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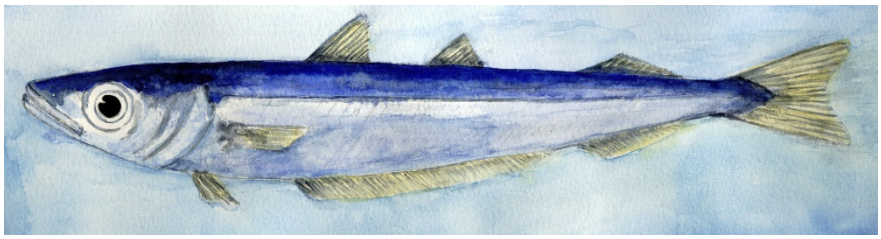

INTERNATIONAL BLUE WHITING SPAWNING STOCK SURVEY (IBWSS) SPRING 2017

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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 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	21/3 – 02/4
Magnus Heinason	Faroe Marine Research Institute, Faroe Islands	1/4 – 10/4
Tridens	Wageningen Marine Research, the Netherlands	22/3 – 2/4
Kings Bay	Institute of Marine Research, Norway	23/3 – 4/4

The survey design applied followed methods described in ICES Survey design Manual (2015) and allowed for a flexible transect design and comprehensive coverage of the spawning aggregations. Overall weather conditions were mixed with periods of poor and good weather. All vessels, with the exception of Kings Bay experienced some downtime due to conditions with the Faroes experiencing the most prolonged period of bad weather at the end of the survey period. The entire survey was undertaken within 20 days and below the 21 day target threshold. The bulk of the survey was temporally consistent with the exception of one transect in the southern Rockall Trough (stratum 3).

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 information 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 was carried out by each participant vessel at predetermined locations (Figure 3 and Table 3). Depth was capped at a maximum depth of 1000 m in open water, with the exception of a dedicated hydrographic transect where full depth was achieved. Norway experienced technical difficulties and therefore no CTD was provided. Equipment specifications are summarised in Table 1.

Plankton sampling

Plankton sampling by way of vertical WP2 casts were carried out by Kings Bay (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 8) post processing software. Data were partitioned into the following categories: plankton (<200 m depth layer), pearlside and mesopelagic species, blue whiting and krill. Partitioning of data into the above categories was based on trawl samples and acoustic characteristics on the echograms.

On Tridens, acoustic data were backed up continuously and scrutinised every 24 hrs using the Large Scale Survey System LSSS (2.0) post-processing software. Blue whiting were identified and separated from other recordings based on trawl catch information and characteristics of the recordings.

On Kings Bay, the acoustic recordings were scrutinized using LSSS (V. 2. 0.0) 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 as the standard 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). Pre-determined survey strata, established in 2016, were adjusted within in StoX based on survey effort and observations in 2017. This occurred mainly in the western fringes where some transects were shortened due to zero registrations of blue whiting (Figure 1). 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 super-individual 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 was used to split the total abundance estimate by any combination of population parameters. The StoX project folder for 2017 is available on request.

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 6,105 nmi (nautical miles) of survey transects were completed areas across six strata relating to an overall geographical coverage of 135,085 nmi.² (Figure 1, Tables 3). Acoustic sampling effort and area coverage were the same as in 2016 (Table 7). Stock containment was considered sufficient for core abundance areas and peripheral 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 86% of total biomass (Table 4). The Rockall Bank (strata 5) accounted for 7% of the biomass in 2017 (Table 4). The two northernmost strata (South Faroes strata 4 and Shetland Ch. strata 6) accounted for the remaining 8% of the biomass (Table 4).

The maximum s_A values (top 3) observed in the survey were recorded in northern part of strata 1 (Porcupine Bank) close to the shelf slope (84,756 m²/nmi², 60,520 m²/nmi² and 51,905 m²/nmi² respectively) by Tridens (Figure 8a). Strata 2 (Porcupine Bank) contained numerous high density registrations as observed by the Celtic Explorer in open water (Figure 8b). Low density registrations dominated the Rockall strata. Northern strata (4 and 6) were dominated by numerous low density registrations.

Stock size

The estimated total biomass of blue whiting for the 2017 international survey was 3.13 million tonnes, representing an abundance of 35.2×10^9 individuals (Table 4). Spawning stock was estimated at 3.11 million tonnes and 35.0×10^9 individuals (Table 5).

Stock composition

Individuals of ages 1 to 13 years were observed during the survey.

The main contribution (81%) to the spawning stock biomass were the age groups 3, 4 and 5 in order of importance (Table 5), with 3- and 4-year old fish contributing 40% and 29% to total biomass, respectively.

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 2017 this stratum accounted for nearly 60% of SSB compared to 55% in 2016 (Table 4). Mean weights of the fish caught in the Rockall Trough area were highest in the survey (Figures 9 and 10). Also in the area south of the Faroe Bank some blue whiting were observed among argentines close to the bottom (Figure 10).

The two northern strata (South Faroes; stratum 4 and Faroes/Shetland; stratum 6) were found to contain significantly less proportions of blue whiting in 2017, a decrease from around 25%

to 8% compared to 2016 (Table 4). There was also a shift in the age composition to older fish in 2017. The age groups 3 and 4 dominated in the strata. The 1-year olds were missing in this area in 2017, as compared to 2016 and 2015 when they were well represented.

The bulk of the blue whiting that was observed in 3 strata bordering the shelf edge (Strata 1, 2 and 3) was dominated by 3 to 5 year old fish, and thus represented most of the fish observed in the survey this year (Figures 13). Three year old fish dominated most strata with the exception of strata 2 and 4, where 4 year olds ranked higher and 3 year olds (Figure 12). The proportion of 1 and 2 year old fish was low in all strata and certainly in northern most strata south and east of the Faroes (strata 4 and 6) where young fish were most abudnance in the 2016 estimate.

The proportion of blue whiting in the Rockall Bank and Hatton Bank decreased from 2016 to 2017, from 10.3% to 6.9%, respectively (Table 4). This decrease was accompanied by a decrease in salinity and temperature in the deeper regions in the Rockall Bank area in 2017 as compared to 2017 (Figure 19).

An uncertainty estimate based on a comparison of the abundance estimates by age was calculated for IBWSS for years 2015, 2016 and 2017 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 2015 to 2017 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 2016 and 2017 estimates. This indicates that the 2015 survey might be biased.

The survey time series (2004-2017) of TSN and TSB has been recalculated using StoX (including uncertainty estimates) and are presented in Figures 14 and 15 respectively and Table 6.

Hydrography

A combined total of 78 CTD casts were undertaken over the course of the survey, excluding those carried out by Norway (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 16-19 respectively. It seems as the salinity and temperature in the deeper regions in the Rockall Bank area decreased in 2017 as compared to the previous years.

Concluding remarks

Main results

- Weather conditions were mixed with both good and bad periods. All but the Norwegian vessel experienced some weather induced downtime ranging from 24 hrs (Ireland) to 48 hrs (Faroes).
- Total area coverage and acoustic sampling effort was maintained as in 2016. However, both acoustic and biological sampling was lower compared to previous years due to the reduced number of vessels over the last two successive years.
- The 14th International Blue Whiting Spawning stock Survey 2017 shows an increase in total stock biomass of 9% with a corresponding increase in total abundance of 2% when compared to the 2016 estimate.
- The survey was carried out over 21 days and thus within the recommended 21 day time window agreed by the group.

- Estimated uncertainty around the total stock biomass remains low, CV=0.14 which is the same value as in 2016.
- The stock biomass within the survey area was dominated by 3, 4, 5 year old fish contributing over 81% of total stock biomass.
- The age structure of the 2017 estimate is considered representative of the age structure of the stock compared to the 2016 estimate.
- The proportion of immature fish (1 year olds) in the 2017 estimate is significantly lower than in 2016 and is most notable in the northern strata around the Faroes. Immature fish were absent from the Rockall and north Porcupine strata.

Interpretation of the results

- The group considers the 2017 estimate of abundance as robust. Good stock containment was achieved for both core and peripheral strata. Sampling effort (biological and acoustic), was comparable to the previous year.
- Total stock biomass is comparable with 2016 (2.9 mt and 3.1 mt respectively). However, the SSB has increased significantly over this time period. This is in part due to the high proportion of one year old fish observed during 2016 that have now recruited to the spawning stock as two year old fish this year.
- The 2017 survey estimate and distribution pattern strengthen the concerns regarding the 2015 survey. The 2017 and the 2016 estimates are similar in abundance and 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.
- Although not considered a reliable indicator of emerging year class strength this survey has in the past foreseen strong or weak signals from observations the northern strata, as in 2016. The lack of abundance of one year olds in 2017, although not definitive may indicate a poor emerging 2016 year class.

Recommendations

- The 2017 acoustic sampling intensity within stratum 2 was deemed too high resulting in the temporal mismatch by the vessel covering this block. To address this issue the group recommends a reduced sampling intensity in this block.
- The group recommends that coverage in the western Rockall/Hatton Bank (stratum 5) should be carried out based on real time observations. That is, effort should not be expended where no aggregations are evident. We propose that western extension of transects is terminated when no blue whiting are observed for 15 nmi consistent ‘clear water’ miles. This applies to peripheral regions to the west of the Rockall and Hatton Bank areas.
- The group recommends that standardised reporting tables, including maturity proportions by length and age, be discussed and agreed upon within internationally coordinated surveys (IBWSS, IESNS, IESSNS & HERAS) at WGIPS in January 2018 and put forward to StoX developers as routine output formats.
- The group requires as a matter of priority that the future contribution of survey effort by Russia is established. If non-participation is on-going then this will require additional survey days by other vessels to meet the shortfall. This will require planning over the

longer term. To that end we ask that the intentions of Russia be clearly laid out in the medium term at WGIPS 2018 or before.

- The group again stresses the need for physical participation of at least one member form each country (vessel) at the post cruise meeting to facilitate the timely delivery of the final report.
- To facilitate the process of calculating global biomass the group requires that all data be made available at least 72 hours in advance of the meeting start date.
- 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 (135,085 nmi²) was covered in 21 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 2016. However, the number of trawl stations and transect miles (acoustic sampling) was less than in years when 5 vessels participated.

References

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Table 1. Country and vessel specific details, IBWSS March-April 2017.

	Celtic Explorer	Magnus Heinason	Tridens	Kings Bay
Trawl dimensions				
Circumference (m)	768	640	860	832
Vertical opening (m)	50	40-45	30-70	45
Mesh size in codend (mm)	20	40	40	40
Typical towing speed (kn)	3.5-4.0	3.0-3.2	3.5-4.0	3.5-4.0
Plankton sampling	-	16	0	22
Sampling net	-	WP2 plankton net	-	WP2 plankton net
Standard sampling depth (m)	-	200	-	400
Hydrographic sampling				
CTD Unit	SBE911	SBE911	SBE911	SBE25/SAI V SD208
Standard sampling depth (m)	1000	1000	1000	1000

Table 2. Acoustic instruments and settings for the primary frequency, IBWSS March-April 2017.

	Celtic Explorer	Magnus Heinason	Tridens	Kings Bay
Echo sounder	Simrad EK 60	Simrad EK60	Simrad EK 60	Simrad EK 60
Frequency (kHz)	**38**, 18, 120, 200	**38**, 200	18, **38**, 70, 120, 200, 333	18, **38**, 120, 200
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)	9.4	10.1	10	9.8
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)	25.90	25.62	26.54	22.94
s_A correction (dB)	-0.67	-0.66	-0.66	-0.64
3 dB beam width (dg)				
alongship:	6.82	7.1	6.87	7.07
athw. ship:	6.88	7.1	6.89	7.08
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 2017.

Vessel	Effective survey period	Length of cruise track (nmi)	Trawl stations	CTD stations	Plankton sampling WP2-net	Aged fish	Length-measured fish
Celtic Explorer	21/3-2/4	1493	16	27	-	749	2179
Magnus Heinason	1/4-10/4	1,212	6	16	11	400	990
Kings Bay	23/3- 4/4	1,711	12	22*	22	328	1,100
Tridens	22/3-2/4	1689	12	35	-	1,000	1,000
Total	21/3-10/4	6,105	46	100	33	2,477	5,269

* Due to technical difficulties these data were discarded

Table 4. Abundance and biomass estimates of blue whiting by stata in 2017 and 2016. IBWSS March-April 2017.

Strata	Name	2017				2016				% difference 2016 to 2017	
		TSB (10^3 t)	TSN (10^9)	% TSB	% TSN	TSB (10^3 t)	TSN (10^9)	% TSB	% TSN	TSB	TSN
1	Porcupine Bank	616	7 367	19.6	20.9	236	2 745	8.2	8.0	139%	163%
2	N Porcupine Bank	177	2 084	5.6	5.9	335	4 078	11.7	11.8	-52%	-50%
3	Rockall Trough	1 871	20 855	59.7	59.3	1 376	14 877	47.9	43.2	25%	37%
4	South Faroes	102	881	3.2	2.5	323	4 321	11.2	12.5	-71%	-80%
5	Rockall Bank	215	2 321	6.9	6.6	295	3 913	10.3	11.4	-33%	-42%
6	Faroe/Shetland Ch.	154	1 670	4.9	4.7	307	4 513	10.7	13.1	-54%	-64%
	Total	3 135	35 178	100	100	2 873	34 447	100	100		

Table 5. Survey stock estimate of blue whiting, IBWSS March-April 2017.

					Age in years (year class)						Number	Biomass	Mean	Prop	SSN
Length	1	2	3	4	5	6	7	8	9	10+			weight	Mature	
(cm)	2016	2015	2014	2013	2012	2011	2010	2009	2008		(10^6)	(10^6 kg)	(g)		(10^6)
18-19	10										10	0.3	29	0	0
19-20	38	50									88	3.8	43	39	35
20-21	89	103									192	9.2	48	83	158
21-22	117	167									284	14.5	51	100	284
22-23	22	187	271	57							537	31.3	58	100	537
23-24		466	1 858	553	60						2 936	187.4	64	100	2928
24-25		558	4 315	1 914	140						6 927	482.9	70	100	6901
25-26		434	4 447	2 058	531						7 470	573.6	77	100	7470
26-27		151	2 816	2 019	415	131	25				5 556	475.9	86	100	5556
27-28		65	1 213	1 563	607	122	107				3 676	351.7	96	100	3676
28-29			739	1 119	677	49	27				2 612	279.6	107	100	2612
29-30			194	469	625	357	104	16			1 765	209.1	118	100	1765
30-31			86	310	238	387	170				1 190	156.3	131	100	1190
31-32				99	158	218	227				701	104.6	149	100	701
32-33				21	126	176	23	2			349	57.0	164	100	349
33-34				8	34	118	65		29	8	262	46.1	176	100	262
34-35					9	51	94			9	162	32.0	197	100	162
35-36						86	5	26		9	126	28.6	228	100	126
36-37				6	2	8	36	10	15	64	141	34.4	245	100	141
37-38						8	18	6	10	41	82	21.4	260	100	82
38-39									12	27	39	10.2	260	100	39
39-40										20	20	6.1	301	100	20
40-41										14	14	4.1	284	100	14
41-42										17	17	6.8	411	100	17
42-43								15			15	5.6	380	100	15
43-44										7	7	2.4	370	100	7
TSN(mill)	275	2 180	15 939	10 196	3 621	1 711	900	75	66	144	35 178				
TSB(1000 t)	13.2	150.2	1 241.2	890.9	381.0	237.4	131.2	17.9	14.3	38.2	3 134.9				
Mean length(cm)	20.6	23.8	25.3	26.2	27.8	30.4	30.9	35.5	35.3						
Mean weight(g)	48	69	78	87	105	139	146	240	219						
% Mature	64	97	100	100	100	100	100	100	100	100					
SSB (1000kg)	8.4	146.3	1239.3	890.5	381.0	237.4	131.2	17.9	14.3	38.2	3104.6				
SSN (mill)											35047				

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
2017	275	2 180	15 939	10 196	3 621	1 711	900	75	66	144	3 135

*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
2017*	135 085	6 105	46	100	33	5 269	2 477

* No Russian vessel in 2016 and 2017.

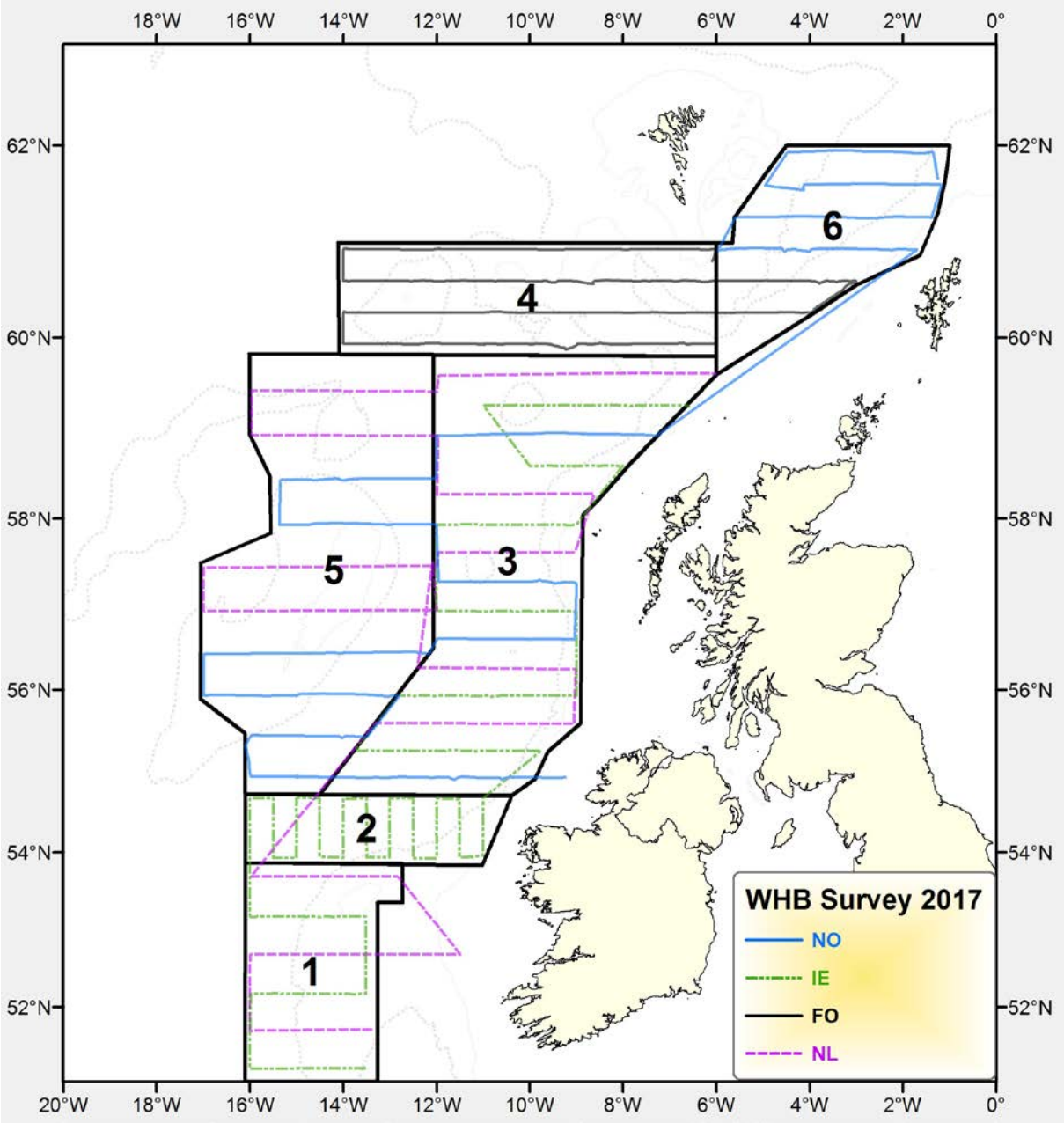


Figure 1. Strata and cruise tracks for the individual vessels (country) during the International Blue Whiting Spawning Stock Survey (IBWSS) from March-April 2017.

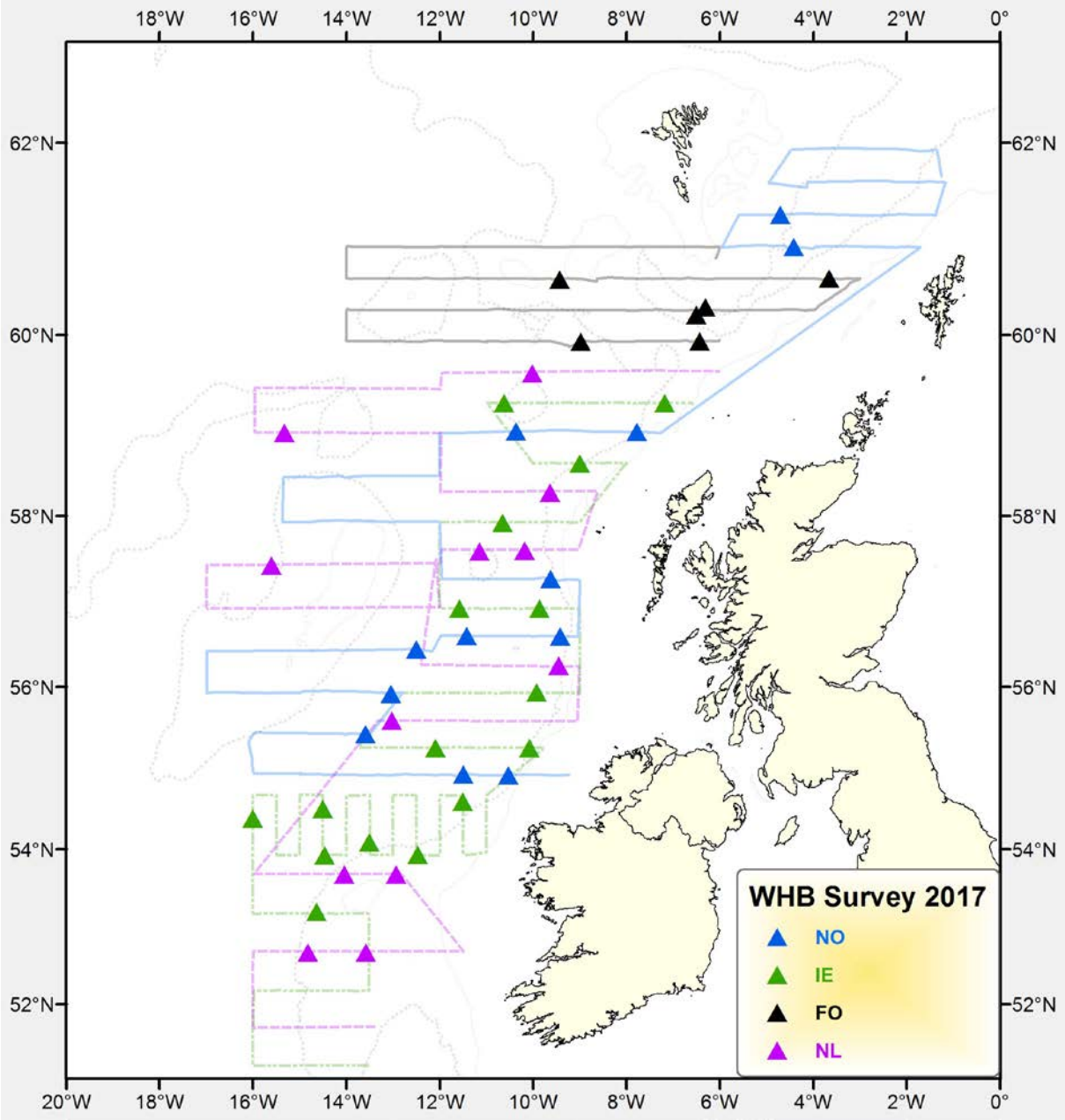


Figure 2. Vessel cruise tracks and trawl stations of the International Blue Whiting Spawning Stock Survey (IBWSS) from March-April 2017. IE: Ireland (Celtic Explorer); FO: Faroe Islands (Magnus Heinason); NL: Netherlands (Tridens); NO: Norway (Kings Bay).

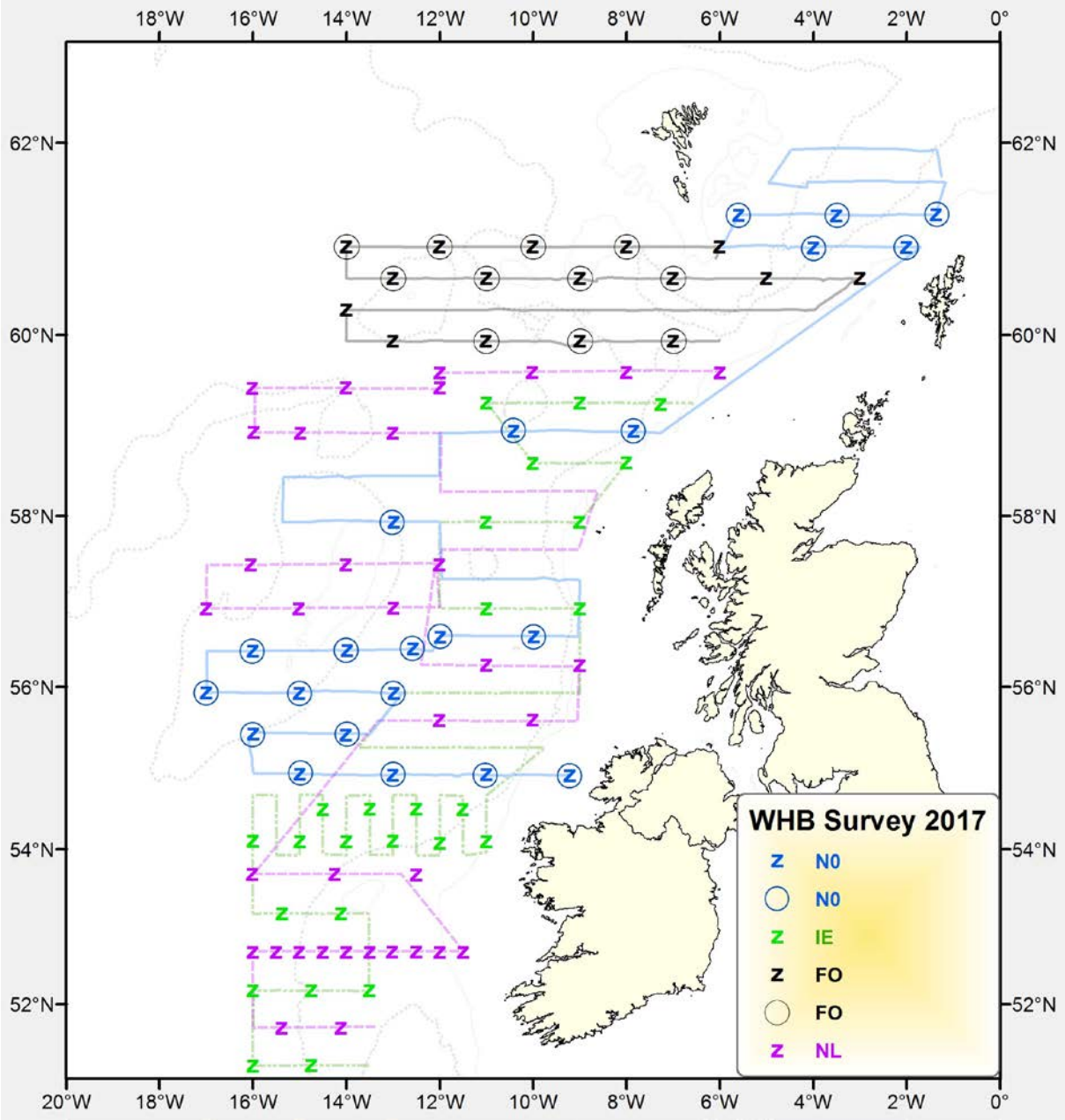


Figure 3. Vessel cruise tracks with hydrographic CTD stations (z) and WP2 plankton net samples (citrcles) during the International Blue Whiting Spawning Stock Survey (IBWSS) from March-April 2017. Colour coded by vessel.

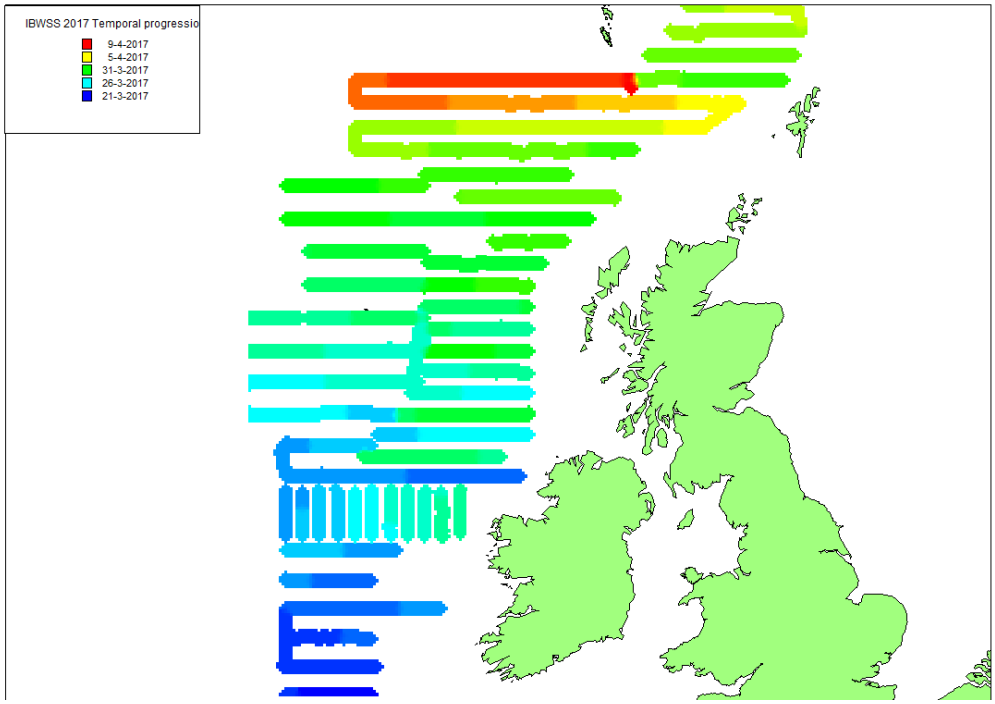


Figure 4. Temporal progression for the International Blue Whiting Spawning Stock Survey (IBWSS) from March-April 2017.

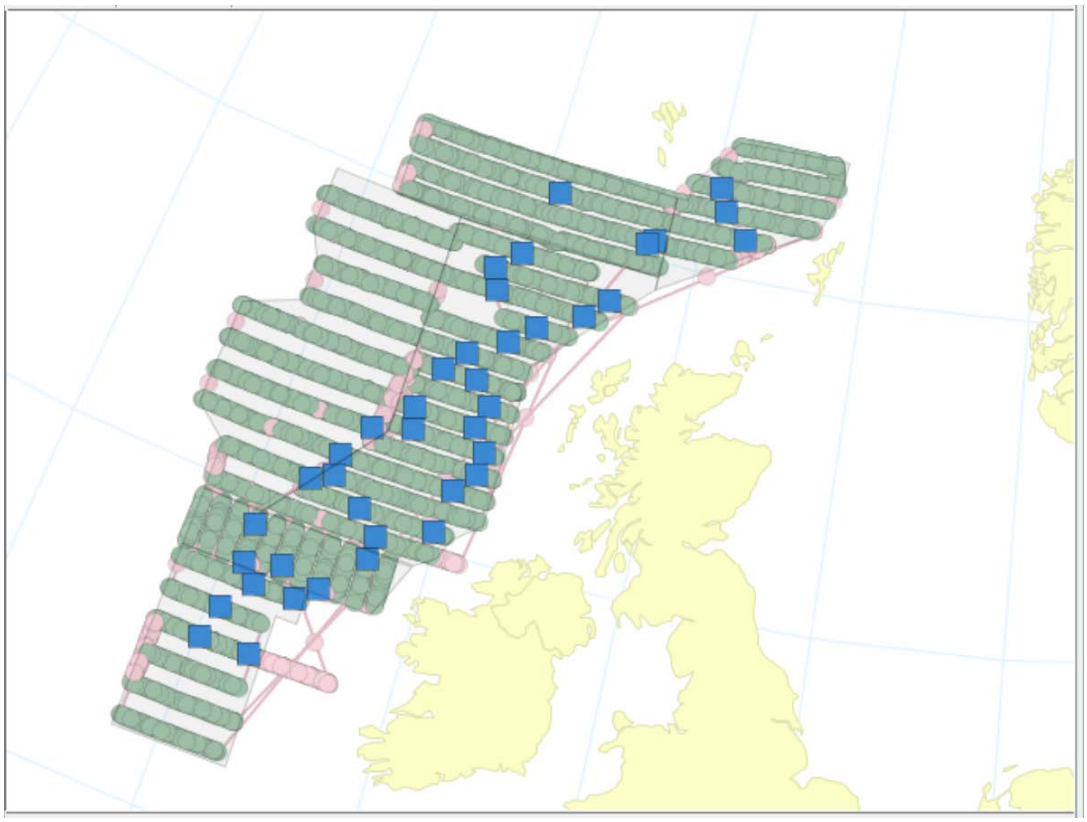


Figure 5. Tagged acoustic transects (green circles) with acociated trawl stations (blue squares) used in the StoX abundance estimation. IBWSS March-April 2017.

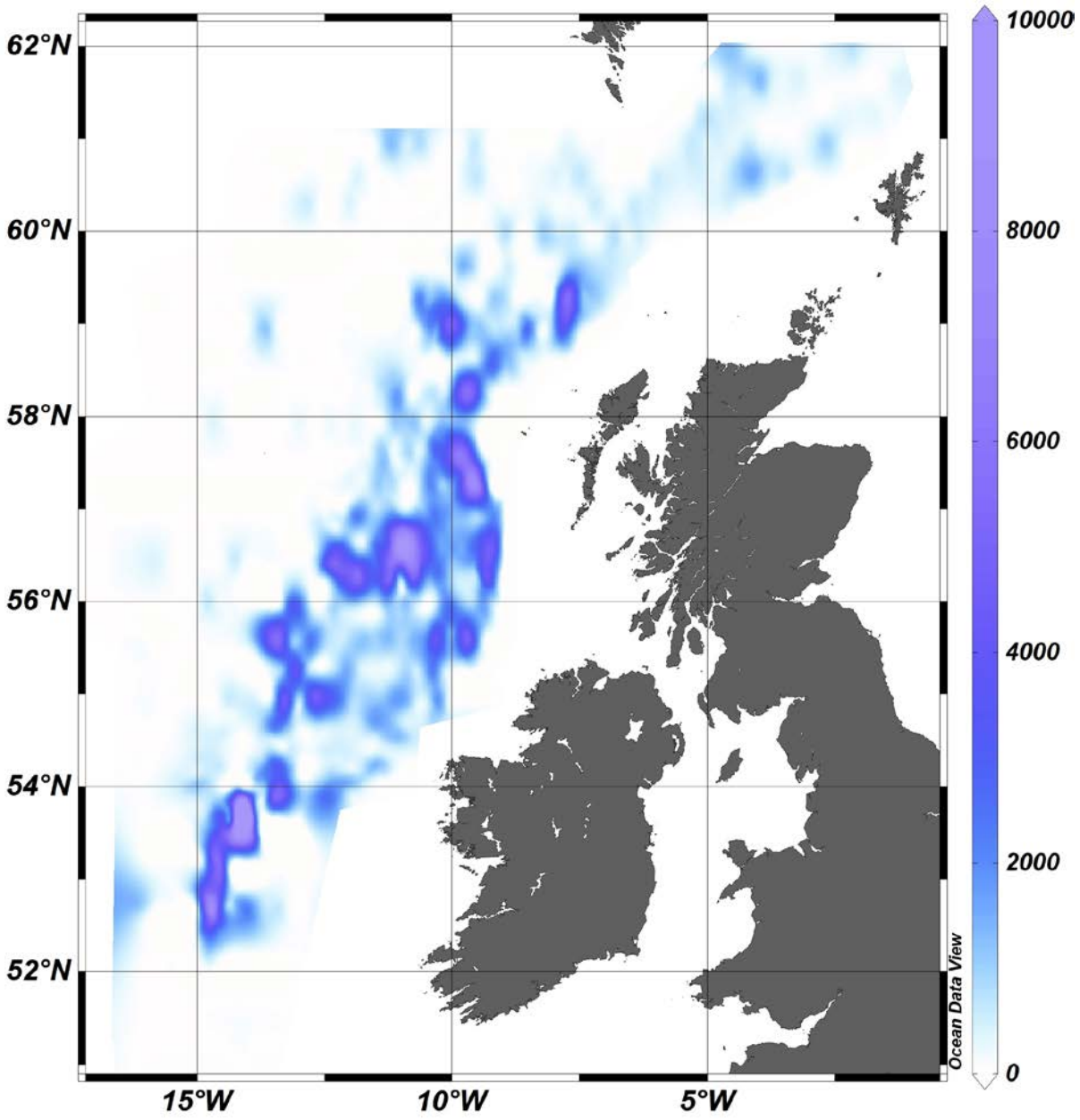


Figure 6. Map of acoustic density (s_A m^2/nmi^2) of blue whiting during the International Blue Whiting Spawning Stock Survey (IBWSS) from March-April 2017.

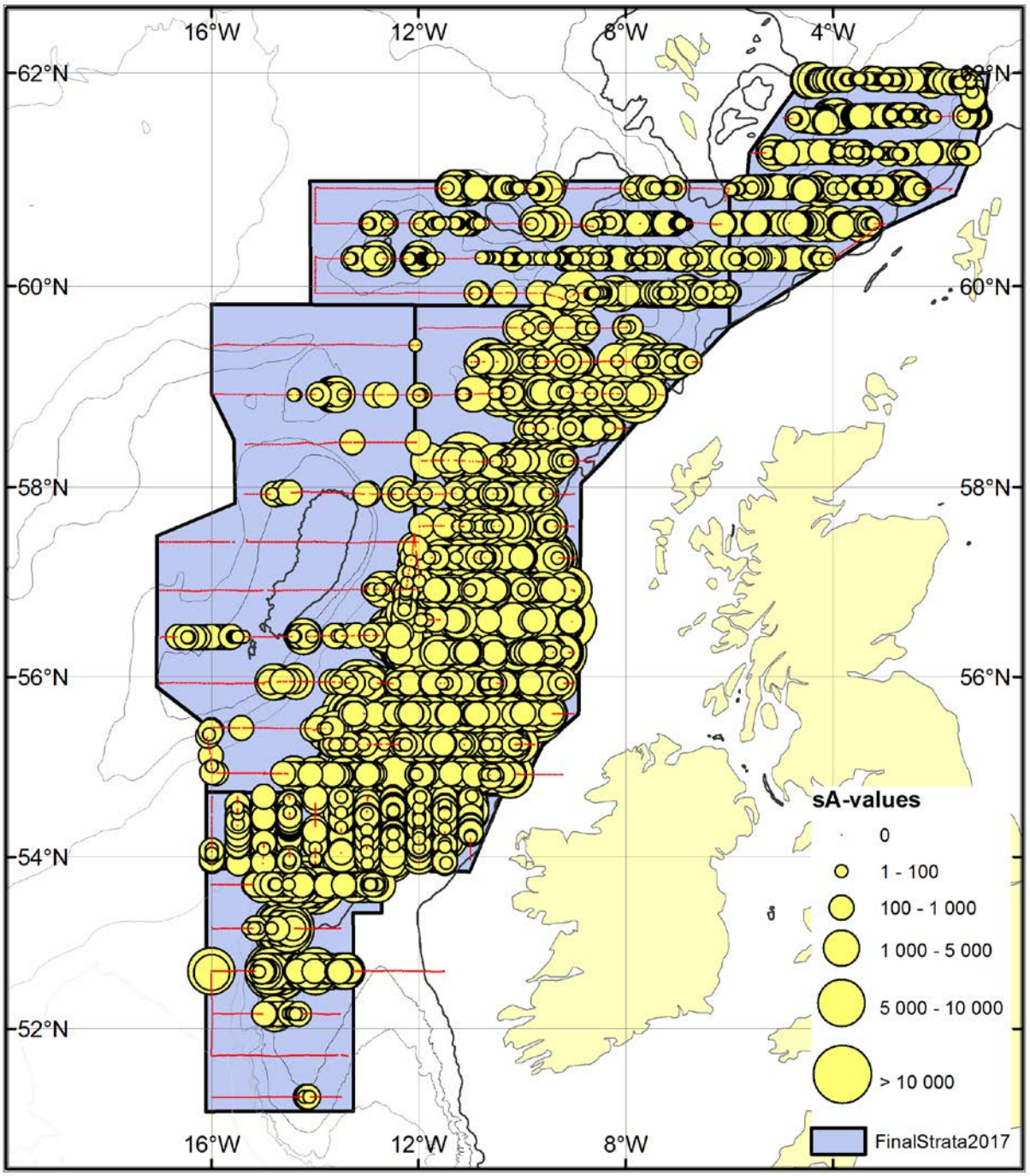
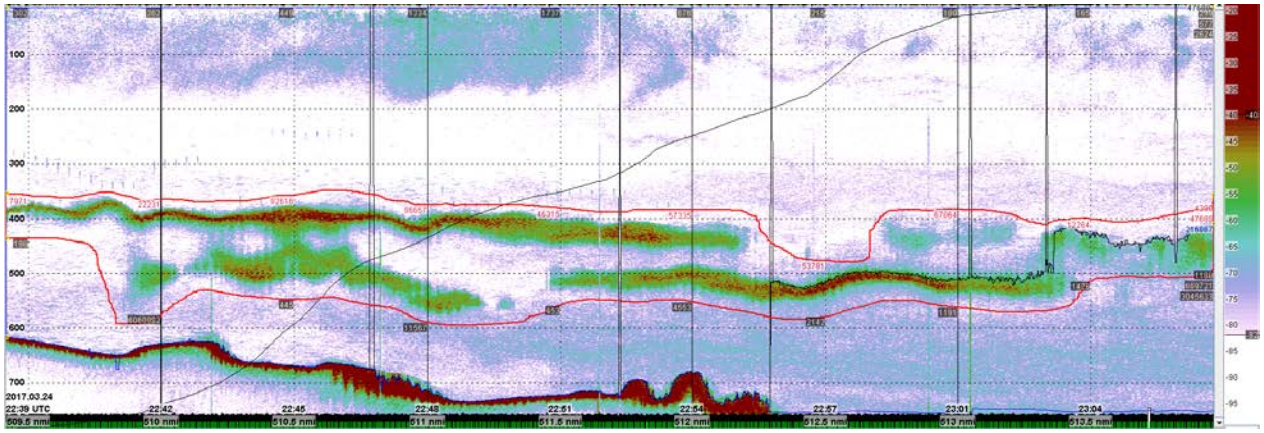
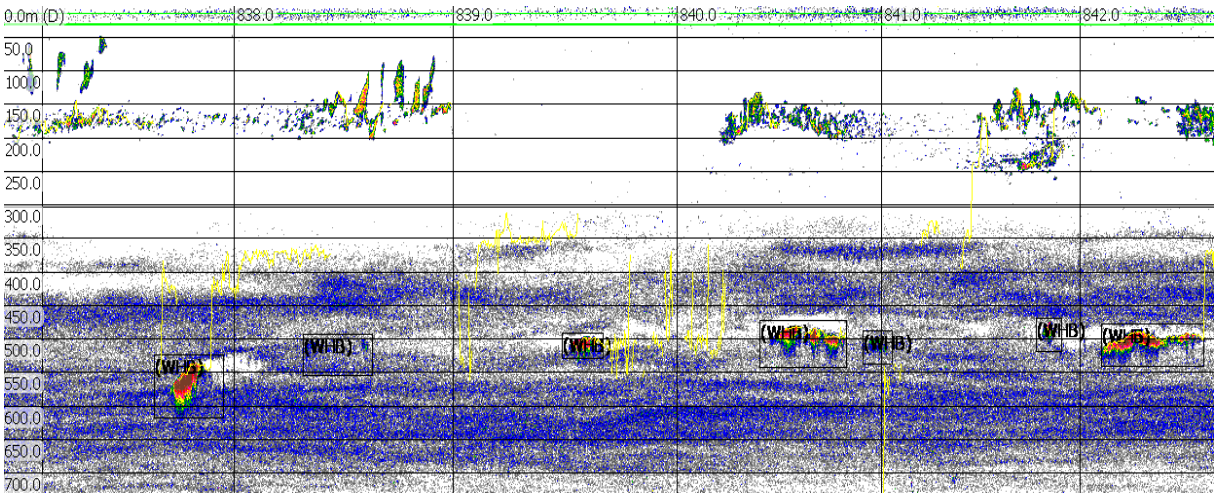


Figure 7. Map of acoustic density (s_A m^2/nmi^2) of blue whiting by 1 nmi (circle scaled by acoustic density). IBWSS March-April 2017.



a) Very high density school of blue whiting registered by Tridens in the Western Porcupine Bank area.



b) High density blue whiting registrations in the northern Porcupine Bank (strata 2) recorded by the Celtic Explorer.

Figure 8. Echograms of interest encountered during the IBWSS, March-April 2017: a) Tridens and b) Celtic Explorer.

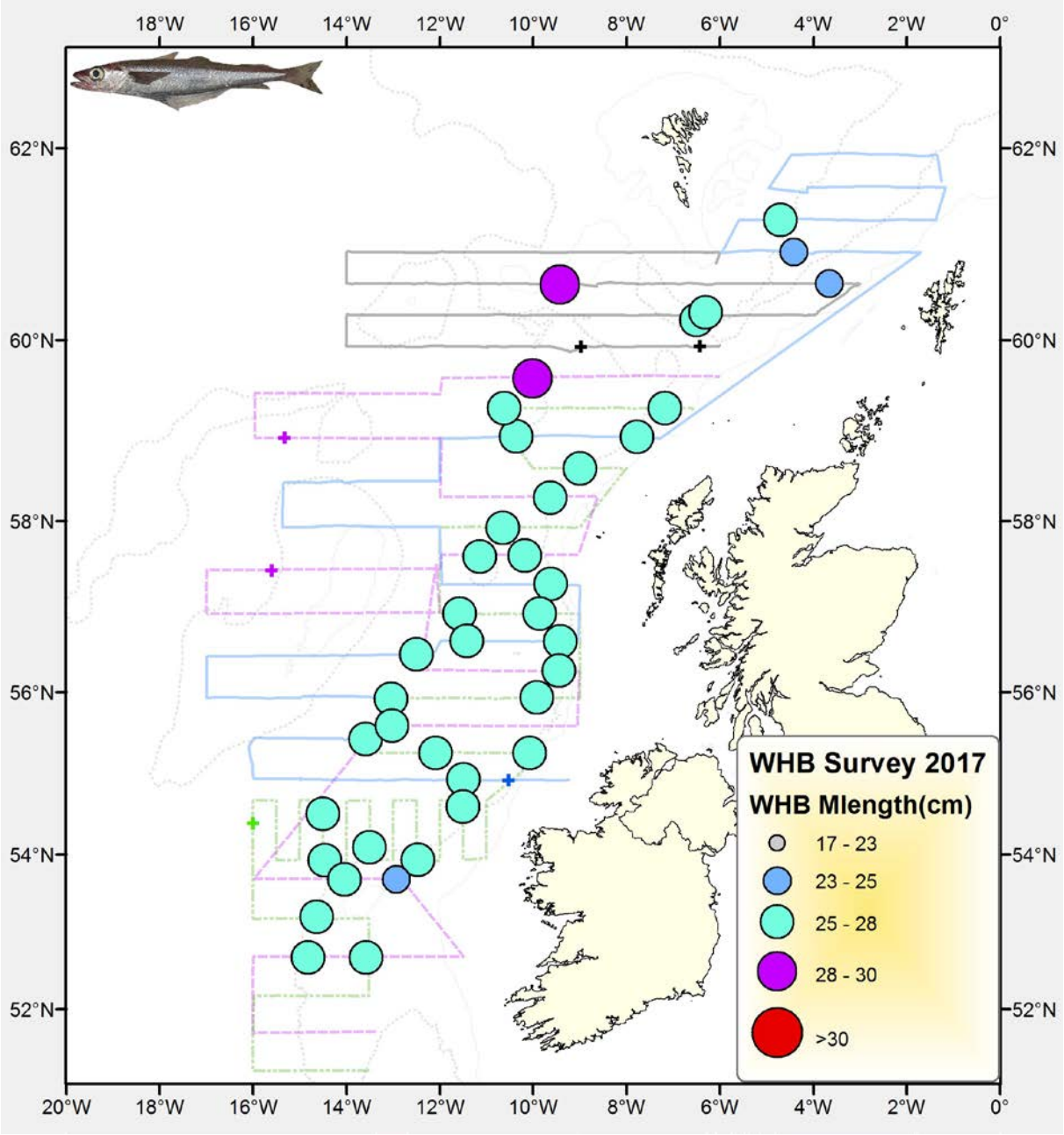


Figure 9. Combined mean length of blue whiting from trawl catches by vessel, IBWSS in March- April 2017. Crosses indicate hauls with zero blue whiting catches.

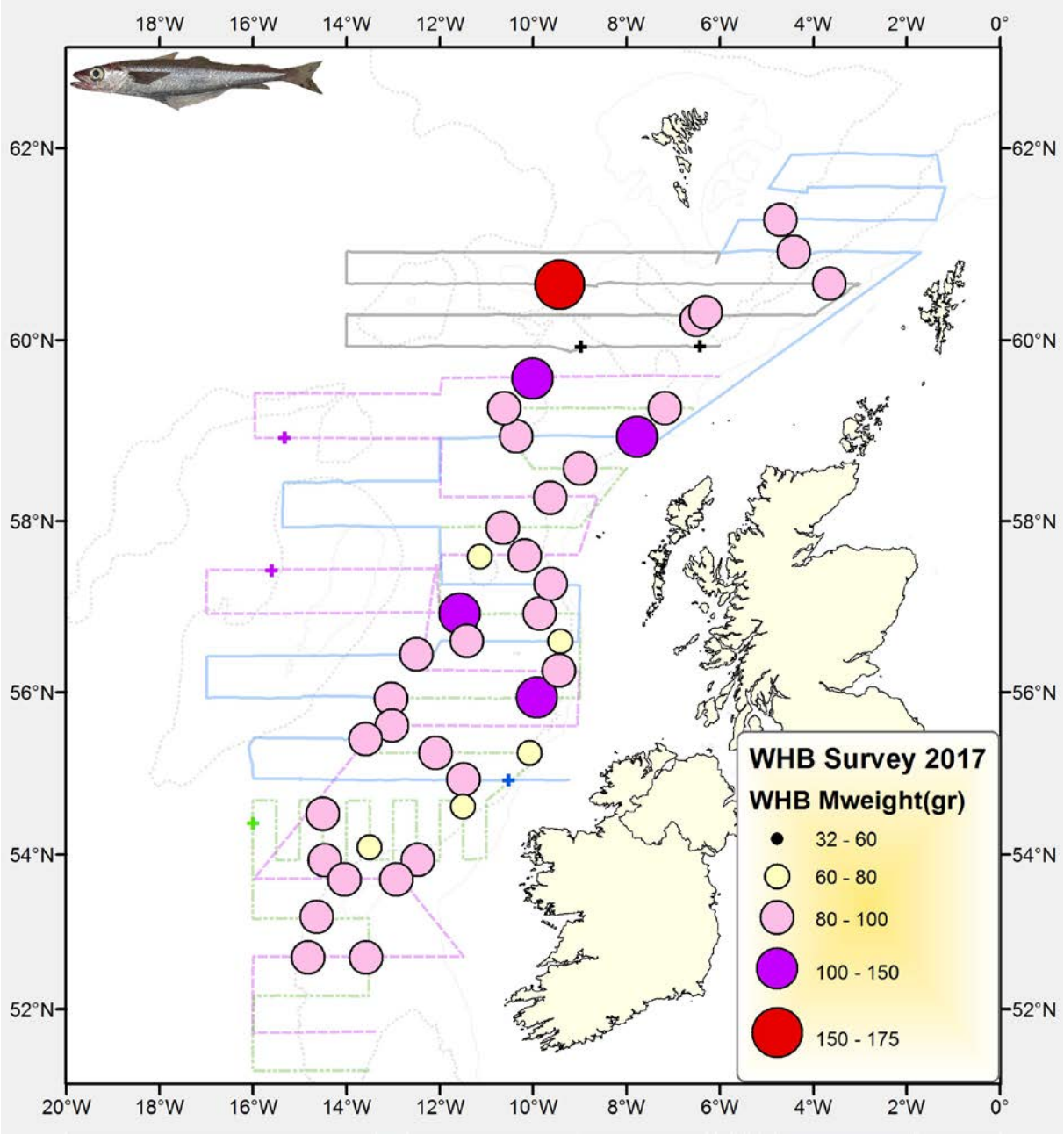


Figure 10. Combined mean weight of blue whiting from trawl catches, IBWSS March- April 2017. Crosses indicate hauls with zero blue whiting catches.

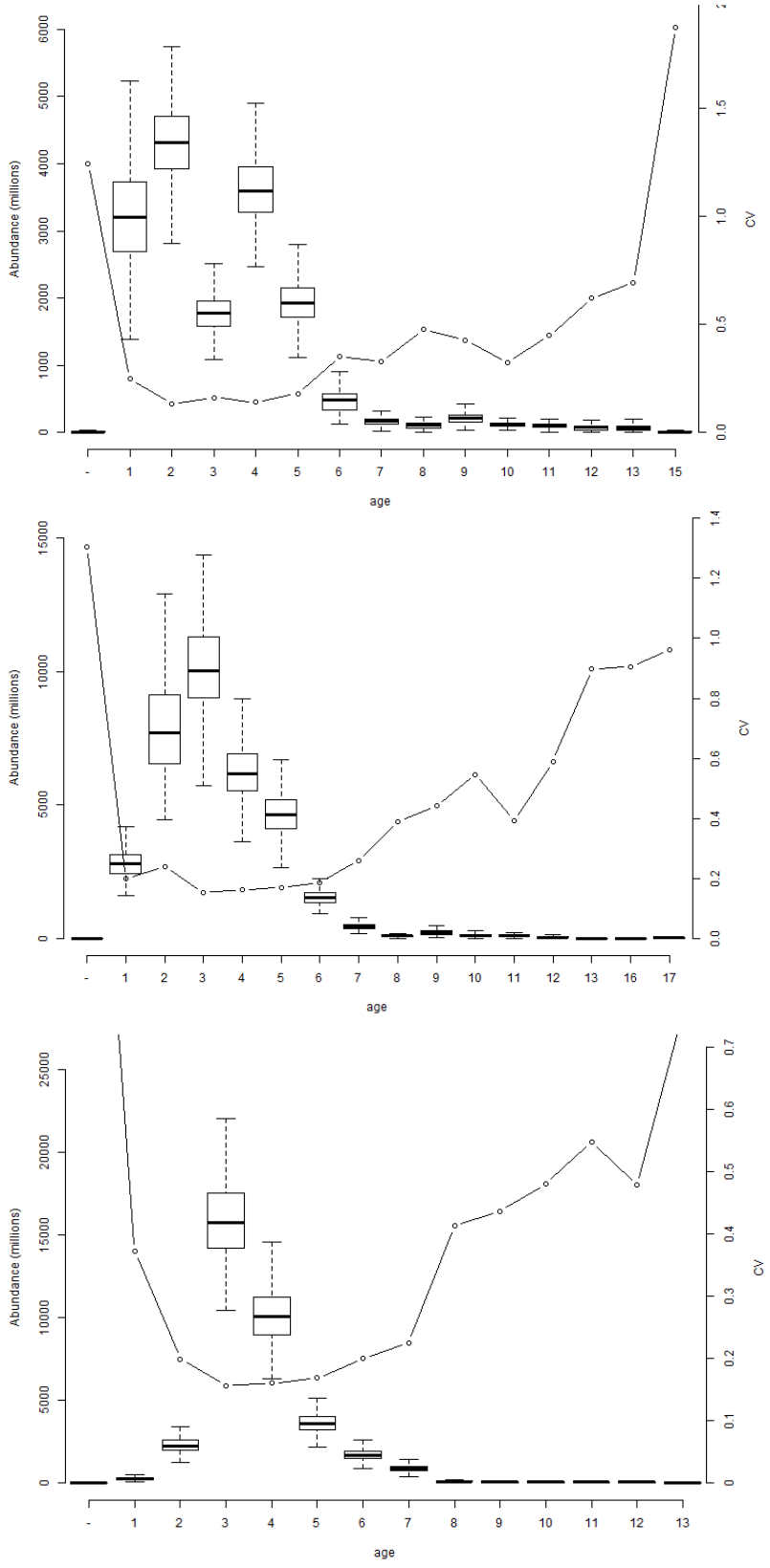


Figure 11. Blue whiting bootstrap abundance (millions) by age (left axis) and acociated CVs (right axis) in 2015 (top panel), 2016 (middle panel) and 2017 (lower panel). From StoX.

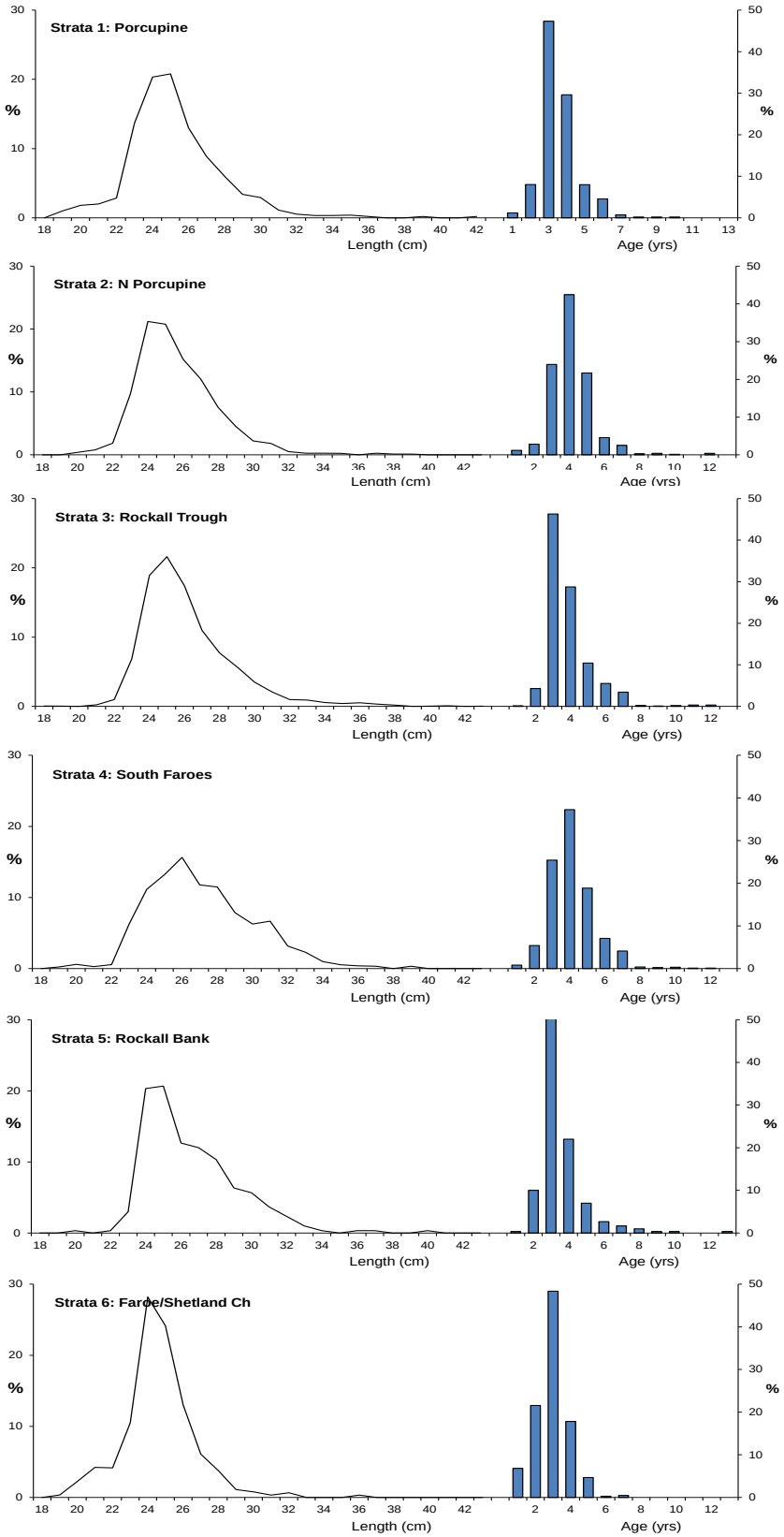


Figure 12. Length and age distribution (numbers) of blue whiting by survey strata. March-April 2017.

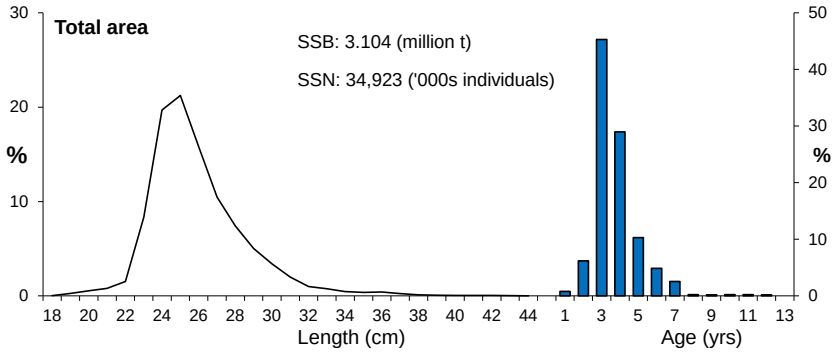


Figure 13. Length and age distribution (numbers) of total stock of blue whiting. March-April 2017.

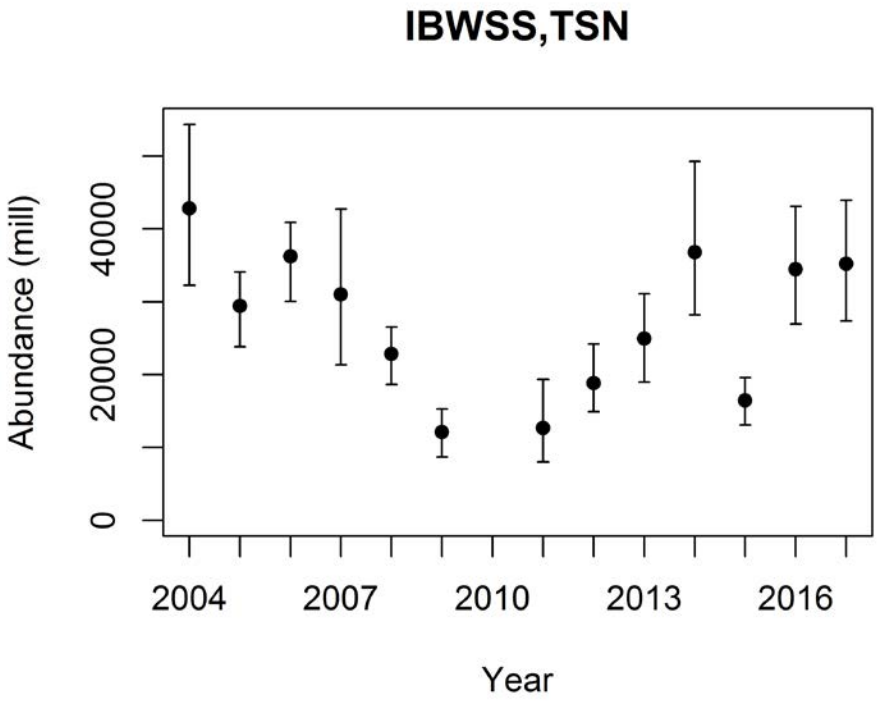


Figure 14. Time series of StoX survey indices of blue whiting abundance.

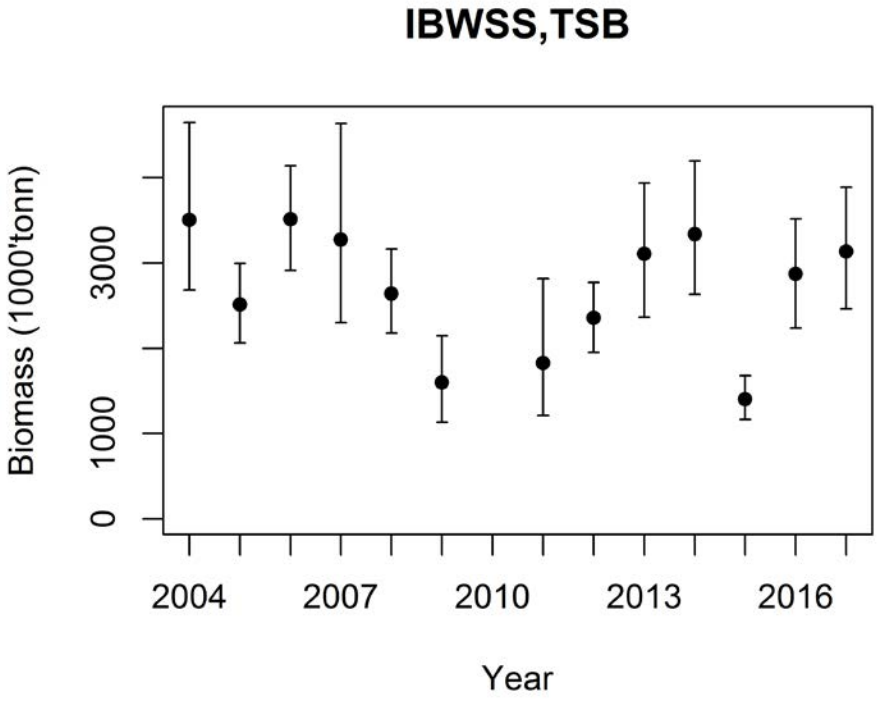


Figure 15. Time series of StoX survey indices of blue whiting biomass.

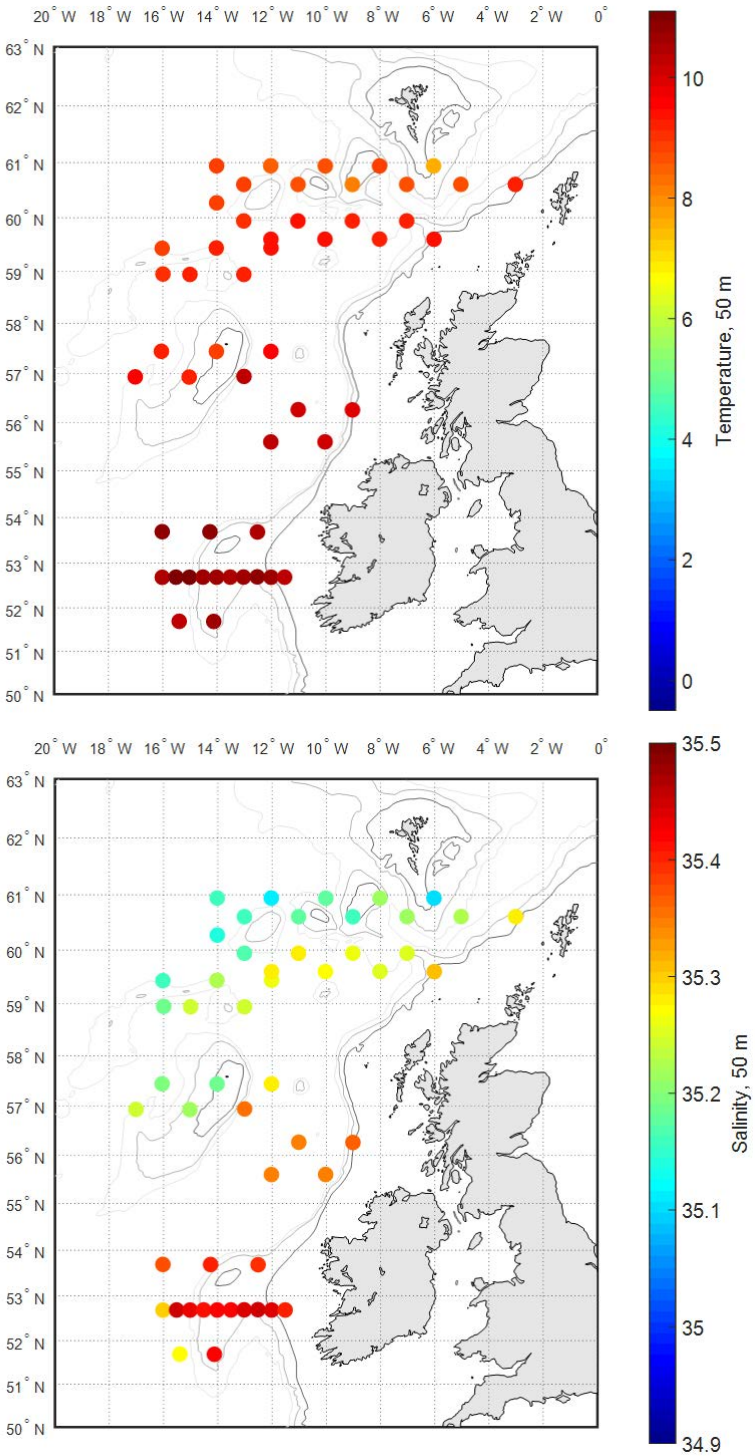


Figure 16. Horizontal temperature (top panel) and salinity (bottom panel) at 50 m subsurface as derived from vertical CTD casts. IBWSS March-April 2017.

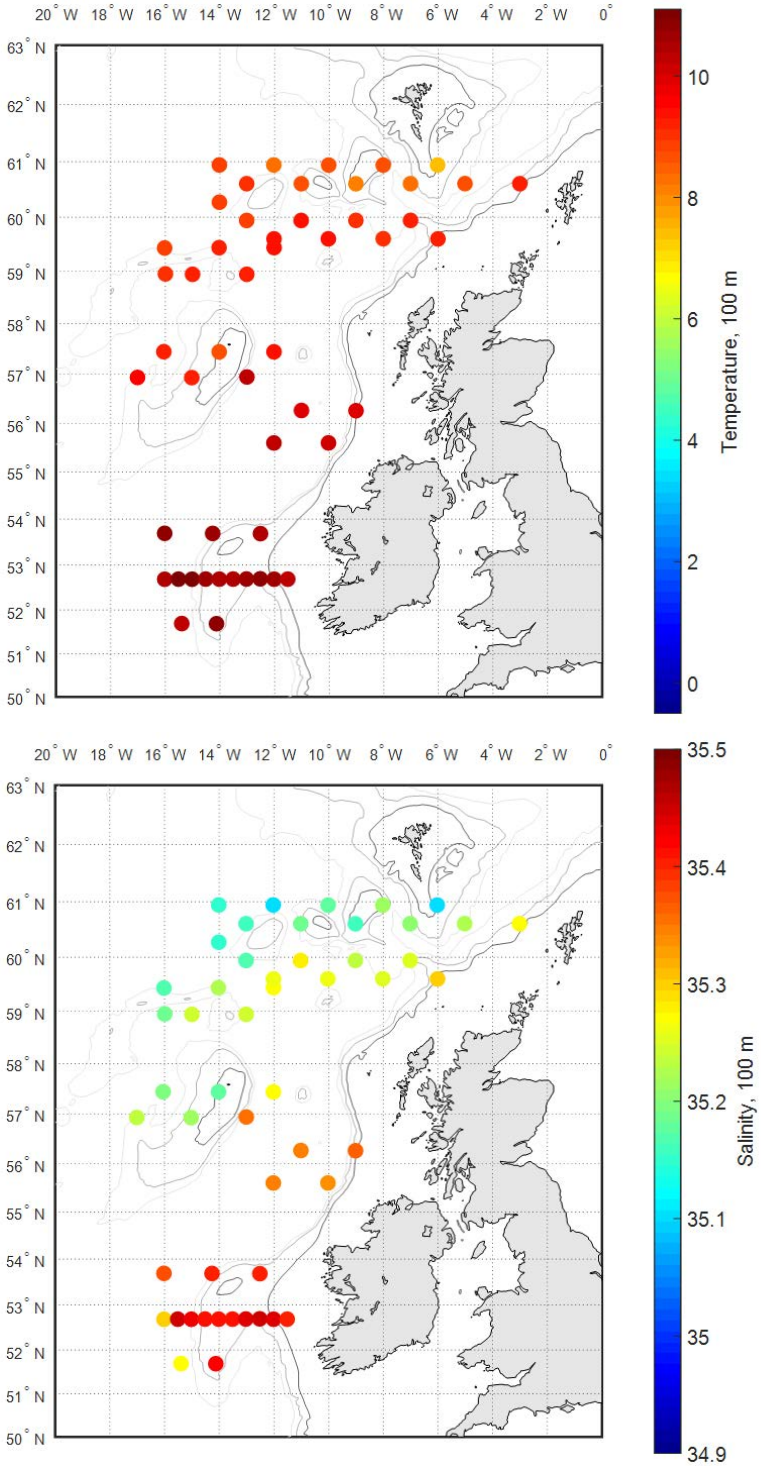


Figure 17. Horizontal temperature (top panel) and salinity (bottom panel) at 100 m subsurface as derived from vertical CTD casts. IBWSS March-April 2017.

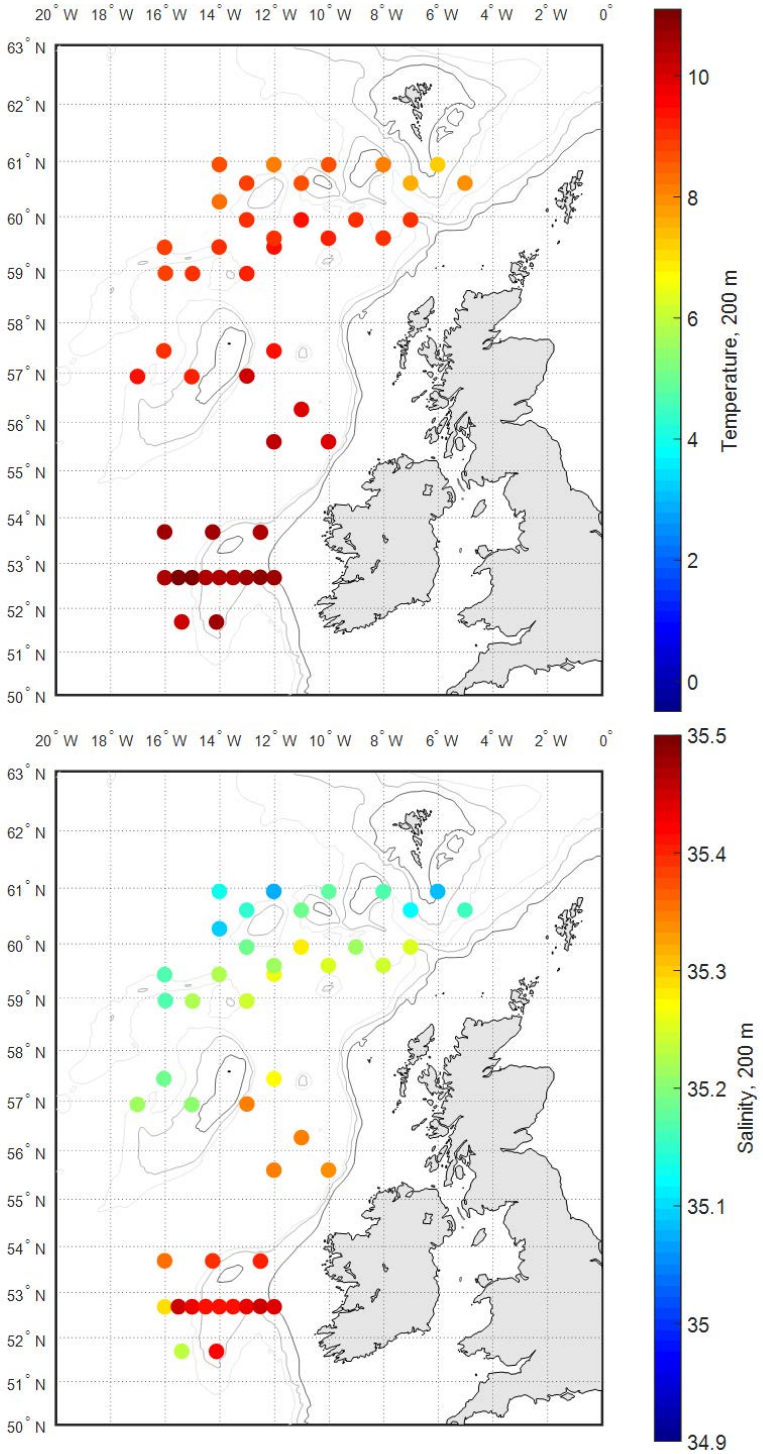


Figure 18. Horizontal temperature (top panel) and salinity (bottom panel) at 200 m subsurface as derived from vertical CTD casts. IBWSS March-April 2017.

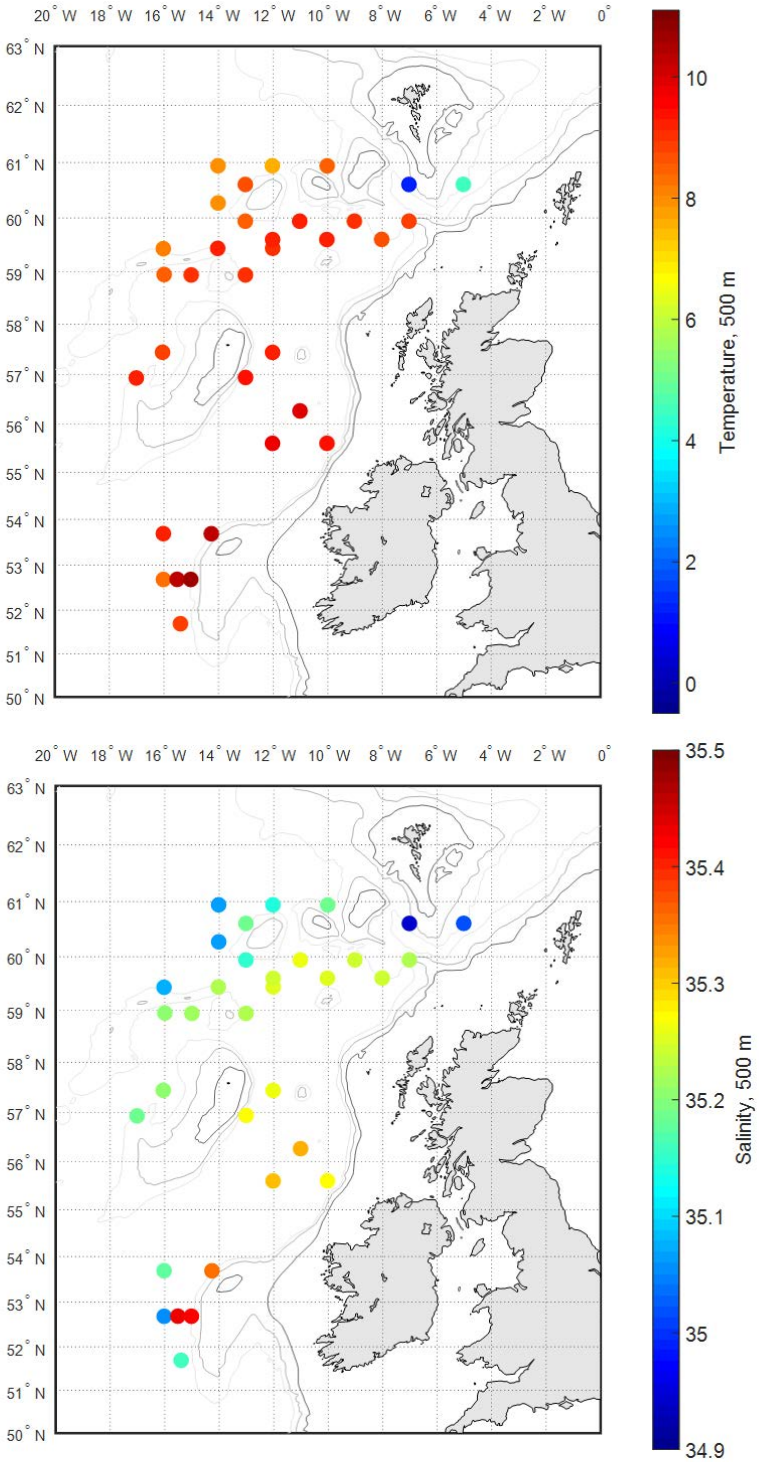


Figure 19. Horizontal temperature (top panel) and salinity (bottom panel) at 500 m subsurface as derived from vertical CTD casts. IBWSS March-April 2017.