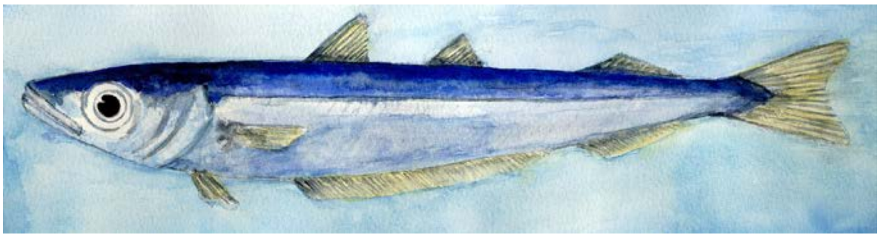
Working Document

Working Group on International Pelagic Surveys

Copenhagen, Denmark, 19-23 January 2015

Working Group on Widely Distributed Stocks

Copenhagen, Denmark, 26 August-1 September 2014



INTERNATIONAL BLUE WHITING SPAWNING STOCK SURVEY (IBWSS) SPRING 2014

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Material and methods

Survey planning and Coordination

Coordination of the survey was initiated in the meeting of the Working Group on International Pelagic Surveys (WGIPS) and continued by correspondence until the start of the survey. During the survey, updates on vessel positions and trawl activities were collated by the survey coordinator and distributed to the participants twice daily. Participating vessels together with their effective survey periods are listed below:

Vessel	Institute	Survey period
Fritjof Nansen	**PINRO, Murmansk, Russia**	**25/3 – 5/4**
Celtic Explorer	**Marine Institute, Ireland**	**26/3 – 6/4**
Magnus Heinason	**Faroe Marine Research Institute, Faroe Islands**	**29/3 – 6/4**
Tridens	**Institute for Marine Resources & Ecosystem Studies (IMARES), the Netherlands**	**26/3 – 5/4**
G.O. Sars	**Institute of Marine Research, Norway**	**27/3 – 7/4**

The survey design used and described in ICES (2014) allowed for a flexible setup of transects and good coverage of the spawning aggregations. Due to acceptable - good weather conditions throughout the survey period, the survey resulted in a high quality coverage of the stock. Transects of all vessels were consistent in spatial coverage and timing, delivering full coverage of the respective distribution areas within 14 days.

Cruise tracks and trawl stations for each participant vessel are shown in Figure 1. Figure 2 shows combined CTD stations. All vessels worked in a northerly direction (Figure 3). Regular communication between vessels was maintained during the survey (via email and internet weblog) exchanging blue whiting distribution data, echograms, fleet activity and biological information.

Sampling equipment

All vessels employed a midwater trawl for biological sampling, the properties of which are given in Table 5. Acoustic equipment for data collection and processing are presented in Table 2. The survey and abundance estimate are based on acoustic data collected through scientific echo sounders using a frequency of 38 kHz. All transducers were calibrated with a standard calibration sphere (Foote et al. 1987) prior, during or directly after the survey. Acoustic settings by vessel are summarized in Table 2.

Acoustic Intercalibration

Inter-vessel acoustic calibrations are carried out when participant vessels are working within the same general area and time and weather conditions allow for an exercise to be carried out. The procedure follows the methods described by Simmonds & MacLennan 2007. This year, no inter-calibration was carried out due to time constraints.

Biological sampling

All components of the catch from the trawl hauls were sorted and weighed; fish and other taxa were identified to species level. The level of blue whiting sampling by vessel is shown in Table 1.

Hydrographic sampling

Hydrographic sampling by way of vertical CTD cast was carried out by each participant vessel at predetermined locations (Figure 2 and Table 1) with a maximum depth of 1000 m in open water. Hydrographic equipment specifications are summarized in Table 5.

Acoustic data processing

Acoustic scrutiny was mostly based on categorisation by experienced experts aided by trawl composition information. Post-processing software and procedures differed among the vessels:

On Fridtjof Nansen, the FAMAS software was used as the primary post-processing tool for acoustic data. Data were partitioned into the following categories: blue whiting, plankton, mesopelagic species and other species. The acoustic recordings were scrutinized once per day.

On Celtic Explorer, acoustic data were backed up every 24 hrs and scrutinised using Myriax's EchoView (V 4.8) post-processing software for the previous day's work. Data was partitioned into the following categories: plankton (<120 m depth layer), mesopelagic species and blue whiting.

On Magnus Heinason, acoustic data were scrutinised every 24 hrs on board using Myriax's EchoView (V 5.2) post processing software. Data were partitioned into the following categories: plankton (<200 m depth layer), mesopelagic species (pearlside in the upper layer and lanternfish in the deeper layer), blue whiting and krill. Partitioning of data into the above categories was based on trawl samples.

On Tridens, acoustic data were backed up continuously and scrutinized every 24 hrs using the Large Scale Survey System LSSS (V 1.8) post-processing software. Blue whiting were identified and separated from other recordings based on trawl catch information and characteristics of the recordings.

On G.O. Sars, the acoustic recordings were scrutinized using the Large Scale Survey System (LSSS) once or twice per day. Data was partitioned into the following categories: plankton (<120 m depth layer), mesopelagic species and blue whiting.

Acoustic data analysis

The acoustic data were analysed with a SAS based routine called "BEAM" (Totland and Godø 2001) and used to calculate age and length stratified estimates of total biomass and abundance (numbers of individuals) within the survey area as a whole and within 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 representatively covered 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.

To obtain an estimate of length distribution within each stratum, all length samples within that stratum were used. If the focal stratum was not sampled representatively, additional samples from the adjacent strata were used. In such cases, only samples representing a similar kind of registration that dominated the focal stratum were included. Because this includes a degree of subjectivity, the sensitivity of the estimate with respect to the selected samples was crudely assessed by studying the influence of these samples on the length distribution in the stratum. No weighting of individual trawl samples was used because of differences in trawls and numbers of fish sampled and measurements. 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 terms described by Toresen et al. (1998). More information on this survey is given by, e.g., Anon. (1982) and Monstad (1986). Following the decisions made at the “Workshop on implementing a new TS relationship for blue whiting abundance estimates (WKTSBLUES)” (ICES 2012), the following target strength (TS)-to-fish length (L) relationship (Pedersen et al. 2011) used is:

$$TS = 20 \log10 (L) - 65.2$$

For conversion from acoustic density (sA, m2/n.m.2) to fish density (ρ) the following relationship was used:

$$\rho = sA / \langle\sigma\rangle,$$

where $\langle\sigma\rangle = 3.795 \cdot 10^{-6} L^{2.00}$ is the average acoustic backscattering cross-section (m^2). 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.

BEAM does not distinguish between mature and immature individuals, and calculations dealing with only mature fish were therefore carried out separately after the final BEAM run for each sub-area. 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.

Results

Distribution of blue whiting

In total 8,231 n.m. (nautical miles) of survey transects were completed and the total area of all the sub-survey areas covered was 125,319 n.m.^{2} (Figure 1, Tables 1 & 3). Covered survey track length was 10% longer and surveyed areas 30% larger than last year as a result of increased and more detailed coverage of the Rockall and Porcupine Bank areas.

Within the Irish EEZ (Exclusive Economic Zone), blue whiting distributions were seen to extend from the shelf edge to the west of the Porcupine Bank. Maximum s_A values observed there reached 64095 m^2/mile^2 with a vertical extension of up to 50-100 m over depths more than 1500 m (near the shelf edge), and 59221 m^2/mile^2 over depths of 770 m in the western area of the Rockall Trough (north of the Porcupine Bank).

Within the UK EEZ, blue whiting were distributed in a continuous layer along the shelf edge up to 58N. The latitudinal width of the aggregation was from 20 to 58 miles. Maximum s_A values observed there reached 41360 m^2/mile^2 with a vertical extension of up to 100 m near the shelf edge.

The highest concentrations of blue whiting were recorded in the Hebrides area but the observed biomass there was 37% less than in the previous year. Due to the perceived later northward migration of the stock as compared to 2013 the centre of gravity was located further south within the northern Porcupine Bank area. This area saw an increase in biomass of 310% as compared to 2013. Medium and high density registrations were concentrated along the shelf slope extending up to 15 nm from the shelf edge (Figures 4 & 5).

Compared to the last year, more high density aggregations were found on the Rockall Bank.

Stock size

The estimated total abundance of blue whiting for the 2014 international survey was 3.25 million tonnes, representing an abundance of 31.1x10^9 individuals (Figure 6, Tables 3 & 4). Spawning stock was estimated at 3.2 million tonnes and 24.4x10^9 individuals. In comparison to the 2013 survey estimate, there is a decrease (-3%) in the observed stock biomass and a related increase in stock numbers (+15%).

		2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	Change from 2013 (%)
Biomass	Total	2.6	3.4	3.6	2.6	2	1.3	1.6	2.2	3.4	3.3	-3%
(mill. t)	Mature	2.4	3.3	3.6	2.6	2	1.3	1.5	2.2	3.2	3	-6%
Numbers	Total	29	34.7	33.5	22.1	15.2	9.3	12.1	18.2	27	31.1	15%
(10^9)	Mature	26.7	33.8	32.9	21.7	15.0	8.9	9.7	16.5	24.4	26.4	8%
Survey area (nm^2)		172,000	170,000	135,000	127,000	133,900	109,320	68,851	88,746	87,895	125,319	43%

The Hebrides core area was found to contain 48% of the total biomass observed during the survey, which is lower than seen in previous years (73% of the stock found in this area in 2013 and 71% in 2012). The major part of the biomass recorded in the area was found more towards the southern part, while in previous years, the bulk of the aggregation was observed further north. The North Porcupine and Rockall areas ranked second and third highest contributing 27% and 15% to the total biomass respectively. Compared to the previous year, less biomass was observed in the Hebrides and Faroes/Shetland area, but more in the Northern Porcupine area, reflecting again the more southern distribution seen this year. An increase in absolute blue whiting biomass was observed in the Rockall area, both on the bank itself and in the Rockall Trough as compared to 2013. However, this increase can be attributed primarily to a high density area in the eastern Rockall Trough, as compared to the lower density echotraces found on the Rockall Bank itself. The breakdown of survey biomass by sub area is shown below:

		Biomass (million tonnes)				
		2013		2014		
	Sub-area		% of total		% of total	Change (%)
I	S. Porcupine Bank	-	-	0.03	1	-
II	N. Porcupine Bank	0.21	6	0.86	27	310%
III	Hebrides	2.44	73	1.54	48	-37%
IV	Faroes/Shetland	0.43	13	0.34	10	-21%
V	Rockall	0.27	8	0.47	15	74%

Stock composition

Individuals of ages 1 to 15 years were observed during the survey. A comparison of age reading between nations was carried out and the results are presented in Appendix 2. Results showed less agreement across participants for especially the younger year classes compared to 2013, with a broad spread of lengths for the youngest and oldest fish in the range.

The stock biomass within the survey area is dominated by age classes 3, 4, and 5 and 1 years of the 2010, 2009, 2008 and 2013 year classes respectively (Table 4 and Figure 10). The main contribution (76%) to the spawning stock biomass were the age groups 4, 3, 5 and 6 (Table 4).

The Hebrides area has consistently been the most productive in the current time series with the exception of this year where a slightly lower but still significant proportion of the overall biomass was located in that area (Figure 6). But this year the contribution was 48% while the Porcupine area contained a significant portion of the spawning stock in 2014. Mean lengths and weights of the fish caught in the Hebrides area were also among the highest within the whole survey area (Figures 7 and 8). The Faroe/Shetland subarea was dominated by mainly 1 and 3 year old fish, with some 2 year olds, and Porcupine sub-areas were dominated by 3-5 year old fish. One year old fishes were mainly observed in subarea IV (Faroes-Shetland). Older fish (8+ years) were predominantly observed in sub-area III (Hebrides) and V (Rockall) (Figure 11).

From the survey data, the Faroese/Shetland sub-area was found to contain significant proportion of young blue whiting (1-3 years), consistent with previous years. This together represents 70% (238,000t) of the total biomass and 85% (4183 million individuals) of the total abundance in this area. This is close to the proportions seen in 2012 (75% and 86% respectively), and larger than last year.

The largest blue whiting were observed on the Rockall Bank and here most of the fish were mature (97%).

Immature blue whiting were present to various extents in all sub areas in 2014 (Figure 11). Maturity analysis of survey samples indicate that 14% of 1-year old, 56% of 2-year old and 90% of 3-year old fish were mature as compared to the 2013 estimates, where 18% of 1-year old fish, 54% of 2-year old fish and 82% of 3-year old fish were considered mature (Table 4). Overall, immature blue whiting from the estimate represented 7.4% (242,000t) of the total biomass and 15% (4667 million) of the total abundance recorded during the survey.

Hydrography

A combined total of 167 CTD casts were undertaken over the course of the survey (Table 1). Horizontal plots of temperature and salinity at depths of 50m, 100m, 200m and 500m as derived from vertical CTD casts are displayed in Figures 12-15 respectively.

Concluding remarks

Main results

- The 11th International Blue Whiting Spawning stock Survey 2014 shows a slight decrease in total biomass of -3% (+15% abundance) when compared to the 2013 estimate, with increased area coverage (2013: 88’000 nmi²; 2014: 125’000 nmi²).
- Favourable weather conditions allowed the five survey vessels to successfully cover the entire planned area within the time available and achieved good containment of the stock.
- The survey was carried out over 14 days this year as compared to 19 days in 2013. Temporal progression of the survey was very good and this was achieved through vigilant survey coordination by means of regular updates. Temporal coverage is well within the 21 day time window recommended by the group to cover the spawning stock and was facilitated by good weather conditions.
- Estimated uncertainty around the mean acoustic density is low and comparable to the previous two years. It is about half as large as those observed in earlier years (2004-2011) with the exception of 2007, when a much higher uncertainty was recorded.
- The stock biomass within the survey area is dominated by age classes 4, 3, 5 and 6 of the 2010, 2011, 2009 and 2008 year classes respectively, contributing 74% of total stock biomass
- Mean length (27 cm) and weight (104.6 g) are lower than in 2013 and in previous years. This can be attributed to the increasing contribution of young fish to the total stock biomass.
- A positive signal of 3 and 4-year old fish (strong 2010 & 2011 year classes) continues to be observed across all areas and the 2009 and 2010 year classes are now considered fully recruited to the spawning stock. Signs of a potentially strong 2013 year class could be seen in the survey. However, it is too early to predict the magnitude of that year class yet with any degree of accuracy until it can be confirmed in upcoming surveys.

Interpretation of the results

- The 2014 estimate of abundance can be considered as robust. Stock containment was achieved for the core stock areas, with close temporal progression between vessels and a high amount of supporting biological data contributing to the analysis. 85% of the total biomass was observed in target areas surveyed by more than one vessel.
- The bulk of the stock was once again located in the Hebrides core area. Within this area the stock was located further south than at the same time in previous years indicating a later than normal migration of the stock northwards.
- Cohort tracking through the time series is possible for the most dominant year classes at present (2010 & 2011) and to a lesser extent for older fish. The presence of three successive years of good recruitment is a positive signal after a prolonged period of poor recruitment. The number of 3 year old fish observed in 2014 (2011 year class) is comparable in terms of weight and numbers to that of the strong 2010 year class. The strong 2009 year class has now fully recruited to the stock.

Recommendations

- It is recommended that Norway update the group as soon as possible regarding participation in 2015 to allow for timely planning and allocation of survey effort for the remaining participants.
- It is recommended that all participants with the capacity to do so begin collecting fluorescence data during routine CTD casts in 2015 and submit the data accordingly.
- The 2015 survey will be carried out as detailed in Appendix 3.

- It is the responsibility of individual survey participants to ensure that all data is screened prior to submission to the PGNAPES data base following the details outlined in the WGIPS survey manual.
- Group members should discuss the blue whiting maturity stage key (use of 7 stages or 8 stages) and use of inter-transects during biomass estimation at the next WGIPS meeting to decide on a common standardised method.
- Due to difficulties in confirming vessel availability in recent years, the possibility of limiting participating vessels by use of a rotation system should be investigated at the next WGIPS meeting. Potential reduction of survey precision should be investigated in this process.
- Vessels should adhere to the common survey speed of 10 knots. If this cannot be achieved, relevant participants have to communicate this prior to the survey to facilitate planning.
- Vessels surveying the Rockall area should be able to sample blue whiting that is occurring close to the sea bed there.

Achievements

- The whole survey area (c.125,000nmi^2) was covered within 14 days within the recommended 21 day maximum.
- Comprehensive trawling and hydrographic sampling were carried out.
- Delivery of survey data to Leon Smith (Faroes, data repository) was achieved prior to the post cruise meeting. Most data were quality controlled prior to submitting to the database. Remaining errors were resolved during the post-cruise meeting.

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Table 1. Survey effort by vessel. March-April 2014.

Vessel	Effective survey period	Length of cruise track (nmi)	Trawl stations	CTD stations	Plankton sampling	Aged fish	Length-measured fish
Celtic Explorer	26/3-6/4	1451	11	24		550	1650
Magnus Heinason	29/3-6/4	1173	10	21	21	337	721
G.O.Sars	27/3- 7/4	1962	8	41	38	204	625
Tridens	26/3-5/4	1997	11	24		1101	1100
Fritjof Nansen	25/3-5/4	1648	12	57		1100	3632
Total	25/3-7/4	8,231	52	167	59	3,292	7,728

Table 2. Acoustic instruments and settings for the primary frequency. March-April 2014.

	Fridtjof Nansen	Celtic Explorer	Magnus Heinason	Tridens	G.O. Sars
Echo sounder	Simrad EK60	Simrad EK 60	Simrad EK60	Simrad EK 60	Simrad EK 60
Frequency (kHz)	**38**	**38**, 18, 120, 200	**38**	**38**, 120	18, 70, **38**, 120, 200,
Primary transducer	ES38B	ES 38B	ES38B	ES 38B	ES 38B
Transducer installation	Hull	Drop keel	Hull	Towed body	Drop keel
Transducer depth (m)	5	8.7	3	7	8.5
Upper integration limit (m)	10	15	7	13	15
Absorption coeff. (dB/km)	10	9.8	10.2	10	10.1
Pulse length (ms)	1.024	1.024	1.024	1.024	1.024
Band width (kHz)	2.425	2.425	2.43	2.43	2.43
Transmitter power (W)	2000	2000	2000	2000	2000
Angle sensitivity (dB)	21.9	21.9	21.9	21.9	21.9
2-way beam angle (dB)	-20.6	-20.6	-20.8	-20.6	-20.6
Sv Transducer gain (dB)					
Ts Transducer gain (dB)	25.52	25.98	25.61	26.18	25.5
s_A correction (dB)	-0.64	-0.69	-0.72	-0.67	-0.65
3 dB beam width (dg)					
alongship:	6.99	6.93	7.02	7.05	6.84
athw. ship:	6.99	7	7.01	7.06	6.85
Maximum range (m)	750	750	750	750	750
Post processing software	FAMAS	Sonardata Echoview	Sonardata Echoview	LSSS	LSSS

Table 3. Assessment factors of blue whiting for IBWSS March-April 2014.

Sub-area			Numbers (10^9)			Biomass (10^6 tonnes)			Mean weight	Mean length	Density
		nmi^2	Mature	Total	%mature	Mature	Total	%mature	g	cm	ton/n.mile^2
I	S. Porcupine Bank	7,999	0.28	0.35	80	0.027	0.031	87	85.3	26.3	3.9
II	N. Porcupine Bank	16,175	8.35	9.37	89	0.8	0.865	92	92.3	26.9	53.5
III	Hebrides	37,371	12.07	12.94	93	1.483	1.544	96	119	28.2	41.3
IV	Faroes/Shetland	23,516	2.38	4.92	48	0.237	0.337	70	68.5	22.6	14.3
V	Rockall	40,258	3.35	3.5	96	0.463	0.475	97	135.8	29.2	11.8
Tot.		125,319	26.43	31.08	85	3.01	3.252	93	121.8	28	25.9

Table 4. Survey stock estimate of blue whiting, March-April 2014.

Length	Age in years (year class)										Numbers	Biomass	Mean weight	Prop. mature*
	1	2	3	4	5	6	7	8	9	10+				
(cm)	2012	2011	2010	2009	2008	2007	2006	2005	2004		(*10-$^{6)}$	(10^6 kg)	(g)	(%)
11.0 – 12.0											0			
12.0 – 13.0											0			
13.0 – 14.0											0			
14.0 – 15.0											0			
15.0 – 16.0											0			
16.0 – 17.0	77	0	0	0	0	0	0	0	0		77	1.7	22	0
17.0 – 18.0	388	6	0	0	0	0	0	0	0		394	10.1	26	0
18.0 – 19.0	784	49	6	0	0	0	0	0	0		839	26.1	31	13
19.0 – 20.0	993	150	1	0	0	0	0	0	0		1144	42	37	14
20.0 – 21.0	435	246	1	0	0	0	0	0	0		682	28.8	42	14
21.0 – 22.0	164	164	4	0	0	0	0	0	0		332	16.9	51	52
22.0 – 23.0	35	113	46	0	0	0	0	0	0		194	11.2	58	62
23.0 – 24.0	0	154	226	18	1	0	0	0	0		399	26.2	66	74
24.0 – 25.0	10	299	941	411	74	0	0	0	0		1735	128.8	75	75
25.0 – 26.0	0	229	2244	1376	597	41	11	0	0		4498	366.5	82	85
26.0 – 27.0	0	81	2476	1834	1320	61	19	0	0		5791	517.7	90	94
27.0 – 28.0	0	11	1660	1888	987	94	0	0	0		4640	462.8	100	98
28.0 – 29.0	0	0	527	1188	1039	228	10	0	0		2992	334.4	112	100
29.0 – 30.0	0	0	206	557	759	208	24	0	10		1764	219.4	125	100
30.0 – 31.0	0	0	28	352	568	285	84	23	0	55	1395	197.4	142	100
31.0 – 32.0	0	0	0	68	278	234	90	70	115	158	1013	169.2	168	100
32.0 – 33.0	0	0	20	49	142	124	109	167	116	276	1003	184.7	185	100
33.0 – 34.0	0	0	9	30	108	85	51	176	73	269	801	163.1	205	100
34.0 – 35.0	0	0	1	0	47	33	58	38	113	228	518	115.1	224	100
35.0 – 36.0	0	0	0	0	4	43	41	21	84	212	405	99.3	246	100
36.0 – 37.0	0	0	0	0	0	25	8	27	59	112	231	58.3	254	100
37.0 – 38.0	0	0	0	0	0	6	21	6	19	78	130	35.1	273	100
38.0 – 39.0	0	0	0	0	3	1	6	6	3	32	51	14.9	280	100
39.0 – 40.0	0	0	0	0	0	0	0	0	4	22	26	8.4	321	100
40.0 – 41.0	0	0	0	0	0	0	0	0	0	0	0	0	.	100
41.0 – 42.0	0	0	0	0	0	0	0	2	0	2	4	1.4	407	100
42.0 – 43.0	0	0	0	0	0	0	0	0	0	10	10	3.9	383	100
43.0 – 44.0	0	0	0	0	0	0	0	0	3	12	15	6.9	455	100
44.0 – 45.0	0	0	0	0	0	0	0	0	0	2	2	1.1	519	100
TSN (10^6)	2886	1502	8396	7771	5927	1468	532	536	599	1468	31085	3251		
TSB (10^6 kg)	102.1	96	761.2	767.4	660.7	215.3	93.7	106.7	127.7	320.6	3251			
Mean length (cm)	19.2	22.8	26.3	27.3	28.2	30.4	32.3	33.2	33.9	34.5				
Mean weight (g)	35.4	63.8	90.7	98.7	111.4	146.5	176.4	199	212.8	225				
Condition (g/dm^3)														
% mature*	14	56	90	94	97	99	99	100	100	100				
SSB	14.7	53.5	685.2	721.8	637.6	213.6	93.2	106.7	127.7	320.6	2974.6			

* Percentage of mature individuals per age or length class

Table 5. Country and vessel specific details, March-April 2014.

	Fritjof Nansen	Celtic Explorer	Magnus Heinason	Tridens	G.O. Sars
Trawl dimensions					
Circumference (m)	716	768	640	1120	832
Vertical opening (m)	50	50	40	30-70	45
Mesh size in codend (mm)	16	20	40	±20	40
Typical towing speed (kn)	3.0-3.7	3.5-4.0	3.0-4.0	3.5-4.0	3.0-3.5
Plankton sampling	0	0	21	0	38
Sampling net	-	-	WP2 plankton net	-	WP2 plankton net
Standard sampling depth (m)	-	-	200	-	400
Hydrographic sampling					
CTD Unit	SBE19plus	SBE911	SBE911	SBE911	SBE911
Standard sampling depth (m)	1000	1000	1000	1000	1000

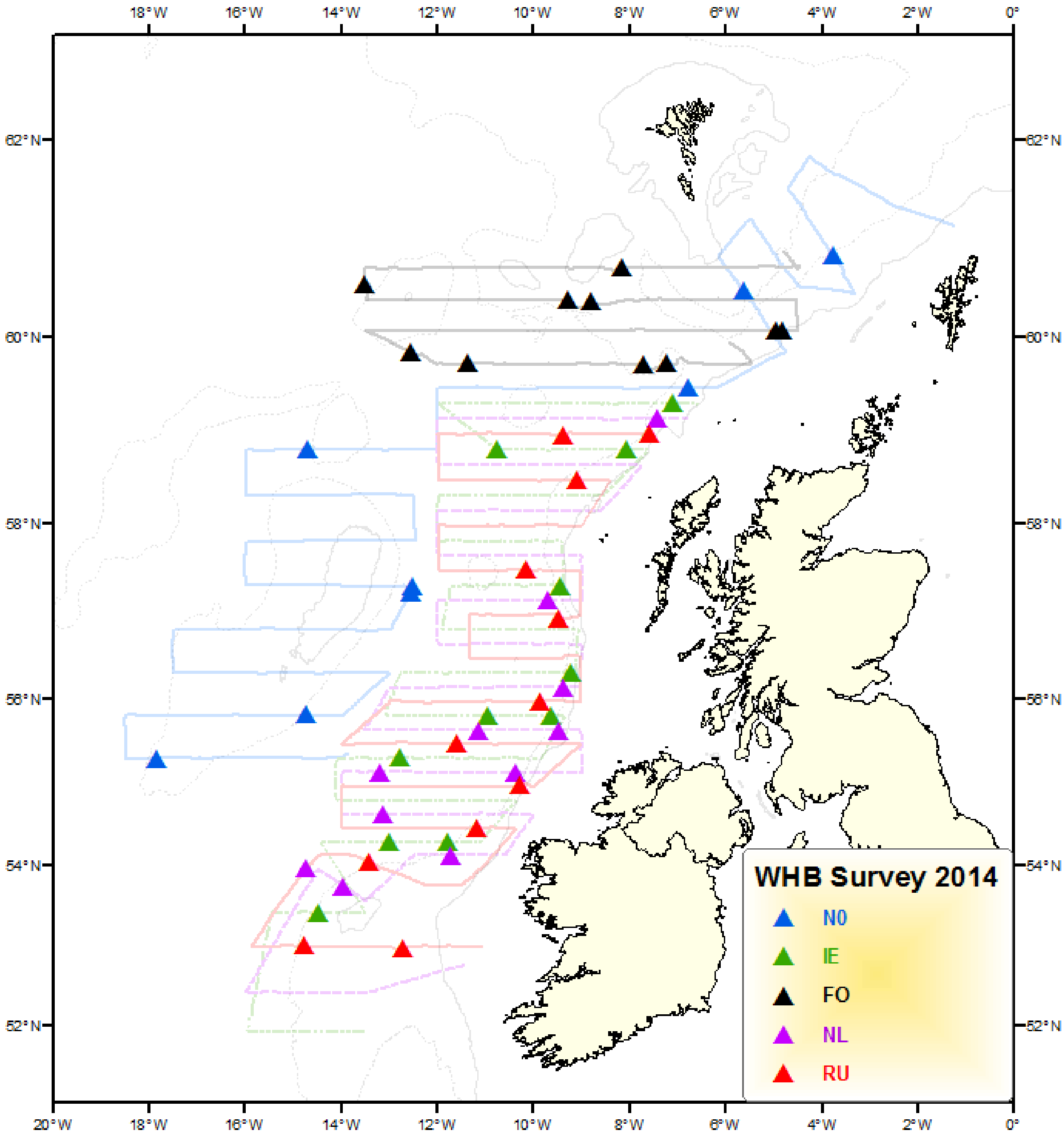


Figure 1. Vessel cruise tracks and trawl stations of the International Blue Whiting Spawning stock Survey (IBWSS) from March-April 2014. IE: Ireland (Celtic Explorer); FO: Faroe Islands (Magnus Heinason); NL: Netherlands (Tridens); RU: Russia (Fritjof Nansen); NO: Norway (G.O. Sars).

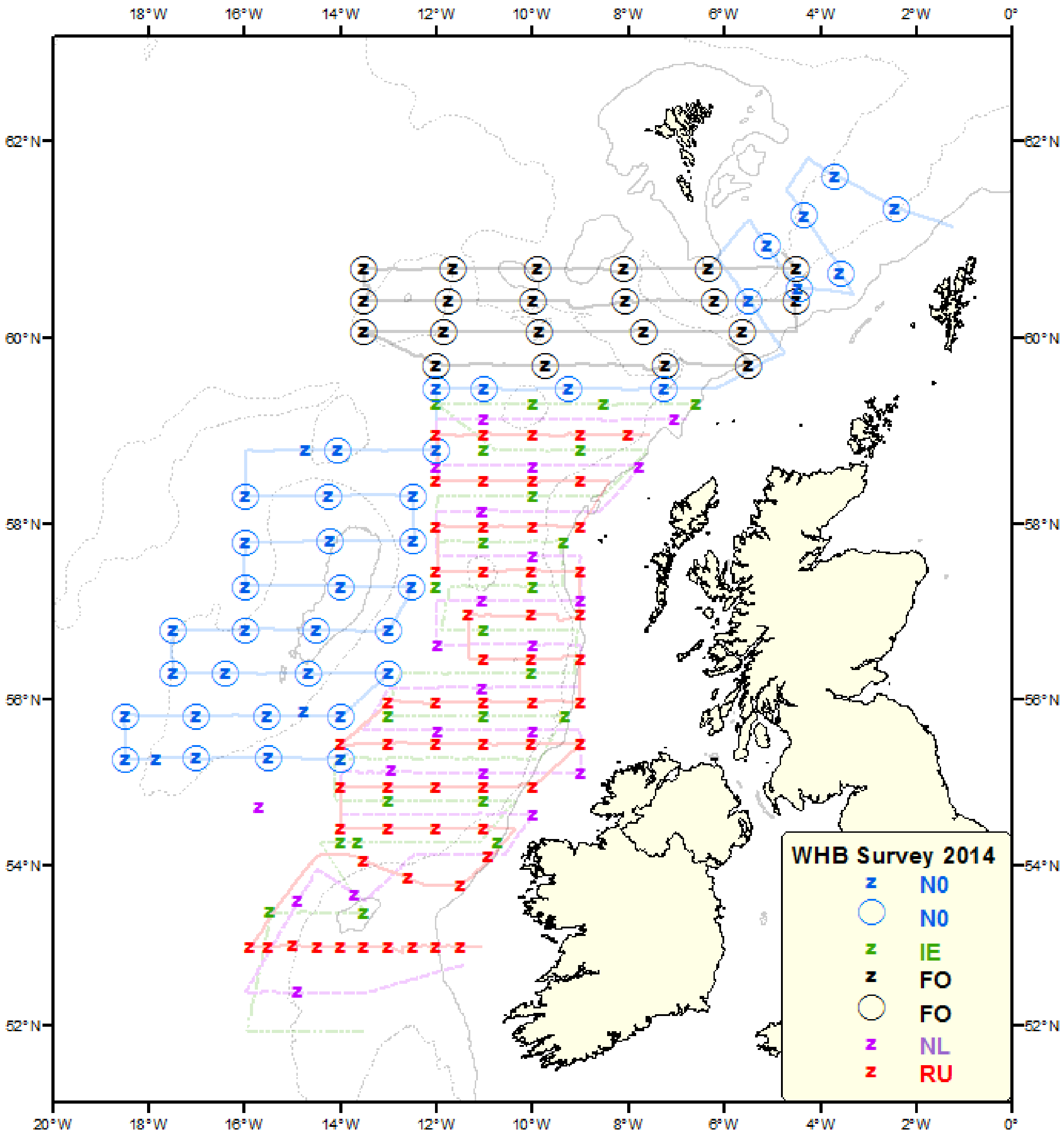


Figure 2. CTD stations overlaid onto vessel cruise tracks for the combined survey ('z'). Circles represent plankton trawls. green: Celtic Explorer; black: Magnus Heinason; purple: Tridens; red: Fritjof Nansen; blue: G.O. Sars. March-April 2014.

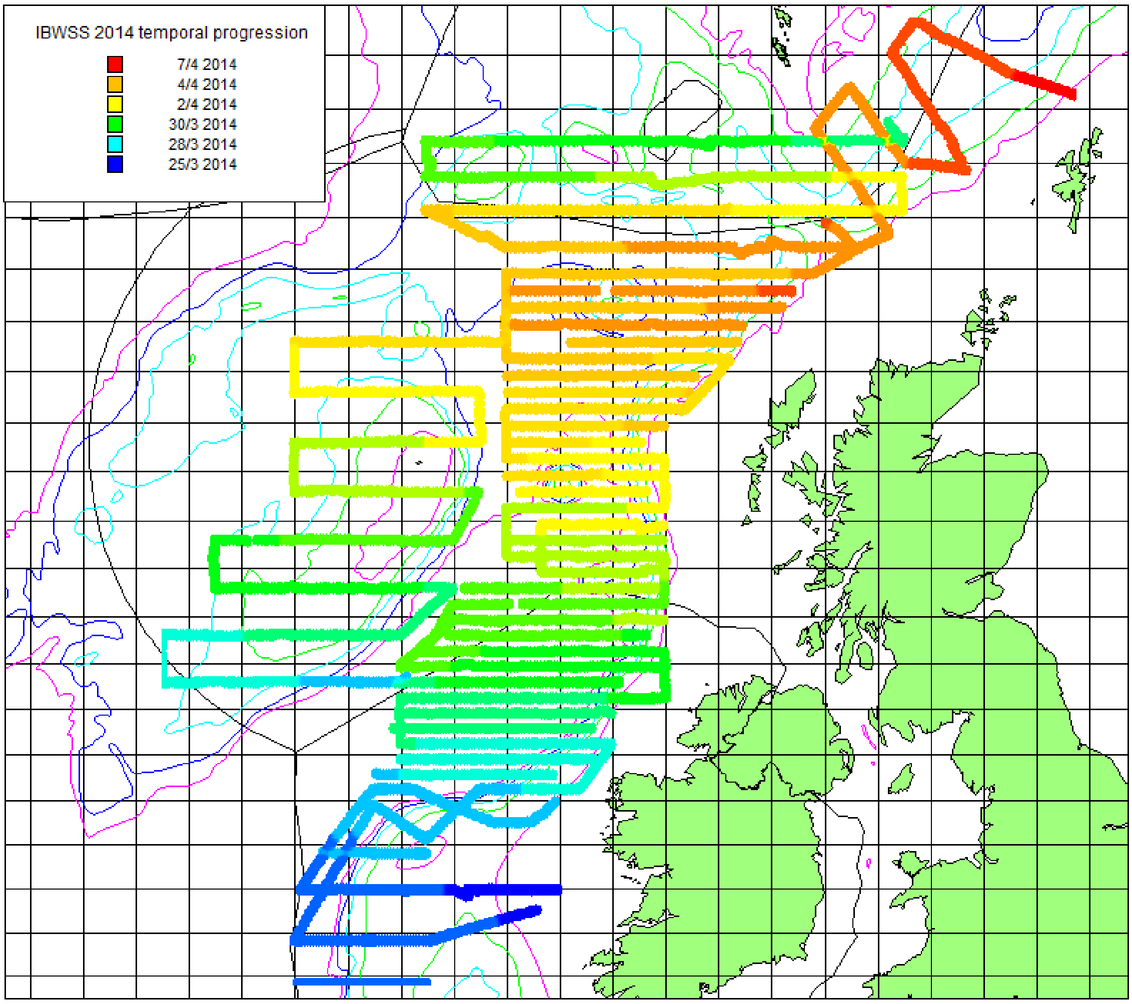


Figure 3. Temporal progression for the International Blue Whiting Spawning stock Survey (IBWSS), 25. March – 7. April 2014.

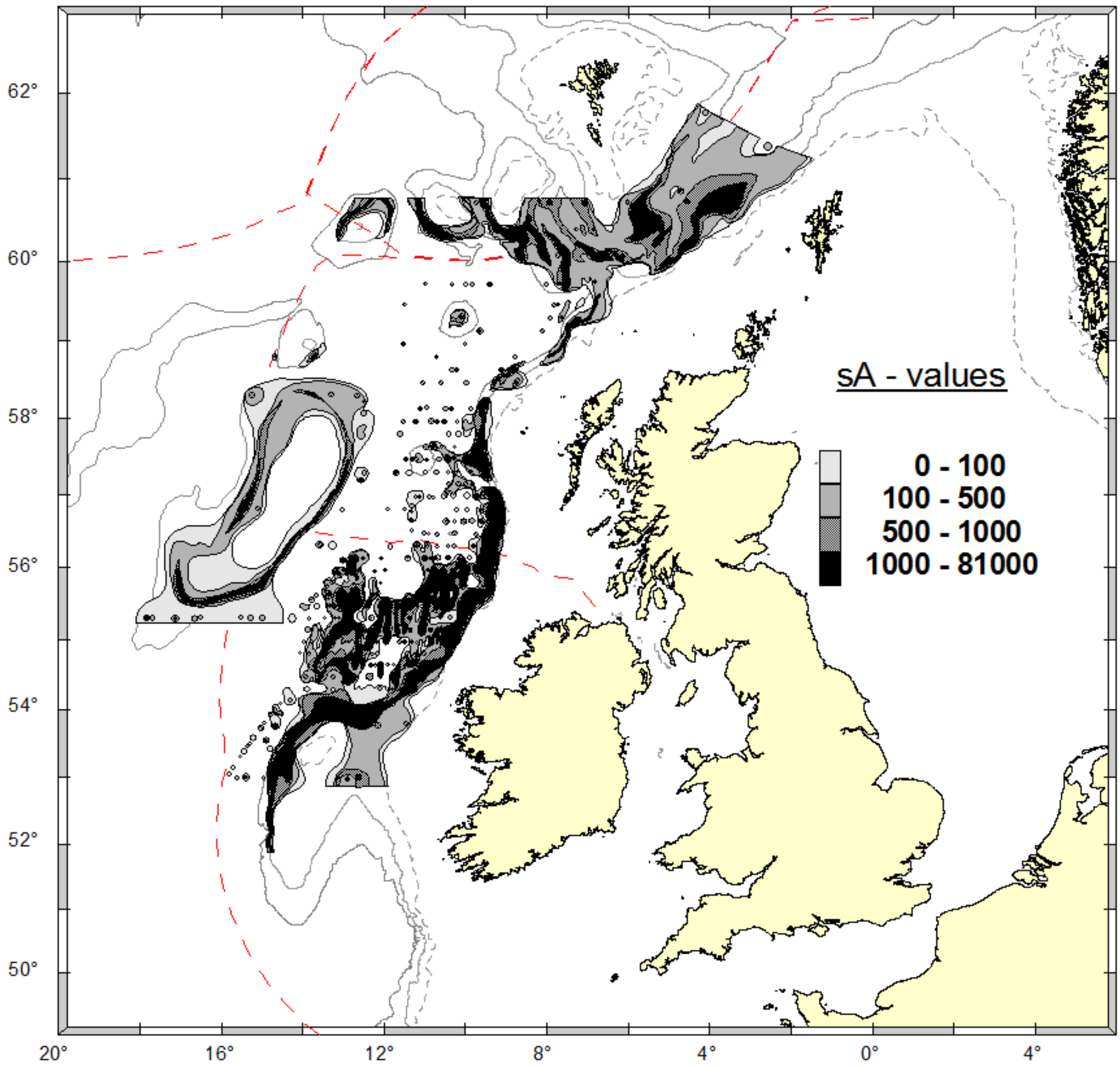


Figure 4. Map of blue whiting acoustic density (s_A, $m^2/n.m.^2$) , 24. March – 07. April 2014.

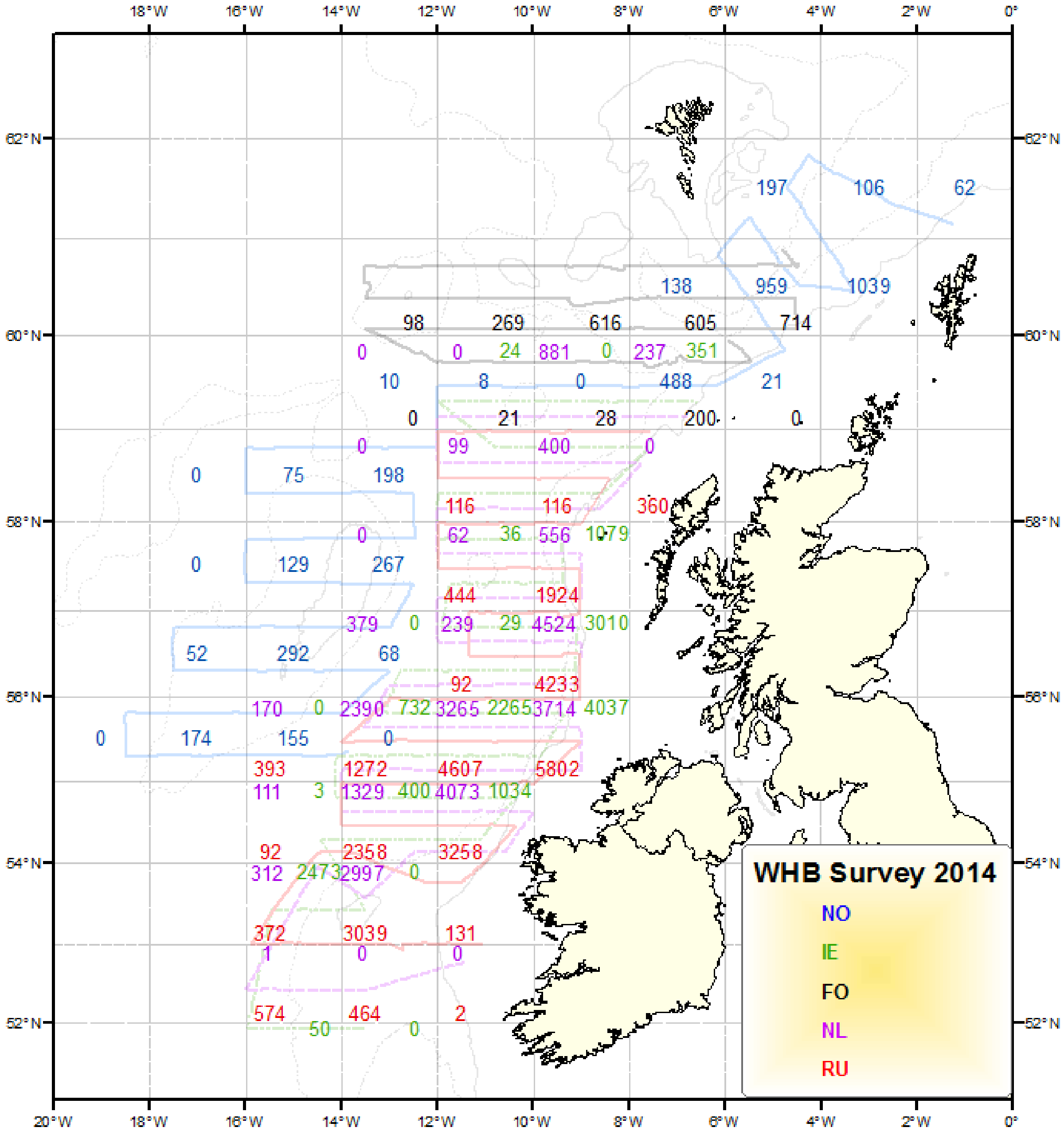


Figure 5. Mean blue whiting acoustic density (s_A, $m^2/n.m.^2$) for IBWSS 2013 by individual vessel: Celtic Explorer: green, Magnus Heinason: black, Tridens: grey, Fritjof Nansen: red, G.O. Sars: blue. March-April 2014.

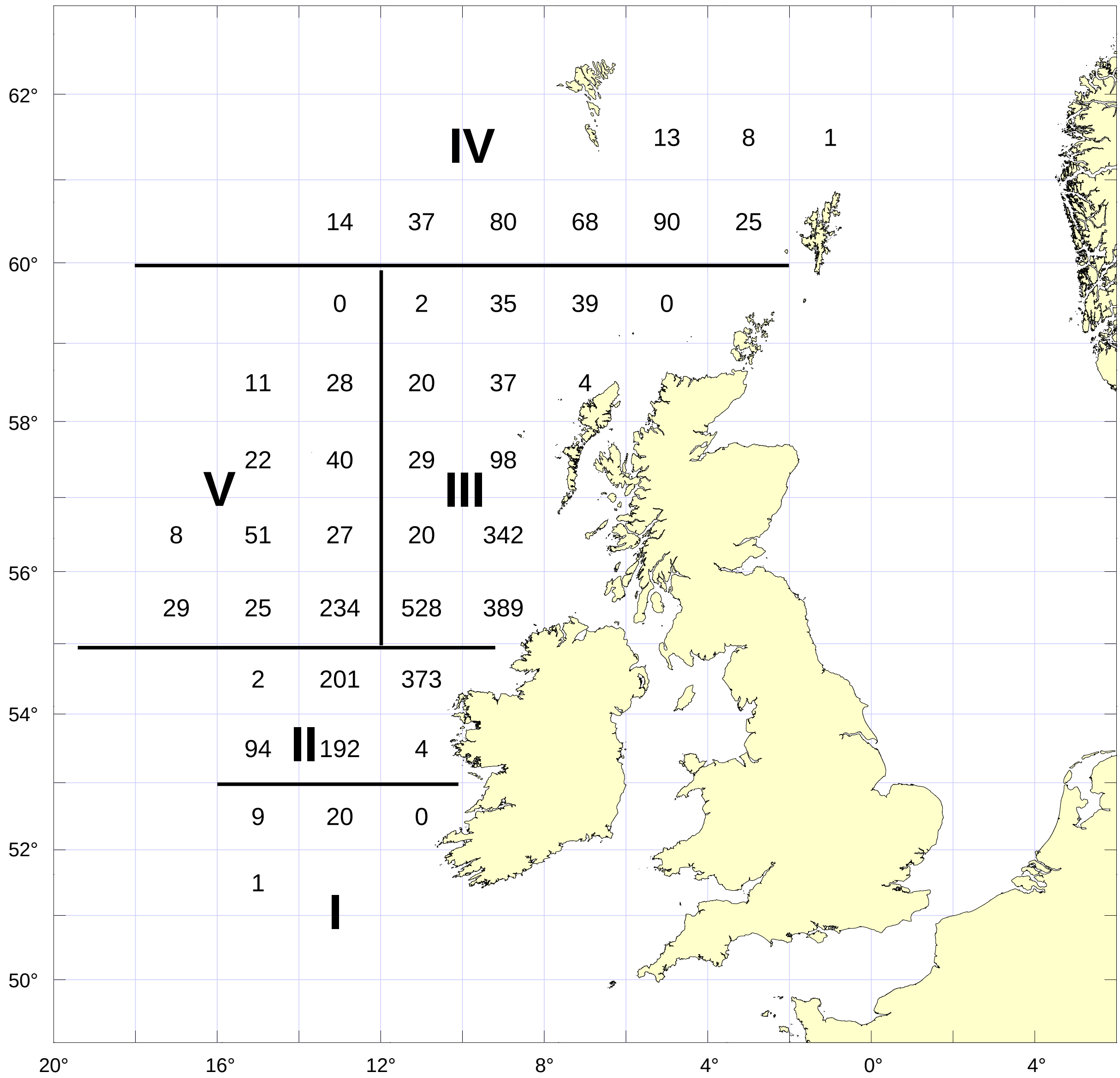


Figure 6. Blue whiting biomass (x1000t) from IBWSS 2014 by sub-area as used in the assessment.

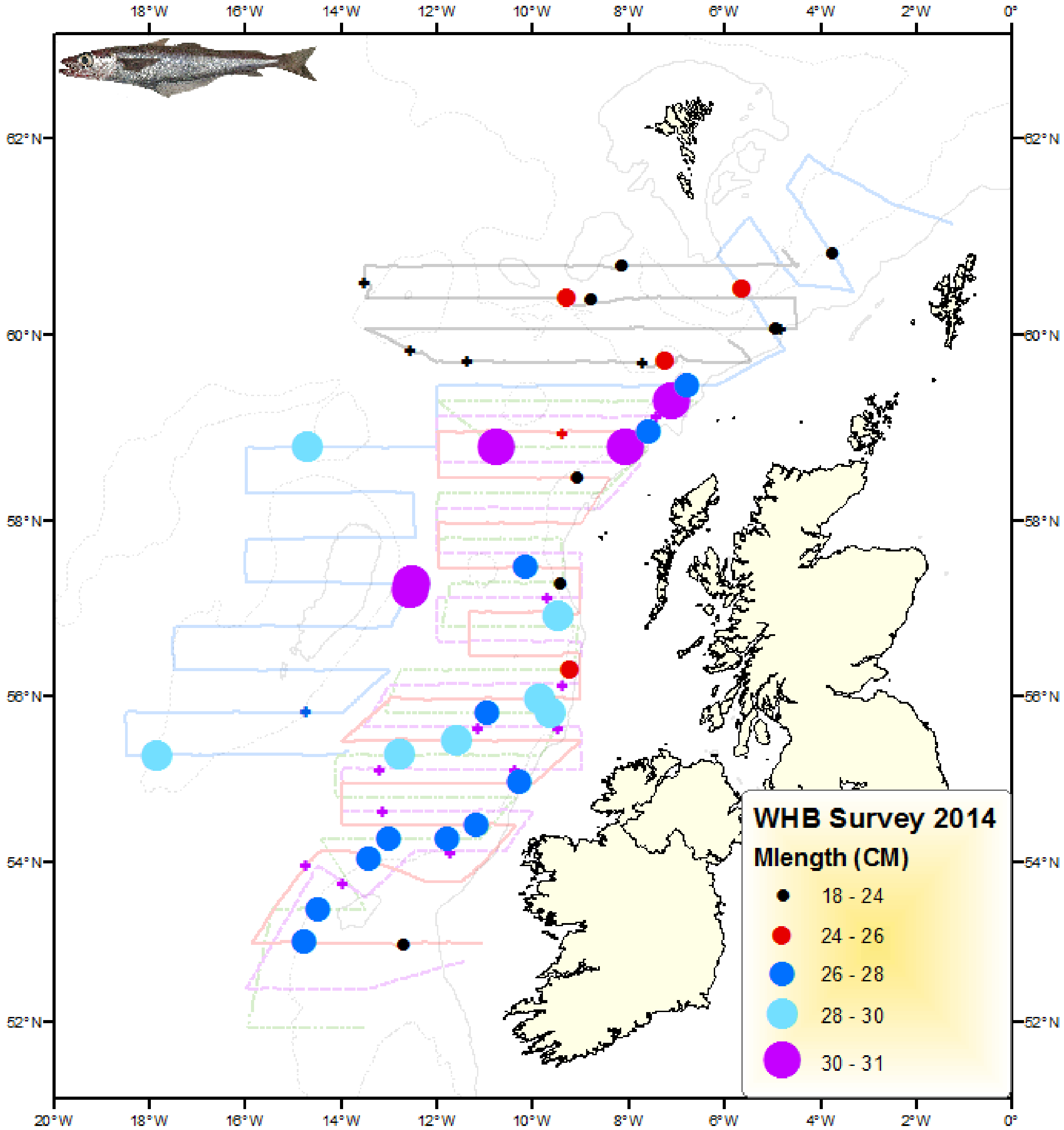


Figure 7. Mean length of blue whiting caught in trawl catches during IBWSS 2014 by individual vessels in March-April 2014. Crosses indicate trawls without any blue whiting catches.

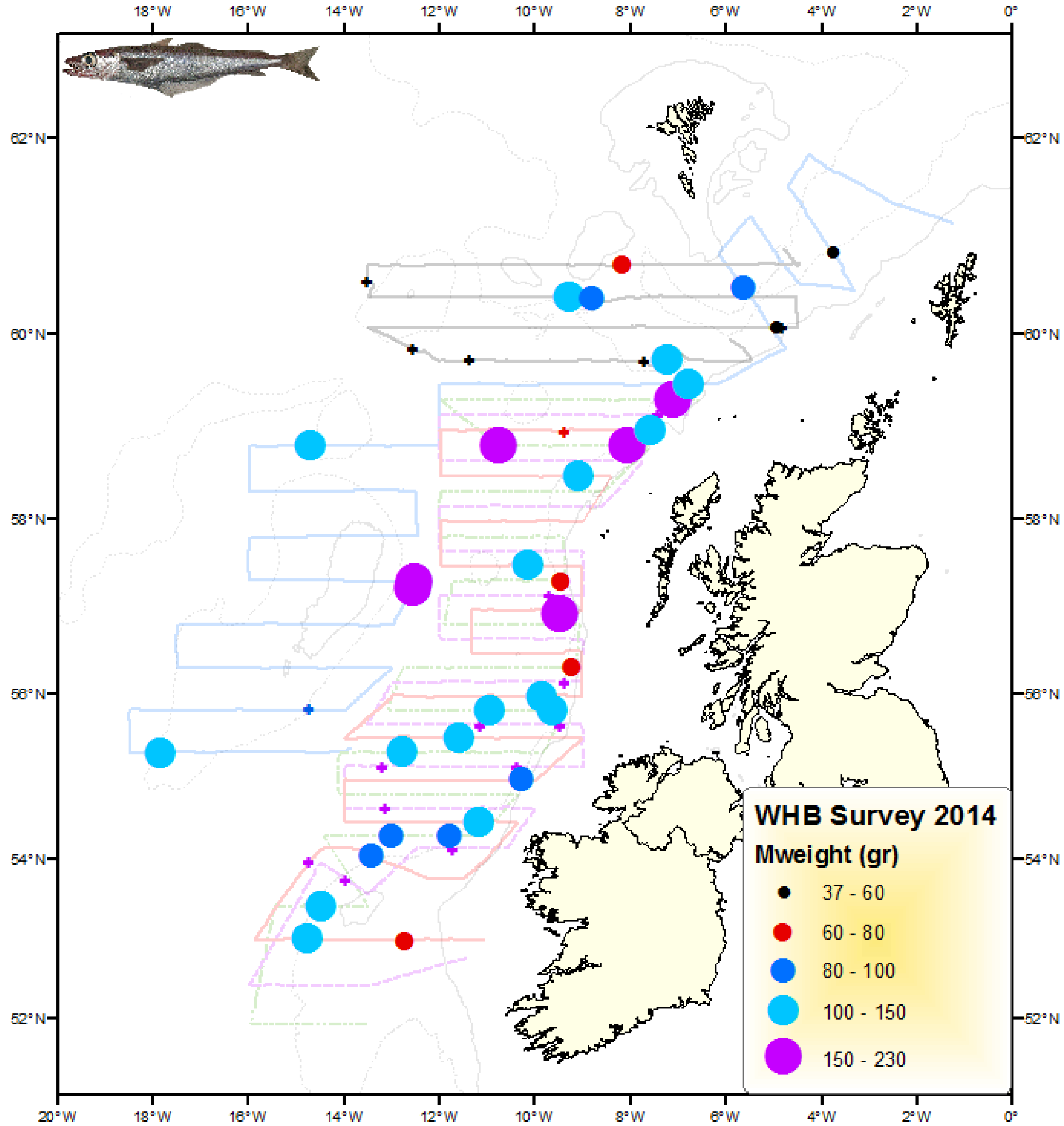
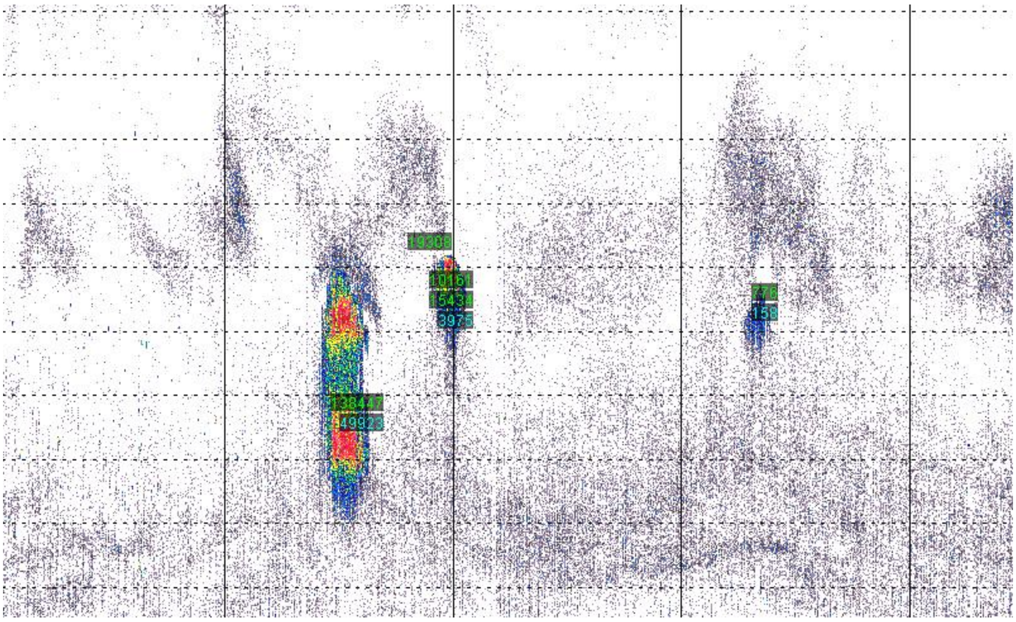
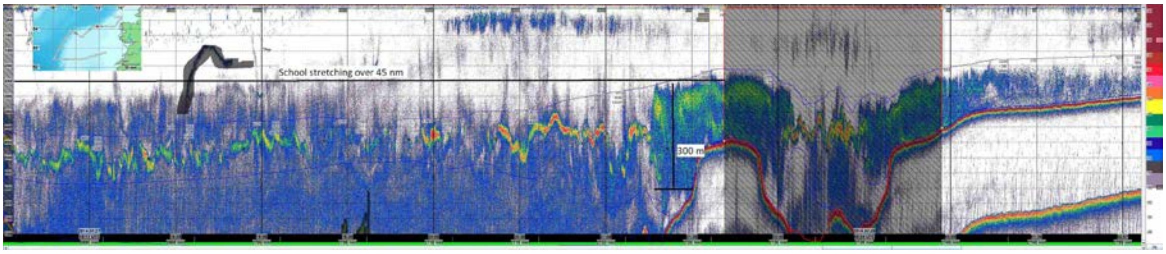


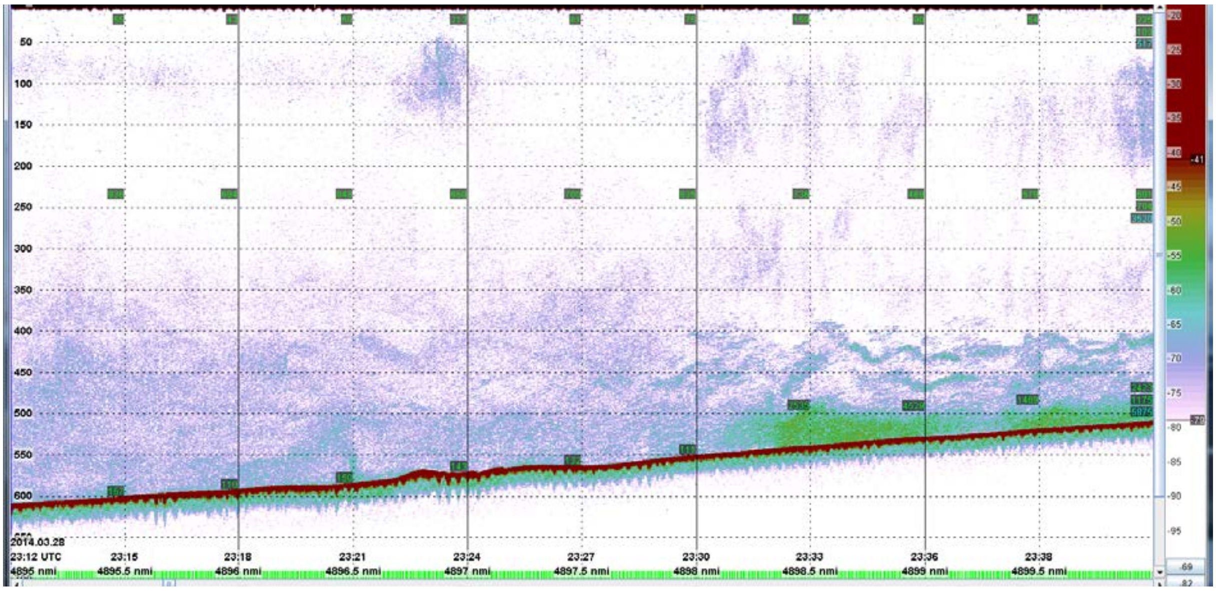
Figure 8. Mean weight of blue whiting caught in trawl catches during IBWSS 2014 by individual vessels in March-April 2014. Crosses indicate trawls without any blue whiting catches.



a). Scattered Double blue whiting echotrace observed by Tridens in the Northern part of the survey area.



b) Long blue whiting school observed onboard Tridens in subarea II (northern Porcupine).



c) Blue whiting schools close to the sea bed on Rockall observed by G.O. Sars.

Figure 9. Echograms of interest encountered during the combined International blue whiting survey in March-April 2014.

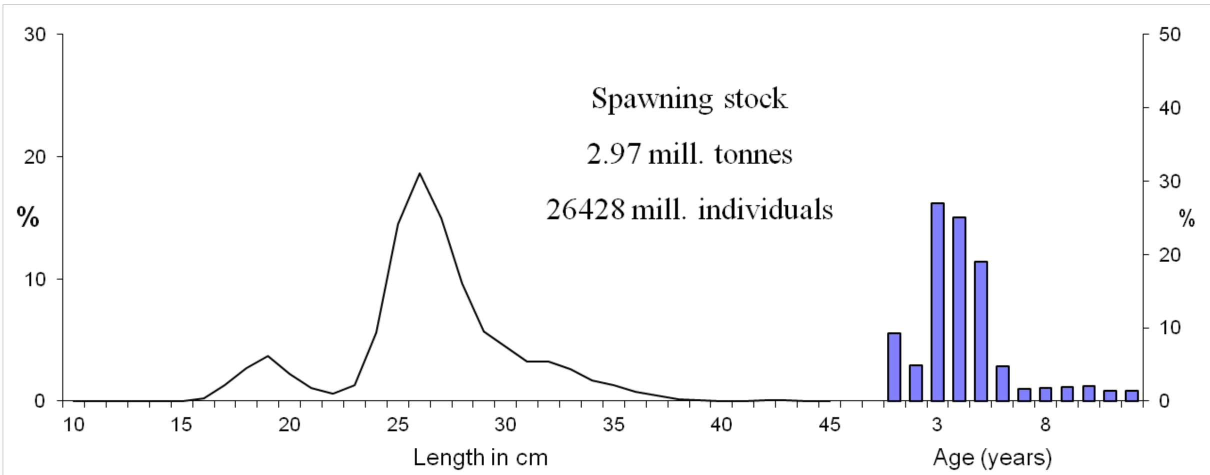


Figure 10. Length and age distributions (numbers) of total stock of blue whiting. Spawning stock biomass is given. March-April 2014.

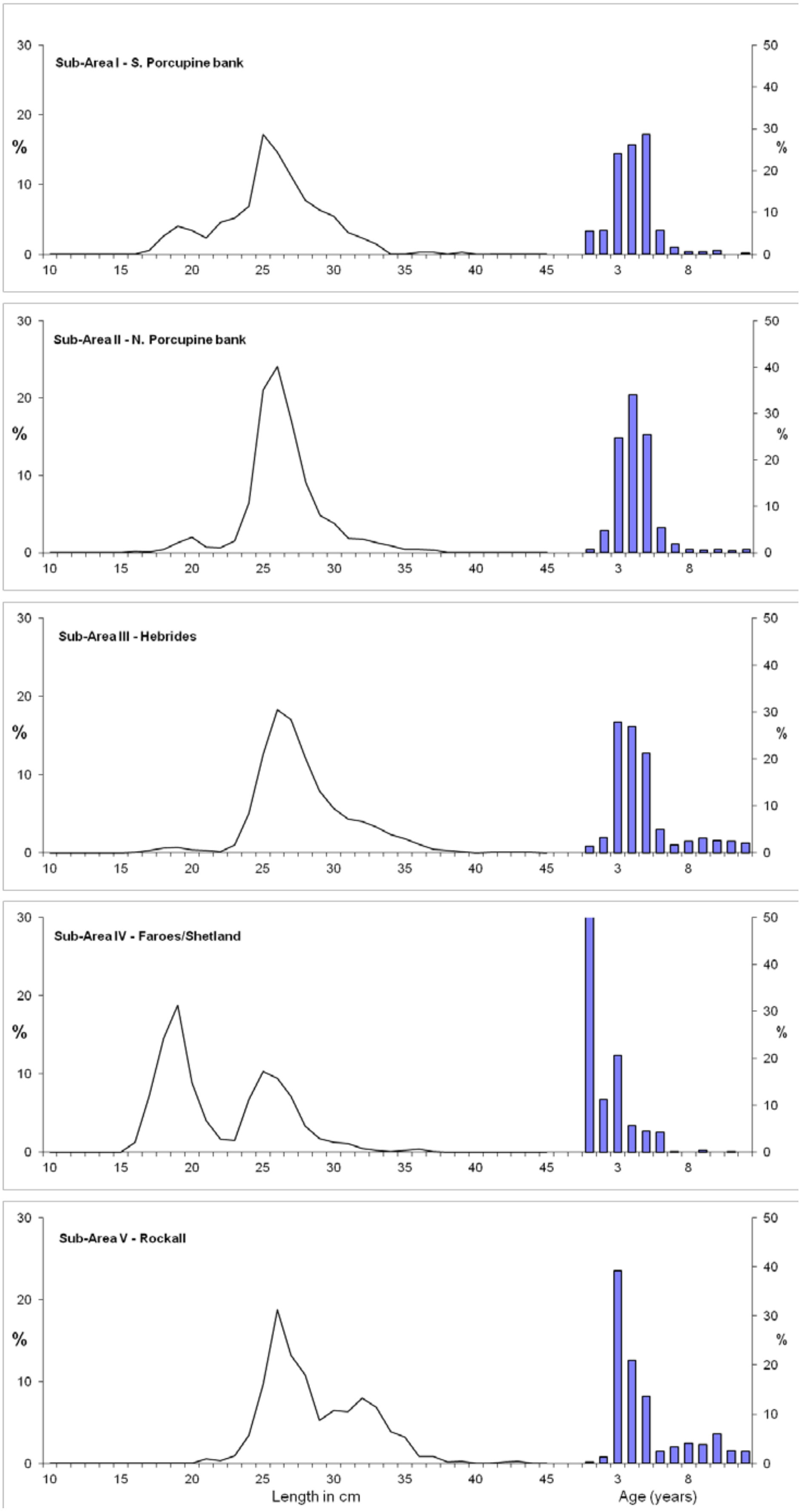


Figure 11. Length and age distribution (numbers) of blue whiting by covered sub-area (I–V). March-April 2014.

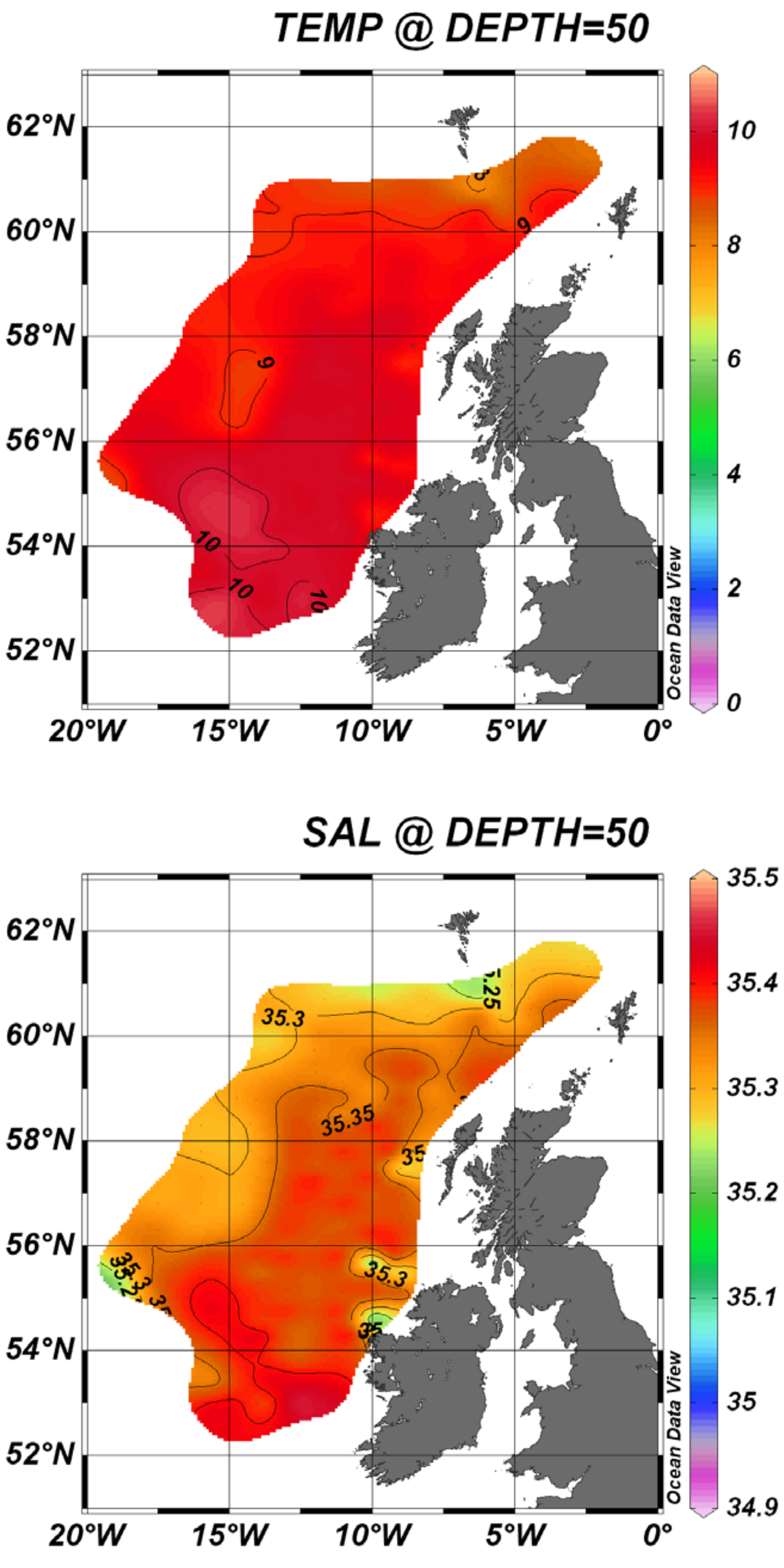


Figure 12. Horizontal temperature (top panel) and salinity (bottom panel) at 50m subsurface as derived from vertical CTD casts. March-April 2014.

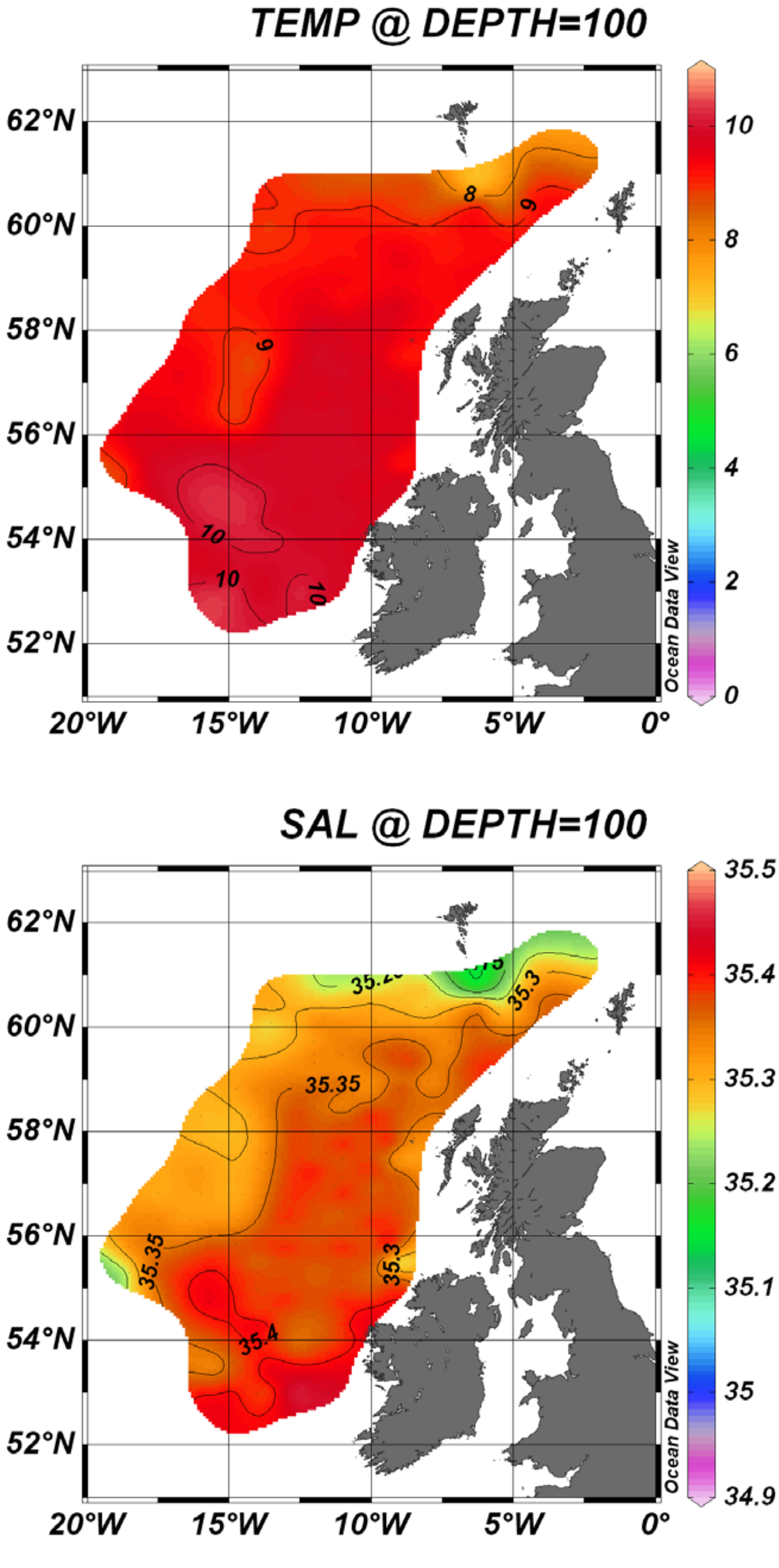


Figure 13. Horizontal temperature (top panel) and salinity (bottom panel) at 100m subsurface as derived from vertical CTD casts. March-April 2014.

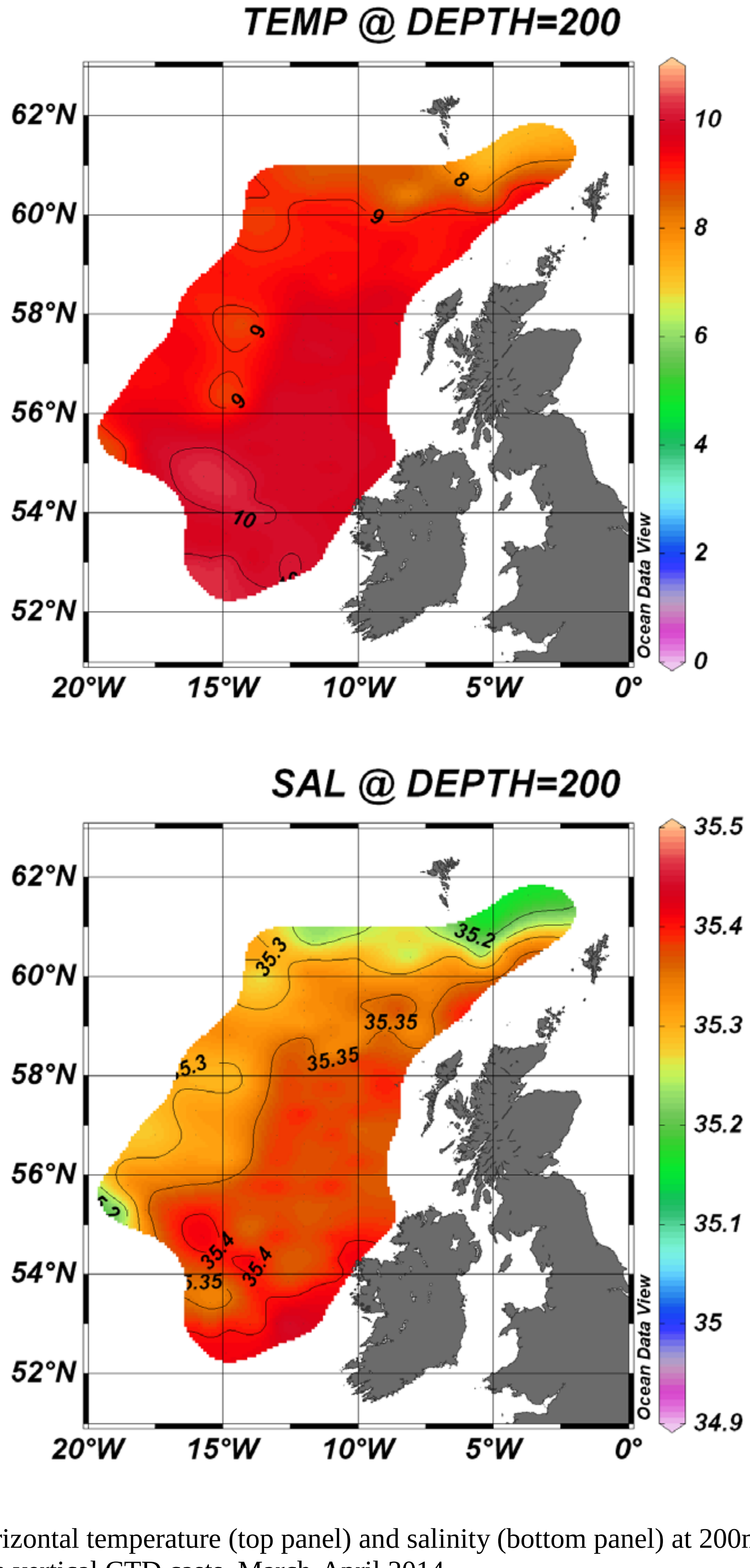


Figure 14. Horizontal temperature (top panel) and salinity (bottom panel) at 200m subsurface as derived from vertical CTD casts. March-April 2014.

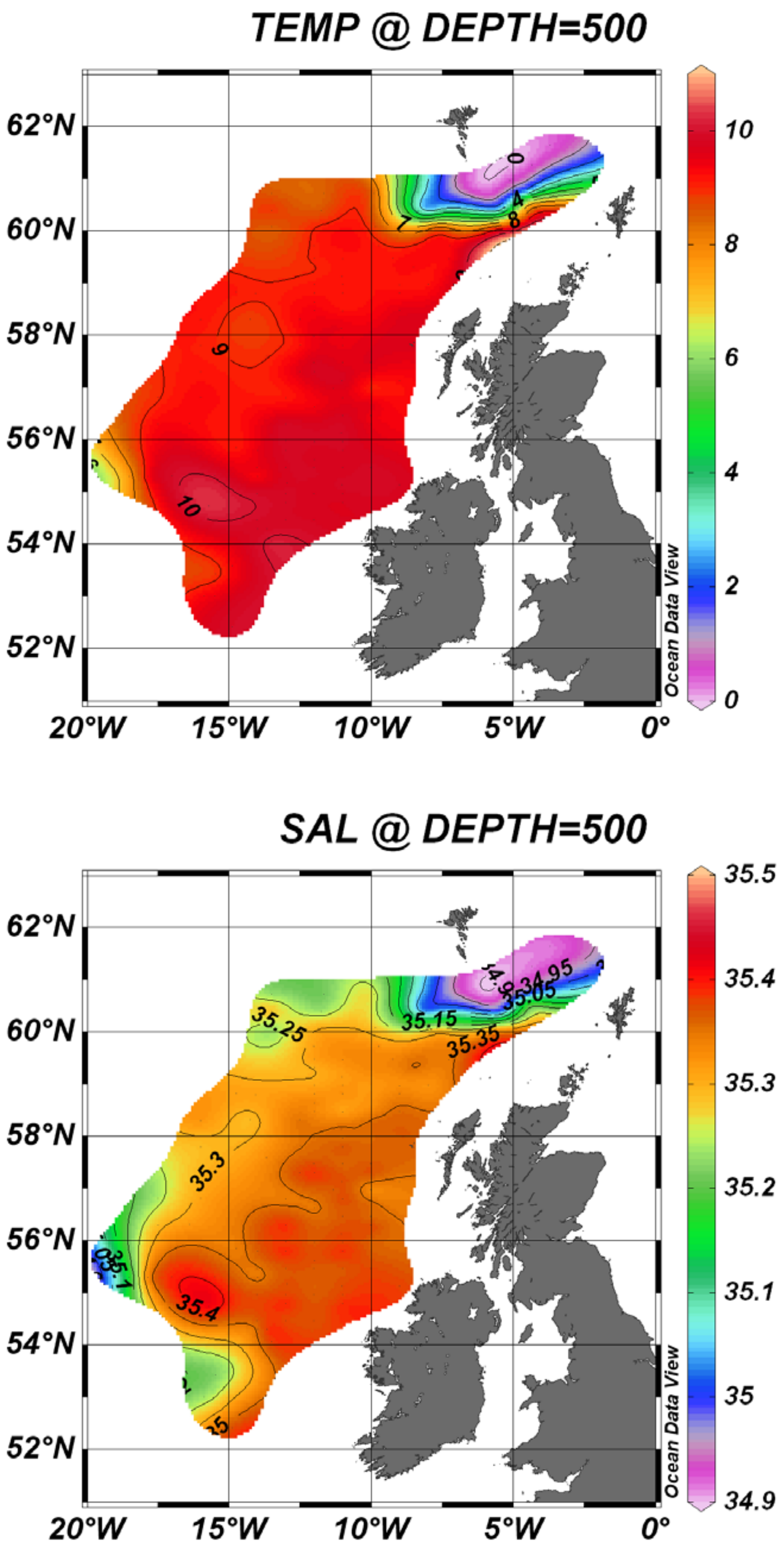


Figure 15. Horizontal temperature (top panel) and salinity (bottom panel) at 500m subsurface as derived from vertical CTD casts. March-April 2014.

Appendix 1. Uncertainty in the acoustic observations and its implications on the stock estimate

The exercise to estimate uncertainty in acoustic blue whiting observations and the consequences of this uncertainty to stock estimates is repeated using the same procedure as in previous years (Appendix 3 in Heino et al. 2007).

When calculating stock estimates from acoustic surveys, the data (acoustics density [s_A] allocated to blue whiting, in units of m^2/n.m.^{2}) from each vessel are expressed as average values over so-called EDSUs (equivalent distance sampling unit) ranging between 1 and 5 n.m. Acoustic density for each survey stratum (subarea with similar fish length distributions) is calculated as an average across all observations (EDSUs) within a stratum, weighted by the length of survey track behind each observation. Normally, these values are then converted to stratum-specific biomass estimates based on information on mean length-at-age of fish in the stratum and the assumed acoustic target strength of the fish; the total survey biomass estimate is the sum of stratum-specific estimates. In the precision estimation exercise routinely performed for the International Blue Whiting Spawning stock Survey (IBWSS), the whole estimation procedure is not repeated, but instead, uncertainty in global mean acoustic density estimates is characterized. As mean size of blue whiting does not vary very much in the survey area, uncertainty in mean acoustic density provides a conservative estimate of uncertainty in total-stock biomass.

Bootstrapping is used to estimate uncertainty in the mean acoustic density. It is calculated by stratum, treating observations from all vessels equally and using lengths of survey track behind each observation as weights when calculating mean density. With 1000 such bootstrap replicates for each stratum, 1000 bootstrap estimates of mean acoustic density, weighted by the stratum areas, are calculated. Bootstrapped mean acoustic density is the mean of these 1000 bootstrap estimates, and confidence limits can be obtained as quantiles of that distribution.

Figure 1 shows the results of this exercise with the data from the 2014 survey as well as ten earlier international surveys. Mean acoustic density over the survey area was 698.5 m^2/n.m.^{2} (as compared to 959.2 m^2/n.m.^{2} in 2013) with 95% confidence interval being 644.1 (lower) and 754.8 (upper) m^2/n.m.^{2}. Relative to the mean, the approximate 95% confidence limits are –7.8% and +8.0%, and 50% confidence limits are –3.0% and +2.9%. This level of uncertainty in acoustic densities is comparable to previous years and among the lowest in the time series so far. Overall, mean acoustic density has shown a consistent decrease annually from 2007 to 2010 and an increase thereafter until 2013. This year, the density has decreased again.

Figure 2 summarises the results and puts them in the biomass context. The overall trend indicates a continued decrease year-on-year in biomass from 2007–2011 for this stock. The uncertainty around the decline in biomass from 2008 to 2011 is more than could be accounted for from spatial heterogeneity alone and is regarded as statistically significant. The biomass estimate from 2010 was omitted in the assessment process due to coverage problems in the survey and a resulting possibility of biomass underestimation. The 2014 estimate shows a slightly decreasing trend in biomass again when compared to the previous two years.

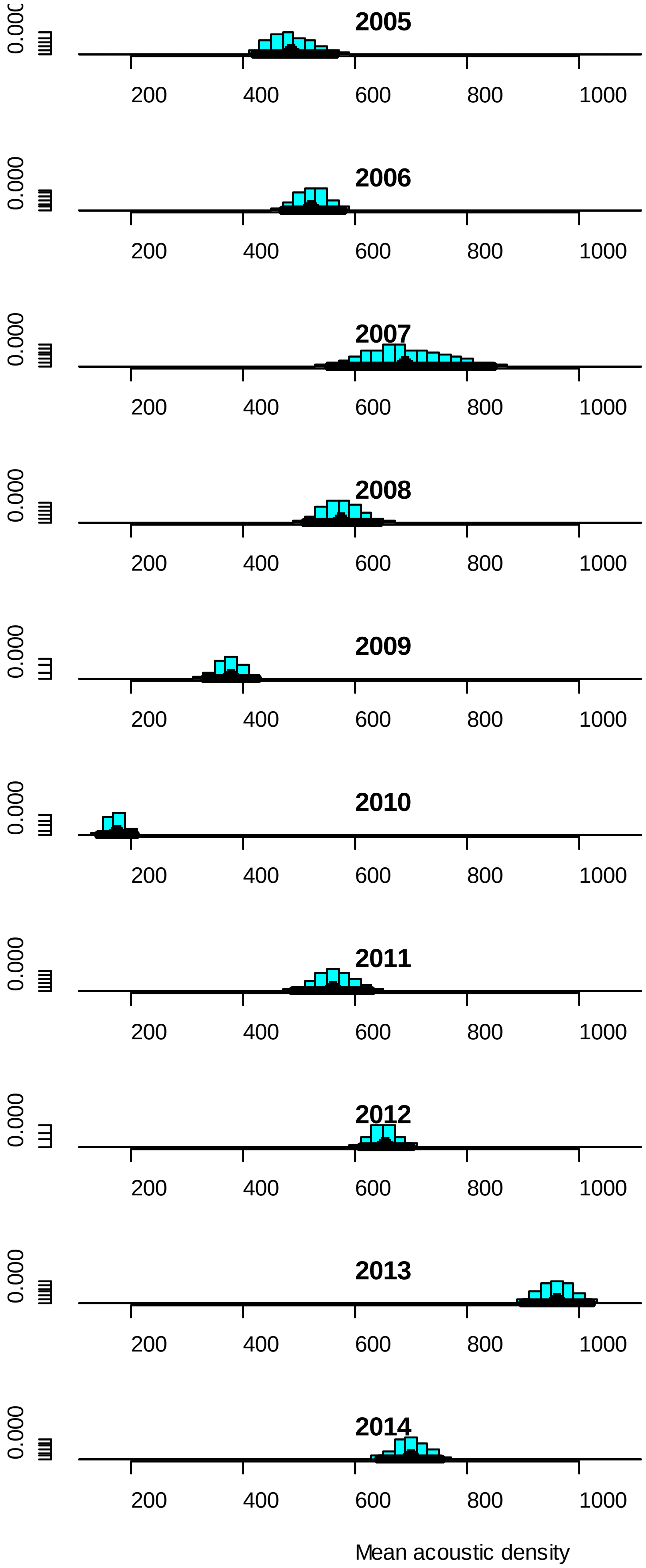


Figure 1. Distribution of mean acoustic density (in $m^2/n.m.^2$) by year based on 1000 bootstrap replicates of acoustic data from blue whiting surveys. Mean acoustic density is indicated with a black dot on the x-axis, while the horizontal bar shows 95% confidence limits.

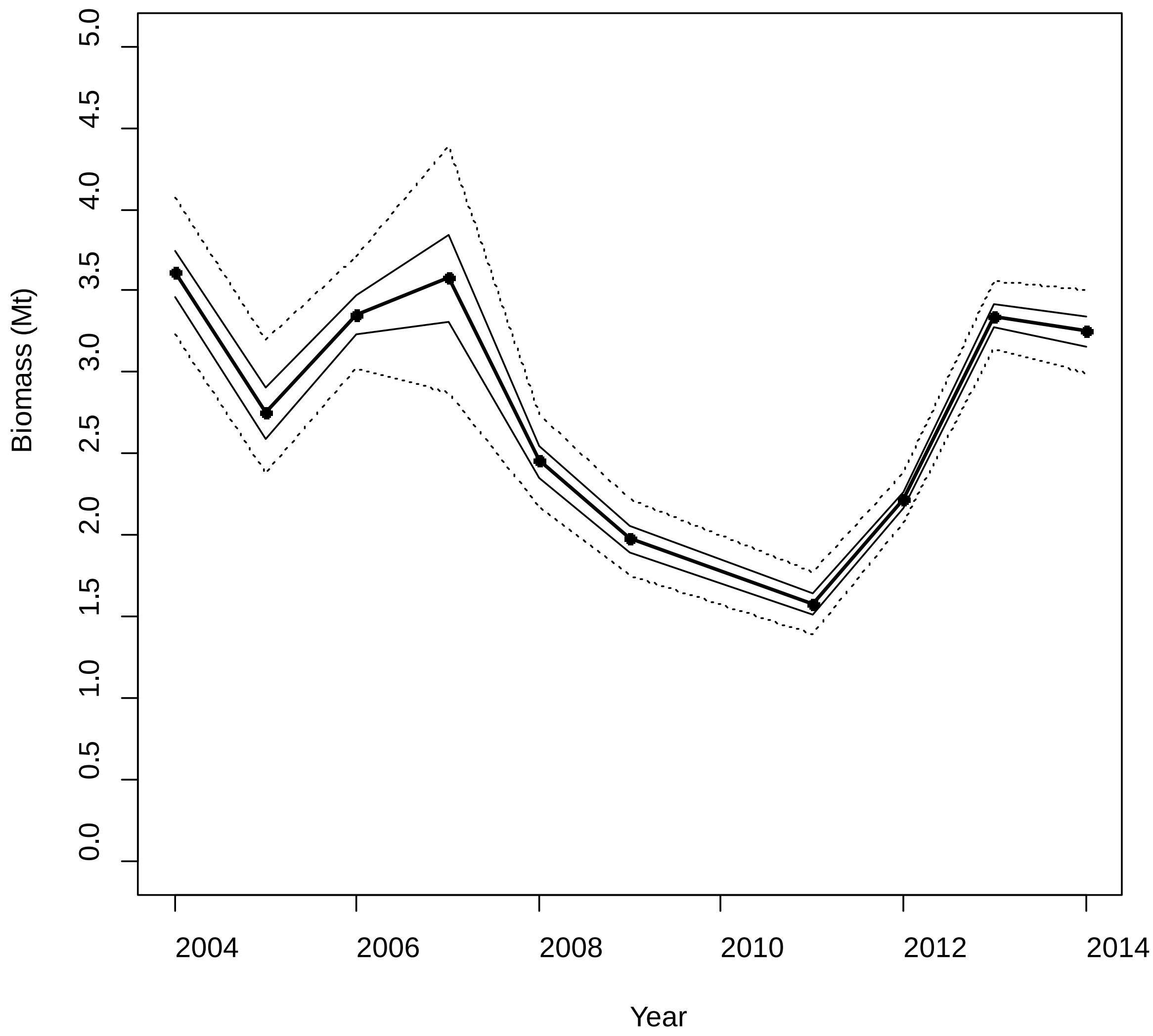


Figure 2. Approximate 50% and 95% confidence limits for blue whiting biomass estimates. The confidence limits are based on the assumption that confidence limits for annual estimates of mean acoustic density can be translated to confidence limits of biomass estimates by expressing them as relative deviations from the mean values. These confidence limits only account for spatio-temporal variability in acoustic observations.

Appendix 2. Review of age determination of blue whiting by national participants.

A review of consistency of age readings was carried out using data collected from all nations. A broad range of ages were observed from 1 to 15 years from survey data in 2014 with a corresponding length range of 16-46cm.

Results show a relatively good agreement for ages 1-6 years (Figure 1). Some inconsistencies still exist for older age classes (6+ years) which are considered the most difficult to age due to the presence of false rings and the lower number of samples overall. However, for the youngest fish (1-3 year olds) some discrepancies were again observed in 2014. There is an indication that Russia seem to have a lower mean length-at-age for two and three year old fish than the other countries in 2014 (i.e. reading the small fish too old), and perhaps Norway had a higher mean length-at-age that the rest for ages two to four (Figure 1).

A review of data across years (2010-2014) shows a year on year improvement especially for younger age classes up to 2013, however, with some discrepancies again for the youngest fish in 2014 (Figure 2).

Most of the survey age reader personnel participated in the blue whiting age reading workshop (Bergen, June 2013), where otoliths collected during the combined survey in 2013 were used as a worked example for the participants. It is recommended that the age readers look into the discrepancy problem for ages 1-3 in the 2014 blue whiting age reading material.

Figure 1. Profile of length at age by nation of blue whiting collected during individual surveys in 2014 (FO; Faroes, IE; Ireland, NL; Netherlands, NO; Norway and RU; Russia).

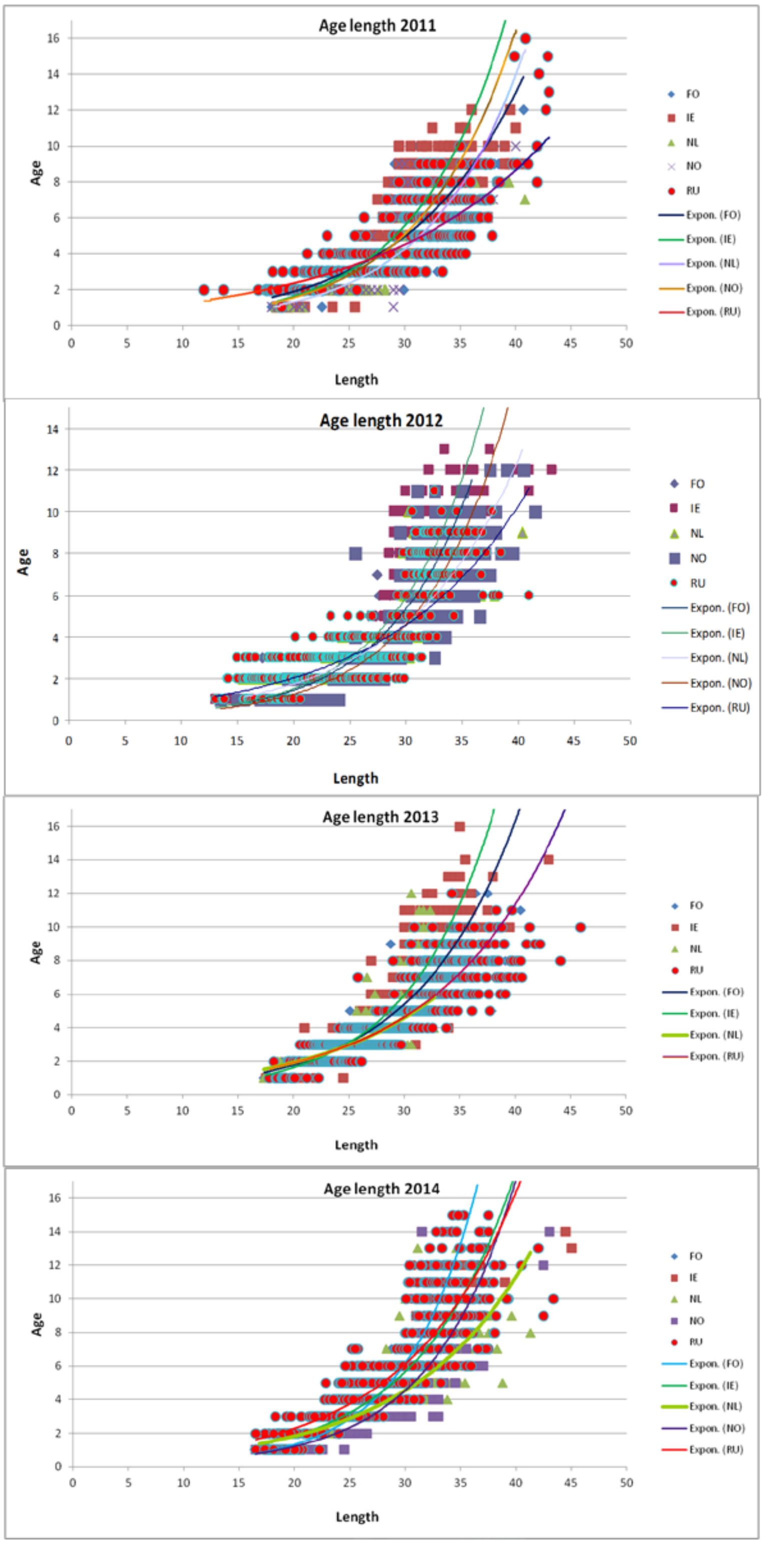


Figure 2. Profile of length at age by nation of blue whiting collected during individual surveys from 2011-2014 (FO; Faroes, IE; Ireland, NL: Netherlands, NO; Norway* and RU; Russia).* No participation from Norway in 2013.

Appendix 3. Planned acoustic survey of the NE Atlantic blue whiting spawning grounds (IBWSS) in 2015

Five vessels representing the Faroe Islands, the Netherlands (EU-coordinated), Ireland (EU-coordinated), Norway and Russia are expected to participate in the 2015 spawning stock survey. There is still uncertainty about the Norwegian participation. Preliminary planning is again based on four vessels at this stage until final participation will be confirmed at the 2015 WGIPS meeting.

Survey timing and design were discussed during the meeting. The group decided that in 2015, the survey design should follow the principle of the one used during the three previous surveys. The focus will still be on a good coverage of the shelf slope in areas II and III. However, given the increasing stock biomass observed over recent years, it can be expected that the distribution will be more extended over the whole survey area as well, as was observed in the 2014 survey. In previous years when larger stock sizes were observed (2004-2007), blue whiting aggregations were distributed more evenly over the whole survey area, including on the Rockall Bank and Rockall Trough. Therefore, the survey design in 2015 will again allocate more effort in these areas as well.

The design is based on variable transect spacing, ranging from 30 nm in areas containing less dense aggregation (e.g. subarea I, south Porcupine), to 10 nm in the core survey area (subarea III, Hebrides) (Figure 4.1). The western borders of the transects in subarea III are extending to 12°W in order to cover potential blue whiting aggregations extending further from the continental slope into the Rockall Trough. To avoid replication, transects will be allocated systematically with a random start location.

The aim is to have three vessels start surveying on their transects just north of subarea II (North Porcupine) at the same time (25.03.2015; Table 1). That way, the core survey subarea III can be covered synoptically by several vessels with a similar temporal progression.

It was decided that the Russian and Irish vessels would start the survey in the southern subareas I and II (Porcupine). 2–4 days after beginning their individual surveys, these vessels will be joint by G.O. Sars and continue surveying the north of subarea II and afterwards area III from the south progressing northwards. Once the Norwegian G.O. Sars vessel has finished surveying subarea III, she will continue northwards into the Faroese-Shetland channel and continue coverage in a north-eastern direction until time allows. The Faroese vessel will primarily survey subarea V (Faroese/Shetland) and join the other vessels in the north of area III once they are present there towards the end of the survey period. The Rockall area will be covered by Tridens, starting in the south on 25.03.2015, progressing northward. Survey extension in terms of coverage (51–61ºN) will be in line with the previous year to ensure containment of the stock and survey timing will also remain fixed as in previous years.

Key will be to achieve coverage of area III in a consistent temporal progression between vessels. It is therefore very important that all vessels covering the core Hebrides area are present on station in the north of subarea II (just north of Porcupine Bank) on 25 March 2015 (Table 1). Nonetheless, if some vessels are found to lag behind others, the tight 10 n.m. transect spacing will allow for adaptation of the survey design without great loss of coverage. For instance, this may mean either skipping or extending some of the horizontal transects to catch up or keep pace with the other vessels. Biological sampling should be carried out following methods normally applied to sampling acoustic registrations.

If registrations of blue whiting marks are continuing at the end of any planned transects, the length of these transects should be extended until no more marks are registered for a distance of 3 n.m. (or 20 minutes at normal survey speed).

Preliminary cruise tracks for the 2015 survey are presented in Figure 1. A new survey coordinator has to be appointed during the next WGIPS meeting, coordinating contact between participants prior to and during the survey. Detailed cruise lines for each ship will be circulated by the coordinator to the group as soon as final vessel availability and dates have been communicated (after WGIPS, latest by the end of January 2015).

As the survey is planned with inter-vessel cooperation in mind it is vitally important that participants stick to the planned transect positioning to ensure that survey effort is evenly allocated and the situation observed in 2010 is not repeated.

Participants are also required to use the logbook system for recording course changes, CTD stations and fishing operations. An example format can be circulated to participants at the 2015 WGIPS meeting. The survey will be carried out according to survey procedures described in the "MANUAL FOR INTERNATIONAL PELAGIC SURVEYS (IPS)" (WGIPS report 2012).

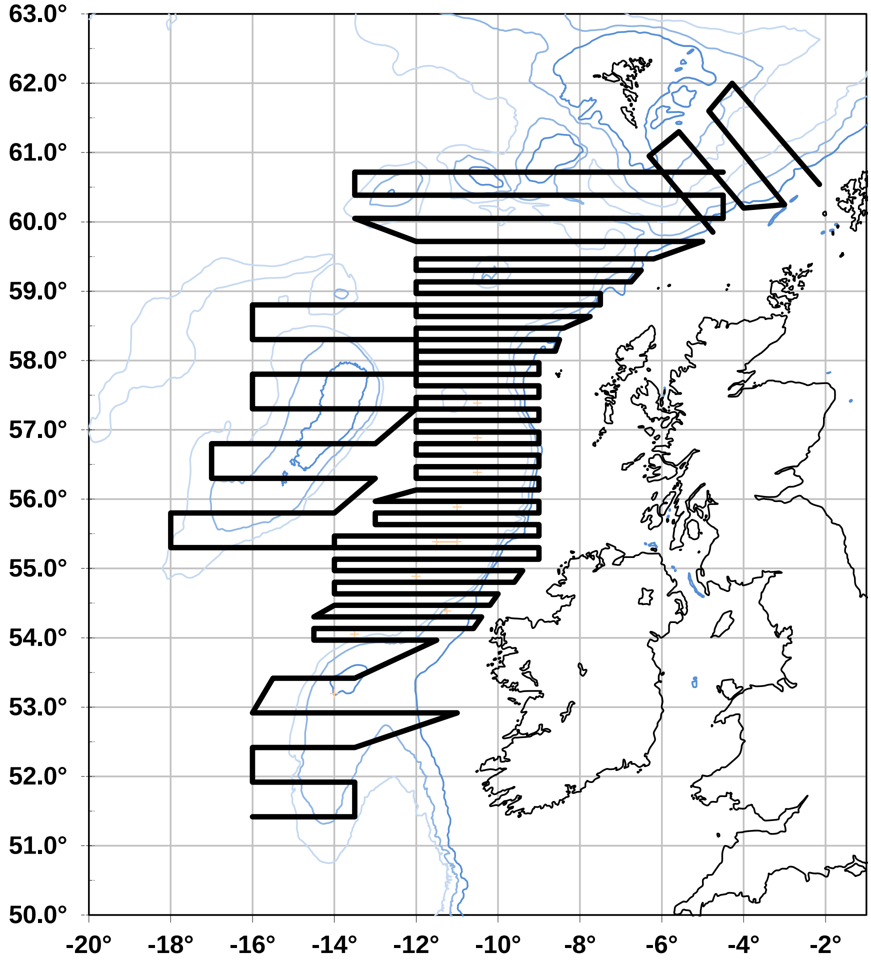


Figure 1. Preliminary survey tracks for the combined 2015 International Blue Whiting Spawning stock Survey (IBWSS).

Table 1. Preliminary individual vessel dates for the 2015 International Blue Whiting Spawning stock Survey (IBWSS).

Ship	**Nation**	**Active survey time (days)**	**Preliminary survey dates**
Fritjof Nansen	Russia	19	23.3.2015 – 10.4.2015
Celtic Explorer	Ireland (EU)	19	23.3.2015 – 10.4.2015
G.O. Sars	Norway	14	25.3.2015 – 7.4.2015
Tridens	Netherlands (EU)	17	23.3.2015 – 8.4.2015
Magnus Heinason	Faroe Islands	11	25.3.2015 – 8.4.2015