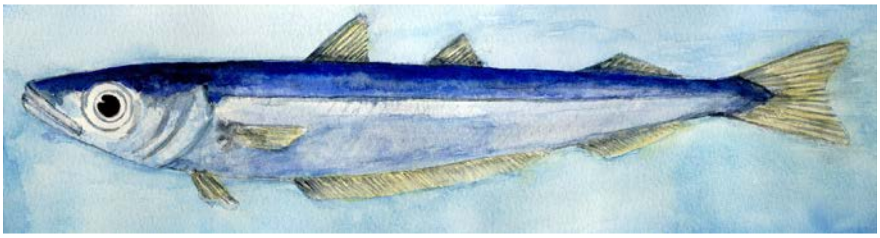
Working Document

Working Group on International Pelagic Surveys

Copenhagen, Denmark, 20-24 January 2014

Working Group on Widely Distributed Stocks

Copenhagen, Denmark, 27 August-2 September 2013



INTERNATIONAL BLUE WHITING SPAWNING STOCK SURVEY (IBWSS) SPRING 2013

Sascha Fässler[1^*], Sven Gastauer[1*], Thomas Pasterkamp[1], Kees Bakker[1], Eric Armstrong[6], Dirk Thijssen[8], Matthias Schaber[7], James Keating[10]

R/V Tridens

Ciaran O'Donnel[5*], Eugene Mullins[5], Graham Johnston[5] , Niall Keogh[9]

R/V Celtic Explorer

Alexander Pronyuk[3], Maxim Rybakov[3], Sergey Kharlin[3], Sergeeva Tatiana[3], Velikzhanin Alexey[3], Alexander Krysov[3(*)]

R/V Vilnyus

Valantine Anthonypillai[2*], Øyvind Tangen[2*], Åge Høines[2]

Jan Arge Jacobsen[4], Ebba Mortensen[4*], Poul Vestergaard[4], Leon Smith[4*]

R/V Magnus Heinason

1 Institute for Marine Resources & Ecosystem Studies, IJmuiden, The Netherlands
2 Institute of Marine Research, Bergen, Norway
3 PINRO, Murmansk, Russia
4 Faroe Marine Research Institute, Tórshavn, Faroe Islands
5 Marine Institute, Galway, Ireland
6 Marine Scotland Marine Laboratory, Aberdeen, Scotland, United Kingdom
7 Johann Heinrich von Thünen-Institut, Hamburg, Germany
8 Danish Institute for Fisheries Research, Denmark
9 Irish Whale and Dolphin Group, Ireland
10 Galway and Mayo Institute of Technology, Ireland
* Participated in post cruise meeting
^ Survey coordinator

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. Norway did not participate in the survey this year. Participating vessels together with their effective survey periods are listed below:

Vessel	Institute	Survey period
Vilnyus	**PINRO, Murmansk, Russia**	**24/3 – 7/4**
Celtic Explorer	**Marine Institute, Ireland**	**27/3 – 8/4**
Magnus Heinason	**Faroe Marine Research Institute, Faroe Islands**	**4/4–12/4**
Tridens	**Institute for Marine Resources & Ecosystem Studies (IMARES), the Netherlands**	**26/3–5/4**

The survey design used and described in ICES (2012) 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 19 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 salient 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 38 kHz frequency. All transducers were calibrated with a standard calibration sphere (Foote et al. 1987) prior to the survey. Additionally Celtic Explorer and Tridens executed a post calibration at the end of 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.x) post processing software. Data were partitioned into the following categories: plankton (<200 m depth layer), mesopelagic species, 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 1.7) post processing software. Blue whiting were identified and separated from other recordings based on trawl catch information and characteristics of the recordings.

Acoustic data analysis

The acoustic trawl 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 7,456 n.m. (nautical miles) of survey transects were completed. The total area of all the sub-survey areas covered was 87,895 n.m.² (Figure 1, Tables 1 & 3).

The total biomass estimate for 2013 showed an increase of 55% compared to 2012. The increase in observed biomass can be attributed to the high amount of blue whiting found in the Hebrides core area (73%, 2.44 mill. tonnes). Blue whiting was found to be distributed over the entire survey area and formed layers over multiple miles extending westward from the shelf edge as compared to the more patchy distribution observed in most recent years.

The highest concentrations of blue whiting were recorded in the Hebrides area, as in previous years but with a more southerly distribution in 2013. This may be an indication for a later start of the northwards migration of the stock. Less blue whiting was found in the Northern Porcupine Bank area (decrease of 16%) compared to 2012. Medium and high density registrations were concentrated along the shelf slope extending up to 15 n.m. from the shelf edge (Figures 4 & 5).

Very low concentrations of blue whiting were found on the southern Rockall Bank itself. Compared to the most recent years, more high density aggregations were found in open waters in the eastern part of the Rockall Trough.

Blue whiting echotraces were recorded down to a maximum depth of 720m (Figure 9), which is considerably deeper than usually observed.

Stock size

The estimated total abundance of blue whiting for the 2013 international survey was 3.35 million tonnes, representing an abundance of 27.0x10^9 individuals (Figure 6, Tables 3 & 4). Spawning stock was estimated at 3.2 million tonnes and 24.4x10^9 individuals. In comparison to the 2012 survey estimate, there is a significant increase (+55%) in the observed stock biomass and a related increase in stock numbers (+48%).

		2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	Change from 2012 (%)
Biomass	Total	3.6	2.6	3.4	3.6	2.6	2	1.3	1.6	2.2	3.4	55%
(mill. t)	Mature	3.6	2.4	3.3	3.6	2.6	2	1.3	1.5	2.2	3.2	45%
Numbers	Total	41.9	29	34.7	33.5	22.1	15.2	9.3	12.1	18.2	27	48%
(10^9)	Mature	39.2	26.7	33.8	32.9	21.7	15.0	8.9	9.7	16.5	24.4	48%
Survey area (nm^2)		149,000	172,000	170,000	135,000	127,000	133,900	109,320	68,851	88,746	87,895	-1%

The Hebrides core area was found to contain 73% of the total biomass observed during the survey, which is in agreement with previous years (71% of the stock found in this area in 2012 and 76% in 2011). A major part of the biomass recorded in this area was found in the southern part, rather than in the Northern part, as has been observed in previous years. The Faroes/Shetland and Rockall areas ranked second and third highest contributing 13% and 8% to the total respectively. A slight 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 2012. However, this increase can be attributed primarily to a high density area in the eastern Rockall Trough, rather than those less dense echotraces found on the Rockall Bank itself. The breakdown of survey biomass by sub area is shown below:

		Biomass (million tonnes)				
		2012		2013		
	Sub-area		% of total		% of total	Change (%)
I	S. Porcupine Bank	0.01	1	-	-	-
II	N. Porcupine Bank	0.25	11	0.21	6	-16%
III	Hebrides	1.58	71	2.44	73	54%
IV	Faroes/Shetland	0.37	16	0.43	13	16%
V	Rockall	0.01	0	0.27	8	2600%

Stock composition

Individuals of ages 1 to 16 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 show better agreement across participants for especially the younger year classes, 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 4, 3, 5 and 8 of the 2009, 2010, 2008 and 2005 year classes respectively (Table 4), contributing over 66% of spawning stock biomass (Figure 10).

The Hebrides area remains the most productive in the current survey time series and has consistently contributed over 50% to the total SSB (Figure 6). This year the contribution was 73%. Mean lengths and wieghts of the fish caught there were also the highest within the whole survey area (Figures 7 and 8). The Faroe/Shetland subarea was dominated by 2-4 year old fish and Porcupine sub-areas were dominated by 3-5 year old fish. One year old fishes were mainly observed in subarea IV (Faroes-Shetland) and in lesser extent in the sub-area III (Hebrides).

From the survey data, the Faroese/Shetland sub-area was found to contain significant proportion of young blue whiting (1-3 years). This together represents 54% (235,000t) of the total biomass and 70% (2965 million individuals) of the total abundance in this area. Though the proportion is less than last year (75% and 86% respectively), due to the strong 4 year class also found in the area.

Blue whiting observed on the Rockall Bank were mostly immature, whereas those from the eastern part of the Rockall area (Rockall Trough) were predominantly mature fish.

Immature blue whiting were represented to various extents in all sub areas in 2013 (Figure 11). Maturity analysis of survey samples indicate that 18% of 1-year old, 54% of 2-year old and 82% of 3-year old fish were mature as compared to the 2012 estimates, where 25% of 1-year old fish, 59% of 2-year old fish and 84% of 3-year old fish were considered mature (Table 4). Overall, immature blue whiting from the estimate represented 5.2% (175,000t) of the total biomass and 9.7% (2627 million) of the total abundance recorded during the survey.

Hydrography

A combined total of 130 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 10th International Blue Whiting Spawning stock Survey 2013 shows an increase in total biomass of 55% (48% abundance) when compared to the 2012 estimate for comparable area coverage (c. 88,000nmi²) and effort. The updated survey time series shows a recovery from the declining trend observed between 2007-2011.
- Favourable weather conditions allowed the four 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 19 days this year as compared to 14 days in 2012. 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 the lowest observed in the time series so far. It is about half as large as those observed in previous years 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 8 of the 2009, 2010, 2008 and 2005 year classes respectively, contributing 66% of spawning stock biomass
- Mean length (28.5 cm) and weight (123.9 g) are slightly higher than in 2012 but still lower than in previous years. This can be attributed to the progression of the 3 dominate year classes and increasing contribution of young fish to the total stock biomass.
- A positive signal of 3 and 4-year old fish (strong 2009 & 2010 year classes) continues to be observed across all areas and the latter is now considered fully recruited to the spawning stock.

Interpretation of the results

- The 2013 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. Over 96% 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 the later than normal migration of the stock northwards.
- Cohort tracking through the time series is possible for the most dominant year classes at present (2009 & 2010) and to a lesser extent for older fish. The presence of two successive years of good recruitment is a positive signal after a prolonged period of poor recruitment. The number of 2 year old fish observed in 2013 (2011 year class) is comparable in terms of weight and numbers to that of the strong 2010 year class but not as strong as the 2009 year class. However, it is too early to predict year class strength with any degree of accuracy until this year class has fully recruited to the stock in 2014.

Recommendations

- It is recommend that the blue whiting age reading workshop (WKARBLUE; Bergen, June 2013) use the otoliths collected during this combined survey as a worked example for all participants. As survey age readers will be present at the workshop this will further improve the experience of readers and increase precision of future survey estimates. It is recommended that the age reading workshop feedback to WGIPS (next meeting in January 2014).

- As Norway did not participate in this year's survey their core aging expertise was also missing. Regardless of future survey participation by Norway it is recommended that aging expertise should be made available in the form of personnel exchange/participation during the survey.
- It is recommended that Norway update the group as soon as possible regarding participation in 2014 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 2014 and submit the data accordingly.
- The 2014 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.
- Norway should provide an update on the progress of the survey analysis software currently under development at WGIPS 2014.

Achievements

- The whole survey area (c.88,000nmi^2) was covered within 19 days within the recommended 21 day maximum.
- Comprehensive trawling and hydrographic sampling were carried out.
- Good agreement in age determination between nations.
- Delivery of survey data to Leon Smith (Faroes, data repository) was achieved prior to the post cruise meeting. All data was quality controlled prior to submitting to the database which allowed for a timely calculation of the survey estimate.

References

Anon. (Monstad et al.), 1982. Report of the International acoustic survey on blue whiting in the Norwegian Sea, July/August 1982. ICES CM 1982/H:5.

Foote, K. G., Knudsen, H. P., Vestnes, G., MacLennan, D. N., and Simmonds, E. J. 1987. Calibration of acoustic instruments for fish density estimation: a practical guide. ICES Coop. Res. Rep. 144: 1–57.

Gastauer, S., Bakker, K., Pasterkamp, T., Armstrong, E., Schaber, M. and D. Thijssen. Cruise report hydro-acoustic survey for blue whiting (Micromesistius poutassou) with F.R.V. “Tridens”, 26 March - 5 April 2013. Institute for Marine Resource & Ecosystem Studies, IJmuiden, The Netherlands.

ICES. 2011. Report of the Working Group on Northeast Atlantic Pelagic Ecosystems Surveys (WGNAPES), 16-19 August 2011, Kaliningrad, Russian Federation. ICES CM 2011/SSGESST:16. 193 pp.

ICES. 2012. Report of the Workshop on implementing a new TS relationship for blue whiting abundance estimates (WKTSBLUES), 23–26 January 2012, ICES Headquar-ters, Copenhagen, Denmark. ICES CM 2012/SSGESST:01. 27 pp.

Jacobsen, J. A., Mortensen, E., and Vestergaard, P. 2013. Túrfrágreiðing Magnus Heinason: Svartkjaftur sunnanfyri, túrur 1314, 3-12/4 2013. Faroe Marine Research Institute, Tórshavn, the Faroes.

Monstad, T., 1986. Report of the Norwegian survey on blue whiting during spring 1986. ICES CM 1986/H:53.

O’Donnell, C., Mullins, E., Johnston, G., Keogh, N. 2013. Irish Blue Whiting Acoustic Survey Cruise Report 2013. Marine Institute, Ireland.

Pronyuk A., Rybakov M., Kharlin S., Sergeeva T., Velikzanin A. 2013. Report of the Russian survey on blue whiting during spring 2013. RV Vilnyus. PINRO, Murmansk, Russia.

Pedersen, G., Godø, O. R., Ona, E., and Macaulay, G. J. 2011. A revised target strength-length estimate for blue whiting (*Micromesistius poutassou*); implications for biomass estimates. ICES Journal of Marine Science, 68: 2222-2228.

Simmonds, J. and MacLennan D. 2007. Fisheries acoustics, theory and practice. Second edition. Blackwell publishing

Toresen, R., Gjøsæter, H. and Barros de, P. 1998. The acoustic method as used in the abundance estimation of capelin (*Mallotus villosus* Müller) and herring (*Clupea harengus* Linné) in the Barents Sea. Fish. Res. 34: 27–37.

Totland, A. and Godø, O.R. 2001. BEAM – an interactive GIS application for acoustic abundance estimation. In T. Nishida, P.R. Kailola and C.E. Hollingworth (Eds): Proceedings of the First Symposium on Geographic Information System (GIS) in Fisheries Science. Fishery GIS Research Group. Saitama, Japan.

Table 1. Survey effort by vessel. March-April 2013.

Vessel	Effective survey period	Length of cruise track (nmi)	Trawl stations	CTD stations	Plankton sampling	Aged fish	Length-measured fish
Vilnyus	24/3-7/4	2156	10	43		900	3507
Celtic Explorer	27/3-8/4	1960	15	37		650	1850
Tridens	26/3-5/4	2180	11	29		1000	1000
Magnus Heinason	4/4-12/4	1160	8	21	21	454	687
Total	24/3-12/4	7,456	44	130	21	3,004	7,044

Table 2. Acoustic instruments and settings for the primary frequency. March-April 2013.

	Vilnyus	Celtic Explorer	Magnus Heinason	Tridens
Echo sounder	Simrad EK60	Simrad EK 60	Simrad EK60	Simrad EK 60
Frequency (kHz)	**38**	**38**, 18, 120, 200	**38**	**38**, 120
Primary transducer	ES38B	ES 38B	ES38B	ES 38B
Transducer installation	Hull	Drop keel	Hull	Towed body
Transducer depth (m)	4.5	8.7	3	7
Upper integration limit (m)	10	15	7	15
Absorption coeff. (dB/km)	10	9.8	9.7	10.2
Pulse length (ms)	1.024	1.024	1.024	1.024
Band width (kHz)	2.425	2.425	2.43	2.43
Transmitter power (W)	2000	2000	2000	2000
Angle sensitivity (dB)	21.9	21.9	21.9	21.9
2-way beam angle (dB)	-30.6	-20.6	-20.9	-20.6
Sv Transducer gain (dB)				
Ts Transducer gain (dB)	25.92	25.46	25.69	26.32
s_A correction (dB)	-0.66	-0.76	-0.69	-0.6
3 dB beam width (dg)				
alongship:	7.2	6.93	6.95	7.04
athw. ship:	7.17	6.99	6.96	7.12
Maximum range (m)	750	750	750	750
Post processing software	FAMAS	Myriax Echoview	Myriax Echoview	LSSS

Table 3. Assessment factors of blue whiting for IBWSS March-April 2013.

	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										
II	N. Porcupine Bank	19,207	1.713	1.779	96	0.205	0.209	98	117.9	28.9	10.9
III	Hebrides	36,463	17.469	18.78	93	2.340	2.437	96	129.8	29.1	66.8
IV	Faroes/Shetland	24,069	3.11	4.234	74	0.353	0.431	82	101.9	25.1	17.9
V	Rockall	8,156	2.111	2.240	94	0.259	0.270	96	120.3	28.7	33.1
Tot.		87,895	24.405	27.03	90	3.157	3.347	94	123.9	28.5	38.1

Table 4. Survey stock estimate of blue whiting, March-April 2013.

	Age in years (year class)										Numbers	Biomass	Mean	Prop.
Length	1	2	3	4	5	6	7	8	9	10+			weight	mature*
(cm)	2012	2011	2010	2009	2008	2007	2006	2005	2004		(*10-$^{6)}$	(10^6 kg)	(g)	(%)
11.0 – 12.0														
12.0 – 13.0														
13.0 – 14.0														
14.0 – 15.0														
15.0 – 16.0														
16.0 – 17.0														
17.0 – 18.0	32										32	1	30	0
18.0 – 19.0	76	14									90	3.1	34	13
19.0 – 20.0	233	96									329	13.9	42	14
20.0 – 21.0	106	288	20								414	20	48	14
21.0 – 22.0	29	311	72	10							422	23.9	57	52
22.0 – 23.0	18	408	485								911	58.5	64	62
23.0 – 24.0	0	338	1316	29							1683	121.4	72	74
24.0 – 25.0	8	137	1669	55							1869	151.6	81	75
25.0 – 26.0		64	1186	349	19		9				1627	146.9	90	85
26.0 – 27.0		26	1036	810	130		13				2015	190.4	95	94
27.0 – 28.0			601	1830	472	41		10			2954	302.7	103	98
28.0 – 29.0			399	1985	558	78			11		3031	346.4	114	100
29.0 – 30.0			234	1438	503	200	17	42			2434	304	125	100
30.0 – 31.0			32	838	527	163	135	95	53	161	2004	281.8	141	100
31.0 – 32.0			6	293	439	281	229	195	123	334	1900	300.4	158	100
32.0 – 33.0				112	221	155	214	277	196	328	1503	265.7	177	100
33.0 – 34.0				15	170	164	203	305	114	295	1266	242.8	192	100
34.0 – 35.0				9	54	110	239	229	149	244	1034	210.2	204	100
35.0 – 36.0				3		54	160	165	78	307	767	169.7	221	100
36.0 – 37.0					7	22	52	124	52	144	401	95.5	238	100
37.0 – 38.0					22	12	29	20	50	41	174	43.9	253	100
38.0 – 39.0						3	11	22	14	17	67	19.5	295	100
39.0 – 40.0						4	11	19	10	8	52	15.5	302	100
40.0 – 41.0							5	8	11	4	28	9.9	344	100
41.0 – 42.0									3	2	5	2	388	100
42.0 – 43.0									3		3	1.2	395	100
43.0 – 44.0										3	3	1.8	534	100
44.0 – 45.0								4		4	8	4	500	100
TSN (10^6)	502	1682	7056	7776	3122	1287	1327	1515	867	1892	27026	3347		
TSB (10^6 kg)	22.4	105.8	611.4	895.8	423.5	209.6	248	293.6	171.8	365.4	3347			
Mean length (cm)	19.7	22.3	25.3	28.5	29.9	31.7	33.3	33.6	33.8	34				
Mean weight (g)	44.4	62.9	86.7	115.2	135.7	162.9	186.8	193.6	198.1	195				
Condition (g/dm^3)														
% mature*	18	54	82	98	99	100	100	100	100	100				
SSB	4.0	56.7	503.3	876.9	420.8	209.5	247.6	293.6	171.8	365.4	3149.6			

* Percentage of mature individuals per age or length class

Table 5. Country and vessel specific details, March-April 2013.

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

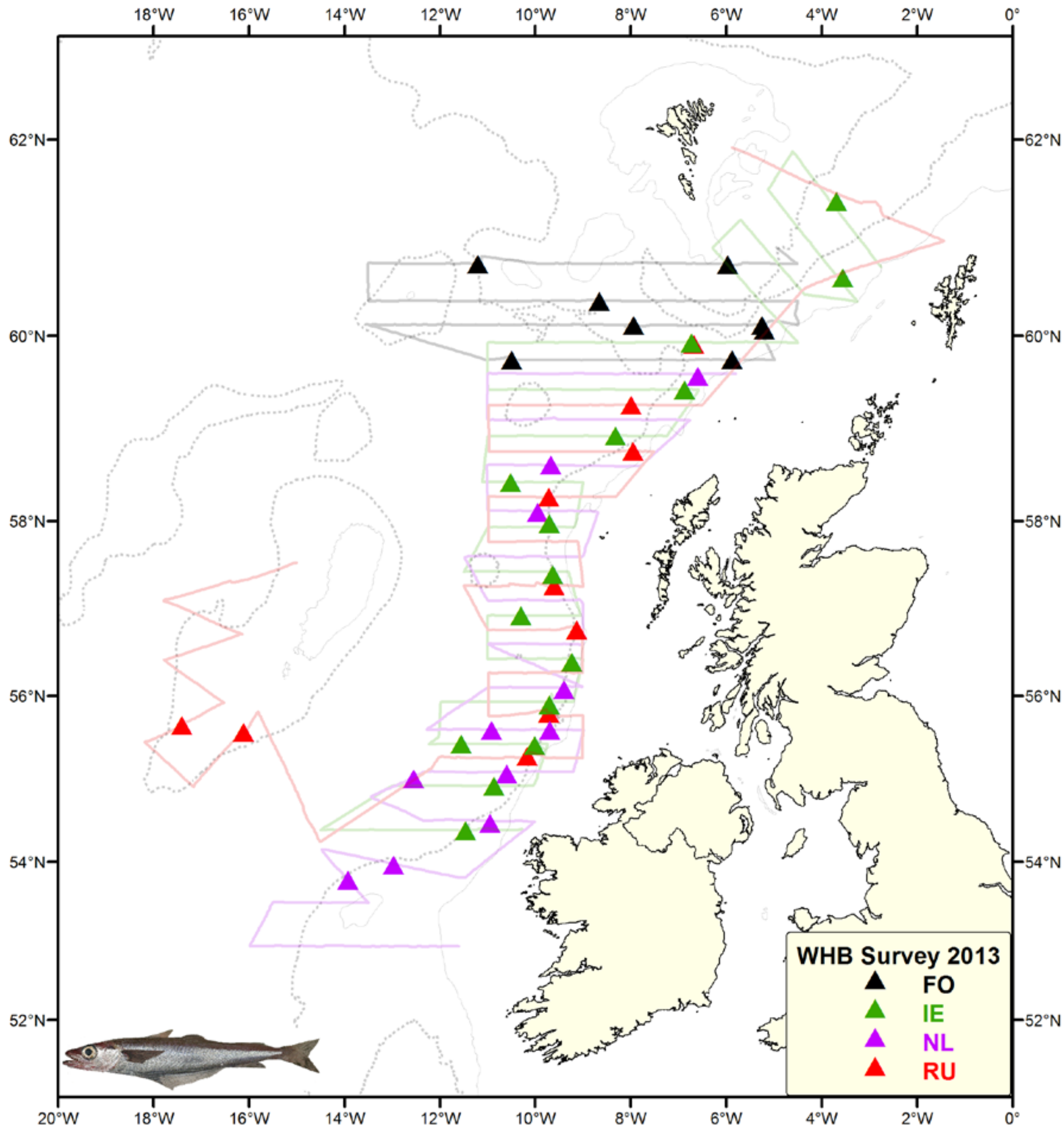


Figure 1. Vessel cruise tracks and trawl stations of the International Blue Whiting Spawning stock Survey (IBWSS) from March-April 2013. IE: Ireland (Celtic Explorer); FO: Faroe Islands (Magnus Heinason); NL: Netherlands (Tridens); RU: Russia (Vilnyus).

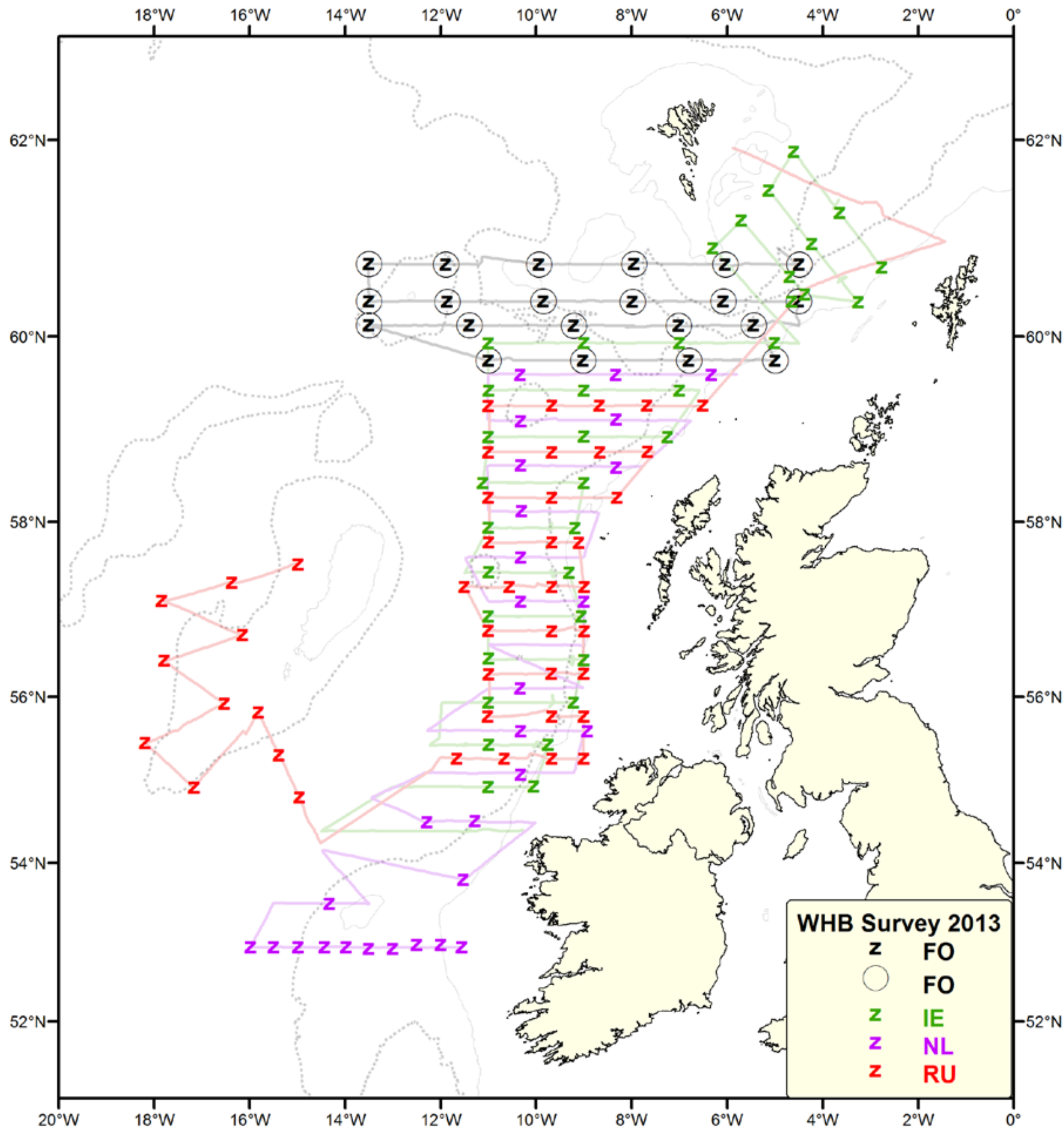


Figure 2. CTD stations overlaid onto vessel cruise tracks for the combined survey ('z'). Circles represent plankton trawls. green: Celtic Explorer; black: Magnus Heinason; purple: Tridens; red: Vilnyus. March-April 2013.

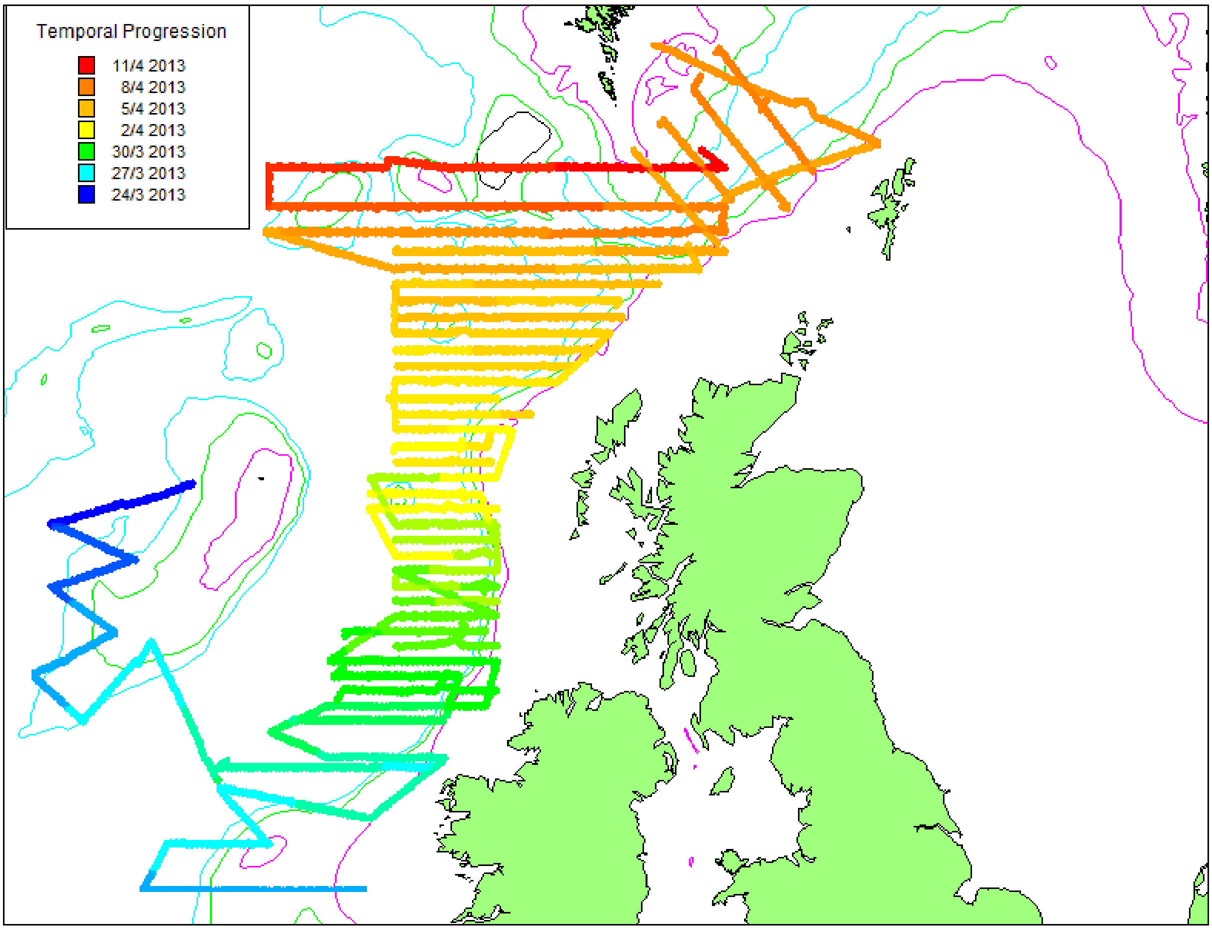


Figure 3. Temporal progression for the International Blue Whiting Spawning stock Survey (IBWSS), 24. March – 11. April 2013.

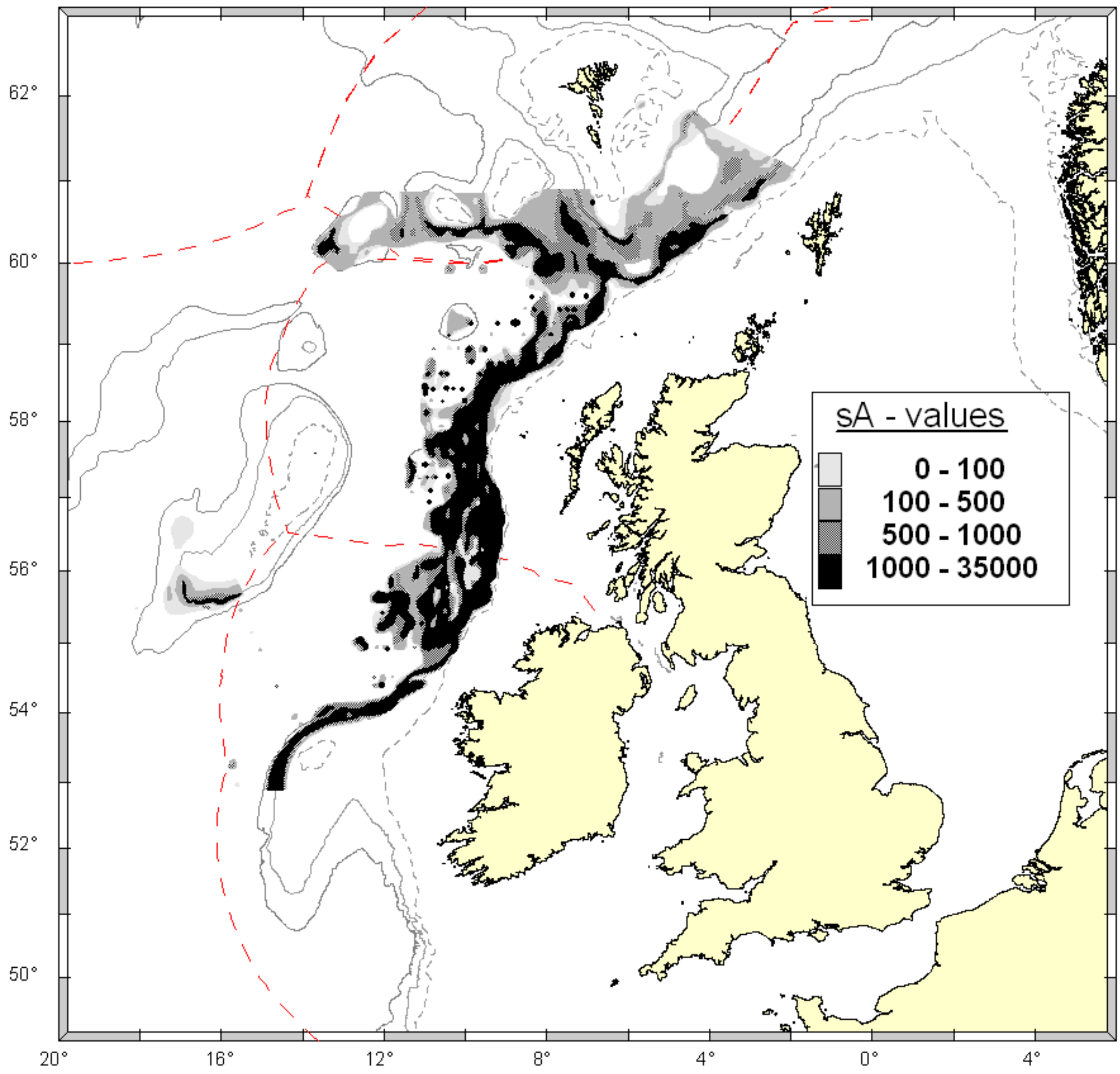


Figure 4. Map of blue whiting acoustic density (s_A, $m^2/n.m.^2$) , 24. March – 11. April 2013.

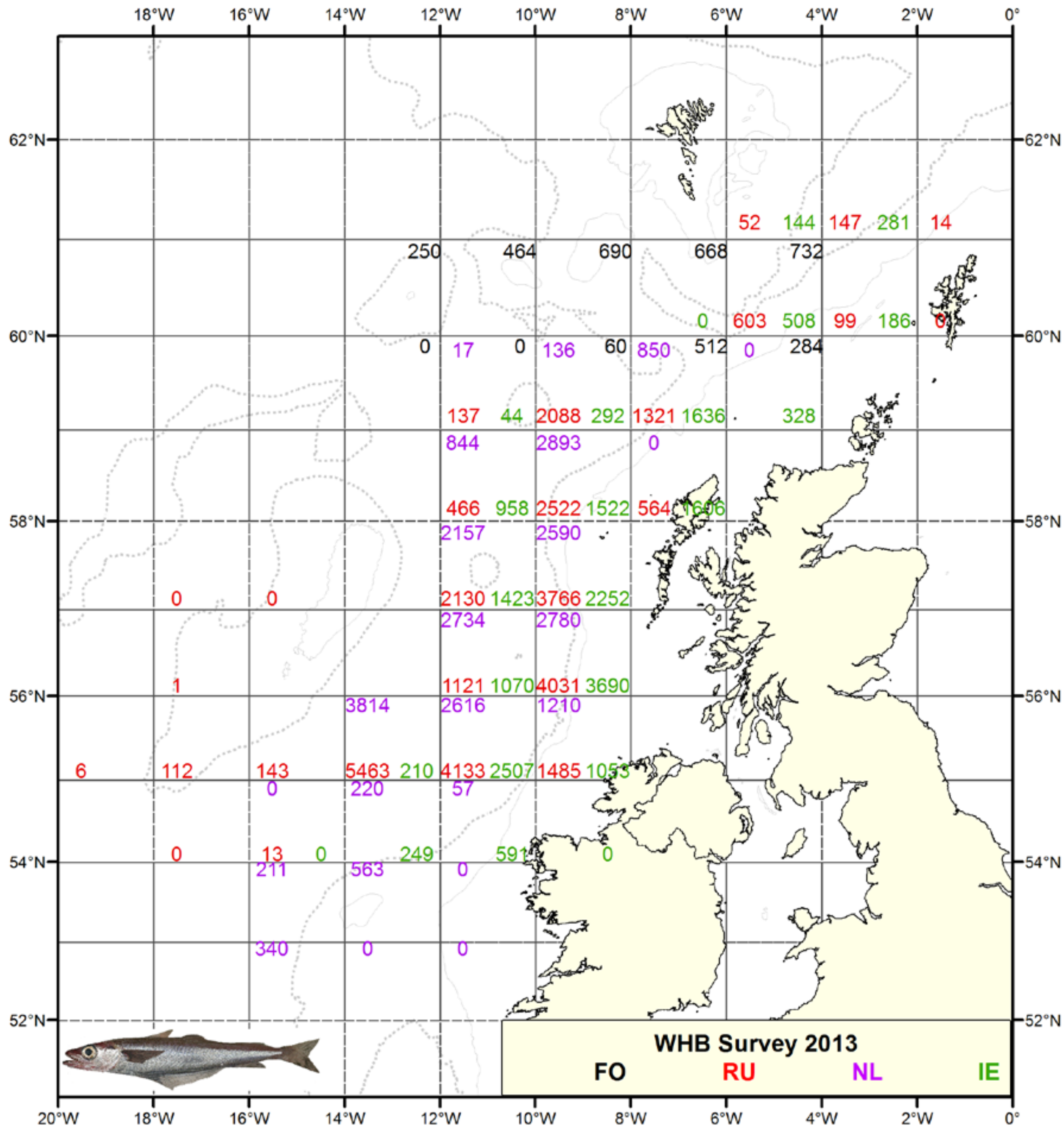


Figure 5. Mean blue whiting acoustic density (s_A, $m^2/n.m.^2$) for IBWSS 2013 by individual vessel: Celtic Explorer: green, Magnus Heinason: black, Tridens: grey, Vilnyus: red. March-April 2013.

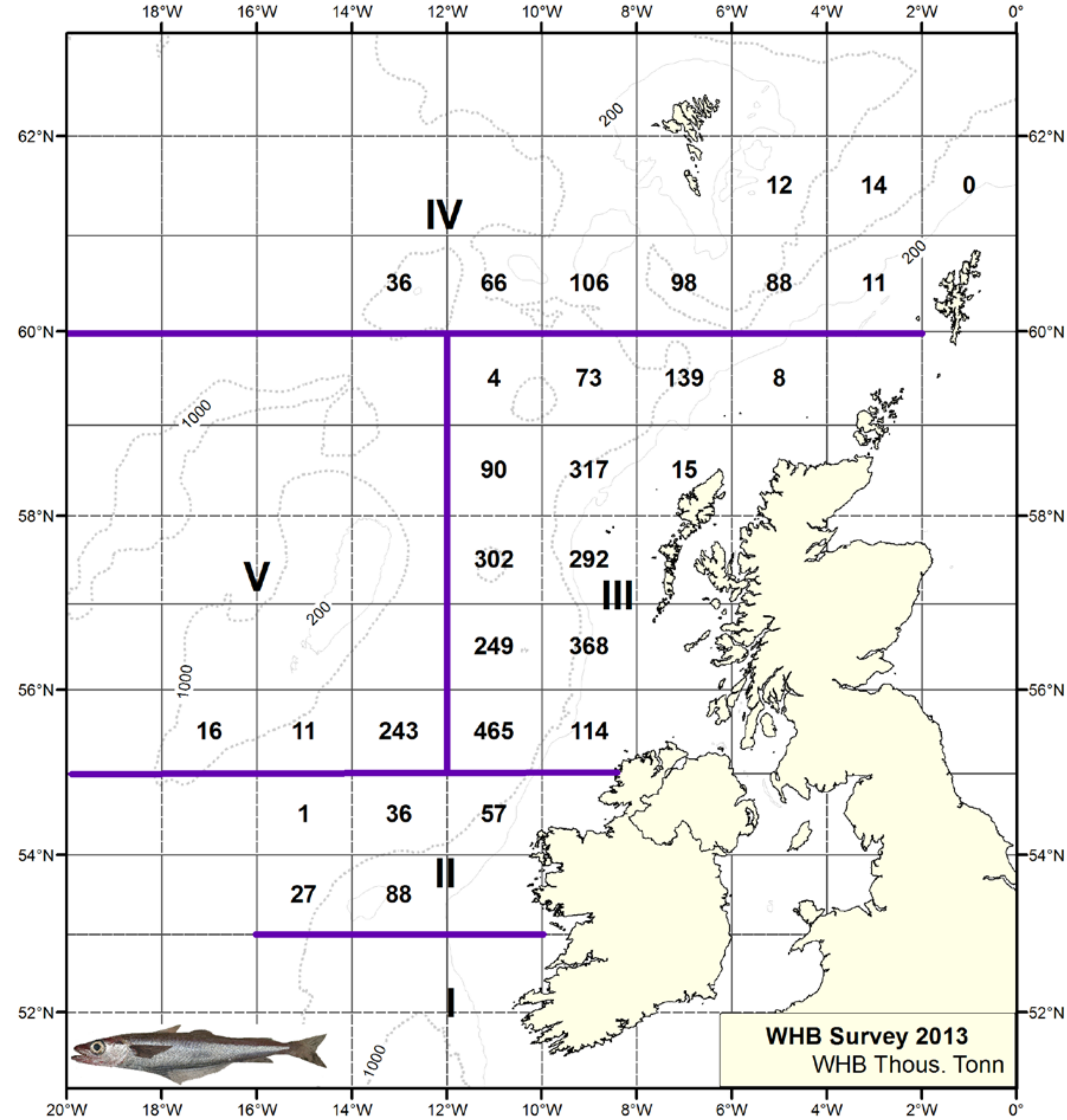


Figure 6. Blue whiting biomass from IBWSS 2013 by sub-area as used in the assessment.

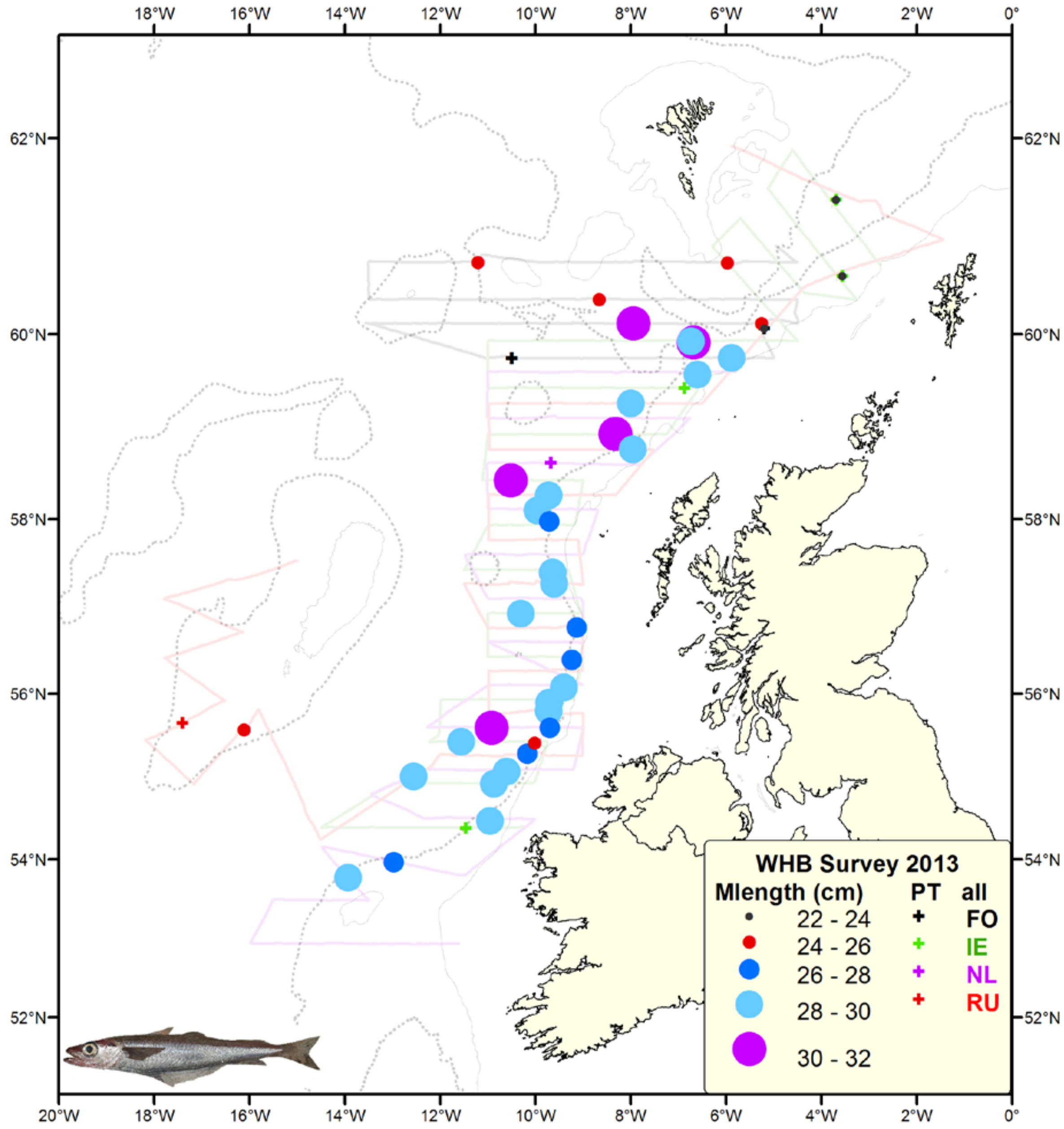


Figure 7. Mean length of blue whiting caught in trawl catches during IBWSS 2013 by individual vessels in March-April 2013. Crosses indicate trawls without any blue whiting catches.

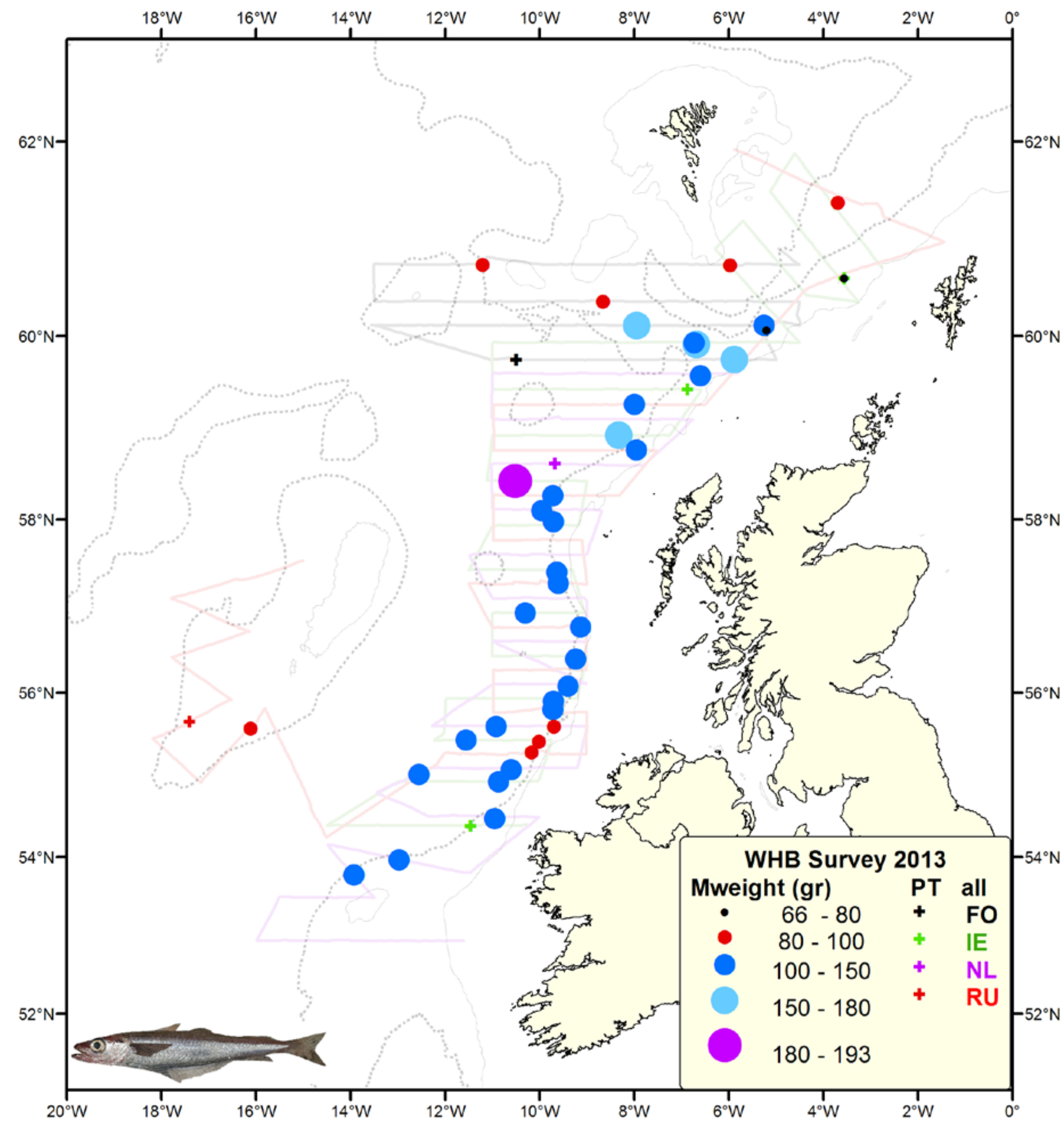
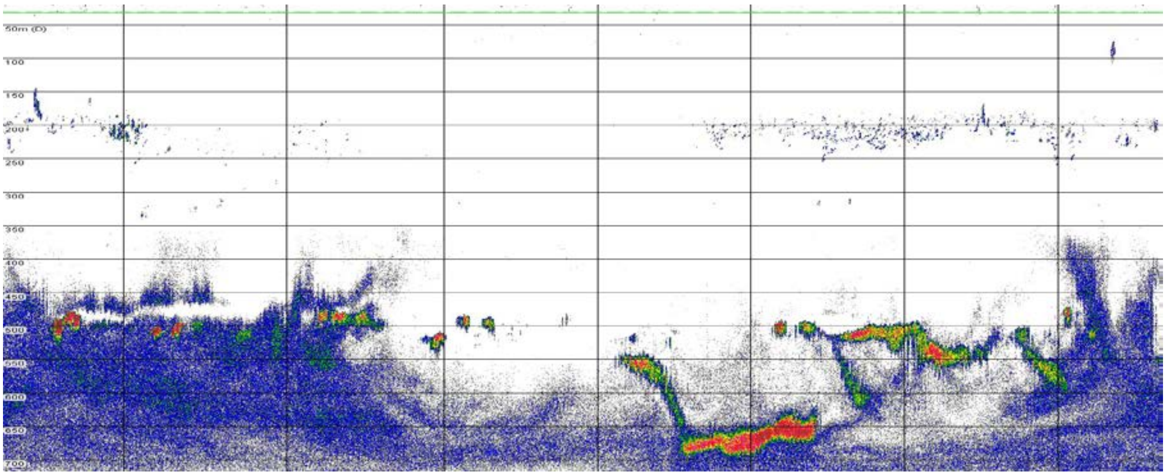
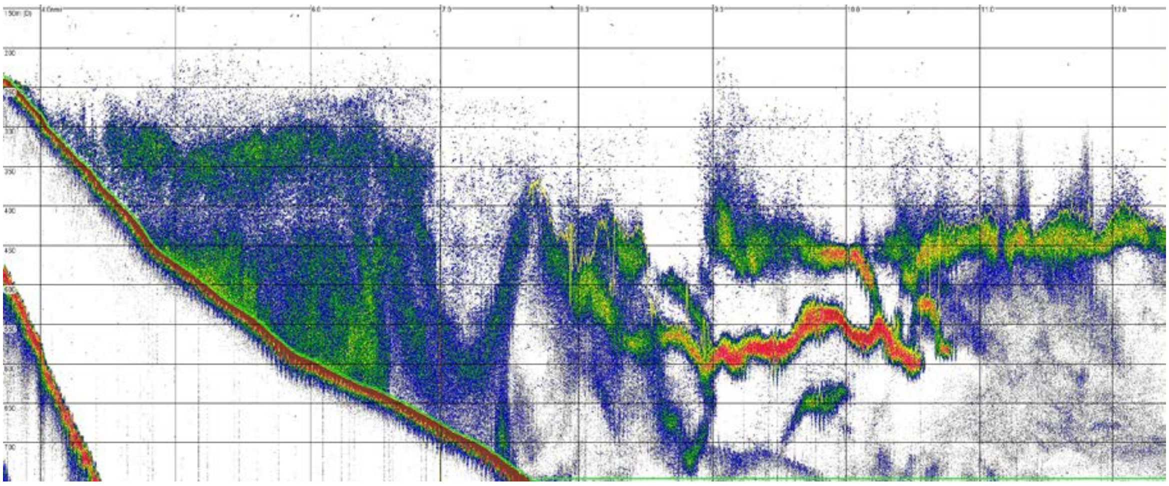


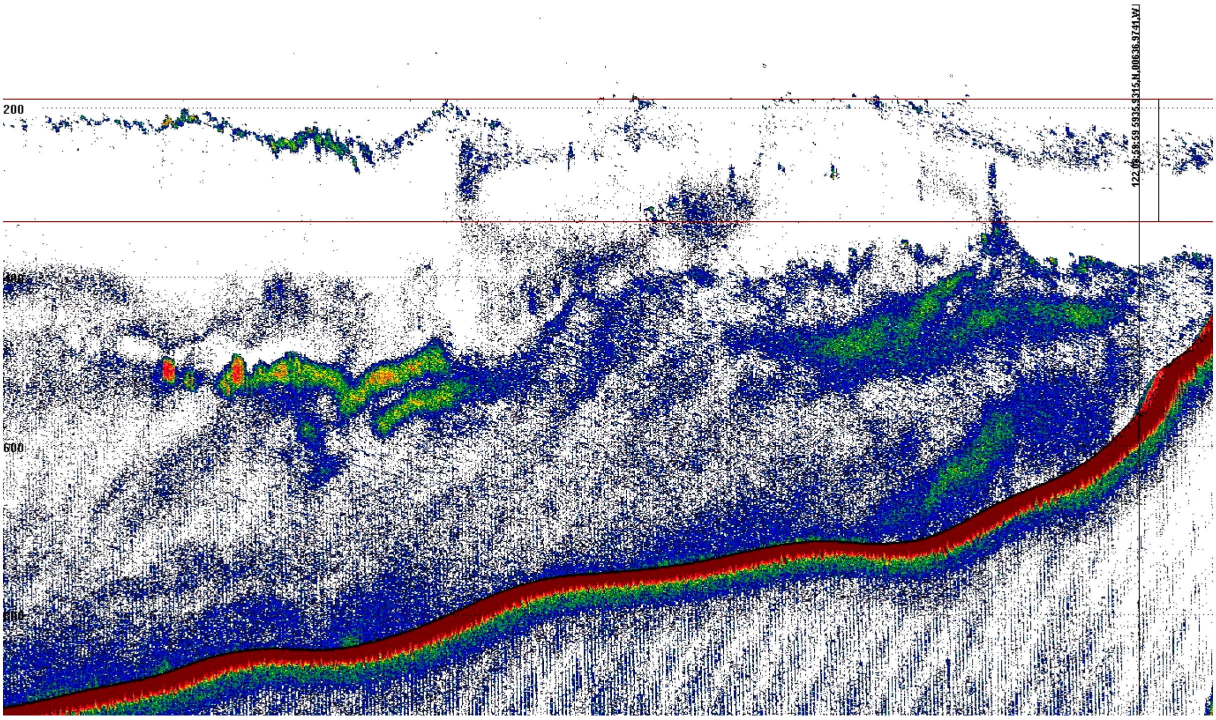
Figure 8. Mean weight of blue whiting caught in trawl catches during IBWSS 2013 by individual vessels in March-April 2013. Crosses indicate trawls without any blue whiting catches.



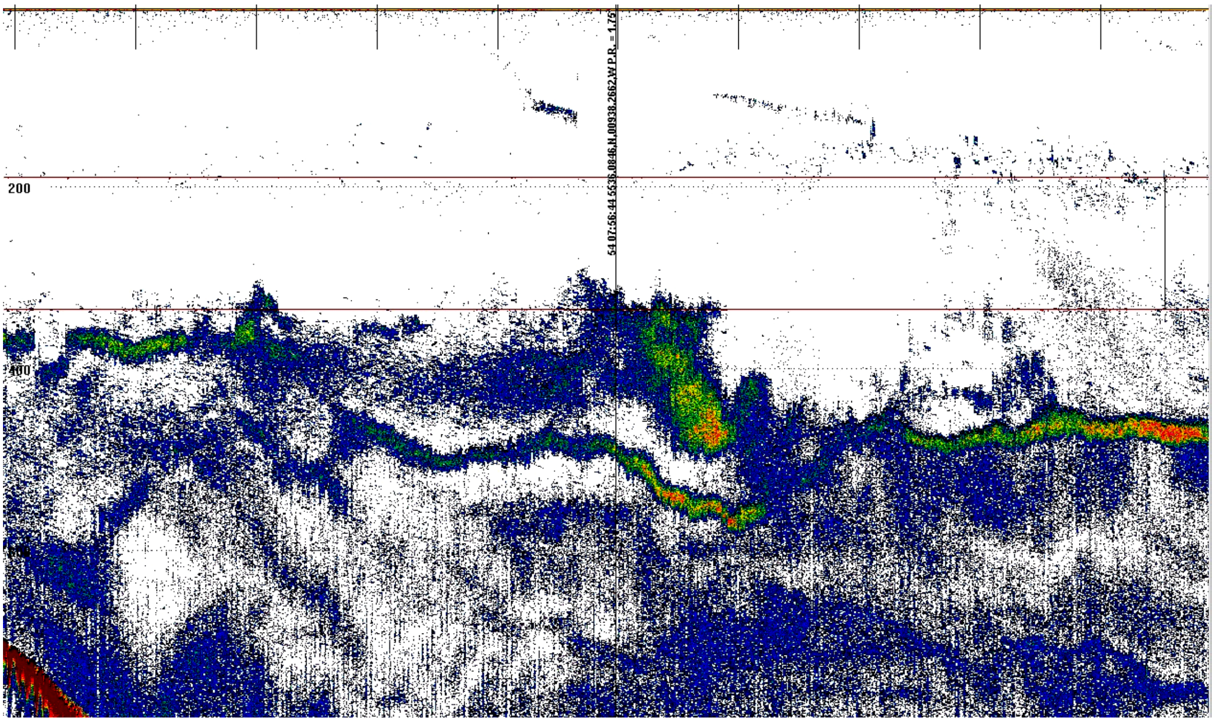
a). Blue whiting echotraces recorded along the 55°30N in the Hebrides target area by the RV Celtic Explorer. Echotraces were observed 15 nmi west of the shelf break in open water. Note the maximum school depth of 680m, the deepest schools recorded during the survey reached 720m.



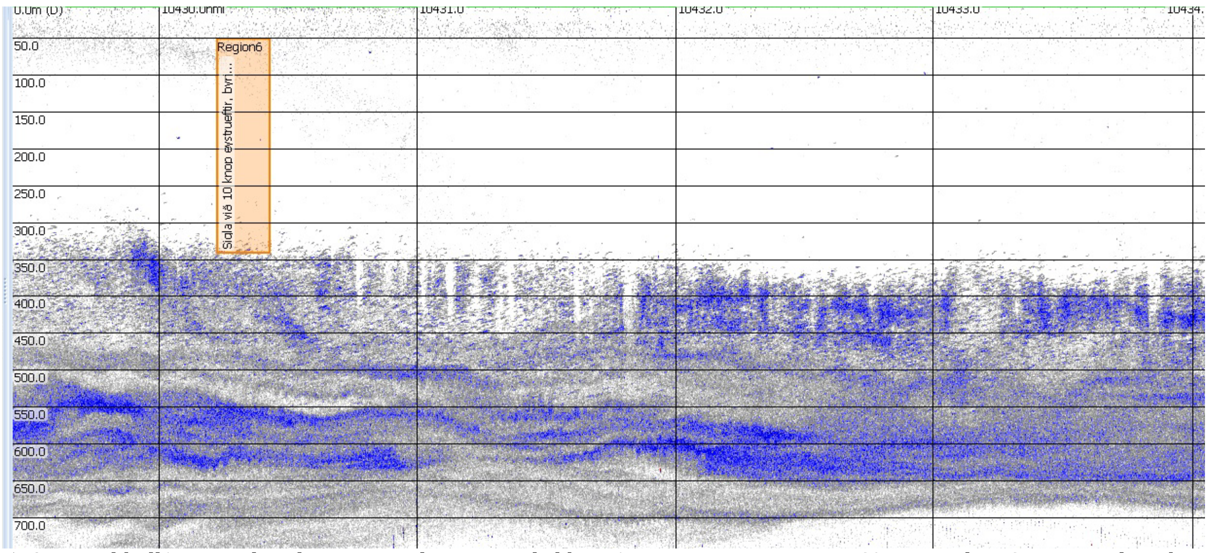
b). A high density blue whiting echotrace recorded by the RV Celtic Explorer along the shelf edge on 56°30'N.



c) Blue whiting school at approximately 500 m of depth, with a layer of pearlsides at around 200 m observed on board Tridens (59°06 N 06°36 W) on the 31th of March 2013 at 8:11, while passing up the shelf.



d) Several blue whiting schools at 400 – 600m of depth, observed on the 30th of March at 8:03 (55°36 N 09°40 W) on board Tridens, while moving off the shelf edge into deeper waters.



e) Assumed hull/wave-induced WHB avoidance recorded by R/V Magnus Heinason on 60.45N and 7.16W. Vessel pitching and disappearance of WHB backscatter coincided. Reducing pitching by slowing down the vessel resulted in steady registrations.

Figure 9. Echograms of interest encountered during the combined International blue whiting survey in March-April 2013.

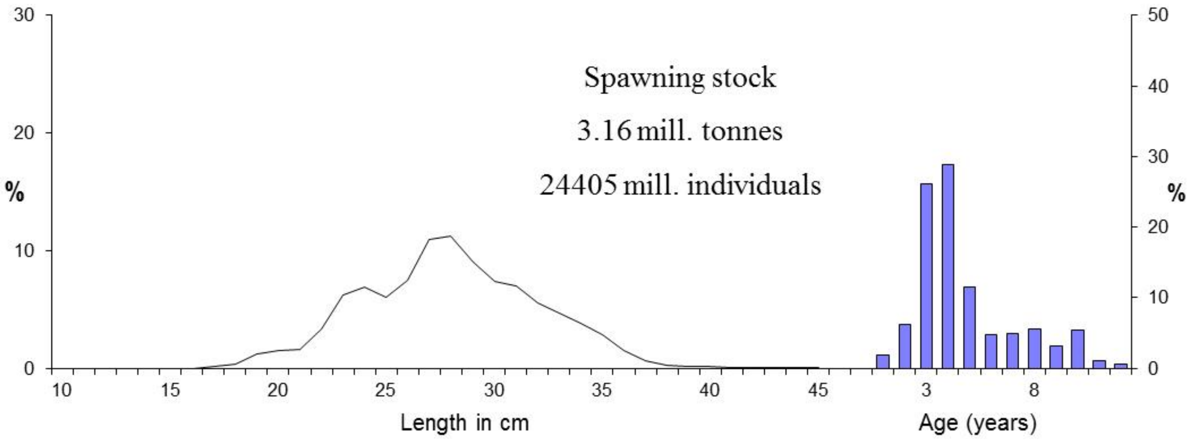


Figure 10. Length and age distributions (numbers) of total stock of blue whiting. Spawning stock biomass is given. March-April 2013.

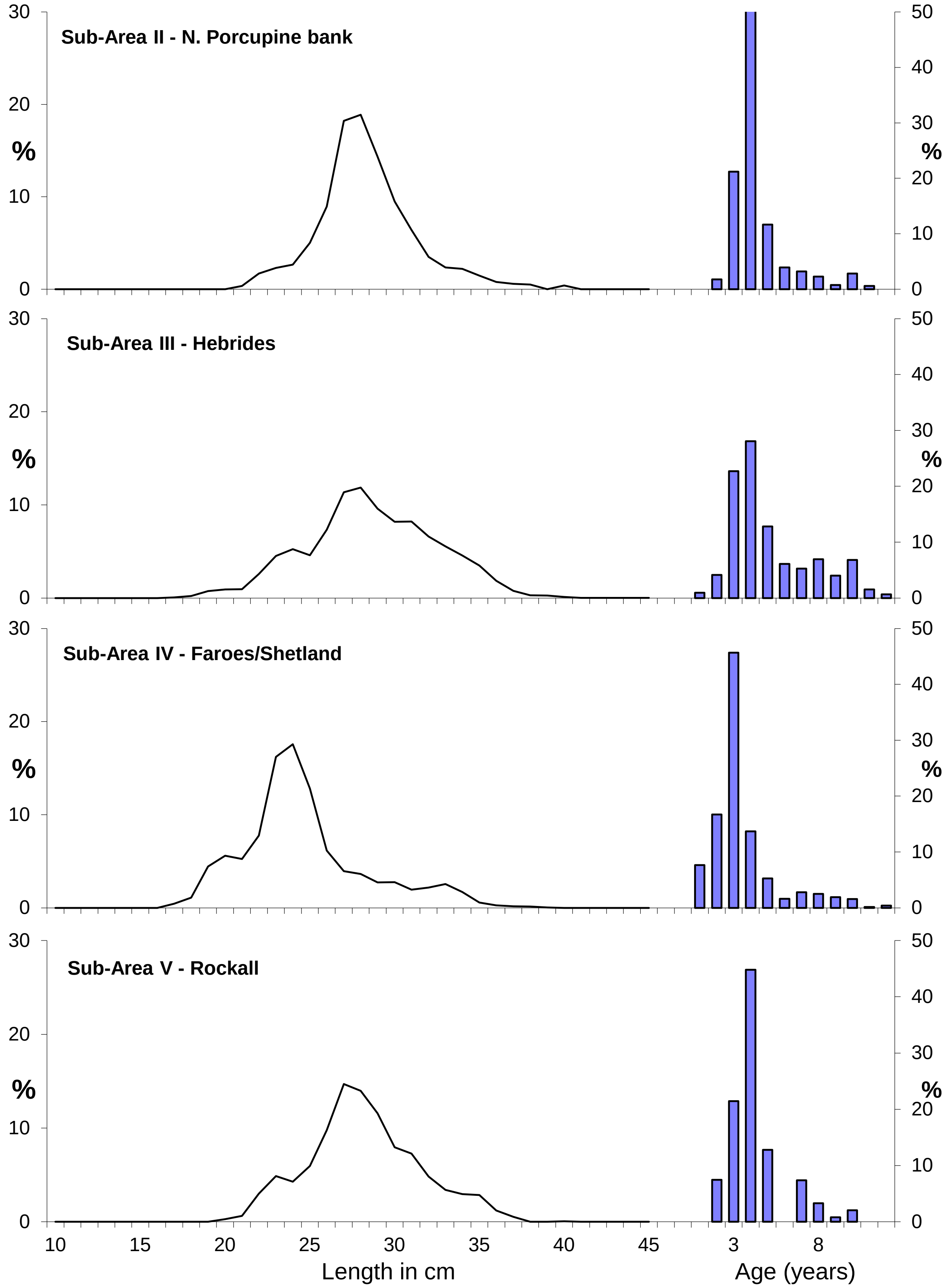


Figure 11. Length and age distribution (numbers) of blue whiting by covered sub-area (II–V). March-April 2013.

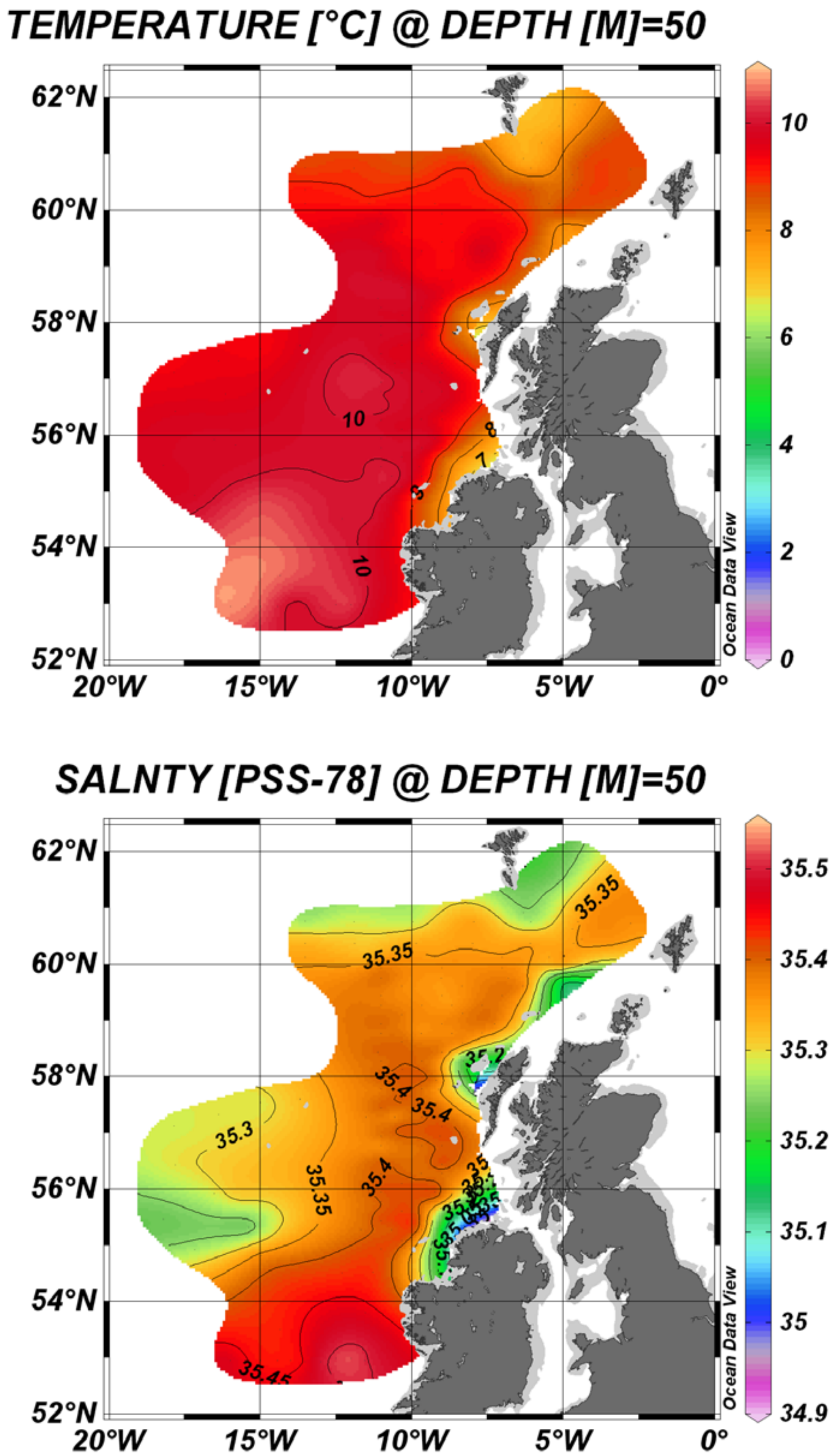


Figure 12. Horizontal temperature (top panel) and salinity (bottom panel) at 50m subsurface as derived from vertical CTD casts. March-April 2013.

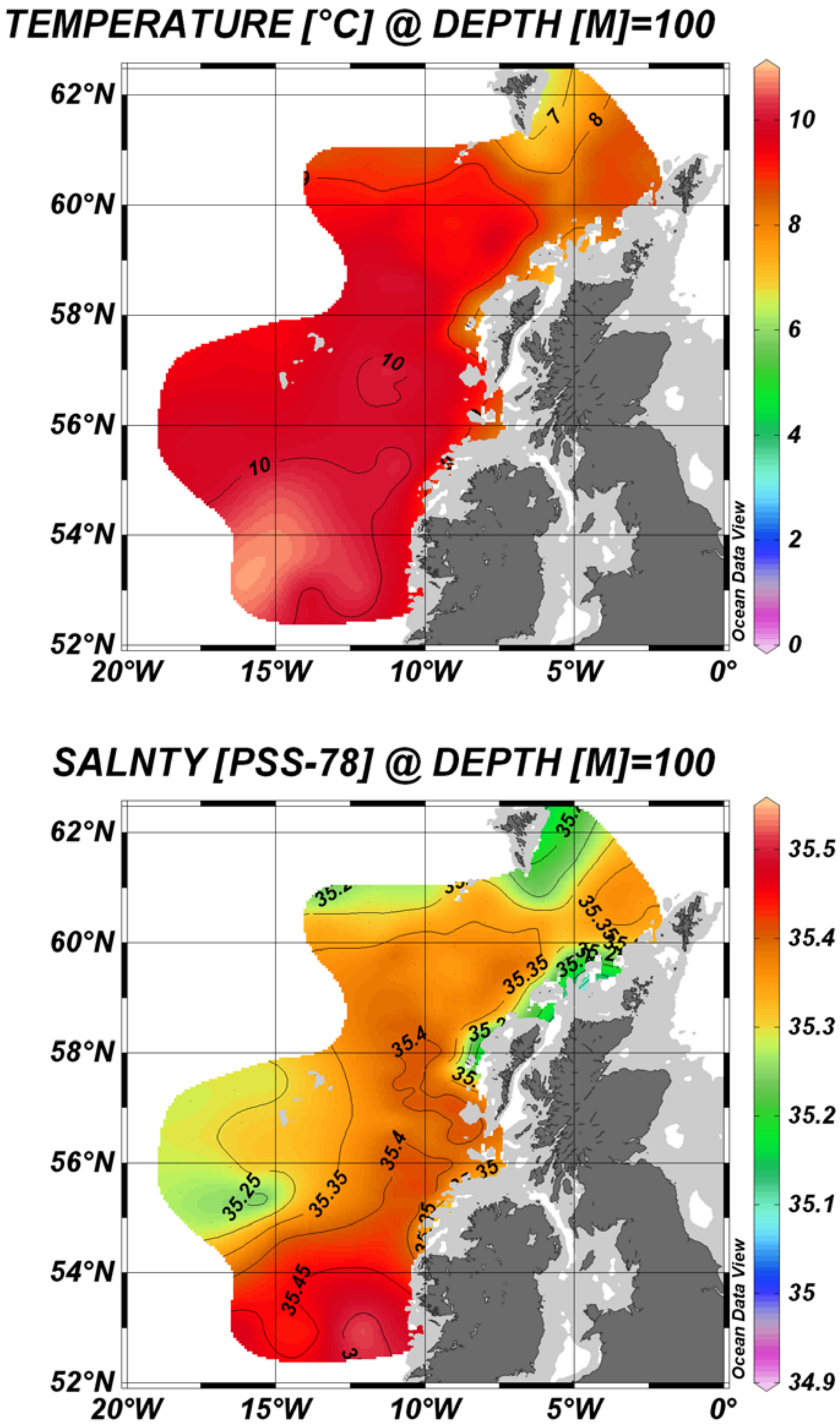


Figure 13. Horizontal temperature (top panel) and salinity (bottom panel) at 100m subsurface as derived from vertical CTD casts. March-April 2013.

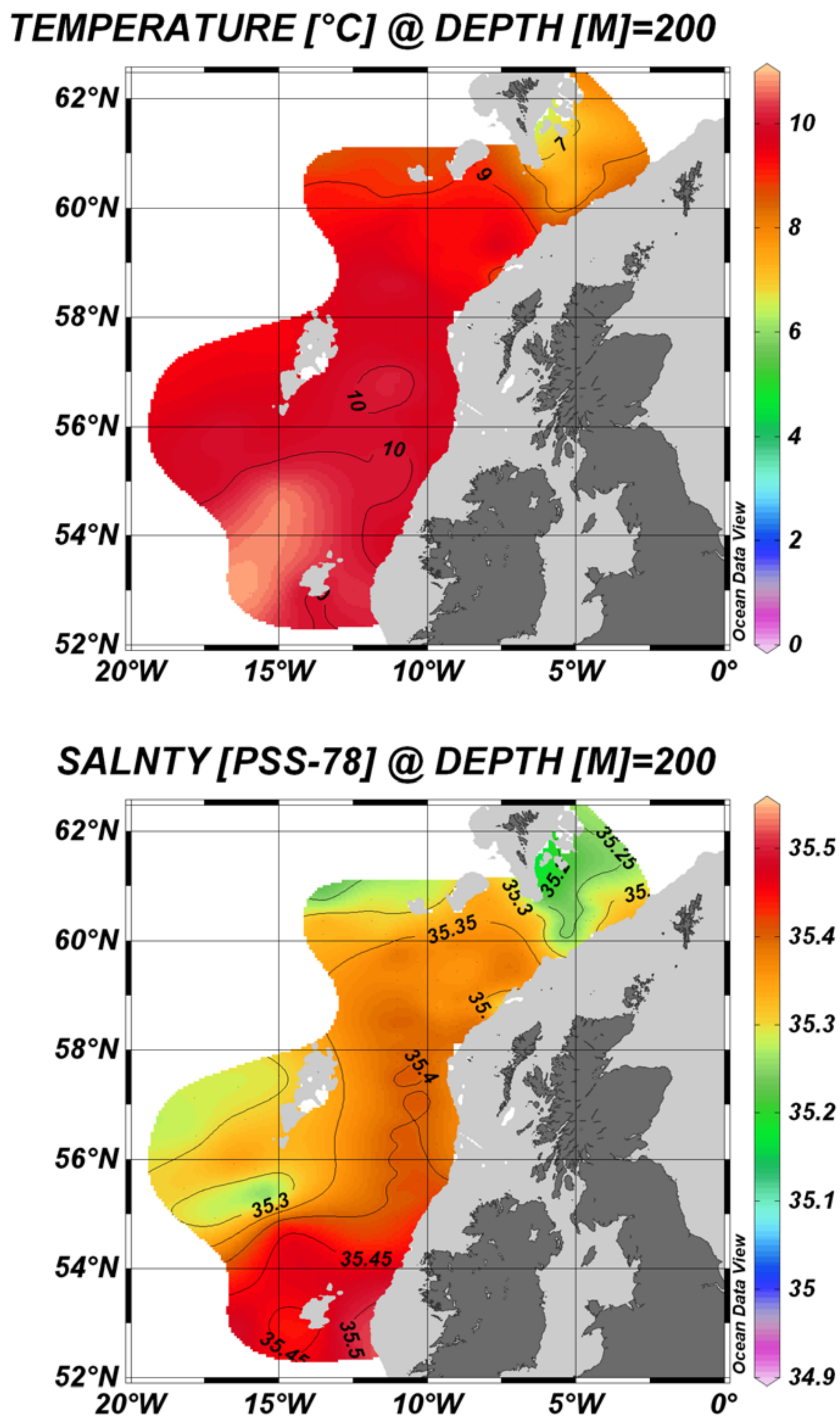


Figure 14. Horizontal temperature (top panel) and salinity (bottom panel) at 200m subsurface as derived from vertical CTD casts. March-April 2013.

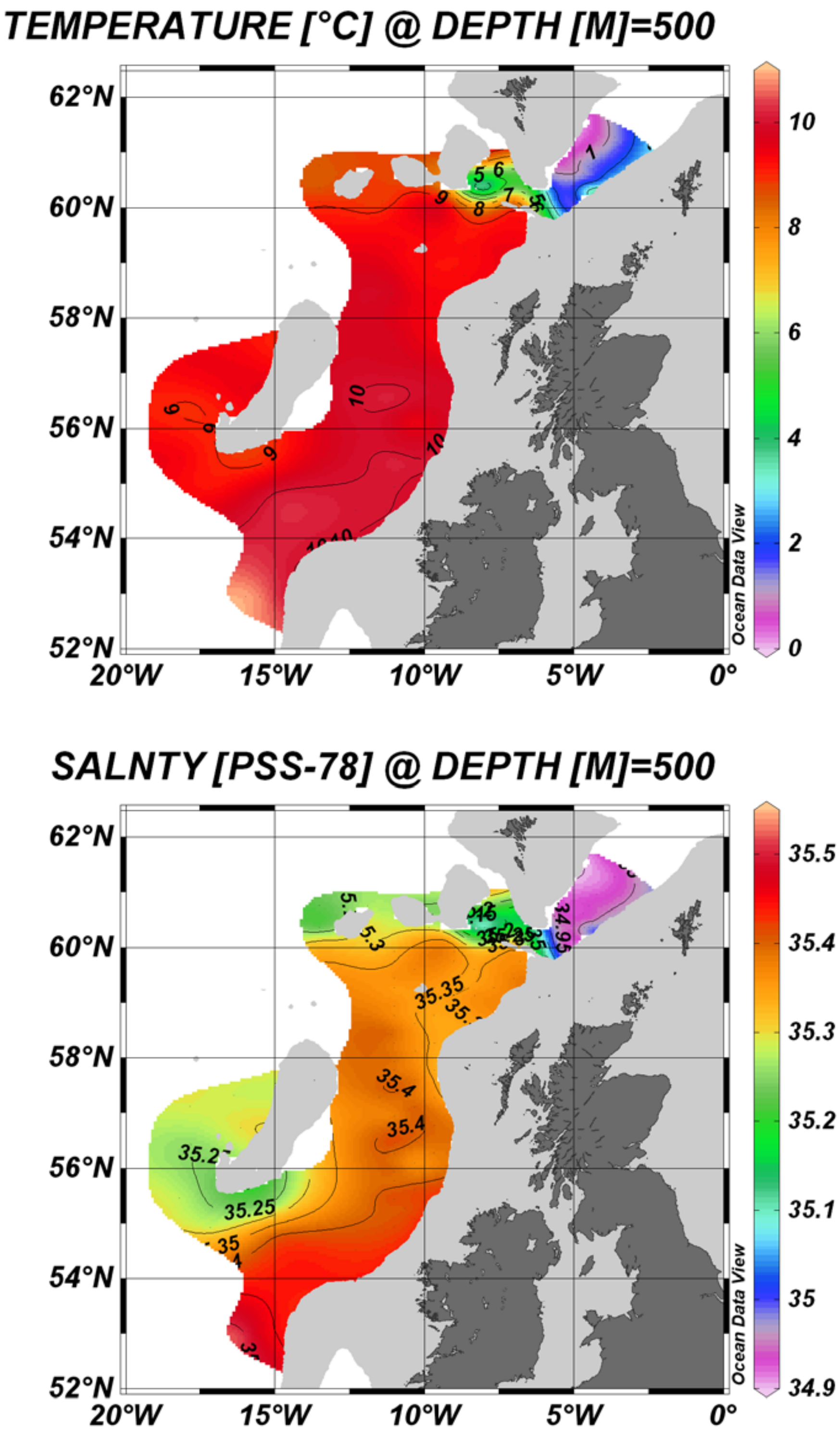


Figure 15. Horizontal temperature (top panel) and salinity (bottom panel) at 500m subsurface as derived from vertical CTD casts. March-April 2013.

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

Sascha Fässler and Ciaran O'Donnell

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 2013 survey as well as nine earlier international surveys. Mean acoustic density over the survey area was 959.2 m^2/n.m.^{2} (as compared to 651.6 m^2/n.m.^{2} in 2012) with 95% confidence interval being 902.5 (lower) and 1015.6 (upper) m^2/n.m.^{2}. Relative to the mean, the approximate 95% confidence limits are –5.9% and +5.9%, and 50% confidence limits are –2.2% and +2.1%. This level of uncertainty in acoustic densities is the lowest observed in the time series so far. It is about half as large as those observed in previous years with the exception of 2007 when a much higher uncertainty was recorded. Overall mean acoustic density has shown a consistent decrease annually since 2007 to 2010 and is now showing an increasing trend over the last three years.

Figure 2 summarizes 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 2013 estimate shows a continuation of the increasing trend observed last year for the first time again since 2007.

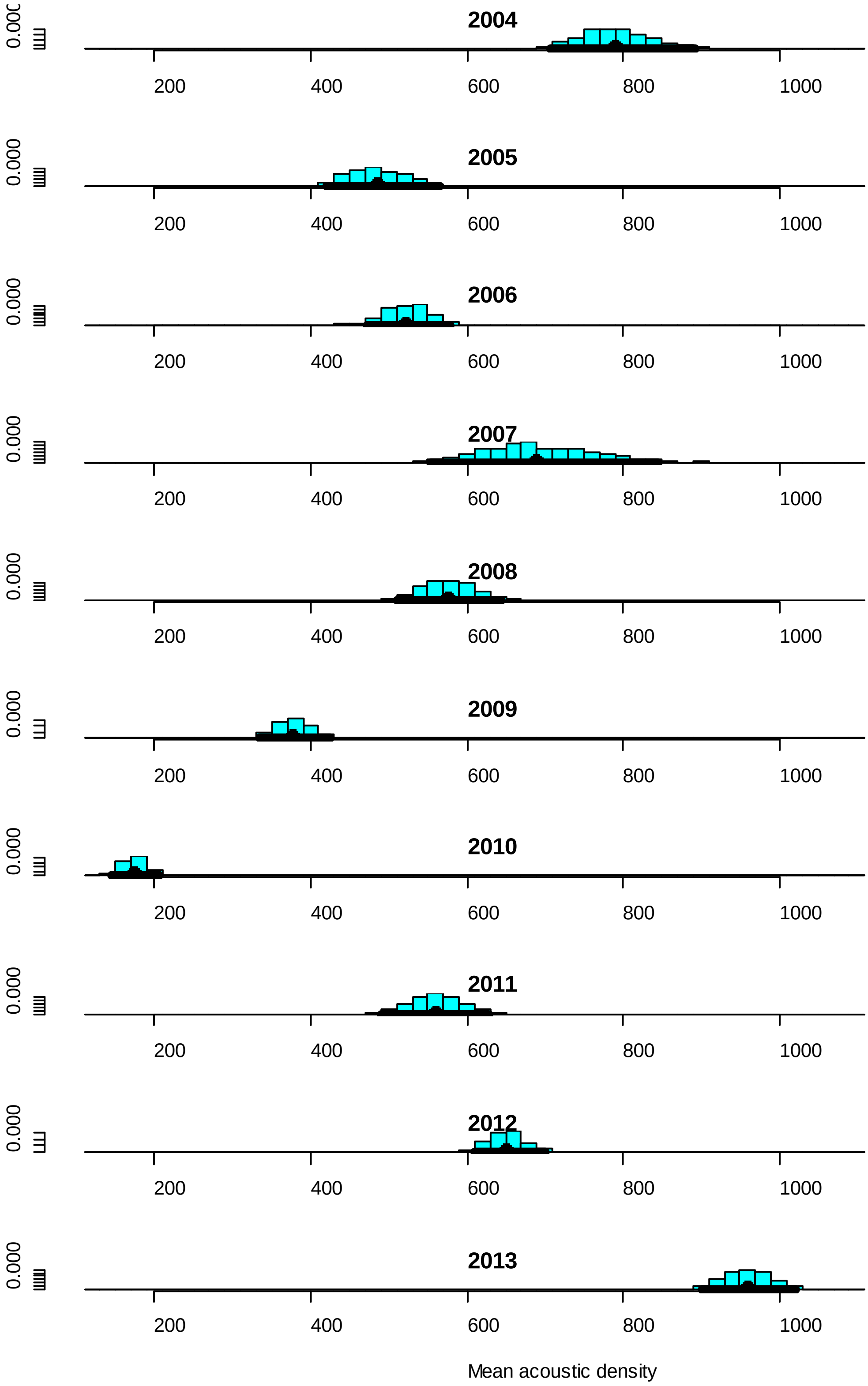


Figure 1. Distribution of mean acoustic density (in $m^2/n.m.^2$) by year based on 1000 bootstrap replicates of acoustic data from blue whiting surveys. Mean acoustic density is indicated with a black dot on the x-axis, while the horizontal bar shows 95% confidence limits.

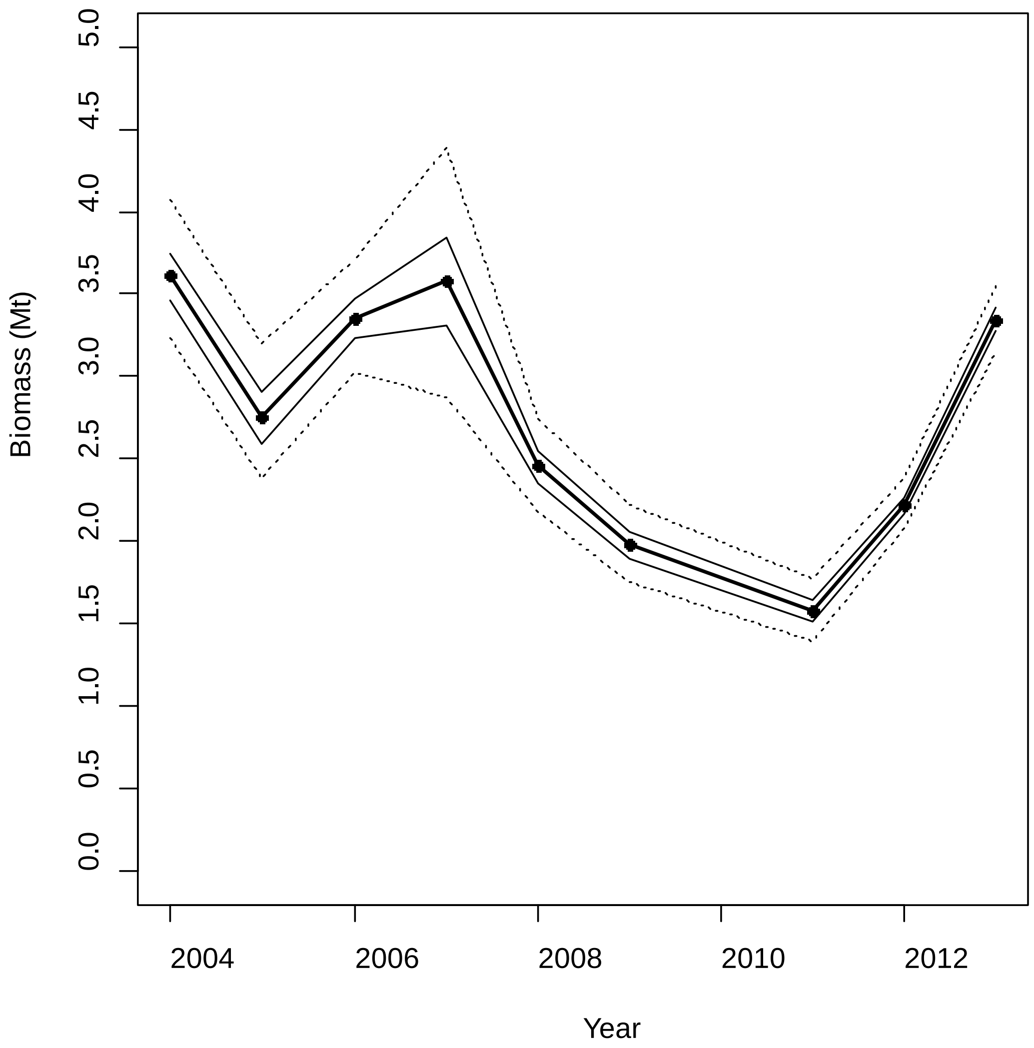


Figure 2. Approximate 50% and 95% confidence limits for blue whiting biomass estimates. The confidence limits are based on the assumption that confidence limits for annual estimates of mean acoustic density can be translated to confidence limits of biomass estimates by expressing them as relative deviations 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.

Ciaran O'Donnell

A review of consistency of age readings was carried out using data collected from all nations. Results show relatively good agreement and are generally well grouped 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 younger age classes an overall improvement was observed across nations as compared to previous years. A broad range of ages were observed from 1 to 16 years from survey data in 2013 with a corresponding length range of 17-46cm.

As Norway did not participate in this year's survey their core aging expertise was also missing. Regardless of future survey participation by Norway it is recommended that aging expertise should be made available in the form of personnel exchange/participation during the survey.

A review of data across years (2010-2013) shows a year on year improvement especially for younger age classes (Figure 2). It is recommend that the blue whiting age reading workshop (Bergen, June 2013) use the otiliths collected during this combined survey as a worked example for all participants. As survey age readers will be present at the workshop this will further improve the experience of readers and increase precision of future survey estimates. It is recommended that the age reading workshop feedback to WGIPS (next meeting in January 2014).

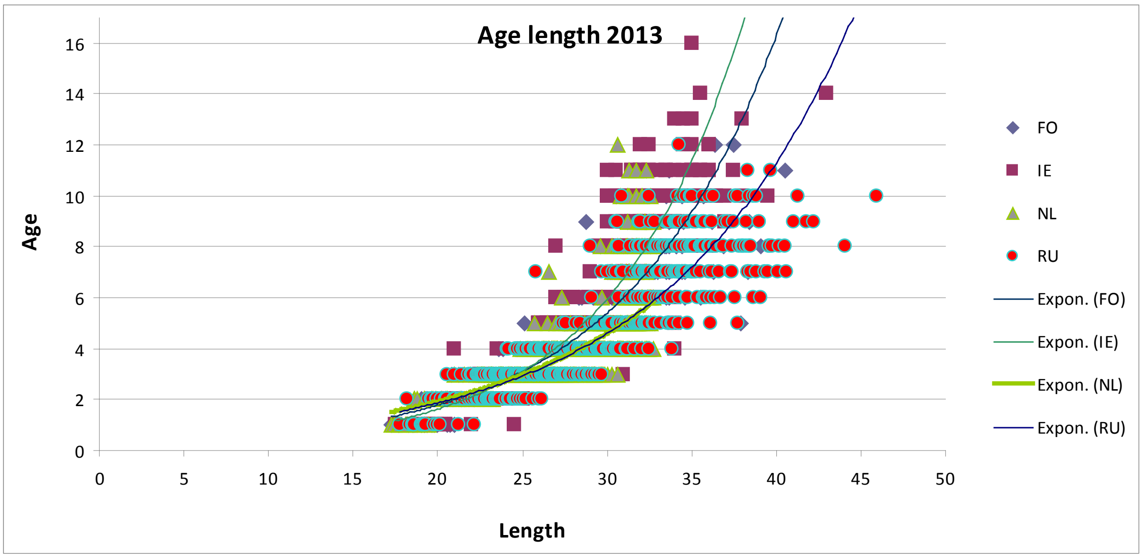


Figure 1. Profile of length at age by nation of blue whiting collected during individual surveys in 2013 (FO; Faroes, IE; Ireland, NL: Netherlands and RU; Russia).

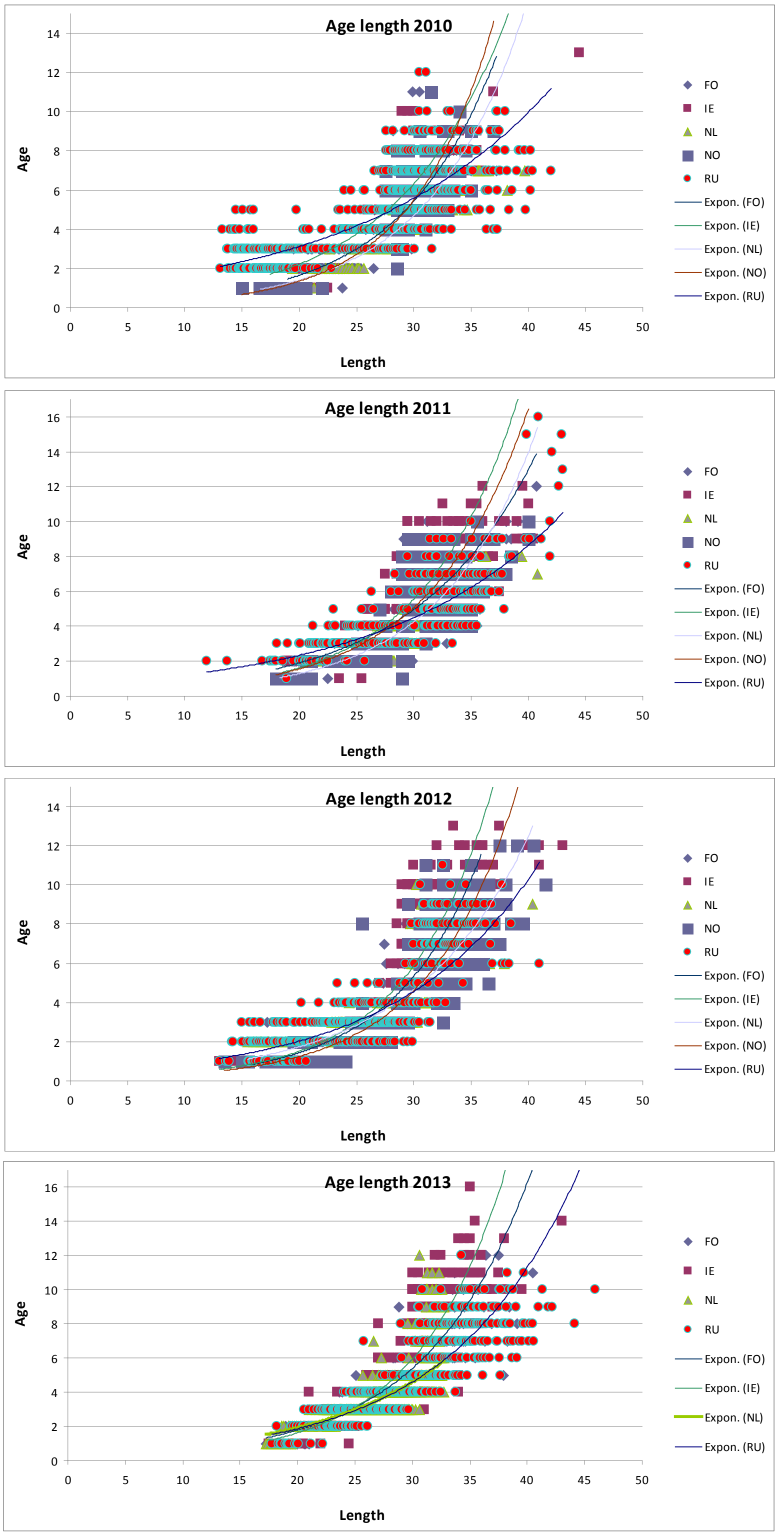


Figure 2. Profile of length at age by nation of blue whiting collected during individual surveys from 2010-2013 (FO; Faroes, IE; Ireland, NL: Netherlands, NO; Norway* and RU; Russia).* No participation from Norway in 2013.

Appendix 3. Planned acoustic survey of the NE Atlantic blue whiting spawning grounds (IBWSS) in 2014

Sascha Fässler

Five vessels representing the Faroe Islands, the Netherlands (EU-coordinated), Ireland (EU-coordinated), Norway and Russia are expected to participate in the 2014 spawning stock survey. There is still uncertainty about the Norwegian participation so planning will again be based on four vessels at this stage.

Survey timing and design were discussed during the meeting. The group decided that in 2014, the survey design should follow the one used during the previous two years. The focus will be on a good coverage of the shelf slope in areas II and III, as it is evident that the bulk of the spawning aggregation was found there during the past few years (2008–2013). The design is based on variable transect spacing, ranging from 30 n.m. in areas historically containing less dense aggregation (e.g. subarea I, south Porcupine), to 7.5 n.m. in the core survey area (subarea III, Hebrides) (Figure 1). From past surveys it was evident that huge areas in the west of the Rockall Trough contained, if at all, only sporadic and small blue whiting concentrations. The western borders of the transects in subarea III were therefore extend to just 11ºW from 2012 onwards, in order to put more effort on the continental slope. However, in the 2013 survey it was evident that blue whiting aggregations extended further west than 11ºW on some of the transects in the core survey area (subarea III, Hebrides). Therefore survey planning for 2014 will take this into account by extending some of the transects to 13ºW or 11.5ºW, respectively. To ensure transect coverage was not replicated, transects were allocated systematically with a random start location.

The aim is to have all but the Faroese vessel start surveying on their transects just north of subarea II (North Porcupine) at the same time (26.03.2014; Table 1). That way, the core survey subarea III can be covered synoptically by 3 vessels with a similar temporal progression.

It was decided that the Dutch and Russian vessels would start the survey in the southern subareas I and II (Porcupine). The Irish Celtic Explorer would first cover subarea IV (on southwest Rockall Bank). 2–4 days after beginning their individual surveys, these vessels will jointly continue surveying the north of subarea II and afterwards area III from the south progressing northwards. Once the Russian 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. Survey extension in terms of coverage (52–61ºN) will be in line with the time-series 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 3 vessels covering the core Hebrides area are present on station in the north of subarea II (just north of Porcupine Bank) on 26 March 2014 (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 2014 survey are presented in Figure 1. As survey coordinator in 2014, Sascha Fässler (Netherlands) has been tasked with 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 2014).

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 2014 WGIPS meeting. The survey will be carried out according to survey procedures described in the "MANUAL FOR INTERNATIONAL PELAGIC SURVEYS (IPS)" (WGIPS report 2012).

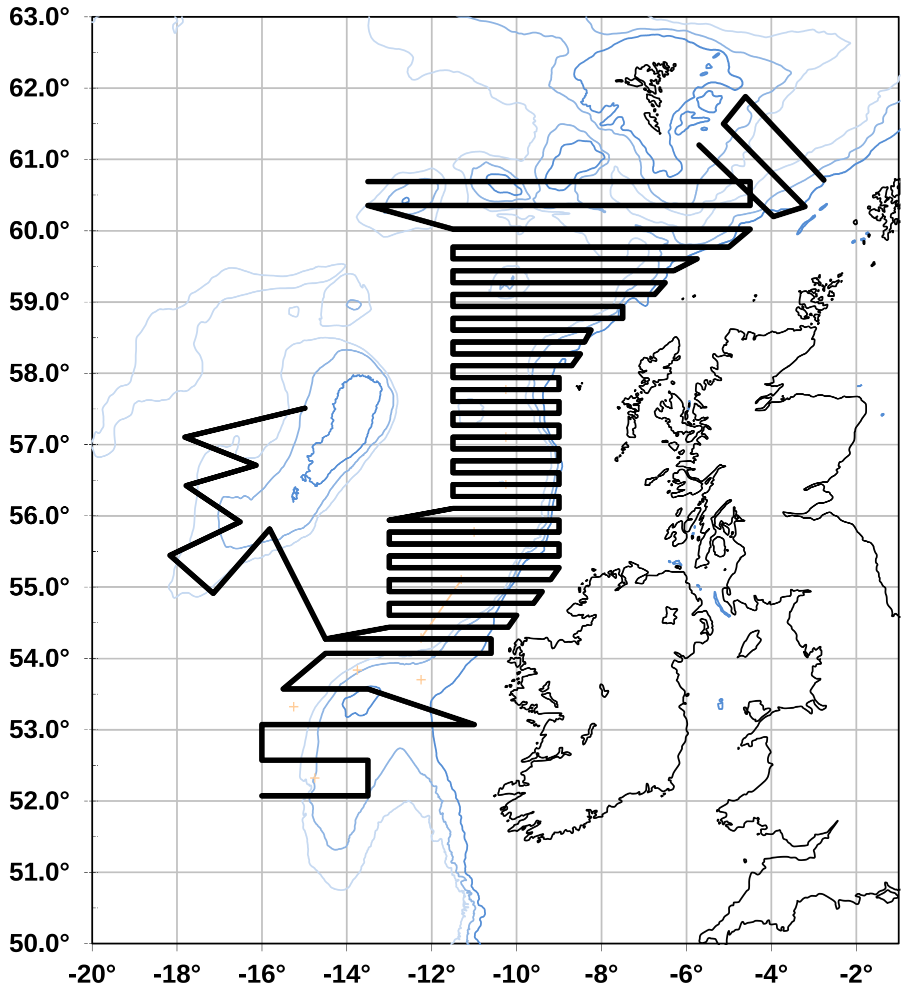


Figure 1. Preliminary survey tracks for the combined 2014 International Blue Whiting Spawning stock Survey (IBWSS).

Table 1. Individual vessel dates for the 2014 International Blue Whiting Spawning stock Survey (IBWSS).

SHIP	NATION	ACTIVE SURVEY TIME (DAYS)	PRELIMINARY SURVEY DATES
Vilnyus	Russia	19	22.3.2014 – 9.4.2014
Celtic Explorer	Ireland (EU)	19	22.3.2014 – 9.4.2014
G.O. Sars	Norway	16	22.3.2014 – 6.4.2014
Tridens	Netherlands (EU)	17	24.3.2014 – 9.4.2014
Magnus Heinason	Faroe Islands	13	28.3.2014 – 9.4.2014