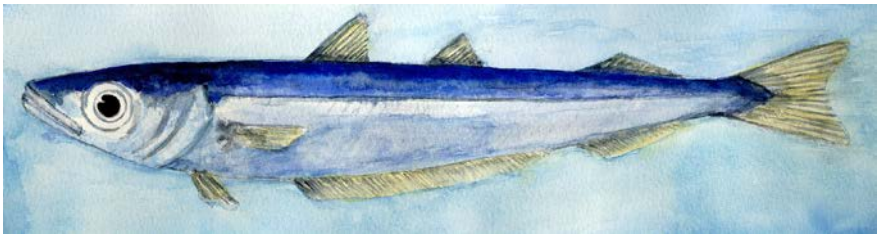
Working Document

Working Group on International Pelagic Surveys

Reykjavík, Iceland, January 2017

Working Group on Widely Distributed Stocks

Copenhagen, Denmark, September 2016



INTERNATIONAL BLUE WHITING SPAWNING STOCK SURVEY (IBWSS) SPRING 2016

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

R/V Magnus Heinason

Ben Scoulding[1*], Kees Bakker[1], Thomas Pasterkamp[1], Dirk Burggraaf[1], Eric Armstrong[6], Dirk Thijssen[8], Felix Muller[7], Laila Higgins[5], Bram Couperus[1*]

R/V Tridens

Graham Johnston[5], Ciaran O'Donnel[5*], Eugene Mullins[5], Niall Keogh[9], Rossa Meade[10]

R/V Celtic Explorer

Valery Ignashkin[3*]

Russian Federation

Åge Høines[2*], Are Salthaug[2*], Espen Johnsen[2*], Valantine Anthonypillai[2*]

M/S Brennholm

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 BirdWatch, Ireland
10 Galway/Mayo Institute of technology
* 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 effort was refined and adjusted by the coordinator based on real time observations. Participating vessels together with their effective survey periods are listed below:

Vessel	Institute	Survey period
Celtic Explorer	Marine Institute, Ireland	20/3 – 03/4
Magnus Heinason	Faroe Marine Research Institute, Faroe Islands	1/4 – 11/4
Tridens	Institute for Marine Resources & Ecosystem Studies (IMARES), the Netherlands	21/3 – 5/4
Brennholm	Institute of Marine Research, Norway	24/3 – 4/4

The survey design applied followed methodss described in ICES Survey design Manual (2015) and allowed for a flexible transect design and comprehensve coverage of the spawning aggregations. Overall weather conditions were good during the survey with a total of 3 days weather down time recorded. Transects undertaken by all vessels were consistent in spatial coverage and timing, delivering full coverage of the respective distribution areas within 23 days.

Cruise tracks and survey strata are shown in Figure 1. Trawl stations for each participant vessel are shown in Figure 2 and CTD stations in Figure 3. All vessels worked in a northerly direction (Figure 4). Communication between vessels occurred twice daily via email to the coordinator exchanging up to date infromaion on blue whiting distribution, echograms, fleet activity and biological information.

Sampling equipment

Vessels employed a midwater trawl for biological sampling, the properties of which are given in Table 1. Acoustic equipment for data collection and processing are presented in Table 2. Survey abundance estimates are based on acoustic data collected from calibrated scientific echo sounders using an operating frequency of 38 kHz. All transducers were calibrated with a standard calibration sphere (Demer et al. 2015) prior, during or directly after the survey. Acoustic settings by vessel are summarised in Table 2.

Biological sampling

All components of the trawl haul catch 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 3.

Hydrographic sampling

Hydrographic sampling by way of vertical CTD casts were carried out by each participant vessel at predetermined locations (Figure 3 and Table 3). Depth was capped at a maximum depth of 1000 m (Magnus Heinason 450 m) in open water, with the exception of a dedicated hydrographic transect where full depth was achieved. Equipment specifications are summarised in Table 1.

Plankton sampling

Plankton sampling by way of vertical WP2 casts were carried out by Brennholm (NO) and Magnus Heinason (FO) to depths of 400m and 200m respectively (Table 3).

Acoustic data processing

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

On Celtic Explorer, acoustic data were backed up every 24 hrs and scrutinised using EchoView (V.6) 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 EchoView (V 7.090) 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 scrutinised every 24 hrs using the Large Scale Survey System LSSS (V.1.9) post-processing software. Blue whiting were identified and separated from other recordings based on trawl catch information and characteristics of the recordings.

On Brennholm, the acoustic recordings were scrutinized using LSSS (V. 1.10.0) 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

Acoustic data were analysed using the StoX software package recently adopted for WGIPS coordinated surveys. A description of StoX can be found here: http://www.imr.no/forskning/prosjekter/stox/nb-no. Estimation of abundance from acoustic surveys with StoX is carried out according to the stratified transect design model developed by Jolly and Hampton (1990). Since this new method required pre-defined strata, the WGIPS in January 2016 designed a new set of strata to be used for IBWSS 2016 (see Figure 1). The new strata were partly based on the previously used sub-areas (see Figure 6 in Appendix 4A, ICES 2016). The strata used in the 2016 IBWSS were adjusted slightly in StoX, mainly in the western fringes where some transects were shortened due to zero registrations of blue whiting. The strata and transects used in StoX are shown in Figure 1 and 5. All trawl stations within a given stratum with catches of blue whiting where assigned to all transects within the stratum, and the length distributions where weighted equally within the stratum (Figure 5).

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:

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

In StoX a superindividual table is produced where abundance is linked to population parameters like age, length, weight, sex, maturity etc. (exact name: 1_FillMissingData_SuperIndividuals.txt). This table can be used to split the total abundance estimate by any combination of population parameters.

Estimate of relative sampling error

For the baseline run StoX estimates the number of individuals by length group which can be further grouped into population characteristics such as numbers at age and sex.

For the baseline run, the user defines which trawl stations should be assigned to the individual acoustic primary samples (typically transects). In simple terms, a total length distribution of

the species of interest is calculated by transect using all the trawl stations assigned to the individual transects. Conversion from NASC (by transect) to mean density by length group by stratum use the calculated length distribution and a standard target strength equation with user defined parameter values. Thereafter, the mean density by stratum is estimated by using a standard weighted mean function where each transect density is weighted by transect distance. The number of individuals by stratum is given as the product of stratum area and area density.

The bootstrap procedure to estimate the coefficient of variance follows the same principle as in the baseline run. However, for each run, transects within a stratum are selected randomly with replacement, and for each selected transect, the trawl stations which are assigned for the selected transect are randomly sampled with replacement. Thereafter, each run follows the same estimation procedure as described above. The output of all the runs is stored in a RData-file, which is used to calculate the relative sampling error.

Results

Distribution of blue whiting

In total 6,257 nmi (nautical miles) of survey transects were completed areas across six strata relating to an overall geographical coverage of 134,429 nmi.² (Figure 1, Tables 3). This represented a reduction of 16% in total survey mileage (acoustic sampling effort) but an increase of 9% in surveyed area compared to last year (Table 7). Coverage was considered sufficient and still takes into account expected distributions on the Rockall and Porcupine Banks. The distribution of blue whiting as observed during the survey is shown in Figures 6 and 7.

The bulk of the stock was located in the 3 strata bordering the shelf edge (Strata 1, 2 and 3) accounting for over 67% of total biomass (Table 4). The 3 western most strata accounted for the remaining biomass which was distributed in relatively equal proportions of approximately 10% of TSB per stratum. The maximum s_A values observed in the survey were recorded in strata 2 (North Porcupine Bank) close to the shelf slope (34,001 m²/nmi²) by Tridens (Figure 8a) and by the Brennholm in strata 3 (Rockall Trough) in open water (32,045 m²/nmi², Figure 6b). Low density registrations dominated the Rockall strata. Strata 1 (Porcupine Bank) contained a low number of mixed of medium and high density registrations as observed by the Celtic Explorer (Figure 8c). Northern strata (4 and 6) were dominated by numerous low to medium density registrations as observed by the Magnus Heinason (Figure 8d).

Stock size

The estimated total abundance of blue whiting for the 2016 international survey was 2.87 million tonnes, representing an abundance of 34.4×10^9 individuals (text table below). Spawning stock was estimated at 2.27 million tonnes and 25.33×10^9 individuals (Tables 4 and 5).

Strata	Name	TSB (10^3 t)	TSN (10^9)	% TSB	% TSN
1	Porcupine Bank	236 089.3	2 744 672	8.2	8.0
2	N Porcupine Bank	335 107.0	4 077 720	11.7	11.8
3	Rockall Trough	1 376 177.4	14 876 900	47.9	43.2
4	South Faroes	322 791.7	4 321 344	11.2	12.5
5	Rockall Bank	295 262.5	3 913 476	10.3	11.4
6	Faroe/Shetland Ch.	307 220.3	4 512 647	10.7	13.1
	Total	2 872 648	34 446 759	100	100

Stock composition

Individuals of ages 1 to 17 years were observed during the survey.

The main contribution (82%) to the spawning stock biomass were the age groups 3, 4, 5 and 2 in order of importance (Table 5), with 3-year old fish contributing 26% to total biomass.

The Rockall Trough is historically the most productive stratum accounting for upwards of 50% of the SBB in all years with the exception of 2013-2014 (48% and 44% respectively in these years). In 2016 this stratum accounted for 55% of SSB (Table 4). Mean lengths and weights of the fish caught in the Rockall Trough area were highest in the entire survey (Figures 9 and 10).

The two northern strata (South Faroes stratum 4 and Faroese/Shetland stratum 6) were found to contain significant proportion of young blue whiting (1-3 years), all together 75% (230.000) of the total biomass and 84% (4513 million individuals) of the total abundance in that area (see text table above), which is similar to the proportions seen in 2014 (70% and 85% respectively) and 2015 (75% and 84% respectively).

The South Faroes and Faroes-Shetland Channel strata were dominated by 1 to 3 year old fish and Porcupine Bank was dominated by 3 to 5 year old fish. In comparison the composition of North Porcupine stratum consisted of younger fish (2 and 3 year old). As in previous years one year old fish was mainly observed in the area north of the (Stratum 4 and 6) and oldest fish (>8+) were predominantly observed in the Rockall Trough stratum (average length and weight, Figures 12 and 13).

The Rockall Bank estimate was composed of limted trawl samples (2 stations)and so provides a limited sample of biomass within this area. Mean length was 24.5cm, the lowest of all strata. As a result the length and age composition from this stratum is considered biased and not representative.

Immature blue whiting were founbd in varying number in all strata in 2016 (Table 4). Maturity analysis of survey samples indicate that 3% of 1-year old, 75% of 2-year old and 76% of 3-year old fish were mature (Table 5) as compared to the 2015 estimates, where 9% of 1-year old fish, 66% of 2-year old fish and 83% of 3-year old fish were considered mature (Table 4, ICES 2016).

Immature blue whiting from the 2016 estimate represented 21% (600,000 t) of the total biomass and 26% (9,007 million) of the total abundance recorded during the survey. This is comparable to 2015 (17% - 239,000 t total biomass; 32% - 5,380 million total abundance). In last years joint cruise report this was considered an indication that the mature part of the stock was drastically reduced, given the much lower proportions of immature in 2014 (biomass 7.4%; abundance 15%).

An uncertainty estimate based on a comparison of the abundance estimates by age was calculated for IBWSS for years 2014, 2015 and 2016 using StoX (Figure 11). It was possible to compare the progress of individual year classes, and by comparing the estimates of young year classes from 2014 to 2016 it appears evident that consistency from one year to the next is acceptable for some year classes. For example the one year olds in 2014 (2013 year class) were high and also as two year olds in 2015 and three year olds in 2016. However, the level in the estimates in 2015 was significantly lower than in the 2014 and 2016 estimates. Indicating that the 2015 survey might be biased.

The survey time series (2004-2016) of TSN and TSB has been recalculated using StoX (including uncertainty estimates) and compared to the Beam estimates, and are presented in Figures 14 and 15 respectively. Comparative estimates are realtively consistent across yearsas all the yearly point estimates from BEAM are within one standard deviation of the

corresponding StoX estimates. The international survey time series (2004-2016) was recalculated using StoX and the results of this exercise are presented in Table 6.

Hydrography

A combined total of 110 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 450m as derived from vertical CTD casts are displayed in Figures 16-19 respectively.

Concluding remarks

Main results

- Weather conditions were good for the main body of the survey with approximately 24 hrs of downtime recorded. Towards the end of the survey, when only one vessel was surveying (M. Heinason) a further two days were lost.
- Total area coverage increased by 9% in 2016 compared to 2015. This is in part due to the implementation of revised survey strata adopted during planning at WGIPS and due to extended coverage on the western fringe of the Rockall Bank.
- Acoustic sampling effort (transect miles) was 16% lower in 2016 compared to 2015 and trawl sampling was 6% lower. This is directly related to the number of vessels participating (no Russian vessel) and the allocation of survey effort to the remaining 4 vessels to ensure coverage.
- The 13th International Blue Whiting Spawning stock Survey 2016 shows an increase in total stock biomass of 108% with a corresponding increase in abundance of 109% when compared to the 2015 estimate.
- The survey was carried out over 23 days and just outside the recommended 21 day time window agreed by the group.
- Estimated uncertainty around the total stock biomass remains low but is slightly higher in 2016 compared to 2015 (CV=0.14, CV=0.12 respectively).
- The stock biomass within the survey area was dominated by 3, 4, 5 and 2 year old fish, contributing over 80% of total stock biomass.
- The age structure of the 2016 estimate is considered representative of the actual age structure of the stock compared to the 2015 estimate. Dominant age classes appear in expected proportions which was not the case in 2015
- The proportion of immature fish within the estimate represented 22% of the total biomass and 26% of total abundance. Strata 4 (south Faroes) contained the largest proportion of immature fish; 81% of biomass, followed by strata 6 (Faroe/Shetland Channel) with 62% biomass.

Interpretation of the results

- The group considers the 2016 estimate of abundance as robust. Good stock containment was achieved for both core and peripheral strata. Sampling effort (biological and acoustic), although slightly lower due to the reduced vessel number, provided full coverage of the stock within the survey area.
- The 2016 survey estimate and distribution pattern justifies concerns regarding the 2015 survey. The 2016 estimate is more closely aligned with trends observed in biomass and age structure during the period 2011-2014 making the 2015 estimate an outlier in the time series.
- The bulk of SSB was distributed from north of the Porcupine Bank and continued northwards through the Rockall Trough. The highest densities were observed further south compared to 2015 indicating a later timing of peak spawning. This was confirmed by the presence of early stage eggs within plankton samples. The distribution of immature fish in

the northern strata follows results from previous surveys and would indicate growth of the stock through positive recruitment.

Recommendations

- The group recommends that aged blue whiting samples put forward for inclusion into the analysis be more closely scrutinised and are not accepted without review.The group recommends that 5 vessels are used to cover the survey area as in previous years to maintain consistency in sampling effort (biological and acoustic) and timing. If a vessel is unable to participate then every effort should be made to notify the group as far in advance as possible to allow for the reallocation of effort.
- The group recommends that a WP2 plankton sampling program is initiated in 2017 to track the progress of spawning during the survey. In 2017 a number of predetermined stations will be defined to cover core and preriferal areas to compliment data already collected by Norway since 2011 during planning. The number of stations will be moderate to provide a good sense of spawning progression while being aware of time and sample processing constraints. (WGIPS and WGMEGS)
- To achieve and maintain a high level of consistency between the age reading of blue whiting by the different nations, the group recommends that the current blue whiting otolith exchange program should be made available and discussed at the next WGIPS. Workshop coordinators are Jane Godiksen jane.godiksen@imr.no and Patrícia Gonçalves patricia@ipma.pt.
- The group recommends that vessels report trawl positions in the daily report and that these are plotted along with cruise track progression by the coordinator.

Achievements

- The entire survey area (136,445 nmi²) was covered in 23 days just over the group recommendation of 21 days, an achievement considering the reduced vessel number.
- The number of aged samples used in the analysis was maintained at a comparable level to 2015 with one less survey vessel. However, the number of trawl stations and transect miles (acoustic sampling) was less.
- Survey data was delivered for upload to the PGNAPES database in a timely fashion and ahead of the post cruise meeting.
- The global estimate of abundance for blue whiting was calculated exclusively using StoX in 2016. The International survey time series (2004-2015) was recalculated using StoX as a sensitivity exercise and the results were presented at WGIPS 2016. The group agreed that 'Beam' and StoX calculated estimates were comparable. The StoX revised time series (2004-2015) was sent forward for use in the intermediate blue whiting benchmark in early 2016.

References

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Table 1. Country and vessel specific details, IBWSS March-April 2016.

	Celtic Explorer	Magnus Heinason	Tridens	Brennholm
Trawl dimensions				
Circumference (m)	768	640	1120	832
Vertical opening (m)	50	40	30-70	45
Mesh size in codend (mm)	20	40	20	40
Typical towing speed (kn)	3.5-4.0	3.0-4.0	3.5-4.0	3.5-4.0
Plankton sampling	0	21	0	28
Sampling net	-	WP2 plankton net	-	WP2 plankton net
Standard sampling depth (m)	-	200	-	400
Hydrographic sampling				
CTD Unit	SBE911	SBE25	SBE911	SBE25/SAI V SD208
Standard sampling depth (m)	1000	500	1000	1000

Table 2. Acoustic instruments and settings for the primary frequency, IBWSS March-April 2016.

	Celtic Explorer	Magnus Heinason	Tridens	Brennholm
Echo sounder	Simrad EK 60	Simrad EK60	Simrad EK 60	Simrad EK 60
Frequency (kHz)	**38**, 18, 120, 200	**38**	18, **38**, 70, 120, 200, 333	18, **38**, 120, 200, 333
Primary transducer	ES 38B	ES 38B	ES 38B	ES 38B
Transducer installation	Drop keel	Hull	Drop keel	Drop keel
Transducer depth (m)	8.7	3	8	8.5
Upper integration limit (m)	15	7	15	15
Absorption coeff. (dB/km)	9.9	10.2	10	9.9
Pulse length (ms)	1.024	1.024	1.024	1.024
Band width (kHz)	2.425	2.43	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)	-20.6	-20.8	-20.6	-20.6
Sv Transducer gain (dB)				
Ts Transducer gain (dB)	25.85	25.61	26.26	24.88
s_A correction (dB)	-0.64	-0.64	-0.53	-1.75
3 dB beam width (dg)				
alongship:	6.89	7.1	7	7.04
athw. ship:	6.96	7.08	6.95	7
Maximum range (m)	750	750	750	750
Post processing software	Myriax Echoview	Myriax Echoview	LSSS	LSSS

Table 3. Survey effort by vessel, IBWSS March-April 2016.

Vessel	Effective survey period	Length of cruise track (nmi)	Trawl stations	CTD stations	Plankton sampling WP2-net	Aged fish	Length-measured fish
Celtic Explorer	19/3-3/4	2,008	8	31	-	300	900
Magnus Heinason	1/4-11/4	1,210	9	21	19	524	1,916
Brennholm	24/3- 4/4	1,675	15	28	28	417	1,374
Tridens	21/3-5/4	1,364	13	30	-	1,200	1,200
Total	23/3-10/4	6,257	45	110	47	2,441	5,390

Table 4. Abundance and biomass estimates of blue whiting by stata. IBWSS March-April 2016.

			Numbers (10^9) mature			Biomass (10^6 tonnes)			Mean weight	Mean length	Density tonnes/
/Strata		nmi2	Mature	Total	%mature	Mature	Total	%mature	(g)	(cm)	nmi^2
I	Porcupine Bank	18 122	2.47	2.74	90	0.22	0.24	92	86	25.9	13.2
II	N. Porcupine Bank	7 138	4.05	4.07	99	0.33	0.34	100	82.2	25.5	47.6
III	Rockall Trough	38 192	12.93	14.88	87	1.24	1.37	91	92.5	26.4	35.9
IV	South Faroes	17 093	0.59	4.32	14	0.06	0.32	19	74.8	22.8	18.7
V	Rockall Bank	42 162	3.81	3.91	99	0.29	0.3	98	75.5	24.5	7.1
VI	Faroe/ Shetland Ch.	11 721	1.48	4.51	33	0.12	0.31	38	68.1	22.4	26.4
Tot.		134 428	25.33	34.43	74	2.27	2.88	79	79.8	25.1	21.4

Table 5. Survey stock estimate of blue whiting, IBWSS March-April 2016.

					Age in years (year class)							Number	Biomass	Mean	Prop
Length	1	2	3	4	5	6	7	8	9	10+	unkn.			weight	Mature
(cm)	2015	2014	2013	2012	2011	2010	2009	2008	2007			(10^6)	(10^6 kg)	(g)	
15-16											3	3			
16-17	50											50	1.3	25	0
17-18	280											280	8.0	28	0
18-19	587											587	20.0	34	2
19-20	868	57										925	36.0	39	8
20-21	585	830	5									1420	63.3	45	49
21-22	301	1955	256									2511	130.7	52	60
22-23	54	2661	1256	23	16							4011	240.9	60	67
23-24	20	1678	2049	319	25							4092	273.1	67	63
24-25		565	1948	764	142							3419	250.9	73	72
25-26		100	2282	1322	247	40						3990	314.5	79	87
26-27		25	1317	1285	599	126	26					3380	294.9	87	84
27-28		0	683	719	903	318	61	36				2719	261.7	96	90
28-29		0	222	649	801	295	3	0	3			1973	209.9	106	86
29-30		23	80	396	799	250	57	0	4			1610	186.8	116	98
30-31			57	299	526	170	108	0	0			1160	149.1	129	94
31-32			0	241	241	117	18	6	3	11		638	90.7	142	93
32-33			8	83	156	46	14	0	45	33		385	61.6	160	100
33-34				51	98	40	29	0	38	57		314	55.4	176	100
34-35				56	54	69	44	0	53	70		347	66.7	192	100
35-36				58	25	38	8	42	0	33		204	42.2	207	100
36-37				8	31	29	6	34	23	47		177	41.2	233	100
37-38					16		8	8	39	51		121	29.5	244	100
38-39					9		0	8	26	0		43	11.3	266	100
39-40							15			16		30	9.5	315	100
40-41							0			18		18	4.9	280	100
41-42							9			9		18	6.9	394	100
42-43							7			0		7	2.7	388	100
43-44										9		9	3.3	378	100
45-46										8		8	5.7	704	100
TSN(mill)	2745	7893	10164	6274	4687	1539	413	133	235	361	3	34447			
TSB(1000 t)	109.2	460.1	760.2	596.7	526.5	192.4	65.2	26.3	48.9	87.1		2872.7			
Mean length(cm)	19.3	22.2	24.6	26.8	28.5	29.2	31.2	33.4	34.6	35.8	15.5				
Mean weight(g)	40	58	75	95	112	125	158	197	208	240					
% Mature	3	75	76	81	87	92	99	100	100	100					
SSB (1000kg)	3.6	342.8	581.5	482.8	458.9	176.1	64.6	26.3	48.9	87.1		2272.7			

Table 6. Time series of StoX abundance estimates of blue whiting (millions) by age in the IBWSS. Total biomass in last column (1000 t).

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	TSB
2004	1 097	5 538	13 062	15 134	5 119	1 086	994	593	164		3 505
2005	2 129	1 413	5 601	7 780	8 500	2 925	632	280	129	23	2 513
2006	2 512	2 222	10 858	11 677	4 713	2 717	923	352	198	31	3 512
2007	468	706	5 241	11 244	8 437	3 155	1 110	456	123	58	3 274
2008	337	523	1 451	6 642	6 722	3 869	1 715	1 028	269	284	2 639
2009	275	329	360	1 292	3 739	3 457	1 636	587	250	162	1 599
2010*											
2011	312	1 361	1 135	930	1 043	1 712	2 170	2 422	1 298	250	1 826
2012	1 141	1 818	6 464	1 022	596	1 420	2 231	1 785	1 256	1 022	2 355
2013	586	1 346	6 183	7 197	2 933	1 280	1 306	1 396	927	1 670	3 107
2014	4 183	1 491	5 239	8 420	10 202	2 754	772	577	899	1 585	3 337
2015	3 255	4 565	1 888	3 630	1 792	465	173	108	206	247	1 403
2016	2 745	7 893	10 164	6 274	4 687	1 539	413	133	235	256	2 873

*Survey discarded.

Table 7. Comparable survey effort in the IBWSS.

Survey effort	Survey area (nmi²)	Transect n. miles (nmi)	Trawls	CTDs	Plankton	Bio sampling (WHB)	
						Measured	Aged
2004	149 000		76	196			
2005	172 000	12 385	111	248	-	29 935	4 623
2006	170 000	10 393	95	201	-	7 211	2 731
2007	135 000	6 455	52	92		5 367	2 037
2008	127 000	9 173	68	161	-	10 045	3 636
2009	133 900	9 798	78	160	-	11 460	3 265
2010	109 320	9 015	62	174	-	8 057	2 617
2011	68 851	6 470	52	140	16	3 810	1 794
2012	88 746	8 629	69	150	47	8 597	3 194
2013	87 895	7 456	44	130	21	7 044	3 004
2014	125 319	8 231	52	167	59	7 728	3 292
2015	123 840	7 436	48	139	39	8 037	2 423
2016*	134 429	6 257	45	110	47	5 390	2 441

* No Russian vessel in 2016

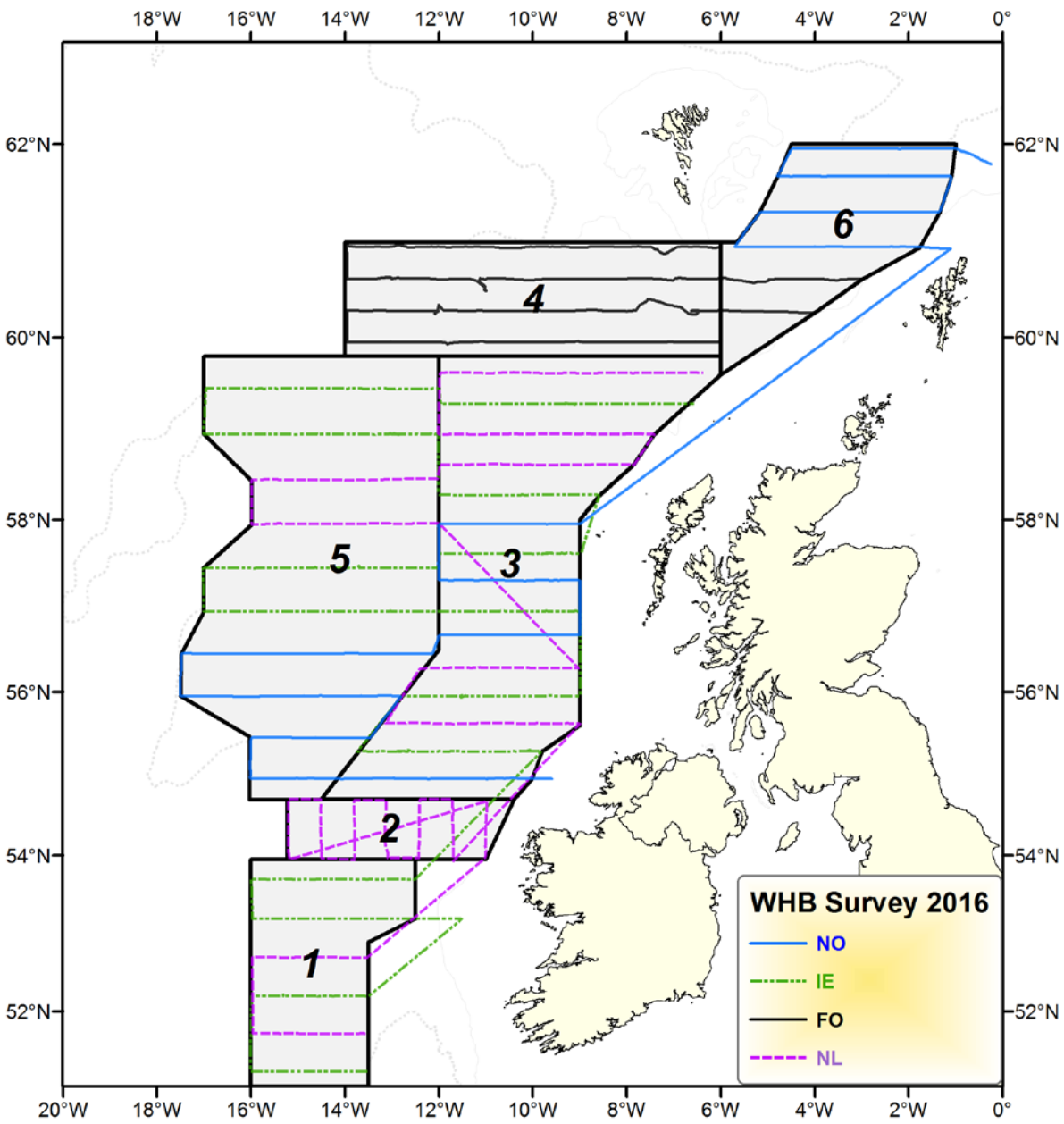


Figure 1. Strata and cruise tracks for the individual vessels (country) during the International Blue Whiting Spawning Stock Survey (IBWSS) from March-April 2016.

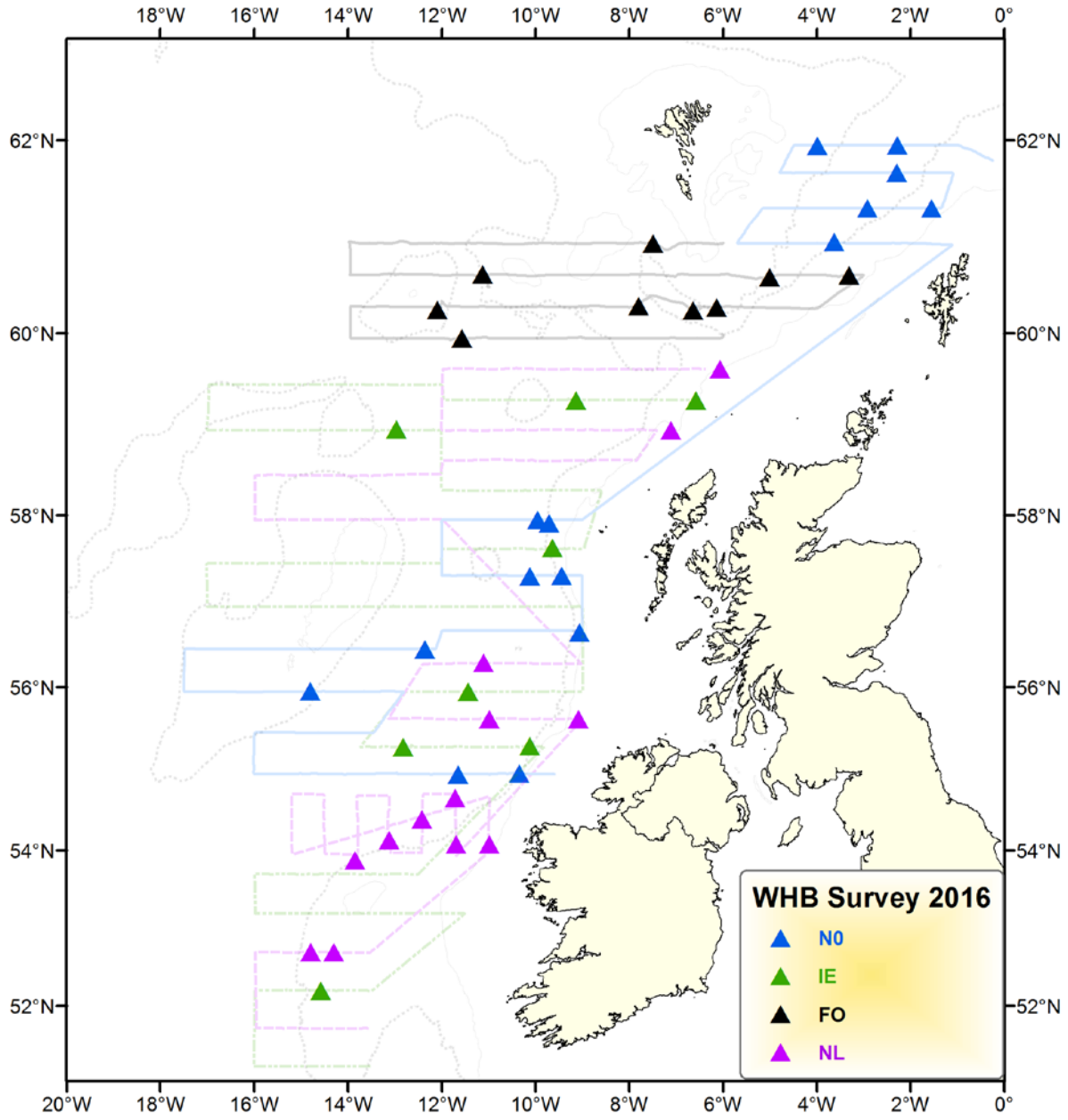


Figure 2. Vessel cruise tracks and trawl stations of the International Blue Whiting Spawning Stock Survey (IBWSS) from March-April 2016. IE: Ireland (Celtic Explorer); FO: Faroe Islands (Magnus Heinason); NL: Netherlands (Tridens); NO: Norway (Brennholm).

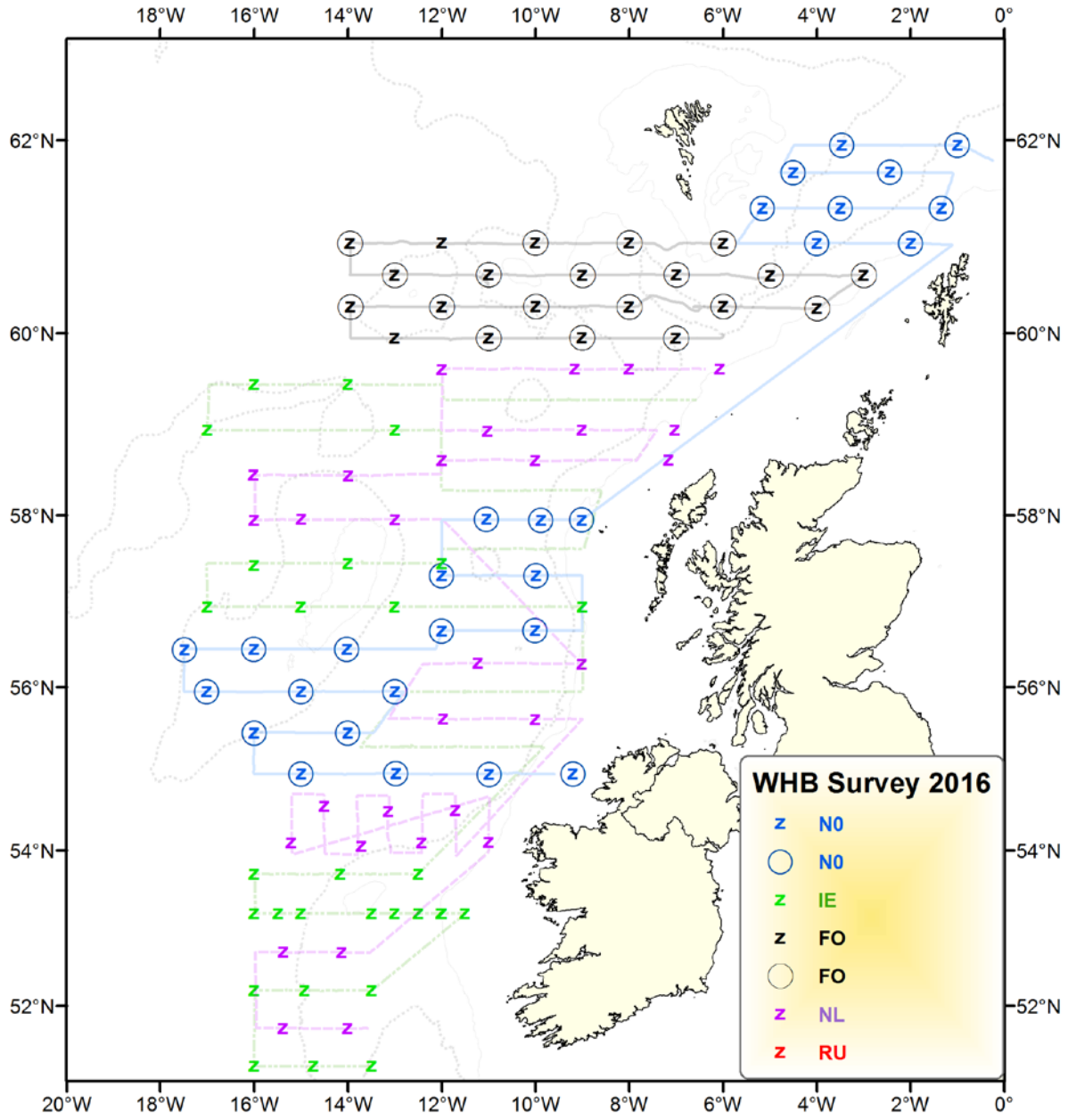


Figure 3. Vessel cruise tracks with hydrographic CTD stations (z) and WP2 plankton net samples (citrcles) during the International Blue Whiting Spawning Stock Survey (IBWSS) from March-April 2016. Coulor represents different vessels.

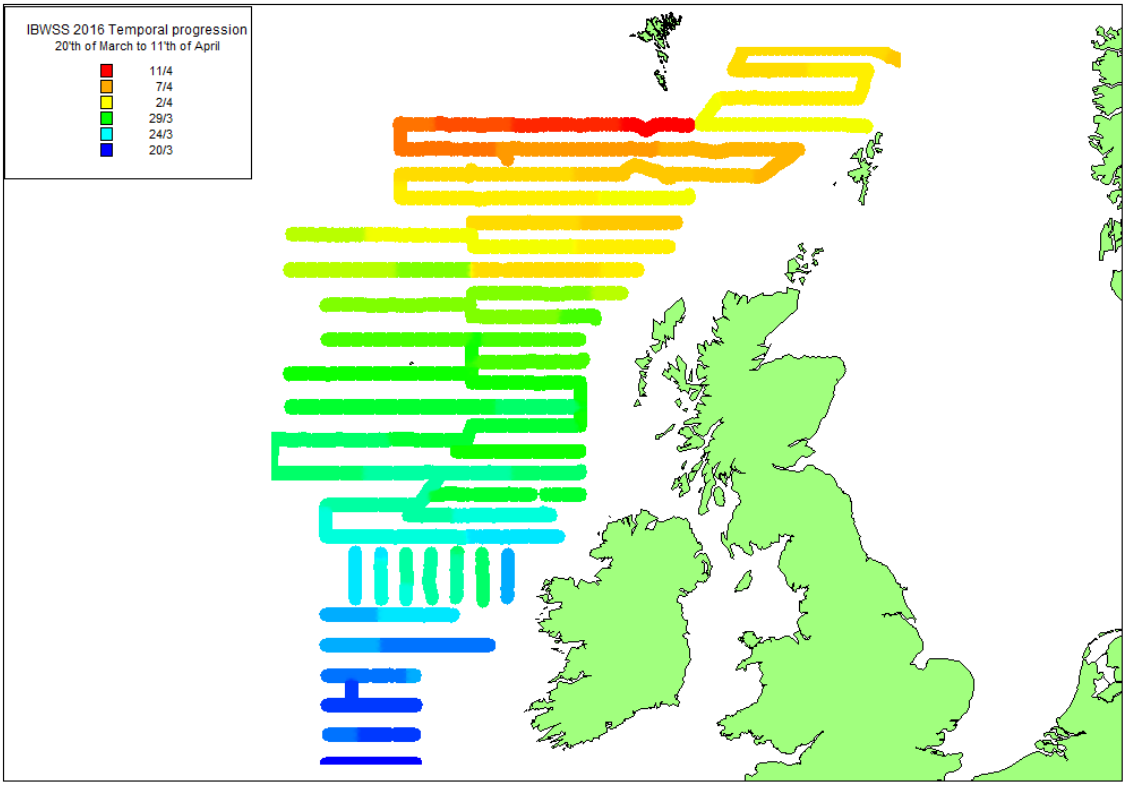


Figure 4. Temporal progression for the International Blue Whiting Spawning Stock Survey (IBWSS) from March-April 2016.

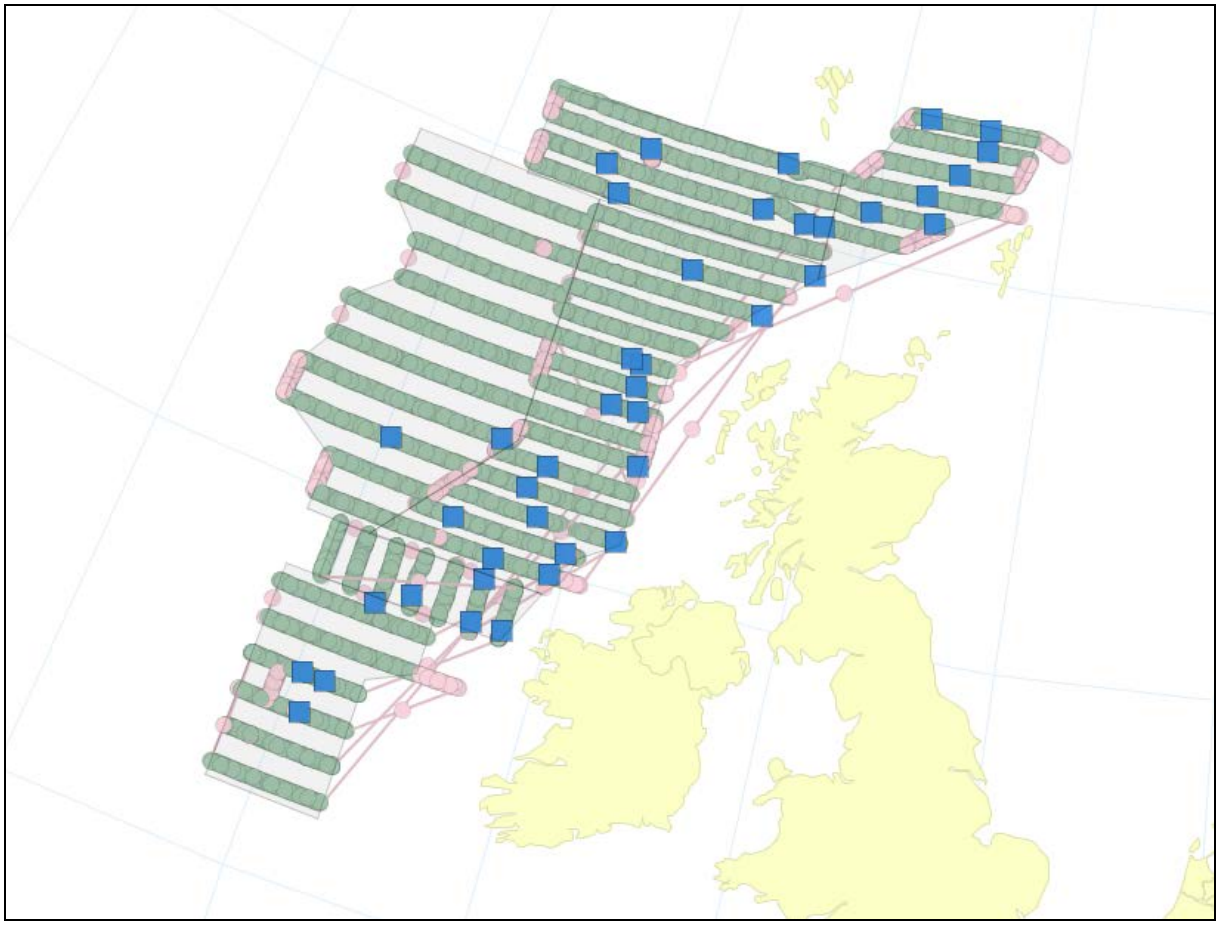


Figure 5. Tagged acoustic transects (green squares) with acociated trawlstations (blue squares) used in the StoX abundance estimation. IBWSS March-April 2016.

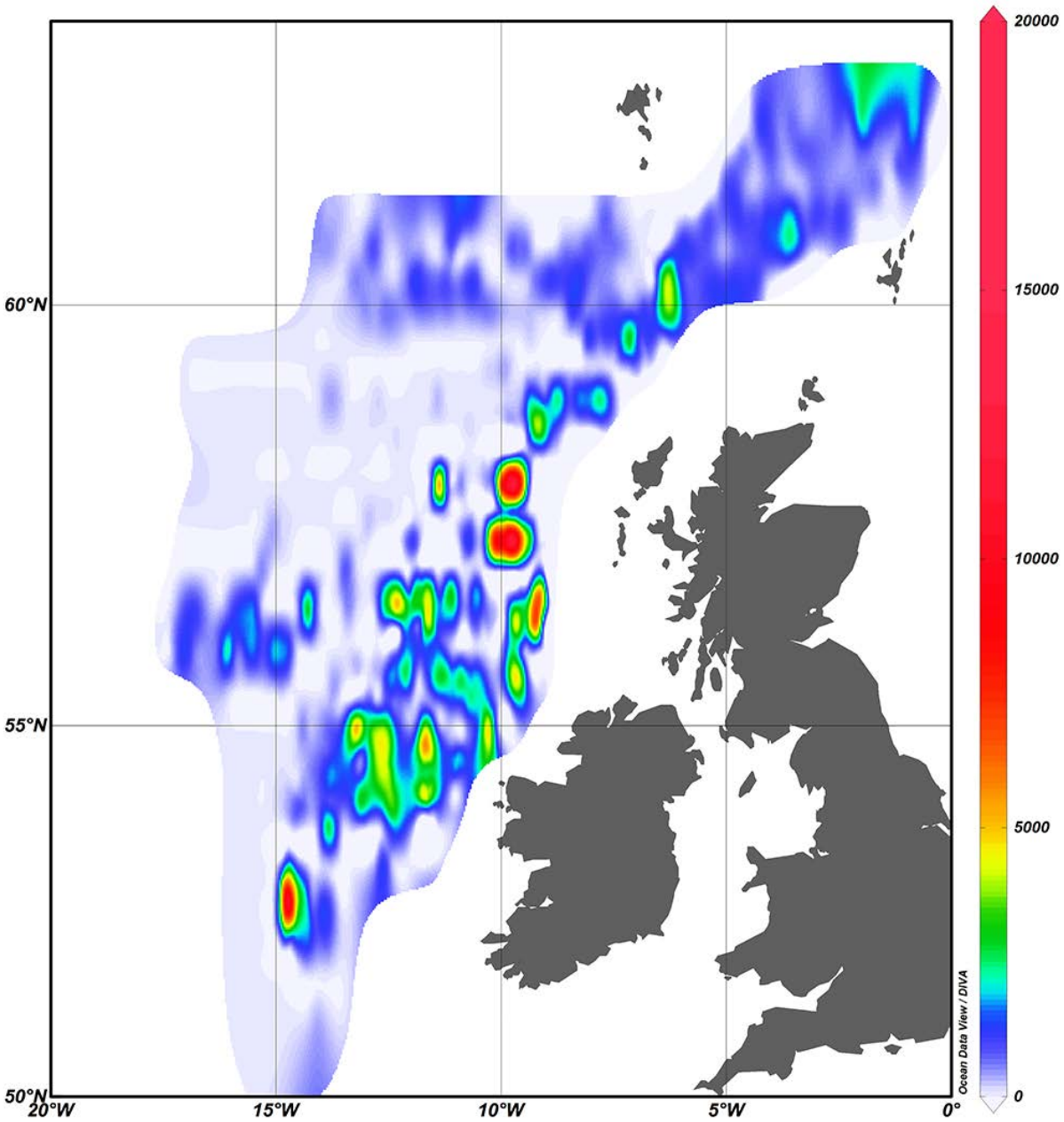


Figure 6. Map of acoustic density (s_A m^2/nmi^2) of blue whiting during the International Blue Whiting Spawning Stock Survey (IBWSS) from March-April 2016.

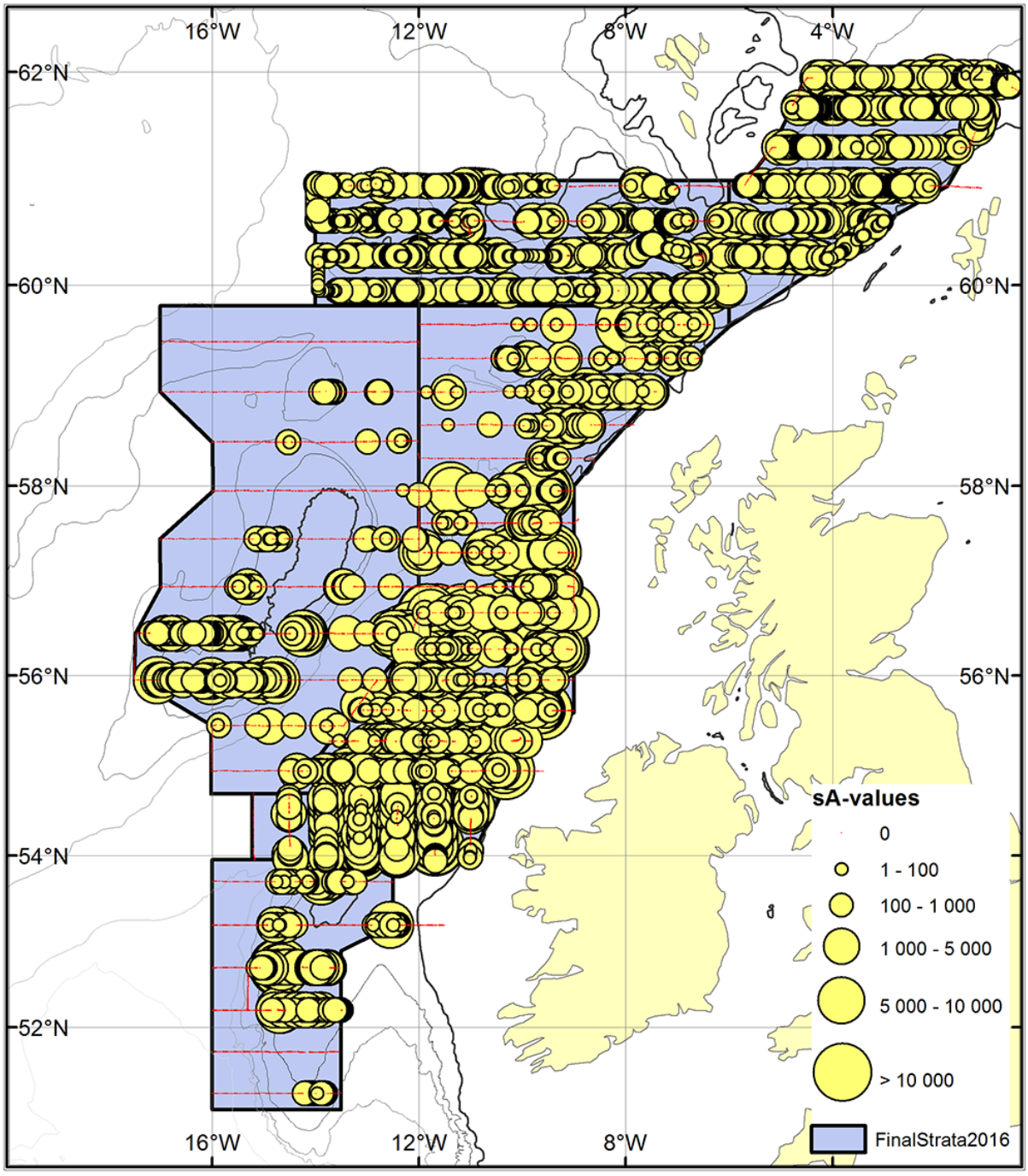
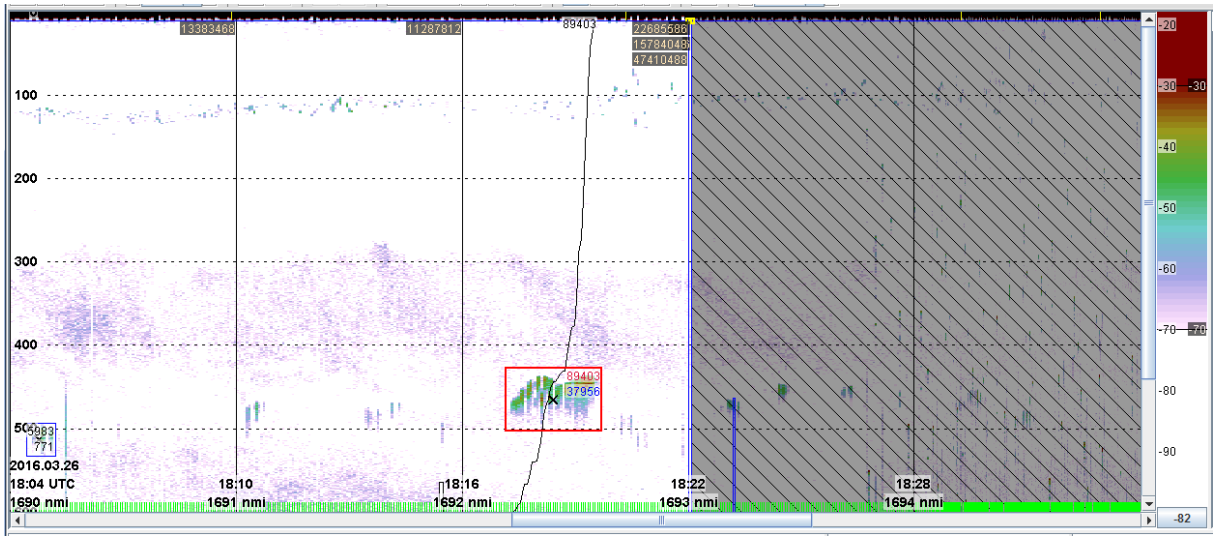
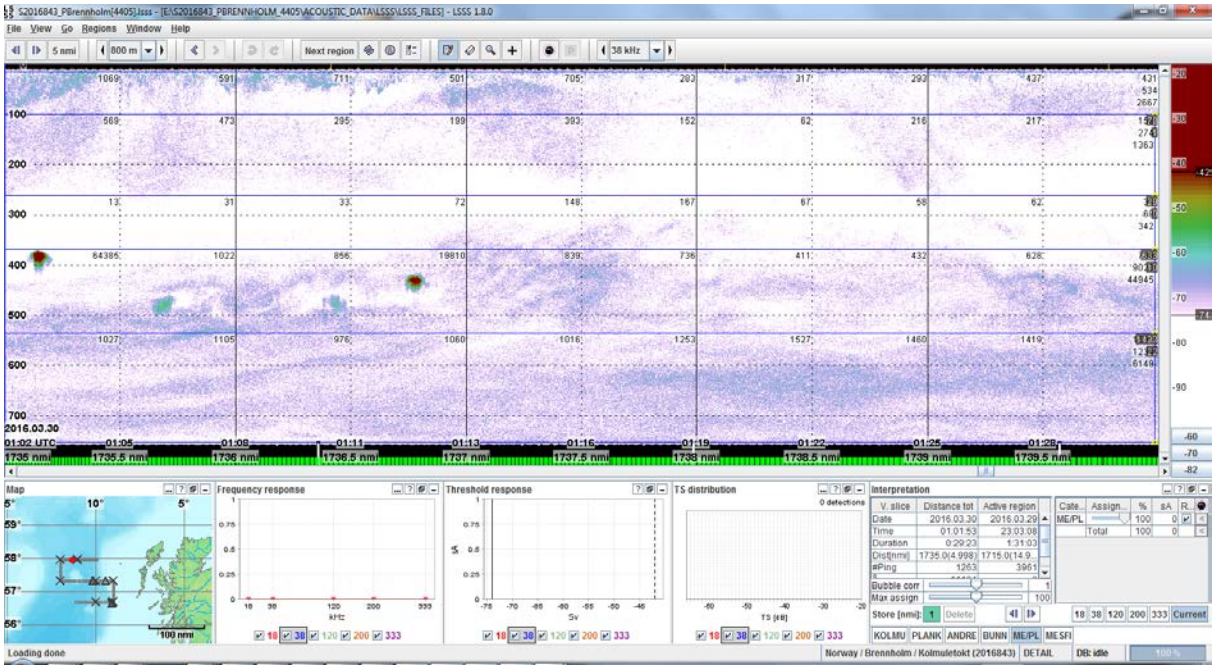


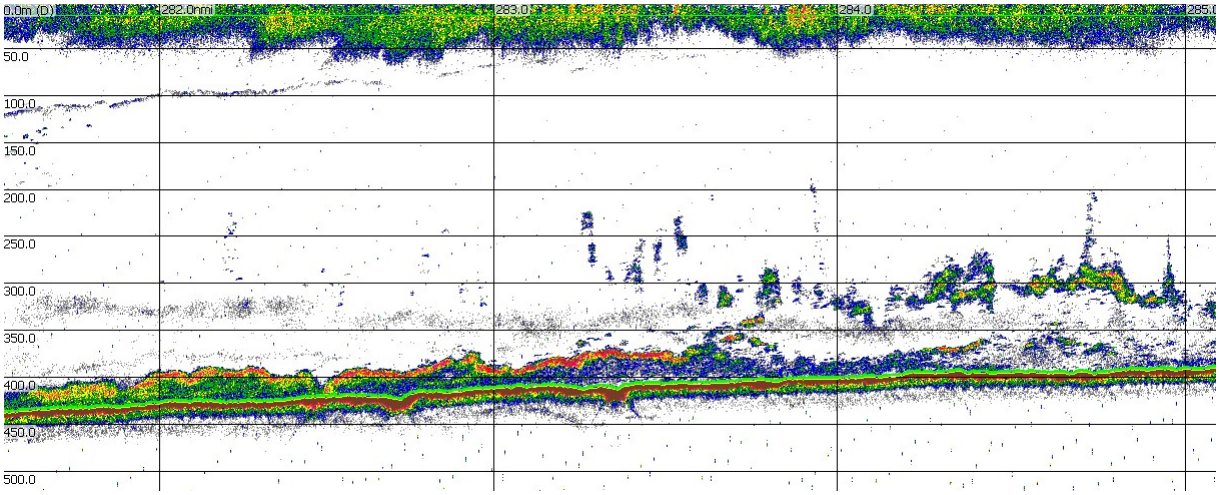
Figure 7. Map of acoustic density (s_A m^2/nmi^2) of blue whiting by 1 nmi (size of sircle represents acoustic density). IBWSS Macrch-April 2016.



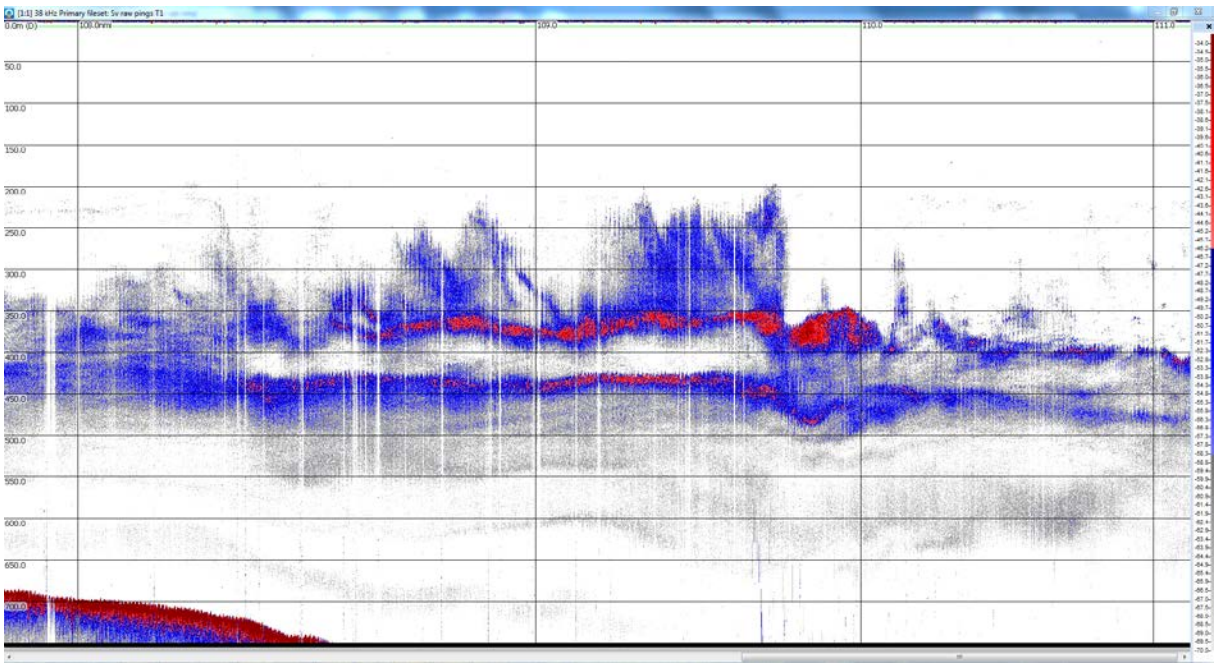
a) Very high density school of blue whiting registered by Tridens on the north Porcupine Bank close to the shelf slope.



b) Small very high density school of blue whiting registered by Brennholm in the Rockall Trough.



c) High density blue whiting registration in the southern Porcupine Bank (strata 1) recroded by the Celtic Explorer.



d) Medium dense layer of mainly immature blue whiting registered by Magnus Heinason in the northern strata (example due south of the "Munk", Faroes).

Figure 8. Echograms of interest encountered during the IBWSS, March-April 2016: a) Tridens b) Brennholm, c) Celtic Explorer, and d) Magnus Heinason.

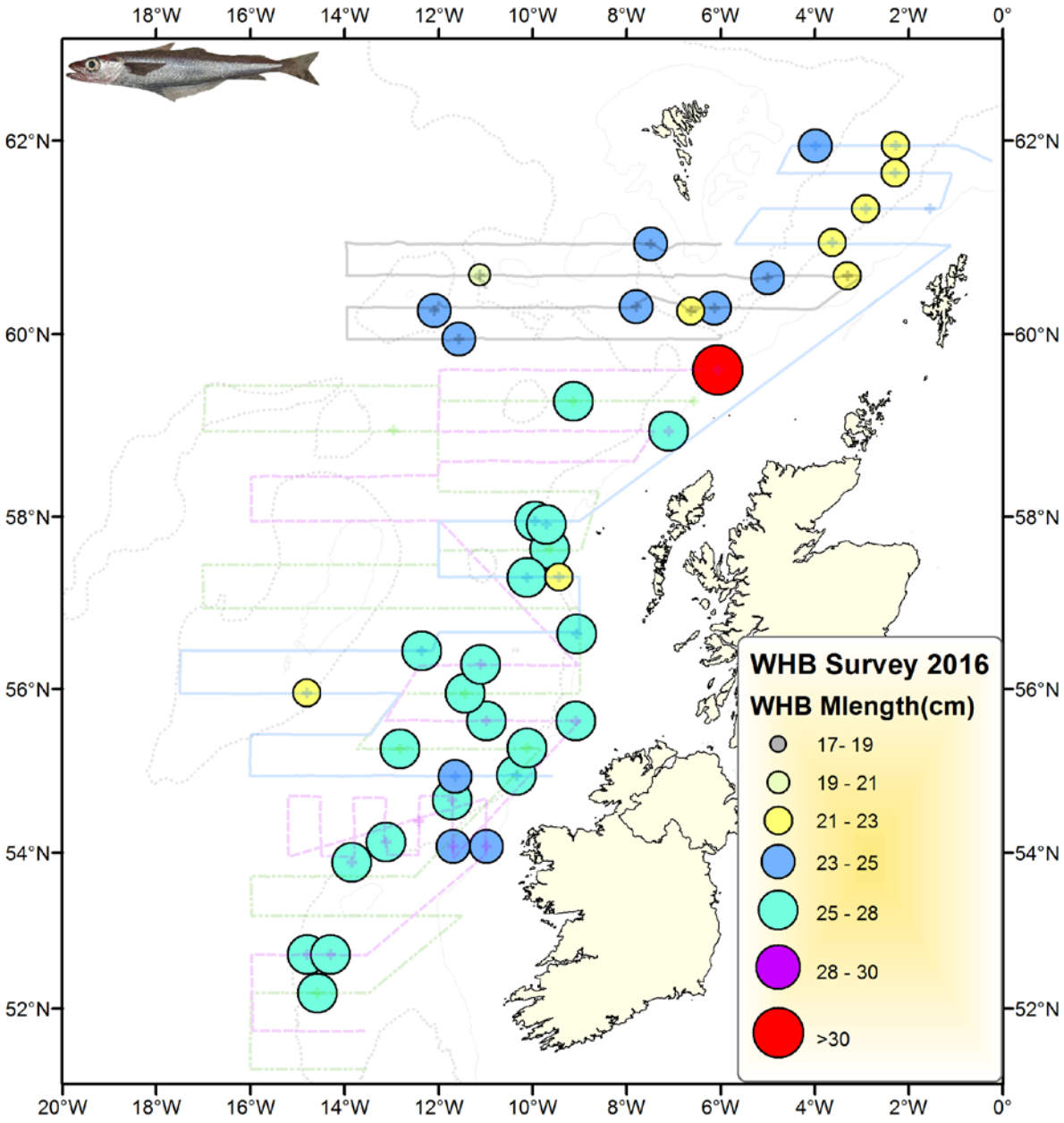


Figure 9. Combined mean length of blue whiting from trawl catches by vessel, IBWSS in March- April 2016. Crosses indicate hauls with zero blue whiting catches.

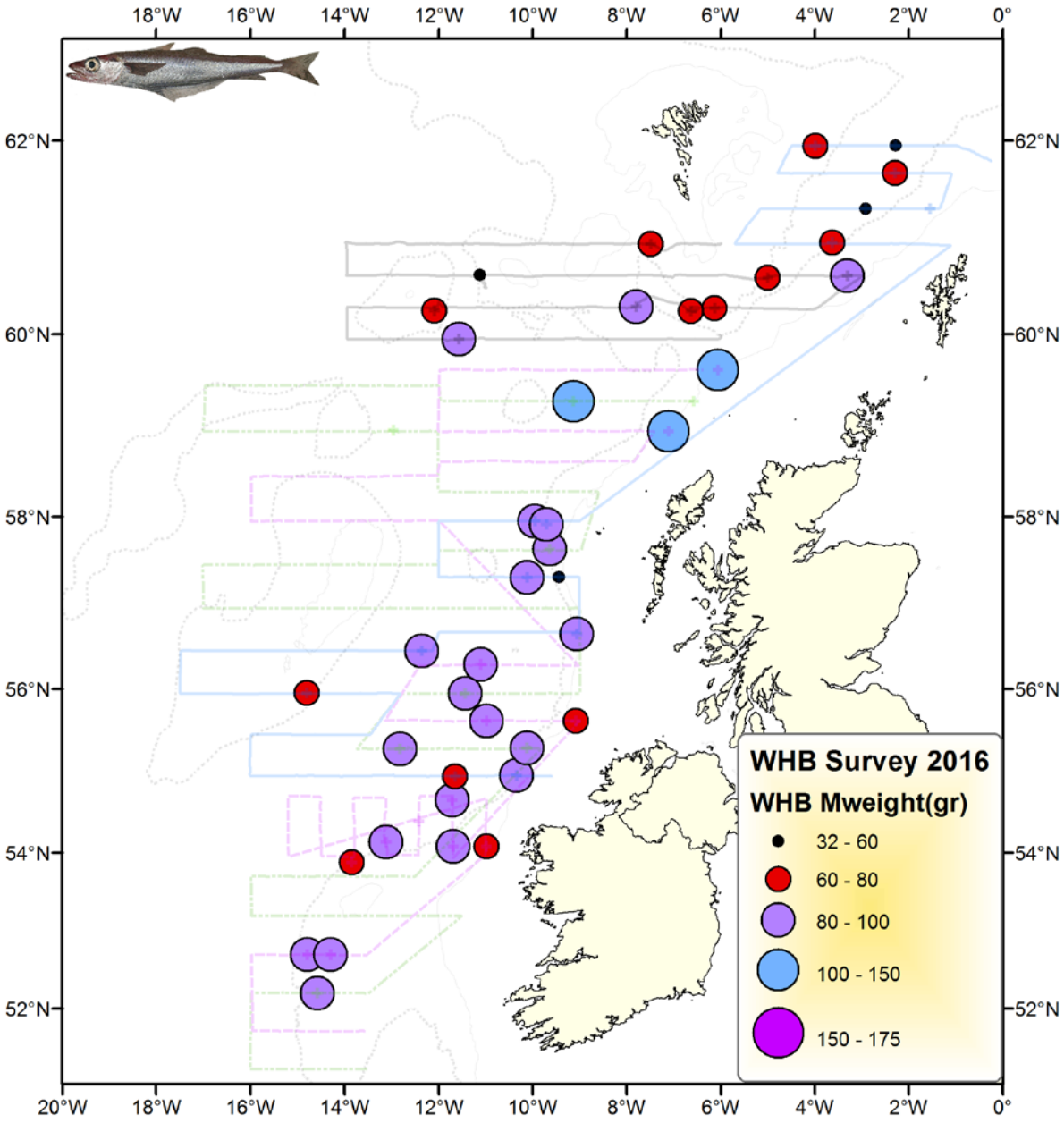


Figure 10. Combined mean weight of blue whiting from trawl catches,IBWSS March- April 2016. Crosses indicate hauls with zero blue whiting catches.

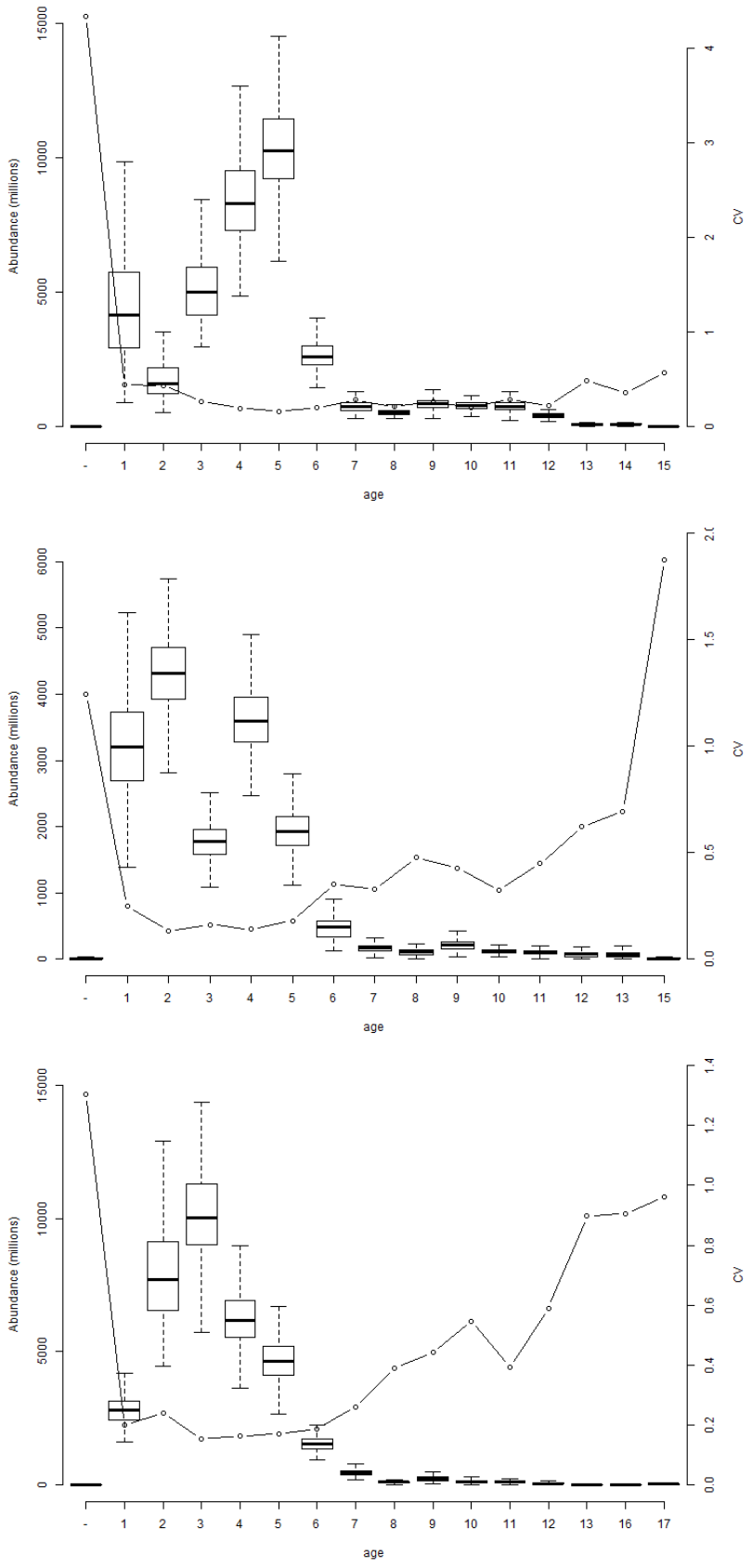


Figure 11. Blue whiting bootstrap abundance (millions) by age (left axis) and acociated CVs (right axis) in 2014 (top panel), 2015 (middle panel) and 2016 (lower panel). From StoX.

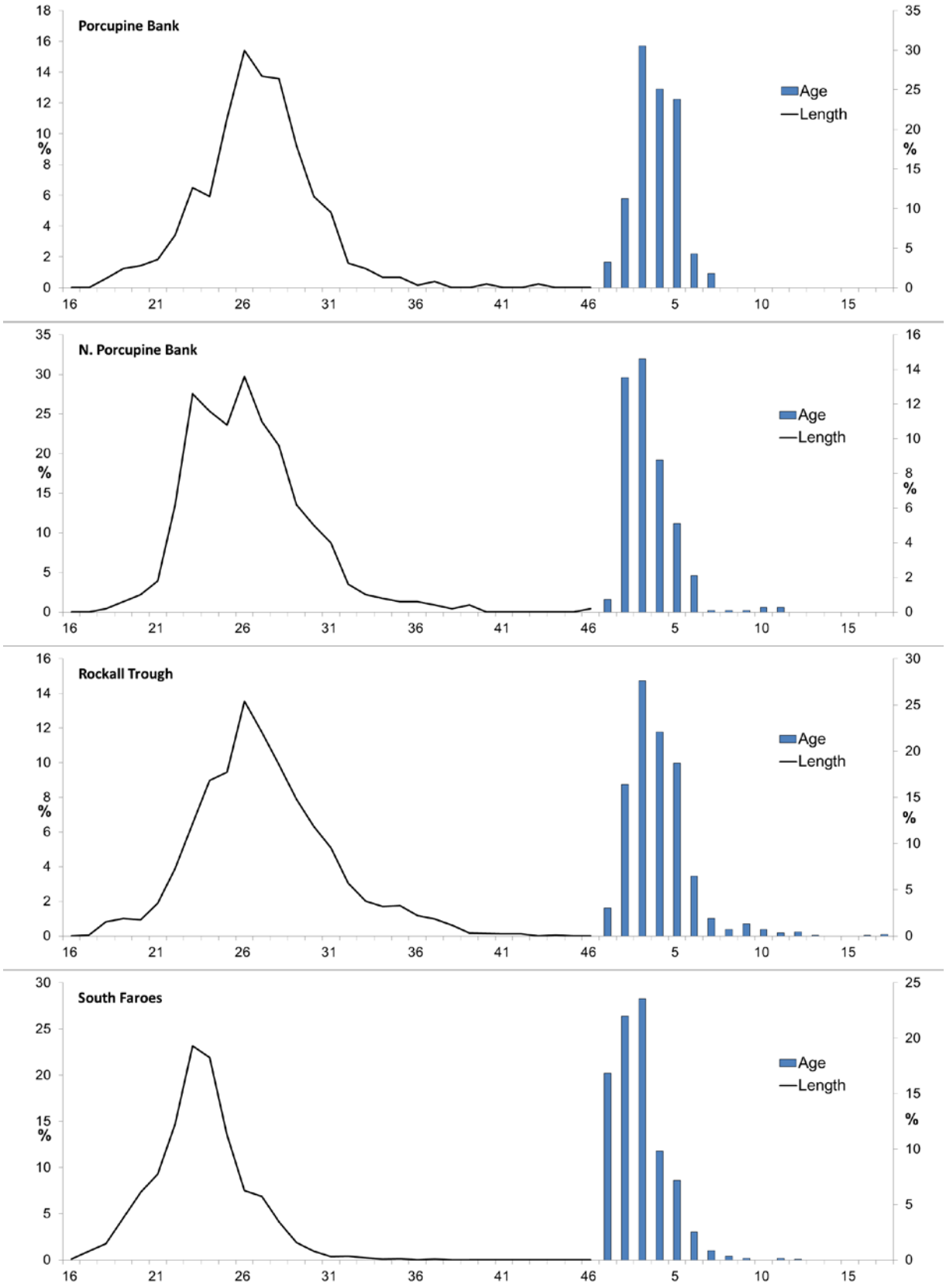


Figure 12. Length and age distribution (numbers) of blue whiting by covered strata, March-April 2016.

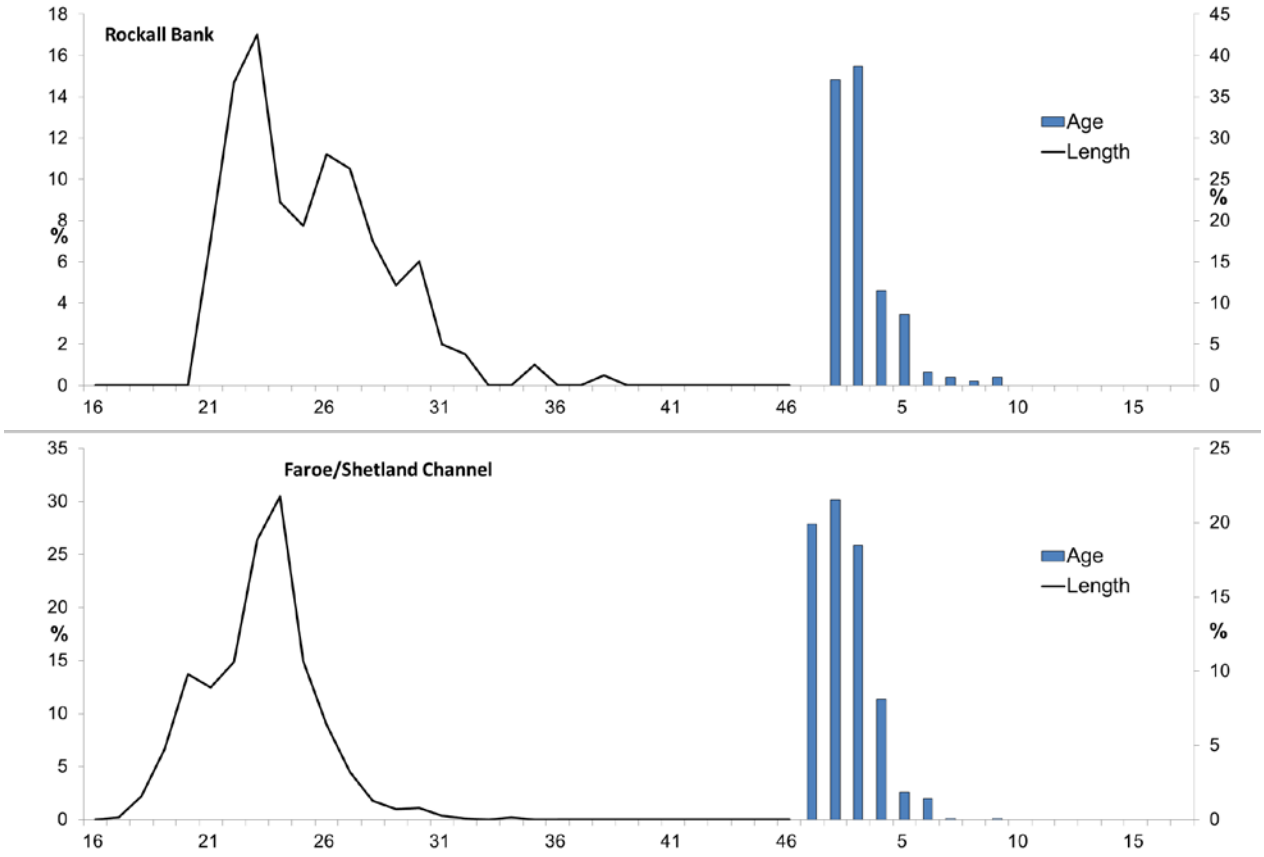


Figure 12 (continued). Length and age distribution (numbers) of blue whiting by covered strata, March-April 2016.

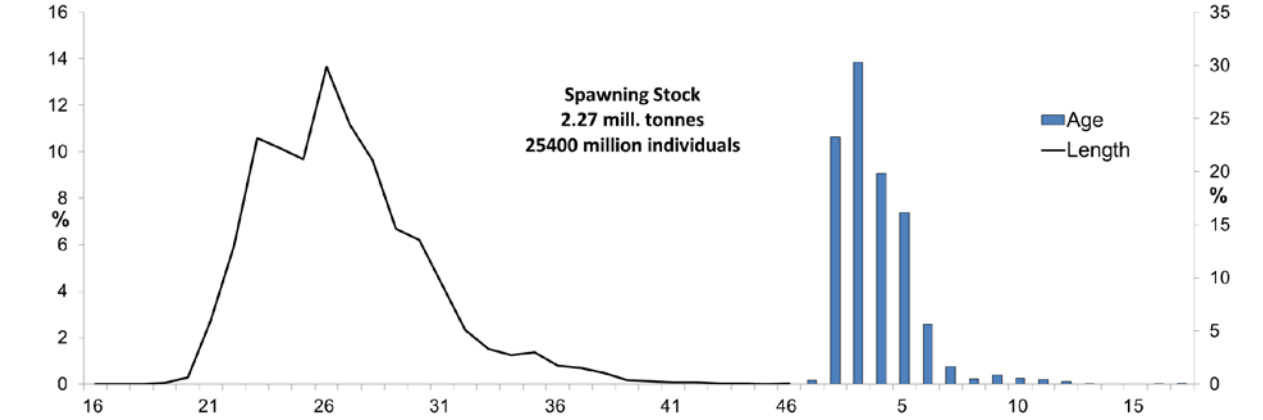


Figure 13. Length and age distributions (numbers) of total stock of blue whiting. Spawning stock biomass is given. March-April 2016.

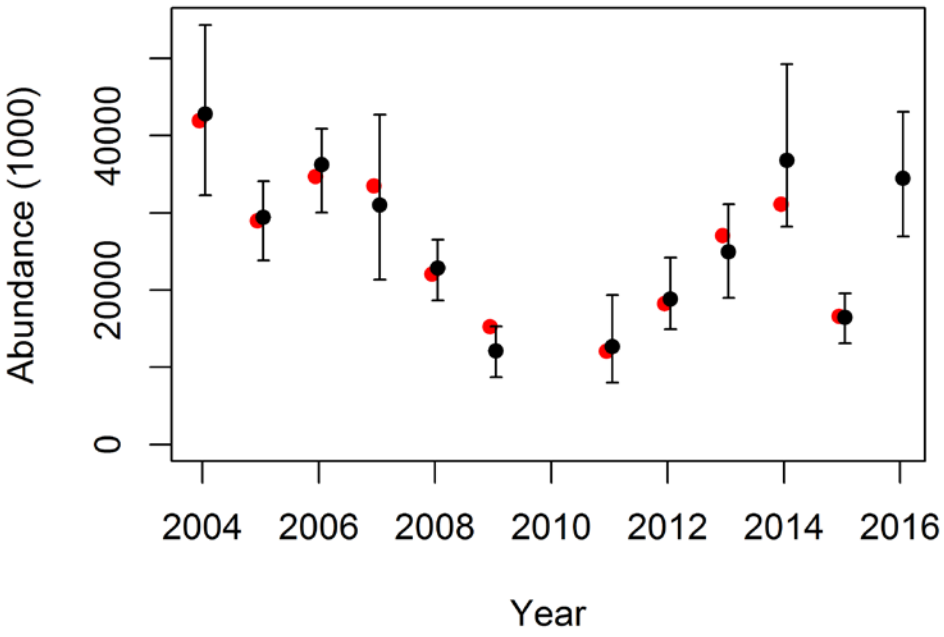


Figure 14. Time series comparison of StoX/BEAM packages for calculated blue whiting abundance.

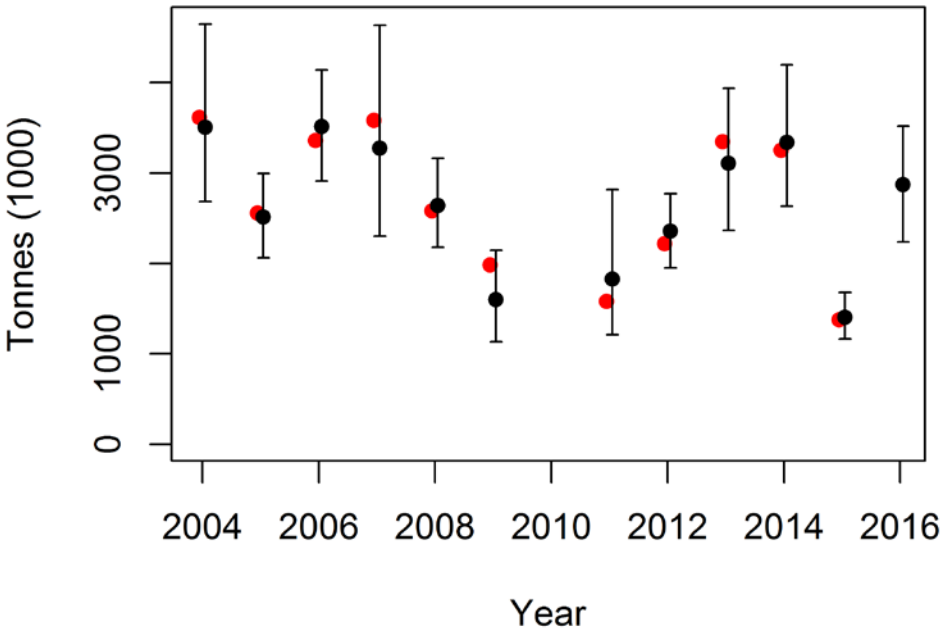


Figure 15. Time series comparison of StoX/BEAM packages for calculated blue whiting total biomass.

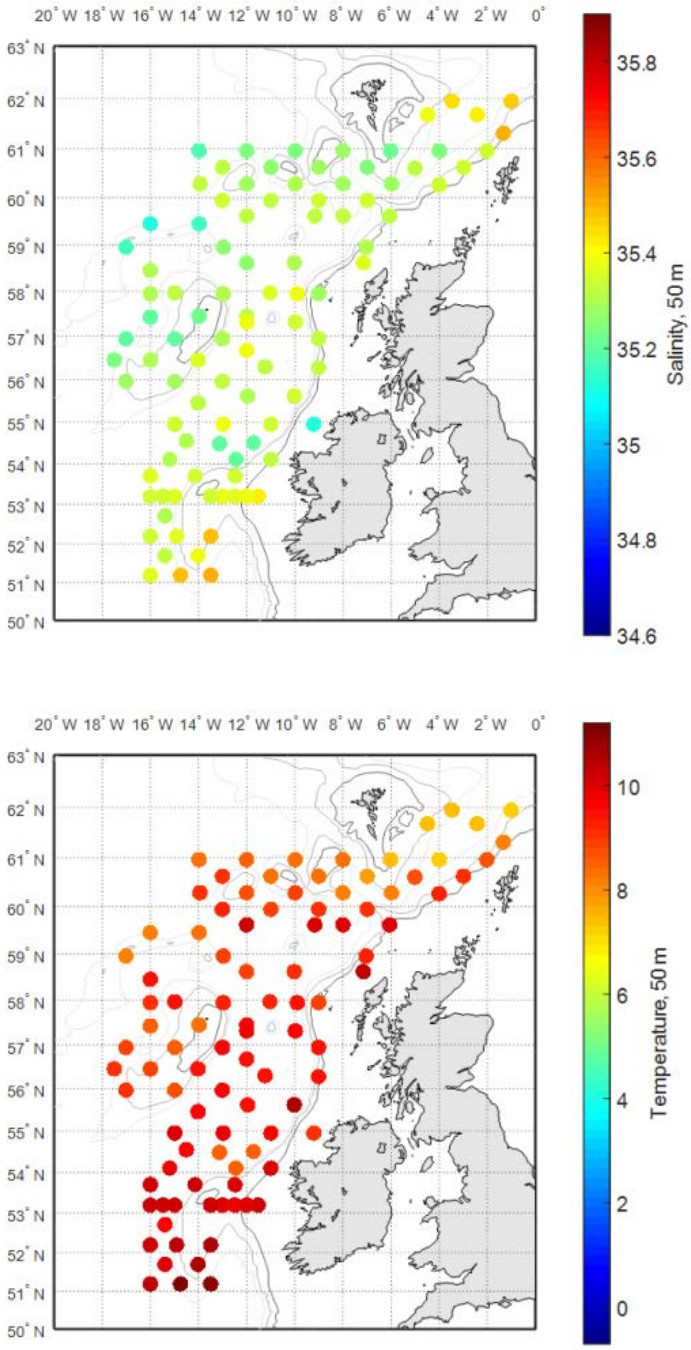


Figure 16. Horizontal temperature (top panel) and salinity (bottom panel) at 50 m subsurface as derived from vertical CTD casts. IBWSS March-April 2016.

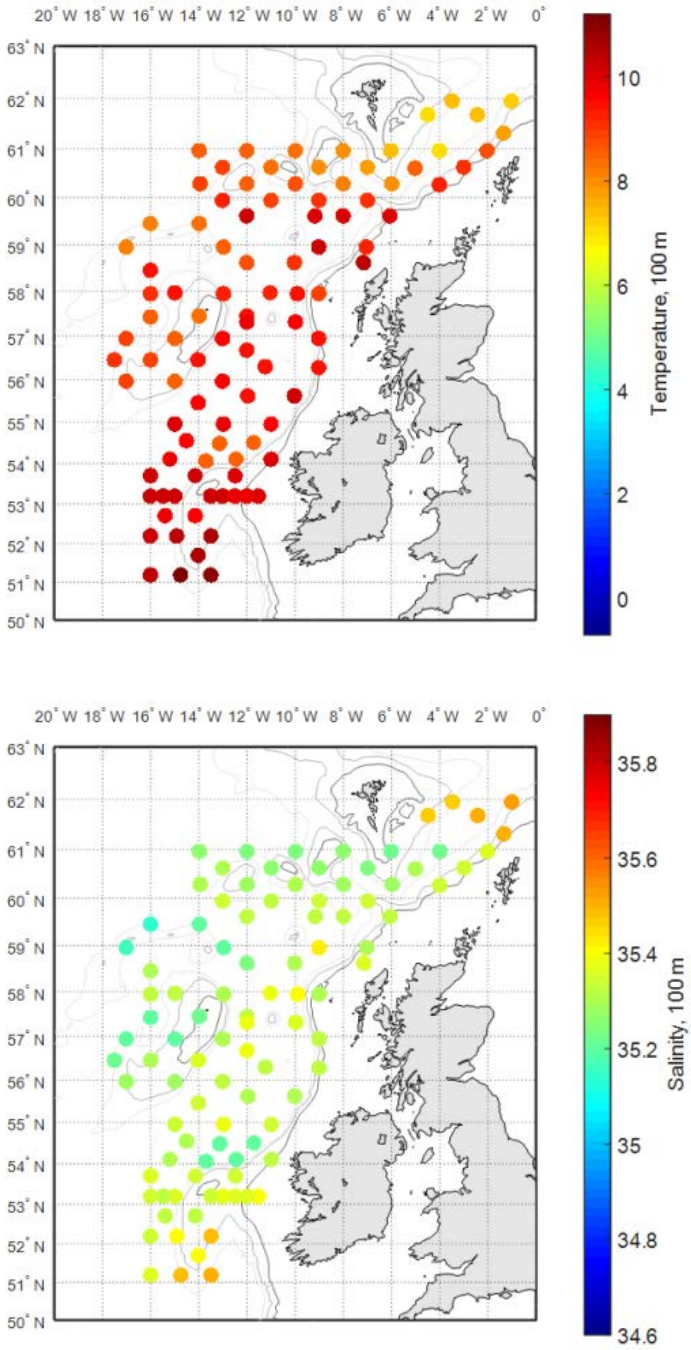


Figure 17. Horizontal temperature (top panel) and salinity (bottom panel) at 100 m subsurface as derived from vertical CTD casts. IBWSS March-April 2016.

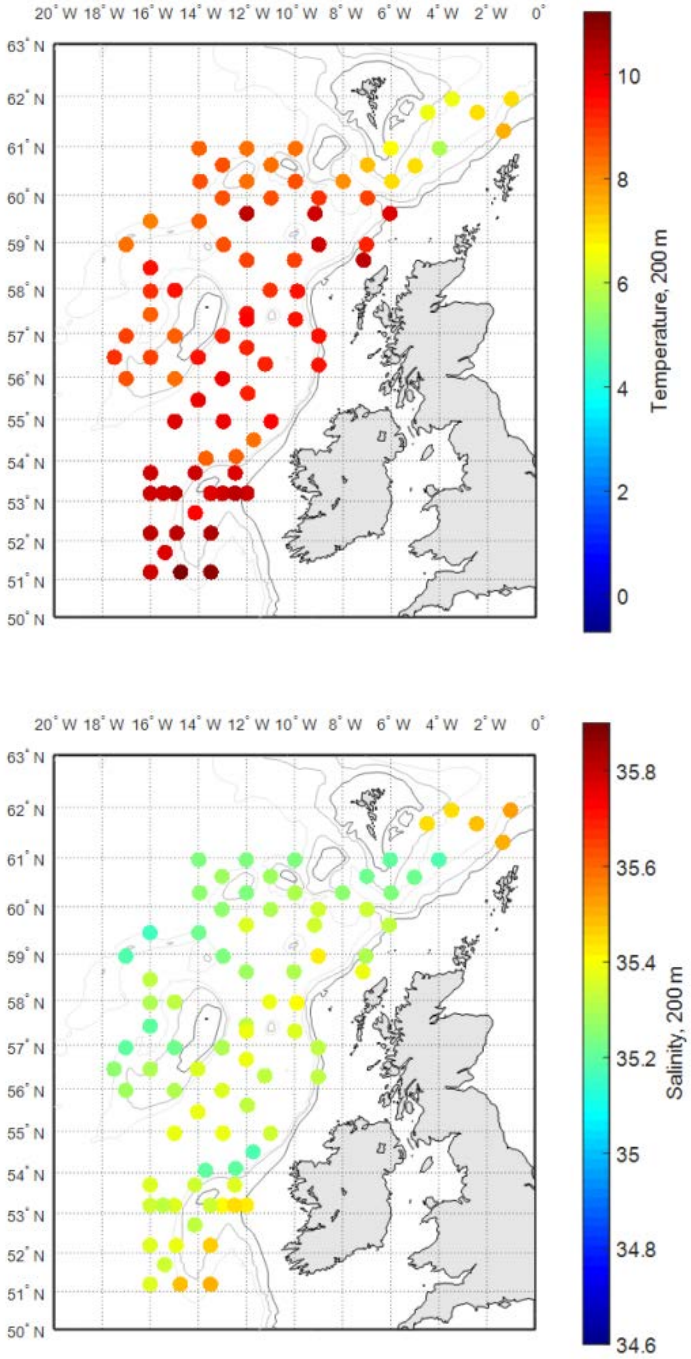


Figure 19. Horizontal temperature (top panel) and salinity (bottom panel) at 200 m subsurface as derived from vertical CTD casts. IBWSS March-April 2016.

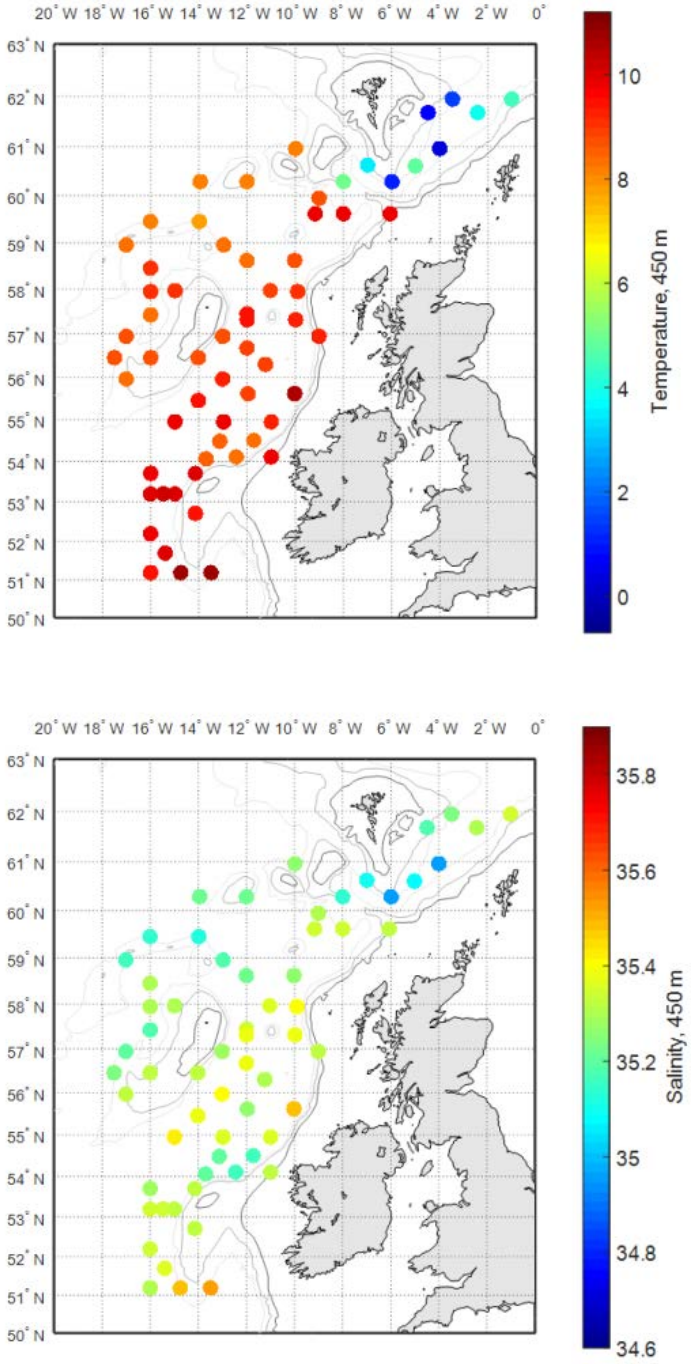


Figure 19. Horizontal temperature (top panel) and salinity (bottom panel) at 450 m subsurface as derived from vertical CTD casts. IBWSS March-April 2016.