International Council for
the Exploration of the Sea

C.M. 1993/H:10
Pelagic Fish Commitee

REPORT OF THE JOINT NORWEGIAN-RUSSIAN ACOUSTIC SURVEY ON BLUE WHITING, SPRING 1993

by

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ABSTRACT

In spring 1993 the fourth joint Norwegian-Russian acoustic survey on the blue whiting spawning stock was carried out. The area to the west of The British Isles was covered by two vessels, one operating in the north-south direction and the other one in the south-north direction. The distribution could hence be confined to two periods and together with recordings in a third period thus gave illustration of a northward post-spawning migration.

The spawning stock size was estimated to 4.9 mill. tonnes; i.e. 0.6 mill. tonnes more than in 1992. This increase was mainly due to the numerous 1989-yearclass which contributed with more than 60% in numbers to the stock.

The influence of the North Atlantic Current was found to be the same as in 1992.

INTRODUCTION

The fourth succeesive joint survey on the blue whiting spawning stock was carried out during the period 12 March-11 April 1993 by research vessels from IMR, Bergen and PINRO, Murmansk. The main objectives of these surveys are to obtain acoustic estimates of the blue whiting spawning stock size and to record the distribution and migration pattern in relation to the hydrological situation, as well as record the structure and composition of the stock.

In 1990, which was the first year of cooperation on a formal basis, the two countries' stock size estimates were not combined due to bad timing of the surveys (Monstad and Belikov, 1990). In 1991 and 1992, however, the conditions were better and common Norwegian-Russian estimates were presented (Monstad and Belikov, 1991; Monstad, Borkin and Ermolchev, 1992).

Before 1990 both countries for several years carried out separate surveys in the area west of the British Isles in spring, and had only informal contact.

MATERIAL AND METHODS

Planning of the joint survey for 1993 took place already at the post-survey meeting in 1992, with further exchange of details by correspondance.

From each country one vessel participated:

Norway: R.V."G.O.Sars", 12 March- 3 Apr.; 49°00'-61°00'N
Russia: R.V."Prof.Marti",21 March-11 Apr.; 50°15'-62°30'N

Both vessels operated echo sounders of 38 KHz frequency (SIMRAD EK 500) with the settings given in the Appendix, and pre-calibration using a copper sphere (Foote, 1981) was performed. A ship-to-ship calibration of the acoustic instruments, which is usual when several vessels cooperate with acoustic recordings, was also performed. As most of the recordings, however, during this intercalibration were of plankton, and the recordings of blue whiting were rather poor, a conversion factor between the vessels was not established. The difference was so small that it was taken as an indication that the echo sounding systems seemed to be in good working condition. Based on this, and on the mentioned copper sphere pre-calibration, it was decided that the relationship between the vessels integrator values should be treated as 1:1 for the present survey.

The shelf edge area west and north of the British Isles was covered from 49°00'N to 62°30'N including the Porcupine Bank. While the Norwegian vessel surveyed the area from the south to the north, the Russian one surveyed it from north to south

(Figs. 1 and 2). On the 28 March the two vessels met at latitude 57°N.

The two vessels had daily radio communication with exchange of information concerning recordings and catch, as well as biological parameters. At the meeting position for intercalibration the data obtained so far were exchanged by use of floats with lines picked up by either vessel.

The echo recordings were identified and biological samples collected by the use of bottom and pelagic trawls. Norway used a Rock-hopper bottom trawl of 18 x 4m opening and a pelagic trawl with 25m vertical opening. Both trawls had 11 mm innernet in cod end. The Russian vessel used a pelagic trawl with 45m vertical opening and 16 mm innernet in cod end.

The area surveyed was handled as six separate subareas which were further divided into rectangles of 30 minutes latitude and 1 degree longitude. The method used for the acoustic estimation was the same as used for the previous blue whiting surveys, described in e.g. Anon.(1982), Monstad (1986) and Belikov et al. (1990). The recordings (S_a-values), given in terms of reflected square meters per square nautical mile based on copper sphere calibration, were integrated continuously with mean values for 1 nautical mile given for each 5 nautical miles throughout the survey. By scrutinizing the echo recordings, the values were allocated to various species or groups of species.

The target strength value :

$$TS = 21.8 \log L - 72.8 \text{ dB}$$

was used, where L is fish length. For a 30 cm fish (cod) this give the density coefficient value:

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

Either country made separate estimates for the blue whiting biomass and abundance, and the results were combined on the subarea basis. The survey time period was divided into two parts, i.e. before and after 28 March, with the areas surveyed from south and from north by either of the vessels up to 57°N respectively and vice versa, and combined for each of the two periods.

This way a more synoptical surveying of the total area was obtained and in addition the distributional picture could be mapped for two separate periods of the spawning season, namely:

1.period: 12 March-28 March, north - "Prof. Marti"
south - "G.O.Sars".

2.period: 28 March-11 April, north - "G.O.Sars"
south - "Prof. Marti".

The acoustic estimate to be the most representative one for the spawning stock size, is obtained from the results of the 1st period.

The hydrological conditions were observed by use of CTD-sonde at a great number of stations, operated from the sea surface to the bottom or to 600m where depth was greater.

RESULTS

Distribution

The blue whiting in the Northeast Atlantic is considered to consist of two major stock units,i.e. a northern and a southern one, in addition to a number of smaller local stocks. The area over the Porcupine bank, west and southwest of Ireland, is likewise considered to be a mixed distribution area for blue whiting from the north, from the south and of some local stocks. The absolute majority is, however, believed by the ICES Working Group on Blue Whiting to belong to the northern stock (Anon.,1986).

In 1992 dense recordings of blue whiting were observed at the shelf edge area south of Ireland, estimated to nearly 1 mill. tonnes between the latitudes 50° and 51° N. As these recordings at that time were allocated to a northward post-spawning migration, and hence should belong to the "northern" part of the stock, the survey in 1993 started at a rather far southern latitude to include any possible mass concentrations of blue whiting in that area.

The density distribution of the blue whiting stock in 1993 for the 1st and 2nd survey period are shown on Figs. 3 and 4 respectively. The all over pattern for both periods was very much like the usual one. From the area southwest of Ireland, over the Porcupine Bank and further northwards to the area west of the Hebredes and Faroes/Shetlands, high concentrations were located close to the continental slope, while density decreased gradually with the distance from the slope.

For either period the highest abundance was found in the south, i.e. west of Ireland, and rather scattered recordings in the north. During the first period, concentrations of high density were located at 400-500m depth in the area west and north of the Porcupine Bank, and of extremely high density within a small area near the slope at 55°N.

The recordings of blue whiting made south of 50°30'N were allocated to the southern part of the stock. This was due to the majority of younger fish in the concentrations, and difference in growth pattern and maturity schedule. A considerable part of one year olds in this area were already mature, and most of them either had running gonads or were spent. However, reliable criteria to distinguish southern from northern blue whiting do not exist yet.

The time difference between the 1st and 2nd coverage of the

area in the south was 2-3 weeks. During this period some changes of distribution could be observed. As mentioned above, the concentrations south of 50°30'N had vanished from the area; probably migrated southwards after spawning. In the area south of the Porcupine Bank, the concentrations were found to have diminished in density; probably migrated northwards.

In the north the concentrations of blue whiting were found to have moved closer to the shelf edge, but without any notable increase of the abundance.

During a third period, i.e. from 15-30 April, the R.V. "Prof.Marti" conducted a survey in the spawning area to the west of the British Isles for investigation on ichthyo-plankton and blue whiting (Belikov, Ignashkin and Molloy, 1993). In this post-spawning season the blue whiting was mainly found in the north, i.e. west and north-west of Scotland between 57°30' and 60°30'N where it was mostly distributed in dense shoals at depths between 350 -550 m. The densest concentrations were located near the slope, but recordings were also made extensively westwards over the deep-sea area up to 12°W (Fig. 6). In the areas to the west of Ireland only minor recordings of blue whiting were obtained. The picture of the distribution for this period clearly shows the northward post-migration that had taken place.

Due to insufficient biological parameters for this coverage, only a very rough estimate was made.

Stock size

The separate estimates from either country of the total biomass and abundance, as well as the absolute length and age distributions of the northern stock are given in Tables 1 and 2. The combined result of the acoustic assessments for the first period, 12-28 March, gave a biomass of 5.1 mill. tonnes, representing the abundance of 41.1 x 10^9 individuals. Of this 4.9 mill. tonnes and 39.3 x 10^9 individuals belonged to the spawning stock. The estimates for the first period by subareas and the totals are given in Table 3, and the biomass estimate on a rectangular basis is shown in Fig. 5.

In the second period the estimates were slightly reduced in quantity compared to the first period, and they are considered less representative for the status of the spawning stock size. Since there is an influx of pre-spawning blue whiting to the spawning area, throughout the season from January to May, and post-spawning migration also takes place, the time chosen for these kind of surveys is crucial. It is not possible to "picture" the entire spawning stock in one "shot", and hence such results will always be underestimates.

The two countries' separate estimates of the stock size in 1990 were not combined due to unfavorable timing of the surveys. The combined Norwegian-Russian acoustic estimates of the northern blue whiting spawning stock size for the recent three years are, however, given in the text-table below:

	N x 10^{-9}	Mill. tonnes	w (g)	l (cm)
1991	35.2	4.4	121.8	28.0
1992	36.9	4.3	113.0	27.5
1993	39.3	4.9	123.6	28.1

The increase of the spawning stock size from 1992 to 1993 was due to the very rich 1989-yearclass. It has increased its recruitment to the spawning stock, as well as a good individual growth in length and weigth.

Stock composition

The total distributions of length and age of the northern stock for the first covrage period are shown in Fig. 7. The 4 year olds (1989-yearclass) dominated and contributed to the observed stock with more than 60%, which actually is the same contribution as it had in 1992 (Monstad et al., 1992). The contributions of younger age groups were mainly from the northern and the southern areas (I and VI). As expected from earlier years results, the 1989-yearclass, i.e. the most numerous one observed since 1983 (Anon.,1993), would contribute considerably to the spawning stock also in 1993 too.

The mean weight at age of blue whiting as observed by either of the countries are shown on Fig. 9. The different results in 5-7 year olds, indicate a disagreement in the ageing of the otoliths. The weight-length relationship was very similar for the two counrties observations, and hence a combine plot is given on Fig.9.

Hydrography

During the study period the meteorological situation was represented by predominant SW and S cyclonic winds with speed of 15-20 m/s. Atmospheric pressure ranged from 980-1000 mbars and the height of waves was 3-5 m. The mean meteorological situation during the cruise was unfavorable.

The horizontal temperature distributions are shown in Figs. 10a-b for the sea surface, 200, 400 and 600m respectively. In 1993 the highest temperatures (11.0-11.3° C) were recorded in the southern part of the surveyed area where the temperature at the 200 m layer was generally higher than in 1992. Water temperatures in the 0-200 m layer were similar to 1992. This suggest that the effect of the North Atlantic Current in 1993 was the same as in 1992.

Generally, water temperatures were the same as last year in the central and northern parts of the surveyed area.

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APPENDIX

Acoustic equipment and settings of the instruments:

	"G.O.Sars"	"Prof. Marti"
Echo sounder:	Simrad EK-500	Simrad EK-500
Frequency:	38 kHz	38 kHz
Noise margin:	1 dB	3 dB
Absorption:	10 dB/km	10 dB/km
Pulse length:	Medium	Medium
Band width:	wide	wide
Max power:	4000 w	2000 w
Angle sensivity:	21.9	21.9
2-way beam angle:	-21.0 dB	-20.4 dB
Sv Transducer gain:	25.6 dB	23.0 dB
TS Transducer gain:	25.6 dB	23.0 dB
3 dB Beam width:	7.1°	7.3°
Bottom detection:	-55 dB	-60 dB
Range:	500 m	500 m

Table 1. Abundance estimate of blue whiting in the northern stock, i.e. 50°30' - 61°00'N, west of the British Isles, March 1993. R.V. "G.O. Sars", Norway.

Number: N x 10^{-6}

Condition: 1000 x Weight/Length^{-3}

Weight: Tonnes x 10^{-3}

All areas

C:1.490 : 10^{6} : $L^{-2.18}$

cm Length	Age 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15+	Tot Wgt	$\bar{w}$
17.0-17.9	50															50	1.4	28.9
18.0-18.9	196															196	6.3	32.1
19.0-19.9	226															226	8.7	38.6
20.0-20.9	397	13														410	18.6	45.5
21.0-21.9	560	80														640	32.7	51.1
22.0-22.9	367	378														745	43.8	58.8
23.0-23.9	70	776	19	9												874	56.4	64.5
24.0-24.9	24	881	178	129												1212	96.7	79.8
25.0-25.9		974	266	230												1470	130.0	88.4
26.0-26.9		992	734	968	13											2707	264.5	97.7
27.0-27.9		322	1134	4710	66											6232	678.2	108.8
28.0-28.9		73	806	7544	227											8650	1034.4	119.6
29.0-29.9			161	6642	660	17										7480	989.1	132.2
30.0-30.9			19	3489	538	104										4150	608.3	146.6
31.0-31.9			4	2107	354	162	73	31								2731	431.8	158.1
32.0-32.9				693	407	193	94	43								1430	258.4	180.7
33.0-33.9				142	186	163	66	90	14	3						664	131.7	198.3
34.0-34.9				95	79	281	98	90	18				3			664	138.6	208.7
35.0-35.9				13	103	218	141	33								508	116.6	229.5
36.0-36.9					10	77	42	95	70							294	74.3	252.8
37.0-37.9						50	3	13		7	12		3			88	20.6	234.6
38.0-38.9						5	34	7				1				47	13.5	286.6
39.0-39.9								12	6	5						23	7.5	327.7
40.0-40.9							6	12		7						25	9.4	374.6
Number	1890	4489	3321	26771	2643	1270	557	426	108	22	12	1	6	0	0	41516		
$\bar{l}$	20.94	25.03	27.30	29.10	30.97	33.72	34.38	34.86	35.94	38.36	37.50	38.50	36.00	.00	.00	28.56		
Weight	91.7	366.8	365.2	3424.1	421.0	249.2	118.6	95.7	26.6	7.1	3.2	.4	1.9	.0	.0	5171.5		
$\bar{w}$	48.5	81.7	110.0	127.9	159.3	196.2	213.0	224.7	246.4	322.4	270.5	380.0	316.0	.0	.0	124.6		
Cond.	5.2	5.1	5.4	5.2	5.3	5.1	5.2	5.3	5.3	5.7	5.1	6.7	6.8	.0	.0	5.2		

Table 2. Abundance estimate of blue whiting in the northern stock, i.e. 50°30′ - 62°30′N , west of the British Isles, March/April 1993. R.V. "Professor Marti", Russia.

Length cm	Age 1	2	3	4	5	6	7	8	9	13	Abundance x 10^6	Biomass T x 10^3	Weight g
19	8	4									12	0.5	36.6
20	22	25									47	2.1	45.4
21	49	92									142	7.2	50.5
22	80	170	20								270	15.2	56.2
23	14	169	63	14							261	16.1	61.7
24	15	304	174	15							508	35.2	69.4
25		205	317	131	168	18					840	70.1	83.5
26		573	475	375	158	98	40				1720	162.2	94.3
27		283	950	1232	412	102	27				3006	300.1	99.8
28		222	1162	2735	881	222	63				5286	583.9	110.5
29		41	992	3400	870	290	168	41			5802	711.9	122.7
30			327	2332	1074	373	46	46			4199	574.0	136.7
31			225	1200	938	263	188	38	38		2888	437.1	151.3
32				745	507	203	68	68	34		1627	286.5	176.1
33				56	222	277	167	138			860	164.5	191.4
34			22	89	44	244	222	133	111	22	887	180.7	203.7
35					16	80	128	32	80	49	385	85.2	221.1
36				13	13	63	50	50	50	13	250	61.6	246.0
37						16	79	47	63	31	236	61.8	261.7
38							71	18		35	124	34.1	275.5
39								11	11		21	6.2	295.5
Abundance x 10^6	188	2089	4728	12337	5304	2249	1316	621	386	150	29368		
Biomass T x 10^3	9.5	145.0	483.3	1550.5	743.2	340.8	252.2	137.4	95.0	39.3		3796.0	
l cm	21.0	24.0	27.1	28.9	29.4	31.4	33.4	34.6	35.4	36.4	28.5		129.3
w g	50.5	69.4	99.8	122.7	136.8	151.5	191.6	221.1	246.0	261.7			

Table 3. Assessment factors of blue whiting west of the British Isles during spring 1993. Combined results of R.V."G.O.Sars"(Norway) and R.V."Prof.Marti"(Russia).

Sub-area	Latitude	Square, naut. miles	Abundance N x 10^{-6}			Biomass t x 10^{-3}			$\bar{w}$	$\bar{l}$	Density tonnes/ n. mil2
			Immat.	Mature	Sum	Immat.	Mature	Sum			
VI	Faroes/Shetl. 60°00'- 62°30'	3400	356	1016	1372	21	156	177	128,7	28,2	52
V	Hebrides - N 58°00'- 60°00'	741	154	867	1021	14	112	126	123,6	27,6	170
IV	Hebrides - S 55°30'- 58°00'	2998	164	4416	4580	24	596	620	135,4	28,8	207
III	Porcupine - N 53°30'- 55°30'	11795	596	20691	21287	76	2607	2683	126	29,1	227
II	Porcupine - M 51°30'- 53°30'	12735	479	9097	9576	56	1073	1130	118	28,2	89
I	Porcupine - S 50°30'- 51°30'	3325	96	3210	3306	10	338	348	105,2	26,6	105
	All subareas	34994	1845	39297	41142	201	4882	5084	123,6	28,1	145

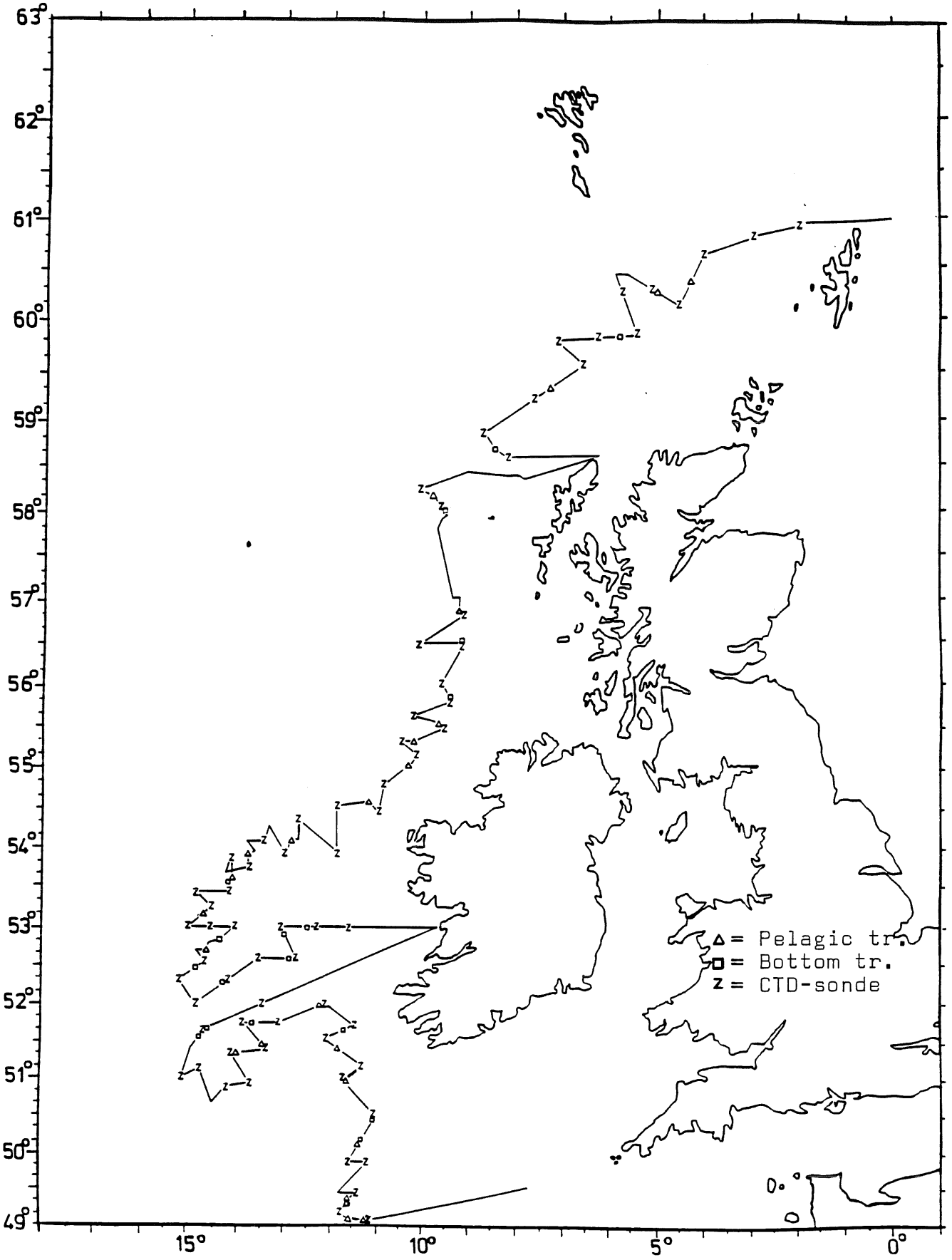

Fig. 1. Cruise track and stations of R.V."G.O.Sars", 12 March - 3 April 1993.

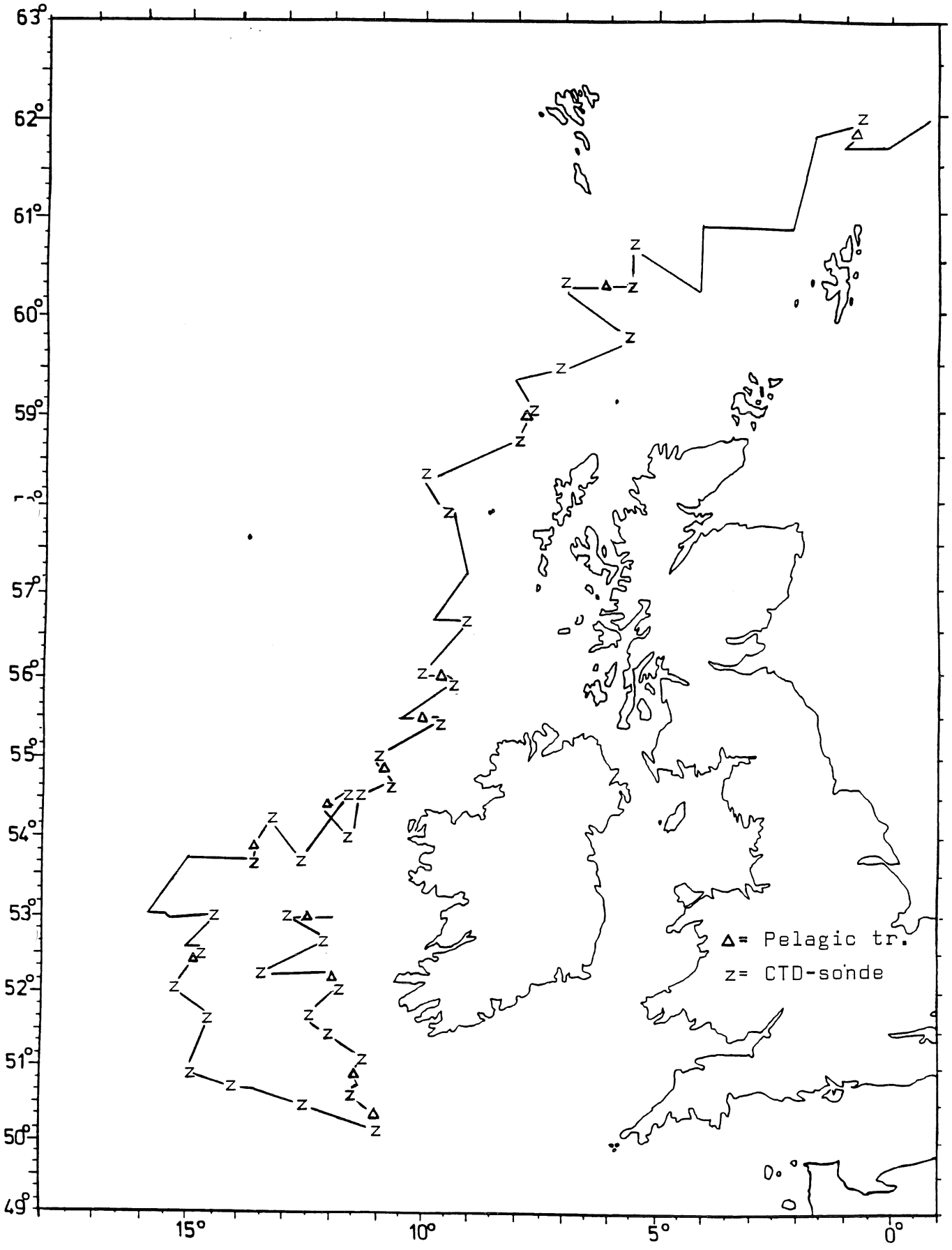

Fig. 2. Cruise track and stations of R.V."Prof.Marti", 21 March - 11 April 1993.

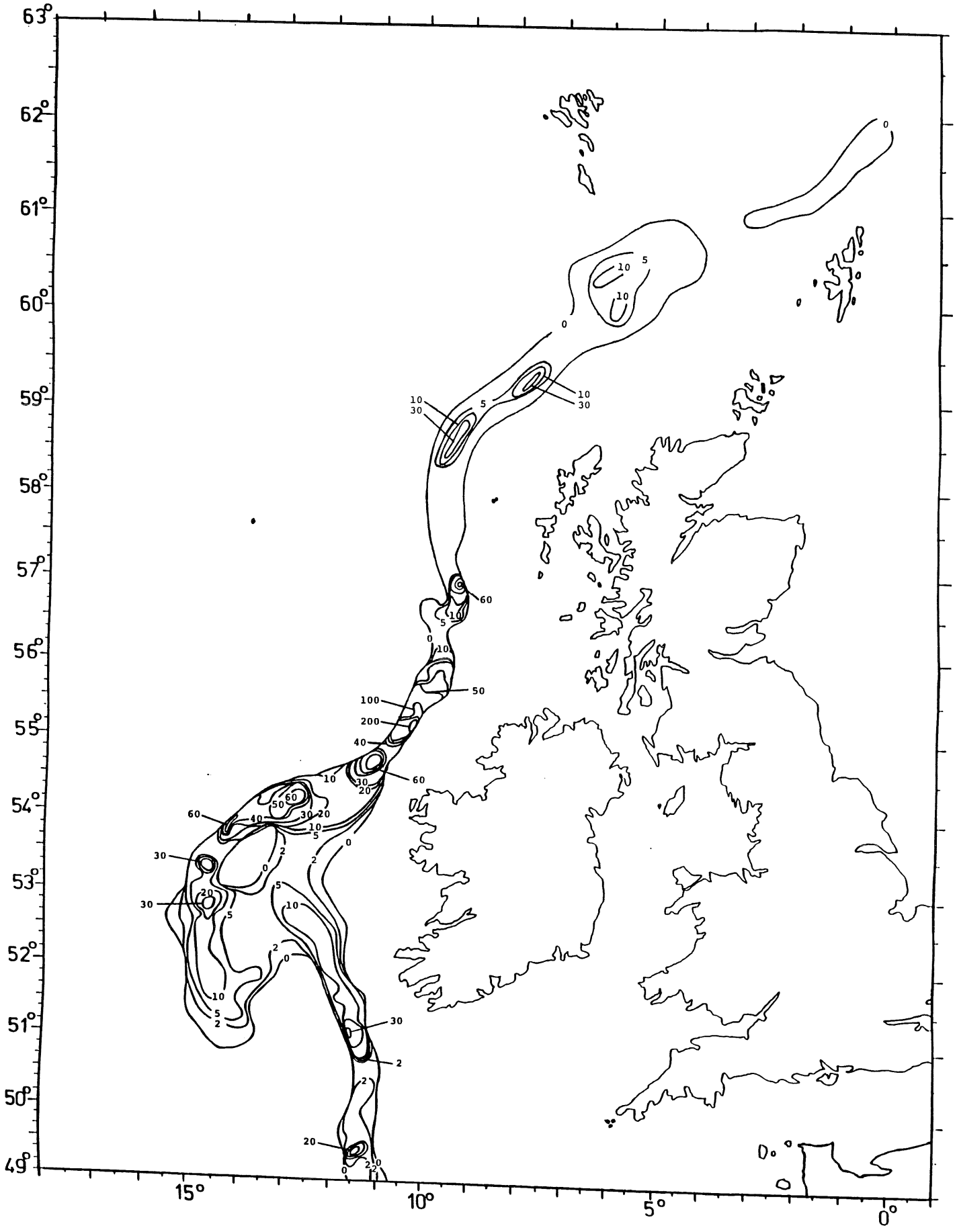

Fig. 3. Density distribution of blue whiting in spring 1993, 1. period: 12-28 March, combined result. Echo intensity in m^2 per $(n.mile)^2$ x 1/100.

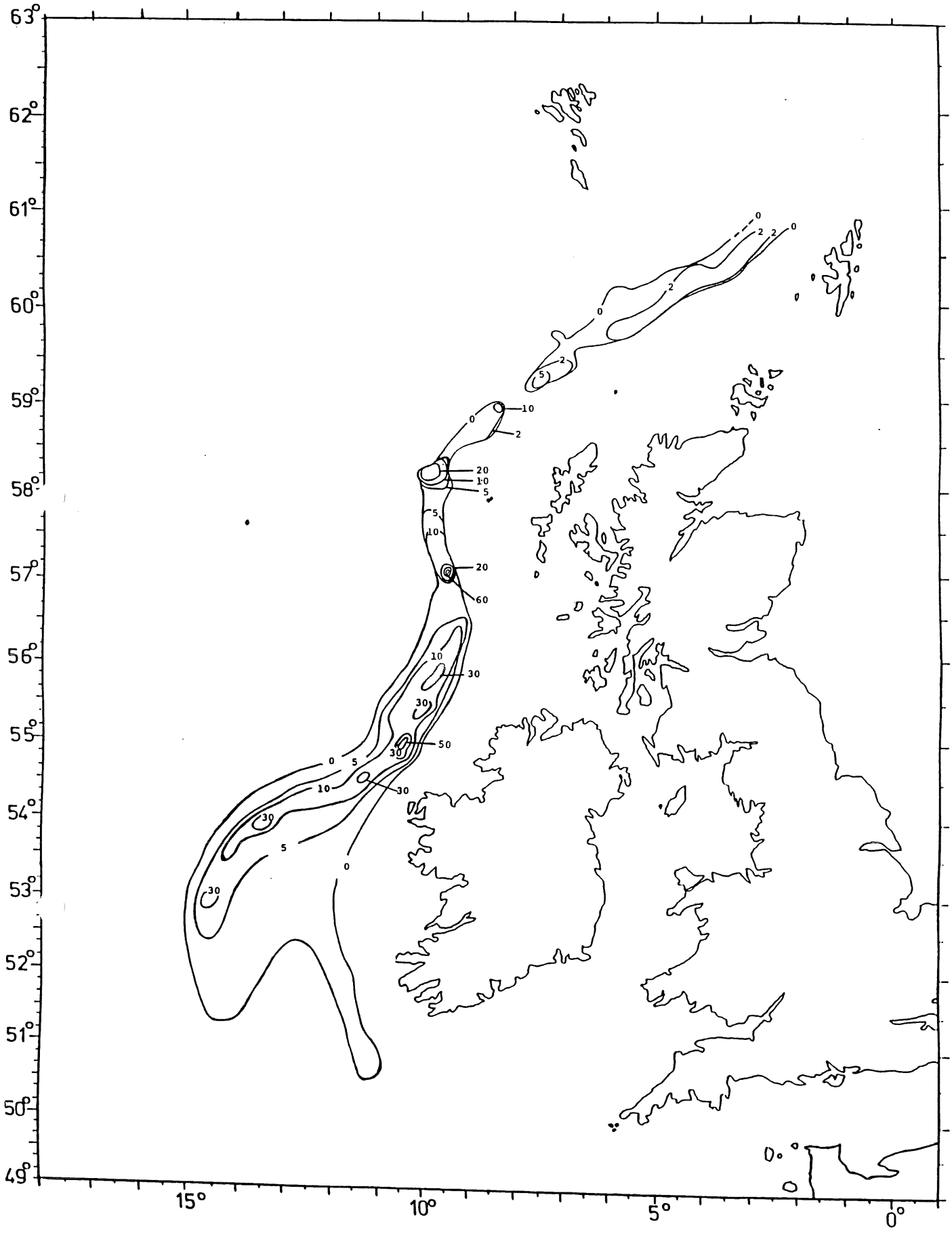

Fig. 4. Density distribution of blue whiting in spring 1993, 2. period: 28 March-11 April, combined result. Echo intensity in m^2 per $(n.mile)^2$ x 1/100.

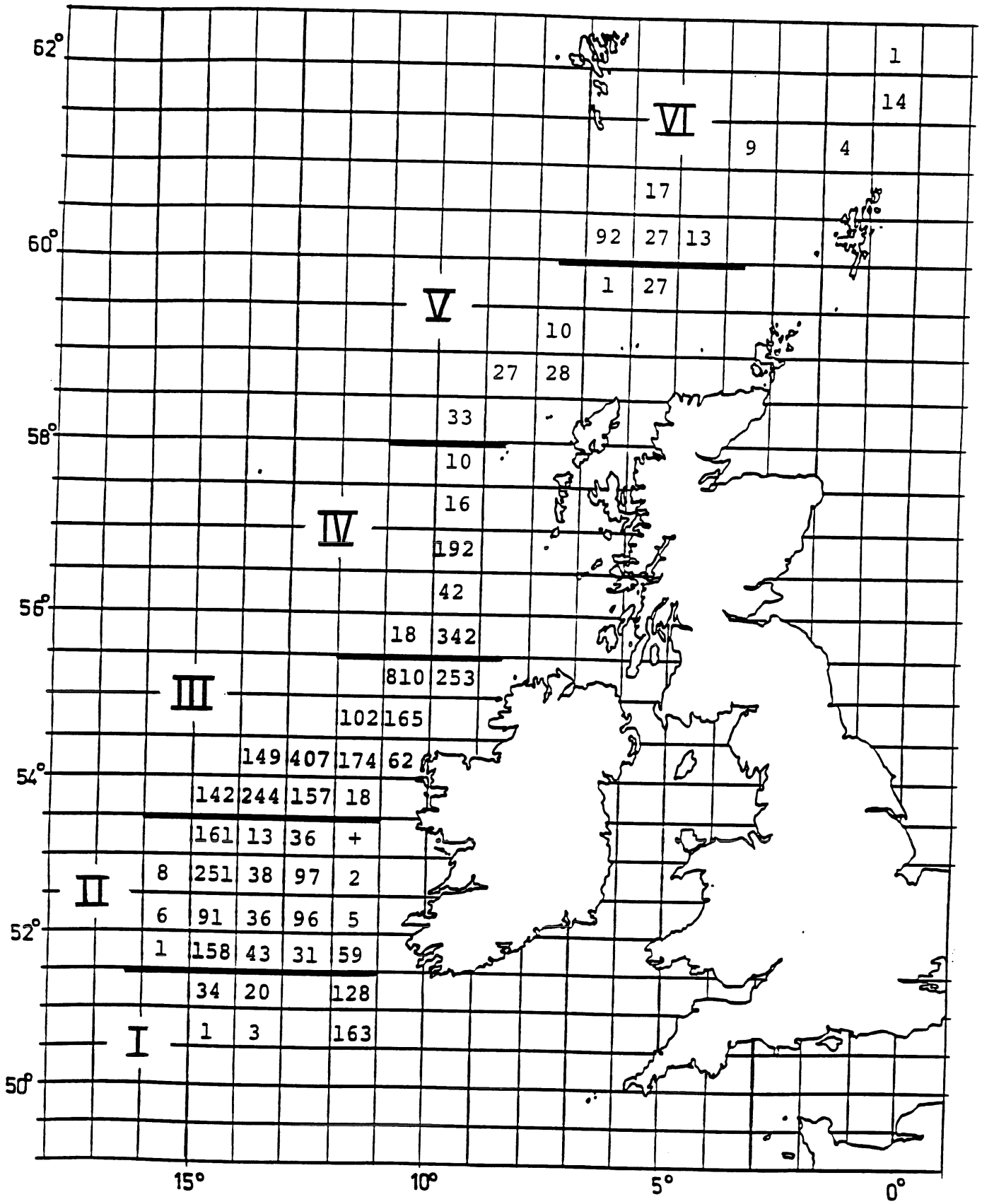

Fig. 5. Blue whiting biomass ('000 tonnes) in spring 1993, 1. period: 12-28 March. Markings of subareas I-VI used in the assessment.

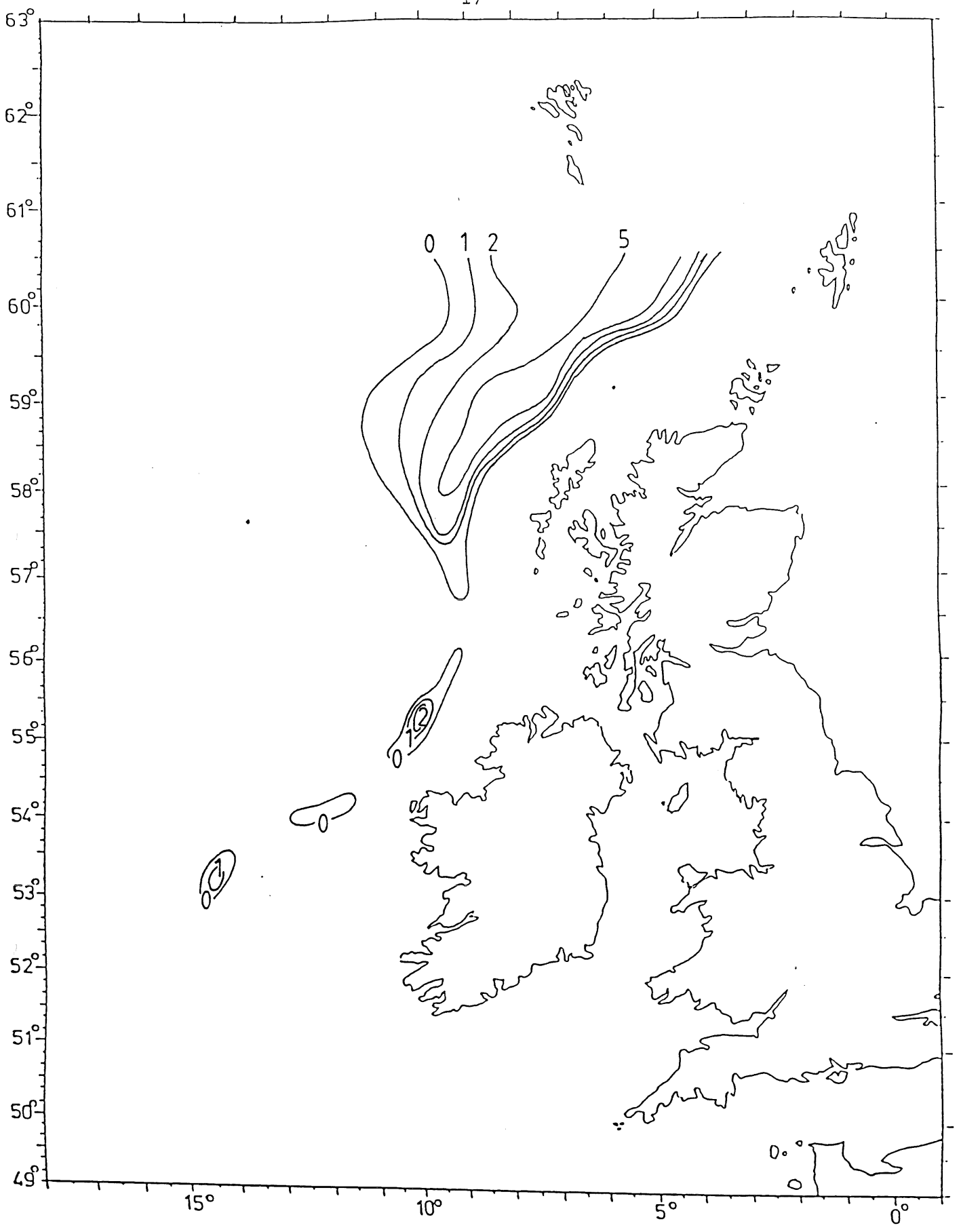

Fig. 6. Density distribution of blue whiting in spring 1993, recorded by R.V. "Prof.Marti" during the 3. period: 15-30 April. Echo intensity in m^2 per $(n.mile)^2$ x 1/100. From Belikov et al. (1993).

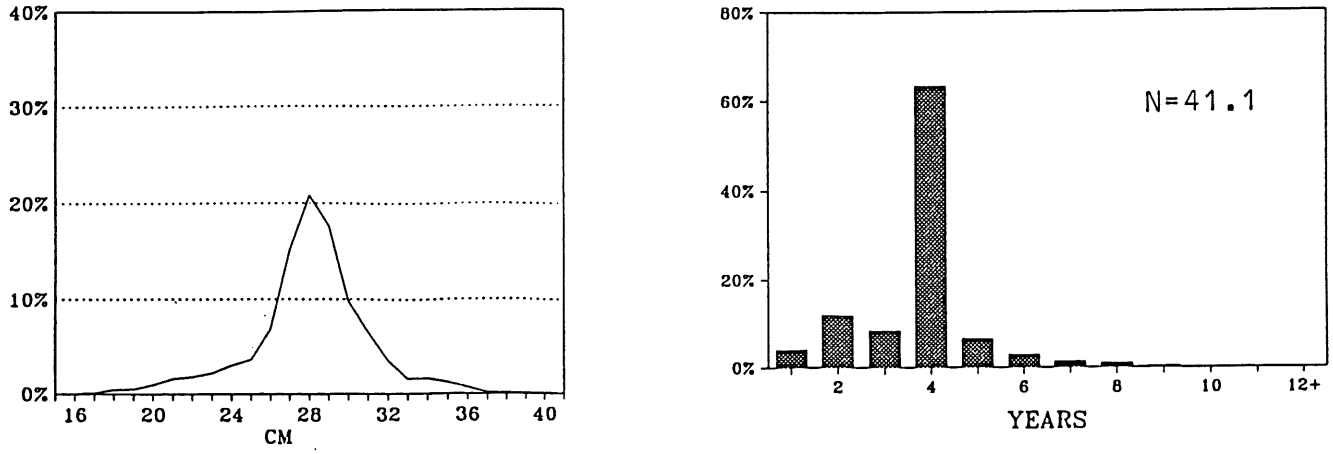

Fig. 7. Total length and age distribution (N%) of blue whiting in the area to the west of the British Isles, spring 1993, in 1. period: 12-28 March. N x 10^{-9}, combined results, weighted by abundance.

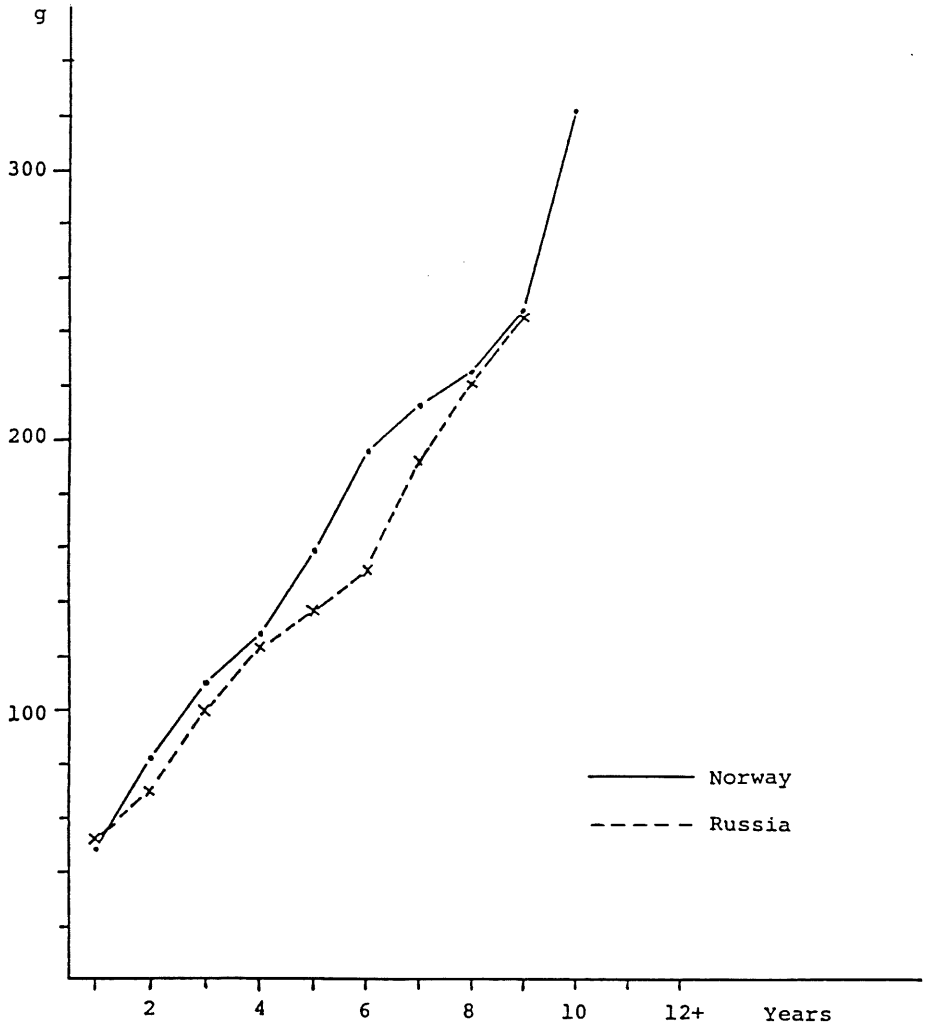

Fig. 8. Weigth by agegroups of blue whiting observed in the spawning area by Norway and Russia in spring 1993.

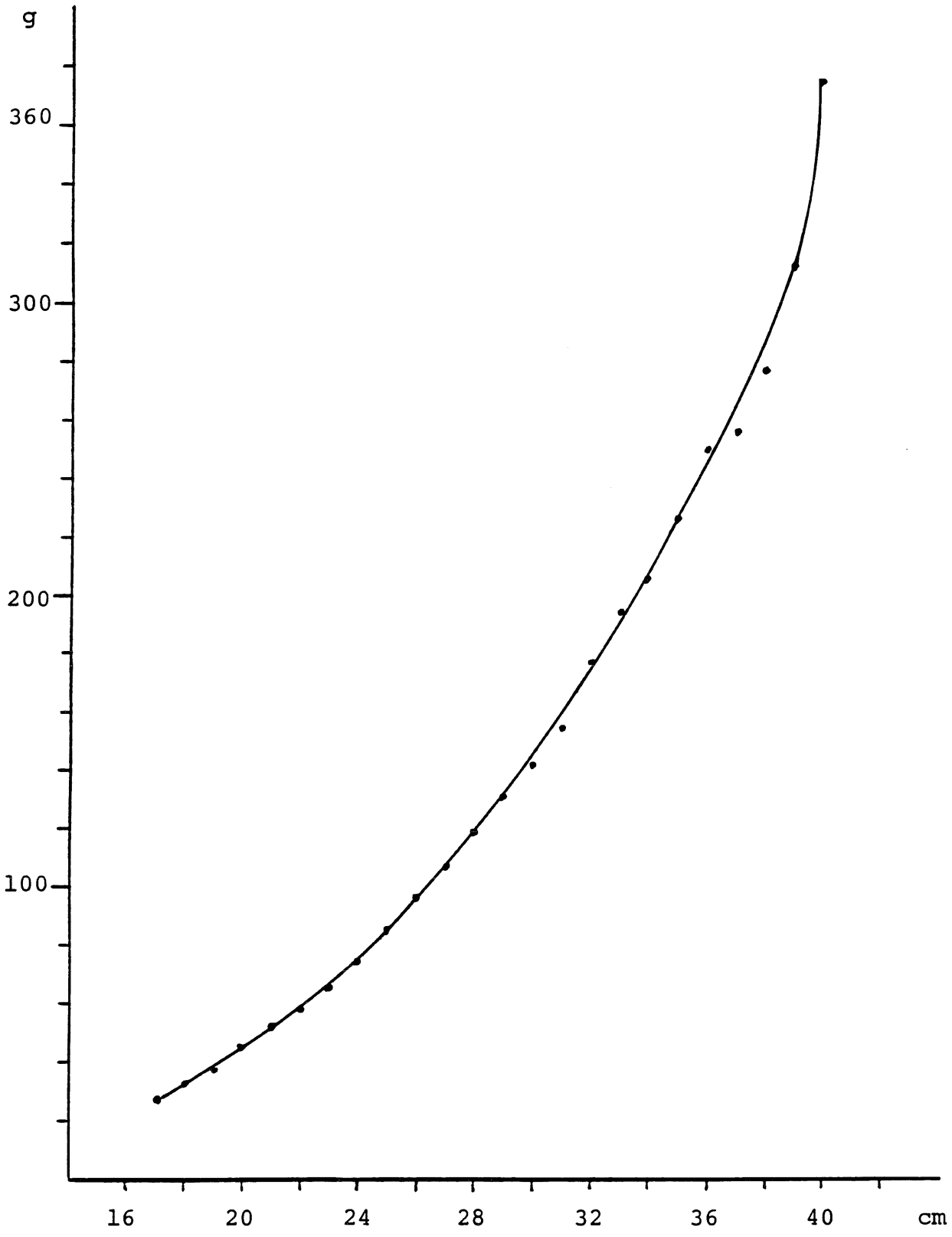

Fig. 9. Weigth by lenght groups of blue whiting in the spawning area in spring 1993. Combined results. Curve drawn by hand.

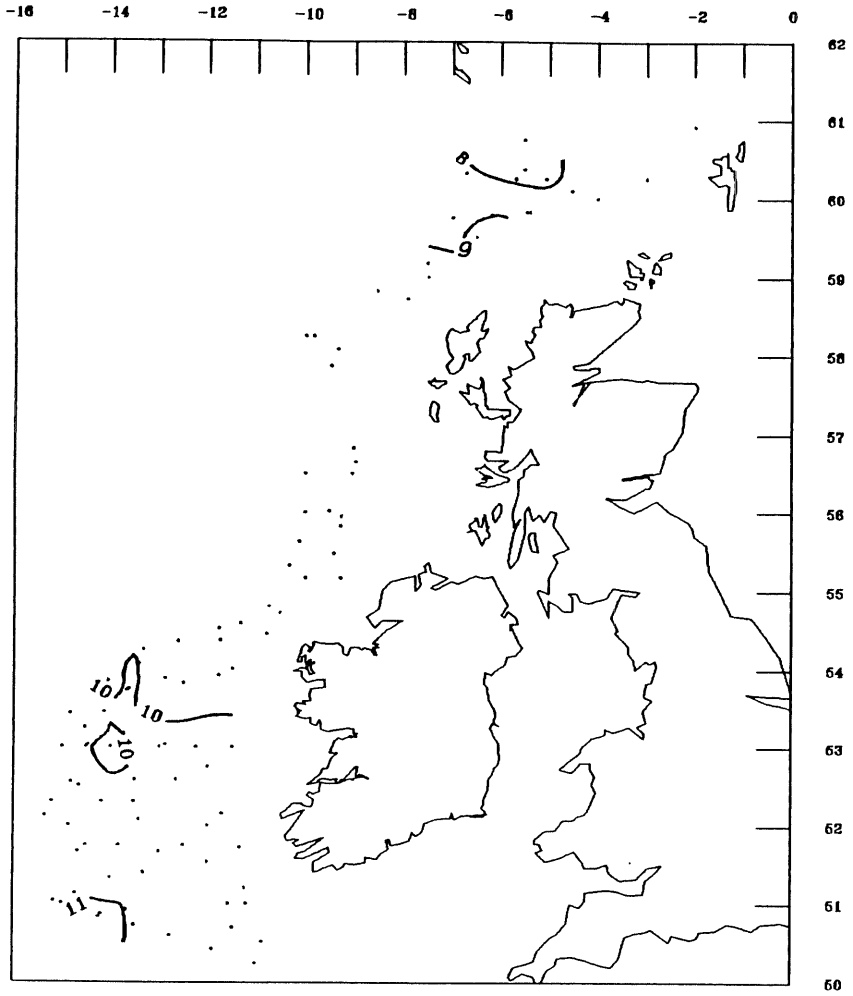

Fig.10a. Temperature, t°C, at sea surface, spring 1993. Dots indicate position of observations.

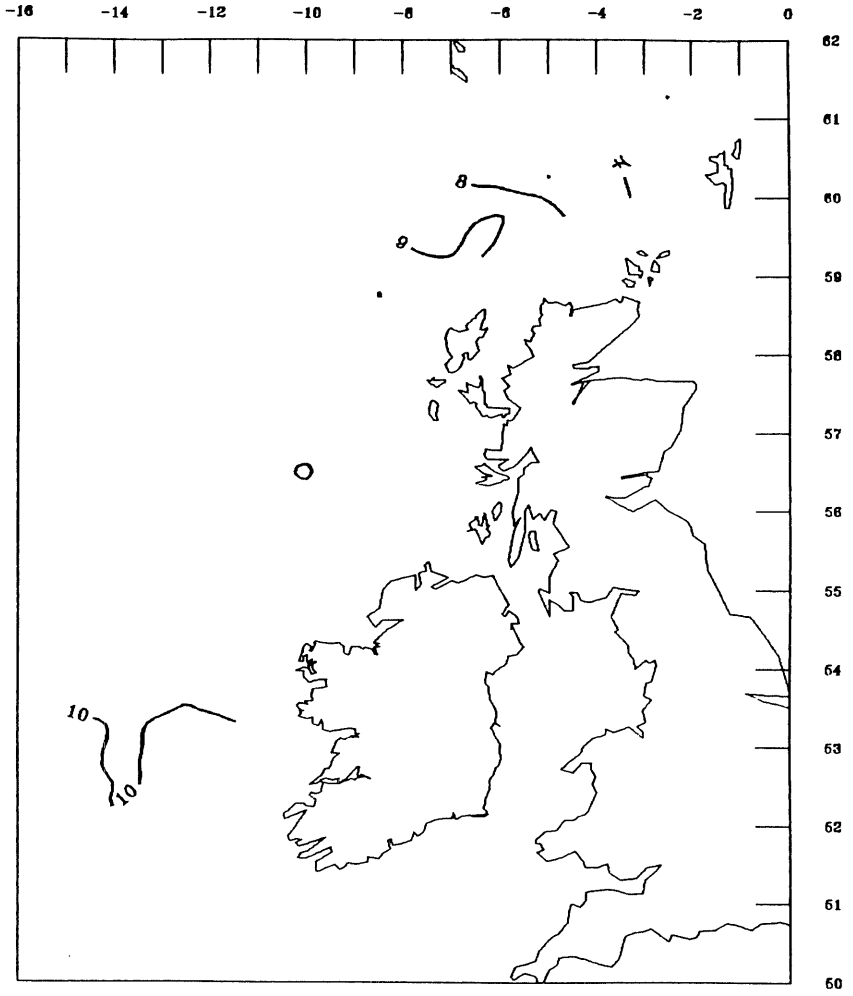

Fig.10b. Temperature, t°C, at 200 m deth, spring 1993.

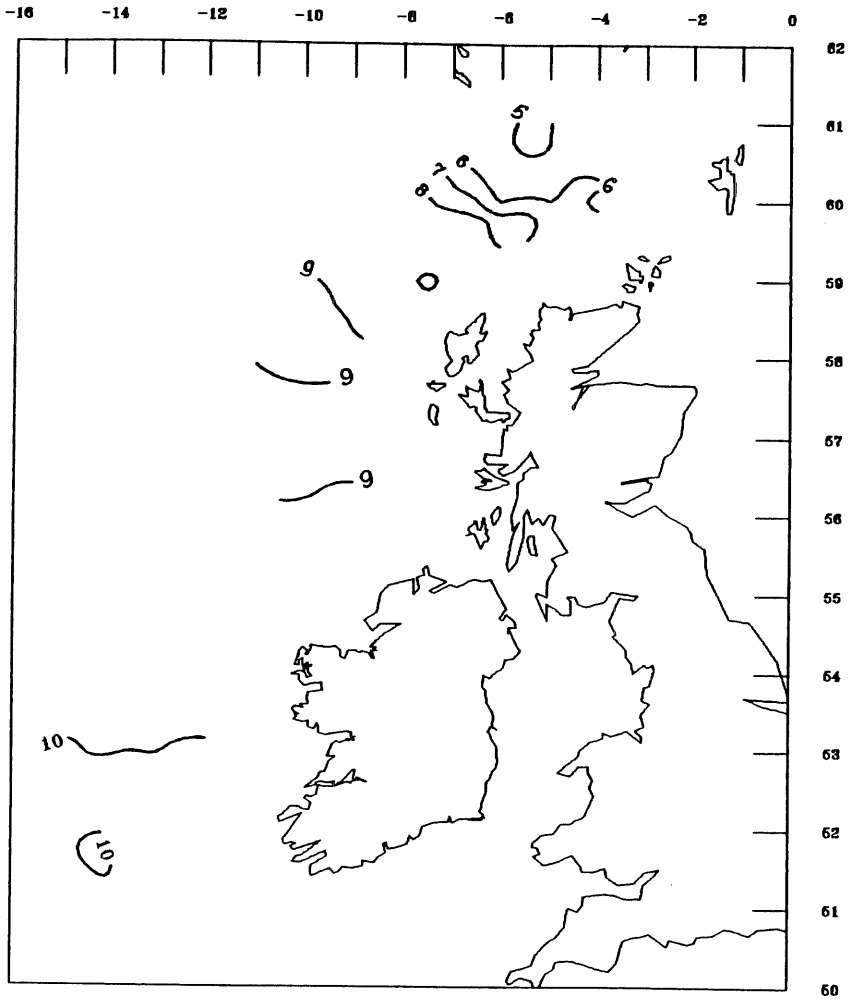

Fig.10c. Temperature, t°C, at 400 m deth, spring 1993.

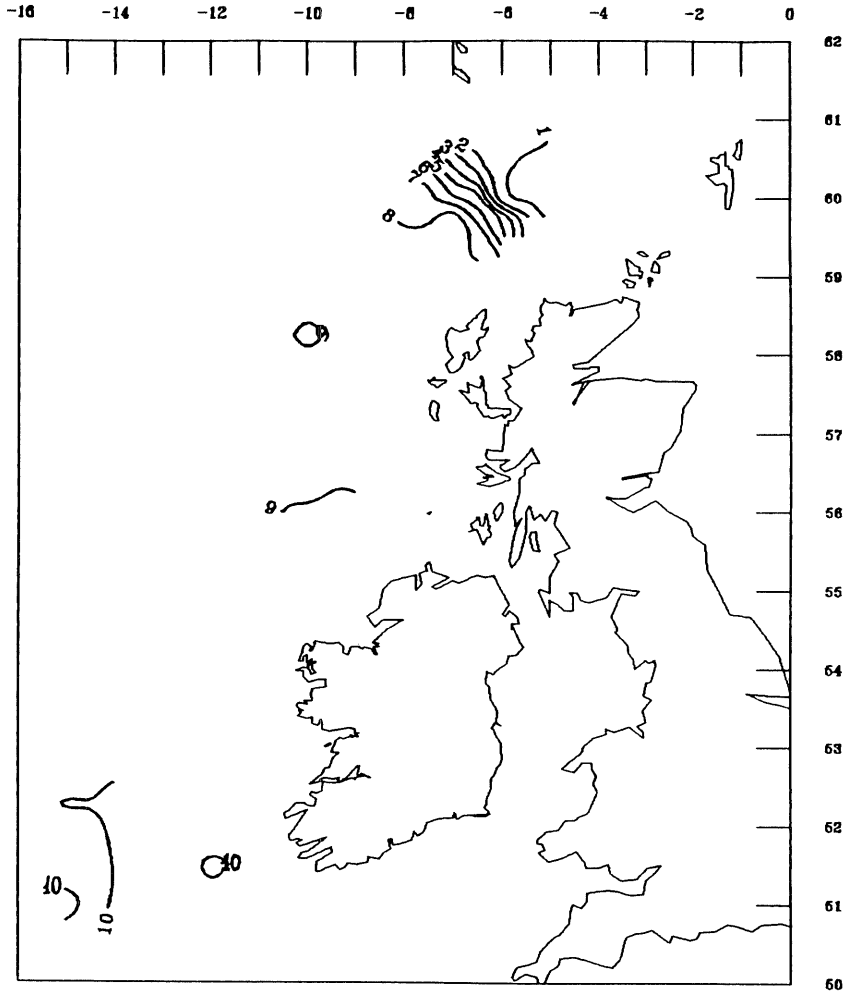

Fig.10d. Temperature, t°C, at 600 m deth, spring 1993.