Working Document

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Working Group on Widely Distributed Stocks

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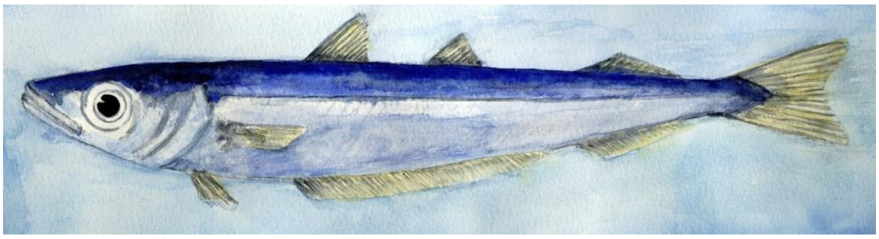

INTERNATIONAL BLUE WHITING SPAWNING STOCK SURVEY (IBWSS) SPRING 2026

Jan Arge Jacobsen[3*], Leon Smith[3*], Petur Mikkelsen[3], Árni Johansen [3], Lauren Clayton[8]
R/V *Jákup Sverri*
Bram Couperus[1*], Serdar Sakinan[1], Dirk Burggraaf[1], Theresa Peters[7], Thomas Pasterkamp[1], Sebastian Thomas Kjelstrup[5],
R/V *Tridens*
Ciaran O'Donnell[4]*, Michael O'Malley[4], Eugene Mullins[4] and Eoghan Daly[4]
R/V *Celtic Explorer*
Åge Høines[2^*], Ørjan Sørensen[2], Herdis Mørk[2], Tommy Gorm-Hansen Tøsdal[2], Christine Djønne[2]
M/S Vendla
Urbano Autón[6], Silvia Rodriguez Climent[6], Pablo Carrera[6]
R/V *Vizconde de Eza*

1 Wageningen Marine Research, IJmuiden, The Netherlands
2 Institute of Marine Research, Bergen, Norway
3 Faroe Marine Research Institute, Tórshavn, Faroe Islands
4 Marine Institute, Galway, Ireland
5 Danish Institute for Fisheries Research, Denmark
6 Spanish Institute of Oceanography, IEO, Spain
7 Thünen Institute, Germany
8 Marine Directorate, Aberdeen, Scotland, UK
* Participated in post cruise meeting,
^ Survey coordinator

Material and methods

Survey planning and Coordination

Coordination of the survey was initiated at the meeting of the Working Group on International Pelagic Surveys (WGIPS) in January 2026 and continued by correspondence until the start of the survey. During the survey, effort was refined and adjusted by the survey coordinator (Norway) using real time observations. Participating vessels together with their effective survey periods are listed below:

Vessel	Institute	Effective survey period
Celtic Explorer	Marine Institute, Ireland	19/3 – 02/04
Jákup Sverri	Faroe Marine Research Institute, Faroe Islands	30/3 – 08/04
Tridens	Wageningen Marine Research, the Netherlands	19/3 – 07/04
Vendla	Institute of Marine Research, Norway	19/3 – 28/03
Vizconde de Eza	Spanish Institute of Oceanography, Spain	20/3 – 27/03

Survey design was based on methods described in ICES Manual for International Pelagic Surveys (ICES, 2015). Overall, weather conditions were poor for a significant portion of the survey, with consecutive storm fronts disrupting progress. All vessels were forced to pause surveying on more than one occasion due poor weather effecting the quality of acoustic data. Good survey coordination ensured key areas were surveyed consistently and by more than one vessel. The eastward distribution of the stock along the shelf break, combined with the poor weather conditions, focused effort in core areas (stratum 2 & 3). Stratum 7 (Porcupine Seabight) was covered by Spanish effort. The entire survey was completed in 21 days, within the agreed 21-day target threshold (Figure 3).

Vessel cruise tracks, trawl positions and survey stratification are shown in Figure 1. CTD and plankton stations are in shown in Figure 2. Communication between vessels occurred daily via email to the coordinator (Norway) exchanging up to date information on blue whiting distribution, echograms, fleet activity and biological information. Tridens keeps a weblog during the survey with echograms, catches and additional information.

Sampling equipment

All vessels employed a single midwater trawl for biological sampling, the properties of which are provided in Table 1. Acoustic equipment for data collection and processing are provided 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 using a standardised sphere calibration (Demer et al. 2015) prior to 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 where possible. A summary of biological sampling by vessel is provided in Table 3.

Hydrographic sampling

Hydrographic sampling (vertical CTD casts) was carried out by all vessels except Tridens (broken CTD winch) at predetermined locations (Figure 2 and Table 3). Depth was capped at a maximum depth of 1,000 m in open water.

Plankton sampling

Plankton sampling, by way of vertical WP2 casts, was carried out by the RV *Jákup Sverri* (FO) to a depth of 200 m (Table 3). WP2 casts were also carried out by FV *Vendla* (NO), with a focus on sampling blue whiting eggs to a depth of 400 m.

Acoustic data processing

Echogram scrutinisation for blue whiting was carried out by experienced personnel, with the aid of trawl composition information. Post-processing software and procedures are described by vessel below;

On RV *Celtic Explorer*, acoustic data were backed up every 24 hrs and scrutinised using Echoview (V 16.0) post-processing software for the previous day's work. Data was partitioned into the following categories: blue whiting and mesopelagic fish species. For mesopelagic fish, categorisation was based on criteria agreed at WGIPS 2021 (ICES 2021, Annex 22).

On RV *Jákup Sverri*, acoustic data were scrutinised every 24 hrs on board using LSSS (3.2.0) post processing software. Data was partitioned into the following categories: plankton, mesopelagics/krill and blue whiting. Partitioning of data into the above categories was based on trawl samples and acoustic characteristics on the echograms.

On RV *Tridens*, acoustic data were backed up continuously and scrutinised every 24 hrs using the LSSS (3.2.0) post-processing software. Blue whiting was identified and separated from other recordings based on trawl catch information and characteristics of the recordings. Recordings have been assigned to blue whiting and mesopelagic fish species, based on the criteria at WGIPS 2021 (ICES 2021, Annex 22).

On FV *Vendla*, the acoustic recordings were scrutinized using LSSS (3.2.0) once or twice per day. Data was partitioned into the following categories: plankton (<120 m depth layer), mesopelagic species and blue whiting.

On RV *Vizconde de Eza*, acoustic data were backed up every 24 hrs and scrutinised after the survey using Echoview (V 16.1.69) post processing software. Data were partitioned into the following categories: Blue whiting and Mueller's pearlside and boarfish which were identified and separated from other recordings based on trawl catch information and characteristics of the recordings.

Preliminary investigation into the effects of acoustic data collection in poor weather

The RV Tridens undertook a preliminary investigation into data quality in poor weather by collecting data along the same transect in opposite directions. During a transect with the high acoustic densities (along 57.38N transect) Tridens was forced to break off the transect in western direction due to rough weather conditions and return on the same transect with tailwind and was thus able to collect data of much better quality. The results of the eastwards (high quality data) data collection were compared with the data from the westward data collection (poor quality data) and the analysis was written down in a working paper (Annex 1) in response to Jech et al (2021). The main conclusion is that there was a 3.6% data loss when using the LSSS spike filter, while there was no significant difference when removing bad sections manually, which is the method currently used by IBWSS participants using LSSS during data scrutinization.

Acoustic data analysis

Acoustic data were analysed using the StoX software package (V4.2.0) and R-StoX packages software package (RStoX Framework 4.2.0, RStoX Base 2.2.0 and RStoX Data 2.2.0). A description of StoX software package is provided by Johnsen et. al. (2019). Estimation of abundance from acoustic surveys using StoX is carried out according to the stratified transect design model developed by Jolly and Hampton (1990). Baseline survey strata, established in 2017, were adjusted based on survey effort and observations in 2026 (Figure 1). Area stratification and transect design are shown in Figure 1 and 4. Within StoX, length and weight data from trawl samples were equally weighted and applied across all transects within a given stratum (Figure 4).

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) is used:

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

In StoX an impute super-individual table is produced where abundance is linked to population parameters including age, length, weight, sex, maturity etc. This table is used to split the total abundance estimate by any combination of population parameters. The StoX project folder for 2026 is available on request.

Estimate of relative sampling error

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

A total length distribution 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 uses the calculated length distribution and a standard target strength equation with user defined parameters. 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 randomly replaces transects and trawl stations within a stratum on each successive run. The output of all runs are stored in a RData-file, which is used to calculate the relative sampling error.

Results

Stock size

The estimated total stock biomass (TSB) of blue whiting for the 2026 international survey was 3.0 million tonnes, representing an abundance of $32.4x10^9$ individuals (Table 4). This is a 32% increase in total stock biomass and a 34% increase in total stock numbers (TSN) from observations in 2025 (Table 4). The spawning stock biomass (SSB) was estimated at 2.9 million tonnes representing $31.0x10^9$ individuals (Table 5). This is a 31% increase in the observed spawning stock biomass and a 33% increase in the spawning stock numbers (SSN) compared to last year. The age structure of the stock changed towards younger ages in 2026 compared to 2025, in that the stock is now dominated by 2–5-year-old fish, the 2021- to 2024-year classes (83% combined).

Distribution of blue whiting

In total, 5,311 nmi (nautical miles) of survey transects (EDSU) were completed across six strata, relating to an overall geographical coverage of 102,498 nmi² (Figure 1, Tables 3 & 7). Area coverage is comparable to 2025 (+2%).

The distribution of blue whiting in 2026 followed a similar pattern as observed in 2025; with fish distributed primarily along the continental shelf break. The bulk of the stock was observed from 55°N to 59°N in the northern region of core stratum 3 (Figures 6 & 7).

Of the seven survey strata, six were surveyed comprehensively, and all saw an increase in abundance and biomass as compared to 2025 (Table 4), with the exception of stratum 1 (Porcupine Bank, TSB -43%, TSN -43%). The increase in biomass and abundance reported at stratum level is in agreement with the overall increase in the TSB and TSN estimates for 2026. Good spatial coverage was achieved given the poor weather conditions and observations are considered representative of the stock distribution. Stratum 5 (Rockall Bank) was not representatively surveyed, and effort was instead reallocated into core areas. Transects extending westward into the mid-Rockall Trough yielded zero values indicating the western boundary of the bulk of the stock had been reached and that distribution was centred more toward the shelf edge. Core stratum 3 (Rockall Trough) was surveyed by four vessels. Temporal progression was considered good and an improvement on 2025.

In the south, stratum 7 (Porcupine Seabight) has historically reported low abundances of blue whiting during the survey, and this continues in 2026. The relatively low abundance observed on the Porcupine Bank (stratum 1) can be largely attributed to the active migration of the stock northward at the time of the survey, this is reflected in the estimate for the North Porcupine Bank (stratum 2) also, albeit in higher numbers than observed in 2025 (Table 4).

The core area (stratum 3), where the bulk of the stock was located, saw an increase of 26% in TSB and 25% TSN as compared to 2025. Stratum 4 (South Faroes) saw an increase of 63% in TSB and 97% in TSN indicating a higher ratio of immature to mature fish, as in previous years (Figure 11). Stratum 6 (Faroes/Shetland Channel), saw the largest increase in TSB (140%) and TSN (181%) by stratum as compared to 2025. A high proportion of immature fish was observed in stratum 6 and this is consistent with previous years.

Echograms

Each survey participant provided an echogram of their highest density registration (NASC) per 1 nmi EDSU (Figure 7a-d).

Stock composition

Otolith aged fish from the survey showed ages from 1 to 10 years (10+ group), Table 5 and Figure 11.

The spawning stock biomass was dominated by the age groups 3 to 5. Combined, these age cohorts represent 72% of TSB and 68% of TSN. In terms of abundance, 5-year-olds (2021 year-class) were most abundant (30%), followed by the 4-year-olds (2022 year-class) at 20% (Table 5).

The largest fish were found in stratum 2, with a mean length of 27.1 cm and a mean weight of 95.6 g (Figures 8 & 9).

Immature fish represented 3% of TSB and 5% of TSN. Over 92% of the 2-year-old fish were mature contributing to the SSB of the stock (Table 5).

The CV of the total estimate of abundance was 0.19, which is higher than 2025 (2025= 0.17, 2024= 0.13 and 2023= 0.16).

The survey time series (2004-2026) of TSN and TSB are presented in Figures 13 and 14 respectively and Table 6.

Hydrography

In total, 69 CTD casts were undertaken over the course of the survey (Table 1), a reduction of 30% as compared to 2025. This can be accounted for mainly by the Dutch mechanical breakdown, and to a lesser extent by unsuitable weather conditions. Horizontal plots of temperature and salinity at depths of 50 m, 100 m, 200 m and 500 m as derived from vertical CTD casts are displayed in Figures 15-18, respectively.

A decrease in salinity observed in 2017 persisted through 2018 and 2019 but seems to have reversed again in 2020 with an increasing trend. Pre-2020, this is thought to have limited the western extent of the blue whiting spawning distribution on the Rockall and Hatton Bank areas. Observations since 2022 are in agreement with a reversing trend (in salinity mainly), with a more western extension of fish into the Rockall Trough than observed in recent years. In 2024, blue whiting were found on the eastern slopes of the Rockall Plateau. However, in 2025 almost no blue whiting was observed towards the western part of the transects in the Rockall Trough (stratum 3) indicating an eastward contraction of the fish in 2025. This was consistent with observations in 2026.

Mesopelagic fish

Echogram scrutinisation for mesopelagic fish species was conducted by participants during the survey and will be uploaded to the ICES database after further analysis.

Concluding remarks

Main results

- Weather conditions were poor for a large portion of the survey, with all vessels experiencing multiple days of weather downtime.
- The International Blue Whiting Spawning Stock Survey 2026 shows an 32% increase in TSB and a corresponding 34% increase in TSN as compared to the 2025 estimate.
- In terms of abundance, 5-year-olds (2021 year-class) were most abundant (30%), followed by the 4-year-olds (2022 year-class) at 20%.
- Immature fish represented 3% of TSB and 5% of TSN. Over 92% of the 2-year-old fish were mature contributing to the SSB of the stock.
- Estimated uncertainty around the total stock abundance was CV=0.19 (CV=0.17 in 2025).
- Stratum 5 (Rockall Bank) was not surveyed this year, or in 2025. Effort was instead focused on core distribution areas on the shelf edge where the bulk of the stock was located. Real time survey observations and fleet activity determined effort allocation during the survey. The group considered that the stock was sufficiently contained within the survey area to support this decision.
- In terms of biological sampling, the number of trawl stations decreased (-24%) as compared to 2025 and this was directly related to the poor weather encountered. As a result, the number of aged fish and measured fish were also reduced compared to 2025 (-9% and –34% respectively). That said, the stock was considered sufficiently sampled across core distribution areas.
- The survey was carried out in 21 days, within the 21-day target window. Temporal progression was considered well aligned, despite the poor weather conditions. Core areas were representatively sampled by multiple vessels.

Interpretation of the results

- The group considers the 2026 estimate of abundance as robust given the poor weather conditions encountered.
- The bulk of the stock was located in the northern half of Stratum 3 and would indicate an earlier peak spawning, as was observed in 2025.

Recommendations

- The group recommends that coverage in the western Rockall/Hatton Bank (stratum 5) should be carried out based on real-time observations, including input from national fisheries to monitor westward expansion an eastward contraction phase.

- To facilitate the process of calculating global biomass the group requires that all data be made available as soon as possible, and no later than 72 hours, before the post cruise meeting.
- It is recommended that the survey coordinator be notified to any changes made to Acoustic or Biotic files upload files to the ICES database after the initial upload. This is to ensure that the most up to date data is available during the meeting.
- Hydrographic and Plankton data along with Logbook files formats should still be submitted in the PGNAPES format
- It is recommended that the effective timing of the survey starting point is maintained to begin around the 20th March in 2026.

Achievements

- All survey data were uploaded to the ICES trawl-acoustic database and the PGNAPES database well in advance of the post cruise meeting.
- Good temporal progression between vessels.
- Good spatial coverage given poor weather conditions.

References

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Table 1. Country and vessel specific details, IBWSS March-April 2026.

	Celtic Explorer	Jákup Sverri	Tridens	Vendla	Vizconde de Eza
<u>Trawl dimensions</u>					
Circumference (m)	768	832	860	832	752
Vertical opening (m)	50	31	30-70	45	20
Mesh size in codend (mm)	20	45	40	40	20
Typical towing speed (kts)	3.5	3.2	3.5-4.0	3.5-4.0	3.5-4.0
<u>Plankton sampling</u>					
Sampling net	-	WP2 plankton net	-	WP2 plankton net	-
Standard sampling depth (m)	-	200	-	400	-
<u>Hydrographic sampling</u>					
CTD Unit	SBE911	SBE911	SBE911	SBE25	RBR Concerto
Standard sampling depth (m)	1000	1000	1000	1000	1000

Table 2. Acoustic instruments and settings for the primary acoustic sampling frequency, IBWSS March-April 2026.

	Celtic Explorer	Jákup Sverri	Tridens	Vendla	Vizconde de Eza
Echo sounder	Simrad EK 60	Simrad EK80	Simrad EK 80	Simrad EK 80	Simrad EK 80
Frequency (kHz)	**38**, 18, 120, 200	18, **38**, 70, 120, 200, 333	18, **38**, 70, 120, 200	18, **38**, 70	**38**, 18, 70, 120, 200
Primary transducer	ES 38B	ES 38-7	ES 38B	ES 38B	ES 38-7
Transducer installation	Drop keel	Drop keel	Drop keel	Drop keel	Drop keel
Transducer depth (m)	8.8	6-9	8.3	8.5	5
Upper integration limit (m)	20	15	15	15	19.08
Absorption coeff. (dB/km)	9.4	10.4	10.1	10.0	9.5
Pulse length (ms)	1.024	1.024	1.024	1.024	1.024
Band width (kHz)	2.43	3.06	3.06	2.43	3.06
Transmitter power (W)	2000	2000	1800	2000	2000
Angle sensitivity (dB)	21.9	21.9	18.0	21.9	21.9
2-way beam angle (dB)	-20.6	-20.4	-20.7	-20.7	-20.7
Ts Transducer gain (dB)	25.55	26.88	26.25	26.82	26.81
s_A correction (dB)	-0.79	-0.03	-0.15	-0.63	-0.1456
3 dB beam width (dg)					
alongship:	6.79	6.43	6.60	6.93	6.76
athw. ship:	6.79	6.43	6.59	6.94	6.91
Maximum range (m)	1000	750	800	750	1000
Post processing software	Echoview	LSSS	LSSS	LSSS	Echoview

Table 3. Survey effort by vessel, IBWSS March-April 2026.

Vessel	Effective survey period	Sum of EDSU (nmi)	Trawl stations	CTD stations	Plankton samples	Mesopelagic samples	Aged fish	Length-measured fish
C Explorer	19/03-02/04	1,011	6	19	-	-	300	3,472
Jákup Sverri	29/03-08/04	1,011	6	18	16	-	399	950
Vendla	19/03- 28/03	1,280	10	18	17	-	300	1,000
Tridens	19/03-7/04	1,341	13	0	-	-	1,000	2,423
Vizc de Eza	20/03-27/03	668	0	14	-	-	0	0
Total	19/03-08/04	5,311	35	69	33	-	1,999	7,845

Note: No CTD sampling by Tridens due to mechanical failure.

Table 4. Abundance and biomass estimate of blue whiting by stratum. IBWSS March-April 2026.

Stratum	Name	2026				2025				Diff 2026-2025	
		TSB (10^3 t)	TSN (10^9)	% TSB	% TSN	TSB (10^3 t)	TSN (10^9)	% TSB	% TSN	TSB	TSN
1	Porcupine Bank	54	579	1.8	1.8	111	1,201	4.9	5.0	-52 %	-52 %
2	N Porcupine Bank	216	2,257	7.2	7.0	132	1,390	5.8	5.7	64 %	62 %
3	Rockall Trough	2,288	24,179	76.7	74.5	1,810	19,323	80.0	79.9	26 %	25 %
4	South Faroes	135	1,762	4.5	5.4	83	896	3.6	3.7	63 %	97 %
5	Rockall Bank	1	8	0.0	0.0	0	0	0.0	0.0	-	-
6	Faroe/Shetland Ch.	274	3,482	9.2	10.7	115	1,249	5.1	5.2	138 %	179 %
7	Porcupine Seabight	15	181	0.5	0.6	12	117	0.5	0.5	28 %	55 %
	Total	2,982	32,448	100	100	2,262	24,176	100	100	32 %	34 %

Table 5. Survey stock estimate of blue whiting (determined from StoX baseline output), IBWSS March-April 2026.

Length	Age in years (year class)										Number	Biomass	Mean	Prop
Length	1	2	3	4	5	6	7	8	9	10+			weight	Mature
(cm)	2025	2024	2023	2022	2021	2020	2019	2018	2017		(10^6)	(10^6 kg)	(g)	
14-15											0	0	0.0	0
15-16											0	0	0.0	0
16-17	26										26	0	18.6	0
17-18	94										94	2	24.7	0
18-19	146										146	4	29.7	86
19-20	384										384	15	38.7	67
20-21	620	10									630	29	45.7	50
21-22	547	166	8								721	37	51.2	56
22-23	194	1,240	5	1							1,441	76	52.9	76
23-24	17	1,728	372		19						2,136	129	60.3	89
24-25	18	1,123	830	3	24						2,000	141	70.6	97
25-26		545	1,637	555	612	21					3,369	268	79.4	99
26-27		222	1,618	1,673	1,453	347					5,312	451	84.8	100
27-28		15	900	1,667	2,046	530	22	14			5,192	492	94.7	100
28-29			303	1,738	2,585	564	33	14			5,238	551	105.2	100
29-30			47	400	1,155	491	15	1			2,109	248	117.4	100
30-31			29	237	983	309	67		32		1,656	215	130.1	100
31-32				92	431	458	9	15		4	1,009	149	147.4	100
32-33				131	194	113	16		13		467	75	159.8	100
33-34			19	0	105	55		19			198	34	173.3	100
34-35				11	15	85	34	23		18	186	36	195.5	100
35-36				25	50		4	9			88	20	222.3	100
36-37						15	7	9			31	7	212.7	100
37-38										3	3	1	235.8	100
38-39							1	5			5	1	282.9	100
39-40										6	6	2	275.5	100
40-41										0	0	0	294.6	100
41-42											0	0	0.0	100
42-43											0	0	0.0	100
43-44														
44-45														
TSN(mill)	2,046	5,048	5,768	6,533	9,674	2,987	209	107	45	22	32,448			
TSB(1000 t)	92.9	322.9	470.3	646.2	1,029.1	359.8	30.4	18.1	6.1	3.9	2,982.2			
Mean length(cm)	20.0	23.3	25.6	27.3	27.9	28.9	30.5	32.2	30.6					
Mean weight(g)	45	64	82	99	106	120	146	169	137					
% Mature	58	92	96	100	100	100	100	100	100	100				
SSB (1000kg)	54.0	297.9	449.7	646.2	1029.1	359.6	30.4	18.1	6.1	3.9	2,894.8			
SSN (mill)	1,189	4,657	5,515	6,533	9,674	2,985	209	107	45	22	30,935.1			

Table 6. Time series of StoX abundance estimates of blue whiting (millions) by age in the IBWSS, 2026. Total biomass in last column (1000 t).

	Age										
Year	1	2	3	4	5	6	7	8	9	10+	TSB (1000 t)
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
2018	836	628	6,615	21,490	7,692	2,187	755	188	72	144	4,035
2019	1,129	1,169	3,468	9,590	16,979	3,434	484	513	99	144	4,198
2020*											
2021	1,948	2,095	2,545	2,275	3,914	3,197	3,379	463	189	114	2,357
2022	4,461	9,313	4,830	5,460	2,587	1,880	898	1,764	71	178	2,707
2023	873	8,135	14,771	2,744	1,352	711	520	202	508	67	2,501
2024	729	2,885	18,767	10,787	1,843	577	518	487	42	41	3,176
2025	650	2,236	3,598	12,034	4,741	546	203	88	37	41	2,262
2026	2,046	5,048	5,768	6,533	9,674	2,987	209	107	45	22	2,982

* Survey discarded. # No survey due to pandemic.

Table 7. IBWSS survey effort time series.

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
2018	128,030	7,296	49	101	45	5,315	2,619
2019	121,397	7,610	38	118	17	6,228	1,938
2021	118,169	7,794	45	102	8	12,019	2,089
2022	126,235	5,812	47	99	57	6,499	2,372
2023	133,186	8,586	42	89	54	7,798	2,365
2024^	127,183	6,411	42	106	38	7,915	2,366
2025	100,490	5,892	46	98	42	11,928	2,199
2026	102,498	5,311	35	69	33	7,845	1,999
Diff	2%	-10%	-24%	-30%	-21%	-34%	-9%

* End of Russian participation, ^ change from sum transect miles to sum of EDSU's (1 nmi) sampled.

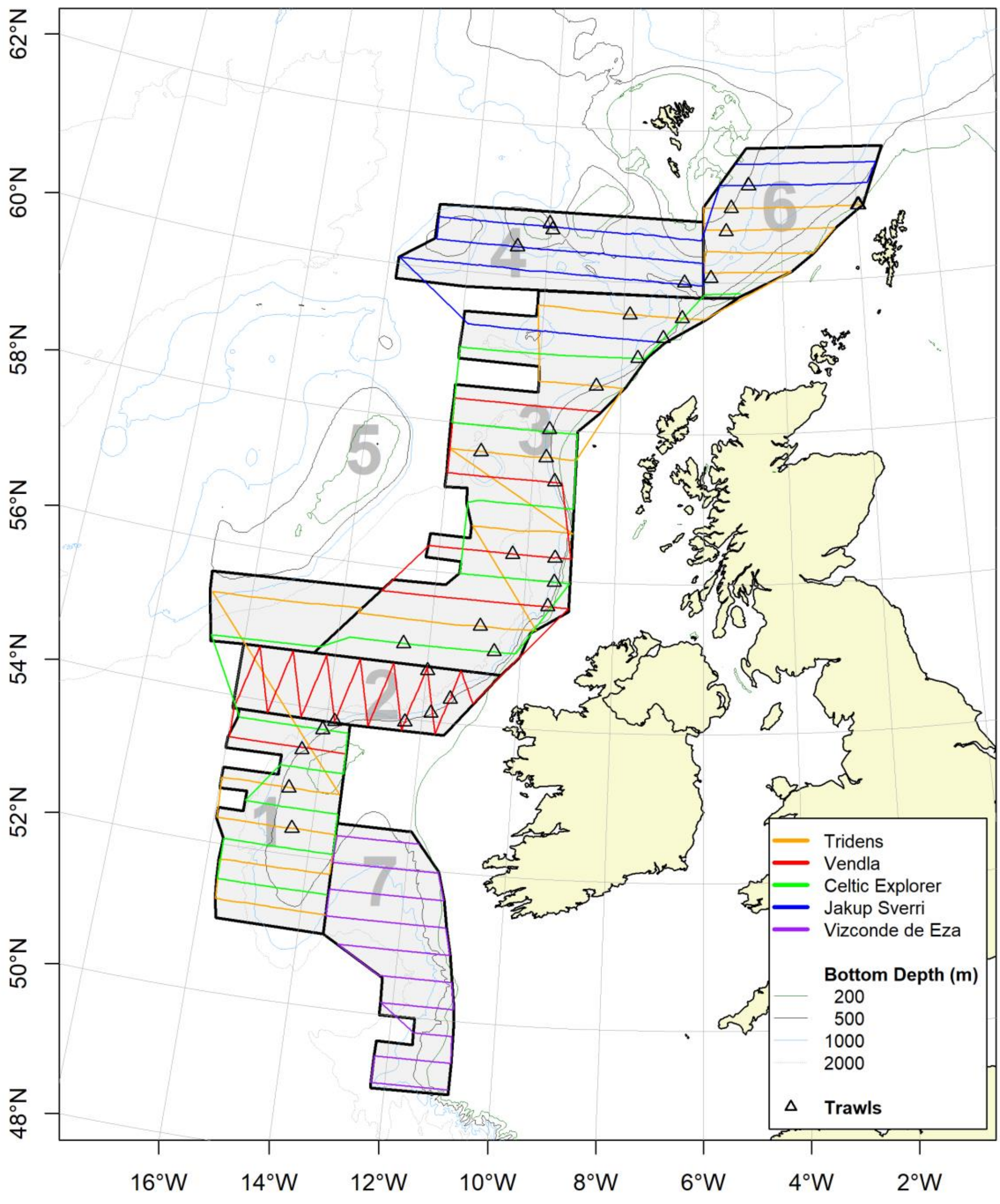


Figure 1. Strata, cruise tracks and trawl hauls for the individual vessels (country) during the International Blue Whiting Spawning Stock Survey (IBWSS) from March-April 2026. Faroe Islands (RV *Jákup Sverri*); Ireland (RV *Celtic Explorer*); Netherlands (RV *Tridens)*; Norway (FV *Vendla*) and Spain (RV *Vizconde de Eza*)

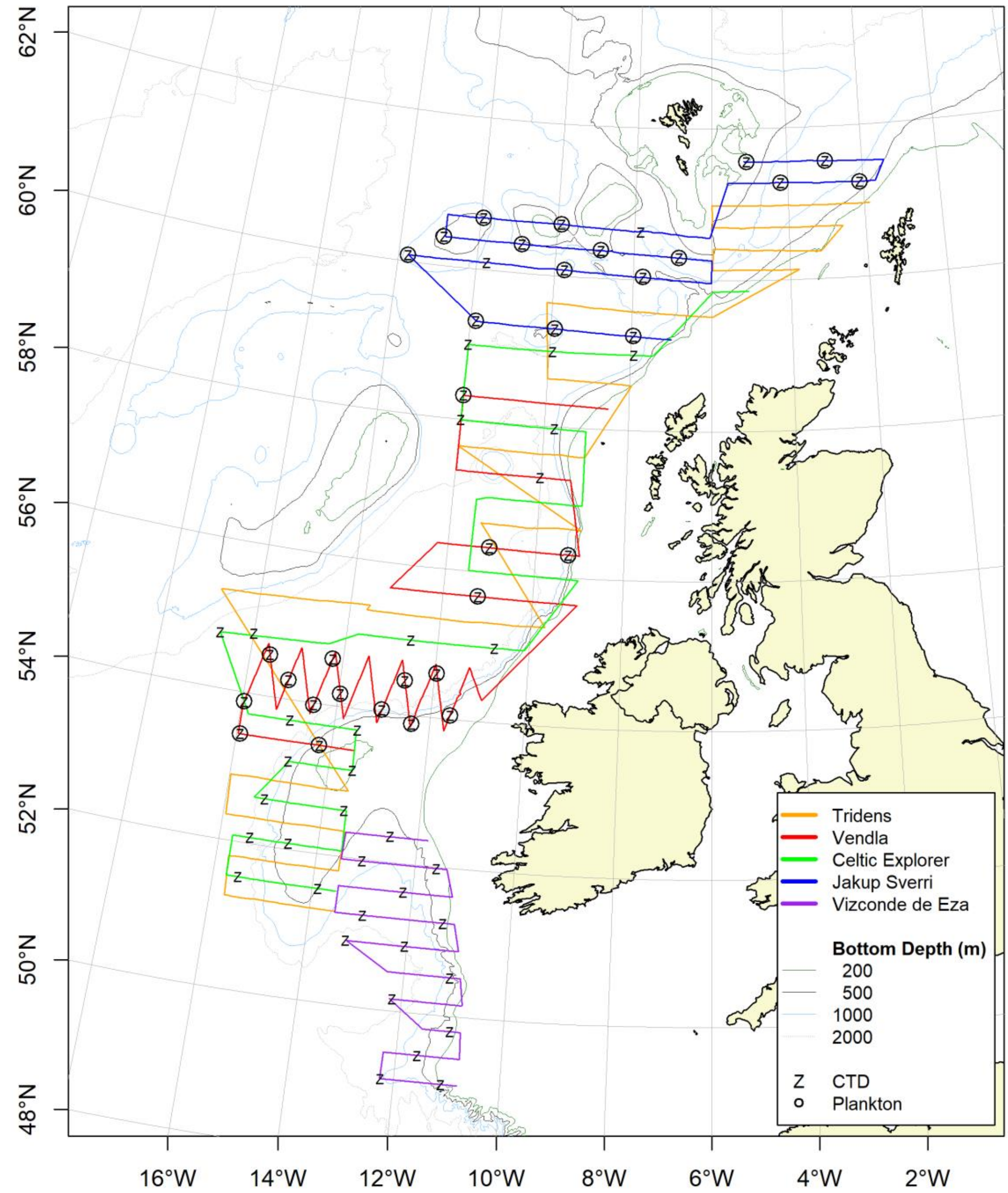


Figure 2. Vessel cruise tracks with hydrographic CTD stations (z) and WP2 plankton net samples (circles) during the International Blue Whiting Spawning Stock Survey (IBWSS) from March-April 2026.

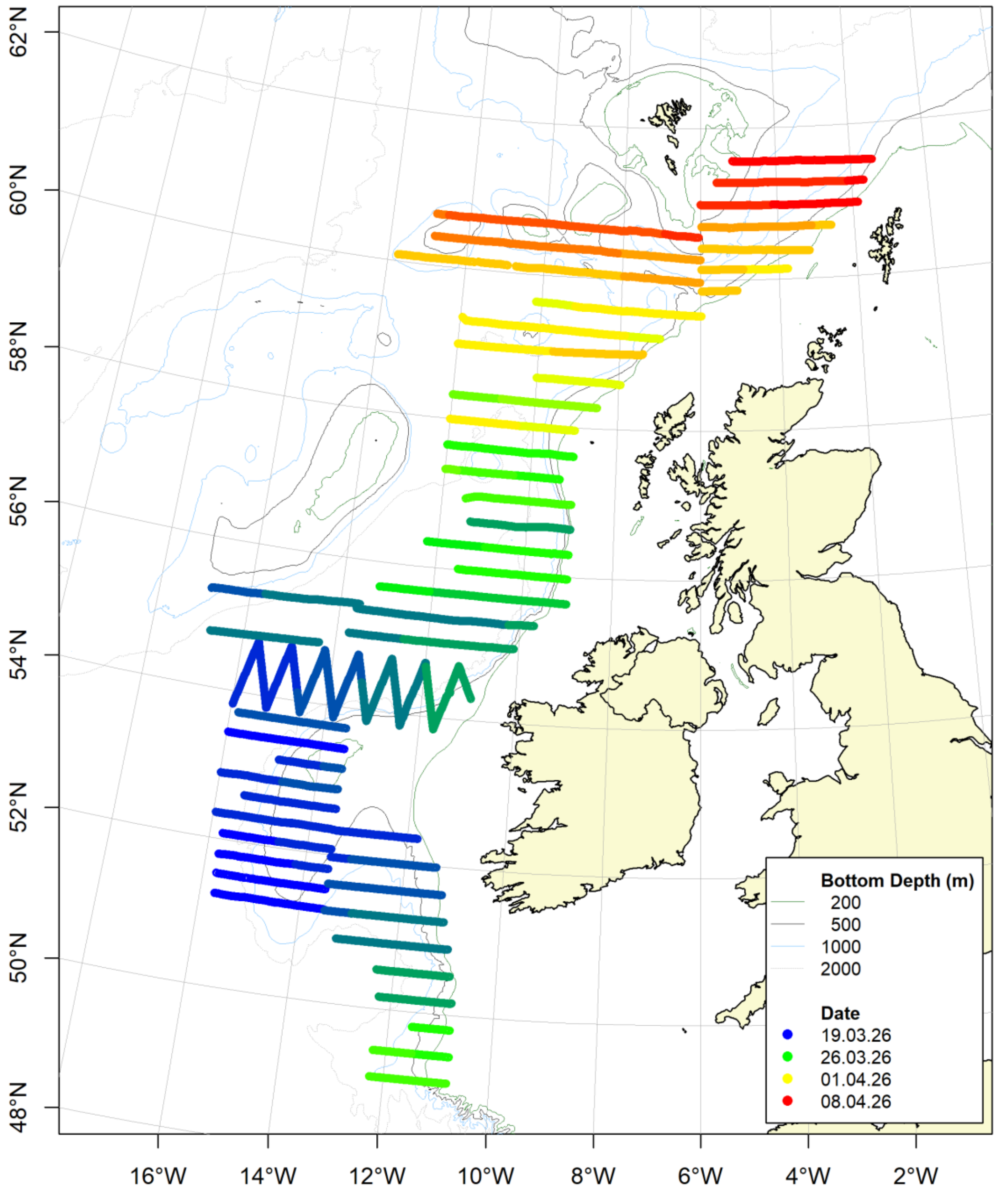


Figure 3. Temporal progression for the International Blue Whiting Spawning Stock Survey (IBWSS) from March-April 2026.

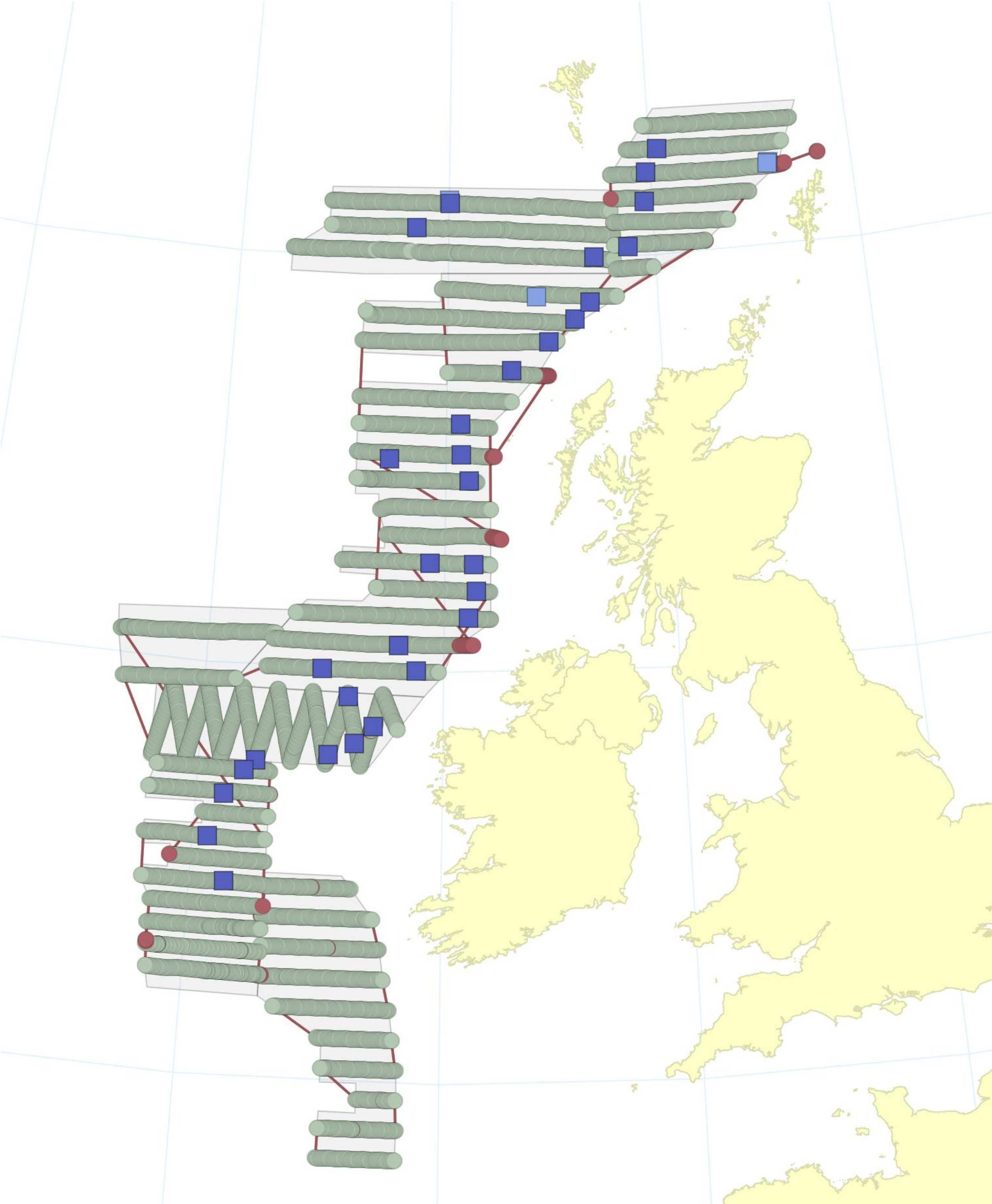


Figure 4. Tagged acoustic transects (green circles) with associated trawl stations containing blue whiting (dark blue squares) used in the StoX abundance estimation. IBWSS March-April 2026.

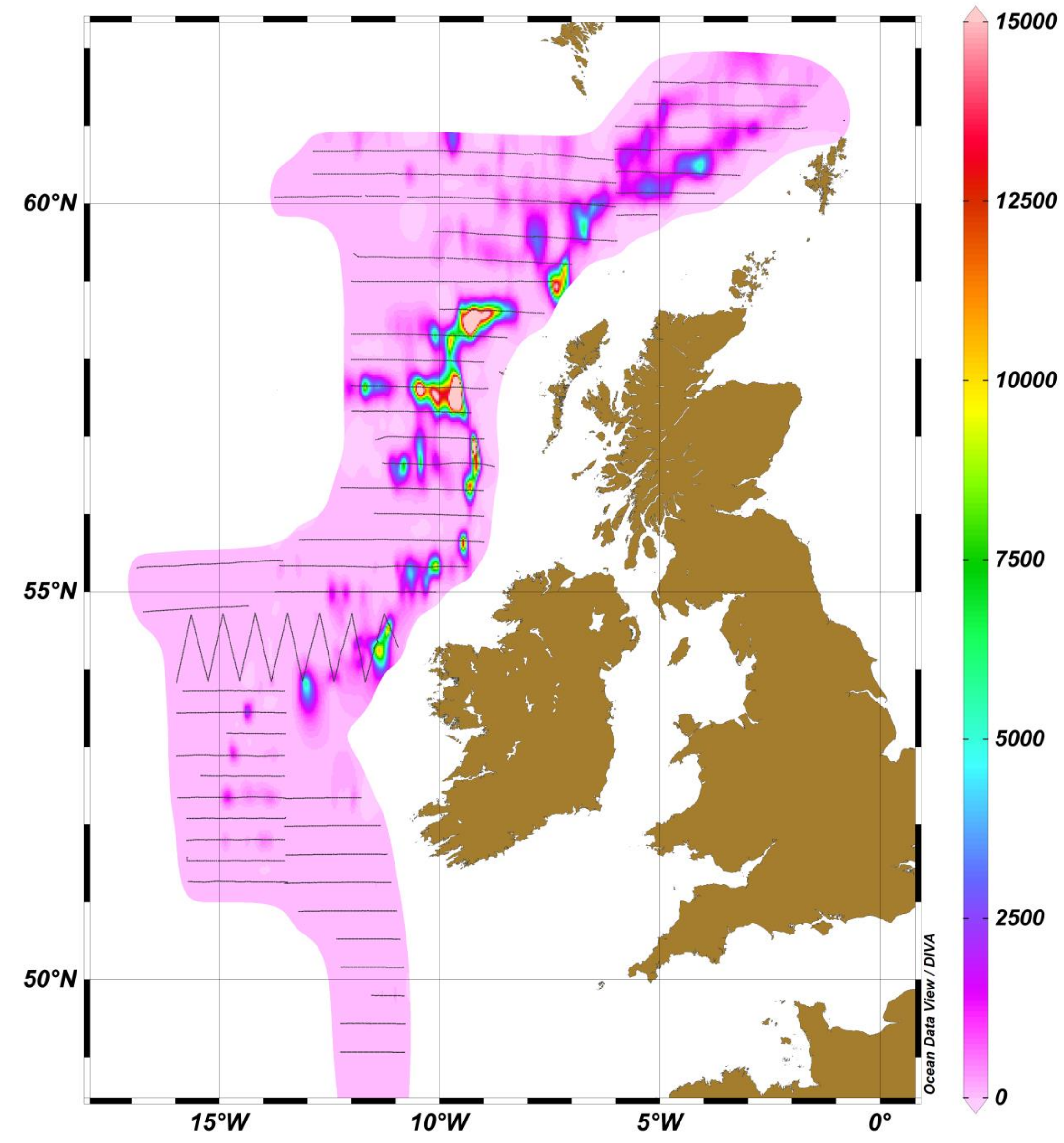


Figure 5. Acoustic density heat map (s_A m^2/nmi^2) of blue whiting during the International Blue Whiting Spawning Stock Survey (IBWSS) from March-April 2026.

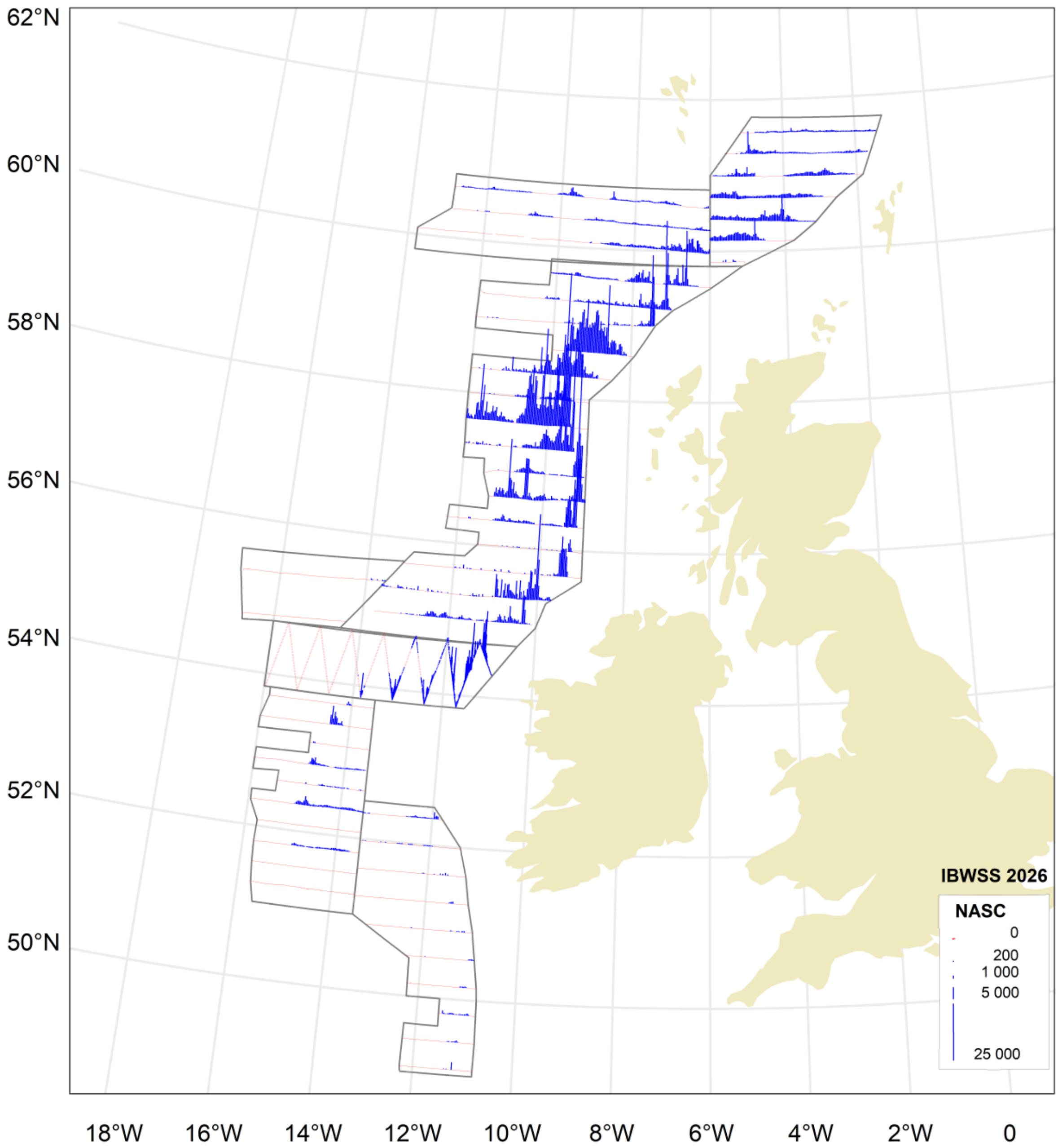
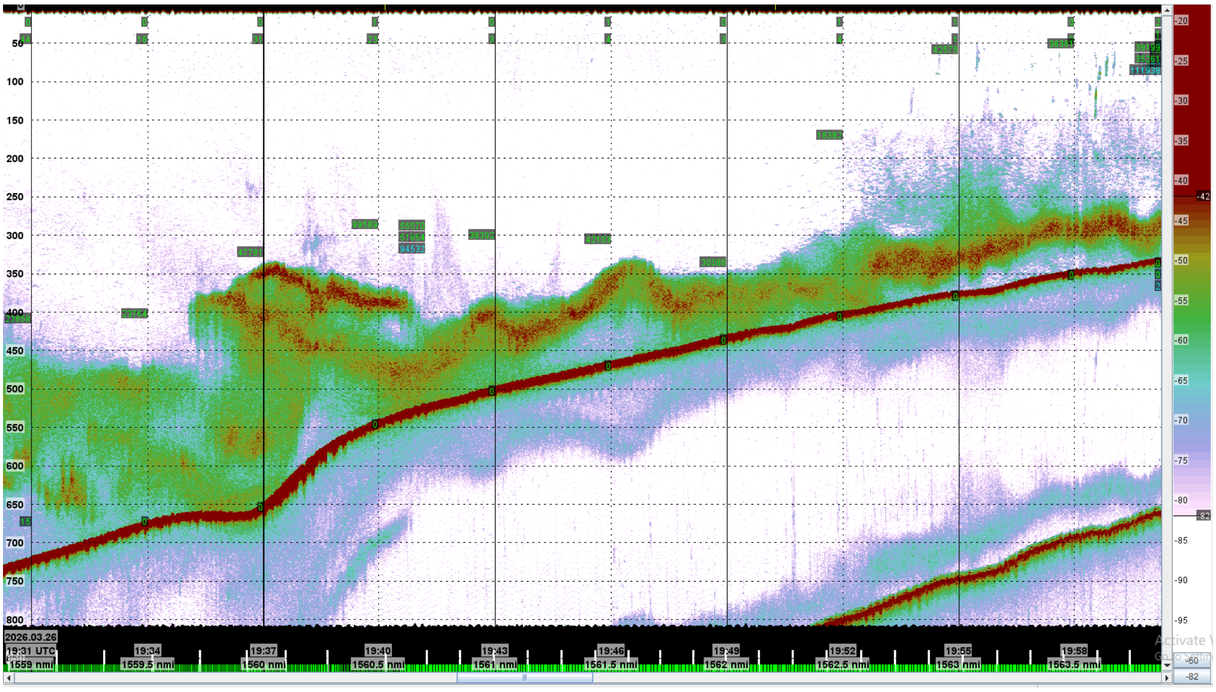
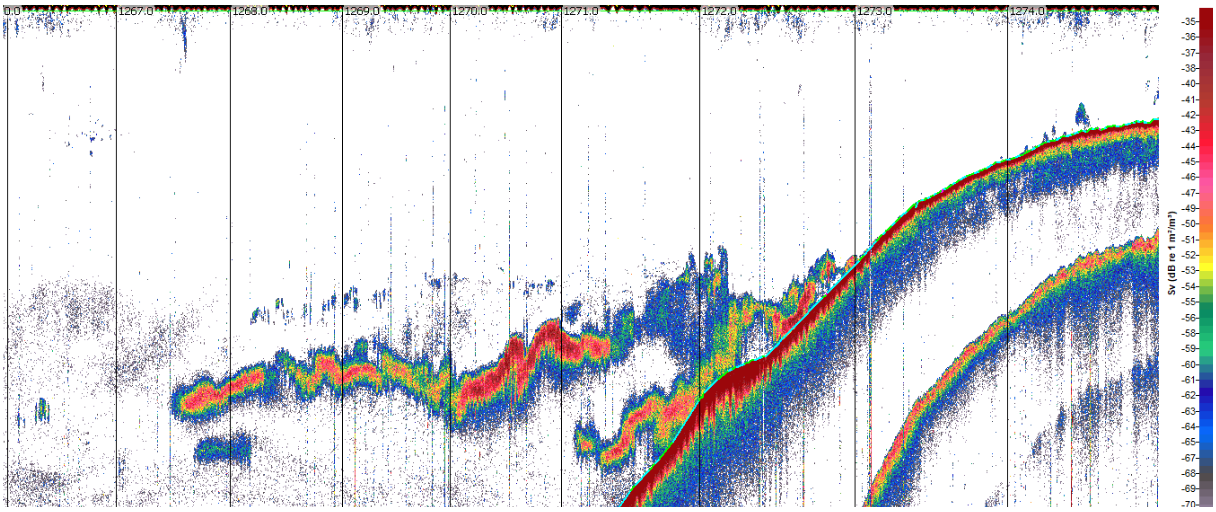


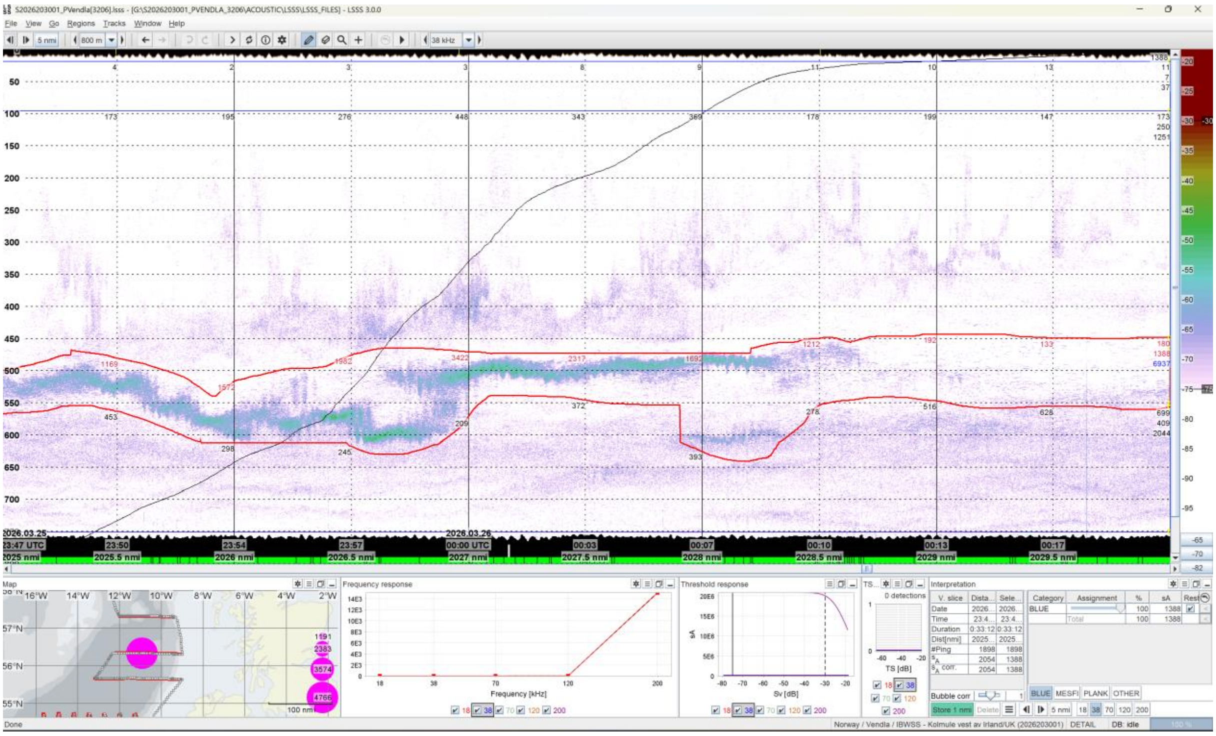
Figure 6. Map of proportional acoustic density (s_A m^2/nmi^2) of blue whiting by 1 nmi sampling unit. IBWSS March-April 2026.



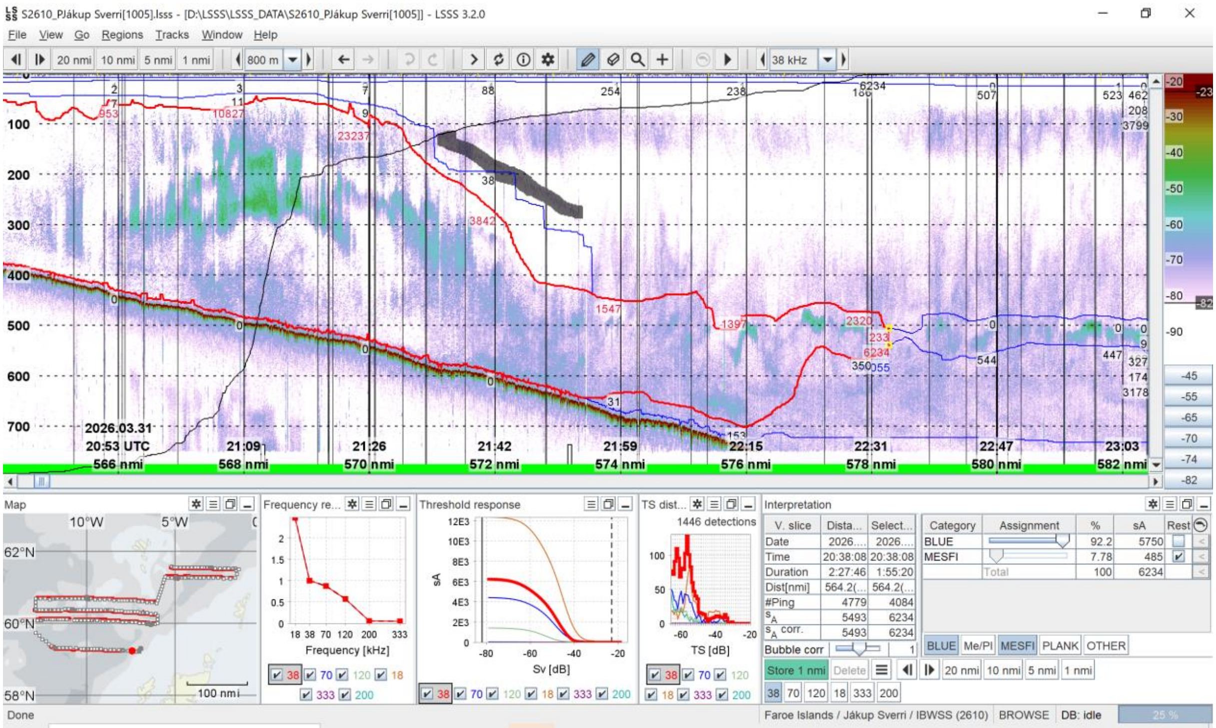
a) Highest density blue whiting recorded by FRV *Tridens*, Netherlands, per 1 nmi log interval (s_A value 67,421m²/nmi², log 1560-1561) during the IBWSS survey in the Rockall Trough area (Stratum 3).



b) Single highest density blue whiting school (s_A value 48,891m²/nmi²) by 1 nmi recorded by the RV *Celtic Explorer* at the shelf edge in the Rockall Trough (Stratum 3).



c) Loose layer of blue whiting recorded by the FV *Vendla* offshore in the Rockall Trough (Stratum 3).



d) High density acoustic registrations (38 kHz) of blue whiting with the Faroese RV *Jákup Sverri* on 31 March 2026 on the shelf break northwest of the Hebrides.

Figure 7. Echograms of interest encountered during the IBWSS, March-April 2026. Vertical banding represents 1 nmi acoustic sampling intervals (EDSU). All echograms presented at 38 kHz.

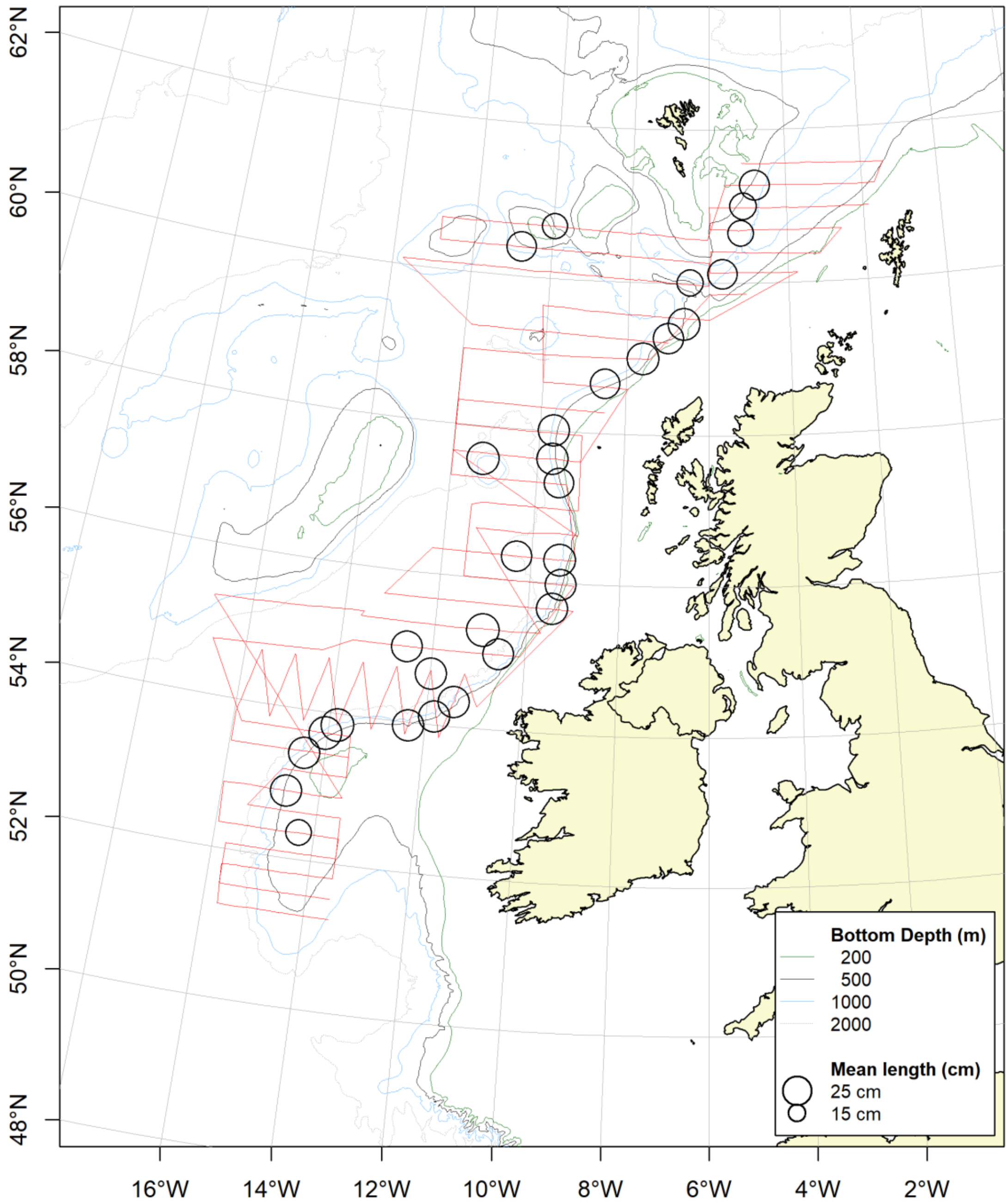


Figure 8. Combined mean length of blue whiting from trawl catches by vessel, IBWSS in March-April 2026.

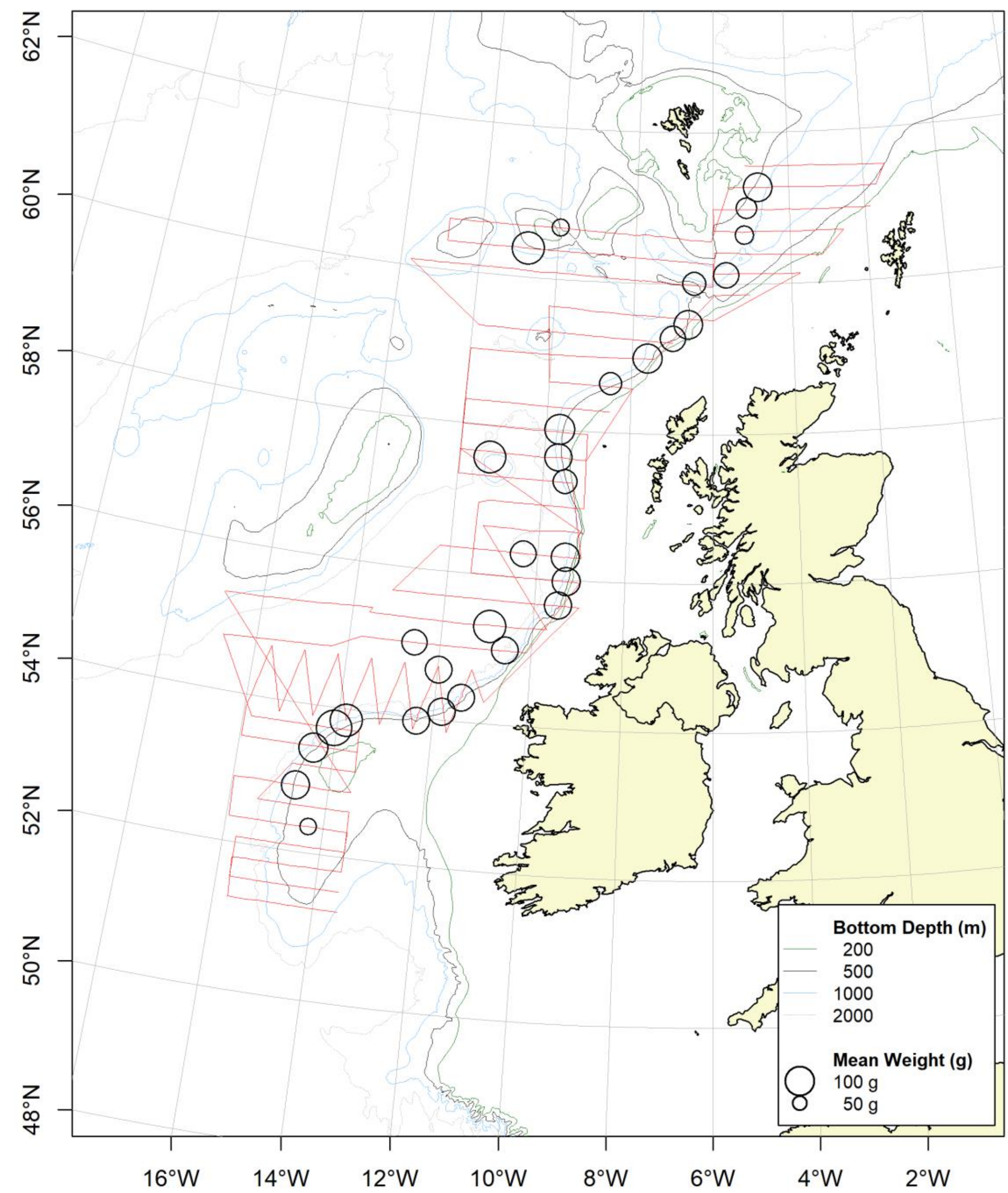


Figure 9. Combined mean weight of blue whiting from trawl catches, IBWSS March-April 2026.

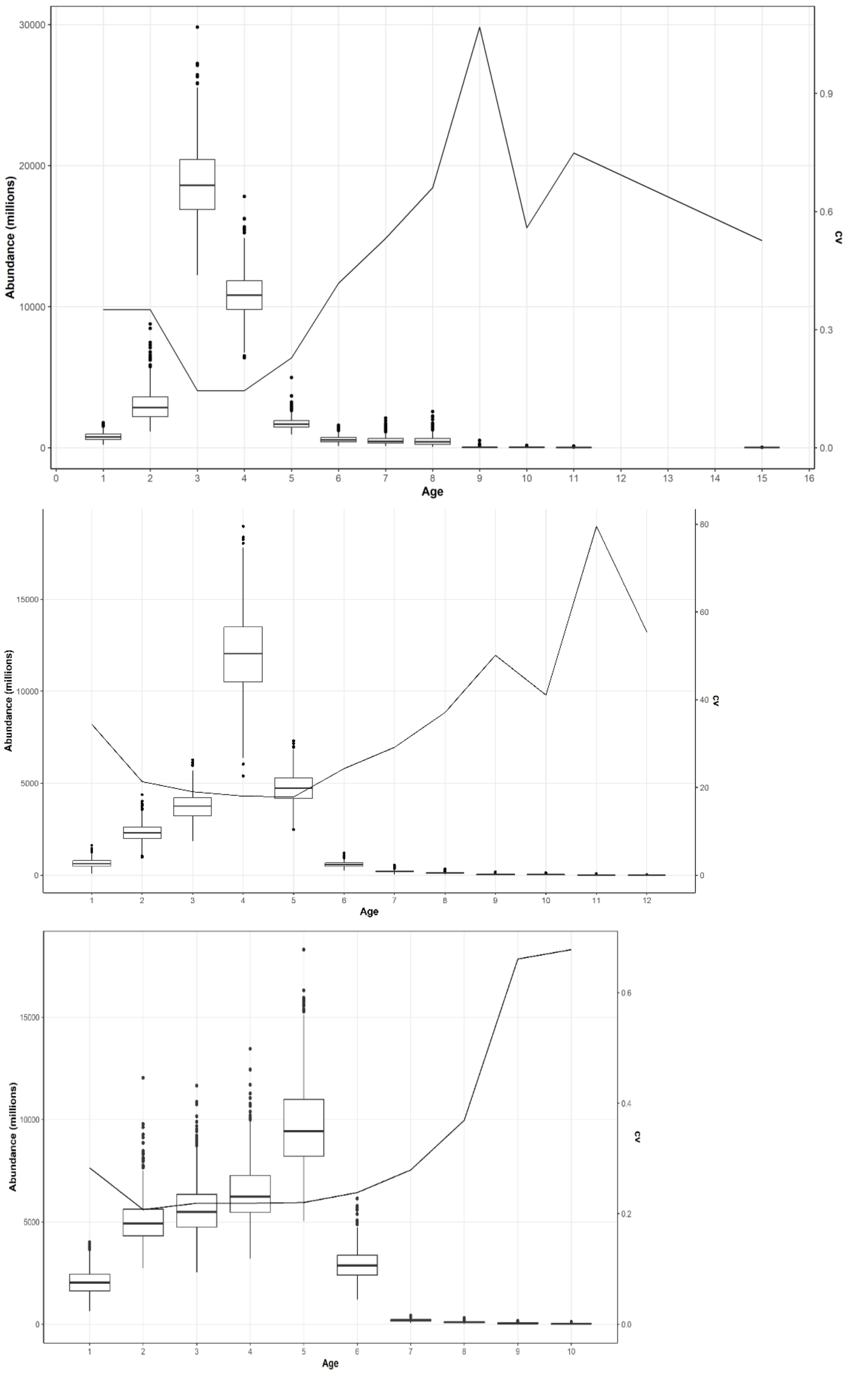


Figure 10. Blue whiting bootstrap abundance (millions) by age (left axis) and associated CVs (right axis) in 2024 (top panel), 2025 (middle panel) and 2026 (lower panel). From StoX.

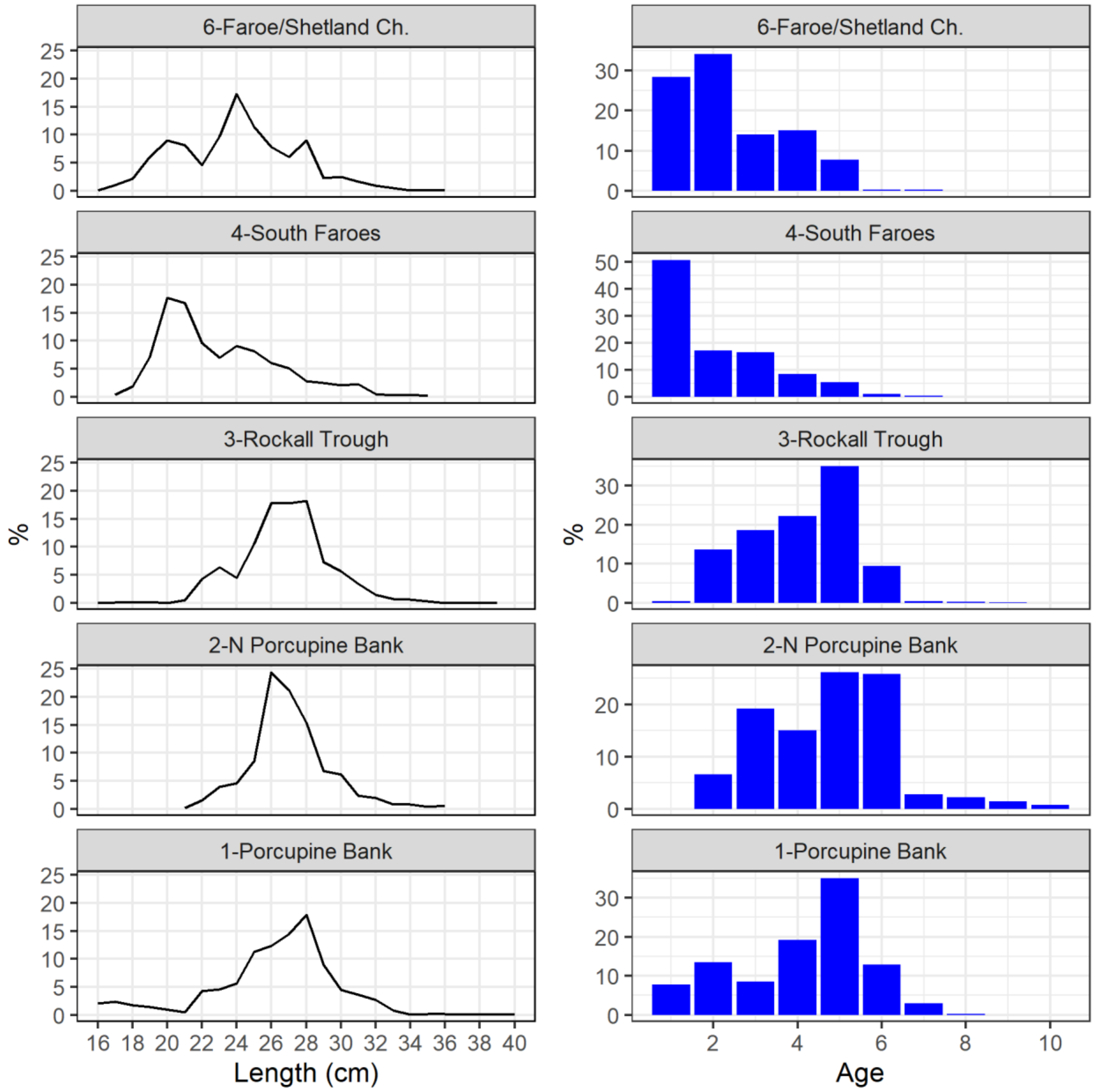
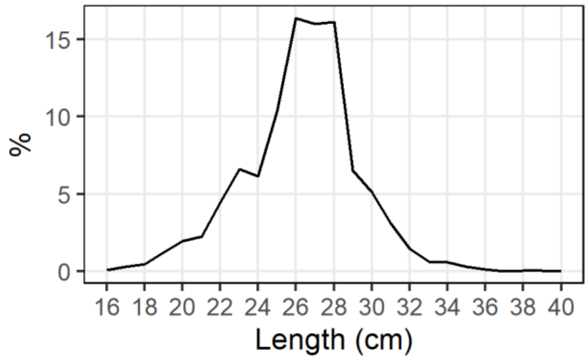


Figure 11. Length and age distribution (numbers) of blue whiting by survey strata. March-April 2026. No biological samples from Stratum 5 and 7.



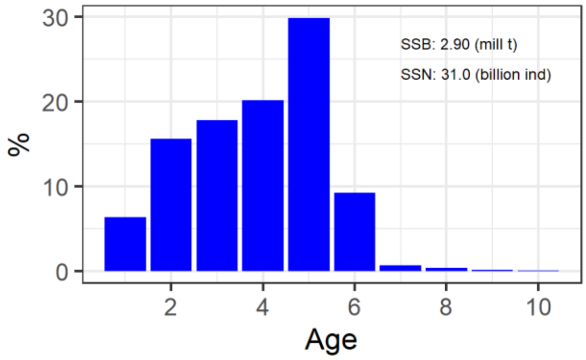


Figure 12. Length and age distribution (numbers) of total stock of blue whiting. March-April 2026.

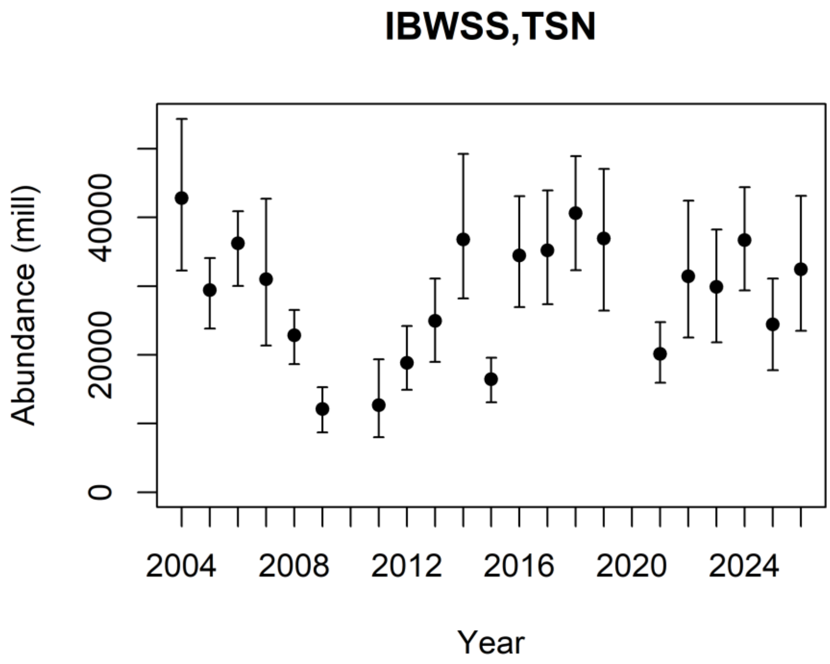


Figure 13. Time series of StoX survey indices of blue whiting abundance, 2004-2026, excluding 2010 and 2020.

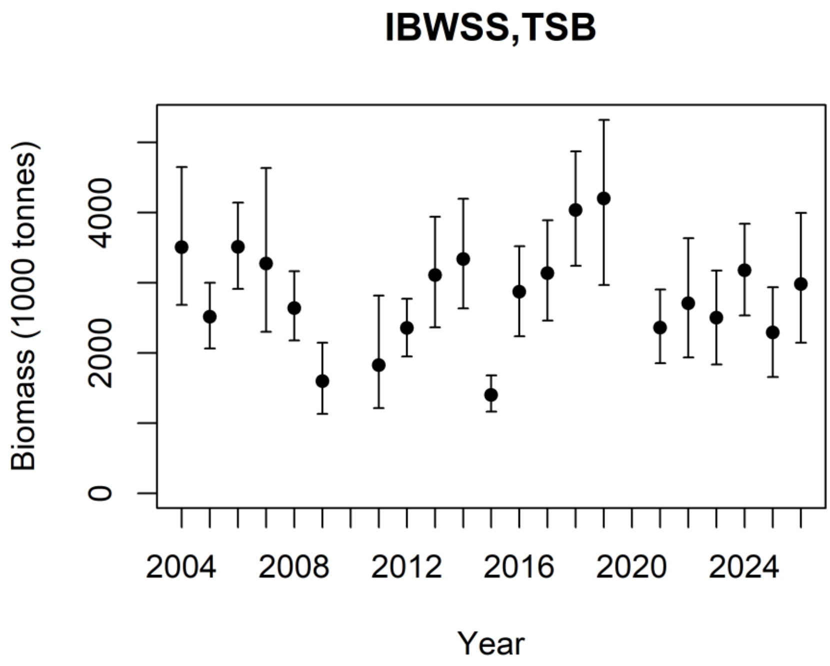


Figure 14. Time series of StoX survey indices of blue whiting biomass, 2004-2026, excluding 2010 and 2020.

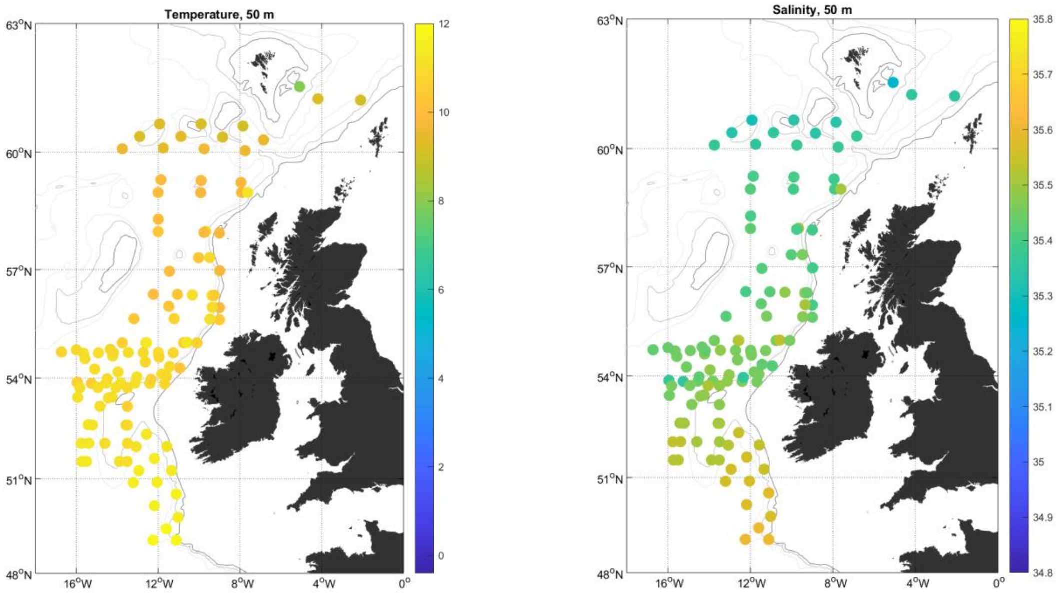


Figure 15. Horizontal temperature (left panel) and salinity (right panel) at 50 m subsurface as derived from vertical CTD casts. IBWSS March-April 2026

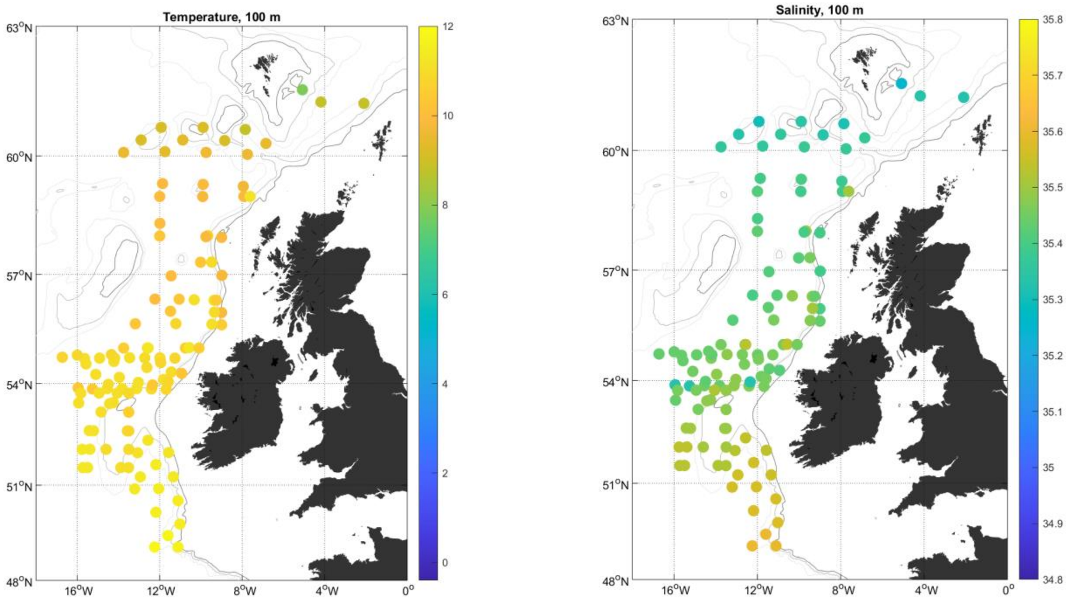


Figure 16. Horizontal temperature (left panel) and salinity (right panel) at 100 m subsurface as derived from vertical CTD casts. IBWSS March-April 2026.

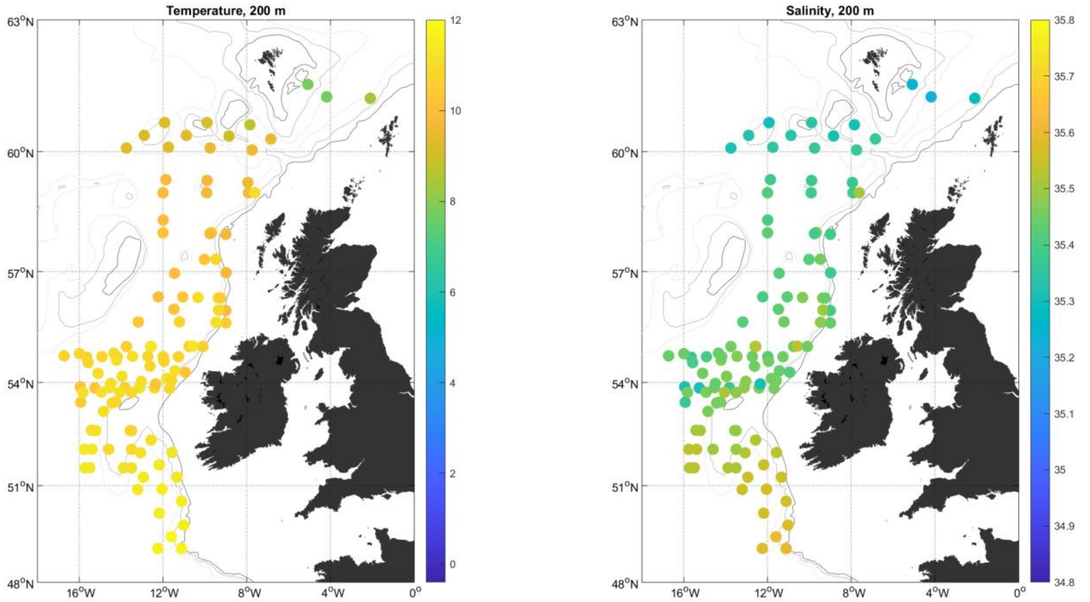


Figure 17. Horizontal temperature (left panel) and salinity (right panel) at 200 m subsurface as derived from vertical CTD casts. IBWSS March-April 2026.

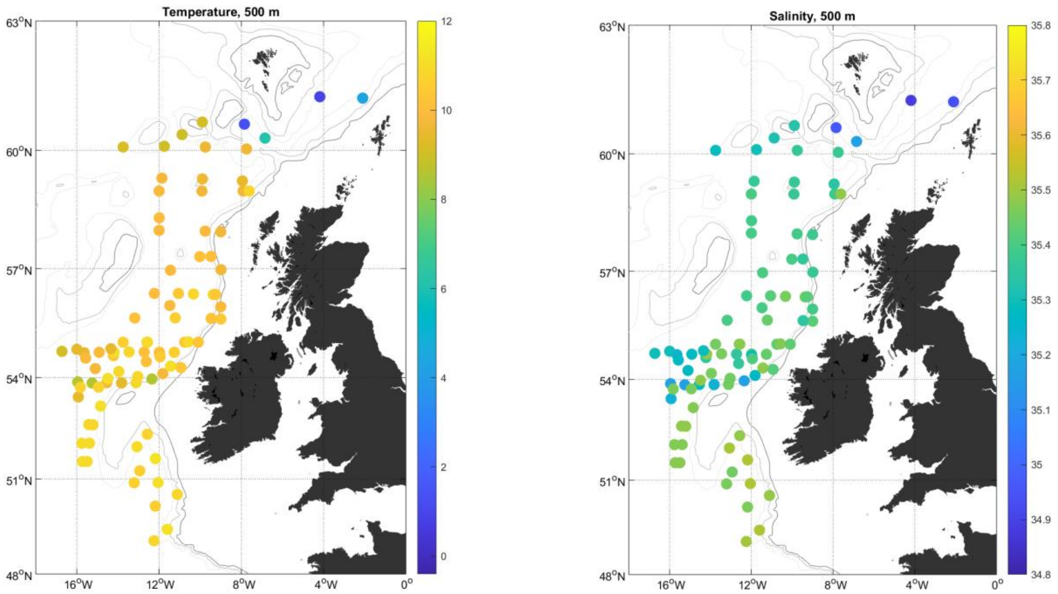


Figure 18. Horizontal temperature (left panel) and salinity (right panel) at 500 m subsurface as derived from vertical CTD casts. IBWSS March-April 2026.

Annex 1

Potential effects of rough weather (IBWSS 2026)

Serdar Sakinan

When steaming directly into oncoming waves during rough weather, air bubbles are frequently forced beneath the drop keel. This phenomenon, known as bubble sweep-down, causes acoustic attenuation and signal degradation that can mask underlying fish schools and negatively bias biomass estimates. On the contrary, steaming with the waves generally reduces vessel pitch and bow-wave breaking, which minimizes sweep-down and yields higher-quality acoustic data. Accounting for these directional weather effects is therefore critical when interpreting survey results. During the IBWSS on March 25–26, 2026, the RV Tridens incidentally recorded a direct comparison of these conditions. The vessel completed a continuous westward transect along 57.63°N (from 9.100°W to 12.000°W) into the Rockall Trough, steaming directly against the waves. Upon reaching the end of the track, the vessel reversed course and returned along the exact same route with the weather behind it. Because this unplanned repeated pass crossed a well-known, high-density blue whiting hotspot on the continental shelf edge, it provided an ideal, real-world demonstration of wave-induced acoustic attenuation and its impact on data quality.

Material & Methods

The *westbound* pass started on 25 March at 20:28 UTC (Log 1367; 9.100°W), moving from the continental shelf into the Rockall Trough. Steaming against a rough westerly sea state causing pronounced vessel pitch and bubble sweep-down. During this leg, a dense blue whiting aggregation was observed along the shelf slope, with densities declining westward. The *eastbound* return pass along the same transect began on 26 March at 12:22 UTC (Log 1483; 12.000°W) and concluded at 21:17 UTC (Log 1577; 9.094°W). Although wind speeds had increased, steaming with the prevailing following seas significantly reduced vessel pitch and largely eliminated bubble sweep-down.

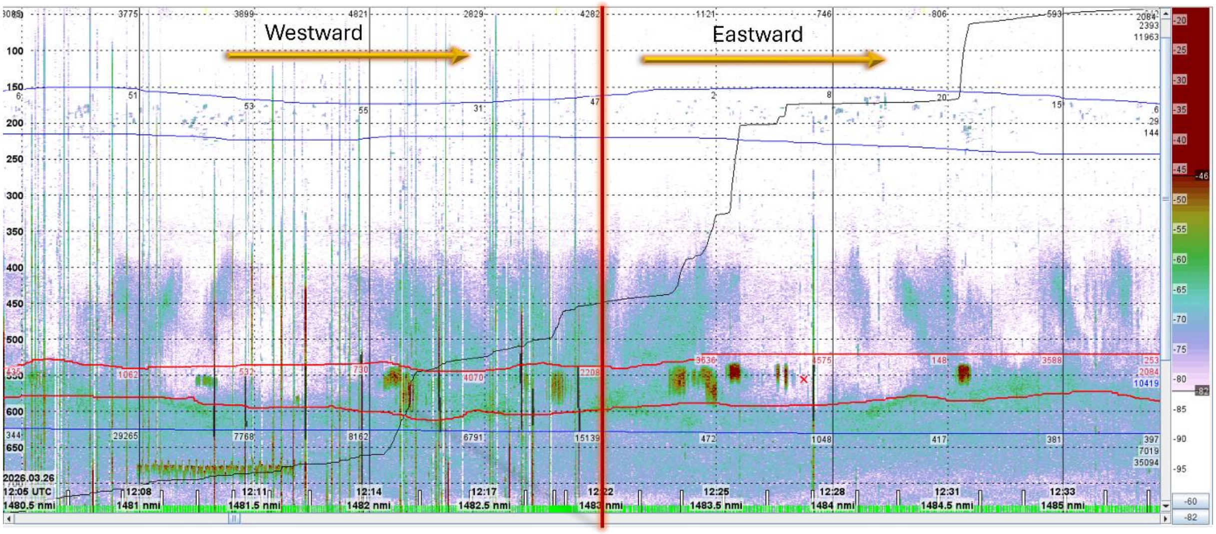


Figure 1 Sample echogram illustrating the impact of vessel steaming direction on acoustic data quality. The left panel (Westward) demonstrates severe signal degradation, characterized by deep vertical noise spikes caused by bubble sweep-down as the vessel steamed directly into prevailing waves. The right panel (Eastward) shows the same transect recorded while steaming with the prevailing seas, resulting in a substantially cleaner acoustic record with clearly defined, continuous blue whiting aggregations and minimal surface noise.

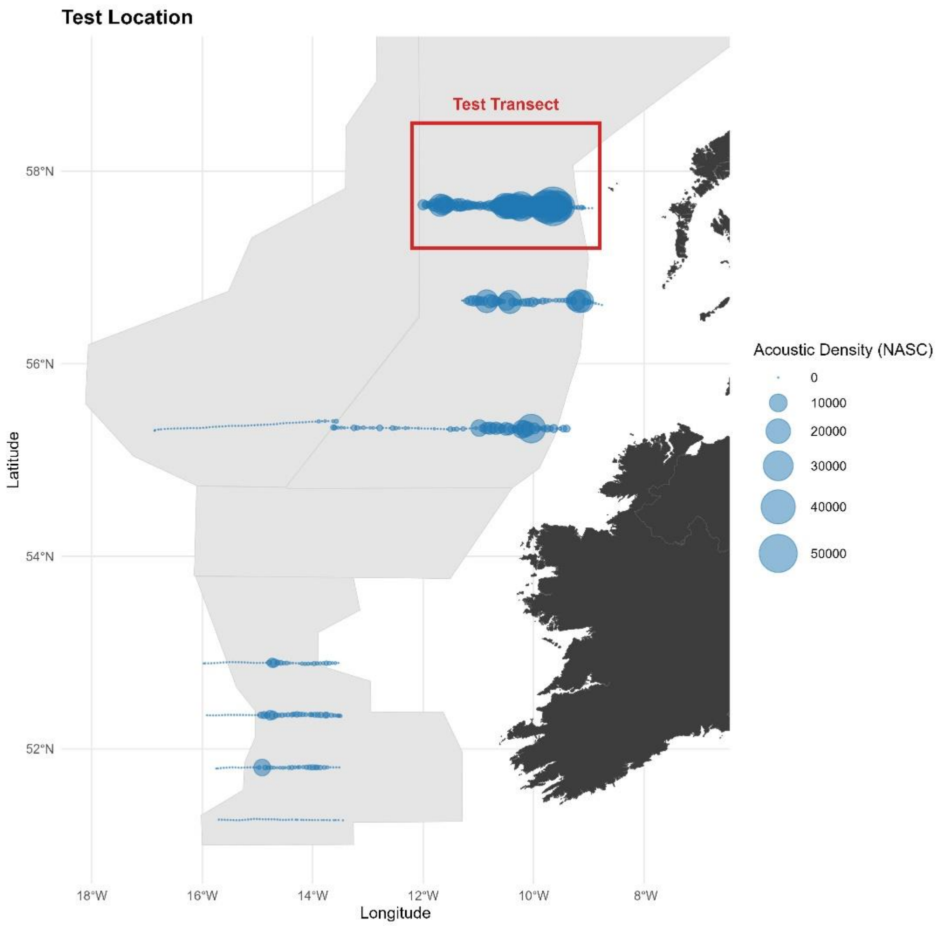


Figure 2 Map of the full acoustic survey area, with the specific test transect indicated by the red bounding box (Longitude -12.2° to -8.8°). Background data points represent the overall acoustic density (NASC) of blue whiting observed across the broader survey

Acoustic Data Processing
Data were processed using the Large Scale Survey System (LSSS). To evaluate the impact of automated noise-reduction algorithms (e.g., "spike removal"), two distinct acoustic cleaning protocols were compared. *Automated Cleaning:* Standard LSSS automated filters combined with manual inspection. *Manual Cleaning:* Purely visual identification and manual exclusion (shading) of weather and bubble-induced noise, without the use of automated algorithms.

Results

Visual inspection of the echograms from the repeated transect revealed visible differences in data quality. During the westward pass (steaming against the waves), the acoustic record was compromised by bubble sweep-down. This interference manifested as deep noise spikes and frequent signal dropouts across the water column, which fragmented and partially obscured the underlying blue whiting aggregations. In contrast, the eastward return pass (steaming with the waves) produced a significantly cleaner echogram, clearly delineating the continuous, high-density schools along the shelf edge.

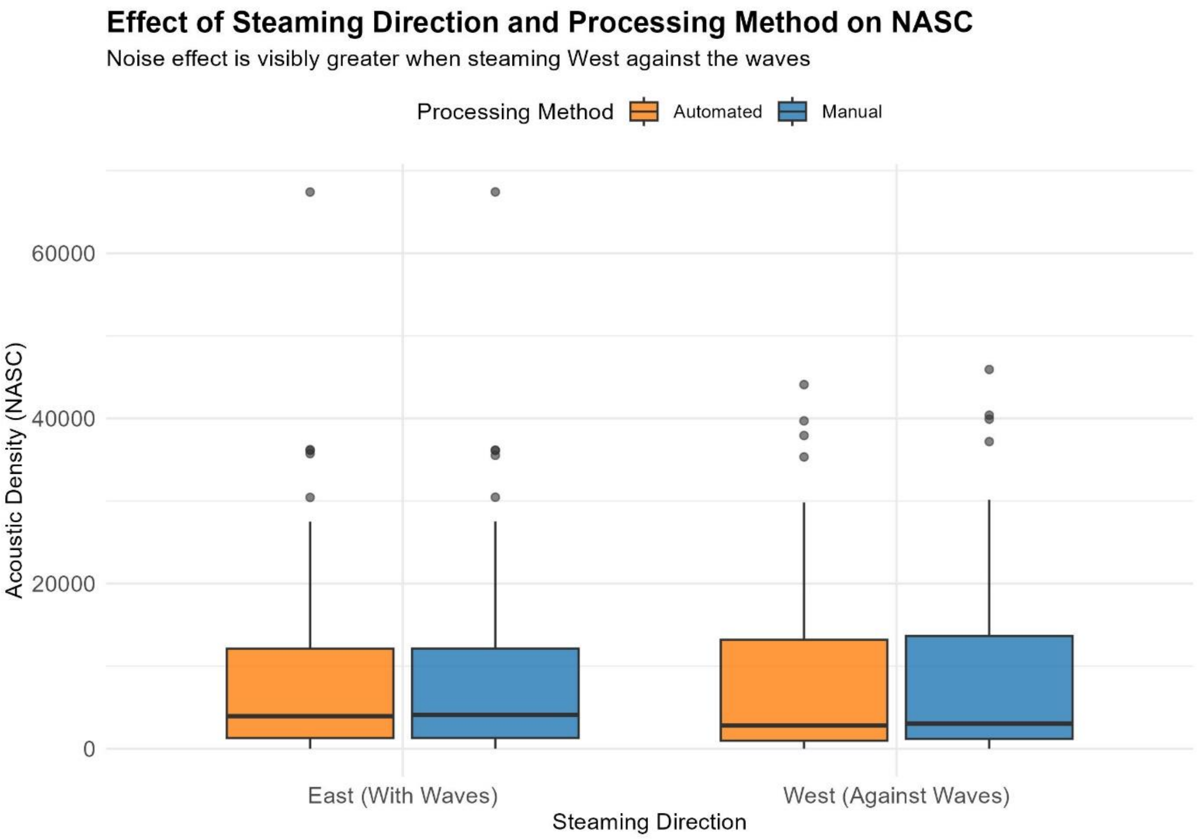


Figure 3 Comparison of blue whiting acoustic density (NASC) distributions by data processing method and vessel steaming direction. The automated LSSS cleaning algorithms (orange) removed significantly more acoustic backscatter compared to manual cleaning (blue) during the Westward pass against prevailing waves.

Quantitative integration of the two passes confirmed a some signal loss under the degraded conditions. The mean Nautical Area Scattering Coefficient (NASC) recorded during the westward leg was 8,264.40 m^2 nmi^{-2}. When re-surveying the same aggregations on the eastward return, the mean NASC increased to 8,570.94 m^2 nmi^{-2}. This discrepancy indicates that steaming directly into the weather resulted in an small but apparent signal attenuation of approximately 3.6% relative to the higher-quality return pass. These results provide a direct, quantitative demonstration of the negative bias introduced when acoustic surveys are conducted under adverse, oncoming sea states, underscoring the necessity of weather-aware survey design and data scrutiny.

Table 1 Summary of Mean Acoustic Density by Direction and Processing Method

Steaming Direction	Processing Method	Mean NASC	Scaled NASC
Eastward *(With Waves)*	Manual	8619.28	1.01
Eastward *(With Waves)*	Automated	8570.94	1.01
Westward *(Against Waves)*	Manual	8610.42	1.01
Westward *(Against Waves)*	Automated	8264.40	0.97

The analysis showed that the outcomes of the acoustic processing methods were dependent sea state. During the calmer Eastward pass (steaming with the prevailing waves), manual and automated cleaning produced nearly identical mean acoustic densities (NASC = 8619.28 and 8570.94, respectively). On the other hand, during the rougher Westward pass (steaming against the waves), the automated LSSS algorithms removed more acoustic backscatter (NASC = 8264.40) compared to manual cleaning (NASC = 8610.42). These findings indicate that while both processing methods perform similarly under favorable weather conditions, the automated algorithms filter out more aggressively during periods of severe vessel pitch and bubble sweep-down.

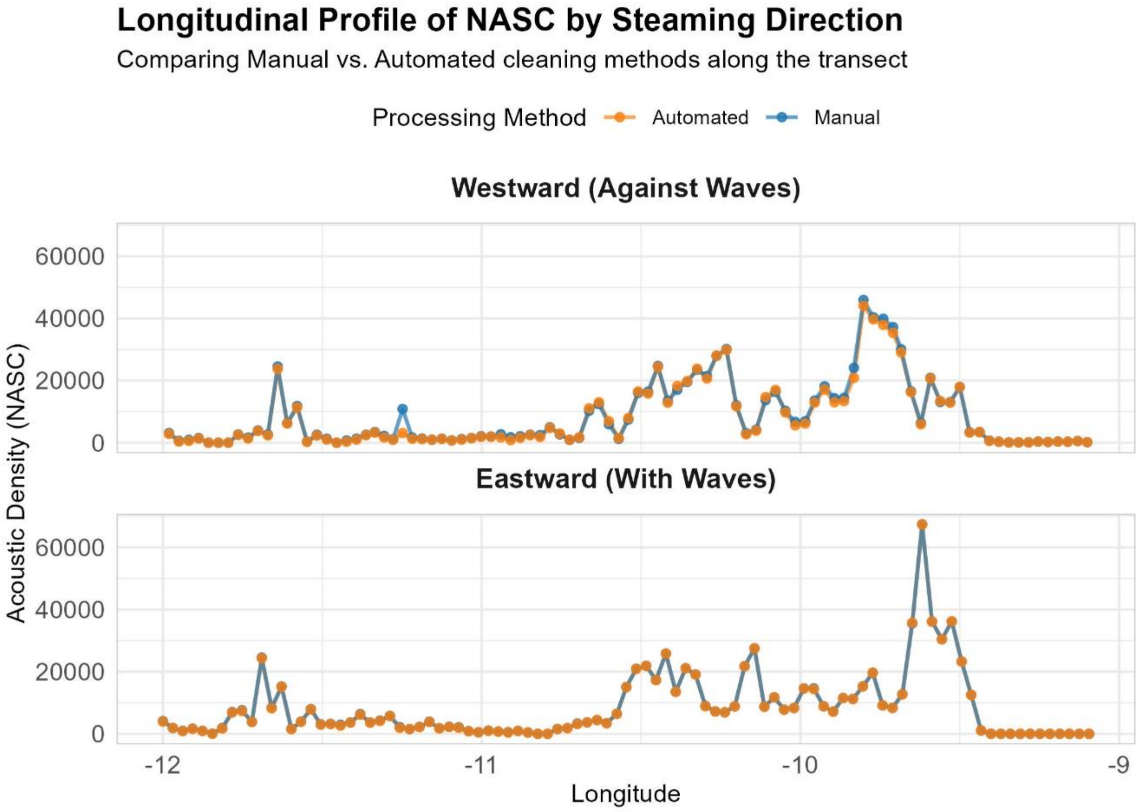


Figure 4 Longitudinal profile of NASC along the test transect, faceted by steaming direction. The plots compare the spatial distribution of acoustic density retained after manual cleaning (blue) versus automated LSSS filtering (orange). The discrepancy between the two methods is visibly pronounced during the Westward pass due to severe vessel pitch and bubble sweep-down.

Conclusion

This exercise demonstrates that vessel steaming direction relative to prevailing sea states measurably impacts both acoustic data quality and the performance of noise-reduction algorithms. Steaming directly into oncoming waves cause signal degradation and introducing a measurable negative bias in acoustic density (a 3.6% attenuation in this study). Under these adverse conditions, automated LSSS filters behave more aggressively, removing more acoustic backscatter compared to manual cleaning protocols. On the contrary, when steaming with the prevailing waves, bubble sweep-down is minimized, and both processing methods produce virtually identical biomass estimates. Results suggest that analysts must be careful when applying automated noise filters to data collected during rough sea states, as these algorithms may inadvertently remove valid biological backscatter alongside weather-induced noise.