International Council for
the Exploration of the Sea

C.M. 1996/H: 12
Pelagic Fish Committee

REPORT OF THE JOINT NORWEGIAN-RUSSIAN ACOUSTIC SURVEY ON BLUE WHITING DURING SPRING 1996.

by

Terje Monstad
Institute of Marine Research
P.O.Box 1870, Nordnes, N-5024 Bergen
Norway

and

Sergei V. Belikov and Eugene A. Shamrai
Polar Research Institute of Marine Fisheries and Oceanography
(PINRO), 6 Knipovich Street, 183763 Murmansk
Russia

ABSTRACT

In March/April 1996 the sixth Norwegian-Russian joint acoustic survey on the blue whiting spawning stock was carried out. The bank and shelf edge area to the west of The British Isles was covered from south to north by a Norwegian vessel and from north to south by a Russian vessel.

Due to time difference between the coverages by the two vessels it was decided not to combine the data for a common estimate. Although there was difference in the observed abundance, and the stock some below than last year's level, it was found to be in a rather stable condition.

The three yearclasses, 1993, 1994 and 1995 dominated in the total estimate of the blue whiting stock.

The hydrographic situation in the surveyed area was sligthly different from 1995, i.e. the temperature being some higher. Due to this the peak of spawning was earlier and hence the postspawning migration from south to north about a week earlier than usual.

INTRODUCTION

Each spring since 1990 Russia and Norway have carried out joint surveys on the blue whiting spawning stock in the area west of the British Isles, except for 1994 when Norway surveyed the stock alone (Monstad and Belikov, 1993; Monstad et al., 1994, 1995). However, for several years before 1990, both countries carried out separate surveys, and although the contact was rather informal, an exchange of biological and hydrological information took place. The sixth joint survey on the blue whiting spawning stock was then carried out during 24 March-19 April 1996.

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 recording the structure and composition of the stock.

The Norwegian survey in 1996 was also included in the SEFOS project (EU-AIR programme), and personell from PML, Plymouth, participated onboard the R.V. "Johan Hjort" for egg-and larvae studies. The results herefrom will be publishes in other reports. In addition several standard SEFOS hydrographical sections (SSS) were worked.

MATERIAL AND METHODS

The bank and shelf edge area between latitudes 48°30' and 62°00'N, i.e. from south of Ireland to Faroese Islands, was surveyed during the period March 24 - April 19 (Figures 1ab and 2). One research vessel from each country participated within time period and geographical area (latitudes) as follows:

Norway: "Johan Hjort", 24 March-19 April, 48°30'-62°00'N.
surveying from south to north.

Russia: "Fridtjof Nansen", 01-17 April, 51°00'-62°00'N,
surveying from north to south.

Both of the research vessels operated echo sounders of 38 KHz frequency (Simrad EK 500), which were connected to integrator systems and precalibrated by use of a copper sphere (Foote, 1981). When the vessels met, neither the weather conditions nor the recordings were suitable for a ship-to-ship calibration as planned, and due to time limit a calibration was therefore not performed. Instead the result of last years calibration, which gave a relationship of 1:1, was decided to be used as reference (Monstad et al., 1995). The instrument settings are given in Appendix I.

Pelagic trawl as well as bottom trawl were used for identifying of the echo recordings and collection of biological samples. The Norwegian vessel used a Rock-hopper bottom trawl with 18 x 4 m opening and a pelagic trawl with 25 m vertical opening (500m circumference), both having an innernet of 11mm mesh size. Russia used a pelagic trawl with 45m vertical opening and an innernet of 16mm mesh size.

For assessment of abundance and biomass the area surveyed was treated on maps as 5

separate subareas, which again were divided into rectangles of 0.5 ° latitude and 1° longitude size. The echo recordings were scrutinized for allocation of the integrator values (S_a) to various species or groups of species.

The method for the caculation was the same as used for previous blue whiting surveys described e.g. in Monstad (1986) and Belikov et al. (1990), with the target strength as:

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

where L is fish length. This gives the density coefficient value:

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

For hydrographic observations a CTD sonde was used at a number of stations, in general operated from sea surface to 600 m depth or to bottom if more shallow, and to 1.500 m at the standard sections worked.

In addition to radio comunication the vessels also met once at open sea for exchange of preliminary data and results. Due to rough sea the data was wrapped in water tigh plastic bags attached to floats, dropped into the sea and picked up by the other vessel. When R.V."Fritdtjof Nansen" called at Bergen 23-24 April, a post-survey meeting was held for a final exchange of data and discussion of the results.

RESULTS AND DISCUSSION

Distribution

Concentrations of blue whiting were recorded throughout most of the area surveyed, with a distribution pattern very similar to that of previous years.

Norway, which surveyed the area from south to north, recorded blue whiting along the continental slope mostly in a 50m thick "belt" varying between 300m and 500m depths, from about 1000m bottom depth towards the edge. The highest concentrations were found in the northern part of the Porcupine bank area at the shelf edge between 53°30' and 54°00'N, and less than a week later along the edge off St. Kilda west of the Hebrides, i.e. between 57°00' and 58°00'N (Figure 3).

Russia, surveying the area from north to south, obtained a similar picture of the distribution, but with the highest concentration found at the shelf between the latitude 56°30' and 57°00'N (Figure 4).

Stock size

The two countries separate estimates of the total biomass and abundance, as well as mean length and weight at age, are given in Tables 1 and 2, and the corresponding results of the acoustic assessment for each subarea in Tables 3 and 4. The Norwegian estimate of the total blue whiting echo recordings came out with a biomass of 5.1 mill. tonnes representing 52.2 x 10^{-9} individuals. Of this, 4.5 mill tonnes, or 36.2 x 10^{-9} individuals belonged to the spawning stock. The corresponding Russian results were a total of 7.1 mill tonnes biomass representing 57.3 x 10^{-9} individuals, of which 5.8 mill tonnes or 39.0

x 10^{-9} individuals belonged to the spawning stock. On Figures 5 and 6 the biomass estimate by rectangle are shown for Norway and Russia respectively.

The time difference between the coverages during the spawning season resulted in different biological data due to changes in proportions of fish at various maturity stages and the corresponding weights. The concentrations had moved northwards or partly migrated to areas outside the surveyed ones.

As much as the difference between the to estimates of the spawning stock size appeared to be 1.3 mill. tonnes biomass and 2.8 x 10^{-9} individuals, they were not to combined to a common result. The size of the spawning stock, however, was found to be at a rather stable level, between 4.5 and 5.8 mill. tonnes.

In the 3 text tables below the total estimates in the spawning area since 1990 are given for the biomass (A), the abundance (B) and the total mean weight and length (C). Corresponding spawning stock sizes are given in brackets.

A. Biomass in mill.tonnes:

	Russia	Norway	Combined
1990	5.4 (5.1)	6.3 (5.7)	-
1991	4.6 (4.2)	5.1 (4.8)	4.7 (4.4)
1992	3.6 (3.3)	4.3 (4.2)	4.6 (4.3)
1993	3.8 (3.7)	5.2 (5.0)	5.1 (4.9)
1994	-	4.1 (4.1)	-
1995	6.8 (6.0)	6.7 (6.1)	6.9 (6.1)
1996	7.1 (5.8)	5.1 (4.5)	-

B. Abundance, N x 10^{-9}:

	Russia	Norway	Combined
1990	39.1 (35.3)	62.9 (56.2)	-
1991	35.8 (29.3)	41.5 (40.9)	38.6 (35.2)
1992	40.2 (36.9)	38.4 (36.8)	40.2 (36.9)
1993	39.3 (29.4)	41.5 (39.8)	41.1 (39.3)
1994	-	26.8 (26.1)	-
1995	66.4 (44.3)	62.0 (45.2)	67.4 (45.5)
1996	57.3 (39.0)	52.2 (36.2)	-

C. Total mean weight (g) and length (cm):

	Russia		Norway		Combined	
	w	l	w	l	w	l
1990	139.0	28.6	100.7	27.1	-	-
1991	124.5	27.5	115.7	27.8	121.8	28.0
1992	113.4	27.5	111.3	27.5	113.0	27.5
1993	123.6	28.1	124.6	28.6	123.6	28.1
1994	-	-	152.9	31.1	-	-
1995	102.6	25.7	108.2	26.9	102.9	26.0
1996	123.1	27.9	94.9	25.5	-	-

Stock composition

The length and and age composition for each sub-area by country are shown on Figures 7 and 8 for Norway and Russia respectively, and the corresponding distributions for the total area on Figures 9 and 10. Norway caught more young fish than Russia, and according to the samples, the 1995 yearclass dominated in the area, contributing with 30% in numbers, while Russia found the 1992, 1993 and 1994 yearclass to be the dominant ones. These yearclasses, however, were also significant in the Norwegian samples, and both countries found them mostly in the middle areas where the highest spawning concentrations were recorded. The one year olds were most numerous in the north and in the south.

This survey verified the strength of the 1995 yearclass, which as 0-group was reported to be abundant in the Norwegian Trench (Tveite, 1996), and formed a significant portion of the successfull fishery of the Norwegian industrial fisheries in the North Sea autumn 1995 (Lahn-Johannessen, pers.comm.).

Hydrography

Synoptical conditions in the area surveyed had a cyclonic character with a well pronounced meridional transport of air masses. Winds of southern directions (55%) were predominant at the wind force 3-5 (46%).

In spring 1996 water circulation was in general similar to the long-term mean. Geostrophic circulation was weak except for a section westwards from the Shetland Isles. Over the Porcupine bank the flow, following the slope in a southern direction, formed a cyclonic meander without a closed structure formation.

Distribution of temperatures at 0, 200, 400 and 600m depths are given in Figures 11-14 respectively. Compared to 1995 a rise in the temperature by 0.2-0.4° C in the sea surface, was observed over the whole area surveyed. Maximum values for temperature, 11.47° C, were registered in the southern area of operation where, for the first time since 1992, the isoterme of 11° C reached 400m depth. More active penetration of the North Atlantic Current Waters into the mid-water of the shelf was observed in 1996, which was confirmed by extreme north-eastern position of the 10° C isotherme for the recent 5 years.

Mean temperature in the section along 53°00'N (Figure 15) was higher than previous years by 0.25-0.28° C in all layers, and positive anomalies made up 0.21° C in 0-200m. Compared to 1995 the temperature was markedly higher, i.e. 0.63° C, in 500-1000m layer on the Porcupine bank western slope, and horizontal gradients in a layer of the most intensive downwelling of waters (650-900m) attained 0.11° /mile. The peak of blue whiting spawning in the area was observed to be earlier than usual, which could be due to this. Consequently the postspawning migration from south to north was also earlier, i.e. about a week.

The temperatures along the section between Faroe Islands and Shetland (Figure 16) were markedly higher than in 1995, showing values of 2-3° C in 500m depth, against 0° C in 1995. Variaton in circulation, from a cyclonic one observed in 1995 to anticyclonic, was observed in the area between the northern extremity of the British Isles and Faroes, which was confirmed by a variation in a temperature field strucure at 600m depth. Compared to 1995, the area occupied by the Arctic waters with negative temperature in 1996, was essentially reduced. This indicates both a poor upwelling of waters, usually observed in the Faroe-Shetland Channel area, and the most intensive advection of the North Atlantic Current waters along this section for the recent 5 years.

REFERENCES

Belikov, S.V., Mahon, D.M. and Molloy, J. 1990. Results of blue whiting investigations in the northeast Atlantic in spring 1990. ICES, Doc. C.M. 1990/H:38.

Foote, K. G., 1981. Echo sounder measurements of back-scattering cross sections of elastic spheres. Fisken og Havet, Ser. B, 1981 (6). Institute of Marine Research, Bergen.

Monstad, T., 1986. Report of the Norwegian surveys on blue whiting during spring 1986. ICES, Doc. C.M. 1986/H:53.

Monstad, T. and Belikov, S.V. 1993. Report of the joint Norwegian-Russian acoustic survey on blue whiting, spring 1993. ICES, Doc. C.M. 1993/H:10.

Monstad, T., Belikov and Coombs, S.H. 1994. Investigations on blue whiting in the area west of the British Isles, spring 1994. ICES, Doc. C.M. 1994/H:12.

Monstad, T., Belikov, S.V., Shamrai, E.U. and McFadzen, I.R.B. 1995. Investigations on blue whiting in the area west of the British Isles, spring 1995. ICES, Doc. C.M. 1995/H:7.

Tveite, S., 1996. Intern toktrapport, F/F "Michael Sars" i Norskerenna, 13.-30. Okt. 1996. "Survey report of R.V. 'Michael Sars' in the Norwegian Trench, 13-30 Oct. 1996" (in Norwegian). IT 1/96, IMR, Bergen.

APPENDIX I. Acoustic equipment and settings of the instruments:

	"Johan Hjort"	"Fridtjof Nansen"
Echo sounder:	Simrad EK-500	Simrad EK-500
Frequency:	38 kHz	38 kHz
Transducer:	ES-38B-SK	ES-38
Absorbtion coeff:	10 dB/km	10 dB/km
Pulse length:	Medium (1 ms)	Medium (1 ms)
Band width:	Wide (3.8 kHz)	Wide (3.8 kHz)
Transmitter power:	2000 W	2000 W
Angle sensivity:	21.9 dB	21.9 dB
2-way beam angle:	-21.0 dB	-21.4 dB
Sv Transducer gain:	28.1 dB	23.1 dB
Ts Transducer gain:	27.8 dB	23.2 dB
3 dB beam width:	7.3 dg	6.5 dg
Range:	1000m	500m

Table 1. Abundance estimate of blue whiting west of the British Isles, March/April 1996.
R.V. "Johan Hjort", Norway.

Number: N x 10^{-6} Mean length: cm

Mean weight: grams Condition: 1000 x weight/length^3 Biomass: Thousand tonnes

cm	years 1	2	3	4	5	6	7	8	9	10	11	12+	N	Biomass	Mean weight
10													0	0	
11													0	0	
12													0	0	
13	2												2	0.0	10.0
14	96												96	1.4	14.8
15	574												574	9.7	16.9
16	1472												1472	31.5	21.4
17	1847	14											1861	49.2	26.4
18	3921	117											4038	127.7	31.6
19	4901	970											5871	221.3	37.7
20	2965	1709											4674	202.4	43.3
21	819	1794											2613	131.0	50.1
22	32	818											850	48.1	56.6
23	42	676											718	48.6	67.7
24		870	49	8									927	68.6	74.0
25		999	490										1489	125.2	84.1
26		678	1819	184	34								2715	250.5	92.3
27		136	2550	920	23	14	30						3673	374.9	102.1
28			1637	2301	76	138	5						4157	476.3	114.6
29			691	2836	386	312	178	8					4411	566.2	128.4
30			186	1330	595	1313	508	6					3938	562.7	142.9
31			11	559	595	1291	882	90	105	39			3572	562.5	157.5
32				122	382	670	584	238	66	5	4		2071	358.6	173.2
33				111	158	237	688	176	25		11	11	1417	260.3	183.7
34					118	374	479	162	73	9	32	4	1251	246.2	196.8
35					20	54	438	227	37	76	34	5	891	196.2	220.2
36					12	44	196	199	62	12	4		529	122.3	231.1
37						5	55	43	44	6	12		165	41.8	253.5
38						3	56	40	28				127	35.3	277.7
39							8	13	6	10			37	11.5	310.1
40							4		5	5			14	4.7	336.2
41									8				8	2.8	352.0
42													0	0.0	0.0
43											8		8	3.0	373.0
Number	16671	8781	7433	8371	2399	4455	4111	1202	459	162	105	25	54169		
Length	18.9	22.5	27.6	29.3	31.2	31.6	33.0	34.5	34.6	34.9	35.8	35.0	25.5		
Biomass	578.6	519.9	776.8	1037.4	367.5	714.7	736.2	247.1	97.5	35.1	25.4	4.3	5140.5		
Weight	34.7	59.2	104.5	123.9	153.2	160.4	179.1	205.6	212.5	216.7	242.0	212.4	94.9		
Cond.	5.0	5.0	4.9	4.9	5.0	5.1	5.0	5.0	5.1	5.0	5.2	5.5	5.0		

Table 2. Abundance estimate of blue whiting in the northern stock, i.e. 51°30'- 62°00'N, west of the British Isles, April 1996. R.V. "Fridtjof Nansen", Russia.

Length	Age											Abundance	Biomass	Weight	C.F.
cm	1	2	3	4	5	6	7	8	9	10	11+	bln.sp.	thou.tonn	g	
14	6.2											6.2	0.1	13.9	5.1
15	56.1											56.1	1.0	17.6	5.2
16	186.4											186.4	4.1	21.9	5.4
17	504.7											504.7	13.4	26.6	5.4
18	819.8	83.7										903.5	27.7	30.6	5.3
19	680.0	413.6										1093.6	39.6	36.2	5.3
20	1024.1	1617.1										2641.2	111.2	42.1	5.3
21		2284.4										2284.4	111.9	49.0	5.3
22	217.0	1561.2	14.3									1792.6	98.5	54.9	5.2
23		1794.5										1794.5	115.5	64.4	5.3
24		1895.4	421.7									2317.1	174.6	75.3	5.4
25		1826.5	614.7	80.5								2521.7	225.6	89.4	5.7
26		1656.0	1975.2	205.1	10.1							3846.3	360.8	93.8	5.3
27		697.6	4240.4	711.1								5649.1	562.0	99.5	5.1
28		34.6	3255.0	830.6		32.3						4152.4	485.1	116.8	5.3
29		82.3	2638.1	1042.2	158.2		25.7					3946.6	498.4	126.3	5.2
30			1334.5	2323.8	397.9	831.1	110.1					4997.4	682.2	136.5	5.1
31			382.0	1707.4	854.6	1033.4	101.9					4079.3	642.9	157.6	5.3
32			169.7	1586.3	1237.3	1196.5	99.6	83.0				4372.3	731.0	167.2	5.1
33			239.3	1521.7	934.0	1178.8	78.6	221.6				4174.0	757.8	181.5	5.1
34				570.6	778.1	785.6	204.4	52.3				2391.1	479.0	200.3	5.1
35				49.9	337.2	740.2	85.3	85.3				1297.9	305.2	235.2	5.5
36					130.1	573.0	174.3	130.1				1007.5	236.6	234.8	5.0
37					20.8	349.6	313.2	5.5				689.2	180.9	262.5	5.2
38					38.4	16.7	121.0	16.7				192.8	61.1	317.0	5.8
39						102.4	112.9	20.6				236.0	79.7	337.6	5.7
40							38.5	38.5	77.1			154.2	52.9	343.2	5.4
41							16.6		8.3			25.0	9.0	359.7	5.2
42											18.6	18.6	7.5	406.1	5.5
43															
44															
Total	3494.3	13946.8	15284.8	10629.1	4896.9	6839.6	1482.2	653.7	85.4		18.6	57331.4			
Length	18.7	23.1	27.8	30.6	32.4	33.0	35.1	34.6	40.1		42.0	27.9			
Biomass	123.3	944.1	1722.2	1579.6	869.7	1291.8	345.1	142.1	29.4		7.5		7055.1		
Weight	35.3	67.7	112.7	148.6	177.6	188.9	232.8	217.4	344.8		406.1			123.1	
C.F.	5.4	5.5	5.3	5.2	5.2	5.2	5.4	5.3	5.3		5.5				5.2

Table 3. Assessment factors of blue whiting to the west of the British Isles, spring 1996. R.V."Johan Hjort", Norway.

Subarea	Latitude north	Abundance N x 10^{-6}			Biomass thousand tonnes			Mean w (gram)	Mean l (cm)
		immature	mature	sum	immature	mature	sum		
6	60°30' - 62°00'	1587	101	1985	27	14	41	40.7	19.3
5	58°30' - 60°30'	11764	3148	14894	444	468	913	61.3	21.7
4	55°30 - 58°30'	0	18362	18362	0	2516	2516	137.0	30.0
3	53°30' - 55°30'	264	7478	7742	10	931	95	121.5	28.8
2	51°00' - 53°30'	2953	6260	9213	81	528	610	66.2	22.6
1	48°30 - 51°00'	1032	968	2000	25	57	82	41.1	19.8
All subareas		15995	36216	52211	560	4501	5061	94.9	25.5

Table 4. Assessment factors of blue whiting to the west of the British Isles, spring 1996. R.V."Fridtjof Nansen", Russia.

Subarea	Latitude north	Abundance N x 10^{-6}			Biomass thousand tonnes			Mean w (gram)	Mean l (cm)
		immature	mature	sum	immature	mature	sum		
5 - 6	58°30' - 61°30'	5640	6350	11990	375	1039	1415	118.0	25.9
4	55°30' - 58°30'	5136	29016	34151	480	4331	4811	140.9	30.0
3	53°30' - 55°30'	3719	2806	6526	241	349	591	90.5	25.3
2	51°30' - 53°30'	3804	861	4665	168	71	238	51.1	21.2
1	48°30' - 51°30'	-	-	-	-	-	-	-	-
All subareas		9469	47863	57331	1265	5790	7055	123.1	27.9

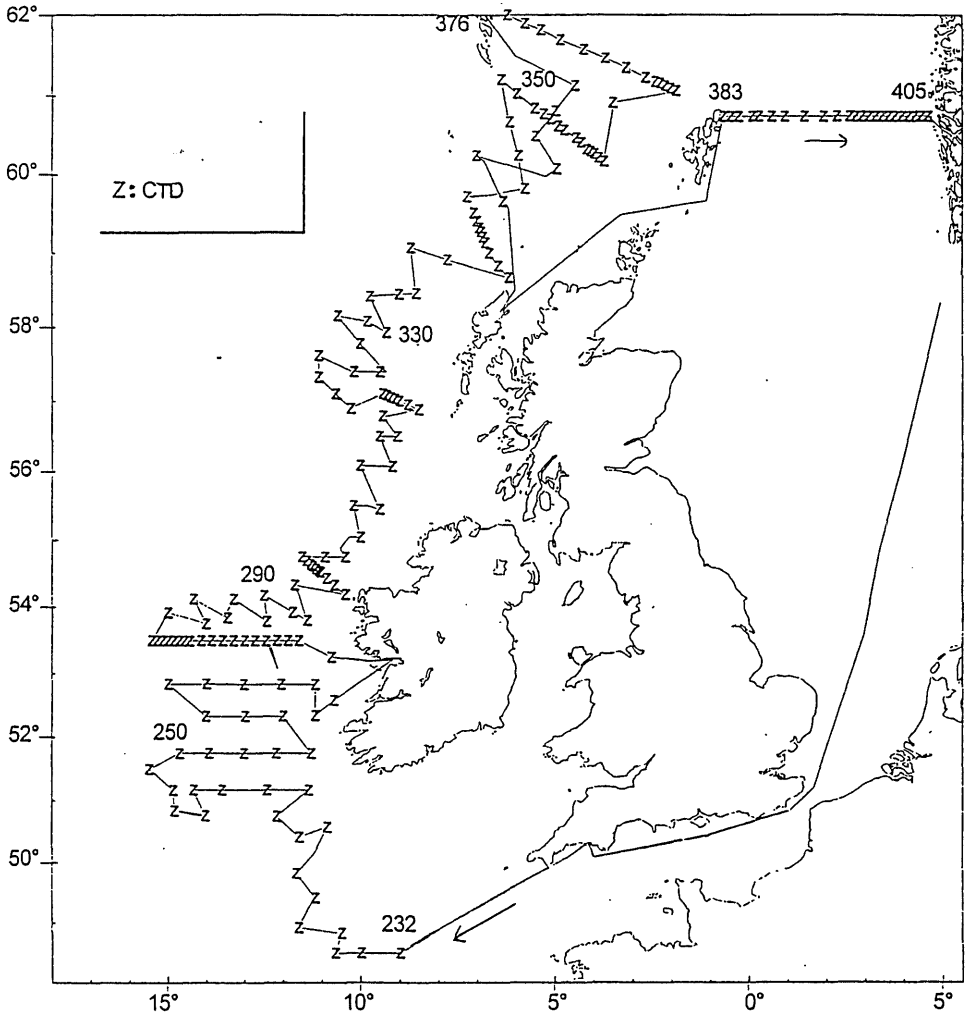

Figure 1a. Cruise track and hydrographic stations (CTD) of R.V."Johan Hjort", Norway, 20 March-22 April 1996.

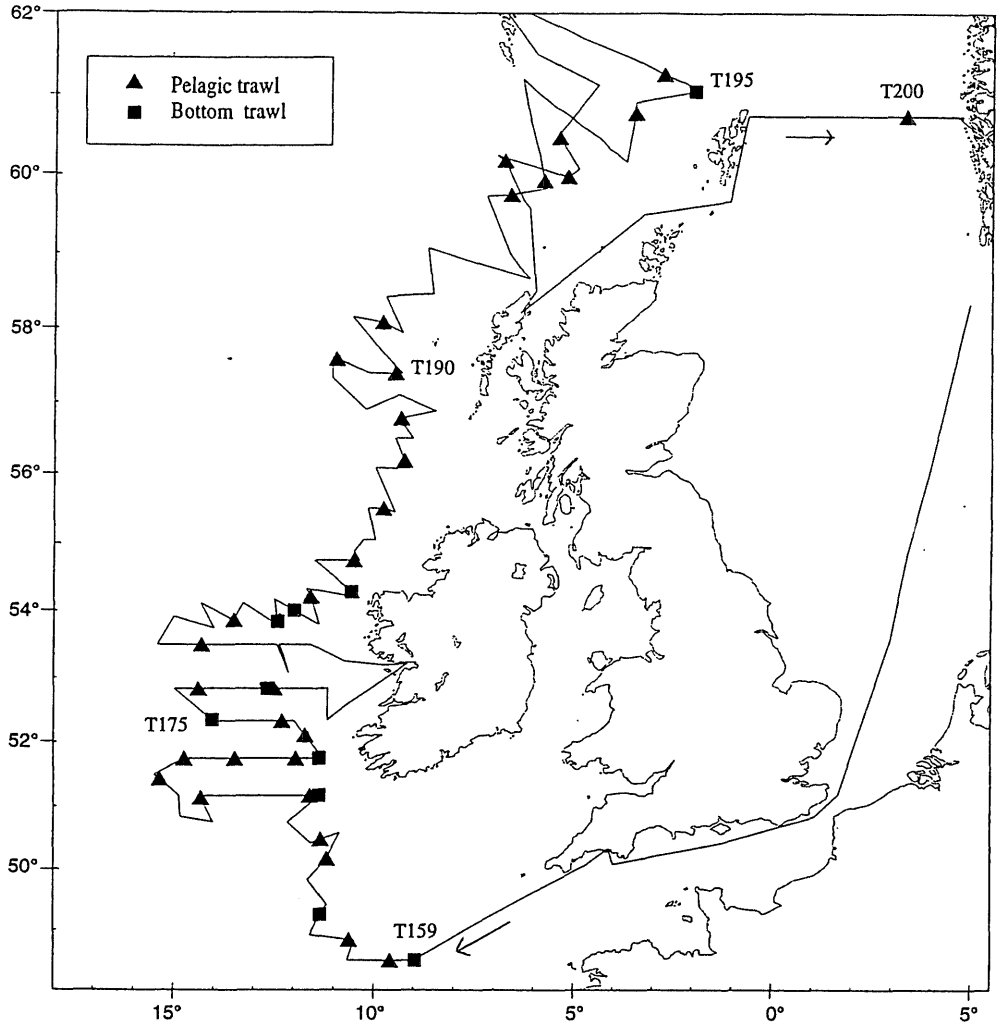

Figure 1b. Cruise track and trawl stations of R.V."Johan Hjort", Norway, 20 March-22 April 1996.

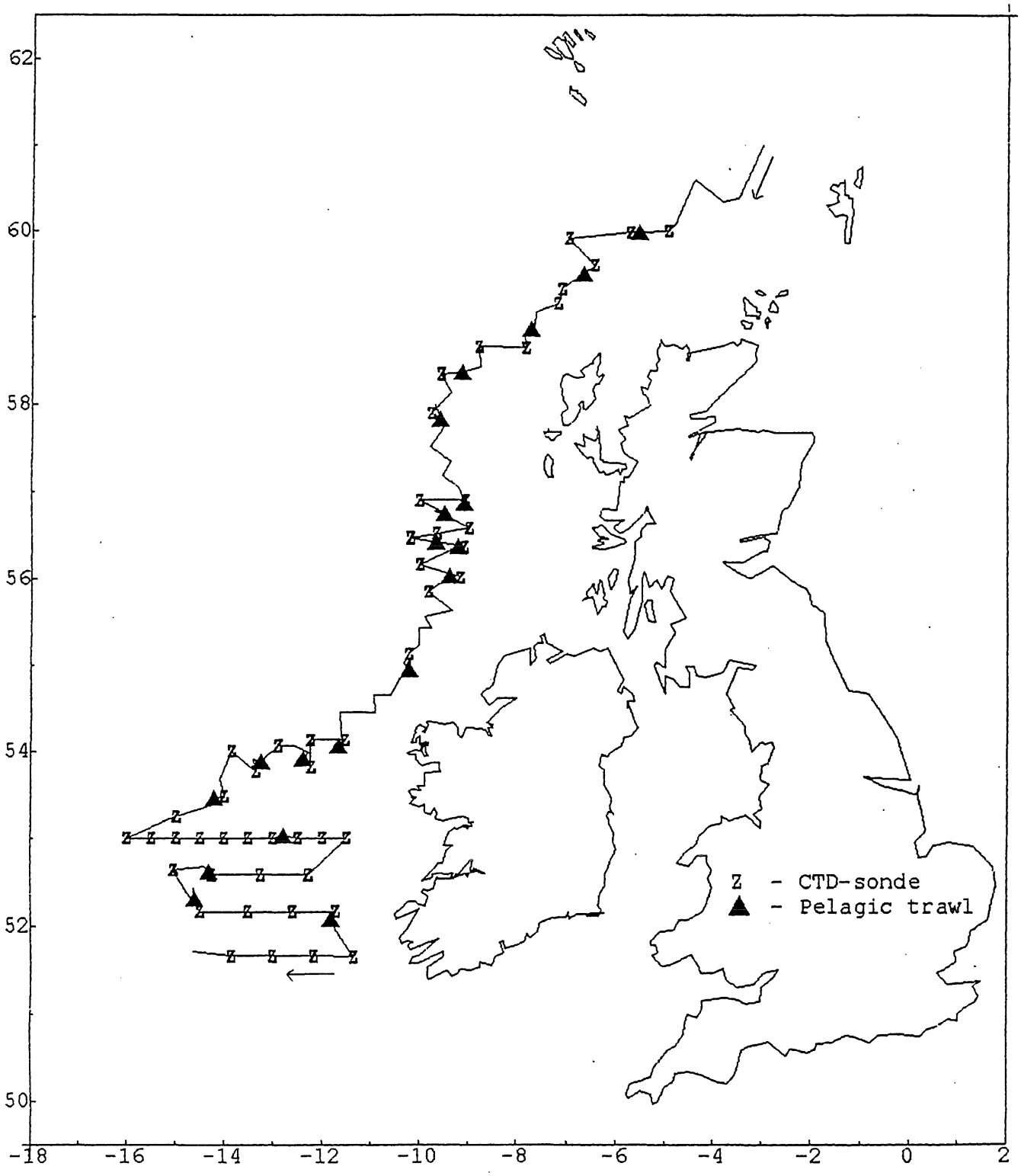

Figure 2. Cruise track and stations of R.V."Fridtjof Nansen", Russia, 1-17 April 1996.

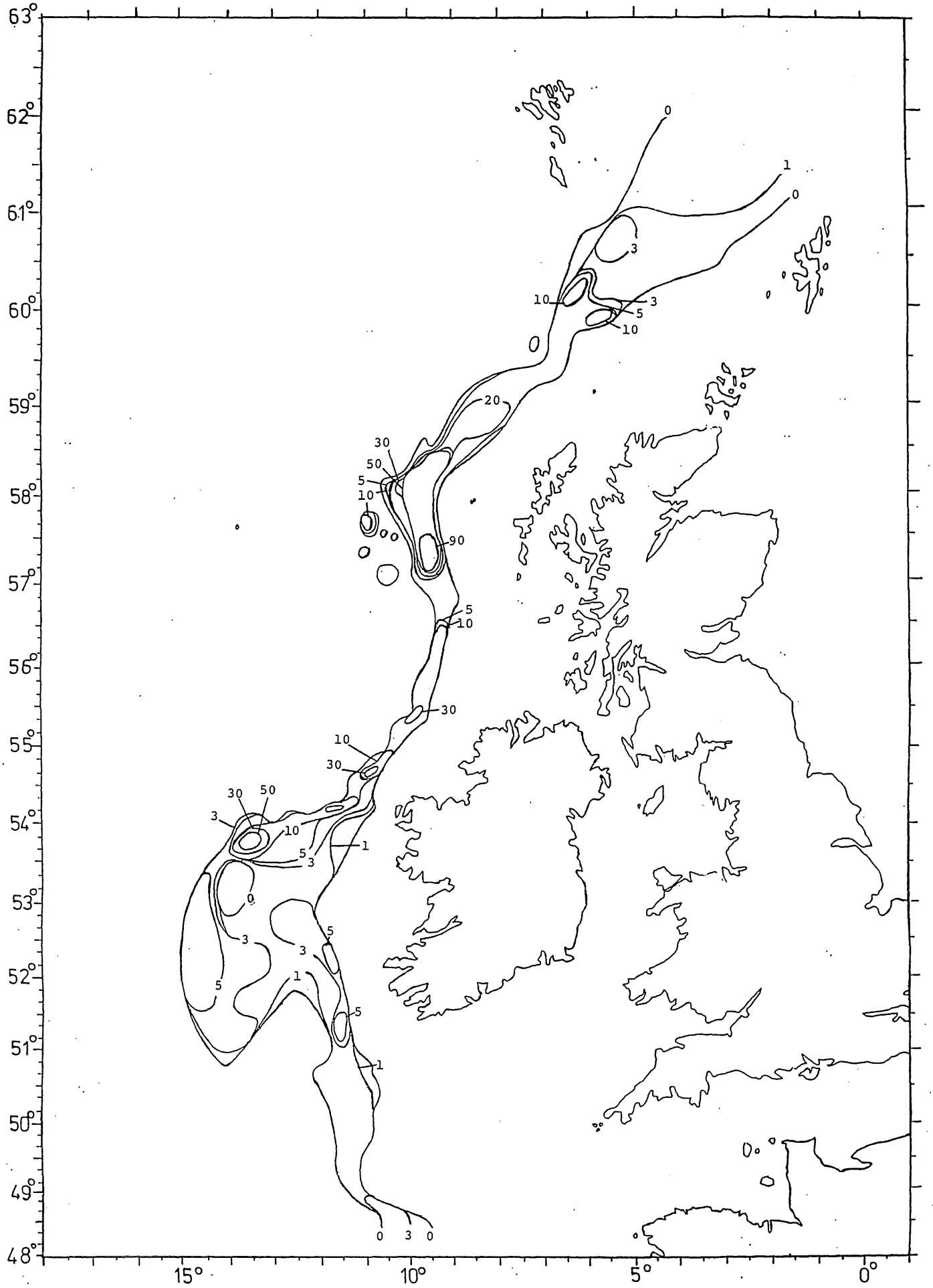

Figure 3. Echo intensity (S_a-values) in m^2/n.mile^2 x 1/100, of blue whiting recorded by R.V."Johan Hjort", spring 1996.

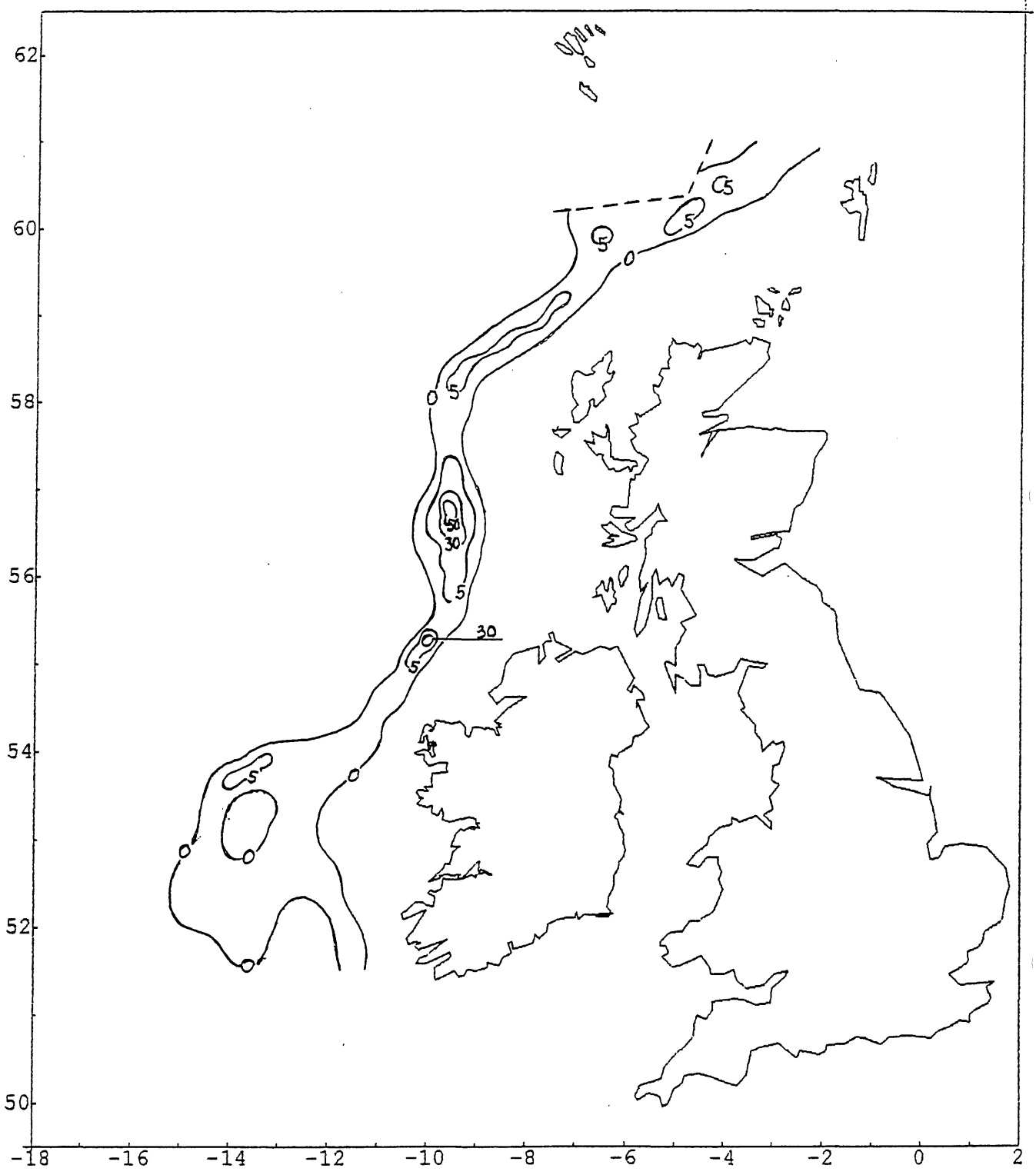

Figure 4. Echo intensity (S_a-values) in m^2/n.mile^2 x 1/1000, of blue whiting recorded by R.V."Fridtjof Nansen", spring 1996.

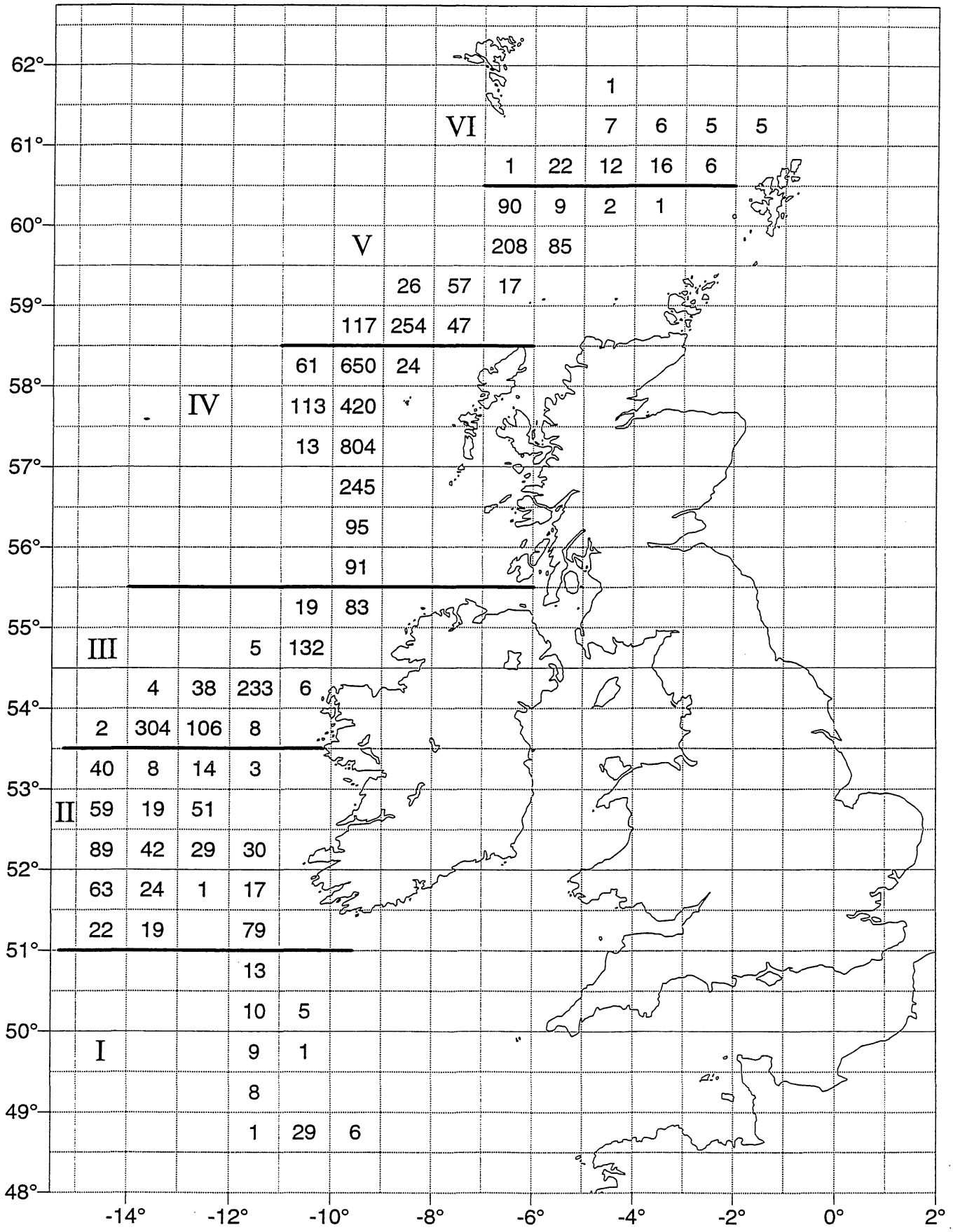

Figure 5. Blue whiting biomass (thousand tonnes), R.V."Johan Hjort",spring 1996. I-VI are subareas used in the assessment.

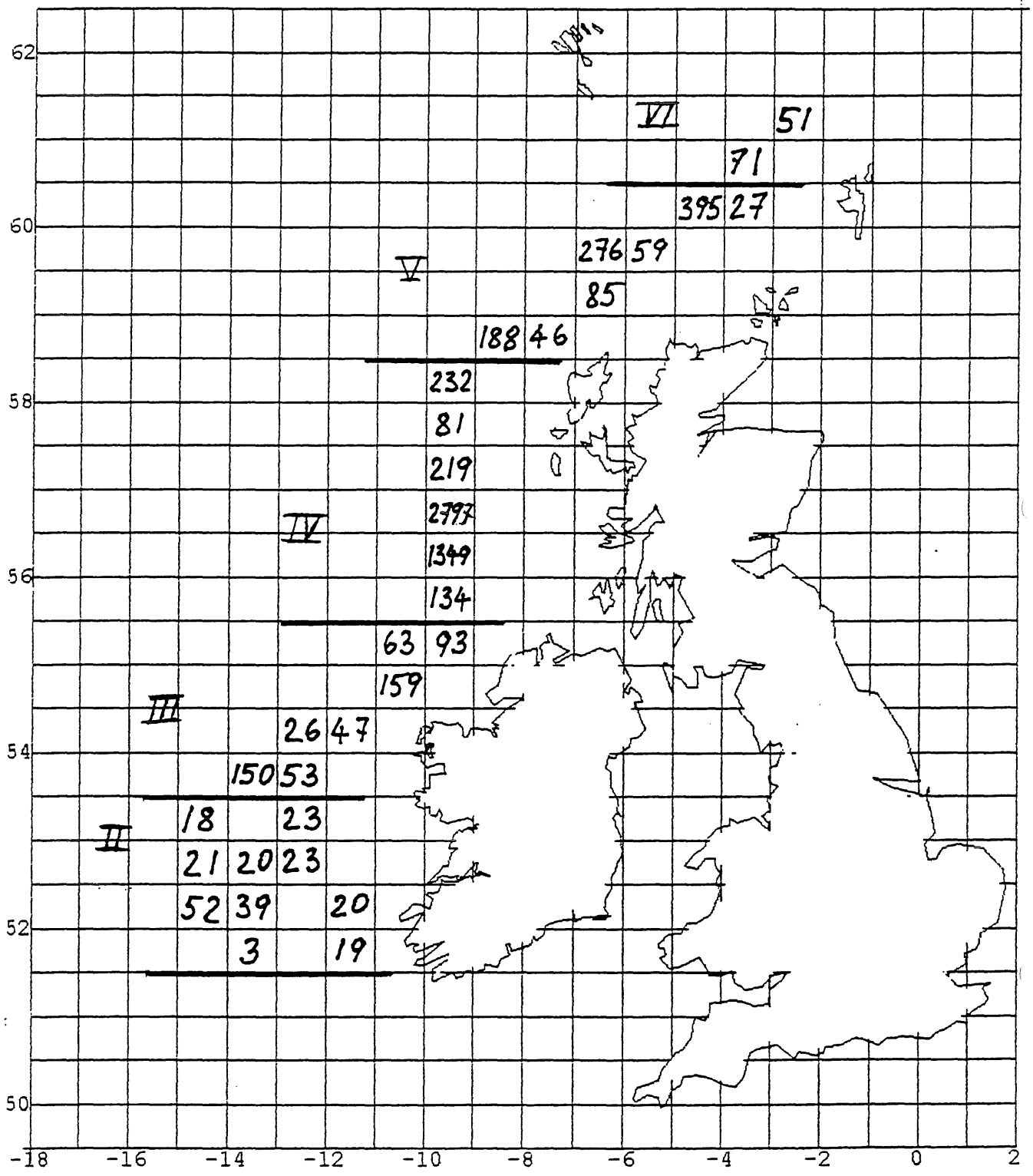

Figure 6. Blue whiting biomass (thousand tonnes), R.V. "Fridtjof Nansen", spring 1996. II-VI are subareas used in the assessment.

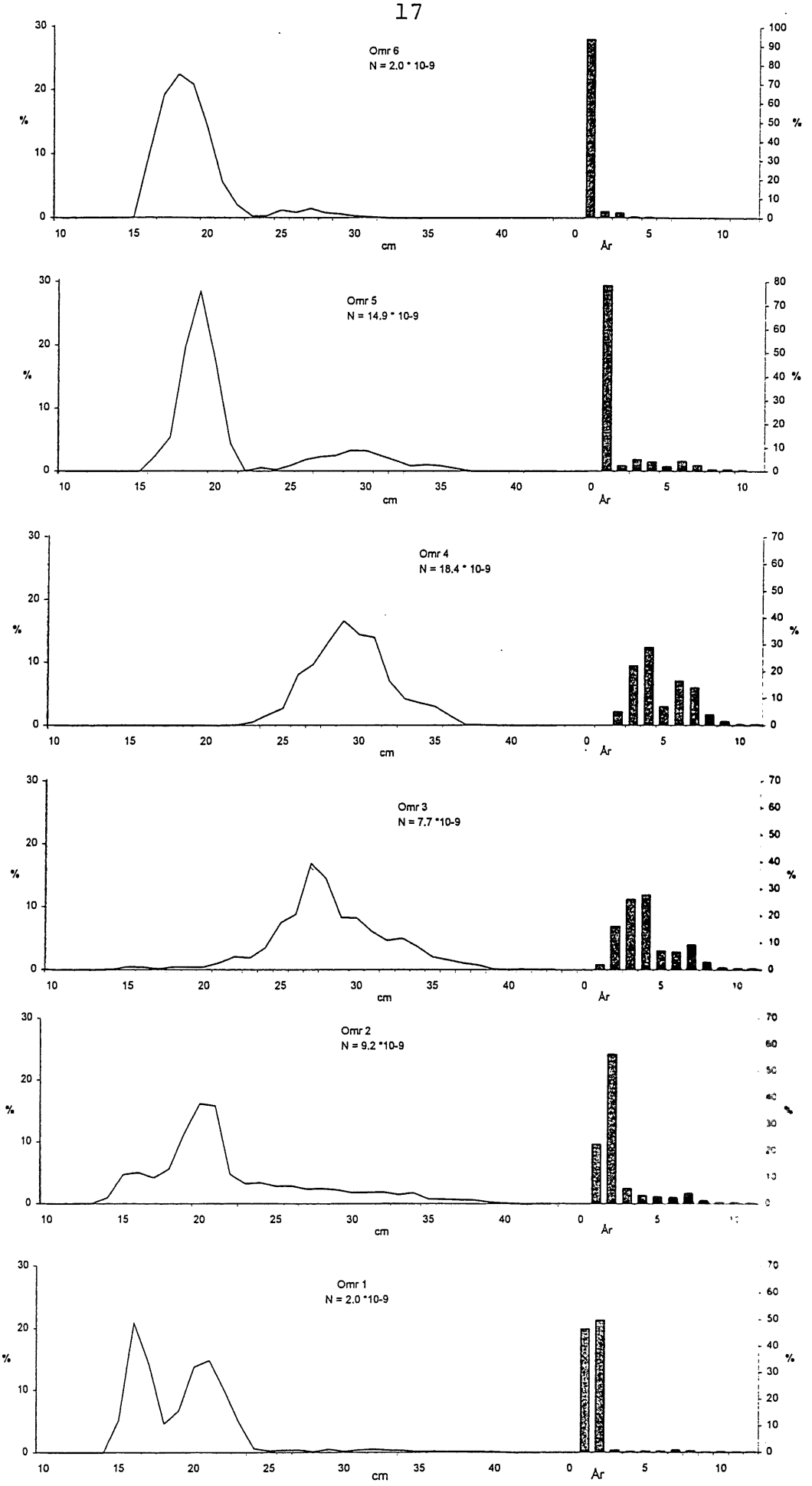

Figure 7. Length and age distribution (N%) of blue whiting by subareas (marked on Figure 5) of blue whiting in the area west of the British Isles, R.V."Johan Hjort", spring 1996. N x 10-9, weighted by abundance.

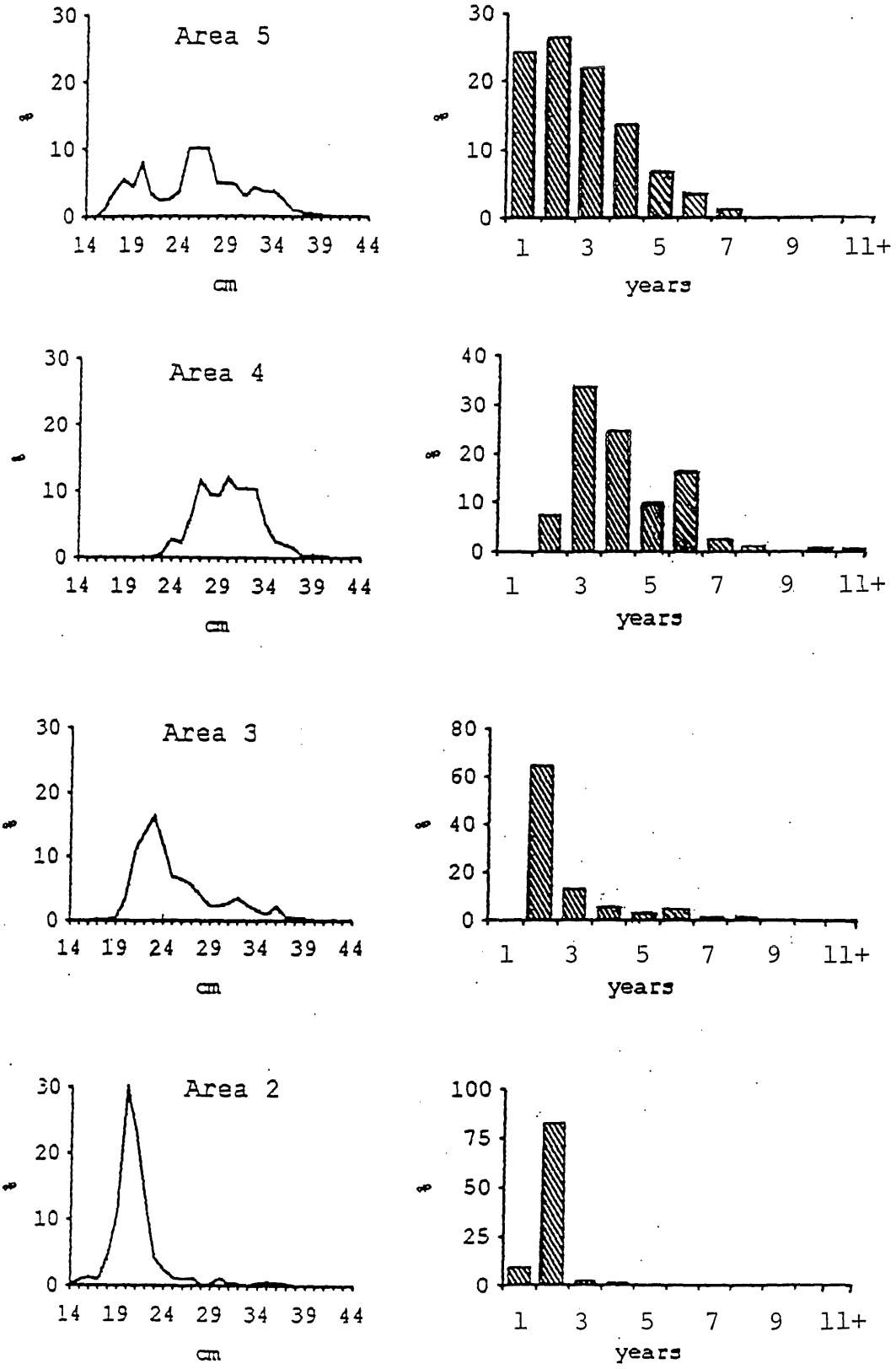

Figure 8. Length and age distribution (N%) of blue whiting by subareas (marked on Figure 6) of blue whiting in the area west of the British Isles, R.V."Fridtjof Nansen", spring 1996. N x 10-9, weighted by abundance.

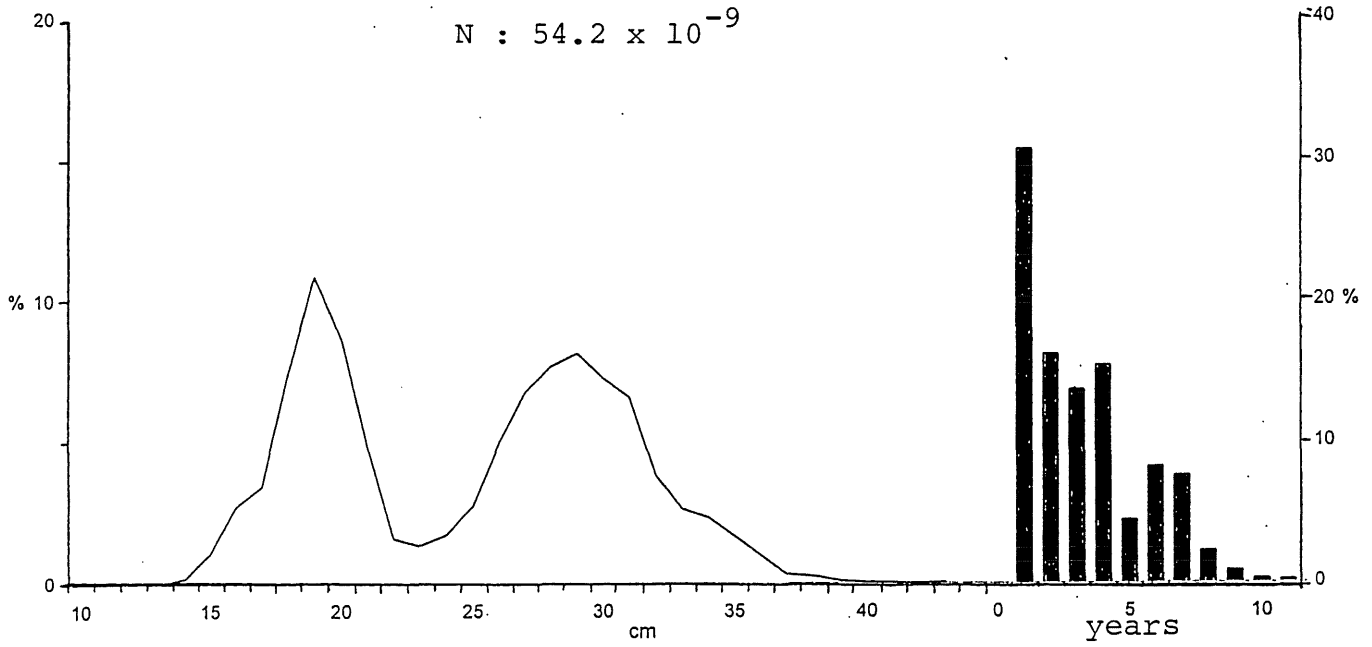

Figure 9. Total length and age distribution (N%) of blue whiting to the west of the British Isles, spring 1996, by R.V."Johan Hjort", Norway, weigthed by abundance.

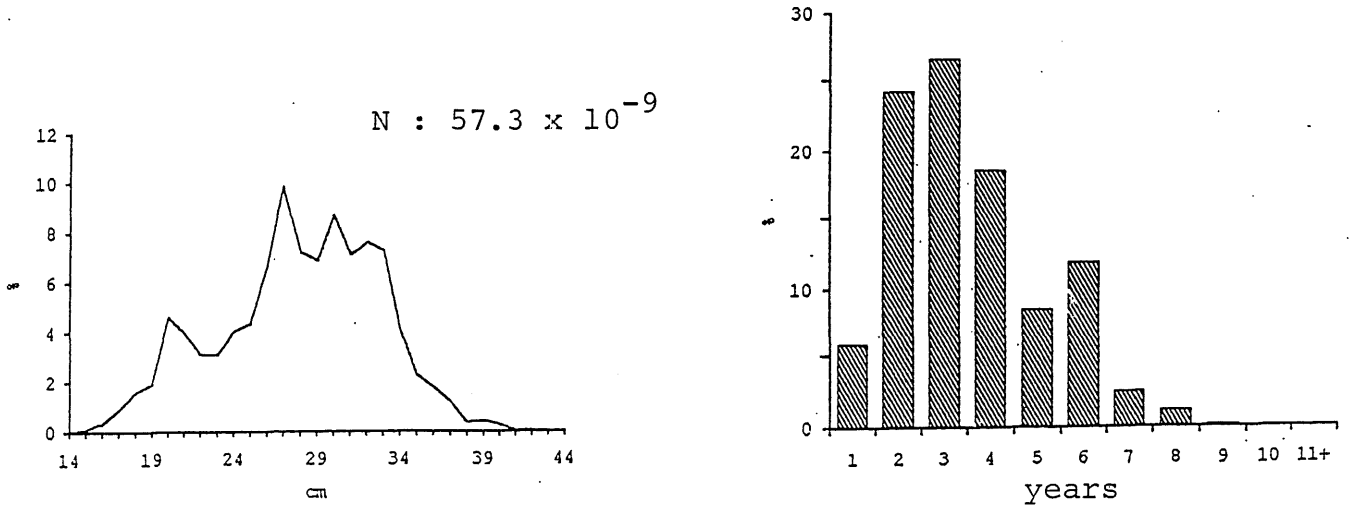

Figure 10. Total length and age distribution (N%) of blue whiting to the west of the British Isles, spring 1996, by R.V."Fridtjof Nansen", Russia. N x 10-9, weigthed by abundance.

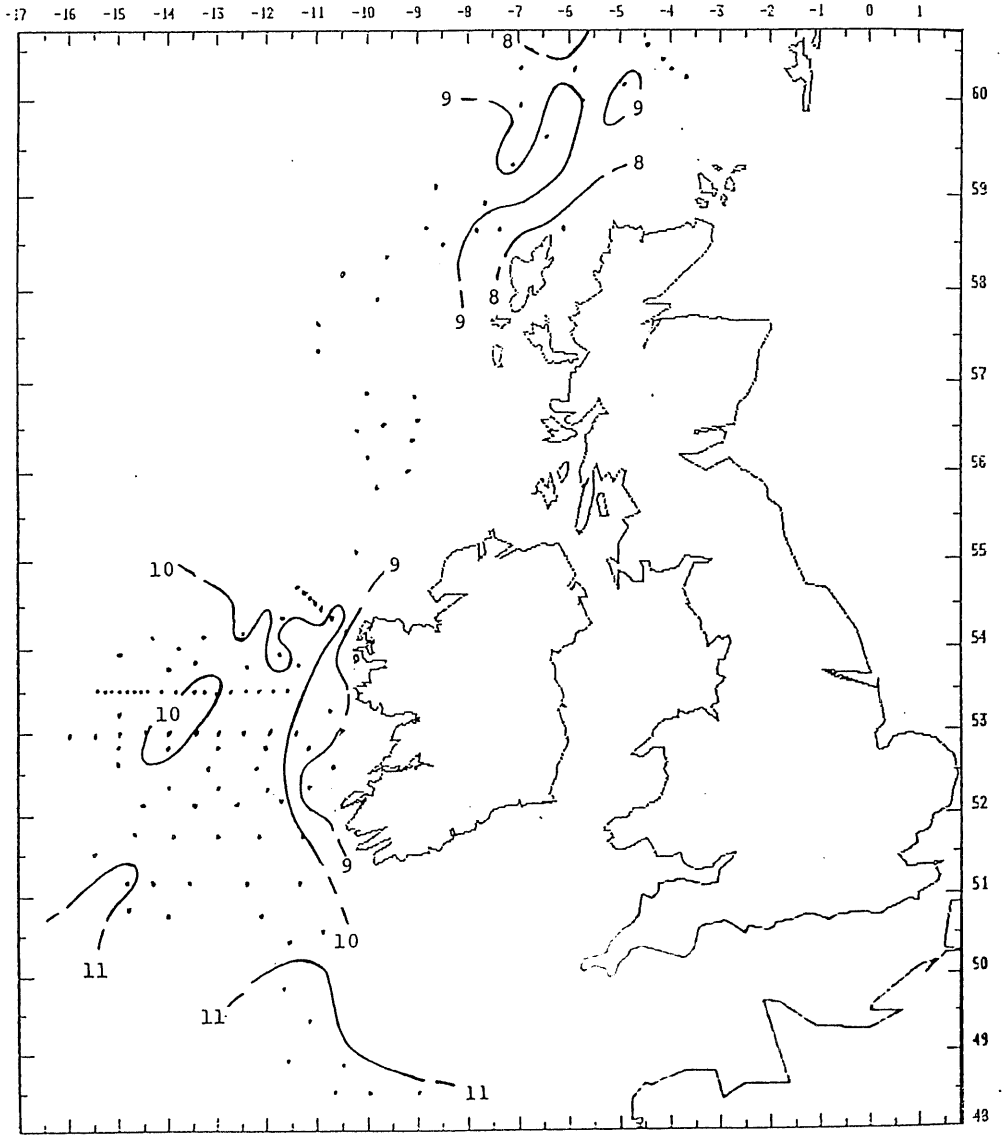

Figure 11. Temperature, t° C, at sea surface, spring 1996.
Dots indicate positions of observation

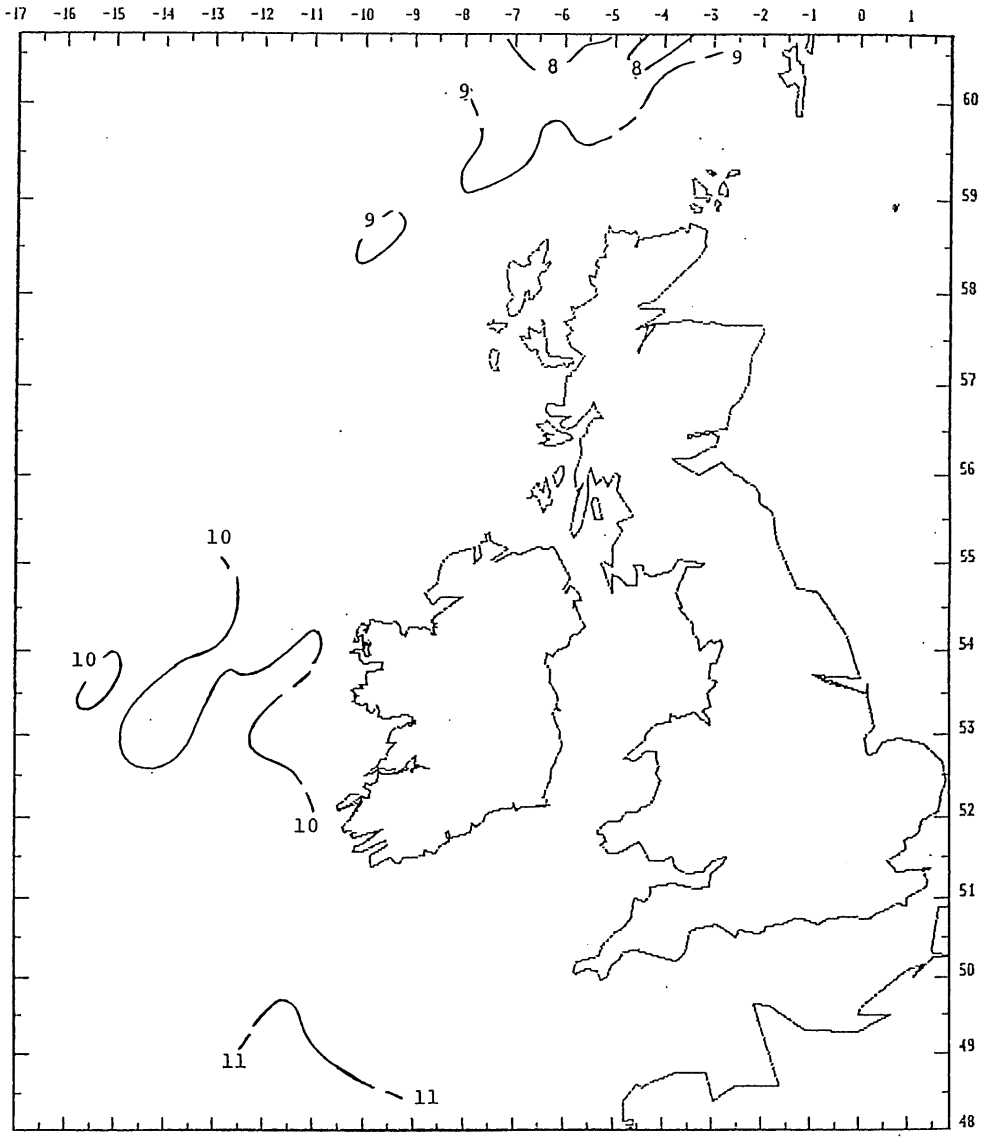

Figure 12. Temperature, t° C, at 200m depth, spring 1996.

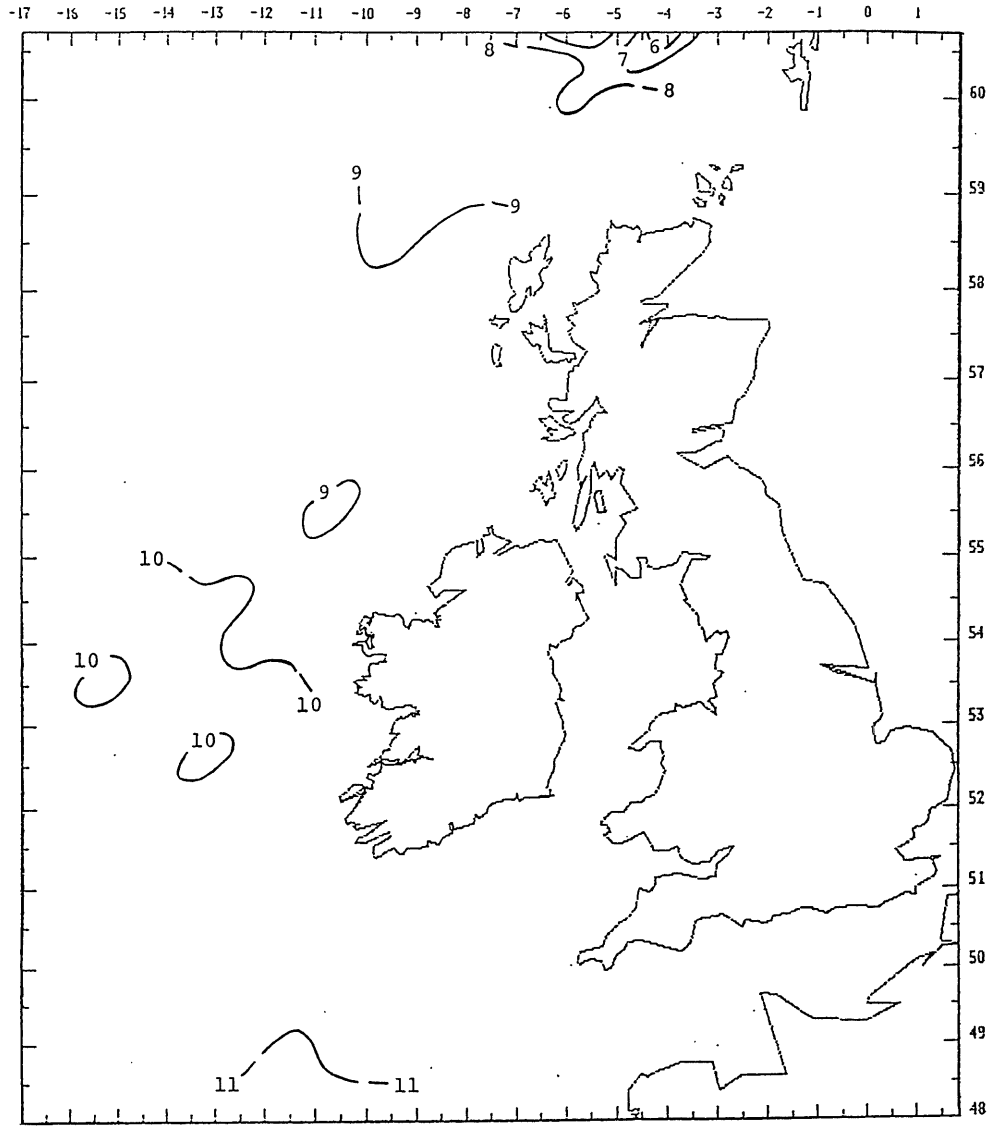

Figure 13. Temperature, t° C, at 400m depth, spring 1996.

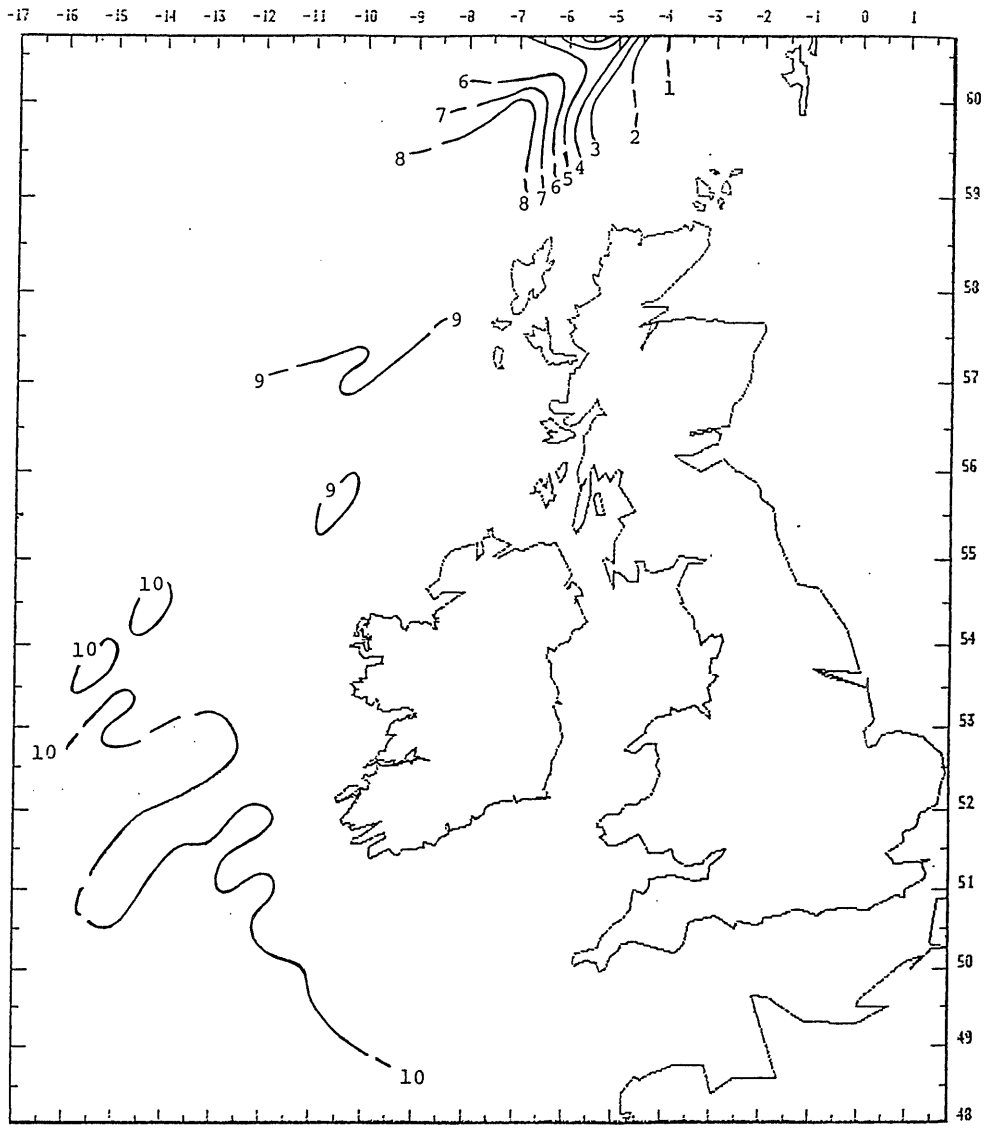

Figure 14. Temperature, t° C, at 600m depth, spring 1996.

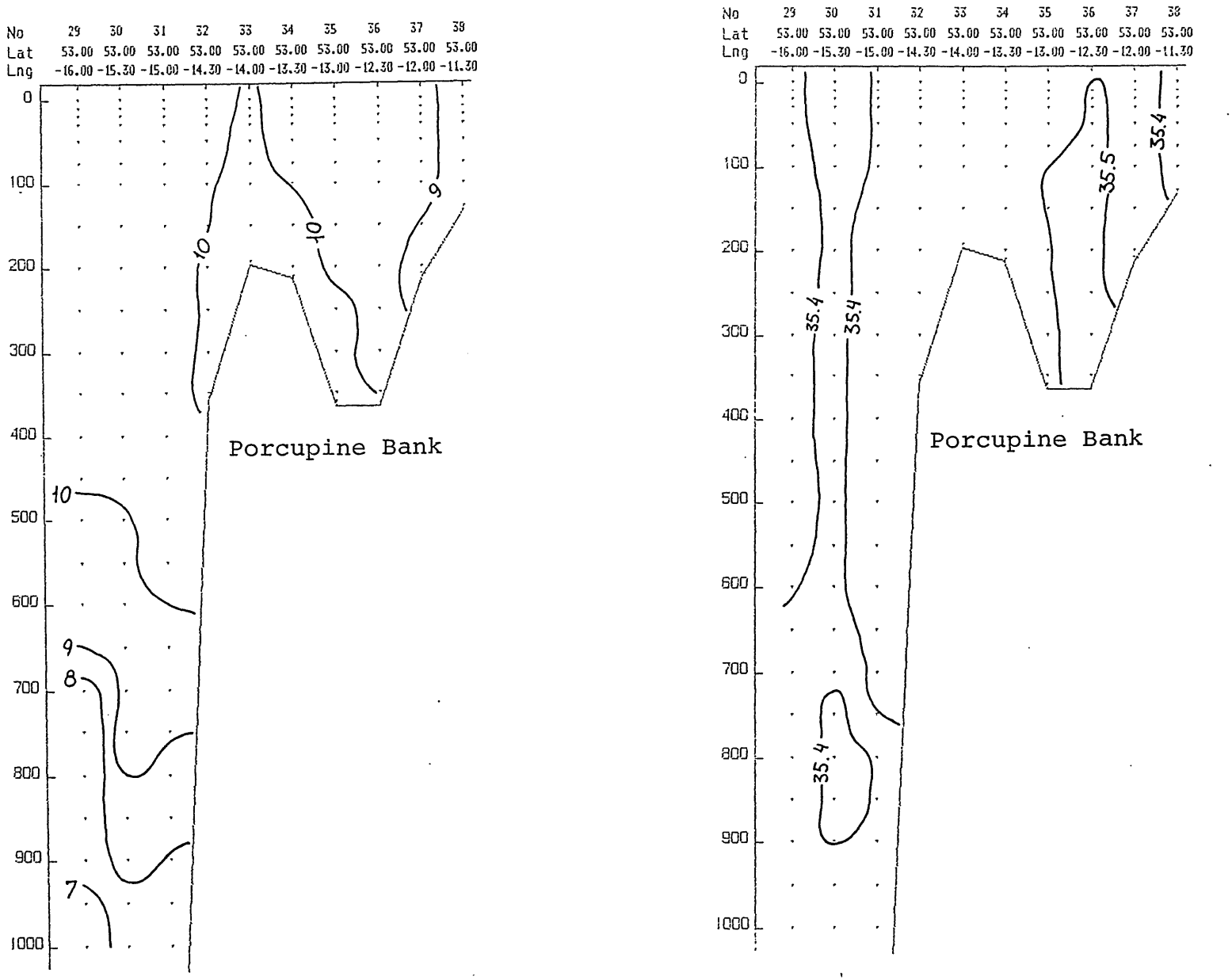

Figure 15. a) Temperature, t° C, and b) salinity, S $^{o}/_{oo}$ along 53°00'N over the Porcupine Bank, R.V."Fridtjof Nansen", 12-13 April 1996.

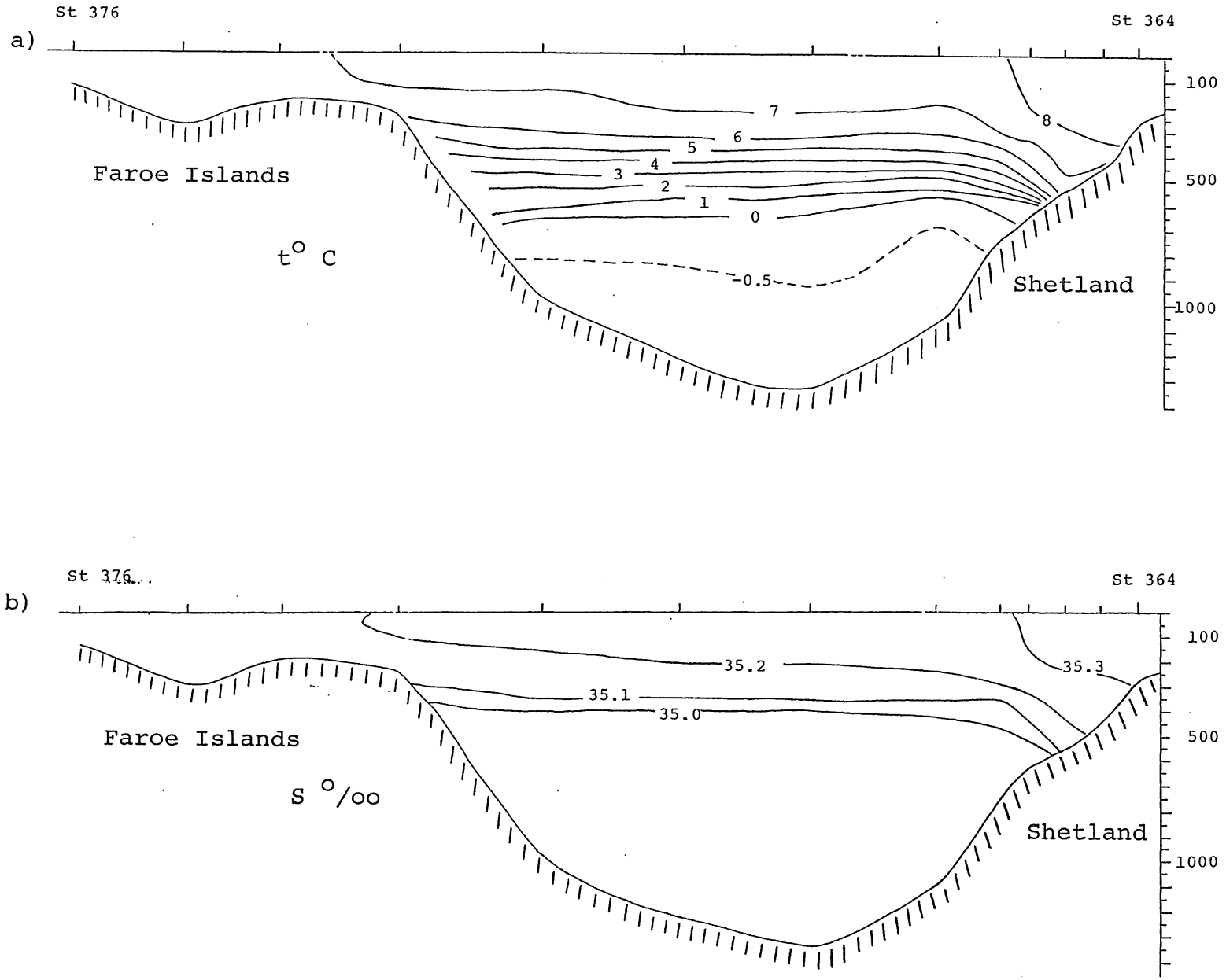

Figure 16. a) Temperature, t° C, and b) salinity, S °/$_{oo}$, in a section from Nolsø (Faroe Islands) to Fluga (Shetland), R.V."Johan Hjort", 15-16 April 1996.