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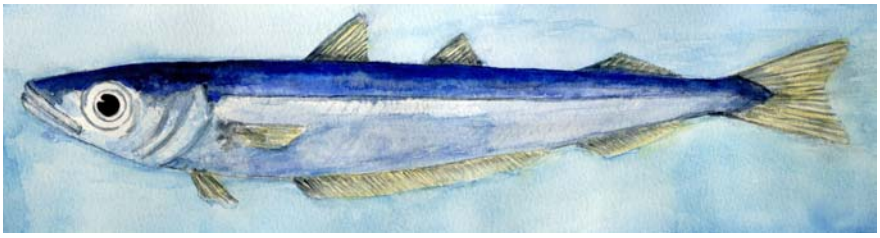

BLUE WHITING SURVEY DURING SPRING 2002

by

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INTRODUCTION

During the period March 23 – April 25 R/V Johan Hjort surveyed the main spawning areas of blue whiting west of the British Isles. The survey is a continuation of a series of surveys that goes back to the early 1970's. The Northern Pelagic and Blue Whiting Fisheries Working Group have used the data from 1981 for tuning the assessment of present stock size. This survey represent the longest continuous time series (only broken by a couple of years) on abundance and distribution of this stock and is as such also an important contributor on knowledge and information about general stock dynamics.

In 2002 the survey was coordinated with the effort from two Russian vessels, R/V Atlantniro who covered the offshore spawning grounds, and R/V Fridtjof Nansen with more coastal cruise tracks. This coordination did not to substantially affect the survey strategy of Johan Hjort so that the abundance estimate presented here is considered a continuation of the Norwegian time series on blue whiting. The combined results of the joint effort are presented in a separate report.

The main purpose of the survey is to assess the abundance of the total and spawning biomasses of blue whiting in the surveyed area using acoustic assessment methodology. Further we want to improve knowledge about the biology and dynamics of this stock, particularly with respect to movements and distribution during and after spawning. This report contains the main results from the stock abundance estimation and will also discuss the quality of the results based on available knowledge and results from the survey.

MATERIAL AND METHODS

The covered area and the cruise tracks of Johan Hjort are shown in Figure 1. Due to the huge area and limited effort available a pragmatic strategy, including a zigzag design off the shelf break of Hebrides and more systematic tracks to the north and south of this, was chosen. This also involved ad hoc cuts of survey track when recordings of blue whiting were absent, and extension of tracks when fish distribution was more extensive than expected (Figure 1). Nevertheless, we were not always able to fully cover the oceanic part of the distribution off the shelf of Hebrides.

The acoustic survey was conducted with Simrad EK 38 and 18 kHz echo sounders. Both sounders were controlled by a standard sphere calibration (ICES 1987) before the actual survey. The 38 kHz sounder was used for the assessment, and differences between the two frequencies were used during the scrutinizing process to improve separation of blue whiting from other scatters. The acoustic recordings were scrutinized twice a day using the Bergen Echo Integrator (BEI, Foote et al. 1991). Blue whiting was separated from other recordings using catch information, characteristics of the recordings, and frequency response between 18 and 38 kHz integration. The main settings of the acoustic instruments are given in Appendix I.

A pelagic trawl ("Åkratrål") with 500 m circumference in front, and a bottom trawl with 4 x 18 m opening equipped with a Rock-hopper ground gear were used for supporting the identification of acoustic scatters, and for collection of biological samples.

The acoustic data were analysed with BEAM (Totland and Godø 2001) to make estimates of total biomass and numbers of individuals by age and length in the whole survey area and within different sub-areas (i.e. the main areas in the terminology of BEAM). Strata of 1º latitude by 2º longitude were used. The area of a stratum was adjusted, when necessary, to correspond with the area that was covered representatively by the survey track. This was particularly important in the shelf break zone where high densities of blue whiting dropped quickly to zero at depths less than 200 m. The shallow areas were normally not covered and these parts of the strata were excluded from the analysis.

To obtain an estimate of length distribution within each stratum, samples from the focal stratum and the adjacent strata were used. BEAM gives the opportunity to choose trawl sample and inspect their effect on the stratum abundance, and gives hence a crude impression of the sensitivity of the estimate caused by the variability of the trawl samples. Length frequency distributions from each sample were weighted with the numbers of fish measured in that sample. The number of fish in the stratum is then calculated from the total acoustic density and the length composition of fish.

The methodology is in general term described by (Gjøsæter et al. 1998). More information on this survey is given by e.g. Anon. (1982) and Monstad (1986). Traditionally the following target strength (TS) function has been used:

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

where L is fish length. For conversion from acoustic density (s_A) to fish density the following relationship was used:

$$s_A = \rho \cdot \langle\sigma\rangle$$

where

$$1/\langle\sigma\rangle = 6.72 \times 10^{-7} \times L^{-2.18}$$

and $\langle\sigma\rangle$ is the average acoustic backscattering cross section (m^2) and ρ is fish density. The total estimated abundance by stratum is redistributed into length classes using the length distribution estimated from trawl samples. Biomass estimates and age-specific estimates are calculated for main areas using age-length and length-weight keys that are obtained by using estimated numbers in each length class within strata as the weighting variable of individual data.

Currently BEAM does not distinguish between mature and immature individuals, and calculations dealing with only mature fish are therefore carried out separately after the BEAM run. Proportions of mature individuals at length and age were estimated with logistic regression by weighting individual observations with estimated numbers within length class and stratum (variable 'popw' in the standard output dataset 'vgear' of BEAM). The estimates of spawning stock biomass and numbers of mature individuals by age and length were obtained by multiplying the numbers of individuals in each age and length class by estimated proportions of mature individuals. Spawning stock biomass is then obtained by multiplication of numbers at length by mean weight at length; this is valid assuming that immature and mature individuals have the same length-weight relationship.

We divided the surveyed area in five sub-areas like in previous years (Figure 5). Due to low coverage of the southern area (sub-area I), no separate estimate was given for that area, but the measured abundance was merged with numbers in sub-area II.

The hydrographical situation in the surveyed area was mapped by a net of 104 CTD stations (Figure 2), including two east-west sections at the Porcupine Bank at latitude 53° 30'N and 51° 30'N, a section from the Rockall Bank to the shelf edge offshore of the Hebrides at 57°30'N and a section from The Faroes to Shetland (i.e. the Nolsøy-Flugga section).
The salinity data presented in this report is not calibrated, but calibration data from the preceding cruises this year has shown that the CTD on Johan Hjort is very stable and only minor corrections (order 0.001) have been applied. The CTD data will be calibrated and subject to final quality control after the cruise. In

addition surface (~4m) temperature, salinity and fluorescence were recorded continuously along the complete track of the cruise using a ship-mounted thermosalinograph.

To study the distribution and development of blue whiting larvae and eggs, plankton samples were collected at CTD stations weather permitting, by use of a plankton dip-net (80 cm diameter) lowered to 200 m depth. The samples were immediately fixed in 4 % buffered formaldehyde. Eggs and larvae were analysed on board.

RESULTS

Distribution of blue whiting

Blue whiting was recorded along the shelf edge in the whole survey are from southern Ireland to the Faroe/Shetland-area including the northern part of the Rockall Bank (Figure 3).

The highest recordings were observed in patches along the west-northwest slopes of Porcupine Bank and in a more or less continuous layer off the shelf from 55^o N to north-northeast of the Hebrides. The highest recordings were observed at 400-600 m depth. The highest and most extensive densities were observed when the fish were distributed in a band of 50-100 m thickness (“the green snake”, Figure 4). In some instances the distributions were resolved in wide layers with a range of several hundred meters. We were not able to identify the cause of these differences in distribution although we expect the dense “snake” layers were migrating post-spawners.

Compared to 2001 dense recordings of blue whiting were extending more offshore. In some of the zigzag courses of the Hebrides change of course took place before recordings ended, as indicated by hatched line in Figure 3. Further, for the section from St. Kilda to Rockall we observed a continuous distribution of blue whiting. During the return track one degree further north, there was a split between the Rockall and the coastal distribution. Nevertheless, Figure 3 clearly demonstrates a wider oceanic distribution compared to previous years. This was also underlined by the northwest-southeast courses run between Hebrides and Faroese waters. Although we never reached the zero line, the cruise track covered more of the main distribution to west and northwest as compared to 2001. Also, the areas of high abundance (>3000 in Figure 3) were more extended than in last year.

Moderate recordings of blue whiting were found around the Rockall bank and the amount of spawners/post-spawners was scarce except for a patch on the northwest side of the bank.

A reliable coverage of the blue whiting spawning stock is hampered by the migration of fish during the survey. This is underlined by the systematic movement of the commercial fishing from south to north ahead of and during the survey. We thus consider both the distribution and the abundance to be affected by migration. In our case we might well have covered the same fish more than once and, hence, observed a too wide distribution and systematically overestimated abundance. Potentially, we could also underestimate the stock if fish were migrating out of the area before full coverage was achieved. This could be the case for the Rockall area. Here a rich fishery had faded out at the time of arrival of Johan Hjort. To what extent fish from this area had migrated into the waters covered further north and east is not known.

Stock size

The estimated total abundance of blue whiting for the 2002 Norwegian survey was 12.2 mill. tonnes, representing an abundance of 176×10^9 individuals. This is an increase of approximately 80% from 2001.

The spawning stock had a similar increase from 5.6 mill. tonnes to 10.9 mill. tonnes. The geographical distribution of biomass by stratum is shown in Figure 5.

The Norwegian acoustic survey estimates of blue whiting in the spawning area since 1990 are shown in the text table below:

Year	Abundance, N x 10^{-9}		Biomass, mill. tonnes		Mean weight,	Mean length,
	total	spawn.	total	spawn.	gr	cm
1990	62.9	56.2	6.3	5.7	100.7	27.1
1991	41.5	40.9	5.1	4.8	115.7	27.8
1992	38.4	36.8	4.3	4.2	111.3	27.5
1993	41.5	39.8	5.2	5.0	124.6	28.6
1994	26.8	26.1	4.1	4.1	152.9	31.1
1995	62.0	45.2	6.7	6.1	108.2	26.9
1996	52.2	36.2	5.1	4.5	94.9	25.5
1997	No survey	-	-	-	-	-
1998	79.9	56.6	5.5	4.7	68.3	23.2
1999	120.2	109.6	8.9	8.5	74.4	25.0
2000	102.4	89.8	8.3	7.8	80.7	25.5
2001	96.5	72.1	6.7	5.6	69.0	24.1
2002	175.6	146.8	12.2	10.9	69.3	24.2

The 2002 estimate is the highest in the time series from 1990. From surveys in the Norwegian Sea we have had strong indications that the 1999 and 2000 year classes could be strong (Anon. 2001a). The results of the present survey fully support this observation. If the 2000 year class is comparable in strength to the 1999 year class, and thus contributes strongly to the spawning population in 2003, we expect a strong spawning population also in 2003.

Seen in the light of the enormous fishery that took place in 2000 and 2001, the observed increase in the spawning stock is exceptional and needs some attention. The methods for calculating abundance are in general terms the same as in previous years. Two changes in the procedures need some attention. Firstly, the basic stratum this year was four times larger than in previous years. Although distribution lines were drawn according distribution of recorded echo intensities in relation to topographical features, and area covered calculated accordingly, it cannot be excluded that this has affected the estimate. Secondly, BEAM was used for the first time to calculate the abundance. This tool was, however, tested in 2001 and identical results were obtained.

To compare the present survey result with 2001 some simple statistics are given in the following text table

	n.miles	Sum of s_A	Mean s_A	CV	% zeros
1991	3570	4297127	1204	254	35
1992	3365	4456620	1324	235	23

Survey tracks in 2002 covered a wider area than in 2001 (Figure 1). As total coverage of the stock is always unobtainable, the larger geographic area involved in the present assessment might have biased the result compared to 2001. Further, the above text table shows that s_A values in 2002 were higher and less variable indicating that the stock densities were higher over larger areas in 2002 compared to 2001.

Stock composition

The stock composition (age and mature/immature) by sub-area (Figure 6) indicates some differences by sub-area, but discrepancies were smaller than in 2001. Age 2 and 3 fish dominate the total population (Figure 7). Age 2 outnumbers age 3, but by weight age 3 is slightly more important that age 2 (Table 1). In all sub-areas there is a significant part of age 1 fish. They appear to be mainly stationary immature blue whiting. This age group was most numerous in the areas where spawning was over when we arrived (see also section eggs and larvae), namely sub-area I+II and V. Similar to 2001, age 2 fish dominated in all sub-areas but this age group was far from being as dominant as in 2001. This was mainly because the dominant year class of the last year (1999 year class) contributes strongly to the spawning stock also in 2002. The 1999 and 2000 year classes made up almost 80% of the stock in numbers. These year classes are observed as strong in earlier surveys by Norway and Iceland (see Anon. 2001a) and constitute clearly the "backbone" of the 2002 spawning stock. Also, it should be noted that the strong 1996 year class still towers above its neighbouring age groups at Rockall (Sub-area V) and in the Faroe-Scotland area (sub-area IV). This has been a strong year class although it did not appear as outstanding in the 2001 survey.

The ogives used to split between mature and immature individuals (Figure 8) indicate that more age 1 fish had matured in 2002 than in previous year and that the fraction of mature fish in lengths classes <20cm was higher than in 2001. This is probably mainly due to local spawners and gives little information about the situation for the total stock. The mean length of age 1 fish is more than 1 cm above the 2001 result and optimal growth conditions could have provoked an earlier maturation. The recorded increase in temperature (see section on hydrography) is a plausible cause of the increase in growth of age 1 fish. In contrast, the dominant age groups 2 and 3 showed a decreasing trend in size as compared to last year. Negative density dependence in growth of these apparently exceptionally rich year classes is expected.

Absolute level of assessment - Target strength (TS)

It has been underlined that the acoustic estimate of the spawning stock of blue whiting is an index of abundance. This is due to several factors, of which the uncertainty in acoustic target strength is the most important. The estimate has always been high compared to the estimate from the analytical assessment (see Godø et al. 2002). During the 2002 survey we measured the acoustic target strength by lowering a pressure resistant pre-calibrated transducer to the depth layer where blue whiting was abundant. To secure a correct registration of TS we attached a standard target sphere 8.3 m below the transducer (Figure 9). Due to some technical difficulties with the equipment only one reliable measurement was obtained (Figure 9). After transformation and averaging we arrived at an average TS of -36.0 dB. Following the TS equation presently used in this report, this measurement would represent a mean fish length of about 49 cm. However, using the TS equation; $TS= 20\log_{10}(L) - 64$, which have been observed for cod under extreme conditions (Anon 2001b), a mean length (root mean square length) of 25 cm is expected. We had two trawl samples available from the experimental area, one taken by Johan Hjort and the other by a commercial trawler, with RMS length of 22.6 cm and 26.6 cm respectively. We know that the trawl onboard Johan Hjort under-samples large fish, and there are all reasons to believe that a commercial trawler under-samples the smallest fish. Hence, a RMS length in between the two would be expected, which fall well together with the proposed TS equation. If this TS relationship were used, the stock abundance would be reduced to about 25% of its present level, dependent of the size composition. If this correction is applied to the earlier acoustic estimates from the Norwegian survey, the estimated spawning stock is closer to the estimates obtained from analytical assessments (Anon. 2001c). We emphasize, however, that these calculations are based only on one experiment, and must therefore considered provisional. Substantial variability is expected in such experiments (Anon 2001b), and measurements of TS will be continued in 2003. We expect to revise the time series of acoustic estimates when more TS measurements become available.

Eggs and Larvae

Sampling of blue whiting eggs and larvae started in 2000. Because the samples from 2001 were not analysed in the survey report for 2001, we present here the results for both 2001 and 2002. In total 41 and 56 samples were taken in 2001 and 2002, respectively. The distribution of sampling effort is similar between the years.

In 2001, there were on average 6.7 eggs (standard deviation 11.2) and 72.9 larvae (s.d. 207) per sample. Eggs in the developmental stage V (Bailey 1982) and larvae of 3-4 mm in length dominated the samples. Eggs and larvae were present in all the subareas, with Porcupine Bank showing the greatest abundance of larvae (Fig. 10).

The abundance values were somewhat lower in 2002: an average sample contained 1.7 eggs (s.d. 4.6) and 21.9 larvae (s.d. 48.2). Eggs of all different stages were present in roughly equal abundance. The samples were dominated by larvae of 3-4 mm in length. Eggs and larvae were present in all the subareas (Fig. 11). There is some indication of a lower density of larvae in both the southern and northernmost part of the study area. Neither in 2001 nor 2002 there was an obvious temporal trend in developmental stage, size or abundance.

As indicated by high standard deviations of the sample means, the distributions of both eggs and larvae are highly skewed, with few samples containing most of the individuals. The most extreme case is distribution of eggs in 2001: of the 41 samples in total, one sample contained 85% of all eggs (233/274), and 34 were empty. Similarly, a single sample contained a substantial proportion of all larvae in 2001, 43% (1293/2987). This indicates that the distributions of eggs and larvae are highly clumped in space and time. We must therefore conclude that with present sampling intensity quantitative differences between years should be interpreted cautiously. However, the sampling can convey qualitative information on areas where spawning occurs (Fig. 10, 11).

With respect to other species, the abundance of mackerel eggs was similar in both years, 23.6 eggs/sample in 2001 (s.d. 61.9), and 27.8 eggs/sample in 2002 (s.d. 98.0). The abundance of horse mackerel eggs shows an increase: 0.5 eggs/sample in 2001 (s.d. 1.4), and 5.3 eggs/sample in 2002 (s.d. 29.9); when the largest sample (224 eggs) is excluded, the average is 1.3 eggs/sample.

Hydrography

The horizontal distribution of temperature at 10 and 400 meters depths are shown in Figure 12 and 13 respectively. The maps are based on data collected onboard Johan Hjort and CTD data kindly provided by the scientists onboard the Russian ships Fridtjof Nansen and Atlantniro, who were running simultaneous surveys. The cooperation has given a much better horizontal coverage of the area.

On the shelf and on the Rockall Bank the water is well mixed with only small vertical variation in salinity and temperature from the surface to the bottom. South of the Wyville Thompson ridge (~60°N) this is true for the waters off the shelf, with temperatures at 1000m typically between 7 and 8°C, i.e. the vertical temperature decreases by only 2-3°C from the surface to 1000m depth (See fig. 14, Porcupine section). In the Faroe-Shetland channel the situation is different with a layer of warm saline Atlantic water overlying cold deep waters originating in the Norwegian Sea (See fig.15, Faroe-Shetland sec).

The horizontal gradients are generally very small in the area south of the Wyville Thompson ridge. In particular the north-south gradients are very small, and along the shelf the temperature drops only by about

2°C from 50°N to 60°N. Thus, along the shelf edge warm water penetrates far north, with the 10°C isotherm at 10m depth extending north to about 60°N. This warm water also has high salinity, above 35.40, and is associated with the shelf edge current flowing north along the shelf edge.

The warm saline water along the shelf edge is typical for the hydrographic conditions in the area, however the both the temperatures and salinities are higher than the previous years. Visual inspection indicates that this year's temperatures are typically 0.5 °C and salinities about 0.05 higher than the previous years. On the section in the Faro-Shetland channel, the warm saline water extends farther towards the Faroes than normal, but this is a dynamically active region and it may be due to an eddy located to the north of the section.

The high temperatures and salinities are confirmed by a study of the temperatures and salinities on all blue whiting cruises from 1986 through 2002. Since the hydrographic surveys have been dependent on the fishery surveys, the CTD stations have been distributed along the shelf edge and have in general not been in the same positions from year to year. In order to make time series, the data were grouped in boxes with horizontal dimensions of 2°latitude times 2°longitude, and for each year the mean temperature and salinity from 50 to 600m of all the stations in each box was calculated. Some of the boxes had good coverage nearly every year, while others had many years missing. However, in general the same variation from year to year was seen in the boxes along the shelf edge south of the Wyville Thompson ridge. The box with limits,52° to 54°N and 16° to 14°W, had few gaps; the temperature is shown in figure 16a. The pattern seen is that after some years with temperatures around 10.1°C in the 1980s, it dropped to a minimum in 1994 (~9.8°C). After 1994 an increase in temperature is seen, and in 1998 temperature reaches a local maximum (~10.5°C) with the three following years a few tenths of a degree colder. 2002 is the warmest on record with ~10.7°C. There is no clear linear trend, but the last five years are warmer than the average of the whole period, and about 0.5°C above the first years in the period. Even though the increase is not as evident in the salinity curve, the high temperatures are associated with high salinities (Fig. 16b). Thus the high temperatures and salinities are probably mainly caused by advection of warm and saline water from lower latitudes, with local winter cooling as the secondary effect.

CONCLUDING REMARKS

The blue whiting stock in the Northeast Atlantic has had a record high production in recent years. Taking into account the present survey results, all years from 1995 to 2000 except 1998 have produced year classes of average size or above. The record high spawning stock observed this year is a result of this situation. Seen in a historic perspective this is exceptional and there is no reason to believe that succeeding recruitment will be at the same level. As shown in this report, this recruitment period falls together with a substantial increase in temperature and a similar but less emphasized increase in salinity. Temperature affected recruitment is well known for gadoids and the exceptional situation during the most recent years could at least partially be driven (directly or indirectly) by the observed phenomenon. We have to expect that a more "normal" situation will appear in the coming years and, hence, the exploitation of the stock should be adjusted accordingly to maintain an acceptable spawning stock also after 2003.

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APPENDIX I.

Acoustic equipment and setting of the instruments.
R.V. "Johan Hjort", 23 March - 24 April 2002.

Echo sounder:	Simrad EK - 500
Frequency:	38 kHz
Transducer:	ES38B - SK
Absorption coeff:	10 dB/km
Pulse length:	Medium (1ms)
Band width:	Wide (3.8 kHz)
Transmitter power:	2000 W
Angle sensity:	21.9 dB
2-way beam angle:	-21.0 dB
Sv Transducer gain:	27.59 dB
Ts Transducer gain:	27.73 dB
3 dB Beamwidth	
alongship:	6.9 dg
athw. ship:	6.8 dg
Range:	1000 m
BEI-threshold:	- 79 dB

Table 1. Stock estimate of Blue Whiting, spring 2002.

Length	Age in years 1	2	3	4	5	6	7	8	9	10	11	Abundance	Biomass	Mean
cm	2001	2000	1999	1998	1997	1996	1995	1994	1993	1992	1991	Nx10-6	1000 tns	weigth, g
15.0 - 16.0	20											20	0.4	18.1
16.0 - 17.0	529											529	11.1	20.9
17.0 - 18.0	1508											1508	37.4	24.8
18.0 - 19.0	4155	36										4191	128.8	30.7
19.0 - 20.0	5572	1056										6628	233.1	35.2
20.0 - 21.0	5987	3091										9077	372.9	41.1
21.0 - 22.0	1872	15874	4									17750	845.9	47.7
22.0 - 23.0	603	21466	254									22323	1191.3	53.4
23.0 - 24.0	115	20117	4120	3								24354	1480.9	60.8
24.0 - 25.0	96	7662	12120	378		1						20257	1365.1	67.4
25.0 - 26.0		2317	18790	1656	214	247						23223	1753.9	75.5
26.0 - 27.0		305	11257	3022	508	480						15572	1334.2	85.7
27.0 - 28.0		74	5937	4156	1061	1683						12912	1240.7	96.1
28.0 - 29.0			1301	2077	1130	1554	368					6429	693.6	107.9
29.0 - 30.0			616	1048	1026	2227	599					5515	673.6	122.1
30.0 - 31.0			341	189	800	932	209	107				2578	334.7	129.8
31.0 - 32.0				198	107	712	33	48		111		1209	175.4	145.1
32.0 - 33.0					296	258	158					712	116.3	163.4
33.0 - 34.0				31		310		65		4	65	475	91.4	192.4
34.0 - 35.0								84		14		99	23.1	234.1
35.0 - 36.0					123		84					207	48.5	233.9
36.0 - 37.0										47		47	9.9	211
37.0 - 38.0											4	4	0.9	256
38.0 - 39.0														
39.0 - 40.0									15			15	6	395
TSN(1000000)	20455	71996	54740	12757	5266	8404	1450	305	15	176	69	175634		
TSB(1000 tns)	756.1	4013.4	4288	1225.5	604.2	986.4	190.5	54.9	6	29.3	14.6	12169		
Mean length (cm)	19.7	22.8	25.7	27.4	28.9	29.1	30.1	32.4	39.3	33.1	33.7	24.2		
Mean weight (g)	37	55.7	78.3	96.1	114.7	117.4	131.4	180.3	389	166.3	212.4	69.3		
Condition	4.8	4.7	4.6	4.7	4.8	4.8	4.8	5.3	6.4	4.6	5.5	4.9		

Table 2. Assessment factors of Blue Whiting, spring 2002.

Subarea	Area	Numbers			Biomass			Mean W	Mean L	Density
	Sq.n.mile	Mature	Total	% mat.	Mature	Total	% mat.	g	cm	t/sq.n.mile
Area V: Rockall	13651	6162	6883	89,5 %	440,5	467,0	94,3 %	67,8	23,8	34
Area IV: Faroes/Shetland	14990	27775	46900	59,2 %	2214,0	3066,5	72,2 %	65,4	23,4	205
Area III: Hebrides	30089	97106	101676	95,5 %	7250,8	7470,4	97,1 %	73,5	24,9	248
Area I+II: Porcupine bank	38949	15764	20176	78,1 %	1023,4	1165,2	87,8 %	57,8	22,8	30
Total	97679	146807	175635	83,6 %	10928,7	12169,1	89,8 %	69,3	24,2	125

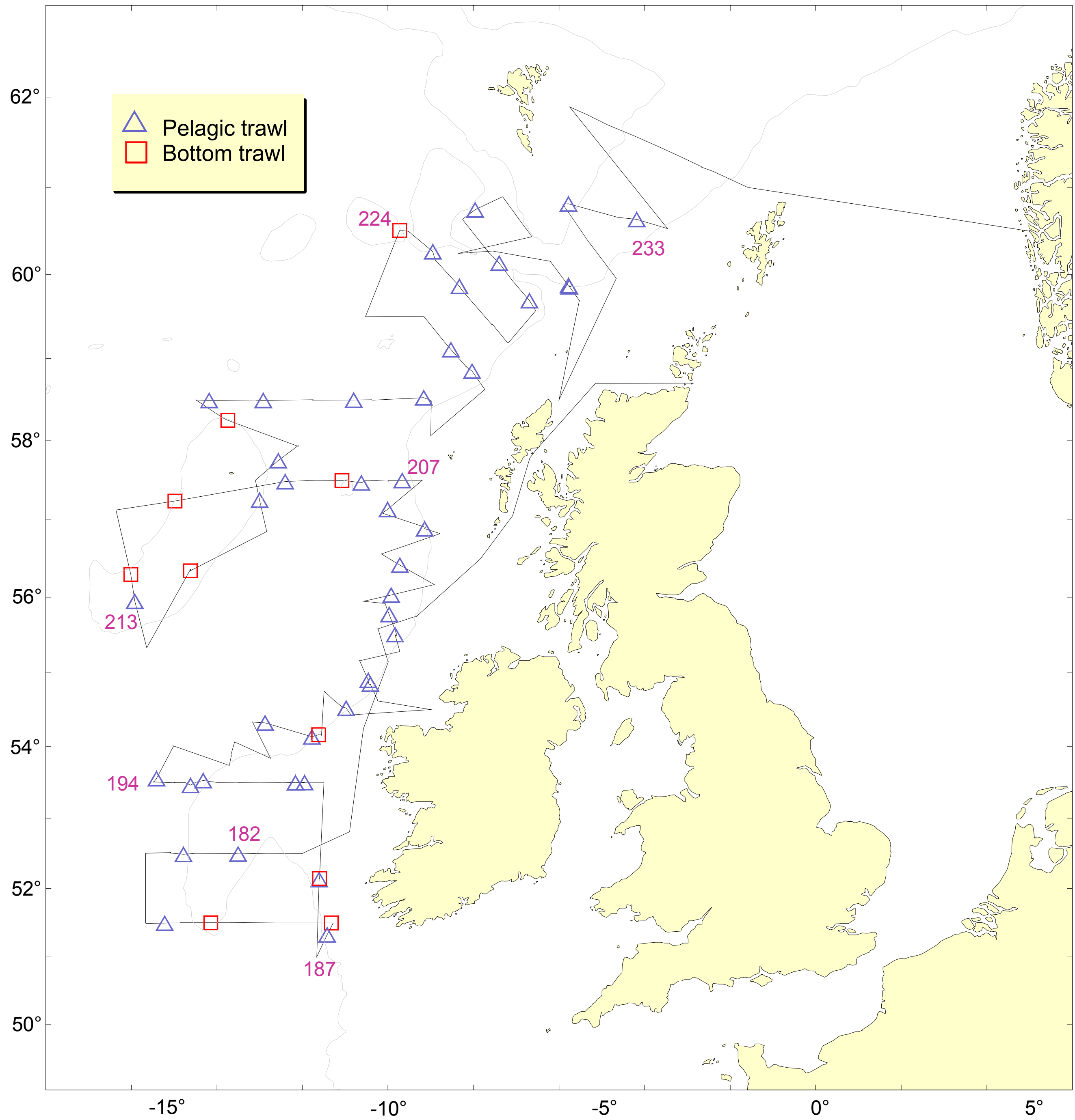


Figure 1. Cruise tracks with trawl stations, R.V. "Johan Hjort" 23 March – 25 April 2002.

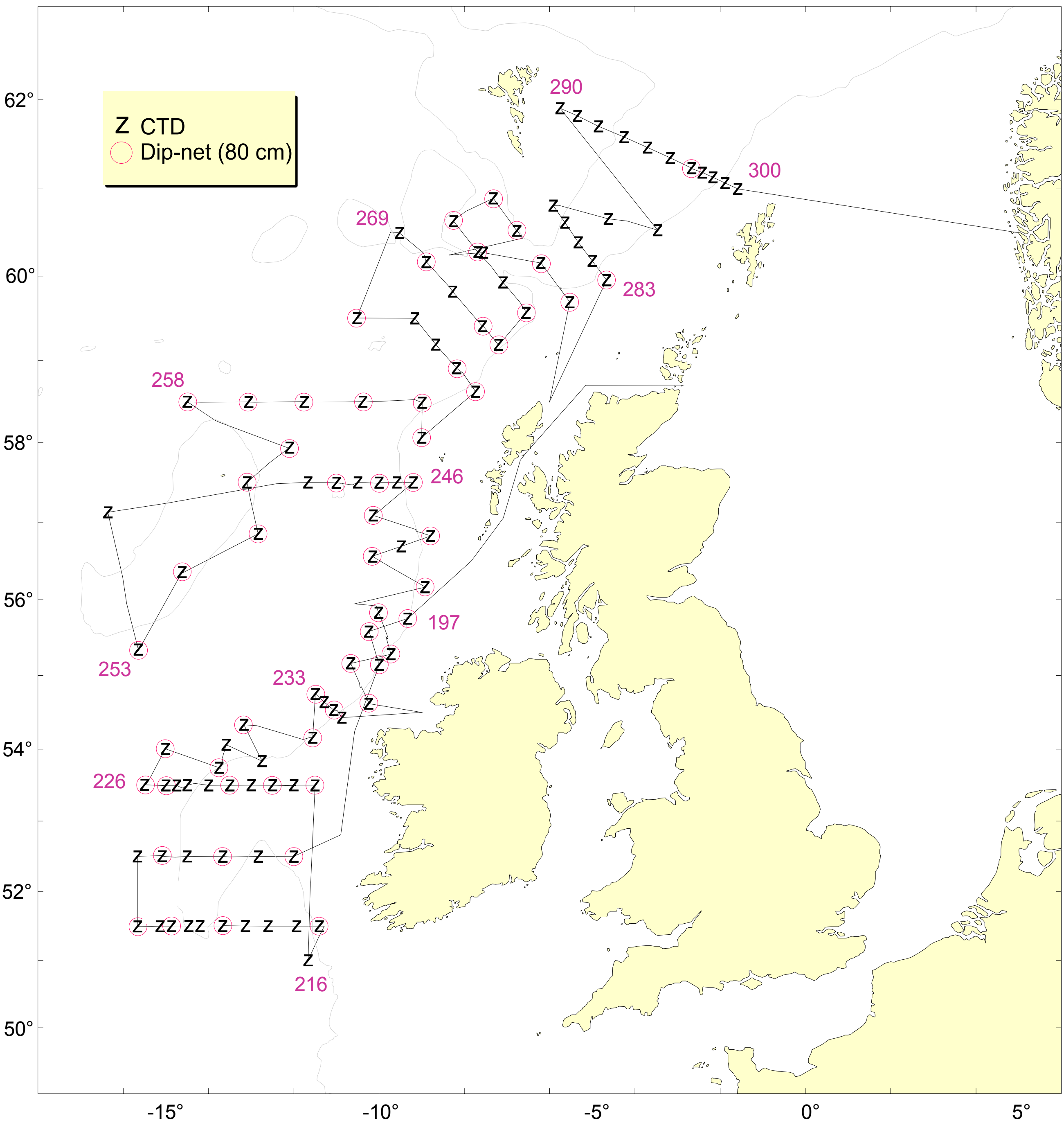


Figure 2. Cruise tracks with CTD and plankton stations, R.V. "Johan Hjort" 23 March – 25 April 2002.

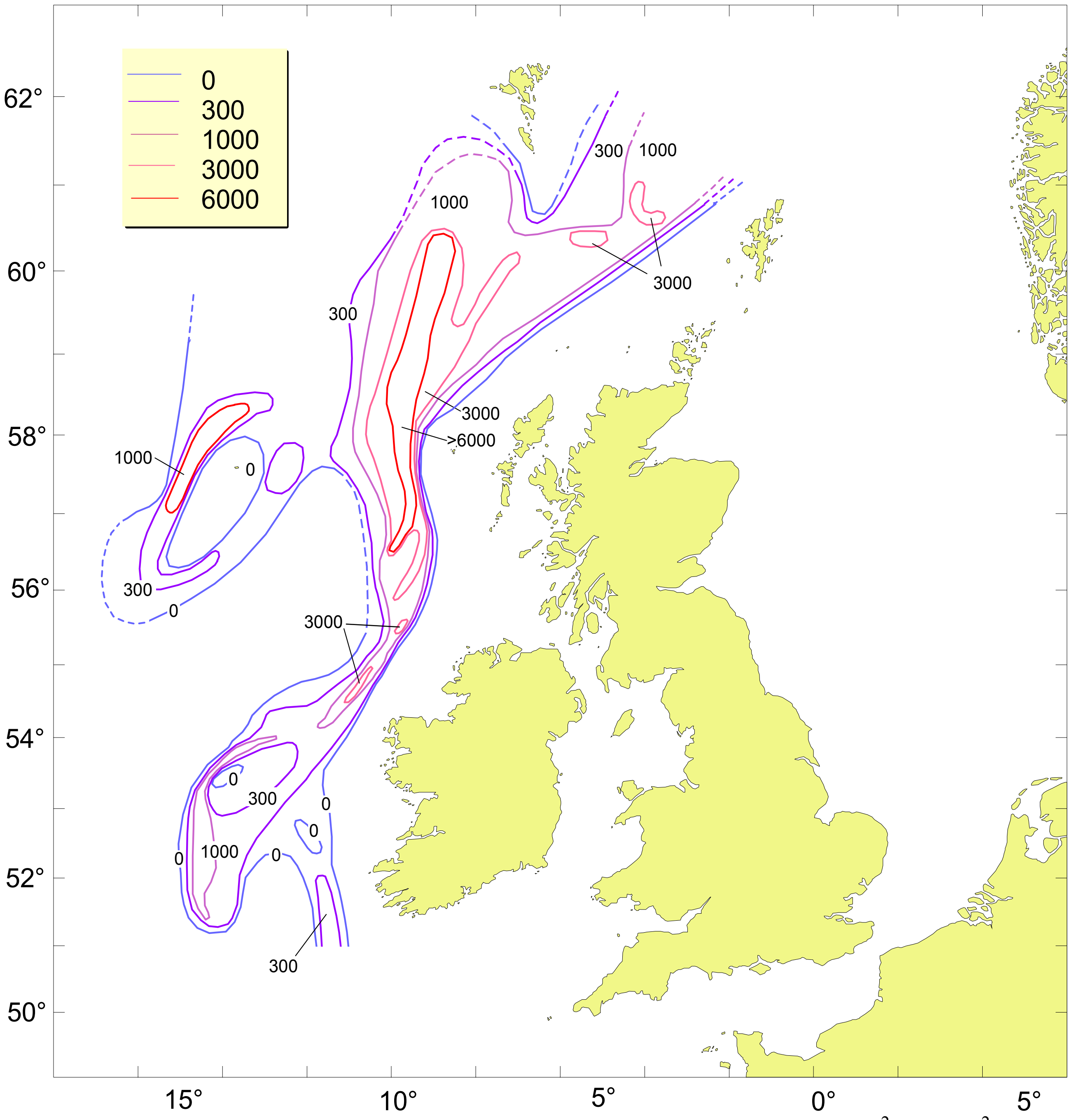


Figure 3. Distribution of blue whiting, spring 2002. Echo intensity (s_A-values) in $m^2/(n.mile)^2$.

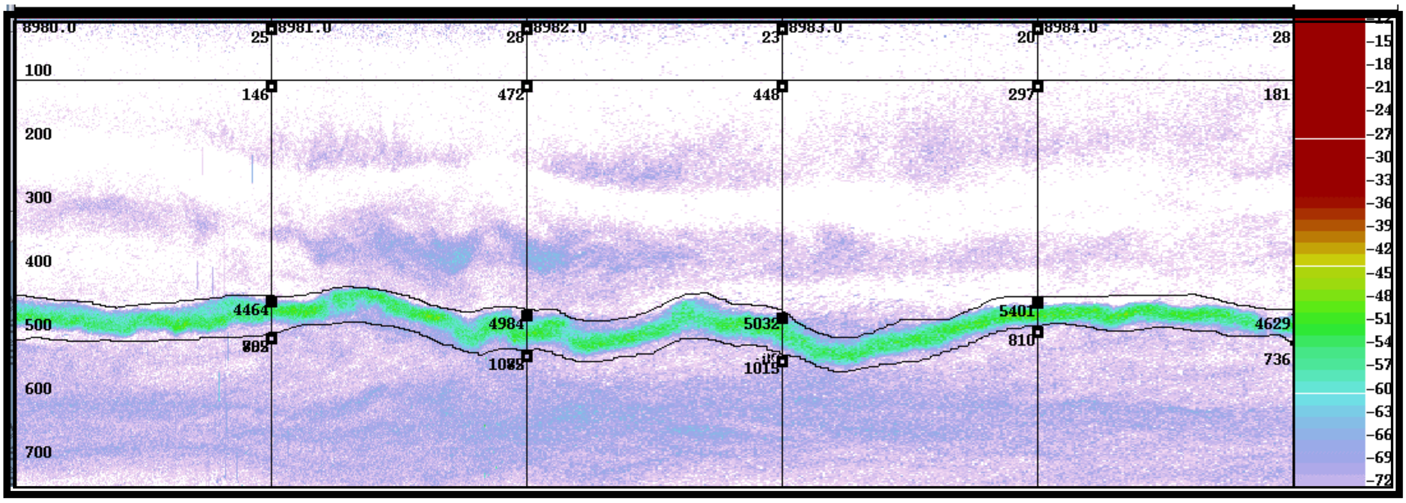


Figure 4. Blue whiting “snake” registration northwest of Hebrides, April 2002.

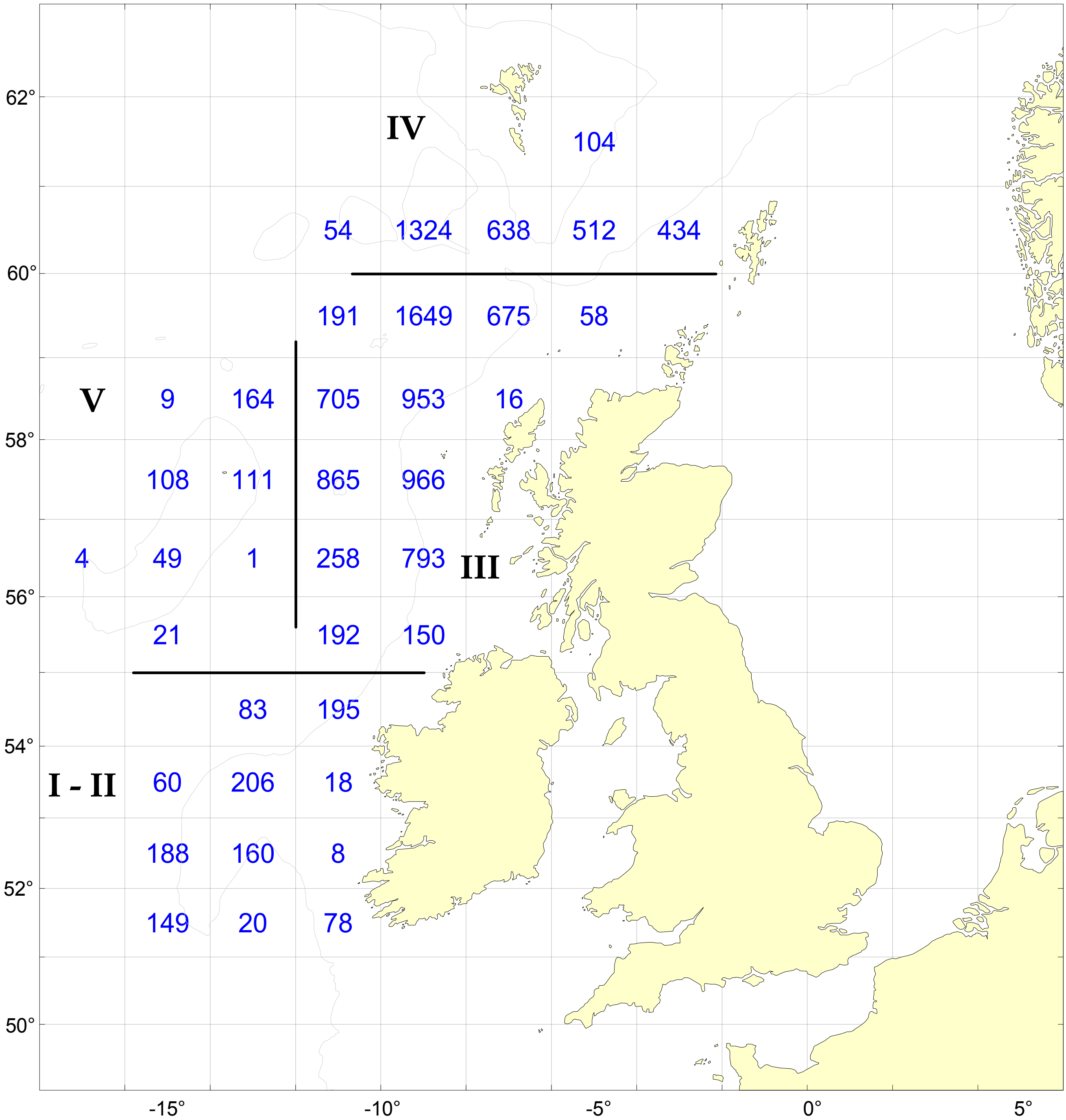


Figure 5. Blue whiting biomass in 1000 tonnes, spring 2002. Marking of sub-areas I-V used in assessment.

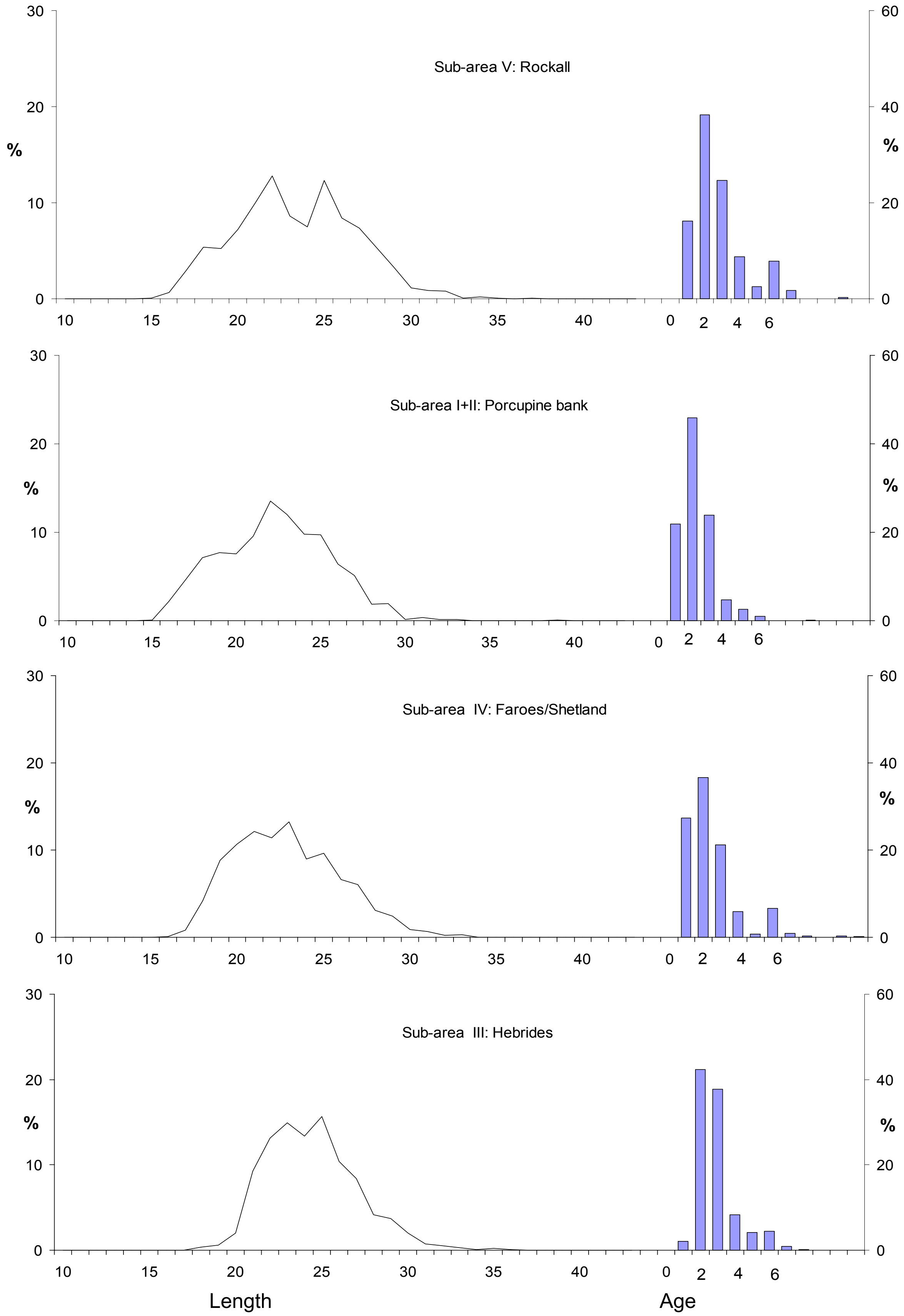


Figure 6. Length and age distribution of blue whiting by sub-areas (I-V), spring 2002. N*10-6, weighted by abundance.

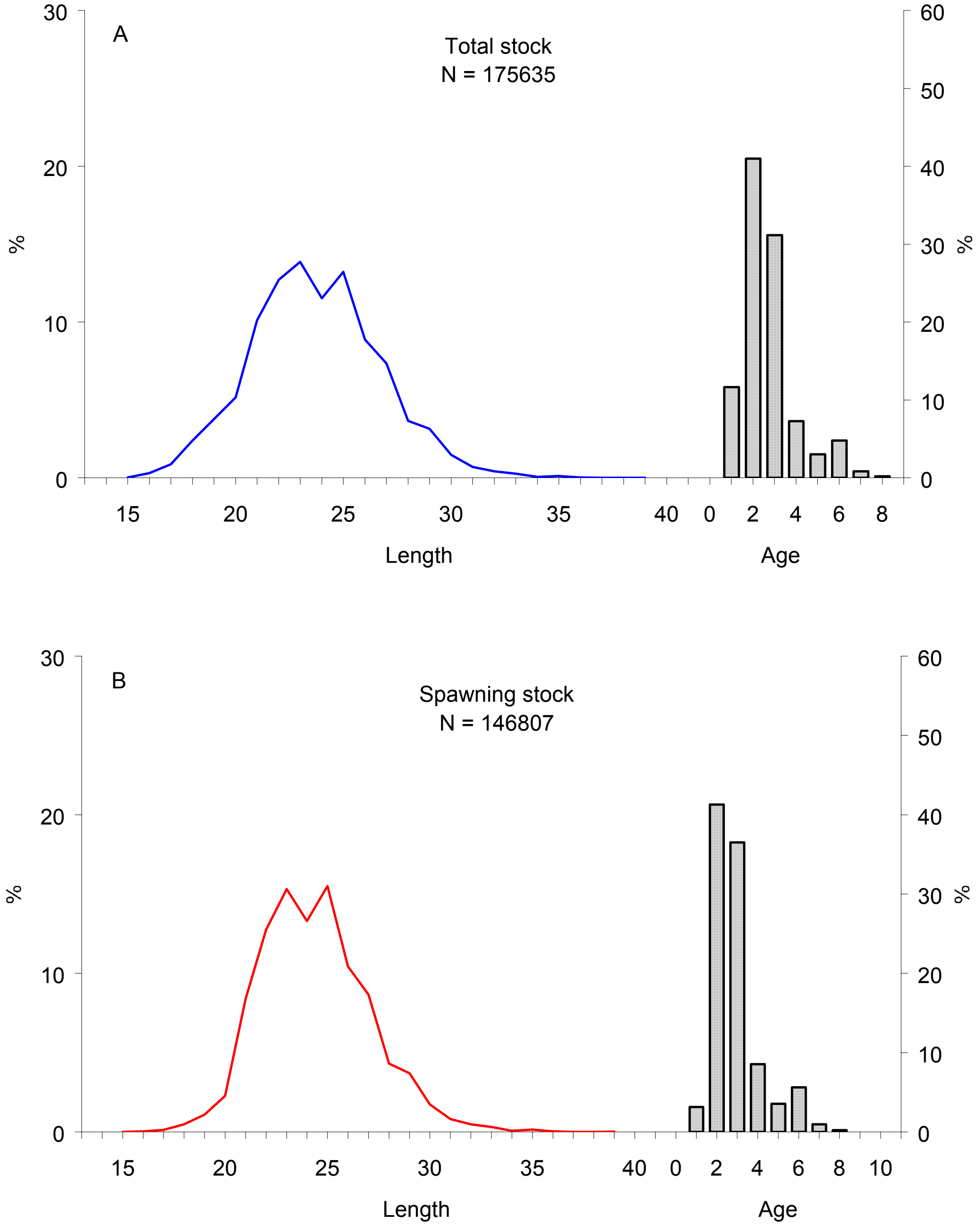
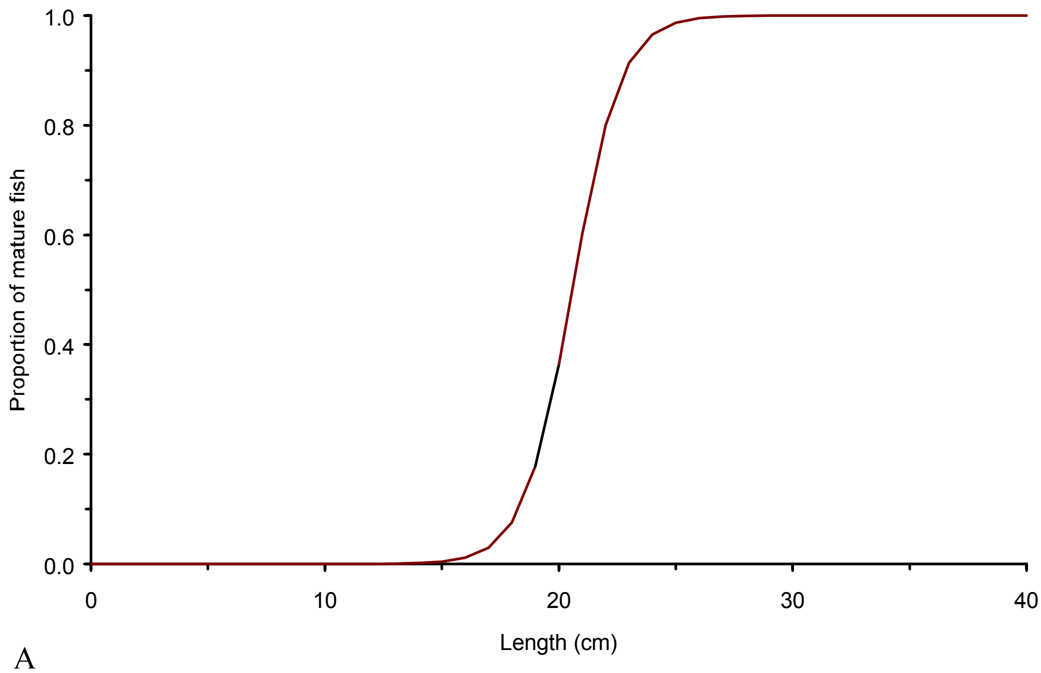
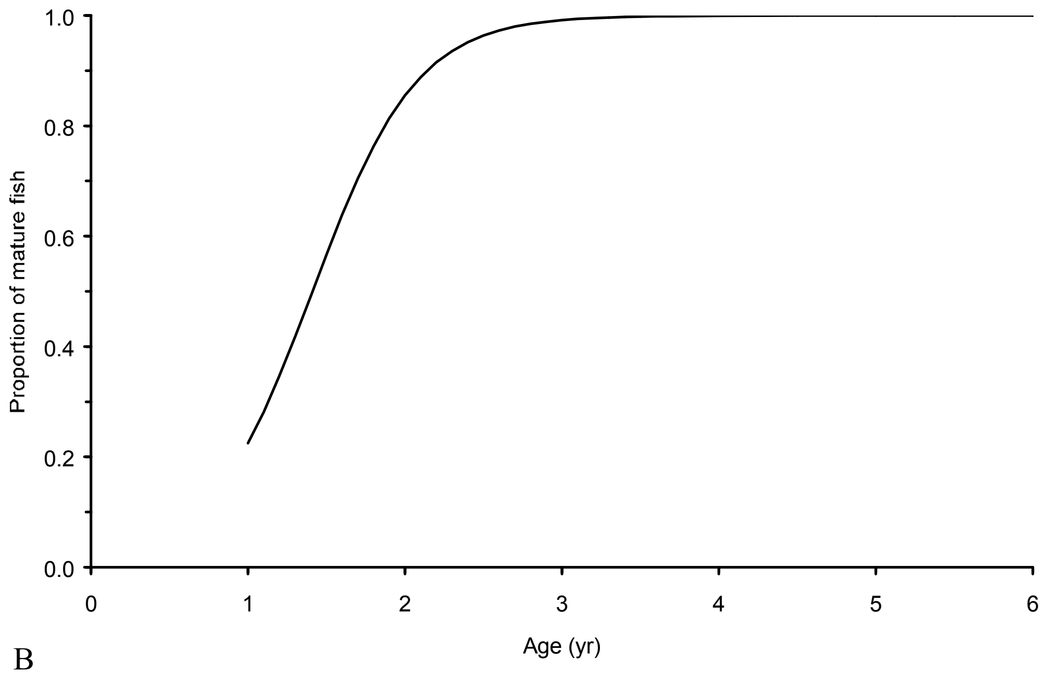


Figure 7. Total (A) and spawning (B) stocks length and age distribution of blue whiting in the area to the west of The British Isles, spring 2002. N*10-6, weighted by abundance.

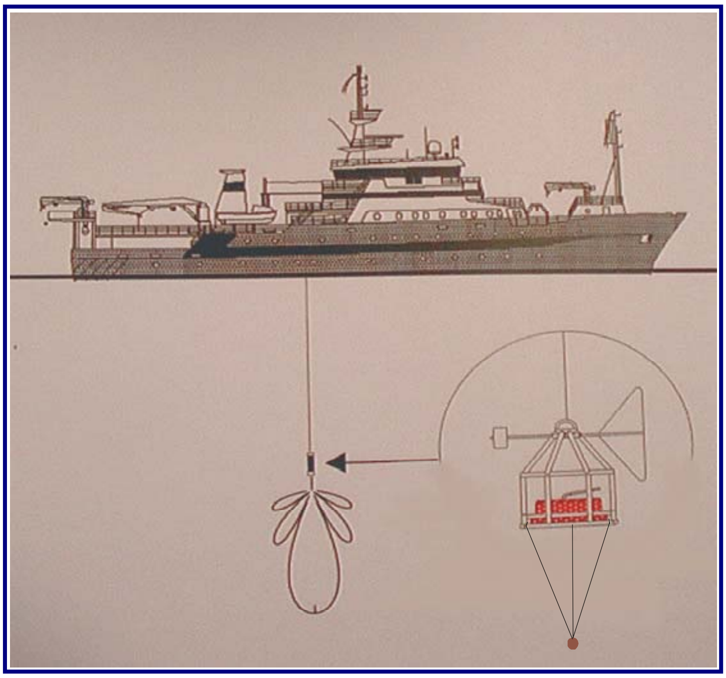


A



B

Figure 8. Maturity ogive of blue whiting in the area to the west of The British Isles, by length (A) and age (B), spring 2002.



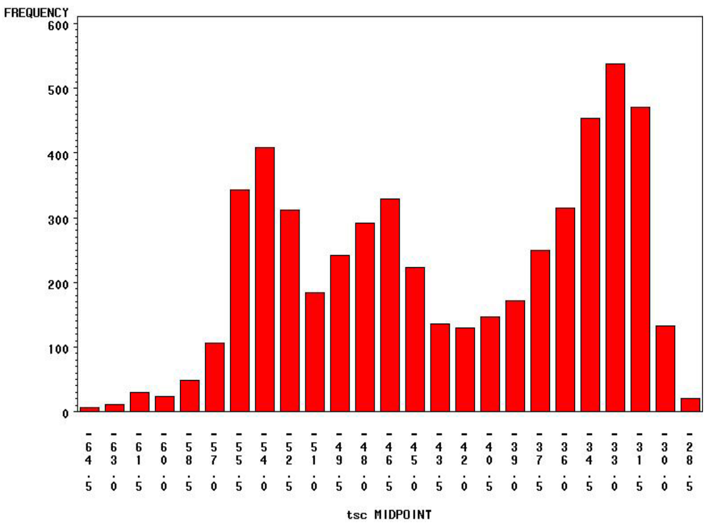


Figure 9. Target strength measurement set-up. Calibration sphere was mounted 8.3 m below transducer. Upper panel adjusted from Anon (2001b). Lower panel shows observed TS distribution.

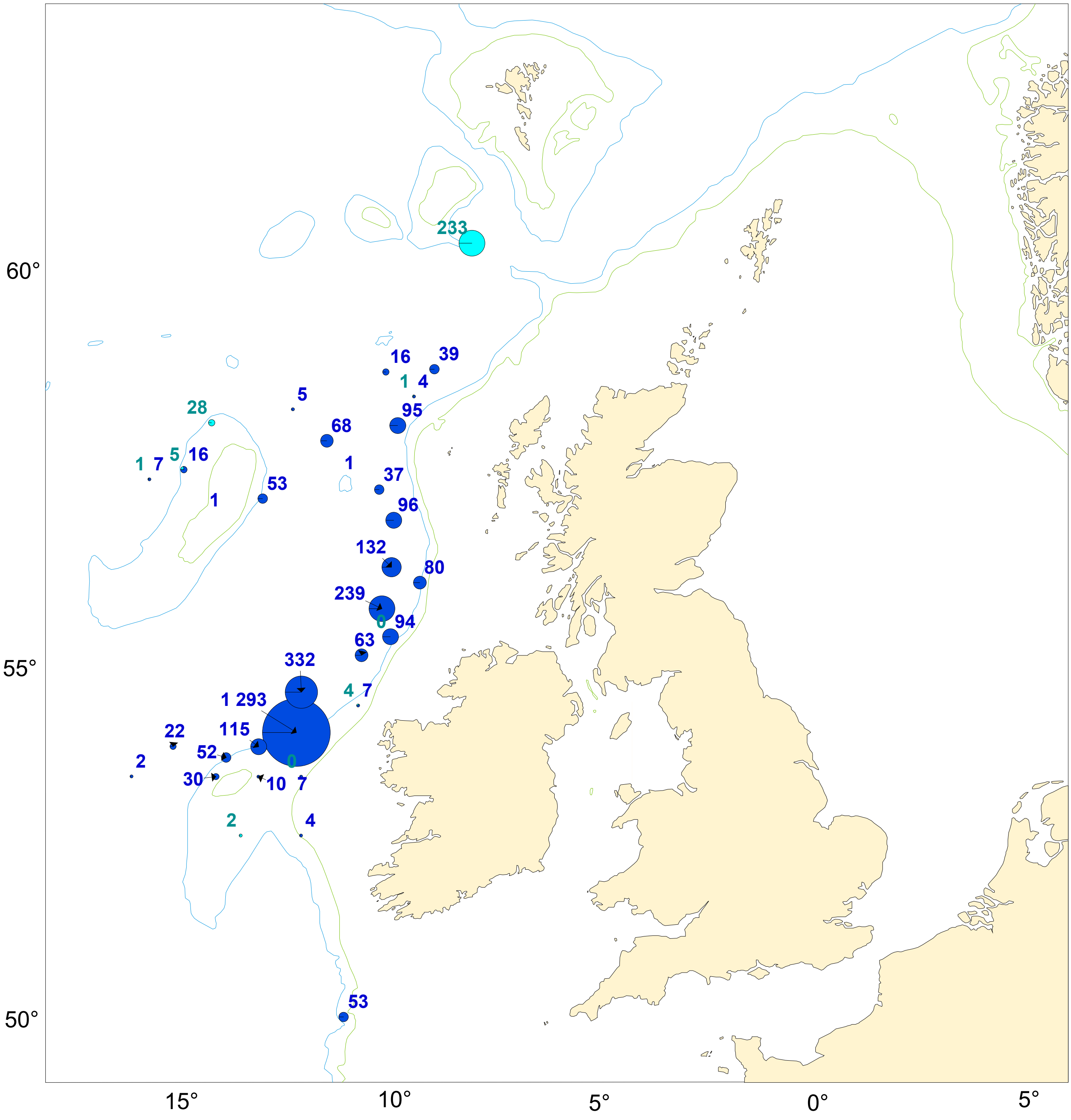


Figure 10. Distribution of blue whiting eggs (light blue) and larvae (dark blue) in spring 2001. Number of individuals is also inserted.

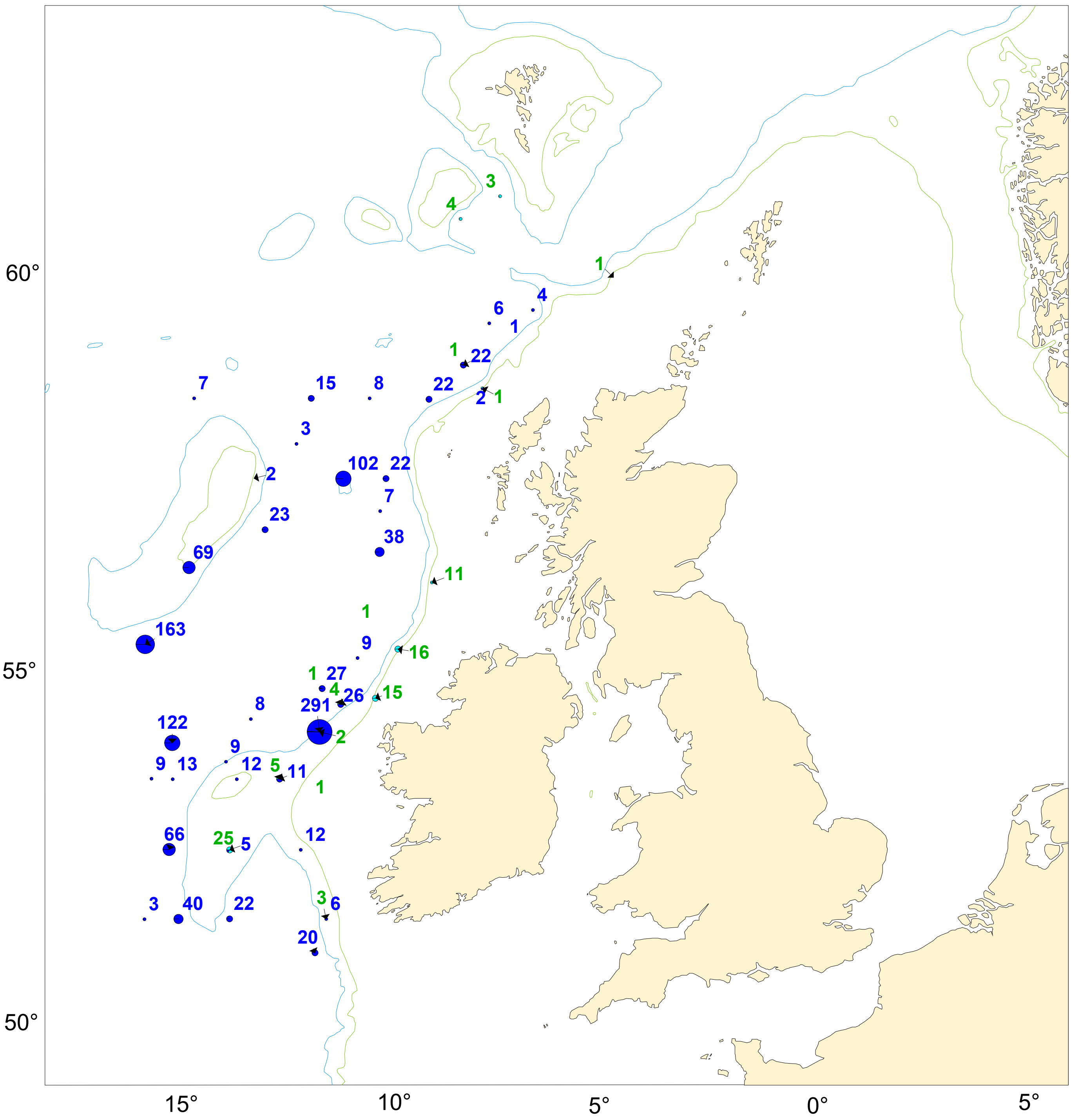


Figure 11. Distribution of blue whiting eggs (light blue) and larvae (dark blue) in spring 2002. Number of individuals is also inserted.

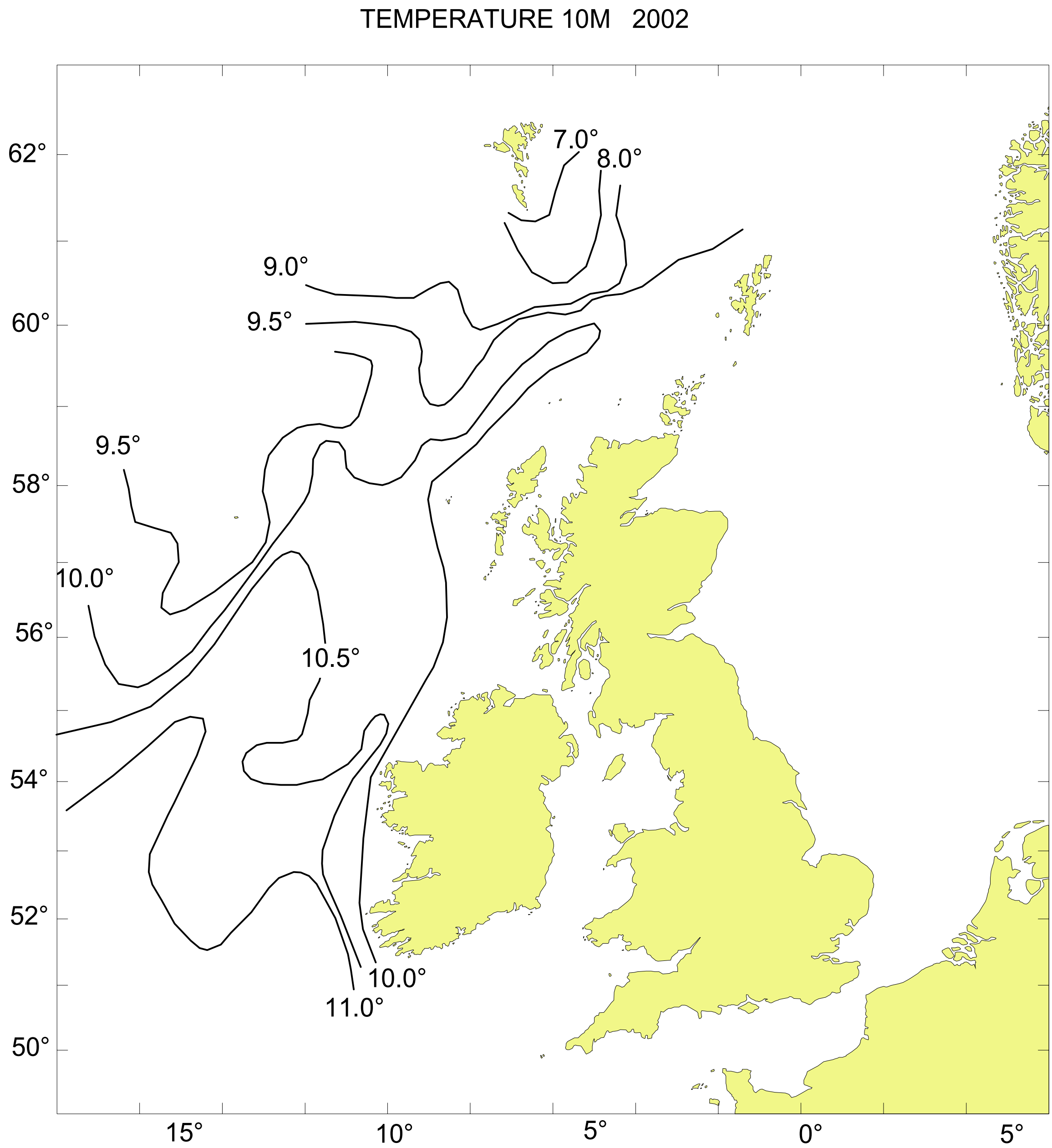


Figure 12. Horizontal temperature distribution, °C, at 10m depth.

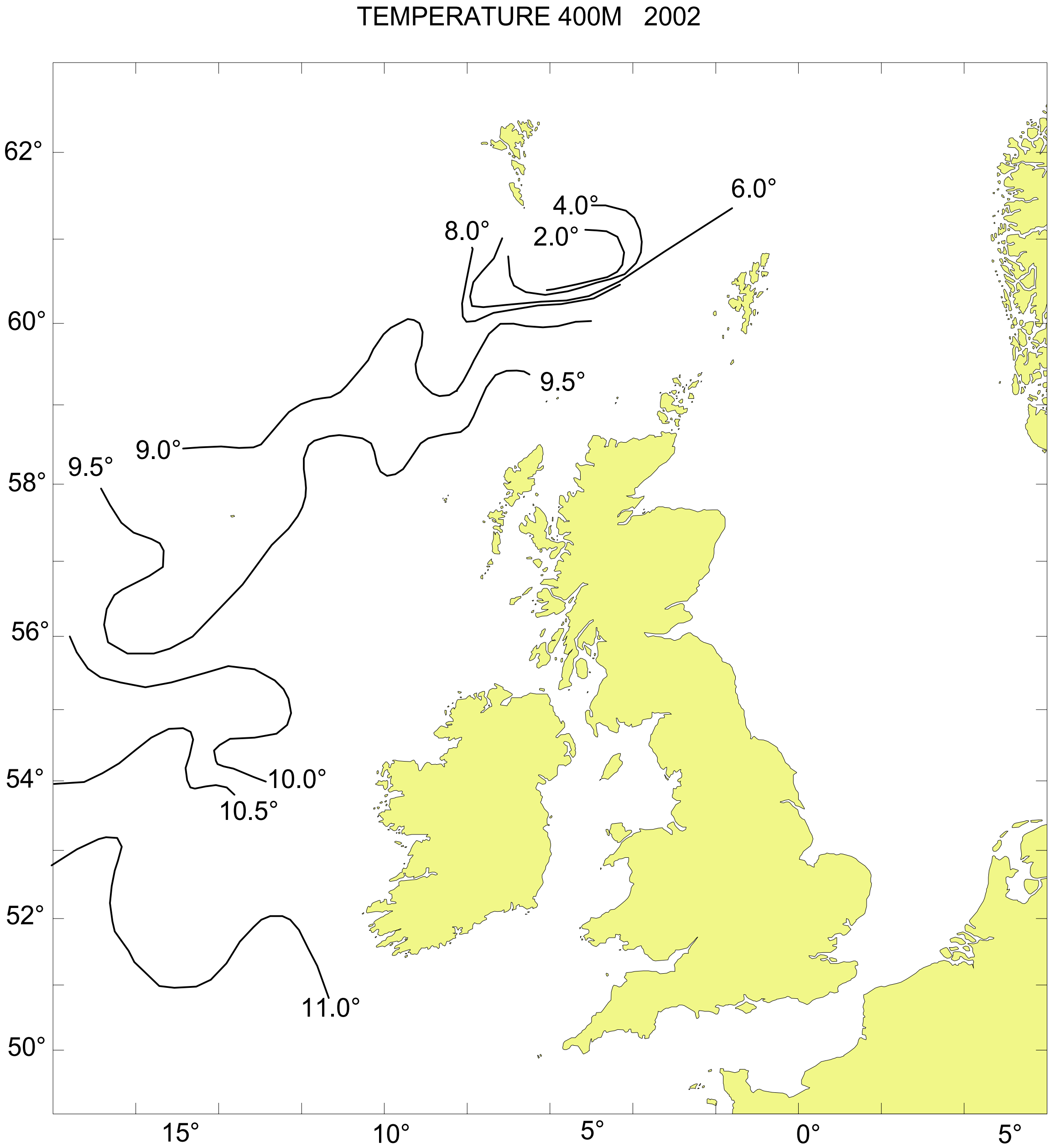


Figure 13. Horizontal temperature distribution, °C, at 400m depth.

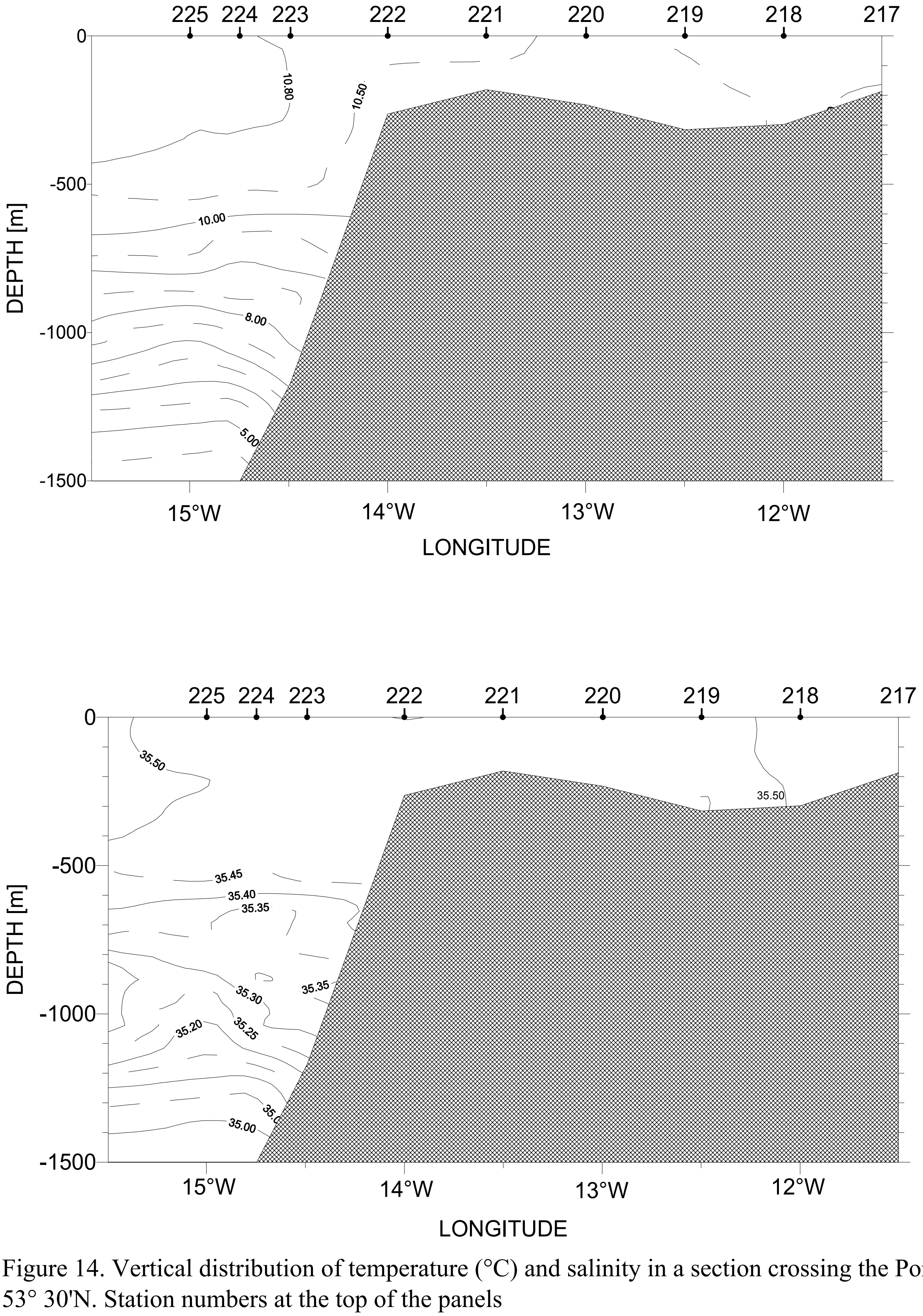


Figure 14. Vertical distribution of temperature (°C) and salinity in a section crossing the Porcupine Bank at 53° 30'N. Station numbers at the top of the panels

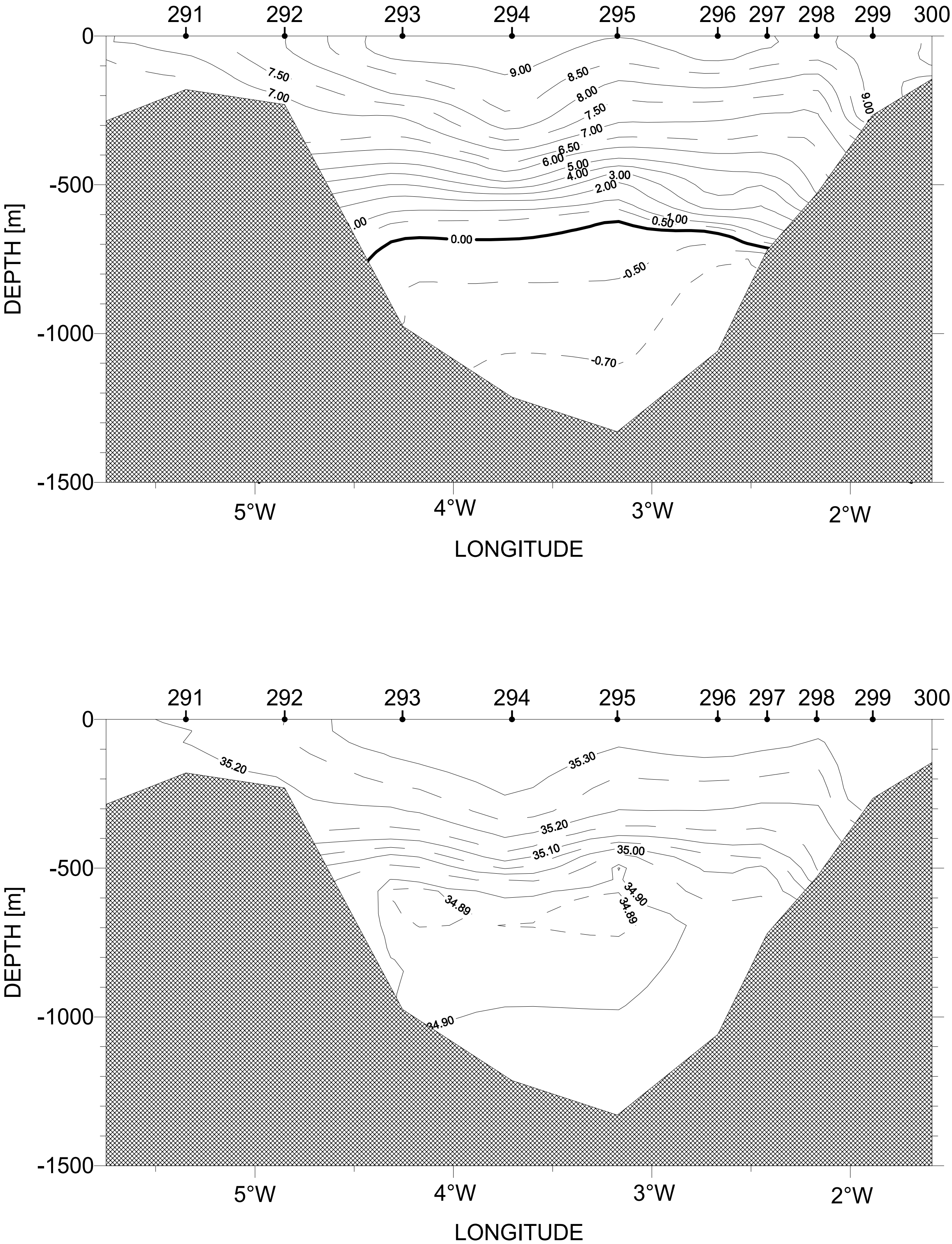


Figure 15. Vertical distribution of temperature (°C) and salinity in a section from the Faroes to Shetland (Nolsø-Flugga). Station numbers at the top of the panels.

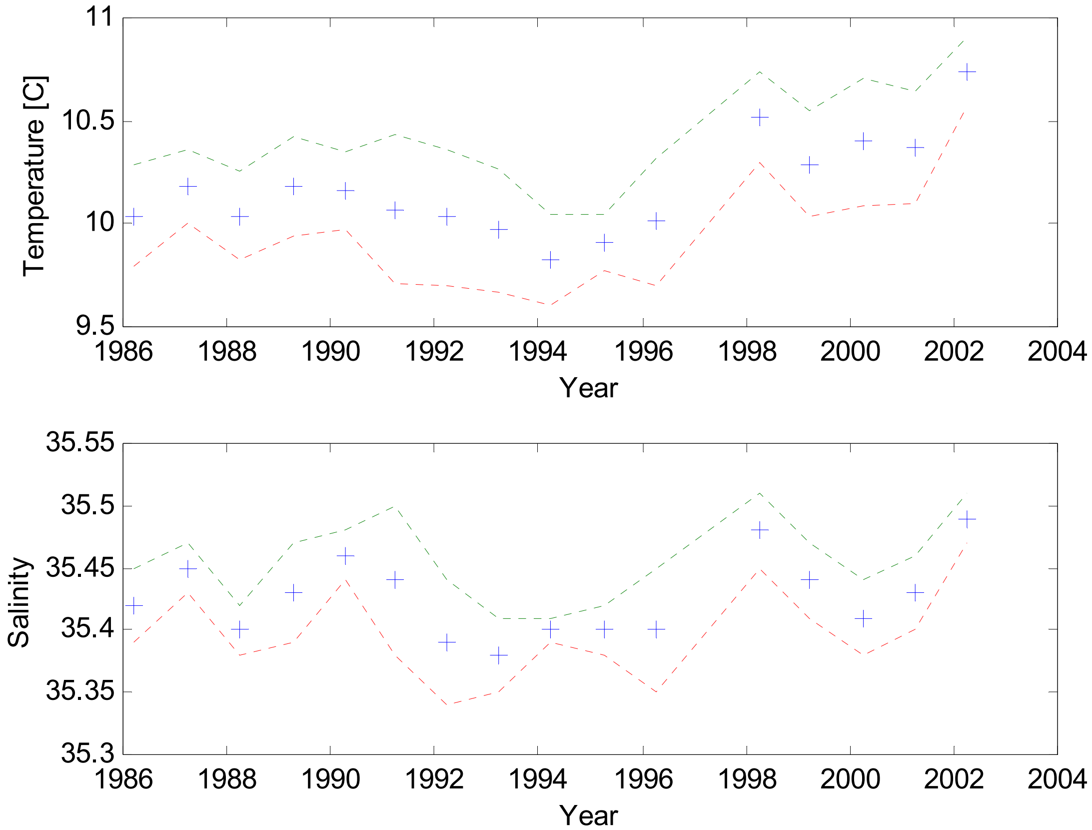


Figure 16. Temperature and salinity from 50-600m means (crosses) of all stations in a box west of the Porcupine bank bounded by 52° to 54°N and 16 to 14°W. Dotted lines are drawn at plus-minus one standard deviation of all observations in each box, each year.