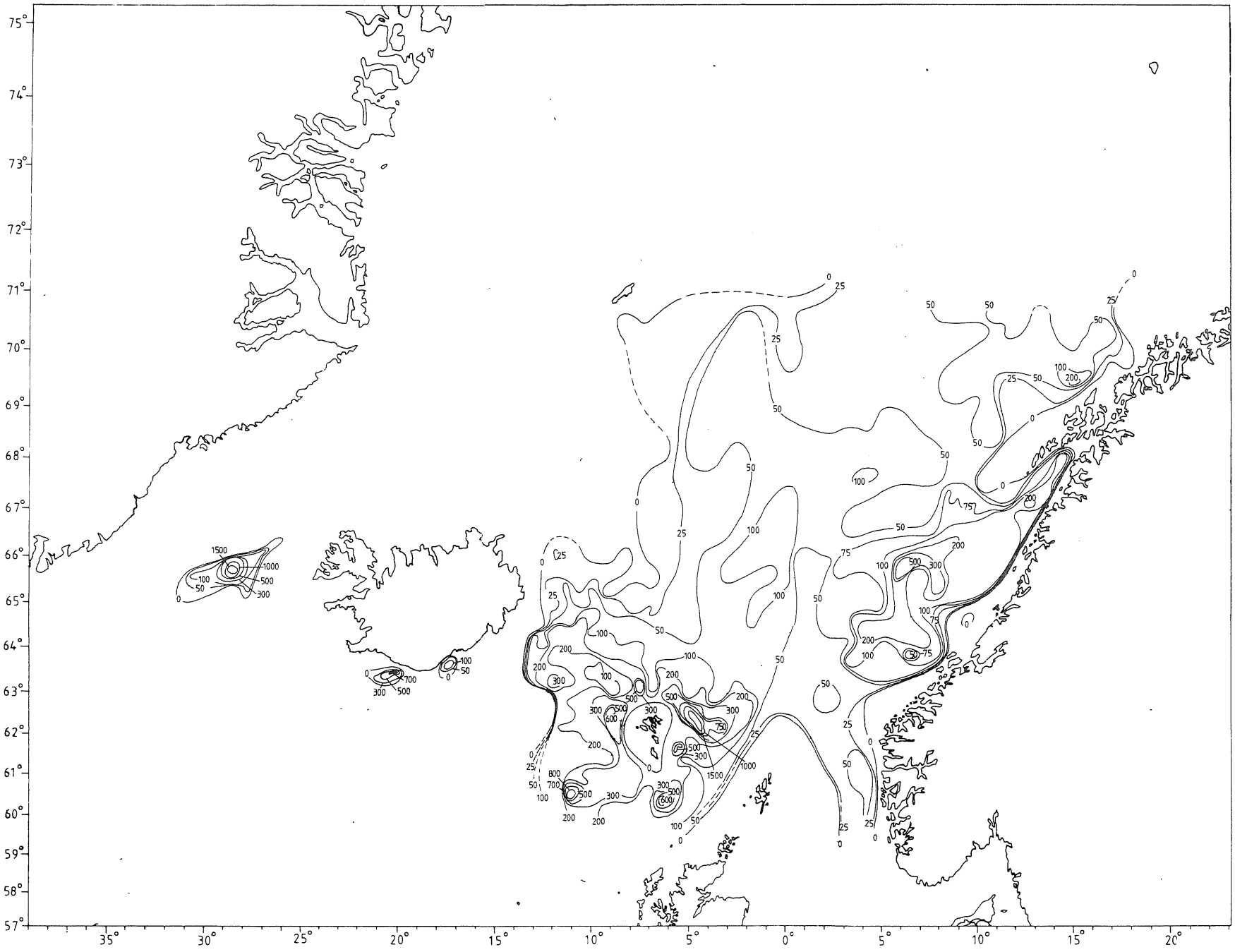

Fig. 6. Distribution and relative abundance of blue whiting, August 1985. Echo intensity in $m^2/(n.mile)^2 \cdot 4\pi$.

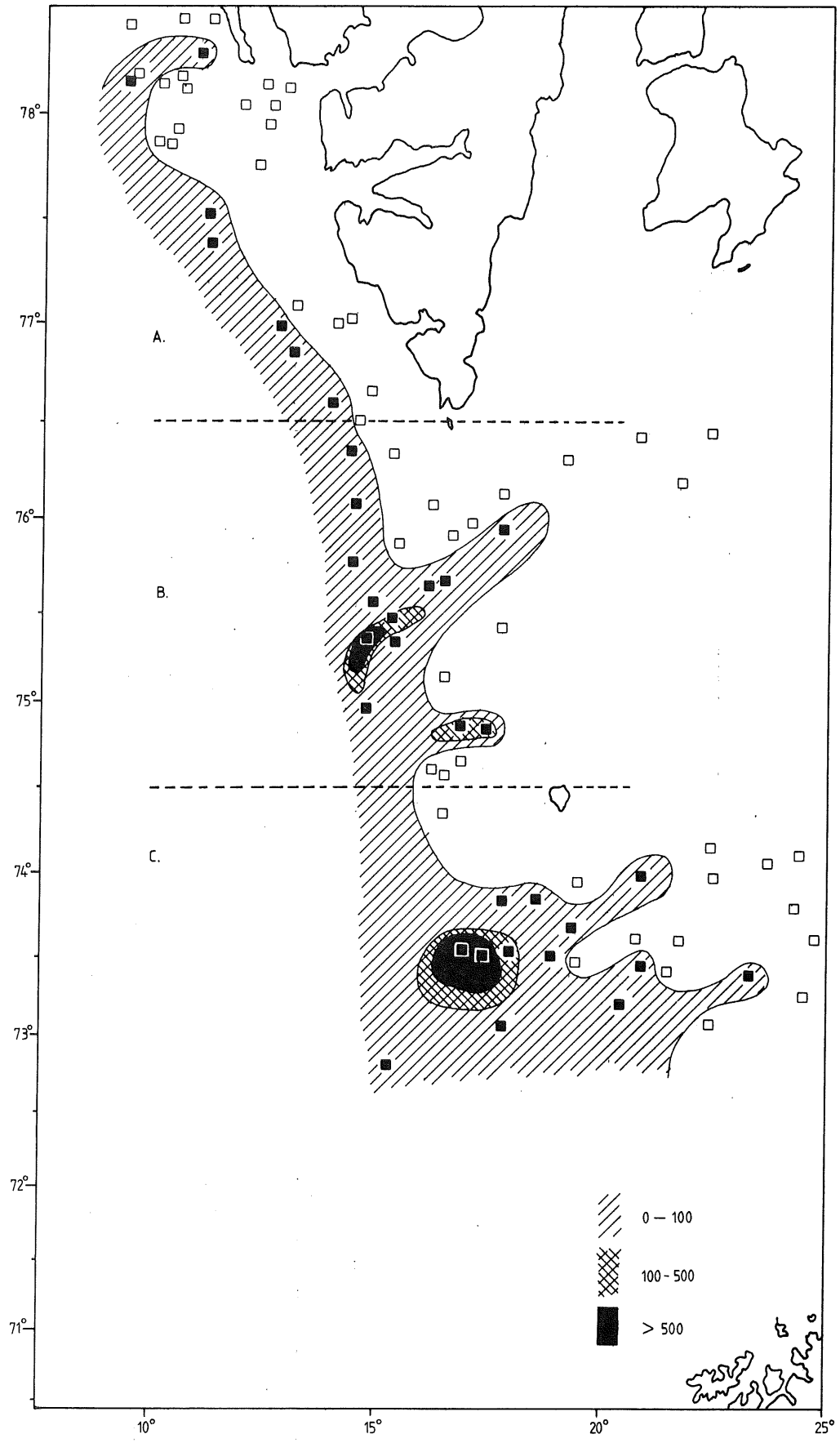

Fig. 7. Observations of blue whiting (filled symbols) as by-catch in bottom trawl catches, "Michael Sars" 15 July - 15 August 1985. Hatched, doubled hatched and black areas show areas with different numbers of specimens caught per hour of trawling. (From Øynes, P. unpublished).

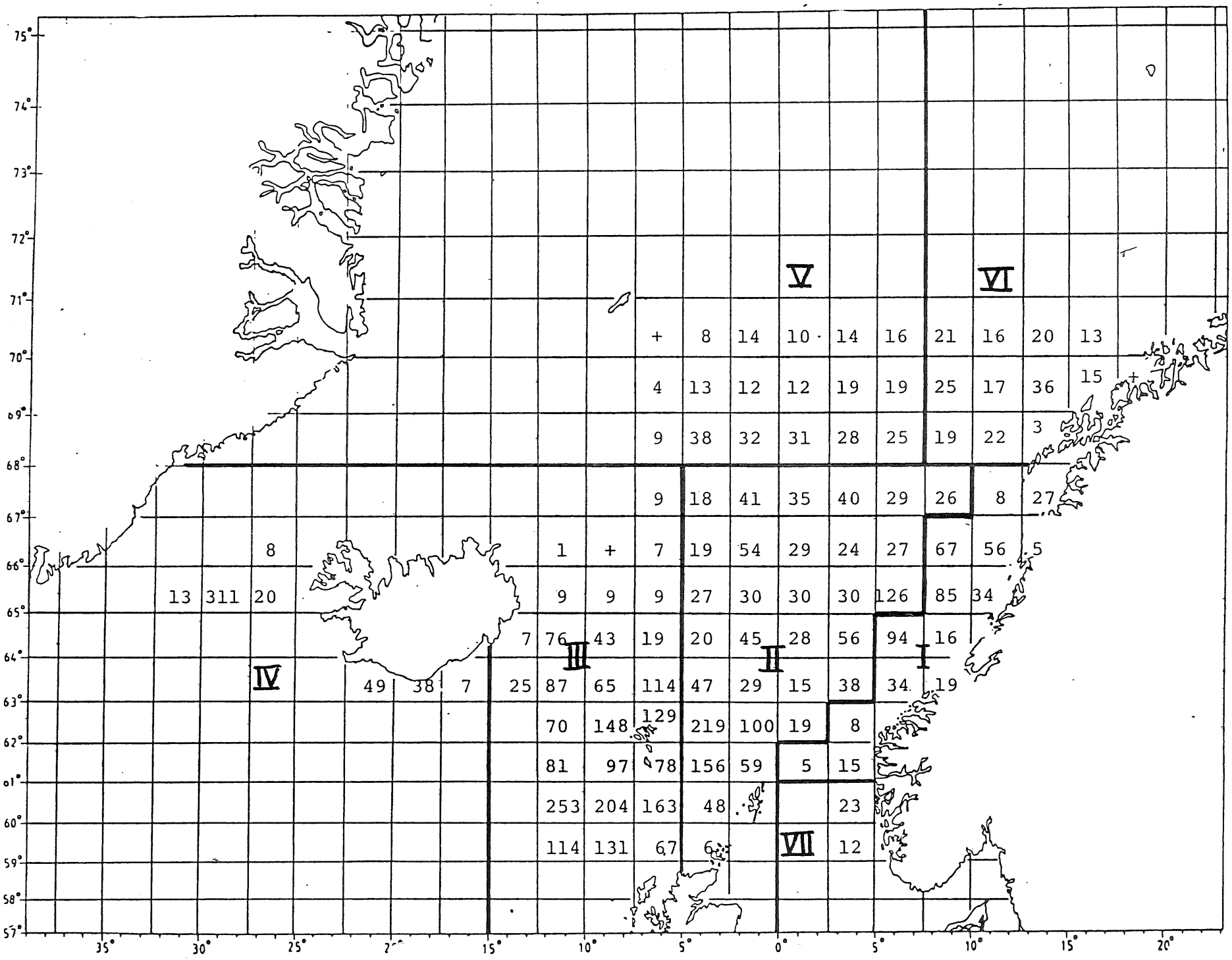

Fig. 8. Biomass of blue whiting (in 1000 tonnes), August 1985. Markings of sub-areas I-VII.

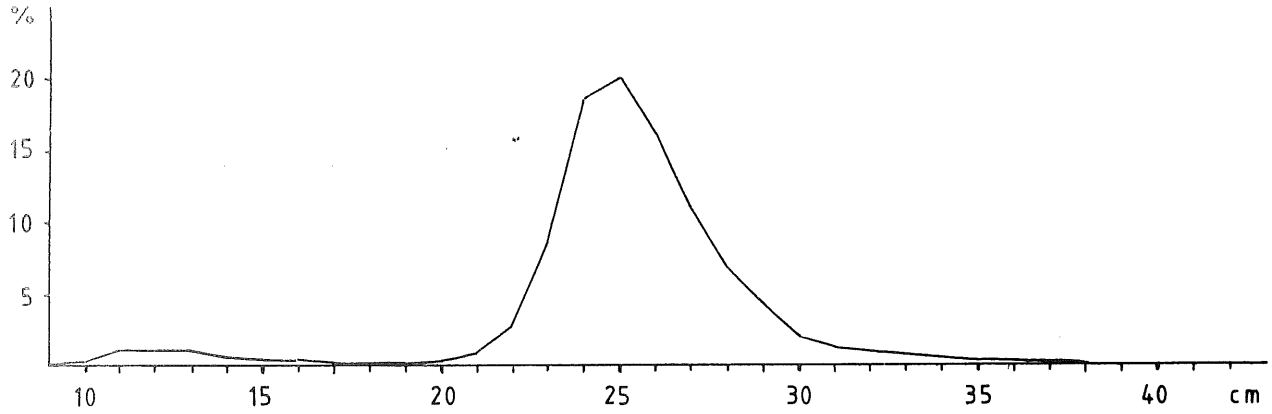

Fig. 9. Total length distribution of blue whiting weighted by abundance, Norwegian Sea, August 1985. N: $47.2 \cdot 10^9$ specimens.

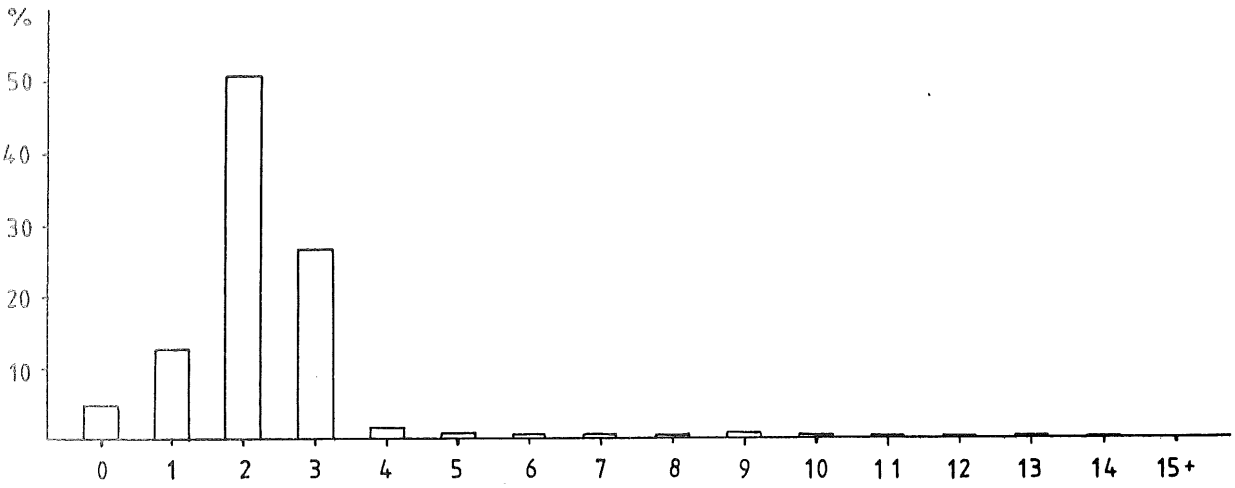

Fig. 10. Total age composition of blue whiting, Norwegian Sea, August 1985. N: $47.2 \cdot 10^9$ specimens.

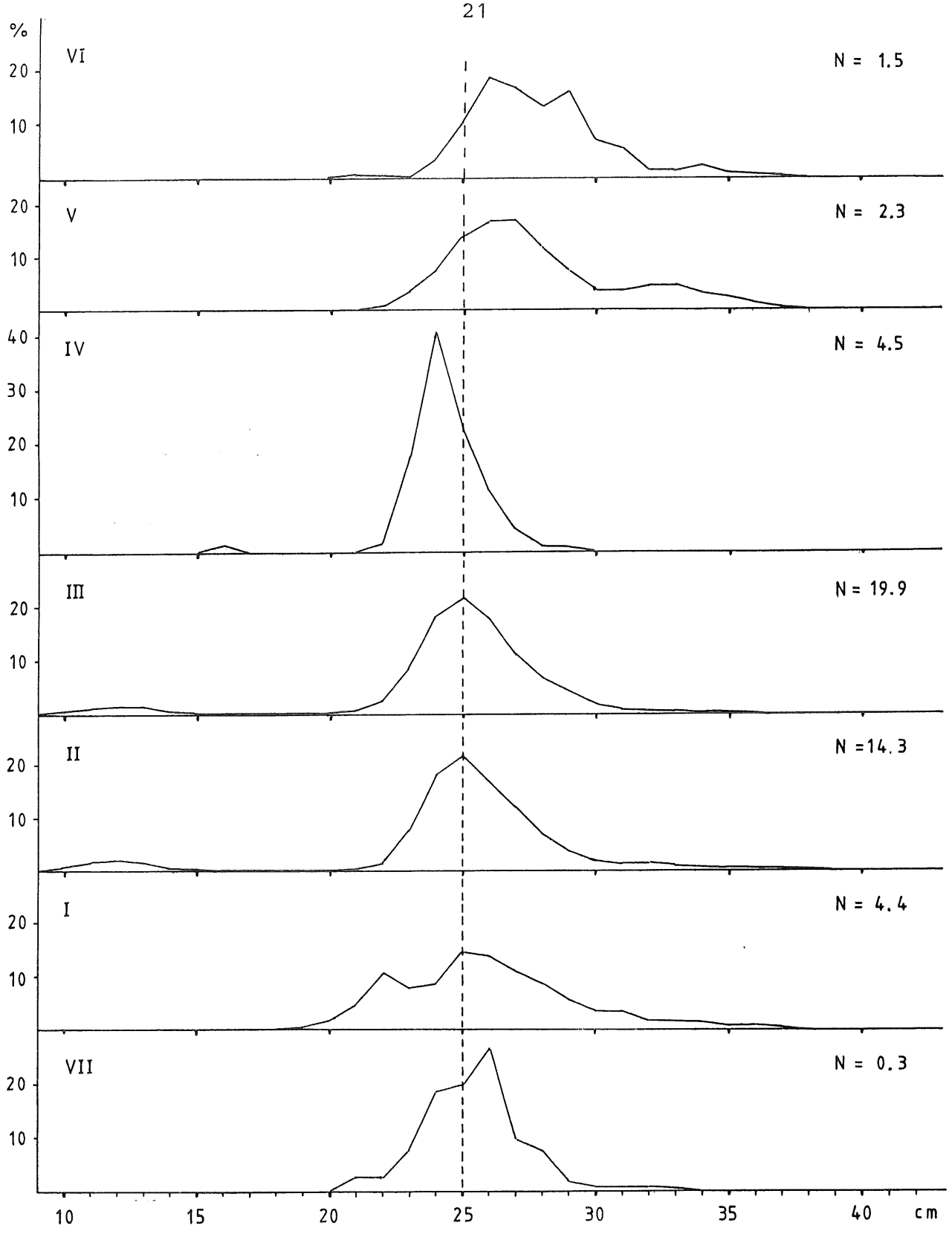

Fig. 11. Length distribution of blue whiting weighted by abundance in sub-areas I-VII (see Fig. 8). N in 10^9 specimens.

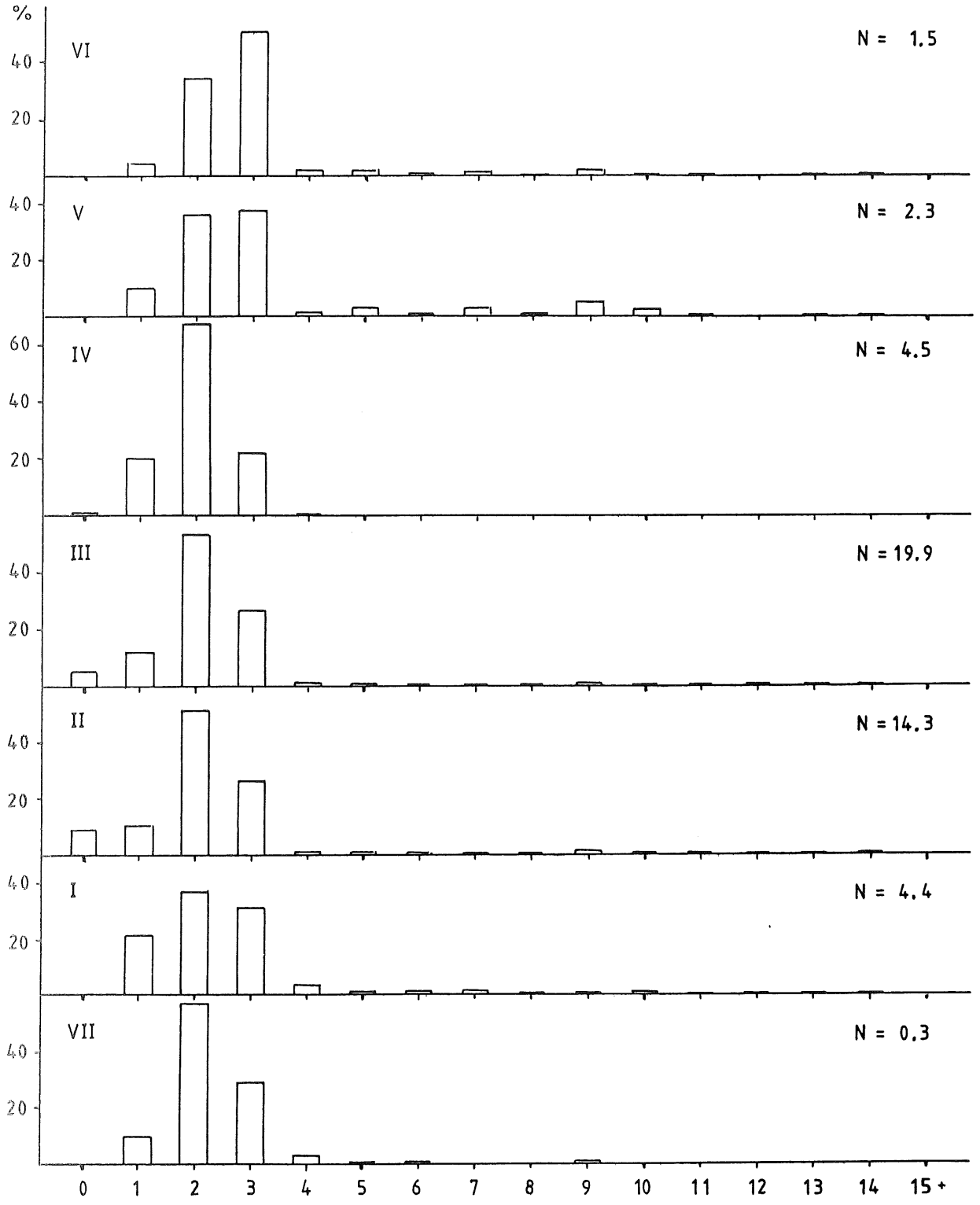

Fig. 12. Age compositions of blue whiting in sub-areas I-VII (see Fig. 8). N in 10^9 specimens.

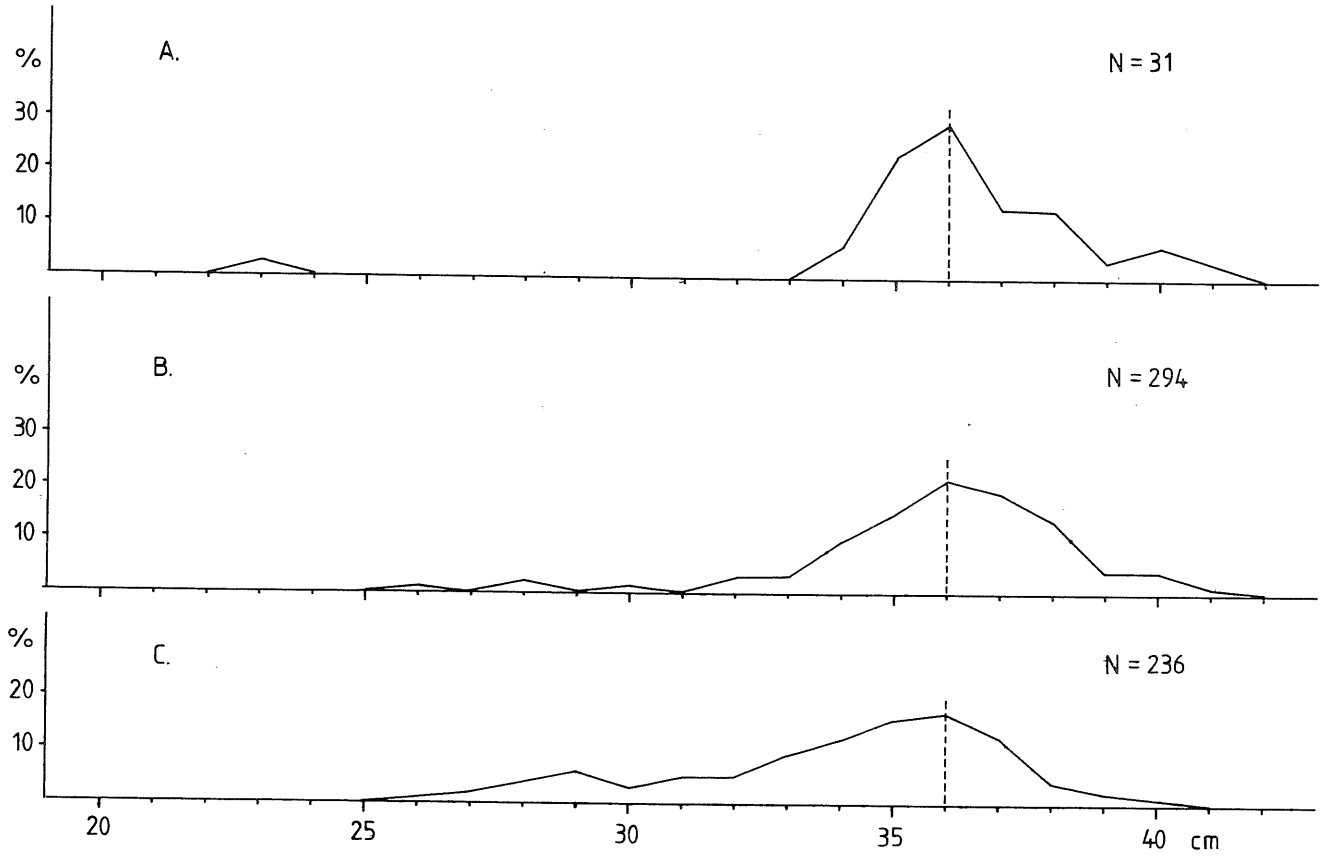

Fig. 13. Length distribution of blue whiting caught as by-catch in bottom trawl in three different areas (A-C) at Bear Island - Spitsbergen, July/August 1985. (See Fig. 7). (From Øynes, P. unpublished).

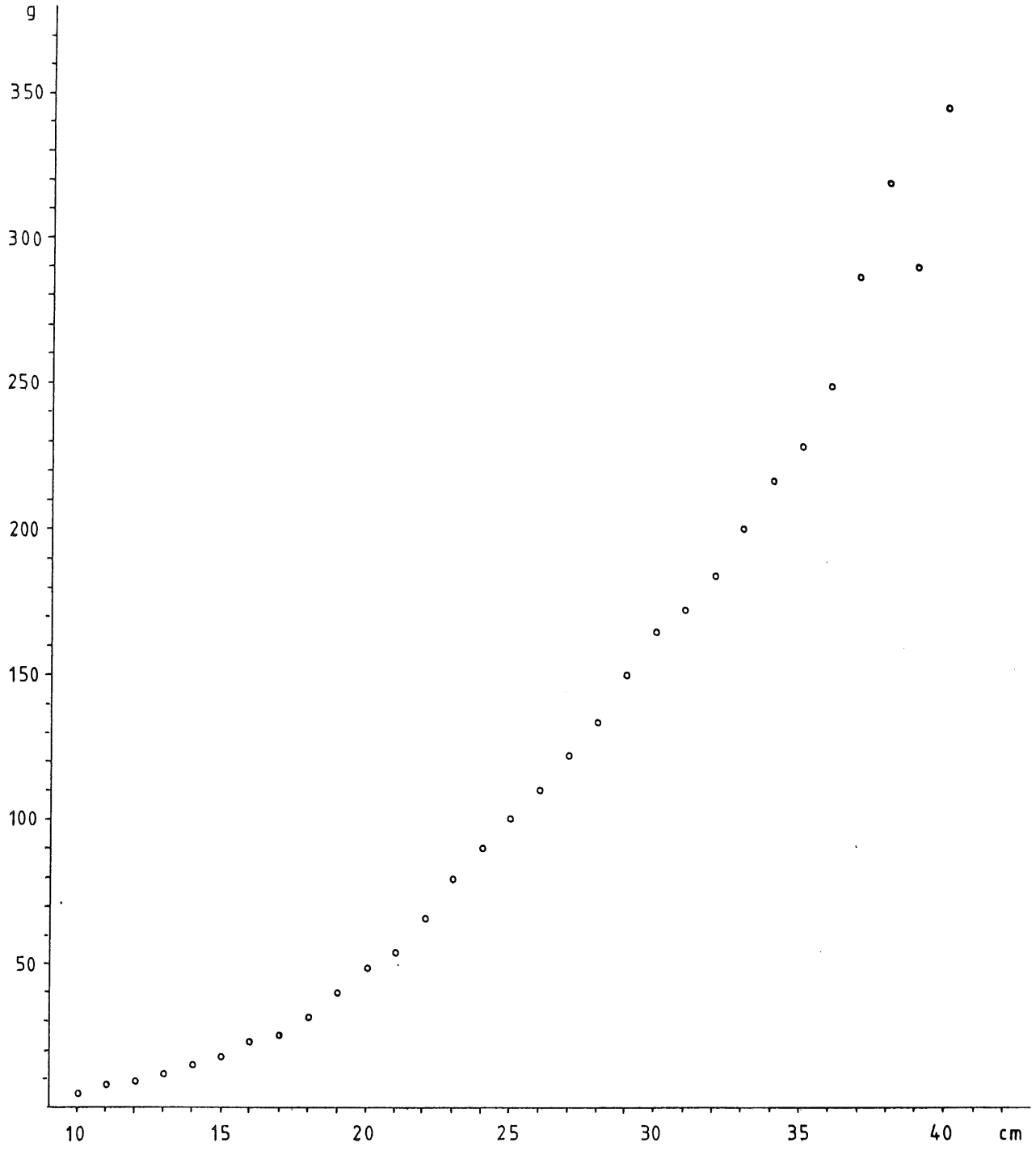

Fig. 14. Total length/weight relationship of blue whiting in the Norwegian Sea, August 1985.