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International Council for the Exploration of the Sea

C.M 1982/H:5

Pelagic Fish Committee

REPORT OF THE INTERNATIONAL ACOUSTIC SURVEY ON BLUE WHITING IN THE NORWEGIAN SEA, July/August 1982.

ABSTRACT

During August 1982 a coordinated acoustic survey on blue whiting was made in the Norwegian Sea. A total of 8 vessels from 5 countries participated, i.e. U.S.S.R., Norway, Faroe Islands, Iceland and German Democratic Republic. All vessels, but one had integrator.

Prior to the survey the acoustic instruments were calibrated against a standard target (60 mm copper-sphere), which enabled the measured echo intensities to be converted into comparable units.

Blue whiting was found distributed over larger parts of the Norwegian Sea, on the warmer side of the polar front. Highest concentrations were recorded in the southern part, especially between Faroes and Iceland.

The acoustic estimate, based upon a fish length-dependent density coefficient, gave the result of 4.6 mill. tonnes of blue whiting within the are covered. This is considered to represent the majority of the total stock in the northern area.

INTRODUCTION

During its feeding season in the summer half of the year, blue whiting, Micromesistius potassou, is distributed over a large part of the Norwegian Sea, on the warmer side of the polar-front. In winter and early spring the main part of the mature

stock migrates southwards to the area west of the British Isles where it spawns along the continental shelf in March/April. During this period the major spawning stock is congregated over an area small enough to be surveyed by one or two vessels within a reasonable short period of time.

Acoustic surveys have been conducted yearly since 1972 in order to assess size of the spawning stock. The results of these surveys have been the main data base for the Blue Whiting Assessment Working Group (Anon 1980, 1981). Though the major part of the spawning stock has been considered measured, still the abundance of the total stock was unknown.

The blue whiting is during the spawning season migrating rapidly. And for the success of an acoustic abundance survey at this time the timing of the survey is crucial.

In 1980 three Norwegian vessels covered the greater part of the Norwegian Sea in August/September to survey the blue whiting stock. The distribution and relative densities as observed during the survey was presented to the WG in 1981. Due to difficulties with the acoustic instruments an estimate of the total biomass was not obtained.

The Working Group, however, felt that the results from the survey showed that acoustic assessment of the stock feeding in the Norwegian Sea was quite feasible. And that despite the large area which has to be surveyed, this approach for a number of reasons, has many advantages compared to assessing the spawning stock. The Working Group consequently recommended that an international acoustic survey coordinated by ICES took place in the Norwegian Sea in August 1982. The terms of reference were set by ICES' resolution passed at its 69th Statutory Meeting, and a planning group established to coordinate the surveys (C. Res. 1981/2: 23).

The planning group met in Copenhagen 3-5 May 1982 and presented the survey plans in reports form to the council (Anon 1982).

The first coordinated international acoustic survey on blue whiting in the Norwegian Sea, was then made during the period 29 July - 31 August 1982.

MATERIAL AND METHODS

The following research vessels participated in the survey:

State	Vessel	Time	Institute
U.S.S.R.	"Perseus III"	3 - 23 Aug	P.I.N.R.O., Murmansk
Norway	"Michael Sars"	3 - 19 Aug	Havforskningsinstituttet, Bergen
Norway	"Johan Hjort"	3 - 20 Aug	——— " ———
Norway	"G.O. Sars"	10 - 20 Aug	——— " ———
Faroe Island	"Magnus Heinason"	5 - 17 Aug	Fiskirannsoknarstovan, Torshavn
Iceland	"Arni Fridriksson"	5 - 31 Aug	Hafrannsoknastofnunin, Reykjavik
Iceland	"Bjarne Sæmundsson"	5 - 31 Aug	——— " ———
German Dem. Republic	"Eisbaer"	29 Jul - 22 Aug	Institut für Hochseefisherie und Fishverarbeitung, Rostock

Name of scientists and technicians who took part on the different vessels are given in Appendix I.

Fig. 1 shows the area covered by the vessels, with cruise tracks and trawlstations.

All vessels except Eisbaer were equipped with echo integrator. These vessels followed in general the tracklines appointed to them on the planning group meeting and the procedure outlined in Anon (1982). "Eisbaer" followed an open trackline southwards from Bear Island to the Faroes, supplying information on relative densities of blue whiting, and biological data from trawl catches.

The echo readings were identified and the biological samples were collected by trawling, mostly by use of pelagic trawl, but in a few cases also by bottom trawl. The pelagic trawls used by the different countries varied in size. While Norway and Iceland used a rather small trawl with vertical opening of 20 and 25 m, U.S.S.R., Faroes and German Democratic Republic used a trawl with approximately 40 m vertical opening.

Echo intensities were integrated and recorded as average per nautical mile for each 5 nautical mile sailed. The values were apportioned on species by the composition of the trawlcatches and analysis of the recordings. A number of hydrographical station were worked during the surveys (Fig. 2).

There was a daily radio-communication between the vessels, exchanging reports with informations on recordings, trawl catches and temperature-observations during the last 24 hours. These data from all the vessels were put together on common working maps. After the survey, "Eisbaer" and "Perseus III" met in Bergen, and further discussion of preparing the results was made. The final data from the other vessels were mailed to Bergen as soon as possible.

Prior to the surveys each vessel calibrated the acoustic instruments against standard target copperspheres (60 mm) (Foote 1981). Based on the calibrations the integrator data from each vessel were standardized and expressed as number of square meters reflected per square nautical mile.

For the estimation of total biomass the area surveyed were divided into subareas, each covering 1^{o} latitude and $2^{o}30'$ longitude, and for each of these the average echo integrator value calculated. Conversion of the echo integrator values to biomass was achieved by length dependent C-value. The method for this conversion is described in Appendix II. The C-value is the same as used for cod in the Barents Sea, and has been used for blue whiting on Norwegian surveys since 1979. The abundance of blue whiting were calculated for each rectangle using mean length and mean weights established for that rectangle.

RESULTS

Hydrography

The temperature distribution at 0, 200 and 400 m is presented in Figs 3, 4 and 5. In the area south and southwest of Jan Mayen and in the frontal zone east of Iceland the isolines represented compromises according to the data. This is due to the non-synoptic character of the data from different vessels and indicates considerable short-time fluctuations in the distribution of the watermasses.

The distribution of temperature and salinity in a section Halten - Jan Mayen is shown in Fig. 6.

Blue Whiting

The distribution and relative abundance of blue whiting are shown in Fig. 7, expressed as m^2 reflection pr. square nautical mile. Blue whiting were found over the major part of the Norwegian Sea between Iceland and Norway from Shetland/Faroes to the Bear Island area.

It was mostly observed as scattered and very scattered recordings, with an area without any blue whiting midways from Lofoten Island to Jan Mayen.

Highest concentrations were located in the southern part of the investigated area, as a "belt" between the western point of the Norwegian Coast and the polar front area off the Icelandic east coast. Best observations were in the western part, where also the most frequent surveying were worked.

The blue whiting biomass was estimated to be 4.6 mill tonnes, representing a total of 24.7×10^9 specimens within the area covered. This is shown in Fig. 8 with the biomass (thousand tonnes) in each of the different rectangles.

The length distribution (Fig. 9) of blue whiting in the samples are grouped on an area bases (Fig. 10). This shows that the major area surveyed mainly mature fish were found. Immature blue whiting were found only along the Norwegian Coast (area I) and off the south-eastern Icelandic coast (area IV)

DISCUSSION

The survey is considered to have covered the main area distributed by blue whiting in the Norwegian Sea. In west, the border of distribution followed the location of the polar front from Iceland to Jan Mayen and further in a north-eastern direction. In north blue whiting was recorded up to $75^{o}45'N$, but integration of the echo intensity was available to latitude $74^{o}N$ only. The northern border therefore is not shown in the distribution map (Fig. 7) knowing that blue whiting is scattered also within a smaller area up to northwest of Bear Island.

In the south-eastern part of the area surveyed, distribution of blue whiting also extended outside the area integrated. For example, blue whiting was recorded in the North Sea along the Norwegian trench and in Skagerak.

In August/September 1981 two Norwegian vessels surveyed the Norwegian Sea covering approximately the same area as in 1982 (Monstad og Blindheim, 1982). The integrated values of blue whiting represented a biomass of 4.9 mill. tonnes, i.e. of the same order as in 1982.

Also in 1981, observations of blue whiting were made as scattered recordings over a large area of the Norwegian Sea, with denser concentrations between the Faroes and Iceland. But in addition, denser concentrations were also found more to the north-east, midway between the Norwegian Coast and Jan Mayen.

In August 1980 (Anon 1981) the best concentrations were found even more north, i.e. east and north-east of Jan Mayen. Though the biomass of blue whiting in the Norwegian Sea was not

estimated for 1980, the recordings were better and the relative densities higher than for 1981 and 1982.

Comparing the distribution of blue whiting in the Norwegian Sea during August for the years 1980-1982, there has been a southward shift of concentrations from year to year, with the impression of lesser abundance in the last two years than in 1980.

Though the complete stock of blue whiting in the "northern area", i.e. north of Ireland, is not surveyed during the investigations, the major part is considered to be covered. Therefore the estimated 4.6 mill. tonnes in 1982 should indicate the level of total stock biomass.

REFERENCES

ANON. 1980. Report of the Blue Whiting Assessment Working Group. ICES, C.M. 1980/H:5.

ANON. 1981. Blue Whiting Assessment Working Group Report. ICES, C.M. 1981/H:12; 1-47.

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FOOTE, K.G. 1981. Echo sounder measurements of backscattering cross sections of elastic spheres. Fisken og Havet, Ser. B, 1981(6): 1-107.

Monstad, T. and Blindheim, J. 1982. Kolmule- og 0-gruppeundersøkelser i Norskehavet sommeren 1981, "G.O. Sars" og "Michael Sars" (Blue whiting and 0-group investigations in the Norwegian Sea in summer 1981, "G.O. Sars" and "Michael Sars"). Fiskeridirektoratets Havforskningsinstitutt, Bergen, 3.3-82: 1-6 p, 15 Figs (Mimeo.).

Appendix I

Survey period	Research vessel	Research Institute	Participants
3 - 23 Aug	"Perseus III"	Polar Research Institute of Marine Fisheries and Oceanography - P.I.N.R.O., Murmansk	N.G. Ushakov, V.N. Shleinik, A.V. Rodin, V.K. Ozhygin, V.M. Kapralov, V.S. Mamylov, V.I. Zubov, A.D. Voloshin.
3 - 19 Aug	"Michael Sars"	Havforskningsinstituttet, Bergen	T. Monstad, G. Sangolt, A. Raknes, B. Kvinge, L. Løvheim, O. Alvheim, H. Abrahamsen.
3 - 20 Aug	"Johan Hjort"	Havforskningsinstituttet, Bergen	J. Blindheim, I. Hoff, S. Andreassen, S. Lygren, K. Gjertsen, J. Klæt, P. Bratland, V.Z. Aung.
10 - 20 Aug	"G.O. Sars"	Havforskningsinstituttet, Bergen	J. Hamre, E. Sælen, K. Hansen, L. Midttun, S. Tjelmeland, K. Hestenes, J.E. Nygård, A. Roald.
5 - 17 Aug	"Magnus Heinason"	Fiskirannsoknarstovan, Torshavn	H. i Jakupstovu, B. Hansen, B. Thomsen.
5 - 31 Aug	"Arni Fridriksson"	Hafrannsoknastofnunin, Reykjavik	S. Sveinbjørnsson, B. Steinarsson.
5 - 31 Aug	"Bjarne Sæmundsson"	Hafrannsoknastofnunin, Reykjavik	H. Wihljamsson, P. Reynesson, S.Aa. Malmberg, O. Asthorsson.
29 Jul - 22 Aug	"Eisbaer"	Institut für Hochseefisherei und Fishverarbeitung, Rostock.	N. Schultz, N. Verch, K. Fadschild, M. Klinkhardt.

O. Nakken, Havforskningsinstituttet, Bergen, participated in preparation of the acoustic data.

APPENDIX II

Computations of fish densities, ρ, from observed echointegration values, M, during the blue whiting survey in August 1982.

The equation

$$\bar{\rho}_A = \frac{1}{\bar{\sigma}_{b.s.}} \cdot \overline{C_I \cdot M} \qquad (I)$$

was used to calculate fish densities.

ρ_A : number of fish per (nautical mile)^2

$\bar{\sigma}_{b.s.}$: the mean backscattering cross section of the fish [$\overline{TS} = 10 \log \bar{\sigma}_{b.s.}$]

C_I : an instrumentation constant determined by calibration of the integration system.

M : echointegration values (usually in mm per nautical mile).

The computations were performed in two steps:

Firstly, the instrumentation constant C_I was calculated for each vessel on the basis of calibration data, and values of $C_I \cdot M$ were calculated.

Secondly, a back scattering cross section, $\sigma_{b.s.}$, similar to the one used in the Norwegian cod surveys, was used to convert the "column scattering strengths" into fish densities. Mean values of $C_I \cdot M$ and $\sigma_{b.s.}$ were calculated for statistical squares of 1^o latitude and $2^o30'$ longitude before computation of ρ_A (Equation I).

1. Computation of C_I.

The formula $$C_I = \frac{\sigma_{S.T.}}{M_{S.T} \cdot D^2_{S.T} \cdot \psi} \cdot 3.43 \cdot 10^6 \left[m^2/(nm)^2 \right]$$

Here $\sigma_{S.t}$ is the back scattering cross section of the standard target in m^2.

$M_{S.T}$ is the integration value of the standard target measured in the same units as during the survey (usually mm per nautical mil).

$D_{S.T}$ is the depth of the standard target during the calibration (in m).

ψ is the solid angle of the equivalent beam width of the transducer (measured in steradians).

All vessel had calibrated the instruments using a copper sphere of 60 mm in diameter as a standard target (CU 60). The target strength of the sphere is -33.6 dB and the corresponding back scattering cross section is $0.436 \cdot 10^{-3}$ m^2 [From the relation TS = 10 log $\sigma_{b.s.}$].

The following table gives the details of the calibration and the computed values of C_I for instrument settings used during the survey. G is the difference in gain (dB) applied during the calibration and during the survey.

Vessel	(SL+VR)	$M_{S.T.}$	G	$D_{S.T}$	ψ	C_I
G.O. Sars	114.6	800	10	19.6	$0.398 \cdot 10^{-2}$	0.122
M. Sars	124.4	2349	0	30	$1.10 \cdot 10^{-2}$	0.064
J. Hjort*	121.0	[$7.67 \cdot 10^5$]	0	[1]	$1.10 \cdot 10^{-2}$	0.175
Persey III**	133.3	[$8.5 \cdot 10^5$]	?	[1]	$1.10 \cdot 10^{-2}$	0.175
A. Fridriksson	115.5	[$2.74 \cdot 10^5$]	0	[1]	$0.855 \cdot 10^{-2}$	0.64
M. Heinason	139.5	39.5	20	18	$1.10 \cdot 10^{-2}$	0.106
B. Sæmundsson	127.0	[$6.55 \cdot 10^6$]	0	[1]	$0.398 \cdot 10^{-2}$	0.057

* For Johan Hjort, $M_{S.T.}$ was not measured during the calibration in July 1982. The value of (SL+VR)=121.0 was 1.2 dB less than during the previous calibration when $M_{S.T}$ was 545 mm referred to 1 m range and 1 m sailed distance. Thus $M_{S.T} = 545 \cdot 1852 \cdot 10^{-0.12} = 7.67 \cdot 10^5$.

** For Persey III the gain factor(s) during calibration and survey were not available. According to information received C_I equals $2.2 \cdot 10^4$ when using the relation

$TS = 10 \log \frac{\sigma}{4\pi}$ with σ in cm^2. Recalculation of C_I, using $\overline{TS} = 10 \log \overline{\sigma}_{b.s.}$ with $\sigma_{b.s.}$ in m^2 gives the figure above.

2. Computation of the mean back scattering cross section, $\overline{\sigma}_{b.s.}$, to be used in equation (I).

In previous years the densities of blue whiting (number per $(nm)^2$) have been calculated from the formula,

$$\rho_A = 5.25 \cdot 10^6 \cdot l^{-2.18} \cdot M \quad (l \text{ is fish length in cm})$$

where M is the integration value for the system previously used onboard the "G.O. Sars". The scaling factor or C-value, $5.25 \cdot 10^6 \cdot l^{-2.18}$, is the one used for young cod. This C-value corresponded to a target strength of -40.5 dB for a 30 cm fish.

The value of $\overline{\sigma}_{b.s.}$ used in the present computations is:

30 cm fish: $\overline{\sigma}_{b.s.} = 10^{0.1\overline{TS}} = 10^{-4.05} = 0.89 \cdot 10^{-4}$

or $\overline{\sigma}_{b.s.} = 0.536 \cdot 10^{-7} \cdot l^{2.18}$

and the quantity $\frac{1}{\overline{\sigma}_{b.s.}}$ used in equation (I) is:

$$\frac{1}{\overline{\sigma}_{b.s}} = 1.87 \cdot 10^7 \cdot l^{-2.18}$$

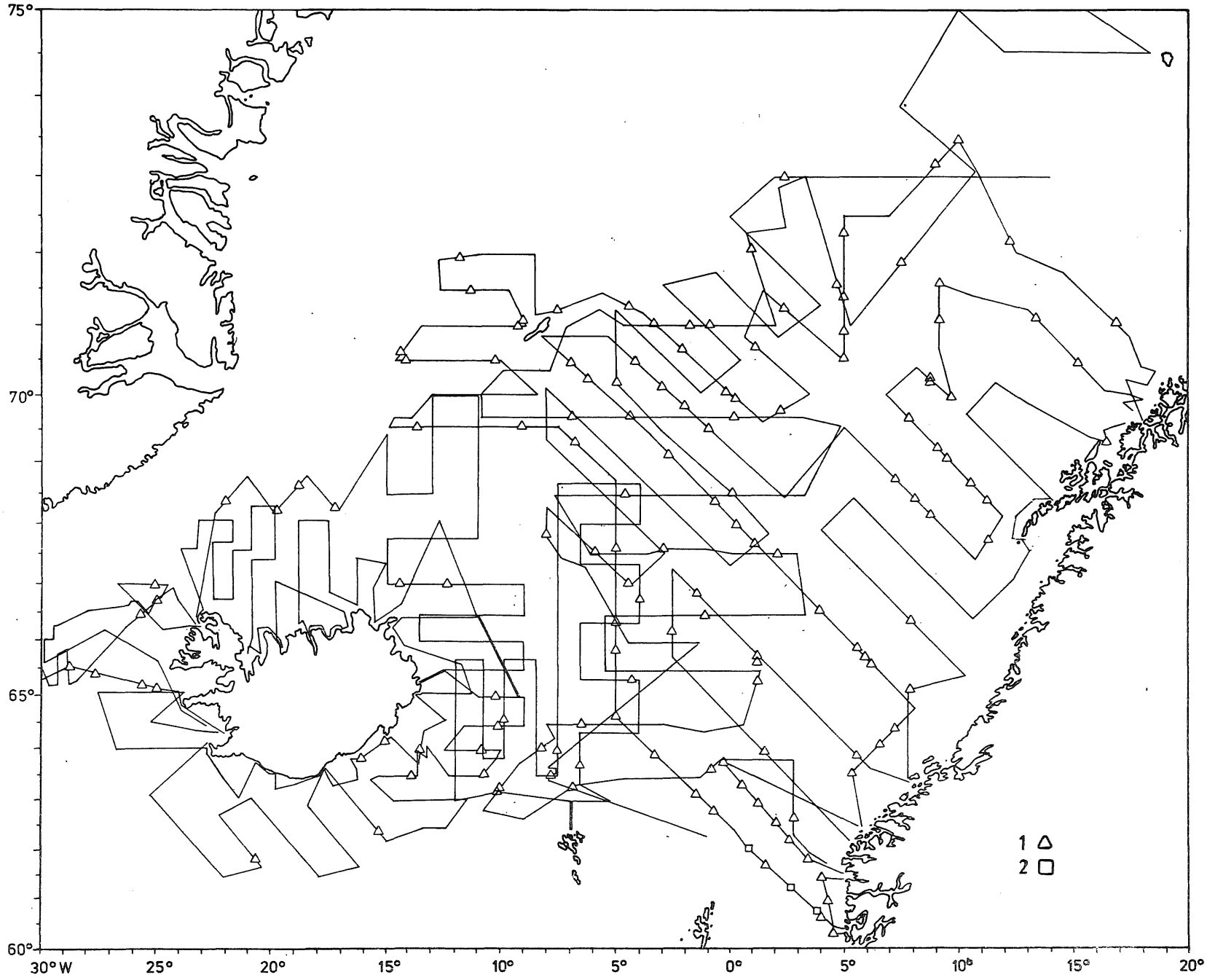

Fig. 1. Cruise tracks with trawl stations from R/V "Perseus III", "Micheal Sars", "Johan Hjort", "G.O. Sars" "Magnus Heinason", "Arni Fridriksor "Bjarne Sæmundsson" and "Eisbaer", 29.7 - 31.8-82. 1) Pelagic trawl, 2) bottom trawl.

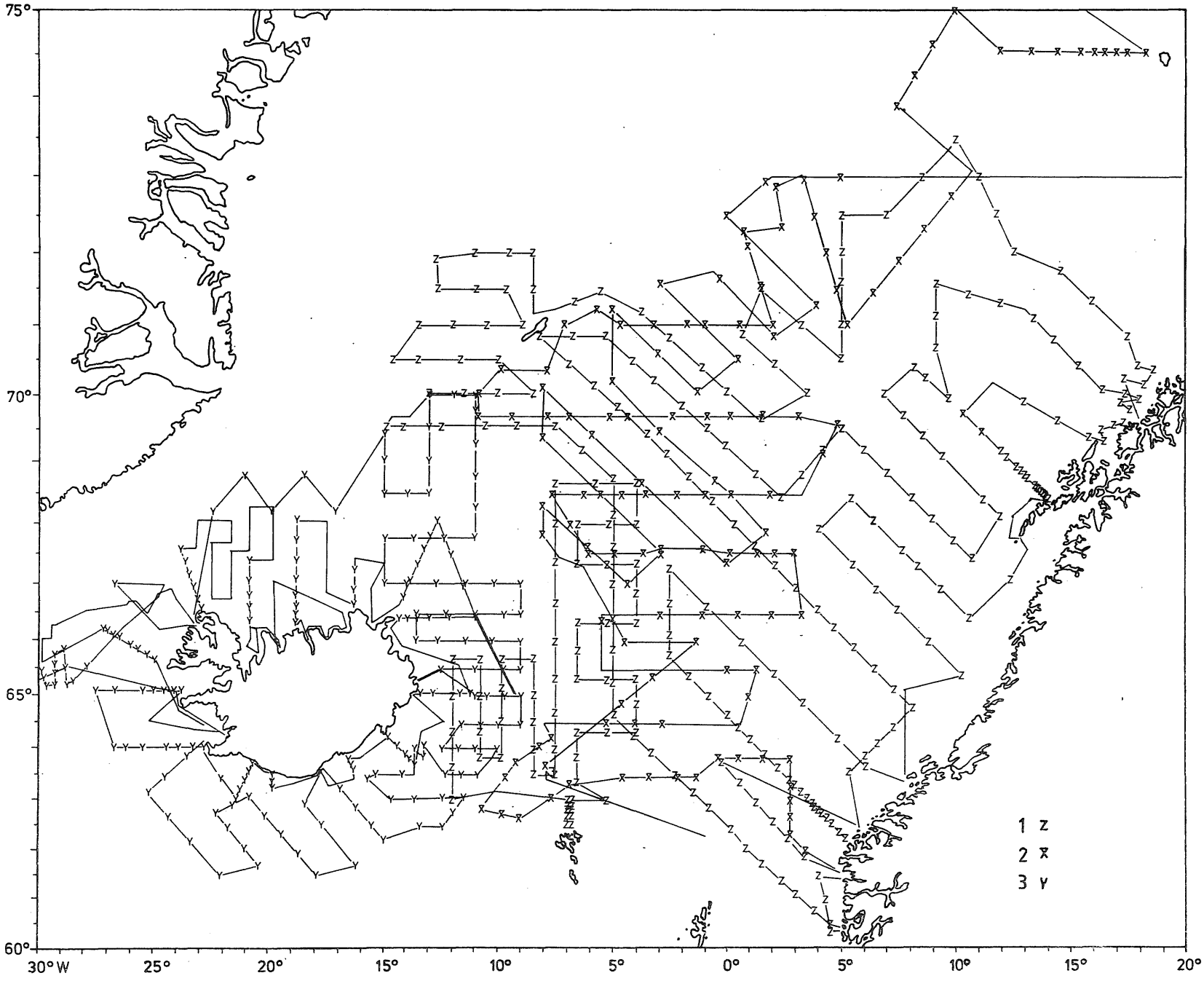

Fig. 2. Cruise tracks with hydrographical stations, 29.7 - 31.8-82. 1) CTD-sonde, 2) Water bottles, 3) XBT.

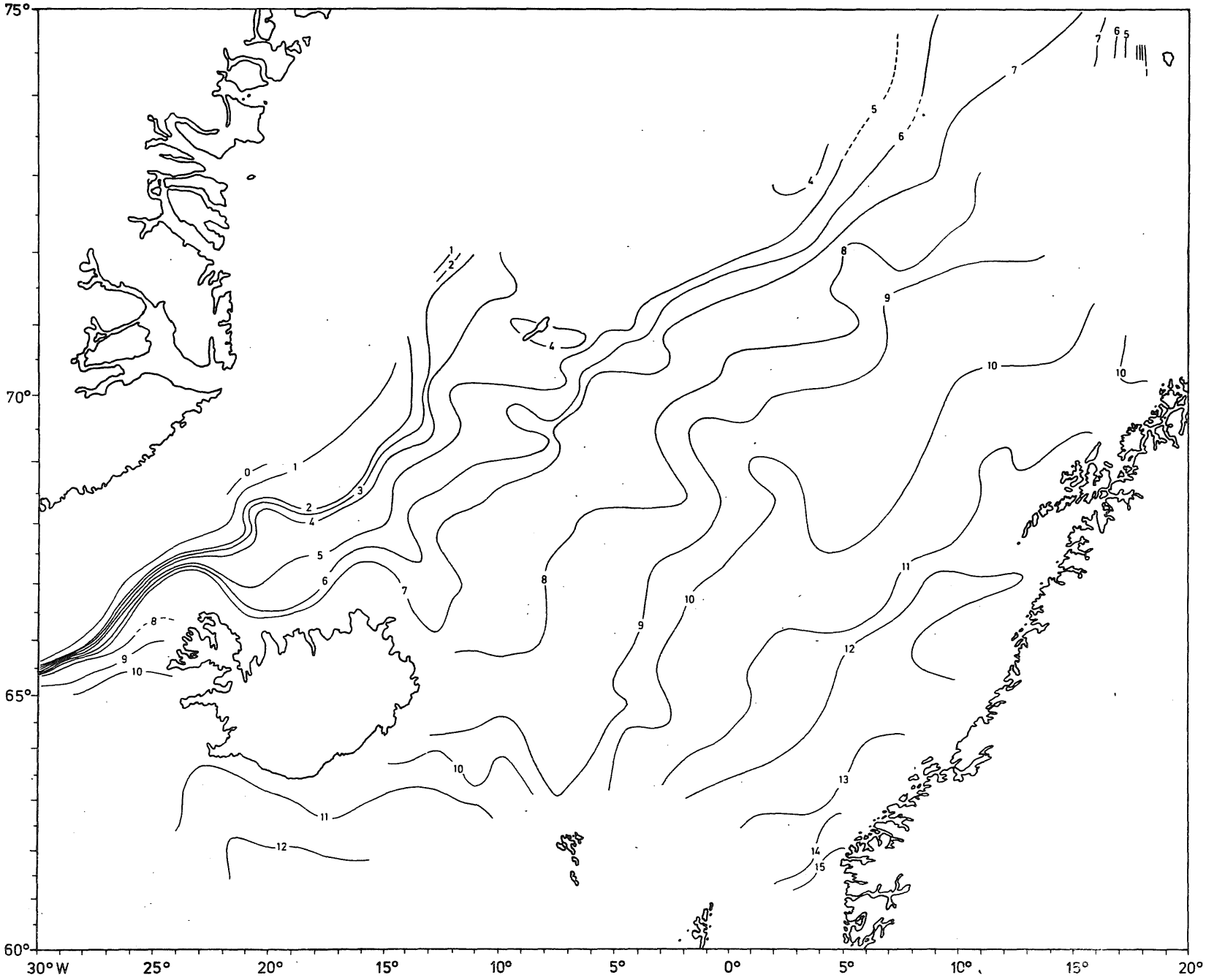

Fig. 3. Temperature ($t^{o}C$) - sea surface, August 1982.

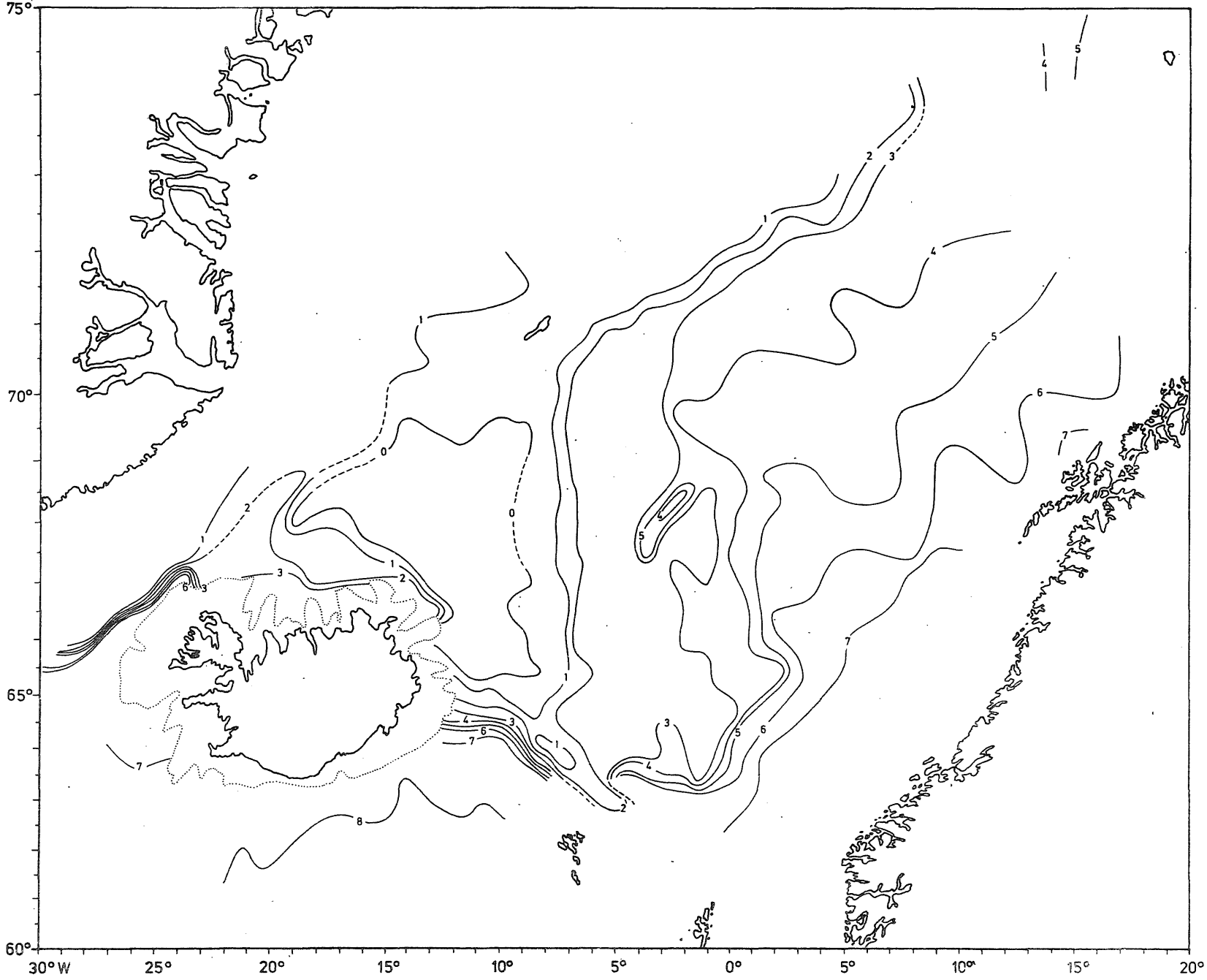

Fig. 4. Temperature (t°C) at 200 m depth, August 1982.

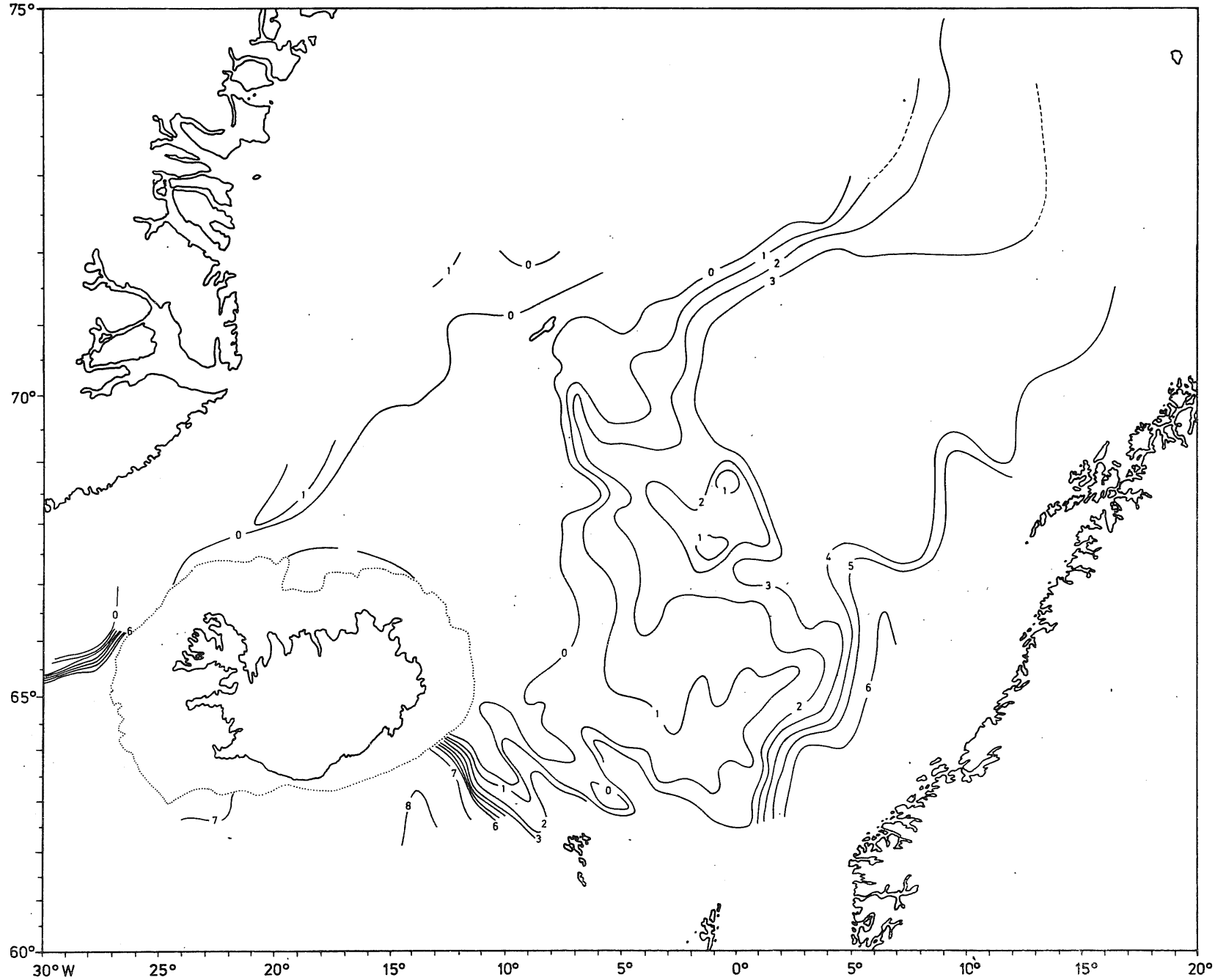

Fig. 5. Temperature (t°C) at 400 m depth, August 1982.

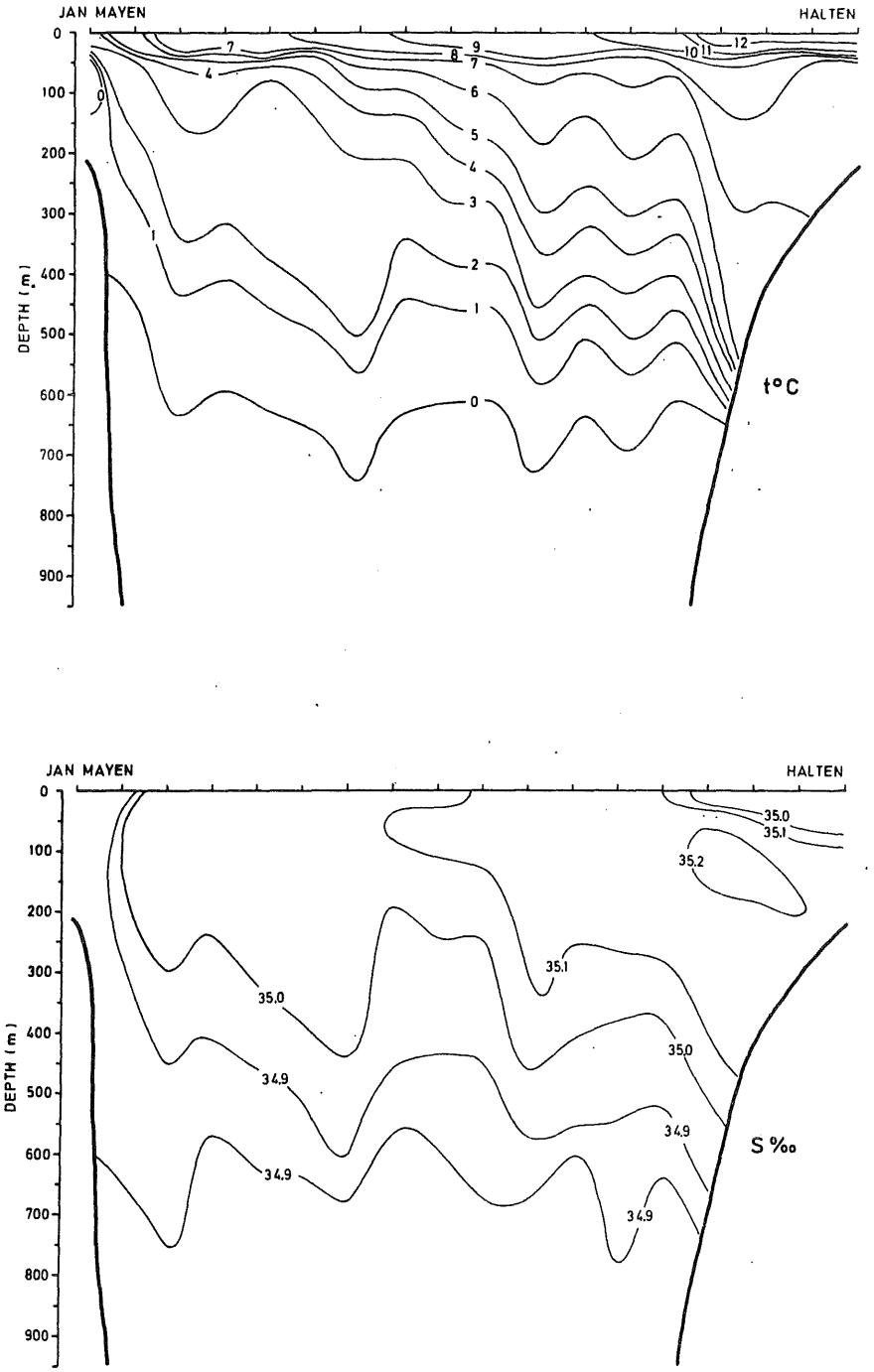

Fig. 6. Temperature and salinity in a vertical section from Halten to Jan Mayen (Pos: N 64°48' E 08°05' - N 70°50' W 08°15') 8-12.8-82.

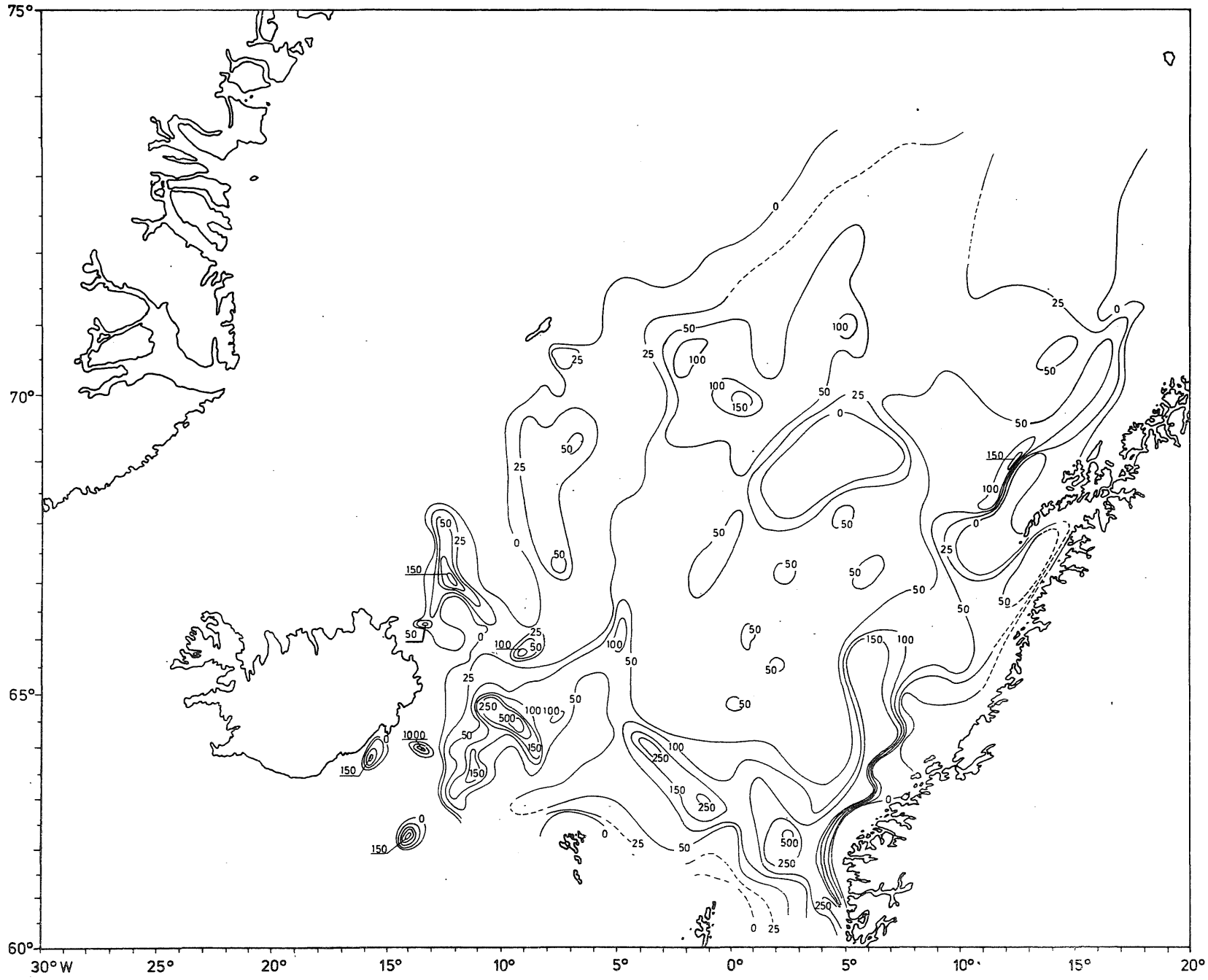

Fig. 7. Distribution and relative densities of blue whiting, August 1982. Echo intensity expressed as square m reflection per square nautical mile x .

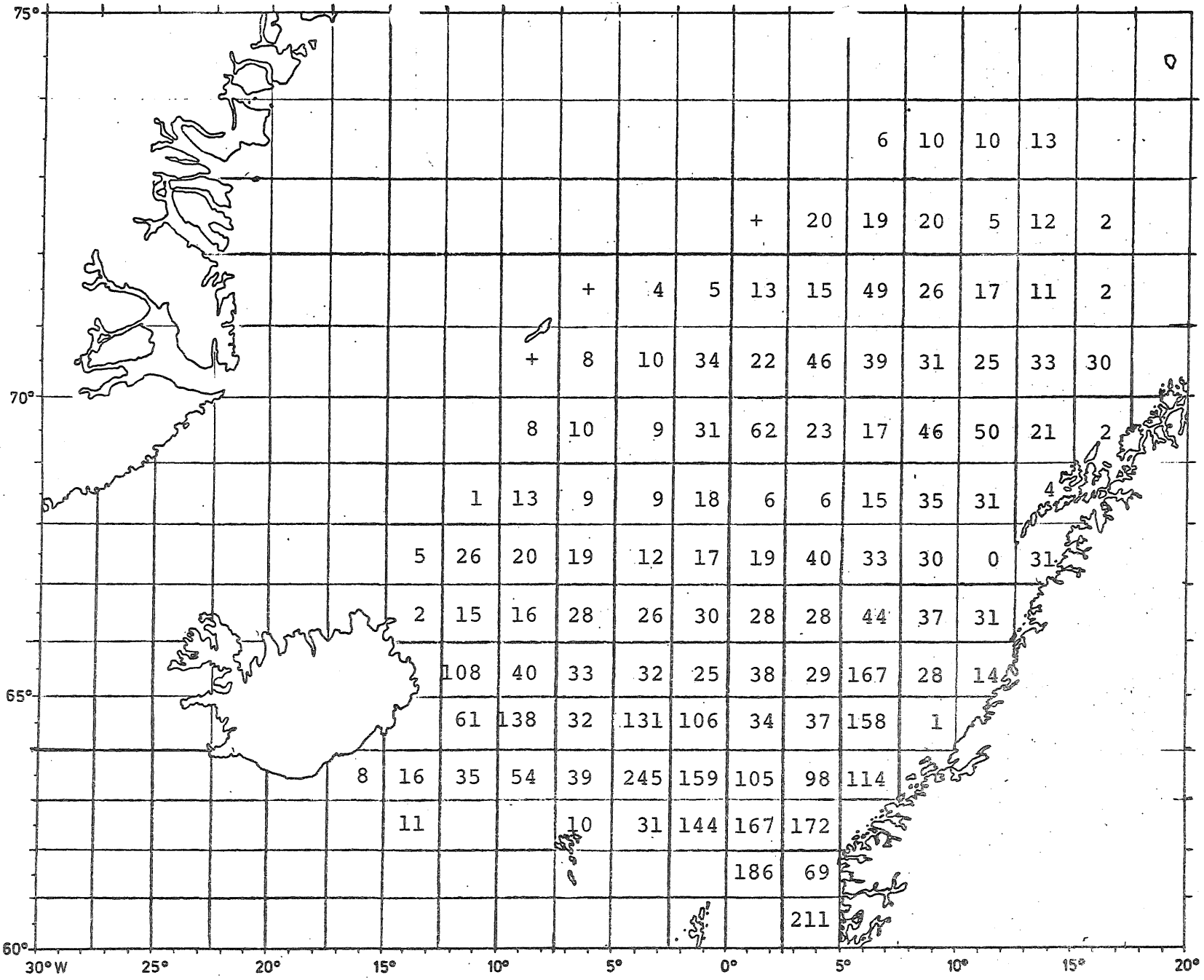

Fig. 8. Estimated blue whiting biomass (1000-tonnes) in each rectangle, August 1982.

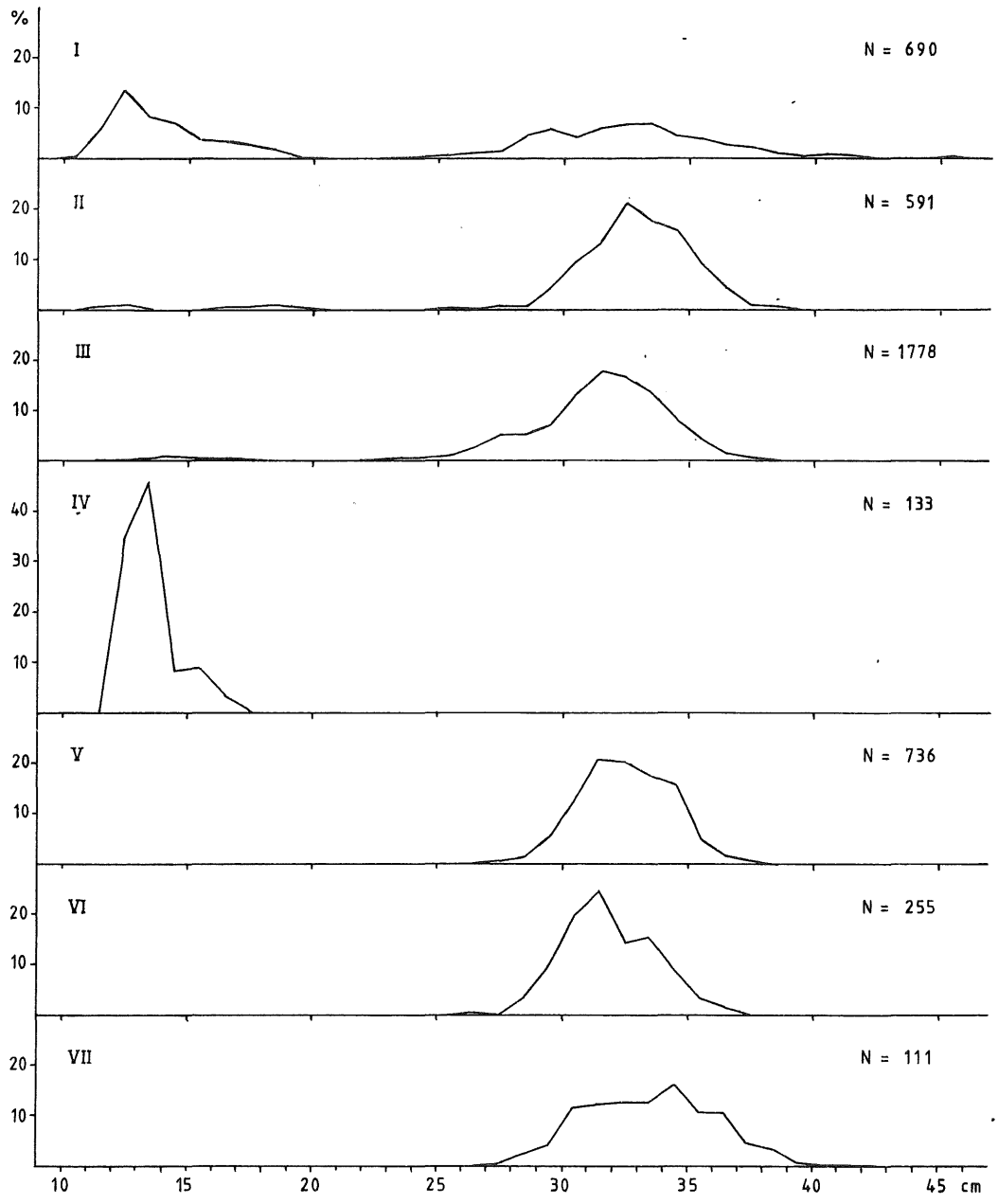

Fig. 9. Length distribution of blue whiting in samples from the Norwegian Sea, August 1982. I-VII are areas shown in Fig. 10.

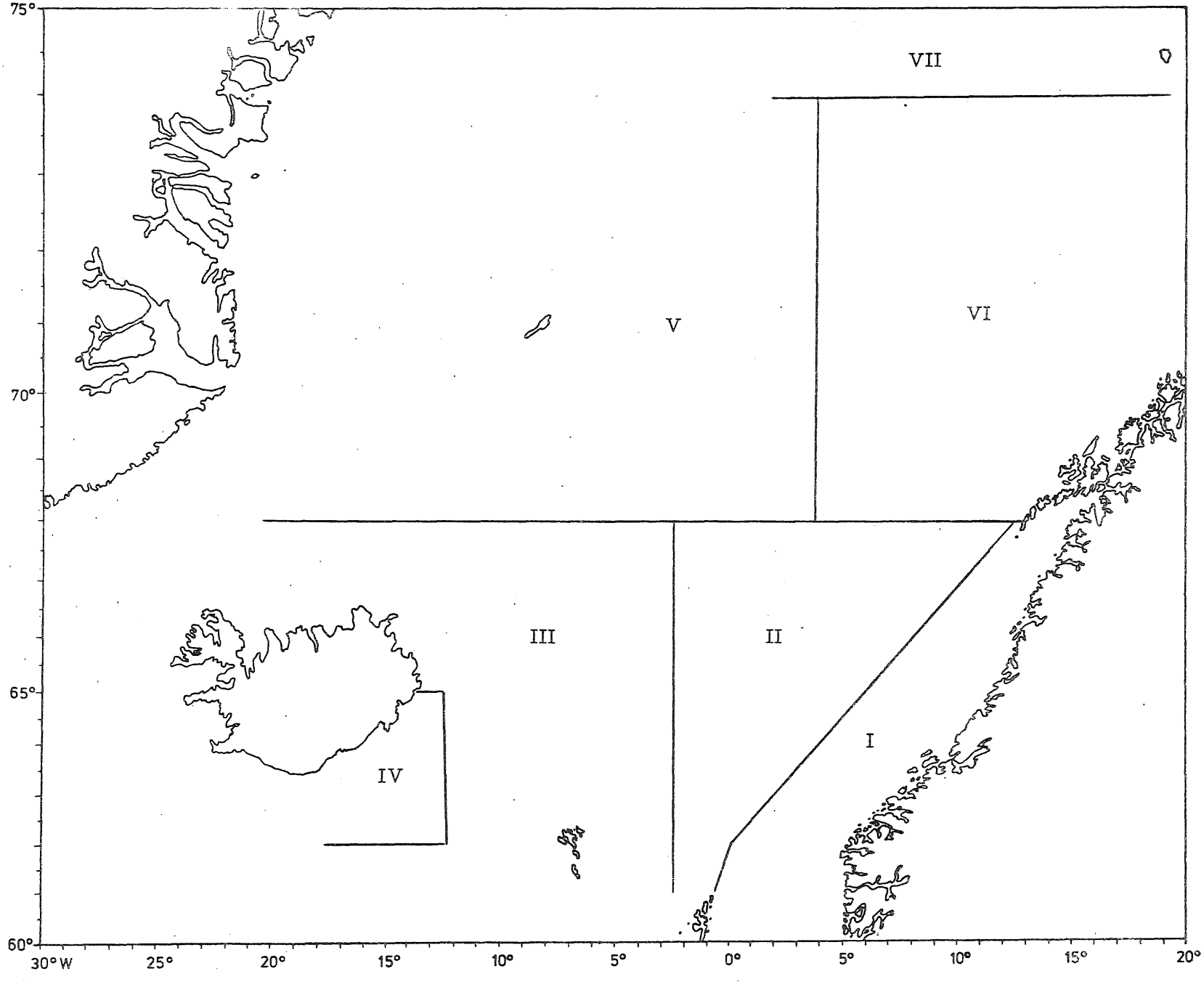

Fig. 10. Norwegian Sea with area division I-VII used for grouping blue whiting samples, August 1982.